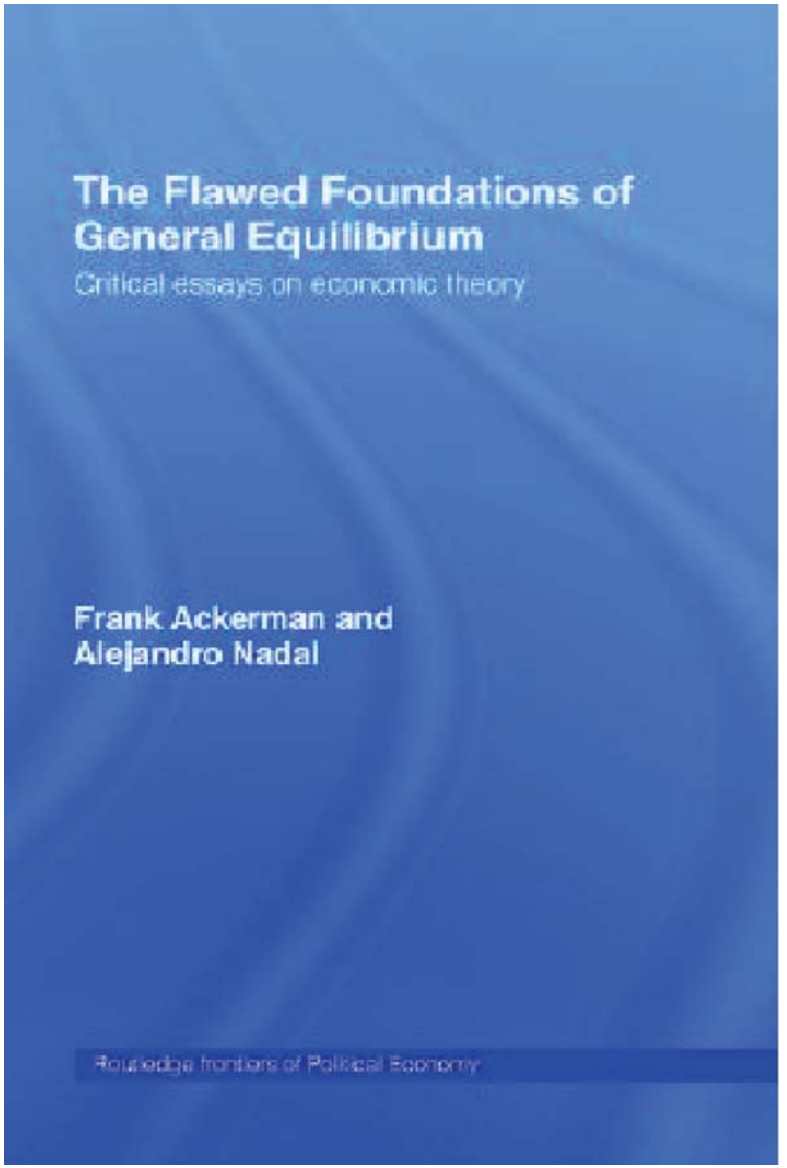

The Flawed Foundations of General Equilibrium

Critical essays on economic theory

Frank Ackerman and Alejandro Nadal with Carlo Benetti, Kevin P. Gallagher, and Carlos Salas

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The Flawed Foundations of General Equilibrium

Does economic theory rest on solid logical foundations? The influence and prestige afforded to orthodox economics – both as a theory and a source of policy advice – suggests the answer is a resounding "yes."

Economists Frank Ackerman and Alejandro Nadal present a fundamental challenge to this received wisdom. They demonstrate that neither the abstractions of general equilibrium nor their real-world consequences stand up to logical scrutiny. Themes critically analyzed in this book include:

- fundamental flaws in the standard theories of general equilibrium;
- conventional economic assumptions about consumer behavior;
- individual choices and the role of money;
- the application of economic theory to current debates in globalization, trade, and development.

The Flawed Foundations of General Equilibrium shows that there are fatal flaws in the standard theoretical model of a market economy. It will be an enlightening read for economists of all persuasions – and for those in law, social sciences, and public policy arenas where economic theory has become inescapable.

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Introduction

Underneath the flawed foundations

Frank Ackerman and Alejandro Nadal

Few academic theories have achieved as much influence as the economics of competitive markets. Few eighteenth-century metaphors are as well remembered and widely quoted as Adam Smith's invisible hand. Mathematical restatements of that metaphor are endorsed by the great majority of economists, and provide the framework for a large and growing number of decisions about public policy. Prominent economists have described the invisible hand as the most important contribution of economics to social theory (Arrow and Hahn 1971: 4). In the case of economics, the ivory tower casts a long shadow over social and political life.

The image of the invisible hand arises in a parable about the socially desirable outcomes of private competition. The magic of the marketplace coordinates isolated individual decisions, "as if by an invisible hand," to achieve the best possible outcome for society. The individuals are assumed to be selfish (if they were selfless altruists, there would be nothing to prove); and the optimal outcome is not foreseen or planned by anyone. In the opening chapters of his *Wealth of Nations*, Smith made an early, but incomplete, attempt to explain how competitive markets achieved this happy result through the price mechanism. Smith's image of invisible coordination was supported by verbal argument, with stories about bakers and butchers learning by trial and error that they will profit by selling the goods that consumers want to buy. These stories are suggestive, but do not strictly prove that the invisible hand is always in touch with our collective best interests.

Recognizing the incompleteness of the theory, economists continued to struggle with the question of the optimality of market outcomes. Almost two hundred years after Smith, his point about the invisible hand and its desirable results was apparently proved by Kenneth Arrow and Gerard Debreu, in the imposingly abstract mathematics of general equilibrium theory. Imagine an economy of many consumers and producers, selfishly engaged in optimizing satisfaction and profits and satisfying a long list of assumptions (many of which are discussed in this book). Under those assumptions, the model built by Arrow and Debreu shows that there is always a market equilibrium at which supply equals demand for every

commodity. It is a "general" or economy-wide equilibrium since it involves the interaction of all prices with the supply and demand for all commodities, as opposed to partial equilibrium theories, which are concerned with price determination in particular markets.

A general equilibrium is always an optimum outcome for society, using the somewhat odd technical definition of "optimum" that has become standard in economics. (On the political biases of Pareto optimality, see Ackerman and Heinzerling (2004, chap. 2).) The mathematics of general equilibrium seems to show that the private greed of bakers, butchers, and all the rest of us, expressed through the market, leads to a collective result that cannot be improved upon for anyone without worsening the outcome for someone else.

The "proof of existence" of a general equilibrium by Arrow and Debreu in 1954 was hailed as a scientific demonstration of the optimal results attained by competitive markets. Amid the celebration, no critical analysis was undertaken of the economic meaning of the abstract mathematical tools used in their opus. Soon the weight of research shifted to the dynamics of price formation, in order to examine just how market forces could lead to that equilibrium point whose existence had been "proven." Here the results were, to say the least, disappointing. The initial work of Arrow *et al*. (1959) concluded with the conjecture that, in general, the Arrow–Debreu model would converge to an equilibrium position. The conjecture was shown to be false by Scarf (1960), using a simple counterexample. Further research soon led to even more negative conclusions, as Frank Ackerman explains in "Still dead after all these years," Chapter 1 of this book. The discipline soon realized that it was unable to provide a theoretical account of the dynamics of the invisible hand and retreated to the apparent robustness and intimidating abstraction of the static "proof of existence." Ironically, the triumph of free market economic policies during the past two decades has coincided with the recognition by economic theorists that the most general theoretical models of the market economy were leading to discouraging results.

Such doubts are not usually presented in textbooks and classroom lectures, let alone public debate. Most economists do not follow the very theoretical branches of the research literature, and typically continue to assert – and believe – that general equilibrium has been definitively proved to lead to the best of all possible outcomes. This conclusion, the optimality of general equilibrium, does not depend on any information about any real economy. It is an axiomatic deduction from a set of abstract hypotheses, based solely on a mathematical model. Yet it often appears to have very specific and controversial implications for the real world, supporting conservative political arguments against any form of government intervention in markets. If unregulated market competition leads to an ideal result, then public programs, regulations, and initiatives of all types can only make things worse.

How can the use of pure mathematics lead to such partisan political conclusions? This paradox suggests that something is wrong with either the theory or its applications. The premise of this book is that there are profound problems both in the theory of general equilibrium and in its common, careless application to reality. A theory built on flawed foundations is unsatisfying for theorists, and has little to say about the economic policy questions that ultimately matter: what changes, what improvements in the status quo, are possible in reality?

Are we beating a dead horse?

A fundamental question needs to be addressed before we go any farther. Is general equilibrium still worth talking about, or is the subject too old and outmoded to bother with? The classic results establishing the existence and optimality of general equilibrium have reached their fiftieth anniversary, and some of the critical findings that we will discuss, concerning the limitations and problems of the theory, are twenty or thirty years old.

When confronted with criticisms of general equilibrium, some economists claim that the discipline has moved on, and that no one still relies on the old Arrow–Debreu framework. Instead, economists are now involved in applications of game theory, chaos or complexity theory, new models of endogenous preferences, the analysis of limited and asymmetric information, and so on. These new approaches lead to varied and intricate results, which, unsurprisingly, fail to exhibit the optimality that general equilibrium so proudly claimed. The old, idealized model of competitive markets is said to be uninteresting, yesterday's news, no longer representative of the leading edge of theory.

We agree that these new approaches can be found in various corners of the economics profession. We wish their advocates well in their efforts to develop new theories. However, they have not yet developed an alternative economic paradigm that rivals or replaces general equilibrium. Perhaps for that reason, the new approaches have not yet had a significant impact on applications of economics to the real world. As Kenneth Arrow (1994: 451) stated not too long ago, "competitive general equilibrium theory is still the only coherent account of the entire economy." This helps explain why both theoretical constructs (see Benetti 1997) and policy recommendations are so often assessed in terms of their deviation from the general equilibrium paradigm.

Game theory is the oldest "new" approach, and has enjoyed decades of mathematically sophisticated applications to economics. Yet its results are unimpressive. With (usually) a small number of participants exploring a small number of choices, with payoffs that depend on the choices made by others, the outcomes of an economic process become indeterminate and need not represent a social optimum. In the prisoner's dilemma, the

ubiquitous introductory example of game theory, the optimum (short sentences if neither prisoner confesses) is unstable, while the worst outcome (long sentences if both confess) is stable. More generally, the "folk theorem" of game theory – a result that was apparently so damning that no one wanted to claim credit for it – shows that essentially anything can happen in an infinitely repeated game. In such a game, multiple equilibria are the norm, while theory in general places very few restrictions on the possible outcomes of the game.

Game theory elegantly clarifies the inherent indeterminacy of oligopoly pricing and other bargaining situations. Its mathematical tools have been applied to a number of abstract economic models. But that is a long way from providing a comprehensive alternative economic theory. Game theory does not provide a new or different framework for a general theory of interdependent markets. Other than stories about oligopolies and bargaining, it is difficult to think of empirical problems that are better explained with game theory than without it.

Chaos theory and complexity theory are two related bodies of analysis that have led to an interesting new perspective on traditional styles of mathematical modeling. (For applications to economics, see, among others, Arthur (1994), Day (1994), Colander (2000), and Ormerod (1998).) In brief, the dynamics of even simple nonlinear systems can be extremely strange, and effectively unpredictable. The smooth movement toward equilibrium, a feature of many traditional economic models, is thus revealed to be dependent on the assumption of linearity – an assumption that is frequently unwarranted. Nonlinear economic systems may exhibit erratic or turbulent patterns of fluctuation ("chaos"), or may develop persistent, disequilibrium structures ("complexity"). Indeed, the dynamic instability of general equilibrium, a topic explored in Chapter 1, rests on similar mathematical insights.

Yet this provocative new body of mathematics has another feature that sharply limits its value in economic modeling. Chaotic and complex systems are sensitively dependent on initial conditions. A trivially small change in data inputs can lead to large qualitative changes in outcomes; since this problem was first noticed in an atmospheric model, it is often referred to as the "butterfly effect." Due to the nonlinear dynamics of atmospheric models, a butterfly flapping its wings could in theory cause a large-scale change in the weather on the other side of the earth. For economic modeling, the butterfly effect means that small errors in data, or even decisions about rounding off data, could utterly change the predicted results. Under these conditions quantitative forecasting and conventional approaches to model estimation become impossible. Thus, we are typically unable to prove the existence of well-defined nonlinear equations that describe the evolution of the system (Ruelle 1988: 197); all that can be proved about nonlinear economic dynamics in general is that almost anything can happen.

Chaotic and complex models can provide qualitative illustrations of the broad range of possible economic dynamics, creating colorful numerical images of potential instability. But thanks to the butterfly effect, they can often do no more. They can be thought of as a null hypothesis for the entire project of quantitative modeling, a mathematical demonstration of the limits of mathematics. The null hypothesis can be rejected only when there are grounds for believing that an economic process is linear or otherwise well behaved. This is an important critique that deserves to be taken seriously; it might imply a greater role for older, verbal styles of historical and political analysis of economic problems. It does not, however, suggest that we are about to achieve a useful quantitative understanding of the economy as a chaotic or complex system. A vigorous recent claim that complexity theory is already influencing policy analysis points to few specifics other than the growing use of the (valuable) notion of path-dependency (Colander 2000).

Another new approach picks up an old theme, criticizing the unrealistic traditional model of consumer preferences (a point that is also discussed in our essay on consumer theory). Standard economics, as embodied in general equilibrium theory, assumes that individual preferences are formed outside the economic system (exogenously) and are not influenced by economic interactions. A modest body of recent literature rejects this assumption and instead explores the more reasonable hypothesis that preferences are in part endogenous, shaped within the economic system. Proponents of this perspective (Bowles 1998; Bowles and Gintis 2000) rightly point out that it is subversive of the traditional general equilibrium model.

However, the new literature on endogenous preferences cannot yet be considered part of an alternative paradigm, for three reasons. First, it has attracted relatively few adherents, and is therefore only in the early stages of development. (On the more widely discussed, but less theoretically ambitious, "prospect theory" of Kahneman and Tversky, see p. 6.) Second, it is often formulated in the narrowly mathematical style of conventional theory, as if seeking to show that new results can be achieved with as few theoretical innovations as possible. This strategy works against the creation of a comprehensive alternative; it proposes minor amendments rather than new constitutions. The more sweeping critiques by Thorstein Veblen and John Kenneth Galbraith, economists who addressed endogenous preferences in the past, were more persuasive and more realistic.

Finally, when the new analyses of endogenous preferences achieve precise mathematical formulations, in this respect surpassing Veblen and Galbraith, they create the kind of nonlinearities that allow chaos and complexity, as discussed above. When people are prone to follow the opinions of others, it is possible for fads and speculative bubbles to arise – species of nonlinear complexity that are unpredictable in any detail. (For our own modest contribution to the massive literature on the subject, see

Ackerman and Gallagher (2002) on the evidence for speculative bubbles in prices of recycled materials.) It is no surprise that some of the researchers examining endogenous preferences are also active in exploring complex economic systems – with all the problems we have described.

There are more innovations that offer other amendments to existing theory, many of them less important than endogenous preferences. One route to status in the mainstream of the economics profession is to explore what happens when a single assumption of the standard theory is relaxed. Yet these isolated innovations are never cumulative; the individual amendments never add up to a whole new draft. The game begins again, from the same starting point, when the next economist proposes to relax a different assumption.

For example, one set of empirical patterns in consumer behavior, described in the so-called prospect theory of Daniel Kahneman and Amos Tversky, has gained widespread attention among economists. Kahneman shared the Nobel Prize for economics in 2002 (Tversky had died a few years earlier) for proving that the standard model of consumer choice is inconsistent with psychological reality in several respects. The Kahneman–Tversky results are often mentioned by economists as an interesting puzzle, but rarely combined with other innovations in the pursuit of a new paradigm; instead, other innovations typically assume the standard model of the consumer, for the sake of mathematical convenience and familiarity.

The last of the new approaches that we will discuss is in some ways the most impressive. The Arrow–Debreu model assumes that all market participants have perfect information about all commodities, employment and investment opportunities, etc., imposing immense and implausible information requirements. Rejecting this assumption, Joseph Stiglitz and his co-workers have explored the economic implications of limited and asymmetric information (see Stiglitz (2000) and numerous sources cited there). Market participants are clearly at a disadvantage when they lack information that others possess, and thus cannot necessarily find the choice that maximizes their welfare. In a limited information context, the unregulated market equilibrium may be far from optimal, and there are frequent justifications for government intervention.

Stiglitz is well known in the economics profession, and shared the Nobel Prize in economics in 2001. His work on the economics of limited information has achieved the widest recognition of any of the "post–general equilibrium" alternatives we have examined (aside from the uneventful assimilation of game theory into the most abstract formulations of economics). Yet here, too, interesting new theoretical developments have failed to dislodge the older dreams of optimality. The economics of limited information has not led to a new synthesis or a comprehensive new method of modeling and prediction. Rather, it justifies intervention to improve on market outcomes on an *ad hoc*, case-by-case basis. It was, in this sense, the ideal theory for the modest and eclectic liberalism of the Clinton administration, in which Stiglitz initially served as chairman of the Council of Economic Advisors.

We are happy to note that we are not alone in seeing a need for reexamining the foundations of general equilibrium theory. In a work with interesting parallels to our own, Michael Mandler (1999) has explored a set of "foundational" problems in contemporary microeconomic theory. He largely addresses a different set of questions than we do: he explores the indeterminacy of factor prices in modern theories of production, the logical problems introduced by the switch from cardinal to ordinal utility, the contradictions of reliance on Pareto optimality, and the surprising difficulty in proving that equilibrium rates of interest are positive. (The first of these has some overlap with Nadal's "Choice of technique revisited," Chapter 6 of this book.) In Mandler's view, the formalization and mathematization of neoclassical economics that occurred from the 1930s to the 1950s solved some problems with earlier theories, but introduced a number of unintended new problems that economic theory has not yet resolved. Thus, the flaws in the foundations of general equilibrium theory extend well beyond the ones examined in this volume.

Economic theory in practice

Turn from theory to practice, and the intriguing new developments in economic theory are nowhere to be seen. Economic arguments are of ever-increasing importance in public life, transforming environmental and social policy, reorganizing international relations, and pressing toward privatization and cutbacks in the public sector, to mention just a few of the leading impacts. In all of these arenas, it is the old, simple theory of the invisible hand, the belief in the optimality of unregulated market outcomes, that drives the economic analysis and the policy recipes. The neoliberal paradigm is founded on this act of faith, as reflected in many areas of contemporary policy and political debate:

- The common practice, in applied economic analyses, of referring to all taxes and tariffs as "distortions" assumes that only a hypothetical pure laissez-faire economy could be undistorted.
- Cost–benefit analyses are becoming the standard for evaluation of environmental, health, and other policies in the United States, testing whether these policies maximize the same benefits as the market would – and, in the process, often clashing with essential, noneconomic policy goals.
- Applied policy analyses frequently rely on "computable general equilibrium" (CGE) models, inspired by the abstract theory of general equilibrium; in many cases, unrealistic assumptions derived directly from the theory (e.g., all markets clear, so involuntary unemployment is impossible) are embedded in CGE models.

- The World Bank and the IMF routinely advise and pressure developing countries to reduce the role of the public sector, to cut tariffs, subsidies, and public spending – in short, to rely only on the market.
- Free trade and investment are increasingly presented as the most effective routes to prosperity and the most urgent policy goals, justifying international agreements that can overturn national laws and regulations if they interfere with global free markets.

No comparable impacts can be detected for any of the sophisticated new departures in economic theory. The mystique of the market, the urgency of rolling back regulation, the verbal equation of freedom and democracy with market competition – the politics that George Soros has called "market fundamentalism" – all these are political reflections of the continuing power of old-fashioned economic theory, as codified in general equilibrium. Some economists may claim to have moved on and started a new life elsewhere, but there is an issue of paternity at stake: market fundamentalism is not a child of the chemistry department, or of classical literature.

In the rush to endorse market-oriented policies, economists have forgotten one of the key theoretical results of past decades. Leave aside, for the moment, the crucial questions about whether the competitive market ideal is a desirable goal, and whether the theory describing it is logically consistent. (This book will argue strongly for negative answers to those questions.) Even if it were desirable, it would clearly be impossible to remove all of the "market imperfections" from the real-world economy, and to make reality conform to the textbook model of perfect competition, perfect information, and all the rest. How do we know, then, that incremental movement toward an unattainable ideal is worthwhile?

The "theory of the second best" (Lipsey and Lancaster 1956) tells us that since the theoretical optimum identified by general equilibrium is not attainable, it may not even be a goal worth striving for. By way of analogy, suppose that you are trying to climb to the highest attainable point in a national park, but the path to the peak of the highest mountain is impassable. Depending on the height of the obstacle, your best strategy might be to abandon the highest mountain and climb the second-highest peak at the other end of the park. Even granting, for the sake of the argument, the debatable proposition that a perfectly competitive general equilibrium represents the highest peak of consumer satisfaction, the real-world obstacles that make that peak unattainable might well make it preferable to pursue a very different economic goal.

Unfortunately, the original idea of the second best has been forgotten even as the words have passed into the jargon of economics – now often contrasted with the awkwardly redundant "first best." In many policy-oriented articles, analyses, the "first best" label is awarded to the option most rigorously deduced from abstract free market theories, while "second best" has come to mean merely "not as good as the first best under idealized, perfectly competitive market conditions." With nothing but the same old theories and some new mathematics in their knapsacks, policy analysts set out to climb what they see as the highest mountain – heedless of the many obstacles that will prevent them from getting anywhere near the top, and uninterested in the rest of the economic terrain.

An overview of the book

The eleven chapters in this book fall into three groups, plus a concluding contribution. The first four deal with the mathematical logic of general equilibrium theory itself. The next three take on particular assumptions of the theory that collide with reality. The following three chapters address issues in the recent discussion of globalization, trade and development, an area where market fundamentalism has become particularly important. The final chapter returns to the "big picture" with a look at the political and philosophical meaning of Adam Smith's invisible hand.

All of the first four chapters address problems that arise within the mathematics of general equilibrium, or in the attempt to make economic sense of the mathematics. In Chapter 1, "Still dead after all these years," Frank Ackerman discusses the troubling finding of dynamic instability in general equilibrium. Imagine that all the assumptions of the model were granted, and that the equilibrium existed, as a static optimum. What would happen if it were perturbed by small random events? What would happen if underlying conditions changed and the economy had to find its way to a new equilibrium point? By the 1970s, analysis of this question had reached a decisively negative outcome: there is no hope of demonstrating the stability of general equilibrium, or even setting any limits on its dynamics. Essentially any dynamic pattern, no matter how unstable and chaotic, could arise in a general equilibrium model. Ackerman explores the implications of this finding for economic theory, seeks to provide an intuitive understanding of the dynamic failure of the model, and suggests new theoretical directions that are needed to overcome the problem.

The next three chapters are the most mathematically demanding of the volume; in these, unlike our others, the reader will necessarily encounter some of the formal mathematical structure of the model. In "Behind the building blocks" (Chapter 2), Alejandro Nadal challenges two of the theory's crucial assumptions that are usually accepted without comment. First, the proof of the existence of general equilibrium requires the assumption that quantities and prices can take on any real number values, which defies common sense and ordinary experience. Most commodities are naturally measured in integers; some bulk commodities might be measured in rational numbers. There is simply no economic meaning, however, to irrational numbers for quantities or prices.

Second, the theory "naturally" leads to the problem of unbounded

consumption and production possibility sets for individuals, yet the mathematical apparatus of the model requires that these sets be bounded. Production possibilities are unbounded if a profitable producer faces truly constant returns to scale; consumption possibilities are unbounded if a household is, or owns a share of, one of these producers. Nadal demonstrates that the device used to demonstrate boundedness of the relevant sets is truly a *deus ex machina*, devoid of economic sense.

In Chapter 3, "Money and prices," our colleague Carlo Benetti brings up the remarkable fact that general equilibrium describes an economy without money. Reviving past lines of analysis that were too quickly abandoned, Benetti shows that pairwise barter cannot always reach an equilibrium, even when aggregate demand equals supply for every commodity. Money is needed, but none of the theoretical devices proposed to explain the existence of money withstand rigorous scrutiny. The existence of money is crucial to, but also external to, the market; it cannot be created by a market process alone. This theoretical finding coexists with the political irony of free market advocates relying on central banks, such as the Federal Reserve in the United States, to provide continual, active, short-term management of the money supply in pursuit of macroeconomic stability. In practice, free market capitalism requires a strictly regulated market in capital. Yet ideologues continue to promote the deregulation of financial markets on the grounds that it will, in theory, bring about a better allocation of resources.

Benetti, Nadal, and a third colleague, Carlos Salas, examine the epitome of the abstract model of general equilibrium in our fourth, and mathematically most difficult, chapter, "The law of supply and demand in the proof of existence of general competitive equilibrium." The standard proof of the existence of equilibrium involves a demonstration that there is a fixed point in the mapping used to represent market processes. Mathematically, the mapping transforms old price vectors into new ones, based on excess demand. Economically, it is supposed to represent (at a high level of abstraction, to be sure) the effects on prices of the market forces of supply and demand. A fixed point in this mapping is a point at which prices are no longer changing; hence it represents an equilibrium. However, as Benetti, Nadal, and Salas demonstrate, the mappings do not make economic sense. Designed for mathematical convenience, they fail to correspond to any plausible economic description of the effects of excess demand on prices. This is, as far as we know, a new and unique critique of the general equilibrium model.

The next group of three chapters moves to a less abstract level, addressing three major assumptions of standard economic theory. (These are not the only such assumptions; they are simply ones we have worked on. Two of the three are published journal articles, and the third is largely derived from a recently published book co-authored by Ackerman. The treatment of labor economics, and of race, gender, and inequality, among many other topics, are deserving of similar treatment.)

In "Consumed in theory" (Chapter 5), Ackerman revisits the stunning unreality of the standard model of the consumer. *Homo economicus*, greedy, insatiable, and antisocial, may not be entirely unknown in real life, but he hardly describes human nature and economic behavior as a whole. Studies of consumer behavior in other social sciences have produced much more interesting and realistic accounts. Critiques of key aspects of the standard economic theory are well known, in some cases dating back as far as Veblen's writings at the turn of the last century. Yet greater realism would undermine the mathematically convenient model of maximizing behavior that is embedded in general equilibrium.

In "Choice of technique revisited" (Chapter 6), Nadal discusses the assumed influence of factor prices on the choice of techniques. Do producers frequently make well-informed choices among different technologies, unconstrained by sunk costs, on the basis of changing relative prices? Neoclassical theory seems to require an affirmative answer, contrary to common sense and ordinary observation. Economic analysis of the choice of technique was debated for a while following Sraffa's critique of marginal productivity theory, but even Sraffa's approach does not provide the basis for a satisfactory theory of technology choice. In view of the importance of technological change for economic growth and development, the creation of a more adequate theory of choice of techniques remains an important goal.

Chapter 7, "Existence values and priceless externalities," is adapted from Ackerman's recent book, co-authored with Lisa Heinzerling, on the limitations of cost–benefit analysis and the market-based paradigm of environmental valuation (Ackerman and Heinzerling 2004). Microeconomic theory assumes, usually with only the briefest of comments, that all externalities must be priced and internalized in order for optimal outcomes to be achieved. In practice, it is clear that many externalities cannot be priced, let alone internalized. Analyses of externalities and attempts at empirical valuation have led to a distinction between use values and nonuse (such as existence) values. The former are often, at least in principle, monetizable; the latter normally are not. Existence values are very important; it is impossible to evaluate the passion surrounding environmental issues without them. Hence the dilemma: monetization of use values alone leads to underestimation of the true social significance of externalities, while monetization of use and nonuse values leads to logically unsound numerical estimates. As Ackerman explains, nonuse values are real, but they are not really numbers.

The next three chapters address three closely related topics in the recent economic analysis of globalization, trade, and development. In Chapter 8, "The Contradictions of the Open Economy Model," Nadal examines the widely accepted Mundell–Fleming model of an open economy – a macroeconomic framework that rests on the microeconomic foundations of general equilibrium – and the collision of that theory with

economic reality in Mexico. The problem is not just that Mexico has suffered from stagnation and unimpressive macroeconomic performance in recent years. Nadal demonstrates that the model is inherently contradictory, as applied to Mexico. The goals of macroeconomic stability and growth, and the needs and demands of foreign capital, place incompatible demands on exchange rates, interest rates, anti-inflation policy, and other measures. Neoliberal advice to shrink the role of the state clashes with the evident need for major public-sector initiatives. The problems of countries such as Mexico will not be solved by advice from a model plagued by internal contradictions.

In "An offer you can't refuse" (Chapter 9), Ackerman reviews trade theory and the search for alternatives. The "science" of neoclassical economics seems to lead straight to policy prescriptions favoring free trade; the numerous critics and opponents of free trade have often failed to articulate their differences in the realm of economic theory. Ackerman suggests that static comparative advantage is to trade and development as gravity is to airplane design: a factor that cannot be overlooked, but far from the whole, or even the most interesting and complex, part of the story. There are good reasons in theory to doubt the simple prescriptions of free trade, and ample historical evidence that successful development has almost never occurred in a free trade environment. Demands from international agencies and treaties for developing countries to adopt free trade today amount to kicking away the ladder that developed countries have climbed in the past.

Ackerman and our colleague Kevin P. Gallagher take up the question of "computable general equilibrium" (CGE) models, as applied to the environmental assessment of trade agreements, in "Computable abstraction" (Chapter 10). On the basis of the name alone, CGE models often inherit the prestige and the aura of well-established science that attaches to general equilibrium theory. But as Ackerman and Gallagher demonstrate, CGE models have extremely high information costs, are lacking in transparency, and frequently resort to questionable or arbitrary assumptions for the sake of completeness and computational convenience. It is hardly surprising that they have a spotty record of prediction in practice. Retrospective analysis finds that CGE models fail to provide accurate descriptions of the effects of major trade agreements. Ackerman and Gallagher end with a call for simpler, more transparent approaches to modeling, to overcome the evident weaknesses of the CGE approach.

Finally, in Chapter 11, "Freedom and submission," Nadal returns to the larger questions about the foundational metaphor of general equilibrium, Adam Smith's invisible hand. Some analysts have suggested that the invisible hand process makes individuals into degraded and unattractive agents, such as the narrow and greedy caricatures discussed in "Consumed in theory." Nadal argues that the invisible hand process – a social system that provides unexpected, unplanned coordination of individual decisions for the common good – is more general, and can be more attractive, than the usual vision derived from Smith's *Wealth of Nations*.

The market system proposed in *Wealth of Nations* has, as this book shows, led to fundamental and unresolved problems. However, Smith offered an earlier version of invisible hand processes in his *Theory of Moral Sentiments*; in this account, the invisible hand is crucial to the evolution of public morality and social justice. While the details of Smith's theory are entangled in the issues and vocabulary of eighteenth-century philosophy, the general point is a hopeful one: under the right circumstances, unplanned coordination of individuals may emerge from a variety of social systems. Could this apply to democratic political processes, and perhaps even the evolution of better economic systems? In any case, the need for better economic theories is clear, as the chapters of this book establish that the dominant school of economics is built on flawed foundations.

1 Still dead after all these years

Interpreting the failure of general equilibrium theory

Frank Ackerman

For years after the Spanish dictator actually died, the mock television newscast on *Saturday Night Live* was periodically interrupted with a "news flash" informing viewers that "General Franco is still dead!" This served both to satirize the breathlessly urgent style of television news reporting, and to suggest that after many decades of taking an absolute ruler for granted, the world needed more than one reminder that he was no longer alive and well.

Much the same is true for general equilibrium theory. In the course of its long decades of rule over the discipline of economics, general equilibrium became established as the fundamental framework for theoretical discourse. Its influence continues to spread in policy applications, with the growing use of computable general equilibrium models. At its peak it even colonized much of macroeconomics, with the insistence on the derivation of rigorous microfoundations for macro models and theories. General equilibrium theory is widely cited in a normative context, often in textbooks or semitechnical discussion, as providing the rigorous theoretical version of Adam Smith's invisible hand and demonstrating the desirable properties of a competitive economy.

Yet those who follow the news about microeconomic theory have known for some time that general equilibrium is not exactly alive and well anymore. The equilibrium in a general equilibrium model is not necessarily either unique or stable, and there are apparently no grounds for dismissing such ill-behaved outcomes as implausible special cases. This conclusion is clearly at odds with established modes of thought about economics; several more "news flashes" will be required to assimilate and interpret the failure of earlier hopes for general equilibrium models, and to formulate new directions for economic theory.

The first section of this chapter, "The limits of general equilibrium," presents one such news flash, summarizing and explaining the evidence of fundamental flaws in general equilibrium theory. But simply hearing the news one more time is not enough. The goal of this chapter is to develop a basic, intuitively comprehensible understanding of *why* it happened, as a guide to future theorizing. What features of the general equilibrium model led to its failure? What changes in economic theory are needed to avoid the problem in the future?

The second section, "Explanations of the fall," examines contemporary interpretations of the findings of instability. Some attempts have been made to avoid the issue, without success. Despite occasional claims to the contrary, general equilibrium remains fundamental to the theory and practice of economics. Analysts who have faced the problem have identified two underlying causes: the inherent difficulties of the aggregation process, and the unpredictable nature of individual preferences.

The third section, "The limits of analogy," pursues the roots of the problem in the early history of general equilibrium theory: a mathematical framework transplanted from nineteenth-century physics was far less fruitful in economics, due to fundamental differences between the two fields. The provocative treatment of this topic by Philip Mirowski asks the right questions, but falls short of adequately answering them.

The final section, "Alternatives for the future," briefly describes alternative approaches that might remedy the earlier flaws in neoclassical theory. Post-general equilibrium economics will need a new model of consumer behavior, new mathematical models of social interaction, and an analysis of the exogenous institutional sources of stability.

The limits of general equilibrium

> Now the reason for this sterility of the Walrasian system is largely, I believe, that he did not go on to work out the laws of change for his system of General Equilibrium.
>
> (John Hicks 1939: 61)

The best-known results of general equilibrium theory are the two theorems proved by Kenneth Arrow and Gerard Debreu in the 1950s. First, under familiar assumptions defining an idealized competitive market economy, any market equilibrium is a Pareto optimum. Second, under somewhat more restrictive assumptions, any Pareto optimum is a market equilibrium for some set of initial conditions.

There is a long-standing debate about the interpretation of the Arrow–Debreu results, in light of the obvious lack of realism of some of their assumptions. For example, nonconvexities, such as increasing returns to scale in production, are common in reality. If they are allowed into the theory, then the existence of an equilibrium is no longer certain, and a Pareto optimum need not be a market equilibrium (i.e., the second theorem no longer holds).

Yet despite awareness of this and other qualifications, economists frequently talk as if deductions from general equilibrium theory are applicable to reality. The most common and most important example involves the relationship between efficiency and equity. (For a critical review of the

standard approach to the subject, see Putterman *et al.* (1998).) The second fundamental theorem is often interpreted to mean that any efficient allocation of resources – for instance, one based on a preferred distribution of income – could be achieved by market competition, after an appropriate lump-sum redistribution of initial endowments.

This interpretation is a mistaken one. Even if the conditions assumed in the proofs applied in real life (which they clearly do not), meaningful application of the Arrow–Debreu theorems would require dynamic stability. Consider the process of redistributing initial resources and then letting the market achieve a new equilibrium. Implicitly, this image assumes that the desired new equilibrium is both unique and stable. If the equilibrium is not unique, one of the possible equilibrium points might be more socially desirable than another, and the market might converge toward the wrong one. If the equilibrium is unstable, the market might never reach it, or might not stay there when shaken by small, random events.

Beyond stability

In the 1970s, theorists reached quite strong, and almost entirely negative, conclusions about both the uniqueness and the stability of general equilibrium. There is no hope of proving uniqueness in general, since examples can be constructed of economies with multiple equilibria. The fundamental result about uniqueness, achieved by Debreu in 1970, is that the number of equilibria is virtually always finite (the set of parameters for which there are an infinite number of equilibria has measure zero). There are certain restrictions on the nature of aggregate demand that ensure uniqueness of equilibrium, but no compelling case has been made for the economic realism of these restrictions.

For stability, the results are, if anything, even worse. There are examples of three-person, three-commodity economies with permanently unstable price dynamics (Scarf 1960), showing that there is no hope of proving stability of general equilibrium in all cases. The basic finding about instability, presented in a limited form by Sonnenschein (1972) and generalized by Mantel (1974) and Debreu (1974), is that almost any continuous pattern of price movements can occur in a general equilibrium model, so long as the number of consumers is at least as great as the number of commodities.[1] Cycles of any length, chaos, or anything else you can describe will arise in a general equilibrium model for some set of consumer preferences and initial endowments. Not only does general equilibrium fail to be reliably stable; its dynamics can be as bad as you want them to be.

A common reaction to this Sonnenschein–Mantel–Debreu (SMD) theorem is to guess that instability is an artifact of the model, perhaps caused by uncommon or unrealistic initial conditions, or by the nature of the assumed market mechanisms. Investigations along these lines have failed to revive general equilibrium, but instead have driven more nails into its coffin.

The SMD result cannot be attributed to a specific, rigid choice of individuals' preferences, nor to a particular distribution of income. In a sweeping generalization of the SMD theorem, Kirman and Koch (1986) proved that the full range of instability can result – this is, virtually any continuous price dynamics can occur – even if all consumers have identical preferences, and any arbitrarily chosen income distribution is used, as long as the number of different income levels is at least as great as the number of commodities. This means that the SMD theorem can be established even for a population of nearly identical consumers – with identical preferences and almost, but not quite, equal incomes (Kirman 1992).

Another important generalization shows that "SMD instability" may be a property of an economy as a whole even if it is not present in any part, or subset, of the economy (Saari 1992). Suppose that there are n commodities; even if every subset of the economy with $n-1$ or fewer commodities satisfies conditions that guarantee stability of equilibrium, it is still possible to have "arbitrarily bad" dynamics in the full n-commodity economy. This means, among other things, that the addition of one more commodity could be sufficient to destabilize a formerly stable general equilibrium model. More generally speaking, dynamic results that are proven for small general equilibrium models need not apply to bigger ones.

Might instability be just a result of the unrealistic method of price adjustment assumed in general equilibrium models? Again, the answer is no. In Walrasian general equilibrium, prices are adjusted through a *tâtonnement* ("groping") process: the rate of change for any commodity's price is proportional to the excess demand for the commodity, and no trades take place until equilibrium prices have been reached. This may not be realistic, but it is mathematically tractable: it makes price movements for each commodity depend only on information about that commodity.[2] Unfortunately, as the SMD theorem shows, *tâtonnement* does not reliably lead to convergence to equilibrium. An early response to the problem of instability was the exploration of alternative mechanisms of price adjustment; but several economically plausible mechanisms failed to ensure stability except under narrow special conditions (Fisher 1989).

On the other hand, any price adjustment process that does reliably converge to equilibrium must be even less realistic, and far more complex, than *tâtonnement*. There is an iterative procedure that always leads to a market equilibrium, starting from any set of initial conditions (Smale 1976). However, there is no apparent economic justification for this procedure, and it requires overwhelming amounts of information about the effects of prices of some goods on the demand for other goods.

A final negative result has been achieved on this question, showing that any price adjustment process that always converges to an equilibrium has

essentially infinite information requirements (Saari 1985). Consider any iterative price adjustment mechanism, in which current prices are a smooth function of past excess demand and its partial derivatives. If there is an upper bound on the amount of information used in the adjustment process – that is, if it relies solely on information about any fixed number of past periods and any fixed number of derivatives of the excess demand function – then there are cases in which the process fails to converge. These cases of nonconvergence are mathematically robust; that is, they occur on open sets of initial conditions, not just at isolated points.

Safety in numbers?

Not much is left, therefore, of the original hopes for general equilibrium. One direction in which theoretical work has continued is the attempt to deduce regularities in aggregate economic behavior from the dispersion of individual characteristics. This approach abandons efforts to prove that market economies are generically stable, and instead suggests that conditions that lead to stability are statistically very likely to occur, even if not quite guaranteed.

In particular, Hildenbrand (1994) and Grandmont (1992) have explored the hypothesis that the dispersion of individual preferences is a source of aggregate stability. That is, predictable, smoothly distributed differences in individuals' demand functions and consumption patterns, of the sort that are observed in reality, could lead to a definite structure of aggregate demand that might imply stability of equilibrium. (For reviews of this line of work, see Kirman (1998), Lewbel (1994), and Rizvi (1997).)

There are two problems with the statistical approach to economic stability. First, it has not yet succeeded. The assumption of a smooth distribution of consumer characteristics seems to help, but has not entirely freed the proof of market stability from arbitrary restrictions on individual preferences or aggregate demand functions.

Second, even if the statistical approach were to succeed in explaining past and present market stability, it would remain vulnerable to future changes in preferences. Suppose that it is eventually demonstrated that the empirically observed dispersion of consumer preferences is sufficient to ensure stability in a general equilibrium model. This finding might not be reliable for the future, since, in the real world, fads and fashions episodically reorganize and homogenize individual preferences. That is, coordinated preference changes involving the media, fashions, celebrities, brand names, and advertising could, in the future, reduce the dispersion of consumer preferences to a level that no longer guaranteed stability.

Explanations of the fall

> In the aggregate, the hypothesis of rational behavior has in general no implications.
>
> (Kenneth Arrow 1986)

The mathematical failure of general equilibrium is such a shock to established theory that it is hard for many economists to absorb its full impact. Useful interpretations of its causes and significance have been slow to appear. This section begins with a presentation and critique of three views that suggest that the SMD theorem is not as important as it looks. It then turns to other interpretations offered by two of the theorists whose work was referred to in the previous section.

Three styles of denial

Is the SMD result only a mathematical curiosity, of limited importance for economics? At least three major arguments make that claim, on the basis of disinterest in dynamics, disinterest in abstraction, and disinterest in the particular theories of the past. As we will see, none of the three is persuasive.

First, some essentially say that we're just not a dynamic profession. A recent graduate text in microeconomic theory presents a detailed explanation and proof of the SMD theorem and then, a few pages later, tells students that

> A characteristic feature that distinguishes economics from other scientific fields is that, for us, the equations of equilibrium constitute the center of our discipline. Other sciences, such as physics or even ecology, put comparatively more emphasis on the determination of dynamic laws of change.
>
> (Mas-Colell *et al*. 1995: 620)

Second, perhaps it was always silly to care so much about empty abstractions. According to Deirdre McCloskey, the whole category of general equilibrium theorizing is merely "blackboard economics," exhibiting the "rhetoric of mathematical formalism":

> None of the theorems and countertheorems of general equilibrium theory has been surprising in a qualitative sense . . . *But the qualitative sense is the only sense they have*. . . . The problem is that the general theorem of Arrow and Debreu or any of the other qualitative theorems do not, strictly speaking, relate to anything an economist would actually want to know.
>
> (McCloskey 1994: 135; emphasis in original)

Things an economist would actually want to know, for McCloskey, necessarily involve information about how big something really is compared to something else.

Finally, it could be that those on the inside track already have learned to avoid the theoretical dead ends of the past. This view is common in conversation with economists, if not in writing. "No one," it is alleged, believes in general equilibrium theory anymore; the profession has moved on to game theory, complexity theory, evolutionary frameworks, and other techniques, allowing the creation of sophisticated new models that do not fit into the old Arrow–Debreu mold.

Each of these claims is narrowly true and broadly false. In a narrow sense, they describe the behavior of numerous economists: many do focus on static rather than dynamic theoretical problems; many others are predominantly engaged in empirical work; and there are theorists who no longer use a general equilibrium framework. Yet in a broad sense, each of these observations misses the point.

The first claim, the dismissal of dynamics, fails because all significant applications of theory are inherently dynamic. This idea is not unknown to economists: some of the earliest theoretical responses to the instability of general equilibrium involved the exploration of alternative dynamics (although those explorations ultimately failed, as explained by Fisher (1989)). In an ever-changing world, or a model of that world, static properties of equilibrium have no practical meaning unless they persist in the face of small disturbances. Advocacy of a policy based on its static optimality in a general equilibrium framework – a common conclusion in applied economics – implicitly assumes some level of dynamic stability, since otherwise the optimum might not last for long enough to matter. Yet the dynamic stability of the general equilibrium framework is precisely what is called into question by the SMD theorem.

In the face of the ongoing mathematical escalation in economic theory, the second claim, McCloskey's call to turn away from empty formalism toward real empirical work has a certain refreshing charm. But even applied researchers often present their work in terms of the abstractions of what she calls "blackboard economics." Facts do not spontaneously assemble themselves into theories; some theory is present, explicitly or implicitly, at the beginning of any empirical study.

In applied economics today, it is increasingly common to find explicit reliance on a general equilibrium framework, often in the form of computable general equilibrium (CGE) models. A typical CGE study is an exercise in comparative statics: the model is run twice, once to calculate the equilibrium before a policy change or other innovation, and once to calculate the new equilibrium after the change. Such an approach rests on what Paul Samuelson (1947) called the "correspondence principle"; he argued that in the neighborhood of a stable equilibrium, comparative statics would yield reliable results while avoiding the need for more complex dynamic analysis of adjustment processes. Unfortunately, Samuelson's strongest conclusions apply only to models with just two or three variables. For bigger models, the instability reflected in the SMD theorem undermines the correspondence principle as well (Hands and Mirowski 1998; Kehoe 1989).

The third claim, the notion that "no one" believes in general equilibrium anymore, is true only of small circles of avant-garde theorists. Look anywhere except at the most abstractly theoretical journals, and general equilibrium still characterizes the actual practice of economics. General equilibrium models have become ubiquitous in such important areas as trade theory and environmental economics, and are continuing to spread. Macroeconomics, a field that once developed its own very different theories, has been led into the pursuit of rigorous microfoundations – in effect seeking to deduce aggregate behavior from general equilibrium theory. An online search for publications on "general equilibrium" turns up more than a thousand citations per year, with no evidence of declining interest in the subject.[3]

General equilibrium is fundamental to economics on a more normative level as well. A story about Adam Smith, the invisible hand, and the merits of markets pervades introductory textbooks, classroom teaching, and contemporary political discourse. The intellectual foundation of this story rests on general equilibrium, not on the latest mathematical excursions. If the foundation of everyone's favorite economics story is now known to be unsound – and, according to some, uninteresting as well – then the profession owes the world a bit of an explanation.

Individualism and aggregation

There are some theorists who have recognized the importance of the failure of general equilibrium theory. Two of the authors cited earlier in the chapter, Alan Kirman and Donald Saari, have published thoughtful reflections on the subject. Kirman, in a dramatically titled article ("The Intrinsic Limits of Modern Economic Theory: The Emperor Has No Clothes"), argues that

> The problem seems to be embodied in what is an essential feature of a centuries-long tradition in economics, that of treating individuals as acting independently of each other. . . . This independence of individuals' behavior plays an essential role in the construction of economies generating arbitrary excess demand functions [the source of instability in the SMD theorem].
>
> (1989: 137–38)

Saari considers the problem from a mathematician's perspective. Examining the "Mathematical Complexity of Simple Economics" (Saari's title), he explores the SMD theorem and related results, and concludes that

> [T]he source of the difficulty – which is common across the social sciences – is that the social sciences are based on aggregation procedures.... One way to envision the aggregation difficulties is to recognize that even a simple mapping can admit a complex image should its domain have a larger dimension than its image space.... [T]he complexity of the social sciences derives from the unlimited variety in individual preferences; preferences that define a sufficiently large dimensional domain that, when aggregated, can generate all imaginable forms of pathological behavior.
>
> (Saari 1995: 228–29)

There are two separate points here: one involves the methodology of aggregation, and the other concerns the behavioral model of the individual. Both are basic causes of the instability of general equilibrium.

Instability arises in part because aggregate demand is not as well behaved as individual demand. If the aggregate demand function looked like an individual demand function – that is, if the popular theoretical fiction of a "representative individual" could be used to represent market behavior – then there would be no problem. Unfortunately, though, the aggregation problem is intrinsic and inescapable. There is no representative individual whose demand function generates the instability found in the SMD theorem (Kirman 1992). Groups of people display patterns and structures of behavior that are not present in the behavior of the individual members; this is a mathematical truth with obvious importance throughout the social sciences.

For contemporary economics, this suggests that the pursuit of microfoundations for macroeconomics is futile. Even if individual behavior were perfectly understood, it would be impossible to draw useful conclusions about macroeconomics directly from that understanding, due to the aggregation problem (Rizvi 1994; Martel 1996). This fact is reflected in Arrow's one-sentence summary of the SMD result, quoted at the beginning of this section.

The microeconomic model of behavior contributes to instability because it says too little about what individuals want or do. From a mathematical standpoint, as Saari suggests, there are too many dimensions of possible variation, too many degrees of freedom, to allow results at a useful level of specificity. The consumer is free to roam over the vast expanse of available commodities, subject only to a budget constraint and the thinnest possible conception of rationality: anything you can afford is acceptable, so long as you avoid blatant inconsistency in your preferences.

The assumed independence of individuals from each other, emphasized by Kirman, is an important part but not the whole of the problem. A reasonable model of social behavior should recognize the manner in which individuals are interdependent; the standard economic theory of consumption fails to acknowledge any forms of interdependence, except through market transactions. However, merely amending the theory to allow more varied social interactions will not produce a simpler or more stable model. Indeed, if individuals are modeled as following or conforming to the behavior of others, the interactions will create positive feedback loops in the model, increasing the opportunity for unstable responses to small fluctuations (see "Alternatives for the future," p. 27).

The limits of analogy

> There is a fairly close analogy between the earlier stages of economic reasoning and the devices of physical statics. But is there an equally serviceable analogy between the later stages of economic reasoning and the methods of physical dynamics? I think not.
>
> (Alfred Marshall 1898)

How did economists come to spend so much time and effort on general equilibrium, only to arrive at a mathematical dead end? What was the source of such long-standing devotion to an ultimately unworkable theory? The problems identified in the previous section – the inherent difficulties of aggregation, and the underspecified model of individual behavior – are not new, and cannot be blamed on the latest mathematical wrinkles in the formulation of general equilibrium. In particular, the microeconomic behavioral model was an intentional feature of the theory, and has been present in something like its current form ever since neoclassical economics was born. A look at the history of economic thought may help to identify what went wrong in the beginning.

In their history of the idea of economic equilibrium, Ingrao and Israel (1990) argue that mathematical modeling of economic systems was a continuation of a major current in eighteenth- and nineteenth-century European social thought, seeking to identify lawlike regularities in social life and organization. Once the idea of equilibrium was given a mathematical form, though, the mathematics itself became the predominant influence on the further development of the theory.

The outlines of general equilibrium theory first appeared in the work of Leon Walras, as part of the "marginalist revolution" of the 1870s. The sudden interest in marginalism in economics in the 1870s is commonly attributed to the influence of mid-nineteenth-century advances in mathematics and the physical sciences. Thus, the original structure of general equilibrium theory reflects the manner in which economists applied the new mathematical techniques of the era.

Breaking the conservation law

The influence of physics on the origins of neoclassical economics is analyzed in depth in an important, controversial work by Philip Mirowski

(1989). The pioneers of marginalism in economics, including Walras, tried to develop analogies to mechanics in some detail. According to Mirowski, several of the early neoclassical economists adopted very similar mathematical models, and incorporated similar flaws.

The physics of the day, much admired by economists, assigned a central role to the conservation of energy. Potential energy could be represented as a vector field indicating the direction in which particles would move unless constrained by other forces. The economic analogy treated individuals as particles moving in commodity space, where the spatial coordinates are quantities of different commodities.[4] Utility was the vector field indicating the direction in which individuals would move, to the extent allowed by budget constraints.

The problem with this economic analogy, for Mirowski, was the failure to take or to understand the logical next step. In physics, the model of potential energy as a vector field induces predictable movements of particles and leads to a related concept of kinetic energy, measured in the same units as potential energy. The law of energy conservation applies to the sum of potential plus kinetic energy, not to either one alone. Much of the power of the physical theory and the effectiveness of its use of mathematics derives from the energy conservation law.

In the economic analogy, if utility as a potential field induces predictable movements of individuals in commodity space, the "kinetic energy" of that movement should be consumer expenditure. The exact analogue of the law of energy conservation would thus be the conservation of the sum of utility plus expenditure, an economically meaningless concept. At this point the analogy breaks down. The resulting economic theory remained fragmented, using bits and pieces of the mathematical apparatus related to energy conservation but unable to draw on the full strength and coherence of the original physical theory. In particular, the economists adapted some of the relationships of static equilibrium but failed to incorporate the more complicated dynamic relationships from physics.

The debate surrounding Mirowski's argument (see, for example, Walker 1991; Varian 1991; Hands 1992; Cohen 1992; de Marchi 1993; and Carlson 1997) raises many other issues, as does his original work. On the central point about the close relationship between physics and early neoclassical economics, Mirowski poses the right question, but his answer is at best incomplete. Mirowski certainly demonstrates that Walras, Jevons, Pareto, Fisher, and other neoclassical pioneers discussed analogies to physics in great detail without always understanding the mathematics that was involved. Moreover, he is persuasive in suggesting that this episode of intellectual history had a formative impact on modern economic theory. Yet Mirowski's version of what went wrong with neoclassical theory is frustrating on two accounts.

First, why should economics need an exact analogue to energy conservation? The failure to create a precisely analogous principle might be taken as a recognition that economics and physics are not identical in structure. While the particular mathematical methods that work in physics are therefore not available, others, more appropriate to economics, could be created. In a sense, it is true that *something* must be conserved in any economic theory that allows quantification and causal analysis; otherwise, there would be no way to compare magnitudes and events at different times (Mirowski 1990). However, this does not imply that the same thing, or the analogous thing, must be conserved in two different theories.

Second, while Mirowski makes a remarkably strong case for the idea that the earliest neoclassicals were mediocre mathematicians, that early history does not explain the persistence of mistakes through successive generations of economists. In the thorough reworking of neoclassical theory in the 1930s and 1940s by Hicks, Samuelson, von Neumann, and others, it seems unlikely that past mathematical errors and oversights would have survived unnoticed.

Nonetheless, the problem remains as Mirowski describes it: the original formulation of general equilibrium by Walras and others relied heavily on analogies to physics, often using the same mathematical structures – that is, the same mathematical metaphor for reality. Why did this metaphor prove so much more fruitful in physics than in economics? Answers must be sought in features of the economic model that are *intentionally* different from the physical analogue, and have therefore persisted through more than a century of development of economic theory. Two such answers are suggested in the following subsections, involving the number of dimensions in the model, and the individual, asocial nature of preferences.

Lost in commodity space

The analogy between mechanics and economics makes the spatial coordinates of a particle correspond to the quantities of commodities held by an individual. Once this step is taken, there is already a significant difference between the two theories, involving the number of dimensions.

Physics is, in this respect, the more modest of the two fields. Physical particles have three spatial coordinates; they travel in the familiar world of three-dimensional space. A paradigm-changing innovation, the theory of relativity, adds just one more dimension to create a four-dimensional space–time continuum. Abstract higher-dimensional constructions are common in physics (e.g., the phase spaces of elaborate theoretical systems), but the resulting theories have observable, testable implications for events in the low-dimensional space of our physical experience.

The analogous space of our economic experience is a commodity space that, in a modern industrial economy, may have hundreds of thousands of dimensions. Even in Walras's day, there must have been thousands of distinct commodities, and hence thousands of dimensions in a general

equilibrium model of the economy as a whole. This is no phase space used to explain a simpler experiential space; the thousands of independent dimensions (commodities) are fundamental to the characterization of economic experience in neoclassical theory.

Intuition is a poor guide to the vast commodity spaces of economics. The ability to visualize shapes and motion drops off rapidly as the number of dimensions increases beyond three. The dynamic possibilities for a model are far more complex in three dimensions than in two; how much greater complexity is introduced by going to thousands of dimensions? No system of actual equations in such high-dimensional spaces can be comprehended or manipulated. All that can be done is to prove completely generic results, or to talk about low-dimensional – usually visualizable, two- or three-dimensional – examples and special cases. Yet as noted in the first section of the chapter, "The limits of general equilibrium" these special cases may be misleading: dynamic results that can be proved for smaller general equilibrium models need not apply to bigger ones.

The huge number of dimensions of commodity space is not only a mathematical problem. It also affects the plausibility of the economic model of the consumer. The consumer must be able to reveal his or her preferences about any of the commodities on the market; this may require knowledge of hundreds of thousands of different items. Whenever a new commodity appears on the market, the consumer must be able to revise his or her preference ordering at once to reflect the change. Clearly, no real person can come close to fulfilling this role. Responses to this problem are discussed in the next section.

A different drummer

The original neoclassical analogy to physics made utility comparable to energy. Yet there are crucial ways in which utility and energy differ. In physics, the same potential energy fields affect all particles in the same manner, allowing structure and predictability in the movements of large groups of particles. In the analogous economic theories, a different utility function motivates each individual, giving a group of people a structureless, unpredictable pattern of change. No common forces move them all in parallel; no interactions with each other, save through market exchange, coordinate their motions.

This is no mathematical accident, but rather a result of the microeconomic behavioral model, which concentrates on one aspect of human activity and assumes away everything else. In fact, human behavior involves a complex combination of relatively predictable responses to social forces on the one hand, and unpredictable individual preferences and choices on the other hand. The former aspect is where an analogy to physical laws of motion might have proved most valuable – but the latter is the focus of neoclassical economics.

At first glance, physics and economics both appear to rely on an unobservable force: potential energy, like utility, is not directly observable. But potential energy is indirectly deducible from, and commensurable with, observable data. The potential energy of any one particle is readily compared to any other. In economics, in contrast, the lack of an observational measure of utility and the absence of interpersonal comparability meant that Walrasian general equilibrium was devoid of empirical content.[5]

Not all the early neoclassical economists saw utility as a completely individual and unmeasurable matter. Alfred Marshall and Arthur Pigou maintained that interpersonal comparison of utility was at least sometimes possible, for group averages if not for individuals. If this "material welfare" school of economics (Cooter and Rappoport 1984) had remained dominant, a different analysis of utility and preferences, and hence a different model of equilibrium, might have emerged. However, any hints of a distinct Marshallian paradigm were swept away by the "ordinalist revolution" of the 1930s, which resolved the conceptual problems with utility by banishing it altogether in favor of revealed preference.

The revealed preference account of consumer choice does not escape all the philosophical problems surrounding the subject (Sen 1973; Sagoff 1994). Nor does it eliminate the asocial individualism of the model, the feature which subverts structure and prediction of group behavior. Each individual still marches to a different drummer, even if the drums are now labeled "revealed preference relation" instead of "utility function." Naturally, this leaves no way of telling where the parade is headed.

Alternatives for the future

> How disappointing are the fruits, now that we have them, of the bright idea of reducing Economics to a mathematical application of the hedonistic calculus.
>
> (John Maynard Keynes 1963: 155n)

General equilibrium is still dead. Exactly 100 years after the 1874 publication of Walras's most important work, the SMD theorem proved that there was no hope of showing that stability is a generic property of market systems. More than a quarter-century of additional research has found no way to sneak around this result, no reason to declare instability an improbable event. These negative findings should challenge the foundations of economic theory. They contradict the common belief that there is a rigorous mathematical basis for the "invisible hand" metaphor; in the original story, the hand did not wobble.[6]

While the SMD theorem itself appears mathematically esoteric, we have seen that its roots are traceable to simple, intentional features of the neoclassical model, which have been present since the beginning. What happens to economic theory when those features are changed? Where

should we look for new alternatives for the future? This concluding section examines three areas where new theoretical approaches are needed in response to the failure of general equilibrium: the commodity-based model of consumer choice; the analysis of social interactions; and the role of institutional sources of stability.

So many commodities, so little time

The discussion, in the previous section, of the high-dimensional nature of the traditional model of consumer choice led to criticism of the implausibly large information processing requirements that the theory imposed on consumers. This criticism of the neoclassical model has been raised before, perhaps initially in Herbert Simon's arguments for bounded (rather than global) rationality.

It is also reminiscent of a classic series of attempts to reconceptualize consumer choice. In roughly simultaneous independent work, Kelvin Lancaster (1966a, b), Richard Muth (1966), and Gary Becker (1965) each proposed that what consumers actually want is not goods per se, but rather characteristics of the goods, or experiences produced by consuming or using the goods. This is consistent with the manner in which psychologists, sociologists, and anthropologists generally understand the process of consumption. Yet surprisingly little has come of this approach in economics. Of the two major versions of the theory, Lancaster's more rigidly – probably too rigidly – structured model was never developed much beyond its provocative initial presentation. Meanwhile, Becker's more amorphous "household production function" model is, like the neoclassical theory of consumption, capable of being stretched to fit virtually all possible situations, and hence ends up explaining very little (Ackerman 1997; Goodwin *et al*. 1997).

Whether an alternative is based on these foundations or other approaches, it remains important to create a mathematically manageable behavioral model with information requirements on a human scale. Such a model cannot be expressed primarily in terms of ownership of, knowledge of, and response to individual commodities, simply because there are so many of them. Human needs and behavior must be described in terms of other categories, more limited in number.

Among other changes, this makes it virtually impossible to demonstrate the optimality of consumer choices and market outcomes. Optimization would require global rationality with its unrealistically high information requirements. Any realistic behavioral theory will, in contrast, embody some form of bounded rationality, defined over a far smaller set of choices – because that is all that real people have time for.

Blowing bubbles

The weaknesses in neoclassical theory that ultimately led to the SMD theorem, as described in the previous section, include not only the high-dimensional model of consumer choice, but also the asocial, individualistic nature of preferences. The absence of social forces that influence individuals (with the sole exception of market exchange) makes the results of the theory underdetermined and unpredictable. In reality, of course, there are numerous nonmarket social interactions that impart structure to group behavior. The importance of these social interactions has been recognized in some recent work in economics, leading to models that add a touch of realism to the theory of economic behavior.

However, models of interaction do not necessarily contribute to an explanation of market stability. On the contrary, social conformity or emulation – such as wanting a consumer good because other people already have it – can create positive feedback in the market, with the potential for destabilization. In the simplest terms, erratic and fragile market bubbles or "cascades" can occur if individuals consider the behavior of others to be a better source of information than their own knowledge or preferences (Bikhchandani *et al*. 1998).

Similar problems arise in more elaborate models. Deterministic nonlinear models can lead to chaotic dynamics, while agent-based models, simulating the actions of individuals under hypothesized behavioral rules, often display nearly chaotic outcomes that have been dubbed "complexity." In such models, positive feedback interactions – in which one person's action makes it more likely that another will act in the same way – are the source of either chaos or complexity. These interactions would be commonplace in a realistic, comprehensive theory of individual economic activity. As Saari puts it, "Economics so effortlessly offers the needed ingredients for chaos that, rather than being surprised about exotic dynamics, we should be suspicious about models which always are stable" (1996: 2268).

Chaos and complexity models are characterized by sensitive dependence on initial conditions, the antithesis of stability. Thus, some promising approaches to modeling social interactions threaten to compound the problem of instability in economic theory. While the underspecified social structure assumed by neoclassical economics contributes to the indeterminacy of its outcomes, the most obvious cures seem to worsen the disease.

Macrofoundations of microeconomics

Where, then, does stability come from? Theoretical analysis to date, which has been impressive in its depth and breadth, has shown that stability is simply not an endogenous mathematical property of market economies under all initial conditions. This provides an elegant theoretical justification for a return to traditional styles of macroeconomics, in which cyclical

fluctuations and potential instability of aggregate incomes are central topics of concern. Yet the demonstration of the robustness of "SMD instability," combined with recent research on nonlinear dynamics, chaos, and complexity, appears to prove too much. Market economies are only episodically unstable or chaotic; it is certainly the norm, not the exception, for markets to clear and for prices to change smoothly and gradually.[7]

In short, it is more obvious in practice than in theory that large, complicated market economies are usually stable. If it is so difficult to demonstrate that stability is endogenous to a market economy, perhaps it is exogenous. That is, exogenous factors such as institutional contexts, cultural habits, and political constraints may provide the basis for stability, usually damping the erratic endogenous fluctuations that could otherwise arise in a laissez-faire economy. Variations on this theme can be found in several alternative schools of thought, such as Marxist, feminist, and institutionalist economics. Mirowski (1991) has even rooted a similar argument in the discourse of postmodernism.

There are other approaches, closer to conventional theory, that also make institutions central to economic analysis. The need for exogenous sources of stability is one of the tenets of what David Colander calls "post-Walrasian macroeconomics." Colander (1996) identifies three distinguishing characteristics of the post-Walrasian perspective. First, the equations necessary to describe the economy have multiple equilibria and complex dynamics. Second, individuals act on the basis of local, bounded rationality, since global rationality is beyond anyone's information processing capabilities. Finally, institutions and nonprice coordinating mechanisms are the source of systemic stability in a market economy. Colander refers to the last of these characteristics as establishing the macrofoundations of microeconomics. The "post-Walrasian" initiative is an encouraging one, but much more remains to be done to create a comprehensive alternative theory, building on what is now known about the limitations of established models.

Colander's approach, like any of the alternative schools of thought, would lead economists to take a humbler stance than they often do in public debate. The guaranteed optimality of market outcomes and laissez-faire policies died with general equilibrium. If economic stability rests on exogenous social and political forces, then it is surely appropriate to debate the desirable extent of intervention in the market – in part, in order to rescue the market from its own instability.

To recapitulate the main points in closing: the first section explained the fact that general equilibrium is, indeed, still dead after all these years. There are two principal causes of the death, as seen in the second section. The instability of the neoclassical model can be attributed to the inescapable difficulties of the aggregation process, and the highly individual, asocial nature of consumer preferences. These are not recent innovations, but design flaws that have been present since the origins of the theory in the late nineteenth century. The third section argued that two intentional features of the theory, present in the original neoclassical analogy to physics, led economics astray: the huge number of dimensions and information requirements of the "commodity space" framework, and the individualistic behavioral model.

Repairing these flaws, as described in the final section, will require a model of human needs and behavior that is not defined in terms of individual commodities. It will involve mathematically complex analyses of social interaction. And it will have to recognize the central role of social and institutional constraints. These new departures will make economics more realistic, but will not demonstrate the inherent stability or optimality of market outcomes, as general equilibrium theory once seemed to do.

The death of General Franco was not a panacea for the problems of Spain. Yet it did open many democratic, pluralist options, no longer requiring the whole country to follow one authoritarian leader. Spain after Franco looks a lot more like neighboring countries in the freedom of expression that it offers its citizens, and the diversity of opinions that can be expressed in public debate. The same might yet be true of economics after general equilibrium.

Notes

1 Recent work in general equilibrium theory has typically assumed a pure exchange economy, without production. The obstacles to proving uniqueness or stability seem to arise on the consumer side of the market; including production would make the mathematics more complicated, but would not change the results discussed here. Real-world applications of the theory, of course, require modeling of production as well as consumption.

2 Other relatively simple adjustment mechanisms have been proposed, such as quantity adjustment in a fixed-price environment. Rizvi (1994) argues that analyses of such mechanisms have often relied on specific, *ad hoc* forms for aggregate excess demand, making them vulnerable to the SMD critique.

3 Publications with the subject "general equilibrium" listed in the EconLit database of the American Economics Association increased from about 100 per year in the early 1980s to more than 1,000 per year throughout the 1990s. Although the number of all EconLit citations grew rapidly in those years, the number of "general equilibrium" citations grew even faster.

4 In comments on an earlier draft of this chapter, Mirowski has objected that the original neoclassical model, as described in his work, makes points in physical space analogous to commodity bundles, but says nothing about physical analogues to individuals. The distinction seems to me a rather thin one: commodity bundles are meaningful as bundles only because they are, or could be, held by individuals; conversely, individuals are located, in an exchange economy, solely by the commodity bundles they possess.

5 More recently, it has been argued that if people respond rationally to lotteries, it is possible to deduce their utility functions, which are unique up to a linear transformation (solving the problem of measurement for an individual, though still not allowing interpersonal comparison). However, this view, introduced by von Neumann and Morgenstern, emerged only after the "ordinalist revolution," and

has always been a minority perspective among neoclassical economists. Thus, it has played very little part in the historical developments described in the text. Moreover, empirical evidence suggests that people often do not respond rationally to lotteries, undermining this approach to measurement of utility.

6 The weakness of the metaphorical hand has attracted other comments along the same lines: if the market economy is not stable, "one would be forced to acknowledge that ... Smith's 'invisible hand' wavers Sisyphus-like around the actually existing equilibrium position without having the strength to push the economic system into it" (Ingrao and Israel 1990: 331).

7 For my own empirical work on one of the exceptions, see Ackerman and Gallagher (2002).

2 Behind the building blocks

Commodities and individuals in general equilibrium theory[1]

Alejandro Nadal

Introduction

Every theoretical model of an economic system uses basic building blocks. They are primitive concepts used to develop other parts of the model. They must be completely consistent with the concepts used by the model, and they must be compatible with the theoretical objective of the model.

In the case of general equilibrium theory, the construction of the classic Arrow–Debreu model (Arrow 1951; Debreu 1951; Arrow and Debreu 1954) starts with the concepts of commodities and prices, and then proceeds to define the economic agents involved in the economic model: consumers and producers.

The primitive concepts of commodities and prices, consumers and producers, have not attracted much attention. Most economists consider the analysis of these primitive concepts part of arcane discussions about value theory and, as such, they are seen as involving metaphysical problems or questions solved a long time ago during the infancy of the discipline. This explains why, fifty years after the appearance of the Arrow–Debreu model, little or no attention has been accorded to the detailed analysis of the economic significance of these concepts. On the other hand, the Arrow–Debreu model did inspire many economists to attempt to relax its more restrictive or cumbersome assumptions, some of which are imposed by its use of certain mathematical tools.[2]

Why is the study of the concept of commodities and prices important today? Because these concepts are the building blocks of the most important theoretical model of the market economy that we have available today. But we have to answer here the questions: What is at stake? What is the relevance of this question today?

This chapter centers on the validity of the procedures followed to build these primitive concepts in the Arrow–Debreu general equilibrium model, a model that uses "the most important mathematical devices in mathematical economics" (Geanakoplos 1989). The first section focuses on the concepts of commodities and prices, while a second section concentrates

on the definition of consumers and producers. Our concluding remarks consider the implications of this analysis for the proof of existence of a general competitive equilibrium.

Commodities and prices

A commodity is a primitive concept (Debreu 1991), and the model comprises a finite set of classes of commodities. The number of distinguishable commodities (Debreu 1959) or commodity labels (Koopmans and Bausch 1959) is a natural number. The Arrow–Debreu model continues by defining these commodities as goods that are physically determined (Debreu 1982). This tradition goes back as far as the origins of economics as an autonomous discipline, and in the context of general equilibrium theory it is firmly endorsed since Walras (1952).

But after asserting that commodities are physically determined, in a number of striking passages Debreu (1959: 30) states that their quantities can be expressed as real numbers. This of course poses a problem, because it means that irrational numbers can be used to express quantities of physical objects, even indivisible things.

Debreu (1959: 28–29) states that "[a] commodity is characterized by its physical properties, the date at which it will be made available, and the location at which it will be made available." He then asserts that "[w]ith each commodity is associated a real number, its price."

As for services, they are also "goods" (Arrow and Hahn 1971), and Debreu considers them in terms of physical characteristics, as well as location and date of availability. As in the case of material commodities, for services Debreu states that "[t]heir quantities can, by assumption, be any real numbers" (1959: 32).

Even the use of rational numbers to denote quantities of physical objects implies assuming that these physical objects are perfectly divisible. This, in turn, means that no matter how far we divide the physical objects, we still obtain objects with the same physical properties. Although this may appeal to our intuition when it comes to milk or flour, it is completely devoid of sense when it comes to physical objects that come in discrete units. Who among us owns exactly 1.379 cars, or gets 2.408 haircuts? The use of real numbers, including irrational numbers, implies that consumers can somehow specify quantities of goods that are not even fractions. This diverges even farther from experience and common sense. After all, nobody goes to the local Wal-Mart to purchase $\sqrt{2}$ vacuum cleaners, or π PCs.

As he discusses some examples, it is easy to observe that Debreu himself is aware of this conundrum (ibid.: 30):

> A quantity of well-defined trucks is an integer; but it will be assumed instead this quantity can be any real number. This assumption of perfect divisibility is imposed by the present stage of development of economics; it is quite acceptable for an economic agent producing or consuming a large number of trucks.

Debreu concludes: "a commodity is a good or service completely specified physically, temporally, and spatially. . . . It is also assumed that the quantity of any one of them can be any real number."

This conclusion notwithstanding, Debreu hesitates and recants in footnote (3) to the chapter on prices and commodities: "Two important and difficult questions are not answered by the approach taken here: the integration of money in the theory of value and the inclusion of *indivisible commodities*" (emphasis added. See Benetti, in chapter 3, on the integration of money into general equilibrium theory). This footnote is important in the light of a comment by Debreu on the axiomatic form of the logical discourse followed in economics: "When [economics] acquires an axiomatic form, its explicit assumptions delimit its domain of applicability and make illegitimate overstepping of its boundary flagrant" (1991: 2). As we shall see, the need to use real numbers to model quantities of physical objects is neither the result of an economically meaningful assumption, nor imposed by the present stage of development of economics. It is imposed by mathematics.

Debreu (1991) admits that mathematics is a very demanding master. And that can appear as an understatement when one realizes that the assumptions of his model, made on the grounds of mathematical convenience, limit the scope of the proof of existence of a general competitive equilibrium to barter economies with perfectly divisible commodities, a curious case that may be devoid of theoretical relevance.

At such a high cost, why would a model of a market economy use real numbers to denote the quantities of physical commodities? The best explanation is provided by Debreu himself. According to Debreu (1991: 3), "the central concept of the quantity of a commodity has a natural linear structure." Thus, actions of agents can be described by listing the quantity of its input or output for each commodity, and that list can be treated as the list of coordinates of a point in the linear commodity space. The price system can be conceived as a point in the linear price space, dual of the commodity space. According to Debreu (ibid.),

> In those two linear spaces, the stage was set for sometimes dazzling mathematical developments that began with the elements of differential calculus and linear algebra and that gradually called on an ever broader array of powerful techniques and fundamental results offered by mathematics.

Among the roles of prices that were illuminated by basic mathematics, Debreu quotes "the achievement of an efficient use of resources, by

results of convex analysis" and "the equalization of supply and demand for commodities, by results of fixed point theory." We know of course that separation theorems, as well as fixed-point theorems, are valid in the space of real numbers, but not in a space restricted to rational numbers (let alone integers). So, the dazzling mathematical developments that called for more powerful techniques appear to be the source of our need to appeal to real numbers for the commodity space and its dual, the price space.

To each commodity is associated its price, which is a real number. The price space is conceived as the dual of the commodity space (Debreu 1991). Because the key conclusions of the model rest on theorems that are valid only in the space of real numbers, the value of economic actions must be able to take on any real value within the relevant range. Thus, it is impossible to confine prices, quantities, or the products of prices and quantities, to rational numbers, let alone integers. Unfortunately, we are stuck with the need to justify the use of irrational numbers such as $\sqrt{2}$, π or e as economically meaningful prices and/or quantities.

One of the theorems that require the use of real numbers is the maximum theorem (Weierstrass's theorem), which is needed to guarantee the mathematical definition of individual supply and demand functions. The other is the fixed-point theorem for upper semicontinuous correspondences (Kakutani's theorem).

The first of these theorems is employed in the construction of individual agents (consumers and producers), which are endowed with maximization functions. Weierstrass's theorem states that given S compact and nonempty, and a function f from $S \rightarrow R$, with f continuous on S, then $f(S)$ has a maximum and a minimum. (A closed, bounded interval is compact in the space of real numbers, but not rational numbers; thus the need for irrational numbers of vacuum cleaners and everything else.)

For each producer, there is a well-defined vector $\boldsymbol{y}$ of activity (inputs and outputs denoted with a negative and positive sign, respectively); the product $\boldsymbol{p}\cdot\boldsymbol{y}$ is the value of the producer's profits. Vector $\boldsymbol{y}$ is selected to maximize $\boldsymbol{p}\cdot\boldsymbol{y}$ over the production possibility set Y_k for producer k, where Y_k is a compact, convex, nonempty set of points in the R_l commodity space. This ensures that $\boldsymbol{p}\cdot\boldsymbol{y}$ attains its maximum value over Y_k for any vector of prices. The supply function and the production possibility set have the required properties so that Weierstrass's theorem can be applied.

In the case of consumers, maximization takes place with respect to a preference ordering $\succcurlyeq$ on a subset X of R_l and the maximization problem consists in the selection of a well-defined consumption menu $\boldsymbol{x}_i$ that is at least as preferred as all the other consumption menus in the consumption possibility set X_i that respect the budget constraint. The existence of a most preferred element is guaranteed if the consumer's set of possible consumption menus X_i in R_l is compact, and if the preference ordering $\succcurlyeq_i$ is continuous (Nikaido 1968).

Thus, in the case of both consumers and producers, commodity bundles are subject to a measure operation determined by the behavioral rule inherent to these economic agents. This measure operation involves magnitudes that need to be expressed in terms of real numbers.

To conclude this section, we need to clarify how these quantities of heterogeneous goods are measured in value terms. Debreu (1959: 32) states that

> With each commodity, say the *h*th one, is associated a real number, its price p_h. This price can be interpreted as the amount paid now by an agent for every unit of the *h*th commodity which will be made available to him.

But Debreu never clarifies what is it that the agent will pay in exchange for a unit of the *h*th commodity. From the standard conventions of economic theory, it would appear that prices are expressed in a common unit of account, or a *numéraire*.

We know of course that the introduction of money in the general equilibrium model poses several problems (see Benetti in Chapter 3), and Debreu himself clarifies in a footnote that his model does not tackle the "difficult issue of money." So if money is not what agents use in transactions, and if commodities are physically determined goods, we need to know more about how agents calculate the value of their economic actions.

Debreu does not dwell much on these issues and simply states that "The price system is the *l*-tuple $\boldsymbol{p} = (p_1, p_2, \ldots p_l)$; it can clearly be represented by a point of R_l. The value of an action $\boldsymbol{a}$ relative to the price system $\boldsymbol{p}$ is $\sum p_h a_h$, i.e., the inner product $\boldsymbol{p}\cdot\boldsymbol{a}$." This leaves two options. First, let commodities be physical entities, and their quantities be expressed by real numbers to which specific dimensions are associated. In that case, the price system cannot be expressed in terms of dimensionless pure numbers. If $\boldsymbol{p}$ is a vector whose elements are the dimensionless numbers denoting the prices of the l commodities, calculating the value of an economic action through the operation $\boldsymbol{p}\cdot\boldsymbol{a}$ cannot be carried out because the sum $p_1a_1 + p_2a_2 + \ldots + p_na_n$ cannot be performed.

The Arrow–Debreu model uses a normalization procedure for the price system. But this does not solve the problem. The normalization procedure is related to the property of homogeneity of degree zero for the supply and demand functions. And the normalization procedure ensures that each price system p has the following property: $\sum p_i = 1$.

If relative prices are pure or dimensionless numbers, then $\sum p_i = 1$ makes mathematical sense. But in that case, given the fact that commodities are expressed in terms of the units specific to the physical characteristics of goods, it is impossible for agents to calculate the value of a given economic action $\boldsymbol{p}\cdot\boldsymbol{a}$, because that inner product is not defined.

The second option relies on the expression of prices in terms of a unit of account that renders these dimensions homogeneous. Prices must now be expressed as a normalized set of ratios defined as physical rates of substitution between goods and are marked by a composite dimension: $p_{i,h}$ is the price of commodity i in terms of commodity h, where h is the unit of account.

In this case, the normalization condition $\sum p_i = 1$ needs to be expressed in terms of relative prices. But here we encounter a difficulty. This normalization condition cannot be carried out in the case of prices taken as physical rates of substitution. Although the normalization condition does not need to have a precise or definite economic interpretation, it must be intelligible from the mathematical point of view. In other words, it must be a well-defined mathematical proposition. As we shall see, this is not the case.

Because the equilibrium price of the commodity chosen as *numéraire* needs to be positive in equilibrium, a composite commodity that will always have this property is chosen as *numéraire*. A composite commodity N made of a unit of each and every good in the economy is sufficient to have this property.

The price vector is expressed in terms of N as follows:

$$p = [\alpha_1 \cdot N/u_1, \alpha_2 \cdot N/u_2, \ldots, \alpha_l \cdot N/u_l]$$

where each component corresponds to the fraction α of the composite commodity N that is exchanged for one unit of each commodity i.

By definition, $p \cdot N = 1N$ (denoting the price of the *numéraire* in terms of itself), and this implies that $\sum \alpha_i = 1$.

The normalization condition that is imposed by the use of mathematical theorems which are defined for compact sets requires that all price vectors remain in the unit simplex of R_l^+. These price vectors have the property $\sum p_i = 1$, and they can now be explicitly written as follows:

$$\Sigma p_i = [\alpha_1 \cdot N/u_1 + \alpha_2 \cdot N/u_2 + \ldots + \alpha_l \cdot N/u_l] = 1$$

The problem now is that this sum is not intelligible because for each element in that sum we have a composite dimension (for every commodity i, α_i units of the composite commodity N per unit of i). This composite dimension expresses a physical rate of substitution. The composite dimension does not disappear in the normalization procedure, and the addition of heterogeneous elements is impossible. And although the normalization procedure is an abstract operation that may be devoid of economic meaning, it must make mathematical sense.

To summarize, when agents need to calculate the value of an economic action, say vector $\boldsymbol{a}$, then they are confronted with the possibilities discussed below.

The quantities of physical commodities and the elements of the price vector are expressed in terms of pure dimensionless numbers, and the interior product $\boldsymbol{p} \cdot \boldsymbol{a}$ is mathematically defined, but the economic sense is unclear; or the quantities of physical commodities and their (relative) prices are both expressed in terms of their dimensions. This makes sense insofar as the numbers associated with specific dimensions cancel out and in the end we have the total value of an economic action expressed in terms of the unit of account. But the normalization operation $\sum p_i = 1$ cannot be carried out.

Therefore, in order to dispense with the second difficulty, general equilibrium theory makes the following choice: the quantities of commodities, as well as prices, are expressed in pure dimensionless numbers. The interior product $\boldsymbol{p} \cdot \boldsymbol{a}$ is then well defined. But dimensionless commodities and prices are entities devoid of physical units: it is not possible to claim that commodities are "goods or services completely specified physically, temporally, and spatially."

Individual agents

The economy that is described by general equilibrium theory is made up of multiple individual agents. There are two classes of agents: producers and consumers. In the Arrow–Debreu model, each individual agent "is characterized by the limitations on his choice, and by his choice criterion" (Debreu 1959: 37). The theoretical problem involved here concerns the possibility of constructing, in a logically consistent manner, the individual agents that interact in the model of a decentralized private economy. They must behave like private agents (they only possess information about their technologies and preferences), and in the pursuit of their self-aggrandizing goals they are not coordinated by a central authority. Of course, the usual assumption about price takers holds.

The problem with the conception of individual agents, as defined by the theory, is that there may be no natural bound for their activities. If a producer makes positive profits and operates under constant or nondecreasing returns to scale, the profit-maximizing strategy is to expand without limit unless the individual possibility sets are bounded. At the level of the overall economy, the set of feasible allocations is bounded because there are no produced resources used as inputs that are unlimited in quantity. But how can individual agents know what are the bounds of the economy? If individual sets are bounded in an arbitrary manner, the equilibrium allocations may be unattainable. For consumers, the argument is similar: if the individual possibility set is not bounded, there may be no preferred element for a given price vector. In addition, the budget constraint of consumers may be undetermined because it incorporates their share of firms' profits, which may not be defined. Let's examine these problems in detail.

Producers are economic agents whose role is to choose a production plan. There are m producers and each one of them is given an index $k = 1, \ldots, m$). A production plan specifies the quantities of inputs (with negative numbers) and outputs (positive numbers). A production plan is a point in R^n, the commodity space. The set Y_k of all the possible production vectors $\boldsymbol{y}_k$ for producer k is a sub-set of R^n. In addition, $0 \in Y_k$. This means that every producer k has the possibility of choosing the vector of zero activity.

There are several important properties of Y_k. Y_k is a closed set in R^n, meaning that it contains all its own limit points. Also, Y_k is convex in R^n: if $\boldsymbol{y}^1 \in Y_k$ and $\boldsymbol{y}^2 \in Y_k$, then $t\boldsymbol{y}^1 + (t-1)\boldsymbol{y}^2 \in Y_k$, for $0 \leq t \leq 1$. This means that if two production vectors are possible for producer k, so is their weighted average with arbitrary positive weights. Particularly important is the following property for individual production possibility sets: Y_k can be a cone with vertex 0. This means that if $\boldsymbol{y} \in Y_k$, then $\alpha \boldsymbol{y}_k \in Y_k$, $\alpha > 0$.

These properties are conserved in aggregation and are thus important for the aggregate production possibility set of the entire economy, $\sum Y_k = Y$: Y is closed and convex, and $0 \in Y$.[3] Also, free production is impossible, $Y \cap \Omega = \{0\}$; $\{0\}$, where Ω is the non-negative orthant of R^n; and in the aggregate, production plans are irreversible, $\mathrm{Y} \cap (-\mathrm{Y}) = \{0\}$.

Finally, producers are endowed with a behavioral rule that enables them to maximize profits. This rule allows them to choose a production plan that maximizes profits and is given by the supply and profit functions $\varphi_k(\boldsymbol{p})$ and $\pi_k(\boldsymbol{p})$ for each producer k:

$$\varphi_k(\boldsymbol{p}) = \{y_k \mid \boldsymbol{p} \cdot \boldsymbol{y}_k = \max \boldsymbol{p} \cdot \boldsymbol{y} \text{ over all } \boldsymbol{y} \in Y_k\}$$

$$\pi_k(\boldsymbol{p}) = \max \boldsymbol{p} \cdot \boldsymbol{y} \text{ over all } \boldsymbol{y} \in Y_k \ (k = 1, \ldots, m).$$

All producers consider prices $\boldsymbol{p}$ as given and choose production vectors $\boldsymbol{y}_k$ so that the product $\boldsymbol{p}\boldsymbol{y}_k$ provides the maximum profit.

Consumers choose consumption plans $\boldsymbol{x}_i$ from their possibility sets X_i. The elements of consumption plans $\boldsymbol{x}_i$ have a positive sign if they are inputs for the consumer and a negative sign if they are supplied by the consumer. As in the case of producers, the set X_i has certain important properties. First, X_i is a convex set in R^n: if $\boldsymbol{x}_1, \boldsymbol{x}_2 \in X_i$, then $t\boldsymbol{x}_1 + (1-t)\boldsymbol{x}_2 \in X_i$ for $0 \leq t \leq 1$. If two consumption sets are possible for consumer i, then the weighted average or linear combination of these two consumption vectors is also possible for consumer i. Second, X_i is closed in R^n. Finally, each X_i has a lower bound $\boldsymbol{c}_i$ which satisfies $\boldsymbol{x}_i \geq \boldsymbol{c}_i$ for all $\boldsymbol{x}_i \in X_i$.

The elements of each consumption possibility set X_i are ordered through a preference relation $\succcurlyeq_i$. The preference ordering is complete – that is, given any two consumption vectors or commodity bundles $\boldsymbol{x}_1$ and $\boldsymbol{x}_2$, the consumer i will be able to order them under $\succcurlyeq_i$. The pair $(X_i, \succcurlyeq_i)$ is a preference field.

In addition, the preference ordering $\succcurlyeq_i$ is convex – that is, given $\boldsymbol{x}_1 \succcurlyeq_i \boldsymbol{x}_2$ for $\boldsymbol{x}_1$ and $\boldsymbol{x}_2 \in \mathrm{X_i}$, then $t\boldsymbol{x}_1 + (1-t)\boldsymbol{x}_2 \succcurlyeq_i \boldsymbol{x}_2$. Finally, the preference ordering is closed.

The aggregate consumption possibility set for the entire economy is $\sum X_i = X$. Some of the properties of X_i are conserved in aggregation. Thus, X is closed and convex, and has a lower bound for $\leq$. Each consumer i has an initial endowment of goods $\boldsymbol{a}_i$ which is a vector of R^n. Finally, there are lm constants $\alpha_{ik} \geq 0$ which represent the share of the ith consumer to the profits of the kth production firm. It is assumed that all profits are distributed in this manner so that $\sum_i \alpha_{ik} = 1$ $(k = 1, \ldots, m)$.

Consumers are specified as preference fields $(X_i, \succcurlyeq_i)$ and their behavior is defined by the demand function $\phi_i(\boldsymbol{p})$: given a price vector $\boldsymbol{p}$, consumer i selects the most preferred commodity bundle among those that satisfy the budget constraint:

$$\phi_i(\boldsymbol{p}) = \{\boldsymbol{x}_i \mid \boldsymbol{x}_i \in X_i, \boldsymbol{x}_i \succcurlyeq_i \boldsymbol{x} \text{ for all } \boldsymbol{x} \in X_i$$
$$\text{subject to } \boldsymbol{p} \cdot \boldsymbol{x} \leq \boldsymbol{p} \cdot \boldsymbol{a}_i + \textstyle\sum_{k=1} \alpha_{ik}\, \pi_k(\boldsymbol{p})\}$$

Once these individual agents have been specified, the model is ready to describe the workings of the market mechanism.

However, in spite of all the assumptions that have been introduced, there are new difficulties arising from the fact that the properties of the individual production possibility sets Y_k are not sufficient to guarantee the existence of production vectors $\boldsymbol{y}_k$ that maximize profits. Thus the profit function is not defined and it is not possible to guarantee $\pi_k(\boldsymbol{p}) \neq \varnothing$.

Debreu (1959: 44) states that "[g]iven a price vector $\boldsymbol{p}$, it may be that there is no production vector that provides a maximum profit for a producer." The reason for this is that "if non-decreasing returns to scale prevail, and if for some $\boldsymbol{y}_k$ in Y_k one has $\boldsymbol{p} \cdot \boldsymbol{y}_k > 0$, profit can be arbitrarily increased."

The same difficulty is identified by Nikaido (1968: 252): "One typical example of factors that cause a no-profit situation is the cone property of the technology set." Consider the case where Y_k is a convex cone. In this case, we cannot guarantee $\pi_k(\boldsymbol{p}) \neq \varnothing$ because if $\boldsymbol{y}_k \in Y_k$, then $\theta \boldsymbol{y}_k \in Y_k$, for any $\theta > 0$. Then $\pi_k(\boldsymbol{p}) = \boldsymbol{p} \cdot \theta \boldsymbol{y}_k = \theta \boldsymbol{p} \cdot \boldsymbol{y}_k$ and this grows without limit as $\theta \to +\infty$. There is no production vector yielding the maximum profit.

If we want to be sure that $\pi_k(\boldsymbol{p}) \neq \varnothing$, we could use Weierstrass's theorem, which states that if f is a continuous function from S to R, and if S is a compact nonempty set, then $f(S)$ has a maximum and a minimum. But, as we have seen, there is in general no reason for the individual production possibility sets to be bounded – a property that is required for compactness.

A similar problem arises in the case of consumers: given a price vector $\boldsymbol{p}$, it may be that there are no most preferred consumption vectors for $\succcurlyeq$

among those that satisfy the budget constraint $\boldsymbol{p}\cdot\boldsymbol{x} \leq \boldsymbol{p}\cdot\boldsymbol{a} + \sum_{k=1} \alpha_{ik}\, \pi_k(\mathbf{p})$. In other terms, the properties of X_i are not enough to guarantee that $\phi_i(\boldsymbol{p}) \neq \varnothing$ – that is, the image set of the demand function is not the empty set.[4]

In the case of demand functions $\phi_i(\boldsymbol{p})$ over preference fields $(X_i, \succcurlyeq_i)$, the existence of a most preferred element is guaranteed if the subset M of consumption vectors satisfying the budget constraint is compact and if the preference ordering $\succcurlyeq$ is continuous.[5] But M cannot be compact unless X_i is compact. Thus, X_i cannot be an unbounded set.

It is important to note that the price mechanism cannot prevent firms from making unbounded commitments over their range of choices. Because agents are price takers, they must believe that for all semipositive price vectors $\boldsymbol{p}$ they may buy and sell whatever amounts they choose to produce or consume. However, because the economy has an endowment of limited resources, a question of scarcity arises and unbounded commitments have to be ruled out. This disconnect between events that take place at the level of the individual agents and those that are intelligible at the aggregate level is described by Arrow and Hahn (1971: 63):

> If Y_k is unbounded, then at a certain $\boldsymbol{p}$ it may be that the firm would like to produce on an infinitely large scale. This possibility, as such, does not make it impossible to conduct an analysis of market equilibrium with positive prices; although the firm is taken to suppose that it can sell and buy whatever quantities it likes at the going prices, the economy, in fact, may be incapable of producing outputs and using inputs in unlimited amounts. Indeed, if we are interested in a world of scarcity, we ought to exclude the possibility.

But excluding this possibility is more difficult. It could be thought that the market mechanism takes care of this problem. Consider the following example of Marshallian inspiration: as a firm chooses to produce a very large quantity of certain outputs, it would exert a great pressure on the market for the required inputs. The prices of these inputs would rise, as the prices of the firm's output would decrease, causing profit to vanish.

In Franklin Fisher's terms (1983: 40), "there is a natural way" to deal with this problem of unbounded commitments:

> That way uses what we know about the role of the price system in a world of limited resources. As resources become scarce, their prices ought to rise. Accordingly, it is possible to argue that unbounded commitments cannot be profitable since the unit costs of production would rise above the price at which output can be sold.

Is this accurate? Unfortunately, in the context of our problem, it is not. The circularity of this claim is obvious: for prices to adjust in this manner, an aggregate excess demand function is needed, and this requires individual supply and demand functions to be defined. But this is precisely the problem that needs to be solved. If these functions are not defined, there is no aggregate excess demand and no price adjustment process: the market cannot perform the task we would expect it to carry out.

From the start, individual production and consumption possibility sets were endowed with the properties of convexity and closedness. But boundedness was not included among the original properties of possibility sets. Grave consequences follow (individual supply and demand functions are not defined), so why is boundedness not included among these original properties? Convexity and closedness are topological features that, in the context of the definition of the general equilibrium model, do not involve any reference to *quantitative* information. But boundedness is different, as it requires a reference to quantitative magnitudes. The viability of production and consumption allocations for the entire economy is at stake if boundedness is treated carelessly.

We know that given a price vector $\boldsymbol{p}$, certain economy-wide allocations may be impossible to attain. For example, a production plan may require inputs in amounts that will not or cannot be supplied by consumers. On the other hand, a consumption allocation may be unattainable because the goods that are required by it cannot be supplied by producers. So if individual production and consumption sets are to satisfy the condition of boundedness, this must be done in a manner such that the set of attainable allocations is not the empty set. In other words, it is not possible simply to assume that the individual consumption and production possibility sets are bounded sets and, at the same time, guarantee that the set of attainable allocations for all semipositive price vectors is different from the empty set. In other terms, the arbitrary introduction of boundedness for the individual possibility sets is a sufficient condition for the definition of individual supply and demand functions, but in and by itself it does not ensure that the set of attainable allocations is nonempty.[6]

Nikaido (1968: 257) proceeds to "substitute certain *virtual* supply and demand functions for the true ones" (emphasis in the original).[7] These virtual functions are to be defined by narrowing the ranges of consumers' and producers' choices to suitable bounded subsets of the original possibility sets. This is done in the following manner. We know that a competitive equilibrium, if it exists, must satisfy the following condition:

$$\boldsymbol{a} + \sum \boldsymbol{y}_k - \sum \boldsymbol{x}_i \in (\boldsymbol{a} + Y - X) \cap R_n{}^+$$

This enables us to define the following subsets of the original consumption and production possibility sets (we follow here Nikaido's approach; Arrow's and Debreu's manipulation of these original sets is the same):

$$\hat{X}_i = \{\boldsymbol{x}_i \,|\, \boldsymbol{x}_i \in X_i,\ (\boldsymbol{a} + Y - \textstyle\sum_{s \neq i} X_s - \boldsymbol{x}_i) \cap R_n{}^+ \neq \varnothing\} \text{ (for } i = 1, \ldots, \text{l)}$$

$$\hat{Y}_k = \{\boldsymbol{y}_k \,|\, \boldsymbol{y}_k \in Y_k,\ (\boldsymbol{a} + \boldsymbol{y}_k + \textstyle\sum_{t \neq k} Y_t - X_i) \cap R_n{}^+ \neq \varnothing\} \text{ (for } k = 1, \ldots, \text{m)}$$

These sets are non-empty, convex and bounded. However, they are not closed. Why? Because although closedness is a property conserved by aggregation, we do not know whether the set of consumption menus and production vectors that satisfy the conditions in parenthesis are closed sets. To bring in this property, a sufficiently large cube E is chosen:

$$E = \{h \mid \xi_j \leq h \leq \eta_j\}\ (j = 1, \ldots, l)$$

such that $0, c_i \in E$, and $\hat{X}_i, \hat{Y}_k \subset E^o$ $(i = 1, \ldots, l, k = 1, \ldots, l)$.

New sets are then defined $X_i \cap E$, $Y_k \cap E$ and these sets have all the desired properties which ensure that the individual supply and demand functions are defined for all semipositive price vectors $\boldsymbol{p} \geq 0$: $\phi_i(\boldsymbol{p}) \neq \varnothing$, $\pi_k(\boldsymbol{p}) \neq \varnothing$. Aggregation of the individual supply and demand functions can now take place and an aggregate excess demand function can be defined.

The proof of existence of a competitive equilibrium now proceeds by applying Kakutani's fixed-point theorem for upper semicontinuous correspondences to a suitable mapping. This mapping is formed by the Cartesian product of two mappings, the aggregate excess demand correspondence and a price adjustment mapping.[8] The aggregate excess demand function $\chi(p)$ is defined as follows:

$$\varphi(p) = a + \textstyle\sum_k^m \varphi_k(p)$$
$$\phi(p) = \textstyle\sum_i^l \phi_i(p)$$
$$\chi(p) = \varphi(p) - \phi(p)$$

Although it is now possible to aggregate the outcomes of individual agents' behavior, an important number of difficult questions pertaining to the nature of the individual agents and the scope of the existence proof must be addressed.

The general equilibrium model attempts to describe a private, decentralized economy in which each agent engages in self-aggrandizing behavior. This is why the individual agents that this model comprises only possess private information about their preferences or their technology. The possibility sets X_i and Y_k correspond to this rationale. But the sets $X_i \cap E$ and $Y_k \cap E$ are not intelligible from this theoretical perspective. They represent an intersection between the private world of individuals and the realm of aggregate information that only a supra-individual agent or institution can possess.

In the proof of existence of a general competitive equilibrium, the initial sets X_i and Y_k are substituted by $X_i \cap E$, $Y_k \cap E$ in order to ensure that the individual demand and supply functions are defined. But through this procedure, the specification of the individual agents changes: they are no longer specified by the purely private information contained in each set X_i and Y_k. The sets $X_i \cap E$, $Y_k \cap E$ involve information that is not known to

the individual agents. Although it makes perfect mathematical sense to define these intersections, from the economic standpoint this involves a deep problem for the model. The agents are now required to have information about the boundaries of their individual sets, which have now been "appropriately" restricted. If individual agents were to know that the range of their individual choices is now restricted in this manner, this is equivalent to having them transcend the realm of their private worlds and use information that is the result of an aggregation process.

The sets $X_i \cap E$ and $Y_k \cap E$ represent impossible intersections between the private realm of the individual agents and the world of aggregate information. The former comprises information that is only available to each individual agent; in fact, it is not an abuse of language to say that the individual agents are made up of this information and the associated behavioral rules (i.e., the consumption and supply functions). But information about the aggregate possibility consumption and production sets, as well as information on the aggregate resource endowment of the economy, can only be possessed by a supra-individual agent or authority.

Therefore, the intersections $X_i \cap E$ and $Y_k \cap E$ are not intelligible from the standpoint of each individual agent. In the context of the general equilibrium model, they represent an unfeasible juncture of the private (X_i, Y_k) and social (E) worlds. Through a manipulation over the original individual possibility sets that restricts the range of agents' choices, the individual demand and supply functions are defined, but the original agents are disfigured beyond recognition.

In other terms, the aggregate excess demand correspondence is unintelligible without the definition of the individual supply and demand functions. And these functions are defined only in the case of adequately constrained possibility sets $X_i \cap E$ and $Y_k \cap E$, which in turn cannot be known by the individual agents denoted through the indexes i and k. Thus, the aggregate excess demand function itself is a construct that clashes with the notion of a private decentralized economy.

At this point, the dilemma facing general equilibrium theory can be stated as follows: either we assume that individual possibility sets are (adequately) bounded and we have well-defined individual supply and demand functions, but end up with a model that cannot be described as a representation of a private decentralized economy; or we consider unbounded individual possibility sets that conform to the notion of decentralized economy, but lose the possibility of having defined supply and demand functions. In this case, the obvious consequence is the impossibility of defining an aggregate excess demand function.

In the first horn of the dilemma, the construction of the model contradicts the object of the theory. But in the second horn we lose the possibility of having an aggregate excess demand function and using it for the proof of existence of equilibrium. This would lead to a dead-end street.

Given what's at stake here, it is not surprising that the authors of this theory chose the first alternative.

The proof of existence proceeds after the manipulation of the individual possibility sets to find a fixed point (interpreted as a general equilibrium) which possesses the desired property $u \in \chi(p)$ with $\chi(p) \cap R^{+}_{n} \neq \varnothing$ (i.e., at the fixed point excess demand is non-negative). It is easy to verify that the individual choices of production vectors $\boldsymbol{y_k}$ and consumption menus $\boldsymbol{x_i}$ are elements of the original individual possibility sets Y_k, X_i. However, this is not enough to conclude that the proof is consistent with the definition of the individual agents. The individual choices y_k and x_i are the result of well-specified behavioral rules that depend on the manipulation that is required by the model. But those rules are incompatible with the specification of individual agents in the context of a decentralized, private economy. To conclude, the proof of existence concerns a state of the economy that cannot be attained by the individual actions of the self-aggrandizing and decentralized agents originally specified for the general equilibrium model.

Concluding remarks

The building blocks of general equilibrium theory, epitomized in the Arrow–Debreu model, have received very little attention. A thorough examination of the central issues surrounding the primitive concepts needed to put together the model has been missing. This is rather surprising, given the fact that the Arrow–Debreu model is the workhorse of the theory of decentralized economies. Its building blocks deserve undivided attention because their coherence conditions the scope and legitimacy of the model's main results.

There is not much merit in debating the soundness of these primitive concepts or building blocks unless it is shown that these are relevant issues for the model's performance – that is, its ability to deliver the expected results. This is of course the ultimate rationale for this discussion. And the model's performance is a function of both the mathematical accuracy and the consistency with the theoretical objectives. Using concepts of prices and commodities that clash with the definitions of goods and services (as physical entities, geographically and temporally determined) poses serious analytical questions that have been largely ignored. The questions surrounding boundedness of individual possibility sets lead to another formidable set of problems.

It is conceivable – indeed, it has been argued – that the issues raised by a more serious scrutiny of the concepts of prices and commodities might be merely a by-product of the necessary simplification that every model of reality entails. This view is wrong and should be abandoned. It is now time to come to grips with the true problems instead of sweeping them under a rug of rhetoric about the formidable mathematical tools that are used.

What is the value of an existence proof that depends on commodities that cannot be measured, and "decentralized" agents whose behavior depends on a *deus ex machina* beyond their individual knowledge?

In attempting to rely on the purity of mathematical discourse, economic theory has frequently sacrificed content for the sake of using mathematical tools (Koopmans (1957) was one of the first to point this out). The current state of applied economics is perhaps one consequence of this state of affairs. All models have to simplify the real world. But the issues examined in this chapter go beyond this problem. It is not a matter of oversimplification that has absorbed our attention. It is a matter of fundamental incompatibility between the building blocks and the house they help build.

Notes

1 Much of the material presented in this chapter comes from two earlier publications. The first part is based on the results in Nadal (1984), while the second distills the main results found in Nadal and Salas (1987).

2 A typical example here is the work of Uzawa (1962) showing how the convexity property for individual consumption and production possibility sets can be replaced by a less restrictive assumption of convexity of the aggregate possibility set for the entire economy.

3 In the case of closedness, the aggregate set Y is not necessarily closed even if every Y_k is closed. However, if every Y_k is closed and convex, and if $Y \cap (-Y) = \{0\}$, then Y is closed (Debreu 1959: 41). In addition, the assumption of convexity for every Y_k can be relaxed and substituted by convexity of the aggregate set (Uzawa 1962).

4 Both Debreu and Nikaido recognize that given a price vector $\boldsymbol{p} \geq 0$, there may be no consumption bundles satisfying the budget constraint. Even if that part of the problem is solved by introducing an assumption over the initial holdings of the individual agents, and the budget constraint is consistent with the consumption set, given a price vector $\boldsymbol{p} \geq 0$ the existence of a most preferred consumption bundle is not guaranteed.

5 See lemma 15.3 in Nikaido (1968).

6 For a discussion on feasible allocations, see Nikaido (1968: 247). Many microeconomic texts avoid the problem by assuming up front that the individual production and consumption possibility sets are bounded, without explaining how this property is introduced: Lancaster (1971), Malinvaud (1975), Quirk and Saposnik (1968), Varian (1992). Other authors, such as Weintraub (1982) and Takayama (1988), erroneously affirm that boundedness is guaranteed through lower boundedness and the budget constraint.

7 In the chapters on individual producers and consumers, Debreu (1959: 44, 62–63) follows a different sequence, restricting the subset of price vectors for which individual supply and demand functions are defined. The assumptions needed to guarantee this result are presented in Chapter 4 and they are equivalent to the procedure followed by Nikaido.

8 In Chapter 4 we analyze the price adjustment mapping in detail.

3 Money and prices

The limits of the general equilibrium theory

Carlo Benetti

Introduction

Can an advanced economy exist without money? Economic theory often seems to assume that paradoxical position. General equilibrium models postulate that individuals trade commodities with each other, without mentioning any monetary medium of exchange. In reality, of course, money and commodities coexist, and clearly depend on each other. Yet the incorporation of money into abstract economic theory has posed serious difficulties. Economists discussed these difficulties for a while in the mid-twentieth century and later, and then seemingly agreed to move on, without having provided a satisfactory solution.

More formally speaking, the theory of value presupposes an initial abstraction by which money and monetary magnitudes are put aside. The first datum of the value theory is a list of commodities physically, temporally, and spatially specified. By hypothesis, the commodity space is the mathematical space of the real numbers R^n. Individuals are defined by their relations to commodities – that is, by their consumption, production, and property relations. The mathematical representation of these relationships consists of utility functions, production functions, and initial endowments of commodities.[1] From this starting point, the theory of value determines (equilibrium) real prices, for instance the price of shoes measured in wheat. It is only in a second stage that the problem of determining monetary prices is set out, allowing the prices of shoes and wheat to be expressed in a common currency. This is the point at which money first appears in economic theory, through its integration into value theory, which was completely elaborated in nonmonetary terms. In this theoretical context, one of the most recurrent complaints is about the delay in the development of the monetary theory in relation to the theory of value.[2]

This chapter is organized as follows.[3] In the first section, we point out that the demonstration of the existence of a general equilibrium does not say anything about the way in which individuals reach their equilibrium allocations; in general, such allocations cannot be achieved by means of decentralized, pairwise trades. Reaching equilibrium requires the use of a

medium of exchange, which cannot be a commodity with a use value of its own.

The second section examines the neoclassical methodology that has been used to integrate money into general equilibrium price theory. That methodology rests on two central notions about individual choice and frictions. In the third section we present a critical appraisal of the main models used to integrate money into the value theory, from the early work by Patinkin to the more recent overlapping generations models. We will show that none of these approaches offers a satisfactory resolution of the problem.

Money and economic equilibrium

In this section, three basic propositions about monetary theory are put forward:

1 The mathematical result of the well-known "theorem of the existence of a general equilibrium" does not correspond to the economic definition of a general competitive equilibrium.
2 In an economy made up of commodities and individuals, the latter cannot reach, in general, their equilibrium allocations through bilateral pairwise trades.
3 Money as a medium of exchange cannot be a commodity; it must be a fiat money, which does not enter into individual utility functions.

Two meanings of equilibrium

Consider a pure exchange economy, with a great number of individuals and consumption commodities. Individual initial endowments and preferences are given. A careful distinction must be made between the concept of a general competitive equilibrium and the result of the "existence theorem," which is often considered to be the crowning accomplishment of neoclassical theory. A general competitive equilibrium is defined as a price vector *and* a set of individual consumption allocations such that:

- No price is negative.
- For each commodity, total consumption is less than or equal to total endowment.
- Each individual achieves the maximum feasible utility subject to the budget constraint – that is, no other commodity bundle of equal market value would produce greater utility.

It is proved by the "first fundamental theorem of welfare economics" that, under the hypothesis of local nonsatiety, such a competitive equilibrium allocation is Pareto optimal.

The mathematical existence theorem demonstrates that under some

conditions there exists a nonnegative price vector such that for every commodity the total demand is not greater than the total supply and if, for some commodities, the total demand is less than the total supply, then their equilibrium price is zero (such commodities are called "free goods"). It is clear that the existence theorem does not demonstrate the existence of the equilibrium as it is defined. When equilibrium prices are determined, individuals still possess their initial endowments. Equilibrium consumption allocations are calculated, but nothing is said about the possibility of reaching them by means of trades.

The distinction between these two meanings of equilibrium might not matter if it were the case that the economic equilibrium could always be reached by trading (although even then, as shown in Chapter 1, the adjustment process may display unstable dynamics). However, in general, "you can't get there from here." According to the theory, at the equilibrium prices individuals begin with their initial endowments and have to reach their equilibrium consumption allocations by a process of trading. The trading process, usually implicit rather than explicit in the theory, is not in general sufficient to reach the equilibrium allocation, as some simple examples will show.

The limits of pairwise trading

In an economy made up of individuals and commodities, but no money, the only possible trades are direct and indirect barter.[4] We will examine them separately.

Direct barter is a bilateral exchange subject to two conditions:

- the quid pro quo – that is, the equivalence between the values that are traded, and
- the "double coincidence of wants": each trader wants the commodity that is offered by the other one. In other words, the utility of each individual endowment increases after each trade.

Indirect barter removes the second assumption, allowing individuals to hold commodities for future barter with others.

Consider an economy with three agents, I, II, and III; and three commodities, A, B, and C. The following numerical example describes a general equilibrium such as it is defined above. Assume that the equilibrium prices are (1, 1, 1). The initial endowments are:

	A	B	C
I	10	0	0
II	0	10	0
III	0	0	10

The equilibrium allocations are:

	A	B	C
I	3	4	3
II	3	5	2
III	4	1	5

The excess demand table (the equilibrium minus the initial endowment) is:

	A	B	C
I	−7	4	3
II	3	−5	2
III	4	1	−5

The individual budget constraint is fulfilled (the row sum is zero for every agent) and each market is in equilibrium (the column sum is zero for every commodity). But whatever the sequence of bilateral trades at the equilibrium prices, the equilibrium allocation cannot be achieved. Consider, for instance, the following sequence of trades: first, the exchange of 3 A and 3 B between agents I and II; second, the exchange of 1 B and 1 C between agents II and III; and finally, the exchange of 3 A and 3 C between I and III. As a result of these three trades, the following three excess demand tables are obtained:

1 Derived from initial excess demand (previous table), followed by I and II exchanging 3 A for 3 B:

	A	B	C
I	−4	1	3
II	0	−2	2
III	4	1	−5

2 Derived from allocation 1, followed by II and III exchanging 1 B for 1 C:

	A	B	C
I	−4	1	3
II	0	−1	1
III	4	0	−4

3 Derived from allocation 2, followed by I and III exchanging 3 A for 3 B:

	A	B	C
I	−1	1	0
II	0	−1	1
III	1	0	−1

At this point, trades are no longer possible. In allocation 3, the economy is in equilibrium from the point of view of the existence theorem (the aggregate excess demand for all goods – that is, the column totals – are zero), and out of equilibrium from the point of view of the definition of the general equilibrium (the equilibrium allocation is not achieved). The reason is embedded in the logic of the model: every commodity is at once a useful thing and a medium of exchange specific to each trade and each agent. In this moneyless trading procedure, an agent accepts a means of payment only if it satisfies his needs.[5]

In an economy of three agents and three commodities, the difficulty of the direct barter can be overcome by eliminating the condition of double coincidence of wants – that is, by allowing indirect barter. An individual can now accept a commodity he does not consume, in order to exchange it for another commodity he consumes. In this system the same commodity can be demanded and offered by the same agent. However, this solution is not a general one; it does not necessarily apply to larger economies. This can be shown by an example of an economy made up of four agents and four commodities. Suppose that direct barter leads to the following excess demand table:

	A	B	C	D
I	−1	0	0	1
II	0	−1	1	0
III	1	0	−1	0
IV	0	1	0	−1

Even allowing indirect barter, there is no way for these four individuals to reach equilibrium through bilateral trading, as the following account shows. Agent I has a final demand for D, which is sold by IV, who has a demand for B, which is offered by II. Agent I's strategy is as follows: he proposes a trade to II in order to obtain B and sell it to IV. The first trade is possible because II is interested in buying A in order to sell it to III and obtain C. However, the same reasoning explains a trade between III and IV, who are preparing for trade with I and II. After these trades it is easily seen that the excess demand table is such that, as above, the equilibrium allocation cannot be obtained by pairwise trades. If the agents try a second round of indirect barter, the same reasoning shows that the same pairs of agents I and II, III and IV, exchange the same commodities as in the first round, and we come back to the initial excess demand table.

The problem is that every agent tries to obtain the "good" means of payment, which allows him to satisfy his final demand. With all agents acting simultaneously, all supplies will change and nobody can obtain, by trade, the commodity he wants. The only way to overcome this difficulty is by means of a centralized organization of transactions. In this case, it consists of permitting trades for instance only between I and II, while requiring III and IV to do nothing. This asymmetric behavior explains the success of the indirect barter in the economy with three agents and three commodities.

In general, the achievement of the equilibrium allocation through barter requires a central authority to assign each agent a role in the trading process on the basis of the excess demand vectors, as has been shown by Ostroy and Starr (1974).[6]

Monetary trades

The origin of the difficulty of barter lies in the twofold function of commodities, which are at once a medium of exchange and a useful commodity. The solution consists in separating these two functions – that is, in introducing a monetary commodity for which all other commodities can be traded. However, this particular commodity must have a specific set of properties. In particular, it cannot have a separate use value: it cannot be one of the commodities that enter the utility functions of individuals.

To see why this is the case, we will imagine the opposite and observe that it leads to a contradiction. Suppose that the commodity designated as money also has a use value to individuals – as in the stories of cigarettes occasionally serving as a substitute for money among prisoners, for example. As soon as each prisoner holds the number of cigarettes that he plans to smoke (zero, for nonsmokers), "cigarette money" disappears from the economy. If this happens before all other transactions have ended (as it easily could), some individuals are in the same situation as the one we saw above: only barter is available to bring other commodities into equilibrium; in general there does not exist any sequence of direct or indirect barter trades such that the equilibrium allocation could be obtained.

This is illustrated by the following six commodities and six agents excess

demand table. Assume that commodity A is accepted as money by all agents.

	A	B	C	D	E	F
I	−1	1	0	0	0	0
II	1	−1	0	0	0	0
III	0	0	−1	0	0	1
IV	0	0	0	−1	1	0
V	0	0	1	0	−1	0
VI	0	0	0	1	0	−1

By spending his money, commodity A, agent I satisfies his demand for B by a trade with agent II, but the latter has a final demand for A. Money "disappears" from the economy, preventing the other four agents from using money to reach equilibrium allocations of other goods.

The origin of this difficulty is that commodity A, like "cigarette money" in prison, is at once a useful commodity and a medium of exchange. It is a commodity-money. To allow a complex market economy to reach equilibrium, the medium of exchange must not be a useful commodity – that is, it must not enter individuals' utility functions. In short, it must be a "fiat money," usually consisting of intrinsically worthless small pieces of metal or paper, or even electronic data in financial institutions' computers, which are accepted as money.

We conclude that the "existence theorem" is by no means sufficient to demonstrate the existence of an economic equilibrium. At the equilibrium prices, aggregate demand and supply are in equilibrium but, in general, individuals cannot reach their equilibrium allocations by trades. The economic equilibrium is an equilibrium of both prices and allocations. It can be reached only in an economy made up of individuals, commodities, *and* a fiat money.

Thus, the supposedly self-regulating market economy is revealed to be crucially dependent on a monetary *deus ex machina*: the inescapable and seemingly arbitrary intervention by the government to create and regulate the supply of money. Considerable theoretical effort has been devoted to retelling the story in a manner that would eliminate the need for this oddly activist political intrusion into the world of laissez-faire. Following the traditional neoclassical position, even if money is included in the model, the main result of the price theory is still valid because money is neutral: it does not modify the equilibrium relative prices, and thus the Pareto-optimal allocation of goods is also unchanged. But in order to deal with

the problem of the neutrality or non-neutrality of money we need a theory of the equilibrium monetary prices – that is, a theory in which money is integrated into price theory. To date, this effort has failed, as the next two sections explain.

The neoclassical methodology

The origin

The general approach used in contemporary neoclassical monetary theory originates in Hicks's famous paper "A Suggestion for Simplifying the Theory of Money" (1935), in which he proposes a methodology for the integration of money into the value theory which is based on two central concepts: individual choice and frictions.[7] The best presentation of this method is given by Hicks himself.

Concerning the first concept: "the marginal utility analysis is nothing else than a general theory of choice, which is applicable whenever the choice is between alternatives that are capable of quantitative expression. Now money is obviously capable of quantitative expression" (ibid.: 63). The method is to consider "the position of an individual at a particular point of time and inquire what determines the precise quantity of money which he will desire to hold" (ibid.: 64). Therefore, the monetary theory is basically a theory of demand for money. This leads to what Hicks considers the "critical question" – that is, "what has to be explained is the decision to hold assets in the form of barren money, rather than of interest– or profit–yielding securities. . . . This, as I see, is really the central issue in the pure theory of money" (ibid.: 66). It is here that frictions come into the picture.

Hicks stresses two types of "frictions" in the market economy that could account for the choice to hold money: transaction costs – that is, "the cost of transferring assets from a form to another" (ibid.: 67); and uncertainty about the timing and amount of return that will result from an investment.

Hicks's method and general equilibrium theory

How is Hicks's methodology applied to contemporary general equilibrium theory? It is evident that the Arrow–Debreu model is a nonmonetary one. But, properly speaking, it is not a model of a barter economy. Two of the hypotheses of the Arrow–Debreu model are related to the absence of money:

1 the existence of a complete set of present and future markets; and
2 the existence of a centralized system – an "accounting system" or a "clearing house" – by which transactions are carried out without cost and without money.

Hypothesis 1 eliminates the need for money as a store of value; if complete futures markets existed, there would be in general no need for financial assets to facilitate intertemporal allocation of resources. Hypothesis 2 excludes the need for money as a medium of exchange. Contrary to the first hypothesis this second one is almost never explicitly set out.

A remarkable exception is Debreu (1959: 28) "No theory of money is offered here, and it is assumed that the economy works without the help of a commodity serving as medium of exchange." It is by virtue of this hypothesis that the Arrow–Debreu general equilibrium model cannot be considered as a barter economy. In the Arrow–Debreu model, transactions can be completed, by virtue of hypothesis 2. On the contrary, in a barter economy this is not the case. (We will return to this distinction in the final section of this chapter.)

In this model, money does not exist and cannot be introduced. Because nobody has a positive demand for money, either as a store of value or as a medium of exchange, money must have a zero equilibrium price. It follows that in order to explain the existence of money, one of these two hypotheses must be violated, thereby giving rise to a positive demand for money, and hence a positive price for money as well.

Strangely enough, this is interpreted as the introduction of frictions in a perfect market system: "In order to get a theory of money, one must generalize the Walrasian model by including in it some sort of frictions, something that will inhibit the operation of markets. On that there is agreement" (Wallace 1980: 50). And: "In a Walrasian model, at least, money cannot facilitate exchange: the non-monetary competitive equilibria are Pareto optimal.... Thus, to get money into a model something must inhibit the operation of markets" (Townsend 1980: 265). The ambiguity of this widespread position is remarkable. If, in the Walrasian model, money does not facilitate exchange, this is not because the equilibrium is optimal, but because, by hypothesis, the exchange itself (spot and future) is absent and substituted by a centralized organization of transactions. As a consequence, (decentralized) markets do not exist and we do not see what it means to inhibit their working.

In addressing the problem of allocating resources over time, hypothesis 1 – the existence of all relevant present and futures markets – allows individuals to make, at the present date, all decisions concerning their trades of present and future commodities. When this hypothesis is suppressed, these decisions are made in a different context. Without perfect future markets, individuals need an asset to transmit value to future periods; a budget constraint exists separately for each period, rather than for the entire range of present and future decisions. This separation of time periods is a necessary condition for a positive demand for money as a store of value.

However, the elimination of hypothesis 1 is not sufficient to explain the coexistence, at the monetary equilibrium, of different assets having different rates of return. We must introduce here a type of friction or market "imperfection" such that individuals choose to keep a part of their wealth in the form of an asset (money) whose rate of return is less than the rate of return of other existing assets. Several types of market imperfections have been nominated to play the role of explaining personal preferences for money, even when higher-yield financial assets are available.[8]

A very different situation is created by the elimination of hypothesis 2. Now the problem concerns trades (at general equilibrium prices). The consequence of hypothesis 2 is not to make trades possible in ideal conditions, but to suppress them: trades are excluded from the set of individual activities. Once the market-clearing prices are reached, the model assumes that all market-clearing reallocations of commodities take place instantly and effortlessly. In this sense, trades are nonexistent. In the Arrow–Debreu model, the economic agent is a consumer and (or) a producer. He is never a trader. In this model, the perfectly competitive market system actually rests on the perfect absence of trade.

The limits of the integration of money into the theory of value

"In general equilibrium theory," Gale tells us, "money has one function. It is a store of value" (Gale 1982: 290–91). The most profound difficulties for the general equilibrium approach arise in the attempts to build a theory of the demand for money as a store of value – attempts that are directly derived from, and further elaborations of, the Hicksian concepts of individual choice and frictions. The integration of money into price theory requires the demonstration of the existence of an equilibrium with a positive price for money – that is, a monetary equilibrium. Contrary to any ordinary commodity, a zero price for money is always an equilibrium price since, whatever individual preferences may be, no one wants money at this price – money cannot be a store of value if it has no value! The problem is to identify the conditions under which the price of money does not fall to zero – that is, conditions implying that at a sufficiently low price of money, the excess demand for money is always positive.

In this section we examine and suggest a critical evaluation of the most important models that have been proposed to deal with money as a store of value.[9] Particular attention will be devoted to the overlapping generations models, which are considered the most sophisticated approaches to this problem.

Finite horizon models

The logical and historical starting point of the contemporary neoclassical monetary theory is found in Patinkin's monetary work, in particular his critique of the traditional monetary theory and his theory of monetary

temporary equilibrium. In the traditional theory, money is integrated into value theory by adding the "Cambridge equation," which equates the demand and supply of money, to the standard general equilibrium equations. The following system is obtained:

$$z_i(\boldsymbol{p}) = 0, \text{ for all } i$$
$$k\boldsymbol{pT} = \overline{m}$$

where z_i is the excess demand function of commodity i, $\boldsymbol{p}$ is the vector of prices, $\boldsymbol{T}$ is the vector of transaction volumes expressed in real terms, k is the proportion of $\boldsymbol{T}$ that individuals wish to hold as real money balances, and $\overline{m}$ is the money supply. The first n equations determine the $(n-1)$ equilibrium relative prices and the quantities of each commodity which are traded (the vector $\boldsymbol{T}$ in the last equation). On this basis, the monetary equation determines the monetary price of the *numéraire* and thus monetary prices.

Patinkin (1965) showed that this system is logically contradictory. Let $\boldsymbol{p}^*$ be the vector of equilibrium prices resulting from the first n equations and multiply it by a scalar $\lambda > 0$. Since demand and supply functions are homogeneous of degree zero in prices, every $\lambda\boldsymbol{p}^*$ is also a vector of equilibrium prices. Since at prices $\lambda\boldsymbol{p}^*$ the n commodity markets are in equilibrium, by Walras's law the $(n+1)$th market, for money, is also in equilibrium. But when prices $\lambda\boldsymbol{p}^*$ are introduced into the last equation, the money demand, on the left-hand side, is different from the money supply, the constant on the right-hand side. The money market is at once in equilibrium by the virtue of Walras's law and out of equilibrium by the monetary equation.

Patinkin's model of monetary temporary equilibrium eliminates this logical inconsistency (Patinkin 1965: 177). Let us consider a pure exchange economy and adopt the Hicksian "week" as the time unit. On Monday morning, individuals have an initial endowment of a perishable consumption commodity, exogenously given, and a durable commodity used as money, which is transmitted from the previous week. On Monday afternoon the Walrasian market is open and a *tâtonnment* process is supposed to lead to the equilibrium prices for the week. Individual demands for and supplies of commodities, and real cash balances, which are transmitted to the next week, are simultaneously determined by a single maximization program. The rest of the week is spent in trading and in consuming. Individuals finish the week with a positive monetary balance. In this model the demand for money is a demand for real cash balances, which is justified by the need to reach a regular flow of consumption in an economy where, by hypothesis, payments and receipts are not synchronized.

It follows that a real cash balance is added to prices as an argument of the individual demand and supply functions. The dichotomy between money and commodities in the traditional neoclassical system is eliminated. As above, let $\boldsymbol{p}^*$ be the equilibrium price vector and multiply it by $\lambda > 1$. At these new prices, each individual's real cash balance is less than its equilibrium level. In order to increase it, individuals reduce their demand for commodities. Commodity markets are no longer in equilibrium. Prices decline until real balances reach their equilibrium level again.

Contemporary monetary theory has been developed on the basis of critiques of different aspects of Patinkin's model, such as the inclusion of money in the utility function, the lack of a proof of the existence of monetary equilibrium (Hahn 1965), the fact that the real balance effect is ineffective in a stationary equilibrium (Archibald and Lipsey 1958), and the incompatibility between the budget constraint used by Patinkin and a monetary economy (Clower 1967).[10]

As far as the integration of money into value theory is concerned, the main point is the existence or nonexistence of the monetary temporary equilibrium. We face the following difficulty. In a sequential model such as Patinkin's temporary equilibrium, the decisions about weekly demand for and supply of commodities should depend on current prices and also on expected prices. Therefore, temporary equilibrium is not compatible with any expected change in prices. Suppose that current prices increase. If expected prices are higher than current prices, agents substitute current commodities for future commodities: they increase their current demand for commodities and reduce their demand for money. The real balance effect – which predicted increased demand for money when prices rise – does not work under these circumstances. Instead, as a consequence of the rise of current prices, expected prices rise further. By virtue of this intertemporal substitution effect, the same process goes on from period to period, which is clearly incompatible with any notion of equilibrium. There does not exist any finite level of monetary equilibrium prices, and the monetary temporary equilibrium does not exist either.

In Patinkin's model, this problem is eliminated by assumption: expected prices are supposed to be equal to current prices – that is, there is no intertemporal substitution effect. But even so, Grandmont (1974) shows that the real balance effect is not sufficient for the existence of a monetary temporary equilibrium. This effect must be accompanied by an intertemporal substitution effect acting in the same direction – that is, agents must anticipate a deceleration of prices. But since nothing is said about the manner in which expectations are formed, the existence of a monetary temporary equilibrium depends entirely on an *ad hoc* hypothesis.

Another important model used to integrate money into value theory is the transaction costs model (Hahn 1971). Consider a general equilibrium model with complete future markets and introduce the hypothesis that future transactions are more expensive than the spot ones. Let there be two agents who wish to trade commodities A and B. At period t, commodity A is owned only by agent I, and at $(t+1)$ commodity B is owned only

by II. In the absence of money as a store of value, the agents are forced to use future markets, which, by hypothesis, are the most expensive exchange procedure. For instance, at period t, I sells and delivers commodity A to II, who pays by selling commodity B, which will be delivered at period $(t+1)$. Now introduce money with a zero transaction cost (or, more generally, as the commodity with the lowest transaction cost). Monetary trades allow individuals to reduce transaction costs by using only spot markets. A positive demand for money is thus generated at the end of each period and a monetary equilibrium may exist. Besides, this model explains why future markets are not complete.[11]

Note that in both the temporary equilibrium and the transaction cost models, the economic horizon is finite, limited by the agent's lifetime. The demand for money at the final period is necessarily zero. Since money is not accepted in the final period, individual demand for money is zero at the penultimate period, and so on. By recurrence, the demand for money is zero at all periods. In finite horizon models, such a difficulty can be eliminated only by means of *ad hoc* hypotheses, such as constraining agents to hold the same stock of money at the final and the initial periods, or to pay a monetary tax properly calculated at the final period, or to bequeath money to the following generation. The artifice is obvious.

Infinite horizon models

Infinite horizon models must, then, be used (even if it makes it more difficult to prove the existence of equilibrium). The most remarkable result has been provided by the overlapping generations models, where the existence of an equilibrium with positive price for money has been proved (Samuelson 1958; Cass and Yaari 1966; Wallace 1980; Cass *et al*. 1980). This explains why it is considered that "the friction in Samuelson's 1958 consumption loan model, overlapping generations, gives rise to the best available model of fiat money" (Wallace 1980).

Consider a pure exchange economy with a single consumption commodity. Time is infinite and divided into discrete periods t. Individuals live two periods. At each period t two groups of agents coexist: those who are in their first period of life, or "young generation," designated h_t^t, and those who are in their second period of life, or "old generation," designated h_t^{t-1}, where the superscript indicates the generation, and the subscript indicates the time period. Individuals are all alike. They receive the same initial endowment and have the same utility function, $U(c_t^t, c_{t+1}^t)$, for the t generation. The only difference between agents is their date of birth.

The individual tries to reach an optimal allocation in order to satisfy his needs in his two periods of life. However, due to the temporal structure of the economy, this is not possible by means of trades, as is illustrated by the following excess demand matrix:

	$t-1$	t	$t+1$	$t+2$
h^{t-1}	-1	1	0	0
h^t	0	-1	1	0
h^{t+1}	0	0	-1	1

The only interesting trade is between individuals belonging to different generations. An individual h^t, for instance, wishes to save – that is, to reduce consumption in the first period of life in order to increase consumption during the second period. But he cannot do it. He can sell only to an individual h^{t-1} belonging to the old generation, who cannot pay since he is no longer living at $(t+1)$. By changing the sign of the excess demands, we see that the opposite trade (buy in the first period of life and sell in the second one) is also impossible. The reason is that the condition of *quid pro quo* is never fulfilled.

We will deal with this problem by examining two overlapping generations models in more detail, one with a durable good and the second with a perishable one.

The *first model* is obtained by adding the following two hypotheses:

1 Individuals receive a positive endowment of a durable consumption commodity, y, in their first period of life and nothing in the second one. In order to simplify the notation, we use the superscript 1 (and 2) to indicate the first (and the second) period of life. The endowment of any generation is $y^1 > 0$, $y^2 = 0$.
2 Population starts at N_0 in generation 0 and increases at a constant rate $n > 0$, so that generation t is made up of $N_0(1+n)^t$ individuals.

Efficiency is obtained when total consumption is maximum, that is, when it is equal to total resources.

$$c_t^1 N_0(1+n)^t + c_t^2 N_0(1+n)^{t-1} = y^1 N_0(1+n)^t$$

or

$$c_t^1 + \frac{c_t^2}{1+n} = y^1$$

where c_t^1 and c_t^2 are individual young-generation and old-generation consumption at time t.

Let us focus on the stationary equilibrium where c_t^1 and c_t^2 are constant for all t, so that this subscript can be omitted. Each individual saves

$(y^1 - c^1)$ in the first period and consumes c^2 in the second period. Thus, the stationary rate of interest is defined as:

$$(1 + r) = \frac{c^2}{y^1 - c^1}$$

It turns out that efficiency of the stationary path implies the equality between the rate of interest and the rate of growth of population (which is a central condition of the "golden age" path). If $r < n$, consumption is less than available resources. The stationary equilibrium is inefficient (and, consequently, not optimal). This is the case in this model where $n > 0$, and $c^2 = y^1 - c^1$, so that $r = 0$. (Note that the only efficient path is $c^1 = y^1$, $c^2 = 0$. It is evident that, in general, this path is not optimal.)

Suppose now that in this general equilibrium model, where individuals are price takers, the auctioneer announces a positive price for an intrinsically worthless durable commodity that can be used as money, and that there is a permanently fixed quantity of money $\overline{m}$, initially all in the hands of the old $(t-1)$ generation. Individuals belonging to the old $(t-1)$ generation are obviously interested in trading money for the savings of the young (t) generation, who will accept money if they expect that they will be able to trade it for the savings of the $(t+1)$ generation in the next period.

Since all individuals are identical, the demand for money grows at the same rate as the population, n. With a fixed supply of money, the price of money grows at the same rate – which is also, therefore, the rate of interest of money. The young generation does better by selling its savings to the old generation and holding money, an asset whose rate of interest is n, rather than by holding its savings in the form of the durable consumption good, with a zero rate of interest. The stationary equilibrium is now efficient, and also optimal, because the volume of savings is determined by the maximization of the utility function under the budget constraint.

The existence of a stationary monetary equilibrium can be expressed in a more general way by supposing that the (physical) rate of return of savings made in the first period of life is positive (instead of zero, as in the above model). The young generation accepts money only if the rate of return of its saving is less than n. In the opposite case, the demand for money is zero and, consequently, the money price is also zero: the stationary equilibrium is a nonmonetary one (Wallace 1980: 54).

The *second model* is obtained by replacing the three hypotheses of the previous case by the following two:

1 Without any loss of generality we suppose a zero rate of growth of the population.

2 Individuals have a positive initial endowment of a perishable consumption commodity in their two periods of life, which, for the t generation, is designated

$$y_t^t > 0, y_{t+1}^t > 0.$$

Except by chance, the initial endowment does not correspond to the consumption profile, which maximizes individual utility at the stationary equilibrium price.[12]

The existence of a stationary monetary equilibrium entirely depends on the utility function and the initial endowment. If the marginal rate of intertemporal substitution at the point of the initial endowment is less than stationary equilibrium price, the young generation t accepts to trade its savings for money from the old generation $(t-1)$. By this trade, the consumption profile reached by the young generation is better than the one that is obtained by consuming the initial endowment. In all other cases, this trade will be refused by the young generation, and the stationary equilibrium will be a nonmonetary one. (Note that regardless of who initially holds money, or the relative size of young versus old endowments, trade is possible only in one direction: the old generation never accepts money since it will die in the next period.)

A critical evaluation

Note first that the overlapping generations model does not provide any answer to the question of the acceptability of money, which is the necessary (but not sufficient) condition for the existence of a monetary equilibrium. It is self-evident that generation t accepts money only if it expects that all future generations will accept it. But in spite of appearances, in the overlapping generations model this problem is eliminated. As we saw, as in the standard general equilibrium theory, all prices, including the price of money, are announced by an auctioneer and are taken as given by agents. There is no room for an analysis of expectations, or for a social agreement about the acceptance of money (more precisely, the only "social agreement" implicit in this theory concerns the existence of an auctioneer).[13]

The main contribution of the overlapping generations model is to prove (without making *ad hoc* hypotheses like those we saw in finite horizon models) that in certain cases, an intrinsically useless commodity can be used as a store of value and thus it can have a positive equilibrium price. The central difficulty arises when this kind of model is used to solve the much more general problem of integrating money into price theory. In this case, the "equilibrium" with or without money as a store of value means the equilibrium with money or without any money at all. Our criticism is developed in two stages: first, we show that no equilibrium exists when the price of money is zero; second, we draw the consequences of it.

1 One of the most widely accepted propositions in monetary theory is that "A model of fiat money may be expected ... to include an equilibrium where price of money is nil" (Starr 1989); this is Hahn's conclusion in his famous 1965 paper. Consider an exchange economy. We saw that a general equilibrium is a nonnegative price vector and a consumption allocation maximizing the individual utility function under the budget constraint. Let us distinguish three kinds of economies:

- Economy *W*, which is made up of commodities, agents, and a centralized accounting system or a central clearing house allowing for the realization of transactions without cost. Arrow and Debreu demonstrated the existence (under some conditions) of a price vector $\boldsymbol{p} > 0$ for which there does not exist any positive excess demand. In the W-type economy this result is sufficient to get the equilibrium allocation.
- Economy M, in which the centralized accounting system is suppressed and replaced by one medium of exchange. In this economy the equilibrium exists: first the vector price $\boldsymbol{p}$ is determined and then monetary trades at these prices lead to the equilibrium allocation.[14]
- Economy B, a barter economy, which is obtained by suppressing the medium of exchange of the previous economy. As we have seen, trades at prices $\boldsymbol{p}$ do not lead, in general, to the equilibrium allocation. In this economy the equilibrium does not exist.

Let us consider an M-type economy where the equilibrium exists, and examine the consequences of a zero price for money. The demand for money is nil, so that the excess demand for money is negative: the zero price of money is an equilibrium price. Economy M transforms itself into a B-type economy where, in general, the equilibrium does not exist. The equilibrium with a zero price for money exists only if we reintroduce the centralized market-clearing procedures of the W economy, which were eliminated in order to introduce money. This is incoherent.[15]

2 From a general point of view, the result of the overlapping generations model is similar to that of the previous models. Depending on the initial parameters, endowments, technique, and utility functions, the stationary "equilibrium" reflecting individual welfare-maximizing choices can be either monetary (i.e., with a positive value for money) or nonmonetary (with a zero value for money in each period). But this result depends on the very restrictive hypothesis that individuals belonging to the same generation are all alike. If we eliminate it and admit some diversity between agents of the same generation,[16] then when money is not chosen as a store of value, the economy is of the B type, where the equilibrium does not exist in general, or it exists only if a centralized transaction system is introduced.

As a consequence, in the general case, Hicks's method of integration of money into price theory implies meaningless comparisons between market and nonmarket economies, or, in a market economy, between equilibrium and the absence of equilibrium. It is not correct to state that the overlapping generation models "do successfully integrate value and monetary theory" (Wallace 1980: 77). Under well-identified conditions, the Arrow–Debreu model always has a solution. This is not the case for models with money as a store of value. Thus, the problem is not that in these models equilibria are "tenuous", as stated by Wallace (ibid.: 50). This would be correct only if these models always had a solution, monetary or nonmonetary. But since, in general, the latter does not exist, the monetary theory of these models is vacuous.[17]

It is clear that individuals choose between transferring or not transferring their purchasing power over time by means of money. Depending on the specification of the initial parameters, at the stationary equilibrium the price of money as a store of value can therefore be positive or nil. But this does not mean that individuals choose between a decentralized and a centralized organization of trades and that the latter is always preferred in economies defined by some initial data.

The only way to avoid this strange conclusion is not to identify money with its function as a store of value, and thus to admit that even when there is zero demand for money as a store of value, money is not eliminated. In other words, money must have a function other than that of store of value, which subsists even when the latter disappears. Obviously, this function is that of being the medium of exchange.

Conclusion

Hicks's method is certainly adapted to deal with the problem of money as a store of value. It is worth noting that in all the models we examined, a monetary equilibrium exists only if money is the most profitable asset. It follows that the kind of frictions used in these models to integrate money do not answer the critical question, posed by Keynes as well as Hicks, of how to explain a positive demand for money in the presence of other assets with a higher rate of return.

The central point is that neoclassical monetary theory has followed Hicks's approach to the very different problem of integrating money into value theory.[18] The resulting program of research, dominant for more than half a century, seems to lead to a dead end.[19] The above analysis suggests that the origin of such disappointing results cannot be ascribed to some difficulties peculiar to the theory of money, or to an (unexplained) weakness of the monetary analysis. This justifies a reexamination of the basis of this analysis – that is, the general equilibrium price theory, in particular one of its central features: the determination of prices independently of (and previously to) trades.[20]

This chapter does not deal with the place and role of money in the working of market economies. Our problem is narrower: the integration of money and price theory. We can conclude that the neoclassical methodology is not well suited to dealing with the problem of integrating money into value theory. Money is not a way to overcome difficulties arising from frictions in an otherwise perfect market system. On theoretical as well as historical grounds, no (perfect or imperfect) market system can exist without a social agreement on the use of money.

Acknowledgment

I am grateful to Frank Ackerman for his valuable comments. Errors are my responsibility alone.

Notes

1 In the classical (or Ricardian) theory of value, only production relationships are considered relevant.
2 See, for instance, Hayek (1931: chap. 1) and Hahn, "Economic theory still lacks a 'monetary Debreu'" (1965: 195).
3 In this chapter we freely make use of Benetti (1990, 1996, 1999). For a clear synthesis of the problem of integrating money in the general equilibrium theory, see Ostroy (1989).
4 For a general treatment of barter trades, see Veendorp (1970) and Ostroy and Starr (1974). For a study of barter and monetary trade in Walras's theory, see Rebeyrol (1999).
5 Note that this result is a general one in the sense that it does not depend on the theory of value which is adopted. The values in the above excess demand matrix correspond to the numerical example used by Sraffa to illustrate the classical (Ricardian) theory of prices of production with a zero rate of profit (1960, chap. 1). Such figures can also be interpreted as labor values. In these cases the agent is defined as a producer, and the above example shows the impossibility for the system to reproduce itself. Note: in what follows, for convenience the masculine pronoun "he" will be used in a general sense, so as to avoid the excessive use of "he or she," etc.
6 In this analysis, trades are made at equilibrium prices. Obviously, the same conclusion is obtained if we consider trades at disequilibrium prices.
7 It is interesting to note that the only affiliation Hicks admits explicitly is with Keynes's *Treatise on Money*. In his paper he declares he is "more Keynesian than Keynes."
8 For instance, uncertainty and transaction costs (Hicks), or legal restrictions that prevent assets such as Treasury bills from circulating as money (Wallace 1983).
9 For an introduction to the neo-Walrasian monetary and interest rate theory, see Rogers (1989: chap. 3). See also Visser (1998: part I).
10 For an evaluation of Patinkin's theory, his defense of the quantity theory of money, and the critiques of his work, see Benetti (1990).
11 Transaction costs theory has recently been used by Starr (2003) in a framework where the budget constraint is enforced on each trade separately, in order to deal with the Mengerian problem of the emergence of a commodity money in a Arrow–Debreu economy.

12 To see why the equilibrium price is stationary, let p_t be the price at t and p_{t+1} the discounted price at $(t+1)$ which is perfectly anticipated during the period t. By definition, $p_t/p_{t+1} = 1 + r_t$, which, at the stationary equilibrium, is equal to $1 + r$, for all t. Efficiency implies that $r = n$. Since $n = 0$ by hypothesis, $r = 0$, and then $p_t/p_{t+1} = 1$.
13 This is the meaning of the criticism of Samuelson by Cass and Yaari (1966).
14 A demonstration of this proposition, as well as of (iii) is given by Ostroy and Starr (1974).
15 Benetti (1996) shows that the result obtained by Hahn is not the existence of a nonmonetary equilibrium in the economy M, but the impossibility of a monetary equilibrium in the economy W. This is not surprising in an economy that is refractory to the introduction of money.
16 In order to obtain a stationary solution we continue to accept the assumption that generations are all alike.
17 In the sense of Debreu's statement that "Walras and his successors were aware that his theory would be vacuous in the absence of an argument supporting the existence of its central concept" (1989: 131).
18 Until recently, it was commonly admitted that the monetary theory developed on the basis of Hicks's methodological suggestion failed to study money as a medium of exchange. This state of things has been radically changed by the use of search theory to model the medium of exchange. In this respect, Wright's models are exemplary, since they give a central role to the Hicksian concepts of individual choice and frictions (transaction costs that are minimized by the monetary trade, or uncertainty derived by the occurrence of bilateral meetings and the double coincidence of wants). In short, they propose a solution of the monetary problem as formulated by Menger, by using Hicks's methodology. The starting point of the monetary search models is Kiyotaki and Wright (1989). For a critical appraisal, see Cartelier (2001). We do not examine these models because they are outside and in opposition to the general equilibrium theory.
19 It would be interesting to examine whether this conclusion is modified by the recent contribution to Walras's monetary theory proposed by Rebeyrol (1999). In the temporary equilibrium framework, money is conceived as a medium of exchange, whose demand is calculated at the beginning of the period. If this solution of the monetary equilibrium problem is accepted, the difficulty is shifted from money to price theory.
20 This critique is put forward by Benetti and Cartelier (2001).

4 The law of supply and demand in the proof of existence of general competitive equilibrium

Carlo Benetti, Alejandro Nadal, and Carlos Salas

Introduction

The proof of existence of a general competitive equilibrium is generally considered one of the most important and robust results of economic theory. The proofs of existence, which appeared in the 1950s, relied on results of topology, using a fixed-point theorem to demonstrate the existence of an equilibrium point. These proofs employ a suitable mapping, transforming points of a convenient set of prices and quantities onto itself. Our argument, in brief, is that the mappings used in these proofs are mathematically convenient but economically meaningless: they do not correspond to any plausible process of price variation.

To understand the mathematical strategy of the existence proofs, it may help to begin with a trivial example. In a one-commodity market, one would expect the change in price to reflect the excess demand for the commodity: price goes up when excess demand is positive, goes down when excess demand is negative, and remains unchanged at the market equilibrium point when excess demand is zero. In an *n*-commodity market, the mapping that determines price changes is more complex, but the underlying idea is similar: price changes are based on a function of prices and quantities, usually involving excess demand. An equilibrium is a vector of prices and quantities at which prices do not change because supply equals demand for all commodities – that is, a fixed point in the mapping which determines quantities and prices. If the sets and mappings have all the required topological properties, the mappings are guaranteed to have a fixed point, demonstrating the existence of general economic equilibrium.

The main objective of this chapter is to analyze the economic interpretations of the mappings involved in the proofs of existence. In the writings concerning the existence of equilibrium, the mathematical proof using a fixed-point theorem is accompanied by an economic interpretation of the relevant mappings. This interpretation evolved through time: in the 1950s it was considered that the mappings described a dynamic adjustment process, but later they were thought to express the law of supply and demand as a price variation rule without any reference to a dynamic

adjustment. This interpretation is commonly shared today in the relevant literature. The main finding of this chapter is that the second line of interpretation is as unacceptable as the first: in general, the mappings used in the proofs of existence contradict the price variation rule that is supposed to justify them from an economic standpoint.

If our analysis is correct, the single most important result of neoclassical theory in the past fifty years is a mathematical theorem devoid of any economic sense. Our results are a direct criticism of dominant economic theory from two points of view. The first pertains to the theoretical soundness and rigor of neoclassical theory. The second is more general, and concerns the relationship between mathematics and economic theory. These two aspects are of relevance today given that (i) on the basis of this purported logical coherence, neoclassical theory claims today to be the only available theoretical construct; and (ii) mathematization of economic theory is one of the most visible traits marking the evolution of the discipline during the past fifty years.[1] Our analysis relies on a thorough investigation of the mappings' behavior, something that surprisingly has attracted little or no attention since their appearance in the theoretical literature in the 1950s.

The first section describes the two economic interpretations of the mappings as they have evolved since the 1950s. In the second section we show that the three main mappings in the literature are inconsistent with the law of supply and demand.[2] In the third section we offer an explanation of the incompatibility between the mappings and the law of supply and demand. Our analysis leads to the question of whether a proof of existence of general equilibrium deprived of any economic meaning can be considered to be satisfactory. This important aspect of the problem is examined in our conclusion.[3]

Economic interpretations of the mappings used in the proof of existence of general equilibrium

The economic sense ascribed to the mappings used in the proofs of existence has evolved over time. In the first writings it was ascertained, sometimes implicitly, that the mappings described a dynamic price adjustment process leading to general equilibrium. However, as the first negative results concerning stability came to light, the economic justification of the mappings was modified and restricted to the law of supply and demand as a rule of price changes without reference to the effects of these price variations on excess demands in the following period. In the following subsection we examine these interpretations in more detail.

Interpretation of the proof of existence in terms of the dynamic adjustment process

The 1956 papers by Nikaido and Debreu respectively stressed the idea that the mappings used in the proof of existence of equilibrium were the mathematical expression of a dynamic adjustment process. Prices changed according to the law of supply and demand as a function of excess demand's signs, while excess demands, in turn, are modified according to the relation $\Delta z_{i,t+1}(p) = G_i(\Delta p_{i,t})$. If such a process converges towards a position of equilibrium, it is defined as stable.

This view was already held by Gale (1955), whose paper suggests a close relation between the proof of existence and the law of supply and demand, defined as the mechanism by which "prices eventually regulate themselves to values at which supply and demand exactly balance, these being the prices at economic equilibrium" (ibid.: 87). The most important texts that pursue this interpretation are the following.

Nikaido uses the following mapping

$$\theta_i(p) = \frac{p_i + \max(z_i, 0)}{1 + \Sigma_j \max(z_j, 0)} \qquad (i = 1, \ldots, n)$$

where p_i and z_i are the price and excess demand of commodity i respectively. The economic interpretation of $\theta(p)$ is advanced by Nikaido in the following terms:

> The mapping θ which appears in the proof of Theorem 16.6 may be interpreted as representing the behavior of the auctioneer who proposes a modification of prices responding to a nonequilibrium market situation.
>
> (Nikaido 1968: 268)

> Goods are exchanged in the market according to their prices. . . . If their demand and supply are not equal, current prices are induced to change under the influence of the "Invisible Hand". If new prices do not equate demand and supply, another round of price changes follows. Successive changes in prices with alterations in demand and supply continue until demand and supply are equated for all goods. In place of the Invisible Hand, we may suppose a fictitious auctioneer who declares prices p in the market. Participants in the market then cry out quantities they buy and sell. If their demand and supply do not match, the auctioneer declares a new set of prices p. $\theta(p, x)$ defined above may be interpreted as an adjustment mechanism of demand and supply that associates new prices with current prices and excess supply x.
>
> (Nikaido 1970: 321–22)

This interpretation was first put forward by Nikaido (1956). Consider a nonnegative price vector.

> If the corresponding total demand $X = \Sigma X_i$ does not match with the total available bundle A, the referee must try to set up a new price constellation which will be effective enough to let the individuals adjust their demands in such a way that the deviation of the total demand from A may be reduced. This scheme of the referee will be most effectively achieved by making the excess of the total monetary value PX to be paid by the individuals for X over their total available income PA as large as possible, i.e., by setting up a price constellation belonging to $\chi(X) = \{P \mid P(X - A) = \max Q(X - A)$ over all $Q \in S^k\}$. This function is multivalued and will be called the price manipulating function.
>
> (Nikaido 1956: 139)

At the time, Debreu (1956) was stating the same thing,[4] mainly that his mapping of Max $\boldsymbol{p}\cdot\boldsymbol{z}$ had "a simple economic interpretation: in order to reduce the excess demand, the weight of the price system is brought to bear on those commodities for which the excess demand is the greatest." He would later restate this as follows:

> [A]n increase in the price of a commodity increases, or leaves unchanged, the total supply of that commodity. This hints at a tendency for an increase in the price of a commodity to decrease the corresponding excess demand. It prompts one, when trying to reduce positive excess demand, to put the weight of the price system on those commodities for which the excess demand is the greatest.
>
> (Debreu 1959: 83)

> According to a commonly held view of the role of prices, a natural reaction of a price-setting agency to this disequilibrium situation [i.e., a price vector with nonzero excess demands] would be to select a new price vector so as to make the excess demand F(p) as expensive as possible.
>
> (Debreu 1974: 219)

According to Debreu (1982: 708), the economic interpretation of this mapping is quite clear, which may explain his allegiance to this mapping over the years:

> the maximization with respect to $\boldsymbol{p}$ of this [excess demand] function agrees with a commonly held view of the way in which prices perform their market-equilibrating role by making commodities with positive excess demand more expensive and commodities with negative excess demand less expensive, thereby increasing the value of excess demand.

Interpretation of the proof of existence in terms of the law of supply and demand

The previous interpretation found less support after the 1960s, especially after a paper by Scarf (1960). It became totally unacceptable in the 1970s after the negative results of Sonnenschein (1973), Mantel (1974), and Debreu (1974), who together resolutely demonstrated that the "commonly held view" on the "market-equilibrating role" of prices in the Arrow–Debreu model is utterly unjustified.

Explicit discussion of this interpretation is given by Hildenbrand and Kirman (1988: 106): "Even though an adjustement process may not converge, nevertheless *a fixed point p** of it exists." This is why

> If we confine ourselves to a fixed point of the adjustment process then this process, as such, has no real intrinsic economic content. We can then arbitrarily choose a process to suit our purpose. The only criterion is its mathematical convenience.

This does not mean that the mapping can remain economically meaningless, but that for its pertinence *in the proof of existence*, a price adjustment process does not have to be stable. The economic interpretation of the mappings in the proof of existence can be suitably based on the law of supply and demand, without any reference to a dynamic adjustment process.

This important point has not been completely grasped. A significant example can be found in the textbook by Mas-Colell *et al*. (1995). They use Debreu's correspondence and state (ibid.: 586), "*This makes economic sense*; thinking $f(.)$ as a rule that adjusts current prices in a direction that eliminates any excess demand, the correspondence $f(.)$ as defined above assigns the highest prices to the commodities that are most in excess demand" (emphasis added). Such interpretation of the mapping in terms of an implicit reference to the stability of equilibrium is surprising.

In contrast, after presenting mapping $\theta(p)$ (see p. 70), Varian (1992: 321) proposes a different interpretation: "This map has a *reasonable economic interpretation*: if there is an excess demand in some market, so that $z_i(p) > 0$, then the relative price of this good is increased" (emphasis added).

A straightforward assessment of this interpretation can be found in a book by Starr (1997: 101):

> We establish sufficient conditions so that excess demand is a continuous function of prices and fulfills the Weak Walras's Law. The rest of the proof involves *the mathematics of an economic story* [emphasis added]. Suppose the Walrasian auctioneer starts out with an arbitrary possible price vector (chosen at random, *crié au hasard*, in Walras's phrase) and then adjusts prices in response to the excess demand function $\boldsymbol{Z}(\boldsymbol{p})$. He raises the price of goods, k, in excess demand, $Z_k(\boldsymbol{p}) > 0$, and reduces the price of goods, k, in excess supply, $Z_k(\boldsymbol{p}) < 0$. He performs this price adjustment as a continuous function of excess demands and supplies while staying on the price simplex. Then the price adjustment function $\theta(\boldsymbol{p})$ is a continuous mapping from the price simplex into itself. From the Brouwer Fixed-Point Theorem, there is a fixed point $\boldsymbol{p}^0$ of the price adjustment function, so that $\theta(\boldsymbol{p}^0) = \boldsymbol{p}^0$.

And, furthermore: "The price adjustment function θ raises the relative price of goods in excess demand and reduces that of goods in excess supply while keeping the price vector on the simplex."

This statement leaves no doubt: the mapping used in the proof of existence is the expression of the law of supply and demand. The Walrasian auctioneer modifies prices according to the sign of excess demand, but the economic story is not affected by the effects of these price variations on excess demands.

Kreps's remarks on mapping $\theta(\boldsymbol{p})$ are as follows:

> Take the numerator first. We add to the old price p_k a positive amount *if* there is excess demand for good k at price $\boldsymbol{p}$. (This makes sense; raise the prices of goods for which there is too much demand). Then the denominator takes these new relative prices and rescales them so they sum to one again.
>
> (Kreps 1990: 212)

In the absence of further comments, the reader is left with the impression that, as the numerator, the mapping $\theta(\boldsymbol{p})$ makes economic "sense." This presentation is misleading, as we will see in the next section.

Mappings and the law of supply and demand

We will show that in the three most important mappings used in the proof of existence of a general competitive equilibrium, the price variation rule does not comply with the law of supply and demand, which is defined in the following subsection.[5] The mappings examined here are from Nikaido (1968, 1970, 1989), Arrow and Hahn (1971) and, finally, Arrow and Debreu (1954) and Debreu (1956, 1959).

The law of supply and demand

In the words of Arrow (1981: 141), the "familiar law of supply and demand" states that the price of any one commodity increases when the demand for that commodity exceeds the supply, and decreases in the opposite case. If we take strictly positive prices, these can be measured in

terms of a *numéraire*.[6] We can also study prices expressed in terms of an abstract unit of account as elements of the n-dimension simplex $\boldsymbol{p} \in S_n \subset R^+_n$.

Let $\Delta p_i = p'_i/\Sigma P'_i - p_i/\Sigma P_i$, and let $z_i(\boldsymbol{p})$ denote the excess demand function for commodity i. The law of supply and demand prescribes a price variation such that

$$\Delta p_i = 0 \text{ if } z_i(\boldsymbol{p}) = 0, \text{ or if } z_i(\boldsymbol{p}) < 0 \text{ with } p_i = 0$$

$$\Delta p_i \cdot z_i(\boldsymbol{p}) > 0 \text{ in all other cases}$$

This is the price variation rule that lies behind the contemporary economic interpretation of the mappings used in the proof of existence. But as we show in the following subsection, the mappings do not respect this price variation rule.

Nikaido's mapping

Nikaido (1968, 1970, 1989) proves the existence of a general equilibrium by using the mapping already mentioned in the previous section:

$$\theta_i(p) = \frac{p_i + \max(z_i, 0)}{1 + \Sigma_j \max(z_j, 0)} \qquad (i = 1, \ldots, n)$$

where p_i and z_i are the price and the excess demand of commodity i respectively. The mapping transforms points in the unit simplex P_n into price vectors $\boldsymbol{p}$ contained in the unit simplex. Each element of the unit simplex P_n is a normalized vector of prices such that $\Sigma_i p_i = 1$. Homogeneity of degree 0 of the excess demand and supply functions in all prices allows the search for equilibrium price vectors to be limited to the unit simplex of R_n.

To determine whether mapping $\theta_i(\boldsymbol{p})$ satisfies the law of supply and demand, we will examine successively the following three cases: $z_i > 0$, $z_i < 0$, y $z_i = 0$.

Positive excess demand

In the case of $z_i > 0$, the law of supply and demand specifies an increase the price of commodity i. This implies $\theta_i(\boldsymbol{p}) > p_i$ and, in turn, according with mapping $\theta_i(\boldsymbol{p})$, this means that we must have

$$p_i + z_i > p_i\,[1 + \Sigma_j \max(z_j, 0)]$$

$$z_i > p_i\,[\Sigma_j \max(z_j, 0)]$$

$$z_i > p_i \cdot z_i + p_i \cdot \Sigma_{j \neq i} \max(z_j, 0)$$

In this case, because $p_i < 1$, then $z_i \cdot p_i < z_i$. The inequality is verified if for all other commodities $j \neq i$, excess demands are negative or null. If one commodity $j \neq i$ has a positive excess demand, then the condition may not be satisfied. Thus, $\theta_i(\boldsymbol{p})$ is not consistent with the law of supply and demand.

Negative excess demand

If $z_i < 0$, the price of commodity i must decrease: $\theta_i(p) < p_i$. Because $\max(z_i, 0) = 0$, this inequality implies

$$p_i < p_i + p_i \cdot \Sigma_j \max(z_j, 0)$$

This condition is verified if there is at least one commodity $j \neq i$ with a positive excess demand, which is guaranteed by Walras's law. In this case, the price adjustment rule expressed by the mapping $\theta_i(\boldsymbol{p})$ appears to be the law of supply and demand. However, the price variation for good i depends not only on the sign of z_i, but also on the presence of positive excess demands for other goods, something not dictated by the law of supply and demand. Thus, if the mapping appears to be consistent with the law of supply and demand, it is by virtue of Walras's law.

Zero excess demand

When $z_i = 0$, the law of supply and demand ordains that price p_i must remain unchanged, thus $\theta_i(\boldsymbol{p}) = p_i$. But once again, we have problems to interpret mapping $\theta_i(\boldsymbol{p})$ as consistent with the law of supply and demand. What are the conditions under which this equality is verified? Because $\max(z_i, 0) = 0$, we have

$$p_i = p_i + p_i \cdot \Sigma_j \max(z_j, 0)$$

This condition is verified if the second term in the right-hand side is zero, and this is the case when for all $j \neq i$, $z_j \leq 0$. Because of Walras's law, this is not possible except in general equilibrium. Outside of *general* equilibrium, there exists at least one commodity $j \neq i$ with positive excess demand. The price adjustment rule in mapping $\theta_i(\boldsymbol{p})$ carries with it the reduction of price p_i. This is in contradiction with the law of supply and demand.

The Arrow–Hahn mapping

For the ith component, the mapping used by Arrow and Hahn (1971) is

$$T_i(p) = \frac{p_i + \max(-p_i, z_i(p))}{1 + \Sigma_j \max(-p_j, z_j(p))}$$

Although it may be somewhat monotonous, an analysis similar to the previous one is required.

Positive excess demand

The price p_i must rise – that is, $T_i(\boldsymbol{p}) > p_i$. This can be expressed as follows:

$$z_i(\boldsymbol{p}) > p_i \cdot z_i(\boldsymbol{p}) + p_i \cdot \Sigma_{j \neq i} \max(-p_j, z_j(\boldsymbol{p}))$$

If there exists a commodity $j \neq i$ with a positive excess demand, the above condition is verified only if the value of $z_i(\boldsymbol{p})$ is sufficiently large to prevail over the positive value of $z_j(\boldsymbol{p})$. The price variation rule imposed by mapping $T(\boldsymbol{p})$ does not respect the law of supply and demand.

Negative excess demand

Price p_i must decrease – that is, $T_i(\boldsymbol{p}) < p_i$. Hence

$$p_i + \max(-p_i, z_i(\boldsymbol{p})) < p_i [1 + \Sigma_j \max(-p_j, z_j(\boldsymbol{p}))]$$
$$\max(-p_i, z_i(\boldsymbol{p})) < p_i \cdot \Sigma_j \max(-p_j, z_j(\boldsymbol{p}))$$

Obviously, the possibility of reducing the price of commodity i depends on the absolute values of p_i, $z_i(\boldsymbol{p})$, p_j and $z_j(\boldsymbol{p})$. Thus, the above inequality may not be verified. According to the values of these variables, we can obtain $T_i(\boldsymbol{p}) > p_i$; this means that, in spite of the excess supply for commodity i, the price imposed by $T_i(\boldsymbol{p})$ may increase.

Zero excess demand

When $z_i(\boldsymbol{p}) = 0$, we should have $T_i(\boldsymbol{p}) = p_i$. Thus

$$p_i + \max(-p_i, z_i(\boldsymbol{p})) = p_i [1 + \Sigma_j \max(-p_j, z_j(\boldsymbol{p}))]$$
$$p_i = p_i + p_i \cdot \Sigma_j \max(-p_j, z_j(\boldsymbol{p}))$$

Equality $T_i(\boldsymbol{p}) = p_i$ is verified only if $z_i(\boldsymbol{p}) = 0$ *and* if $z_j(\boldsymbol{p}) = 0$ for all commodities $j \neq i$. This is not what the law of supply and demand states.

Debreu's approach

Debreu (1959) considers a price vector $\boldsymbol{p}$ in the unit simplex $P_n = \{p \in R_n^+ \mid p \geq 0, \Sigma_i\, p_i = 1\}$, and the set of possible excess demands Z. He defines an aggregate excess demand correspondence $\zeta(p) = \xi(\boldsymbol{p}) - \eta(\boldsymbol{p}) - \{\omega\}$ (where $\xi(\boldsymbol{p})$ is the aggregate demand correspondence, $\eta(\boldsymbol{p})$ the aggregate supply correspondence and $\{\omega\}$ the vector of initial endowments of the economy) which associates to each price vector $\boldsymbol{p} \in P_n$ a vector $\boldsymbol{z} \in Z$. A new correspondence $\mu(\boldsymbol{z})$ then associates to $\boldsymbol{z}$ a vector of prices within P_n such that $\boldsymbol{p} \cdot \boldsymbol{z}$ is maximized:

$$\mu(\boldsymbol{z}) = \{p \in P_n \mid \boldsymbol{p} \cdot \boldsymbol{z} = \max P \cdot \boldsymbol{z}\}$$

Debreu then defines a new correspondence ψ of set $P_n \times Z$ on itself $\psi(\boldsymbol{p}, \boldsymbol{z}) = \mu(\boldsymbol{z}) \times \zeta(\boldsymbol{p})$. This mapping $\psi(\boldsymbol{z}, \boldsymbol{p})$ implies that to each vector $\boldsymbol{z}$ a price vector $\boldsymbol{p}$ is associated in order to maximize $\boldsymbol{p} \cdot \boldsymbol{z}$. This is what Debreu (1959: 83) calls "the central idea in the proof," which is then described in the following terms: "Let H be the set of commodities for which the component of $\boldsymbol{z}$ is the greatest. Maximizing $\boldsymbol{p} \cdot \boldsymbol{z}$ on P_n amounts to taking $\boldsymbol{p} \geq 0$ such that $p_h = 0$ if $h \notin H$, and $\Sigma_{h \in H} p_h = 1$."

The price adjustment rule is the following: the commodity k with the highest excess demand in vector $\boldsymbol{z}$ is chosen, such that $z_k \geq z_i$, $\forall\ z_i \in Z$, $i \neq h$. The new price vector resulting from correspondence $\mu(\boldsymbol{p})$ has all of its components $p_{i \neq k} = 0$ and component $p_k = 1$ (because no linear combination of the price vector and the excess demand vector results in a higher value than $p_k \cdot z_k$). That is to say, outside of the fixed point, the prices of commodities with positive excess demands (at positive prices) inferior to the largest excess demand are reduced to zero. Their prices are brought to zero for the simple reason that their excess demand is not superior to the other excess demands.

An alternative approach to examine this is as follows. Let $\boldsymbol{p}$ be a price vector, $\boldsymbol{z}$ the vector of excess demands calculated at these prices and $\boldsymbol{p}'$ the new price vector resulting from the law of supply and demand. Necessarily we have $\boldsymbol{p}' \cdot \boldsymbol{z} > \boldsymbol{p} \cdot \boldsymbol{z}$. The consequence of this law is that, outside the fixed point, the aggregate value of excess demand must increase. But the economic meaning of this result stems from the same reason advanced by Debreu: the increase (or decrease) of the prices of commodities with positive (or negative) excess demand. Thus, contrary to Debreu's assertion, the value of $\boldsymbol{p} \cdot \boldsymbol{z}$ cannot be a maximum without contradicting the law of supply and demand. This is self-evident: to reach this maximum, the prices of commodities with excess demands that are both positive and inferior to the largest must be reduced to zero; in the case that several commodities have the same largest excess demand, all of their prices, except one, can be reduced to zero, reserving $p = 1$ for the exception.[7] There is here a brazen contradiction with the law of supply and demand.[8]

These considerations should help explain Arrow's reservations: "this rule is somewhat artificial" (1972: 219) and, later, Debreu's (1989: 134):

> Maximizing the function $\boldsymbol{p} \to \boldsymbol{p} \cdot \boldsymbol{z}$ over P_n carries to one extreme the idea that the price-setter should choose high prices for the commodities that are in excess demand, and low prices for the commodities that are in excess supply.

But these calls for caution are useless: the mapping that maximizes $\boldsymbol{p}\cdot\boldsymbol{z}$ is *totally* artificial, and it does not carry to one extreme the law of supply and demand, but utterly *contradicts* it.[9]

The special case of a two-commodity economy

Consider a two-commodity economy with p_1, p_2 and z_1, z_2, the prices and excess demands of commodities 1 and 2 respectively, and suppose that all customary conditions for the existence of equilibrium are verified. By virtue of Walras's law, $\boldsymbol{p}\cdot\boldsymbol{z}=0$, and thus $z_1\cdot z_2<0$.
Consider Nikaido's correspondence:

$$\theta_i(p)=\frac{p_i+\max(z_i,0)}{1+\Sigma_j\max(z_j,0)}$$

when $z_1>0$. Because $z_2<0$, $\theta_1(p)>p_1$ is true if $z_1>p_1z_1$, the last inequality holds since $p_1<1$. If $z_1<0$, we have $p_1z_2>0$, which is equivalent to $\theta_i(\boldsymbol{p})<p_1$. Since these inequalities are verified, the price of commodity 1 increases in the first case and decreases in the second.

We arrive at the same conclusion considering the correspondence of Arrow–Hahn:

$$T_i(p)=\frac{p_i+\max(-p_i,z_i(p))}{1+\Sigma_j\max(-p_j,z_j(p))}$$

Suppose $z_1>0$. Because $p_1<1$, we have $(1-p_1)z_1>0$. Since $z_2<0$, $p_1[(\max(-p_2,\ z_2)]<0$, thus $(1-p_1)z_1>p_1[(\max(-p_2,\ z_2)]$. The conditions for increasing p_1 are satisfied.

Consider now $z_1<0$. Let $u_1=\max(-p_1,\ z_1)$. Then $(1-p_1)u_1<0$, $z_2>0$ and $\max(-p_2,\ z_2)=z_2$. Therefore, $p_1\ (\max(-p_2,\ z_2))>0$ and $(1-p_1)u_1<p_1(\max(-p_2,\ z_2)$. Thus the conditions for the reduction of p_1 are verified.

Finally, the price adjustment rule imposed by Debreu mapping which maximizes the value of $\boldsymbol{p}\cdot\boldsymbol{z}$ yields the following result. If $z_1>0$, we have $z_2<0$ and p_1 is increased until it equals 1. If $z_1<0$, p_1 is reduced until it becomes 0. In the special case of a two-commodity economy, the property $\Delta p_i\cdot z_i(\boldsymbol{p})>0$ is verified by virtue of Walras's law, and *not* by the law of supply and demand.

Synthesis of results

1 $z_i>0$
(a) $z_i>0\Rightarrow \mathrm{p_i}$ increases
(b) p_i increases $\Rightarrow \mathrm{z_i}>0$

For correspondences $\theta_i(\boldsymbol{p})$ and $T_i(\boldsymbol{p})$, statement (a) is false and (b) is true. Therefore, $z_i>0$ is the necessary condition, but not sufficient, for the increment in p_i.

2 $z_i<0$
(a) $z_i<0\Rightarrow p_i$ decreases
(b) p_i decreases $\Rightarrow z_i<0$

For correspondence $\theta_i(\boldsymbol{p})$, statement (a) is true by virtue of Walras's law, but statement (b) is false. Thus, $z_i<0$ is the sufficient condition, but not the necessary condition for the reduction of p_i.

For correspondence $T_i(\boldsymbol{p})$, both statements are false: $z_i<0$ is neither the sufficient nor the necessary condition for the reduction of p_i.

3 $z_i=0$
$z_i=0\Rightarrow \mathrm{p_i}=\theta_i(\boldsymbol{p})$
$\mathrm{p_i}=\theta_i(p)\Rightarrow z_i=0$

For correspondence $\theta_i(\boldsymbol{p})$, (a) is false, but (b) is true only if $z_j=0$ for all $j\neq i$. Thus, we have that $z_i=0$ is a sufficient but not a necessary condition for $p_i=0$.

For correspondence $T_i(\boldsymbol{p})$, (a) and (b) are both false. Thus $z_i=0$ is neither the necessary nor the sufficient condition for $T_i(\boldsymbol{p})=p_i$.[10]

The law of supply and demand and the normalization of prices

The nature of the problem occupying our attention is clearly revealed if we follow the different stages of the construction of the mappings as exemplified in Arrow and Hahn's (1971: 25–27) procedure. The starting point is a two-commodity economy for which four price-variation rules, valid also in the general case of an n-commodity economy, are adopted:

(i) Raise the price of the good in positive excess demand.
(ii) Lower or at least do not raise the price of the good in excess supply, but never lower the price below zero.
(iii) Do not change the price of a good in zero excess demand.
(iv) Multiply the resulting price vector by a scalar, leaving relative prices unchanged, so that the new price vector you obtain is in S_n.

(Arrow and Hahn 1971: 25–27)

In the construction of the correspondence,

we first seek for a continuous function $M_i(\mathbf{p})$ with the following three properties:

(1) $M_i(\boldsymbol{p}) > 0$ if and only if $z_i(\boldsymbol{p}) > 0$
(2) $M_i(\boldsymbol{p}) = 0$ if $z_i(\boldsymbol{p}) = 0$
(3) $p_i + M_i(\boldsymbol{p}) \geq 0$

It is intended that $M_i(\boldsymbol{p})$ represent an adjustment to an existing price so that a price vector $\boldsymbol{p}$ is transformed into a new price vector with components $p_i + M_i(\boldsymbol{p})$.

(Arrow and Hahn 1971: 25–27)

There are correspondences with properties P1–P3, for example:

$M_i(\boldsymbol{p}) = \max(-p_i, k_i \cdot z_i(\boldsymbol{p}))$, where $k_i > 0$.

[I]f we interpret $(p_i + M_i(\boldsymbol{p}))$ as the ith component of the new price vector that the mapping produces, given $\boldsymbol{p}$, the procedure for finding these new prices satisfies the rules discussed earlier. However, while all $(p_i + M_i(\boldsymbol{p}))$ are certainly non-negative, there is nothing to ensure that they will add up to one. In other words, ... there is no reason to suppose that $(\boldsymbol{p} + \boldsymbol{M}(\boldsymbol{p}))$ is in S_n when $\boldsymbol{p}$ is in S_n. Since we seek a mapping of S_n into itself, we must modify the mapping.

(Arrow and Hahn 1971: 25–27)

This is where the price normalization implied by rule (iv) intervenes and the result is correspondence

$$\boldsymbol{T}(\boldsymbol{p}) = \frac{\boldsymbol{p} + \boldsymbol{M}(\boldsymbol{p})}{[\boldsymbol{p} + \boldsymbol{M}(\boldsymbol{p})]\boldsymbol{e}}$$

According to Arrow and Hahn, this is an "obvious way" of solving the difficulty they identified (see also Arrow 1968: 117). But this assertion is incorrect, because rule (4) modifies the initial mapping so as to make it *noncompliant with the first three rules*.

Our analysis of the most important mappings used in the proof of existence of GCE (pp. 74–77) reveals that under these conditions, the adjustment of price p_i does not depend so much on the sign of $z_i(\boldsymbol{p})$ as on the relation between $z_i(\boldsymbol{p})$ and the other $z_j(\boldsymbol{p})$ for $j \neq i$. It is the relative weight of $z_i(\boldsymbol{p})$ within the set of excess demands that has an influence on the direction of the change in p_i. This is the source of the strange price adjustment mechanism established by these correspondences: in a market i with positive excess demand, the price can increase or decrease depending on the relative importance of the excess demands on the other markets.[11] The interdependencies acting on the direction of the price variation of the mappings are a direct consequence of the normalization of the price system.

The predicament can be stated as follows. *In order to avoid falling outside of the price simplex, one leaves the law of supply and demand*: we either have a fixed point and the mapping is devoid of economic sense; or we use a correspondence with an economic meaning, but lose the fixed point.[12]

Conclusion

We can now summarize our key findings. The proofs of existence for a general competitive equilibrium are associated with an economic interpretation of the mappings used in the demonstration. We have shown that the interpretation of price variation generated by these mappings in terms of the law of supply and demand cannot be accepted.[13] With greater strength, this conclusion can be applied to interpretations in terms of a dynamic adjustment process.

The point is not a defense or critique of the law of supply and demand as it is conceived and presented in the framework of general equilibrium theory. What we are simply stating is that, first, this definition is unanimously accepted. Second, the authors we consider here claim that the mappings used in their proof of existence of equilibrium obey this law. Third, our analysis reveals that this is not the case. As a consequence, there is a difficulty in the proof of existence insofar as that which is actually accomplished does not correspond with what is claimed to be achieved.

It could be thought that because an "abstract economy" intervenes in the proof of existence, there is no need to provide an economic interpretation of the mappings. In point of fact, the economic interpretation of the mappings is described and justified precisely as the concept of an abstract economy is introduced by Arrow and Debreu. In their first proof of existence, advanced in 1954, which relies on the construction of an abstract economy, these authors propose an economic interpretation of their mapping precisely in terms of the law of supply and demand. The insistence on resorting to economically meaningful mappings is present in all of the relevant works of Arrow (including his conference on the occasion of the Nobel Prize), Debreu and Hahn. Debreu himself advances as the central justification of his excess demand approach the fact that it has a clear and simple economic interpretation.[14]

These authors' approach is quite correct, for the abstract economy they build is not isolated from the original economy, and the fundamental laws of the latter apply to the former. Or to put it in other terms, it is inconceivable that the rules that apply in the abstract economy contradict the laws of the original economy. The fact that we can deal with an "abstract" economy does not eliminate the fact that we are dealing with an "economy" subject to economic "laws". This is precisely the reason why it is possible to make the "return trip" from the abstract to the original

economy in the attempt to complete the proof of existence of equilibrium. Thus, the construction of an "abstract economy" in no way justifies the idea that the mappings can be exempt of an economic interpretation.[15]

We thus arrive at the following crossroads. If it is considered that only the mathematical properties of the mappings are necessary, quite independently of their economic meaning, it is difficult to understand why claims to the contrary are so abundant. If the mappings are considered to have an economic meaning, as it is ascertained, then the use of mappings that lack such an economic meaning entails the lack of pertinence of the proof of existence from the economic viewpoint, whatever the mathematical properties of the intervening sets and mappings. Clarifying this situation is important because, due to the shortcomings of stability theory, the existence theorems play an all-important role in economic theory.

From our standpoint, we consider that if, mathematically, an economic equilibrium can be represented as a fixed point of a suitable mapping, it does not follow that every fixed point is an economic equilibrium. This depends on the nature of the intervening variables and the definition of the mapping used in the proof of existence of equilibrium. Given the nature of the task at hand, the rest point determined by the fixed-point theorem must be an economic rest point representing a state of the economy in which economic forces intervening in price formation are in balance. The search for a mapping with an economic meaning is thus a legitimate concern. It would be rather surprising to use a mapping that did not represent the law of supply and demand to demonstrate, by means of its fixed point, the existence of an equilibrium between supply and demand.

In the mappings used, the excess demand z_i generates a variation of price p_i that contradicts the law of supply and demand. This is true regardless of the sign of excess demand (positive or negative), as well as when excess demand is zero. If, in the fixed point, no individual prices change, this is not by virtue of the law of supply and demand: price p_i does not change only when $z_i = 0$ *and* $z_j = 0$, for all $j \neq i$. The excess demand $z_i = 0$ is a necessary condition for keeping p_i unchanged, but it is not a sufficient condition, contrary to what is stated by the law of supply and demand. Thus, whichever point over the mappings' domains is considered, such mappings are deprived of the economic meaning commonly attributed to them.

We reject the idea that *only* the mathematical properties of the proof should be taken into account. We have not encountered this proposition under the penmanship of the founders of contemporary general equilibrium theory, nor in later presentations. On the contrary, as we have seen, the authors have explicitly described the economic interpretation that they claim is inherent to the mappings they use. The task now is to draw out the consequences of the fact that, since the said mappings do not have the meaning attributed to them, the main result of the modern neoclassical theory is a mathematical theorem devoid of economic sense.

Notes

1 A recent, and lively, discussion of the relation between economic theory and mathematics can be found in d'Autume and Cartelier (1997).

2 We do not examine the proofs of existence that rely on the results of welfare theory (Arrow and Hahn 1971), nor do we consider the existence results that rely on assumptions of differentiability of individual supply and demand functions. It is true that in the context of general equilibrium theory, global analysis represents an approach that is closer to the older traditions (Smale 1989). Nonetheless, the crucial point for our purposes is that work along these lines (Smale 1981; Mas-Collel 1985) imposes assumptions that are more restrictive than those required by Arrow–Debreu models. Thus, our chapter is concerned with proofs of existence of general equilibrium in the more general setting.

3 We assume the reader is familiar with the techniques used in the proof of existence of general competitive equilibrium.

4 As to Debreu's approach, Hildenbrand (1983: 20) describes it as follows: "Debreu used another method of proof in his further work on competitive equilibrium analysis ... i.e. the 'excess demand approach' because he thought that this method of proving existence is more in line of traditional economic thinking."

5 This carries negative implications for the two economic interpretations described in the previous section, for the economic interpretation based on a dynamic price adjustment process rests on the assumption that the law of supply and demand is respected by the mappings.

6 We are not concerned here by the effects of the choice of *numéraire* on stability.

7 "[T]otal prices must add up to one, but this total is to be distributed only over those commodities with maximum excess demand" (Arrow 1972: 219). The mapping used by Arrow and Debreu (1954) and Debreu (1959) finds its origins in the hypotheses of the maximum theorem. According to Takayama (1988: 254), although Debreu used the maximum theorem in his *Theory of Value* (1959) in order to establish the upper semicontinuity of the demand and supply functions, no explicit mention of the literature on the theorem (in particular, the seminal work of C. Berge) was made by him. Debreu (1982) does make an explicit reference to Berge's maximum theorem. This theorem can be used to prove the upper semicontinuity of multivalued correspondences, and is employed to establish this property for the supply and demand correspondences. Although the correspondence $\max \boldsymbol{p} \times \boldsymbol{z}$ does exhibit this property, the difficulty is that in order to ensure the property of upper semicontinuity, the proof relies on a correspondence lacking a reasonable economic meaning. The predicament here is that the property of upper semicontinuity is guaranteed at the cost of rendering the correspondence incompatible with the law of supply and demand.

8 In Arrow and Debreu (1954: 275), a "market participant" with a price-setting role is introduced. This agent, renamed by Debreu (1982: 134) the "fictitious price-setting agent" and endowed with a "utility function" that "is specified to be $\boldsymbol{p} \times \boldsymbol{z}$", chooses a price vector $\boldsymbol{p}$ in P for a given $\boldsymbol{z}$ and "receives $\boldsymbol{p} \times \boldsymbol{z}$". As we have seen, this new price vector $\boldsymbol{p}$ maximizes $\boldsymbol{p} \times \boldsymbol{z}$, which implies, outside the fixed point, that all prices are zero except the price of the commodity with the largest excess demand. Arrow and Debreu (1954: 274–75) continue: "Suppose the market participant does not maximize instantaneously but, taking other participants' choices as given, adjusts his choice of prices so as to increase his pay-off. For given $\boldsymbol{z}$, $\boldsymbol{pz}$ is a linear function of $\boldsymbol{p}$; it can be increased by increasing p_h for those commodities for which $z_h > 0$, decreasing $z_h < 0$ (provided p_h is

not already zero). But this is precisely the classical 'law of supply and demand', and so the motivation of the market participant corresponds to one of the elements of the competitive equilibrium." This behavior, which is totally artificial, reinforces our conclusion. Instead of abruptly contradicting the law of supply and demand, the contradiction is obtained gradually. In this case, the law holds as long as the market participant does not maximize his utility function, and ceases to hold when this agent at last behaves according to the rationality that is assigned to him.

9 Nikaido (1968: 267) also presents this type of correspondence as an alternative way to approach the proof of existence of a competitive equilibrium. Correspondence η yields equilibrium solutions for the excess-supply correspondence χ as fixed points of mapping:

$$f(u,p) = \chi(p) \times \eta(u)\colon \Gamma \times P_n \rightarrow 2^{\Gamma \times Pn}$$

where $\boldsymbol{u}$ represents the vector of excess supplies, and $\eta(\boldsymbol{u}) = \{\mathrm{r} \mid \text{minimizes } \boldsymbol{u}\cdot\boldsymbol{q} \text{ for all } \boldsymbol{q} \in P_n\}$. Our remarks on the Arrow–Debreu mapping apply *mutatis mutandis* to this approach to the proof of existence of a general competitive equilibrium.

10 If we consider relative prices of the form p_i/p_j, then

(a) $z_i > 0$ and $z_j < 0$ then p_i/p_j increases;
(b) p_i/p_j increases, then $z_i > 0$ and $z_j < 0$

Whichever correspondence is considered, $\theta_i(\boldsymbol{p})$ or $T(\boldsymbol{p})$, (a) is true and (b) is false. Thus, $z_i > 0$ and $z_j < 0$ is the sufficient condition, but not the necessary condition for the increase of p_i/p_j. The same conclusion applies in the opposite case ($z_i < 0$ and $z_j > 0$). Evidently, the comparison of "relative prices" does not furnish indications about the state of supplies and demands which, through these correspondences, have generated the price variation. The only thing it reveals is that if, for example, $\theta_i(\boldsymbol{p})/\theta_j(\boldsymbol{p}) > p_i/p_j$, then $z_i > z_j$. But these excess demands can be both positive or both negative.

11 Note that this rule which brings to bear the relative weight of excess demands in the other markets on the direction of price variations in one market has nothing to do with the type of interdependencies commonly considered in general equilibrium theory, such as substitution and income effects. The latter concern the effects of the changes in the prices on the excess demands and not the effects of changes in excess demands on prices. None of these interdependencies can explain why the price of one commodity decreases (increases) when its excess demand is positive (negative).

12 Would it be possible to avoid this predicament? This would imply seeking a fixed point in a correspondence consistent with the law of supply and demand, for example $p_i + M_i(\boldsymbol{p})$. To our knowledge this has not been attempted. The reason for this probably lies in the additional restrictions that would have to be imposed on the supply and demand correspondences. As is well known from the work of Sonnenschein, Mantel, and Debreu, there is no economic justification for such restrictions. Moreover, such additional constraints on these correspondences would limit the generality that is commonly attributed to the proof of existence in Arrow–Debreu models.

13 It is straightforward to construct numerical examples in which the relevant assumptions hold (Walras's law and prices belong to the unit simplex) but where price changes contradict the law of supply and demand.

14 In their classic 1954 paper, Arrow and Debreu set the precedent as their concept of an abstract economy includes the market participant, his payoff function ($\max \boldsymbol{p} \times \boldsymbol{z}$) and the economic behavior of consumers and producers. Debreu's survey article (1982: 708) is quite explicit on this point, for in order to cast the abstract economy "in the form of the general model of a social system," Debreu introduces a fictitious market agent whose role is to choose a price vector $\boldsymbol{p} \in P$ and whose utility function depends on choosing $\boldsymbol{p}$ so as to make excess demand as expensive as possible.

15 The construction of an abstract economy implies, among other things, modifying the original possibility sets of individual producers and consumers in order to ensure boundedness. This property is in turn required to ensure that individual supply and demand functions are defined. Chapter 2 by Nadal, on the building blocks of general equilibrium theory, examines the shortcomings of this procedure.

5 Consumed in theory

Alternative perspectives on the economics of consumption

Frank Ackerman

In many disciplines, the study of consumption has become a dynamic, changing field. A new interdisciplinary area of research on consumption has emerged in the past ten to fifteen years, drawing contributions and participants from sociology, anthropology, history, philosophy, literature, and marketing – even, on occasion, from economics. (See Miller (1995) for a collection of bibliographic essays and surveys from each of the relevant disciplines.) Yet despite the central role that consumption plays in economic theory, economics has been one of the least important contributors to the new wave of research – and one of the disciplines least affected by new approaches to consumption of any variety. A recent review of innovations in neoclassical economic theory simply asserts that "the microeconomic theory of consumer choice under conditions of certainty is well developed, and has not been the subject of any significant advances in recent years" (Darnell 1992: 1).

Economists' lack of interest in new approaches to consumption largely reflects the rigidity of the conventional economic theory of consumer behavior. That theory, of course, assumes that consumers come to the market with well-defined, insatiable desires for private goods and services; those desires are not affected by social interactions, culture, economic institutions, or the consumption choices or well-being of others. Only prices, incomes, and personal tastes affect consumption – and since tastes are exogenous to neoclassical economics, there is little point in talking about anything but prices and incomes.

The correspondence between this theory and the visible facts of economic life is tenuous at best. If there have been no recent advances in the microeconomics of consumer behavior, it is not because of a lack of room for improvement. Nor has there been any scarcity of good critiques and suggestions of alternative theories in the economics literature. The problem is that the alternatives have been too quickly fragmented and/or forgotten.

This chapter reviews the history of dissenting economic perspectives on consumption and argues that they provide ample material for the construction of an alternative – especially if the dissenting views are combined

into a comprehensive new theory. However, the academic development of alternatives has often gone in the opposite direction, toward narrow, single-issue models. Viewed in isolation, such fragmentary alternatives have little power to transform economic thinking; the best-known one, Gary Becker's implausible extension of the standard analysis of consumer choice, appears to reinforce much of what is wrong with neoclassical theory. A synthesis of the various available critiques would have a very different meaning. (For a broader survey of the frontiers of the economics of consumer behavior, see Goodwin *et al*. (1997).)

To present the alternative theories, it will be helpful to outline three fundamental assumptions of the neoclassical theory of consumption; these assumptions may be called asocial individualism, insatiability, and commodity orientation:

- *Asocial individualism*. Consumer desires and preferences are exogenous; they are not affected by social or economic institutions, interactions with others, or observation of the behavior of others.
- *Insatiability*. It is human nature to have a multiplicity of insatiable material desires; the only economically meaningful forms of individual satisfaction result from more consumption (or less work, a related point that will not be addressed here).
- *Commodity orientation*. Consumer preferences consist of well-informed desires for specific goods and services available on the market.

The three assumptions are closely related; any comprehensive critique of neoclassical theory will include alternatives to all three. Veblen, for example, is famous for his alternative to the asocial individualism assumption – but he also mocked the hedonistic conception of a person as a "homogeneous globule of desire," arguing that far from having an insatiable desire for pleasure, human nature is "a coherent structure of propensities and habits which seeks realization and expression in an unfolding activity" (Veblen 1948). And he maintained that much of consumer behavior is fundamentally driven by desires for intangibles such as status, not just for the commodities that symbolize status at the moment.

Nonetheless, it seems safe to say that Veblen is best known for the critique of asocial individualism contained in his analysis of conspicuous consumption. Many other economists writing on consumption can also be viewed as developing alternatives to asocial individualism, as argued in the next section of this chapter. Subsequent sections examine economists whose work provides alternatives to the second and third assumptions.

No consumer is an island

Veblen's treatment of consumption has been well described by David Hamilton (1987). Hamilton reminds us that in describing status-conscious

conspicuous consumption, Veblen was developing a theory of consumption, not just presenting social commentary or satire. For Veblen, goods were both ceremonial and instrumental, yielding both status and use value to their consumers. Over time, the ceremonial aspect of consumption could expand indefinitely without producing any net increase in satisfaction, as Veblen so effectively and satirically demonstrated; but at any point in time, there was an appropriate level of status-oriented consumption for each group in society.

The lull of some decades following Veblen's writings is noted in a more recent article by Roger Mason (1995). The generation of institutionalists that followed Veblen concentrated on issues other than consumption; at the same time, neoclassical economics was engaged in codifying and formalizing its own approach. The next major contributions to an alternative theory of consumer behavior came in the work of James Duesenberry (1949), Harvey Leibenstein (1950), and John Kenneth Galbraith (1958). Writing in the 1940s and 1950s, at a time when the success of Keynesian economics may have opened the profession to new perspectives, they suggested innovative ways of analyzing and modeling consumer behavior. A common theme in their work is the identification of social factors that influence consumer preferences; in our terms, they are all concerned with failures of the asocial individualism assumption.

Duesenberry began with an empirical puzzle: the decline over time in the amount of savings by households at any constant level of real income. Rejecting much of the neoclassical theoretical apparatus, he took it as self-evident that individual preferences are interdependent, in part socially determined, and subject to learning and habit formation. The result of social interdependence was the "demonstration effect": contact with superior consumer goods and higher standards of living leads to a desire to increase one's own consumption. As everyone else's consumption rises in a growing economy, therefore, a household at any given income level will consume more and save less.

Ragnar Nurkse (1953), drawing on Duesenberry's work, made the demonstration effect central to early debates in development economics. Nurkse suggested that the attempt to emulate developed-country consumption patterns could depress savings rates in developing nations. In development theory, as elsewhere in the discipline, the early interest in broader alternatives has now largely died out, and the economics of consumption in developing countries remains an underdeveloped area. However, Jeffrey James (1993) has analyzed the implications for development economics of several of the alternative perspectives discussed here.

Another approach to modeling of alternative theories can be seen in Leibenstein's classic paper (1950). His "bandwagon, snob, and Veblen effects" are simplified models of three different ways in which social interaction can alter consumer demand for a good. All three would have made sense to Veblen, despite the fact that his name appears on only one of them. Each of Leibenstein's models implies a socially determined relationship between price and demand that differs from the standard neoclassical model. Yet despite the clarity of their presentation and the analogy to more familiar models, Leibenstein's models have been pursued by only a handful of later writers.

One of the best-selling books of all time on the economics of consumption is surely *The Affluent Society*. In a discussion of economic policy that sounds remarkably current well over forty years after it was written, Galbraith (1958) argues that it is no longer appropriate for affluent societies to place a priority on economic growth and maximization of output. Overemphasis on production for private consumption leads to too little spending on public goods and services and too little leisure and economic security, among other undesirable consequences. Galbraith considers it obvious that increasing affluence constantly threatens to make the further growth of private consumption less urgent. Something unnatural has to happen, therefore, to keep people spending. The villain is the all too visible hand of advertising, creating the demand for new products as part of the process of production. It cannot be considered of great social importance, Galbraith suggests, to satisfy desires for products if the desires result from their producers' advertising.

The nature of social influences on consumption was further elaborated by Fred Hirsch (1976), who introduced the concept of positional consumption. Positional goods are ones that are desirable because they are scarce; examples include paintings by old masters, antiques, and exclusive access to scenic land. Jobs at the top of a hierarchy have a similar positional value. Unlike ordinary goods, the supply of positional goods cannot be increased when demand rises. There is no way to create more Rembrandt originals, beachfront properties, or jobs in the top 10 percent of the labor force. While positional goods quickly become status symbols that play a role in conspicuous consumption, the two categories are not identical: some status symbols, such as fashions in cars or clothing, are manufactured goods that can be produced to satisfy rising demand.

Productivity increases occur in the production of ordinary, but not positional, goods. Over time, ordinary goods therefore become relatively cheaper. This leads both to consumption of increasing quantities of ordinary goods, and (since the two categories are imperfect substitutes for each other) to expenditure of a growing share of income on positional goods. When demand for positional goods rises, there are three possible responses: congestion or crowding; increased screening and positional competition (e.g., greater educational credential requirements for top jobs); or price increases. The result for society is at best a zero-sum game, with one person's loss being another person's gain; nothing of value is created in response to the increased demand. Thus, if aggregate output grows and the income gains are spent on positional goods, there is no reason to believe that there has been a net increase in social welfare.

(For this reason, Scitovsky (1995) has argued that in terms of macroeconomic effects, positional consumption is more like an unproductive form of savings than like ordinary consumption.)

Robert Frank (1985) draws on the work of Hirsch and Duesenberry to create a formal model of positional consumption and the demonstration effect. If people engage in positional competition – for example, striving to ensure that their children are better educated than anyone else's – the result is more work and less leisure than people would really prefer. A cooperative outcome, which the market alone cannot achieve, would yield greater satisfaction than unfettered competition. The bias in favor of visible, positional expenditures has exactly the same effect on savings as Duesenberry's demonstration effect (see also Kosicki 1988). Frank shows that the existence of positional consumption and the related bias against both savings and leisure imply that people can be made better off by many forms of regulation, including pensions and other forced savings requirements, limits on hours and conditions of work, and taxes on positional expenditures.

Finally, for this section, it is almost but not quite accurate to say that the issue of social influences on consumption has vanished from the mainstream of neoclassical economics. Heroic attempts were made by Robert Pollak in the 1970s to develop elaborate mathematical models inspired by Duesenberry and Leibenstein (Pollak 1970, 1976, 1977, 1978), but his work had little effect on others. Most recently, Laurie Simon Bagwell and B. Douglas Bernheim (1996) have created a model updating Leibenstein's "Veblen effect." Laudable as the goal may be, it is remarkable how little of Veblen shines through the dense mathematical thickets of contemporary economics.

Bagwell and Bernheim show that if consumer indifference curves have an unusual but not impossible shape, an equilibrium may result in which some consumers buy luxury brands priced above marginal cost, while others buy ordinary brands of the same quality, priced at marginal cost. Potential reasons for the unusually shaped indifference curves (aside from a peculiar wrinkle in the tax structure) include the possibility that low-income consumers may be driven to the brink of bankruptcy by conspicuous consumption or may derive greater intrinsic satisfaction from conspicuous expenditure than rich people do. When indifference curves have the shape assumed under normal conditions, however, the latter-day "Veblen effect" – that is, persistent sales of overpriced luxury brands – mathematically impossible. If Veblen's analysis is to be sliced up into pieces this small for modeling purposes, there will be enough left for many, many more models.

The focus on the social factors that affect consumer preferences is the best-developed strand of alternative economic theorizing on consumption. It is a coherent story that combines provocative satires, serious analyses, formal mathematical models, and policy recommendations that flow logically from the analysis. It cannot, however, provide an adequate new theory entirely on its own. Critiques and alternatives to the second and third assumptions are needed as well.

In fact, the very process of mathematical formalization of hypotheses seems to limit the scope of new theorizing. Works discussed in this section range from the sweeping critiques and systemic, nonmathematical analyses of Veblen, Galbraith, and Hirsch, to the creative tension between formal model and broader perspective seen in Duesenberry and Frank, to the purely formal and increasingly mathematical treament of Leibenstein, Pollak, and Bagwell and Bernheim. One might argue about the relative merits and potential complementarity of the Veblen/Galbraith and Duesenberry/Frank levels of abstraction and formalism. But there can be little doubt that economists have gone overboard in acceptance of the third choice, the entirely mathematical mode of analysis.

Mathematical models may be essential status symbols, if one's peer group consists of economists; on occasion, they may even have instrumental as well as ceremonial value. Yet their hidden limitation is that they typically assume the rest of the mathematical apparatus of the neoclassical model; it is as if the established theory challenges the model-builder to a game of "what can you explain if you accept all of the standard assumptions except one?" There are economists who excel at this game: George Akerlof comes to mind as one of the most successful (see, for example, Akerlof 1991). But each round of the game begins anew; the results never accumulate into a comprehensive alternative framework.

Human nature: enough is enough

To turn now to the second assumption, the view of human nature as an ensemble of insatiable desires for private consumption is as standard as it is silly. Many great economists of the past have known better. Here there are few if any mathematical models, but there is a distinguished history of alternative perspectives. Adam Smith is often quoted on the importance of motivations such as self-respect; John Stuart Mill is a treasure trove of quotations supporting a more complex understanding of human behavior. Alfred Marshall believed that it was possible to make a distinction between higher and lower desires; indeed, a hierarchy of more and less urgent wants is one basis for the declining marginal utility of consumption. Unfortunately, Marshall concluded that such subtleties could not easily be incorporated into economics, writing that

> The higher study of consumption must come after, and not before, the main body of economic analysis; and, though it may have its beginning within the proper domain of economics, it cannot find its conclusion there, but must extend far beyond.
>
> (Marshall 1920: 90–91)

(See also Goodwin (1991) and Endres (1991) on Marshall's views of consumption.)

Dissent from the neoclassical caricature of human nature was also shared by John Maynard Keynes. His "Economic Possibilities for our Grandchildren" (Keynes 1963a), written in 1930 was a utopian speculation based on the premise that material wants must be satiable – and must be destined to reach the point of satiation within the hundred years after he wrote. Two-thirds of the way through that period, there is little evidence of impending satiation of material desires. Instead, such factors as advertising and the competitive pursuit of styles and status have postponed indefinitely the era of widespread agreement that enough is enough.

Although his views on this subject were rarely spelled out explicitly, Keynes emphatically rejected the neoclassical model of behavior and its philosophical foundations, as demonstrated by S. A. Drakopoulos (1992). In some of his less well-known writings, Keynes referred to the "Benthamite tradition" as "the worm which has been gnawing at the insides of modern civilization and is responsible for its present moral decay," and commented on early work in microeconomics, "How disappointing are the fruits, now that we have them, of the bright idea of reducing Economics to a mathematical application of the hedonistic calculus of Bentham" (Keynes 1972, as cited in Drakopoulos 1992). Keynes's error lay only in the assumption that this disappointing tree had reached full fruition in his lifetime.

Unfortunately, Keynes offered only scattered comments about his preferred alternative; Drakopoulos argues that those comments are consistent with belief in a hierarchy of wants of differing urgency and importance. A formal model based on such a hierarchy provides a neat explanation of one of Keynes's more puzzling (but realistic) observations, the "stickiness" of prices and wages: in essence, the model shows that quantities and prices get temporarily stuck at the cusps between satisfaction of wants of differing levels of urgency. Thus, an alternative model of consumer behavior may be lurking behind the scenes of Keynesian macroeconomics.

At about the same time that Keynes was reshaping macroeconomics, Paul Samuelson introduced the theory of revealed preference, an important innovation in the microeconomics of consumption. It was, and often still is, claimed that revealed preference avoids the need for any hypotheses about utility or human nature. It is said to be enough for consumers to reveal their preferences via their actual choices in the marketplace. So long as the observed choices satisfy a few innocuous-sounding consistency conditions, the standard results of consumer theory can still be derived. In particular, since people reliably buy more when they have more income, the insatiability of material desires is apparently "revealed."

But Samuelson's sleight of hand only conceals, but does not remove, the restrictive and unrealistic neoclassical assumptions about the basis for consumer behavior, as both Amartya Sen (1973) and Mark Sagoff (1994) have persuasively argued. Since preferences cannot be directly observed, the assertion that behavior reveals preferences cannot be tested. Sen suggests that revealed preference is either a tautology or a controversial assertion about human motivation, depending on the meaning of "preferences." If preferences are defined as that which behavior reveals, then revealed preference is true by definition and utterly uninformative. Sagoff proposes that on this interpretation, the sun prefers to rise in the east, and in English the letter "i" prefers to come before "e" except after "c."

On the other hand, if your preferences are interpreted as "that which makes you more comfortable, all else being equal," as is often suggested in discussion of consumer choice, then behavior need not reveal preferences. Instead, behavior may also be based at times on empathy, ideals, commitments, moral and personal obligations, etc. Once the distinction between choices and preferences is recognized, Sagoff argues that there are good reasons to favor maximizing freedom of choice but no compelling grounds to support maximizing satisfaction of preferences.

One of the most extensive examinations of human nature and its implications for economic behavior is found in a study by Tibor Scitovsky (1976). While economics assumes that there is a single thing called consumer satisfaction, psychology, according to Scitovsky, makes a sharp distinction between two different types of satisfaction: comfort and pleasure. Pain is not, as common figures of speech suggest, the opposite of pleasure; it is more properly speaking the opposite of comfort. The complex and sometimes surprising relationship between comfort and pleasure provides Scitovsky with a much richer and more specific theory of human wants than is normally seen in economics.

When he turns to the implications for economic theory, Scitovsky asks two principal questions. First, which desires are insatiable? And second, which satisfactions are necessarily obtained through purchases in the marketplace? His answer to the first question is that virtually all desires for comfort are satiable. Discomforts are specific things, and it is easy to tell when they have been eliminated; there is a limit to how "not-hungry" you can be. The one exception harks back to Veblen and conspicuous consumption. The comfort of belonging, of winning social acceptance, can require indefinitely rising consumer expenditure as the price of status. In addition, pleasure, which often results from novelty, can absorb ever-increasing expenditures. As yesterday's novel pleasures become today's habits and tomorrow's socially defined necessities, maintaining the same level of pleasure requires new levels of consumption.

This leads Scitovsky, like Galbraith and Hirsch, to skepticism about the urgency of incessant growth in production. That attitude is reinforced by Scitovsky's answer to the second question: many of life's most important satisfactions come from nonmarket activities or from the process of work, rather than from consumption of purchased goods and services.

A different but complementary perspective is provided by a feminist

economist, Paula England, who suggests that basic economic assumptions about human nature reflect a male bias (England 1993). In particular, the conventional economics of consumer choice assumes that interpersonal utility comparisons are impossible, that tastes are exogenous and unchanging, and that individuals are uniformly selfish in market interactions. Feminist theory, with roots in and respect for women's traditional roles, would lead to opposite assumptions in each case: those who are used to an empathic, emotionally supportive role would naturally assume that some types of interpersonal comparisons are the norm, that people are constantly shaped by social influences, and that altruism is common in public life. Yet the unempathic standard assumptions, which England ascribes to a traditionally male model of the "separative self," are fundamental to neoclassical theory. Feminist theory also leads to a different view of economic power within the household, about which more will be said below.

The authors discussed here have not produced formal models, with the exception of Drakopoulos's reinterpretation of Keynes. They have, however, raised important aspects of a critique of the neoclassical theory of consumption: human nature is much more complex than a bundle of insatiable consumer desires. It would be hard to construct an economic theory on these arguments alone – but they are an indispensable part of the broader project of developing a new understanding of consumption.

Characteristics and homemade commodities

Critiques of the third basic assumption, the commodity orientation of consumer desires, are implied in some of the economic alternatives discussed above. Such critiques are also commonplace in the treatment of consumption in fields such as sociology and anthropology. Marx's concept of "commodity fetishism" is relevant here and has been put to good use in a number of recent analyses of consumption (see the survey by Lee (1993)).

A more formal, mathematical alternative to the commodity orientation assumption has also gained widespread recognition in the economics profession. Almost simultaneously, Kelvin Lancaster (1966a, b), Richard Muth (1966), and Gary Becker (1965) each proposed very similar rethinkings of the theory of consumer behavior. Conventional theory posits a direct relationship between goods and consumer satisfaction; consumers know exactly how much they will enjoy each potential purchase. In contrast, the new approach holds that consumers want something – experiences, satisfactions, characteristics of goods – that results from their purchases. (Recent discussion of energy conservation makes use of similar concepts, though expressed in a different jargon: what consumers want is not, say, heating fuel, but rather "energy services" such as comfortable room temperatures – which can be produced by many different combinations of fuel and insulation.)

The motivation for the new approach can be seen in Lancaster's objections to one aspect of standard consumer theory: no one can possibly know exactly how satisfying each available good or combination of goods will be; when new goods appear, as they constantly do, there is no plausible way for consumers to revise their preference rankings to encompass the expanded set of possibilities. The alternative is to recognize that what consumers want are not goods per se, but characteristics that they obtain from goods: e.g., flavors, textures, and nutrition from food, or fuel-efficient transportation, comfortable seating, and visible status from cars.

Lancaster's version of the new approach is by far the most accessible (Lancaster 1966a; for the more mathematically rigorous presentation, see Lancaster 1966b), and imposes a specific structure on the supply and demand for characteristics. He assumes that consumer demand for characteristics resembles the conventional picture of demand for goods: consumers know exactly which characteristics they want, and they always want more. The relationship of characteristics to goods is strictly linear and determined by technology: twice as much of a good always produces twice as much of each of its characteristics.

Lancaster's model is in some ways a departure from neoclassical theory, but in other ways it is still closely connected to it. Insatiability is still assumed, though now at the level of characteristics. Interdependence is implicitly included, via Lancaster's discussion of status as a characteristic, but is not directly addressed. His idea that people consume characteristics rather than goods has been cited in a number of recent studies of consumption, particularly in other disciplines, but usually only as an image or metaphor; application of his model in any detail is much less common. (For a technical application of Lancaster's framework, see Jones (1988).)

Critics have questioned Lancaster's approach, challenging two assumptions in particular (Hendler 1975; Ratchford 1979). First, do all characteristics of goods produce positive satisfactions? If some goods have negative characteristics, or if satiation sets in so that some characteristics can switch from positive to negative sources of satisfaction (if one glass of wine with dinner is pleasant, how about five?), the model as formulated by Lancaster can no longer be applied. The same is true of neoclassical theory, which must assume that all consumers obtain either positive or at worst zero satisfaction from each unit of each good.

Second, is the satisfaction obtained from characteristics independent of the goods that deliver them or the combinations in which they are experienced? Does one cup of tea with lots of sugar followed by another cup with none produce the same satisfaction as two cups of tea with a little sugar in each? If the satisfactions obtained from goods are inseparable package deals, then there are limits to the usefulness of the characteristics framework. Lancaster's work is more reasonably seen as a provocative starting point for the development of a new theory than as its final form.

The Muth and Becker variants of the new approach drop the assumption of a linear relationship between goods and characteristics. They use

the language of a household production process: the household combines purchased inputs (groceries, cooking utensils, fuels) and household labor to produce desired outputs (meals). The image of the consumer as a firm allows the extensive mathematical apparatus used to analyze ordinary production to be applied to household production as well. (For an argument that the parallel between neoclassical analyses of production and consumption reflects the lack of understanding of consumption, see Fine and Leopold (1993, chap. 4).) Becker highlights the analogy with a uniquely obscure choice of terminology, referring to the outputs of household production as "commodities" analogous to those produced by businesses. The reader who lacks an English-to-Becker dictionary must remember that what Becker calls commodities are what others would call experiences or satisfactions, while the commodities visible to the rest of us are, for Becker, inputs purchased by households in order to produce commodities.

Of the three founders of the new approach, Muth went on to other pursuits almost immediately, as did Lancaster after a few years. Becker, however, has persisted; he won the Nobel Prize in Economics in 1992, in part for his far-reaching applications of the household production model. He has argued that the theoretical apparatus of selfish, rational maximization can produce explanations of education, discrimination, crime, marriage and divorce, childbearing, and many other behaviors, often through use of the household production model.

The dangers of overextension of this model can be seen in the argument by Stigler and Becker (1977) that it is rarely necessary to assume that consumers' tastes have changed. In cases where preferences appear to have shifted, Becker and co-workers prefer to say that the technology of household production has changed, while the satisfaction obtained from homemade "commodities" (i.e., experiences) may have remained constant. Thus, a growing appreciation of and desire for a particular style of music reflects a change in the technology of production of the commodity "music appreciation." Pursuit of new and changing styles means that a changing technique is needed to produce the commodity "distinction." Advertising, unfairly accused by Galbraith and others of manipulating consumer preferences, actually provides information about new technologies that have become available to produce commodities such as "prestige." Addiction to harmful drugs does not represent a change in tastes; it is merely a change in the technology that the household uses to produce the commodity "euphoria."

In each case a story can be told about the change in the household production function that produces the apparent change in tastes. The household can then be described as acting rationally, meaning that it is engaging in utility maximization, with unchanging tastes for some hypothetical, unobservable commodities. In effect, this is mathematical deconstruction: pick a behavior and tell a story about what it might be maximizing. Even the beginning of lifelong addiction can be described as a rational choice,

not a change in tastes. The addict, equipped with high-powered intertemporal maximizing capabilities, recognizes that use of an addictive substance today will make it more enjoyable to continue using the same substance in the future (Becker *et al*. 1991; for a more intuitively plausible model of addiction as a process akin to procrastination, see Akerlof 1991).

One might excuse all this if the household production model achieved great insights into consumer behavior. However, as England (1993) points out, Becker makes trivial and stereotypical assumptions about the dynamics within the household. There is a single head of household, repeatedly referred to as male, who is efficient at earning money and completely altruistic about sharing it within the family. England objects that it is unreasonable to expect the same person to be perfectly selfish in the market and perfectly unselfish at home. Either the external greed should affect family life, or the internal altruism should affect public life; in fact, spillovers do occur in both directions. Unfortunately, a model that begins with trivially stereotypical premises is in danger of ending with conclusions such as the following:

> A person may be well-read (i.e., have read the recent books generally believed to be important), but if his time is valuable in the market place, it is much more likely that his spouse will be the well-read member of the family.
>
> (Stigler and Becker 1977)

Although alternatives to the assumption of commodity orientation have been extensively developed and debated within economics, one can hardly say that an adequate new theory has been created. On the contrary, the overdevelopment of an isolated insight, in the work of Becker and his colleagues, simply takes narrow neoclassical themes on the road to perform in other arenas. As in the case of alternatives to the individualism assumption, mathematical formalization of one aspect of an alternative can prevent connection with other, equally essential aspects.

Toward a new theory

It is beyond the scope of this chapter to elaborate a full-blown new economic theory of consumption. Hopefully, the review of past contributions has identified some of the building blocks of such a new theory. Alternative views in all three areas discussed here need to be synthesized, including at least the following:

1 We are all social beings, not isolated, autonomous individuals; our tastes are not exogenous to our interactions, but reflect long-standing customs, contemporary symbols of status, the demonstration effect of consumption by our peers, overt pressures from advertisers, and the

frustrating processes of positional competition. This is the most familiar aspect of the alternative, and it has been well addressed by Veblen, Galbraith, and others cited in the chapter.

2 Insatiable material desire is not the whole, or even most, of human nature. There are differentiated wants of varying urgency – some of them social, many of them satiable. Economic theory needs to comprehend the sources of differing wants. People do not always act on selfish preferences for their own comfort, but are often motivated by empathic, altruistic, or principled feelings and beliefs. Far from human nature being inherently insatiable, it is possible that competition, emulation, and socially learned behavior in general may be the primary sources of apparently insatiable desires.

3 Consumers rarely want specific marketed goods per se. Rather, they want characteristics, experiences, or services obtainable from goods, some of which are based on technical performance of the goods (transportation, from a car), and others based on the social meanings ascribed to goods (status, perhaps from the same car). Lancaster's linear technological relationship between goods and desired characteristics is too rigid, but Becker's alternative of limitless flexibility explains everything and nothing. Development of an adequate theory of the real relationship between marketed goods and the characteristics desired by consumers is one of the remaining frontiers of the economics of consumption.

6 Choice of technique revisited

A critical review of the theoretical underpinnings

Alejandro Nadal

Introduction

Literature on economic development frequently includes statements that critically rely on a key assumption: under diverse economic environments, individual producers choose process technologies from among a set of available techniques. The choice itself is a function of a series of economic parameters such as prices, wages, and the rate of profits (or the rate of interest). As price distortions appear, because of market failure or trade union influence on the relative price of labor, the choice of technique may be affected and resources may be misallocated. Problems in areas such as growth, employment, international trade, agriculture, and industrial economics are analyzed through an approach that all too frequently relies on the crucial assumption that producers are engaged in a process of choice of technique. Recent literature, whether on sectoral or macroeconomic themes, continues to adopt this perspective. For example, many scholars believe that misallocation of resources and involuntary unemployment are caused by distortions in the relative price of labor. Thus, when making new investments, producers (capitalists) select techniques of production that have a labor-saving bias in an economy with abundant labor resources.[1] In the field of development economics there are several classic critiques of this paradigm (Sen 1962; Bhalla 1975; Stewart 1977). The neoclassical apparatus has also attracted criticism from economists specializing in the history of technology (Rosenberg 1976). However, their criticism was limited to the lack of realism of the production function.

A common objection is that the production function assumes the existence of a continuous succession of techniques with different combinations of production factors. Thus, it cannot deal with the existence of strong discontinuities in the production possibility frontier. These analyses, however, have essentially ignored the theoretical assumptions or foundations of the choice of technique paradigm.[2] Research is still frequently based on the premise that from a logical viewpoint, the neoclassical theory of choice of technique is unassailable (Amsalem 1983: 3).

The logical structure of the choice of technique paradigm hinges on

three premises: first, a set of technical alternatives is readily available; second, economic agents are familiar with each of the alternatives and can thus compare them; and third, the act of choosing one alternative does not imply any additional cost for the producer. The rules of behavior of the relevant economic agents have been clearly defined within the neoclassical framework. Maximizing behavior can be defined through conditions of first and second order (Hicks 1932; Samuelson 1947), or, in the case of set production theory, where the form of the production function is not specified, through conditions imposed on the production feasibility set (convexity, closedness, and boundedness) and the supply schedule (continuity) in such a way that with the aid of a well-known theorem, the existence of a maximum can be guaranteed.[3]

The basic idea of choice of technique is also associated with neo-Ricardian economic theory. Although the economic forces that rule the selection process are different, and the theory of the individual economic agent has not been thoroughly developed, Sraffa's theory relies on essentially the same assumptions outlined above. The fact that this assumption is shared by radically different theories reveals its importance in the development of economic theory. However, very few analyses are available on the origins and main features of this fundamental perspective on technology. Insofar as many of the studies in the area of development economics are policy oriented, it is necessary to examine the rational foundations of the policy recommendations emanating from them. Usually, when choice of technique is considered in policy-oriented research, no reference is made to the crucial fact that this idea is embedded in the neoclassical theory of price formation. Also ignored are the very restrictive assumptions and conditions that guarantee the formation and convergence of prices (all prices, including prices of factors of production) toward an equilibrium point and their relevance to any analysis involving the assumptions of choice of technique. Policy-oriented research frequently ignores the limitations of the theories it invokes as its rational foundation. Thus, the rational foundations of economic policies are not explicitly incorporated into more applied or policy-oriented analysis. As a result, the boundaries of validity of policy recommendations are sometimes blurred. The objective of this chapter is to identify the origins, evolution, and shortcomings of this assumption in order to bridge the gap between abstract theory and policy-oriented studies.

In neoclassical theory, technology is conceived of as an exogenous variable, and therefore the rate and direction of technical change remain outside the theory's explanatory power. Most of the attention is centered on the choice of technique, because neoclassical tradition is based on the assumptions that the producer is familiar with the latest technological possibilities and that the movement of the relative prices of production factors provides the producer with enough information to decide which technique will maximize profits. In this way, the phenomenon of technological change is reduced to a problem of substituting production factors. When neoclassical instruments have been used to analyze economic growth, technological change has been a very important theme. Unfortunately, such analysis has remained bounded by the simplistic assumption that technological change is nothing more than a regular influx of innovations, exogenously determined and introduced at a constant rate.[4]

The neoclassical approach to production at the microeconomic level is based on the description of the relation between inputs and outputs. The most important are the notions of production function and the production possibility set. Both ideas are closely linked, but in the case of the production function, as Samuelson (1947) noted, an implicit maximization process (that leads the producer to discard dominated activity vectors) has already been carried out. At any rate, in both cases available technology is considered a datum in the maximization problem. In the case of models with variable technological coefficients when changes in the relative prices of production factors appear, the producer responds to this market signal by substituting among factors. In the model of fixed technological coefficients, the substitution is carried out through consumer markets.[5]

The origins

The origins of the choice of technique approach can be found in classical political economy. Adam Smith's theory of the gravitation of market prices around natural prices shows the first systematic attempt to examine the process of allocating productive resources among alternative uses (Smith 1904). A key underlying assumption is that new entrants and incumbent producers are familiar with alternative techniques of production in different branches of economic activity. However, it was Ricardo (1951–52) who first proposed substitution among productive resources on the basis of movements in relative prices. In this way, despite the profound differences between classical and neoclassical theories of value and distribution, in both cases technical change is absorbed into the concept of substitution among productive resources. This is remarkable, considering that wages are the price of labor in the neoclassical framework, while classical political economy considers wages as a variable of income distribution.

By adding chapter 31, "On Machinery," to the third edition of his *Principles*, Ricardo emphasized the need to study the consequences of mechanization on the distribution of income among different social classes. One element of Ricardo's analysis opened an interesting avenue for further theoretical development. Ricardo (1951–52: 387) indicates that

> With every increase of capital and population, food will generally rise on account of its being more difficult to produce. The consequence of a rise of food will be a rise of wages, and every rise of wages will have a tendency to determine the saved capital in a greater proportion than

> before to the employment of machinery. Machinery and labour are in constant competition, and the former can frequently not be employed until labour rises.

In Ricardo's theory of value, a change in distribution (e.g., an increase in wages) leads to a new relative price structure because the prices of the commodities produced with different proportions of capital and labor are affected in different ways. Ricardo's statement, however, really concerns the effects of changes in distribution on the choice of production techniques (that is to say, *before* the process of production is carried out). Neoclassical theory interpreted this proposition as a reference to the analysis of the substitution between capital and labor in the context of a production function, and not to the *effects* of technical change. Thus, Ricardo's analysis contributed to an analytic paradigm based on the assumption that technical change is an exogenous variable.

In the Ricardian scheme, the direction of technological change remains without explanation, although it has serious repercussions on the distribution of income among social classes. Neoclassical theory devotes a great deal of analytical effort to this problem. One of the authors who helped recover Ricardo's statements in the neoclassical context was Hayek (1942). Using the Austrian school's theory of capital in the analysis of economic cycles, Hayek demonstrated that increases in consumption reduce the rate of investment. During the rising phase of these cycles, real wages decrease, and therefore capitalists choose production methods that reduce the period of production and are more labor intensive. In contrast, in the downward phase of the cycle, wages increase and capitalists choose capital-intensive techniques that lengthen the period of production. This phenomenon is due to what Hayek labeled "the Ricardo Effect" (i.e., the replacement of work by machinery when wages increase and the reverse when the interest rate rises). In this analysis, the techniques associated with an increase or a reduction of the average length of the period of production are considered to be readily available during the entire process.[6]

The fact that these theories consider technology an exogenous variable explains why they do not regard technological change as an important theme. In contrast, the theme of "technology *choice*" acquires great importance. Working under the assumptions of substitution and rational behavior, neoclassical tradition concludes that when a new investment is made, the technique chosen from a catalog of available technology is the one whose marginal rate of substitution among factors (i.e., the ratio between the corresponding marginal products) is equal to the slope of the factor price curve. However, this analysis is embedded in the neoclassical theory of price formation. The assumptions required to guarantee a coherent process of *price formation* and *convergence* are seldom mentioned.

Choice of technique and induced innovations

Many authors have pointed out that factor substitution does not correspond to a process of technical change; the latter can be understood only in terms of a displacement of the production function itself (or modifications in the configuration of the production possibility set). In fact, even the heuristic value of the idea of a production function for the study of technical change has been the object of serious criticism, because it implies that the transition from one technological alternative to another is continuous and without sudden jumps. In this way, any possibility of analyzing technological discontinuity is eliminated. This idea also implies that an economy has information about combinations of production factors that could be quite different from the factor endowment actually available within that particular economy. This means that the economy has information on technical combinations far away from the interval of the production function relevant to its real factor endowment (Rosenberg 1976). As a result, the production function can provide no information about the origins of a specific range of technical options or about the nature of the economic forces that determine its existence.[7]

According to this description of available technological alternatives, technological change in the strictest sense can be understood only through a displacement of the production function. Nevertheless, the problem of this displacement is very complex and presents serious difficulties to the neoclassical approach. The theme of "induced technological change" is based on the question of whether the structure of relative prices provokes or induces technological changes that make it possible to cut back on more costly investment capital. After attempting an initial classification of innovations as a function of factor participation in distribution, Hicks theorized that technological change is induced by modifications in the relative prices of production factors. According to this theory, inventions fall into two large classes: "autonomous" and "induced" (by movements in factor prices). As Hicks stated, "A change in the relative prices of production factors is, in itself, an incentive to invention, and invention of a certain type – aimed at cutting back on the factor that has become more expensive" (1932: 124).

This type of statement encouraged research on the history of technology to examine the conclusions of Hicks's model. Hicks himself opened this road with a brief review of the previous two hundred years of European economic history, concluding that labor-saving technological changes have had more impact than capital-saving changes. Other historians such as Habakkuk (1962) and David (1974) have followed this line of investigation, but their conclusions show that relative prices are neither the only nor the most effective parameter for stimulating innovations.[8]

On the other hand, the idea of innovations "induced" by changes in relative factor prices implies that the production of technological information

can be represented by a production function; one of the arguments of this function would be the relative prices of production factors. In this context, it is important to remember that Salter (1960) and others criticize Hicks's statements on the grounds that the producer's objective is to minimize total cost and not simply reduce a specific cost: any increase in the wage bill can be countered with technologies that are less labor or capital intensive.[9] This criticism once again emphasizes factor substitution at the expense of technological change, but it is not the only criticism directed at models of "induced" technological change. If the lessons learned from empirical research on inventive activity are also considered, it is impossible or very difficult to predict the results of research and development (R&D) activities. Under these conditions, there are absolutely no grounds for claiming that the outcome will be induced by changes in relative factor prices.[10]

Kennedy (1964) and Weizsacker (1966) concentrated on "applications" of available knowledge instead of posing the problem of new inventions per se. According to this approach, managers try to maximize "technological progress" (corresponding to a function of maximizing reductions in unit costs) along a "limit of invention possibilities." Each point on this curve represents the inverse relation between increments of capital and labor.[11] But the position of the curve is not determined by the relative prices of production factors and, consequently, factor substitution is once again the dominant theme. Thus, the Kennedy–Weizsacker approach returned to the view that technology is determined exogenously, and technological change does not depend on changes in relative prices. The theory of induced bias in innovations was abandoned, marking the return to the choice of technique paradigm. In fact, we are left with a series of definitions, such as neutrality in Hicks's or Harrod's sense, that can only be *ex post* explanations in a framework of comparative statics.

Faced with the problem of technological change, neoclassical theory finds itself in serious trouble. If technology is considered a datum for the producer, then the producer chooses from among different alternatives as a function of relative factor prices. In this case, technological change is reduced to a simple problem of factor substitution, but the bias in this substitution cannot be defined, because in equilibrium the producer is not interested in any particular type of cost reduction. However, if technology is considered an exogenously determined set of possibilities, it is impossible to develop a theory about technological change. At the beginning of the 1960s the weaknesses in this analysis of technological change were recognized, but it was still regarded (Blaug 1963) as the most effective frame of reference for organizing our knowledge about the subject. The theoretical debate that followed, however, revealed that such enthusiasm was unfounded.

Contemporary classical political economy and choice of technique

The work of Garegnani (1960) and Sraffa (1960) initiated a period of intense criticism of neoclassical theory, directed mainly at its concepts of capital and of marginal productivity as the determining element in distribution. Garegnani concentrated his criticism on Walras's (1952) capitalization equations, but Morishima (1964) demonstrated that by using a more general definition based on inequalities, the existence of equilibrium in an economy producing capital goods could be guaranteed.[12] Garegnani's critique of Walras played an important role in the theoretical development of the 1970s but seems to have been based on a confusion between stability and equilibrium.

Sraffa's (1960) criticism of the theory of marginal productivity gave rise to a theoretical debate with vast implications for marginalist theory. As far as choice of technique is concerned, Sraffa's work challenged the idea that there is an inverse and monotonic relation between the total amount of capital per employed worker and the level of the rate of profit. As a result, the neoclassical theory of marginal productivity was put on the defensive (for a detailed account of the debate, see Harcourt 1972). Today, the intensity of the debate has diminished, the neoclassical theory of capital has continued to be developed, and the problems presented by the concepts of technology and technical choice still occupy an important place (e.g., Brown *et al*. 1976).

Sraffa's (1960) work powerfully criticized the theory of marginal productivity, the concept of production factors and an aggregate production function, and, consequently, the idea of factor substitution.[13] This critique is synthesized in the phenomenon of "switching of techniques" (i.e., the fact that the same production technique that was considered the most efficient at a certain level of profits may be discarded when profits rise and, later, chosen again as the most efficient at even higher levels of profit).[14] This phenomenon, so surprising for orthodox neoclassical theory, is a normal element of the world of production by means of produced inputs, and leads to results difficult to assimilate into neoclassical theory.

In spite of its profound differences with neoclassical theory, Sraffa's analysis has been considered a possible foundation for the analysis of choice of technique (Steedman 1977). Even in this limited sense, however, various difficulties must be overcome. For example, if technology is chosen for the production of basic commodities (i.e., commodities entering directly or indirectly into the production of all other commodities), we are faced with the problem of comparing two different techniques (Sraffa 1960). Each economic system has a unique, standard (composite) commodity guaranteeing exact value measurements in a system of production by means of produced inputs.

In comparing two economic systems, they can be conceived as matrices

of technological coefficients that, at the points of intersection of their technological frontiers of distribution possibilities, differ only in a column and line vector. Nevertheless, as Bharadwaj (1970: 415) notes,

> the assumption [required for the analysis of reswitching of techniques] that the two productive systems are made up of the same number and type of basic commodities, but have different methods of production is extremely restrictive because it is difficult to find two different methods that use identical inputs and tools.

In addition, it is necessary to explain how economic forces act on these individual agents. In the words of Steedman (1977: 64):

> Faced with one or more available methods for the production of each commodity and with a given real wage bundle which must be paid to each worker, capitalists in each industry will seek to adopt that production method which minimizes costs and maximizes the rate of profit. The forces of competition will lead to that selection of production method, industry by industry, which generates the highest possible uniform rate of profit throughout the economy.

Thus, without an adequate theory of intercapitalist competition (which, in turn, requires a theory of market prices), the Sraffa-based analysis of choice of technique can advance very little. Steedman (1984) shows the difficulty of developing a theory of market prices and intercapitalist competition in a Sraffian economy, because it is impossible to establish a positive correlation between changes in market prices and the (market) profit rate in each branch. Since the convergence of market prices to a vector of prices of production (with a uniform rate of profit) cannot be established, the model cannot show that capitalists choose the "most efficient" technique (market prices higher than production prices may be associated with sectoral profit rates lower than the natural rate of profit).

Neo-Ricardian theory has not been able to offer an explanation of the process of technical change. In fact, in more developed models, the phenomenon of substitution depends entirely on an autonomous normal pattern of technical progress (Pasinetti 1983). In this context, it seems that the main issue is related to the fundamental problem of how economic theory can integrate a concept of technology into its discourse.

Neo-Walrasian general equilibrium models

During the 1970s it was thought that Sraffa's critique destroyed the foundations for a possible theory of factor substitution as a function of relative price movements, because there was no monotonic relation between interest rates and the capital:labor (or capital:product) ratio.[15] Although

this critique does apply to marginalist theory, Hahn (1981) correctly states that contemporary general equilibrium theory is unaffected. Nuti, another of the outstanding participants in the controversy over the concept of capital, states the following:

> Within a multi-commodity multi-period system of general equilibrium, the vexed question of the measurement of capital presents no difficulty. The value of a capital asset is the present value of its net output over time, i.e., the value of the discounted flow of the outlays and receipts associated with it. The value of the capital stock of an economy is the present value of its reproducible physical assets (non-reproducible assets are classified as "land"). The accusation that an implicit assumption of malleable capital exists in the multi-commodity multi-period model (Garegnani 1960) may hold for Walras' treatment (1900, lesson 41) but not for recent formulations (Debreu 1959) where the allocation of all inputs, the level of outputs and the prices of inputs and outputs are all determined *simultaneously,* given productive transformation possibilities, individual preferences, competitive exchange, and wealth and utility maximization. One thing that cannot be done within this model is to use the aggregation of capital goods at the given equilibrium prices to construct an aggregate production function summarizing alternative states of resource allocation.
>
> (1976: 75)

In other words, in Arrow–Debreu models, there is no room for a concept of capital or uniform profit rates, or for the aggregate measurement of capital. Furthermore, there is no simple relationship between interest (or wage) rates and what could be considered technological characteristics of the system (such as the relative scarcity or intensity of capital).

In contemporary general equilibrium models, producers choose the activity vector that maximizes their income, taking into account the prices of investment capital and its products. In this way, technology is also an exogenously determined component of the model, and the producer, acting as a price taker, only has to choose from among different alternatives. Of course, the hypothesis of perfect substitution among inputs is a basic part of this analysis and, as such, contradicts one of technology's most important characteristics.

Neo-Walrasian general equilibrium models have other serious problems.[16] They have not been able to incorporate a convincing analysis of the dynamic processes of price formation and stability. In this sense, the stability analysis by Arrow and Hurwicz (1958) and Arrow *et al.* (1959) still represents the state of the art. There is a consensus that their results are rather modest because, among other things, a crucial assumption of gross substitutability of all goods is required. Thus, economic systems for which these stability theorems apply can only have goods for which the

cross price elasticities have a positive sign. This is, of course, extremely restrictive. A similar assumption must be introduced to guarantee the uniqueness of equilibrium. This is of great importance in policy-oriented research. Policy recommendations are almost always based on comparative statics, where the assumption of uniqueness of equilibrium is crucial.[17]

In relation to the theory of price formation processes (including the prices of factors of production), general equilibrium models face an endemic problem described by Arrow and Hahn (1971): if all firms are competitive and thus have price-taking behavior, who changes prices during the adjustment process? This unsolved problem is critical and has been the source of considerable embarrassment for neoclassical economics. Attempts to solve this problem are based on a procedure first introduced by Walras in his theory of production: a market auctioneer acts as the central authority charged with announcing price vectors that are the parameters in the agents' maximizing calculations. Once individual supply and demand plans have been determined, the auctioneer centralizes this information, calculates excess demands and adjusts prices of individual markets that are not in equilibrium. This central figure is needed in all versions of the neoclassical price formation process.[18]

The presence of a *central authority* performing such an important task as adjusting prices, however, contradicts the essential features of the definition of a decentralized market economy. The issue is relevant to the choice of technique because factor prices are formed through the same processes. This means that neoclassical theory does not have a *particular* explanation of the price formation mechanism for productive factors such as capital and labor. Thus, for example, agents offer to sell and purchase labor at the going prices and announce these intentions to the auctioneer, who in turn recalculates excess demand and adjusts prices accordingly. Thus, in the field of price formation mechanisms, general equilibrium theory is plagued by assumptions that are both restrictive and necessary.[19]

The difficulties facing the idea that productive agents are involved in a process of choice of technique are not only present in price formation theory. The theorems that prove the existence of a competitive general equilibrium in Arrow–Debreu models require conditions and assumptions that have serious implications for the theory of choice of technique in a microeconomic context. The demonstration is carried out by applying fixed-point theorems to a complex mapping that is interpreted as the excess demand correspondence (see, for example, Debreu 1959; Nikaido 1968; Arrow and Hahn 1971). Every individual producer is endowed with a production feasibility set, which is composed of possible production vectors. The production sets are assumed to be convex and closed, but not bounded. This entails a serious difficulty: if possibility sets are not bounded, the production vector associated with a maximum profit may not exist. When facing price vectors in a competitive economy, individual agents will be unable to behave as theory predicts; the productive agents

are incapable of choosing among alternative techniques to maximize profits. This difficulty is rarely recognized in the literature involving applied research; in fact, the conclusions of applied research and policy recommendations frequently imply an assumption that agents select production vectors from their production possibility sets without any problem. However, every author who has made a meaningful contribution to proving the existence of competitive equilibrium has had to introduce the hypothesis that individual production possibility sets are bounded because they are intersected by the *aggregate* feasibility set. Because the aggregate feasibility set is bounded by limited (unproduced) resources, it is thought that the intersection is enough to justify boundedness as a property of the individual possibility sets.

The nature of this problem has been analyzed in detail by Nadal and Salas (1987). The difficulty can be restated in the following terms. Individual agents have production possibility sets where each element is a production vector. The sets are closed and convex, two more or less harmless topological properties; but boundedness cannot be assumed, because the agents are defined as maximizing agents. If the set is not bounded, the image set of the supply function, which is a standard maximizing function, may be empty (i.e., there is no production vector to maximize profits). Because it is not possible to assume that production sets (or consumption sets) are bounded, the only way to introduce boundedness is through the overall restriction of the economy: resources are limited and the economy cannot produce infinite quantities of commodities. The behavior of individual agents is restricted to the intersections between individual possibility sets and the aggregate feasibility set. However, the theoretical implication of this assumption is that individual agents have information on the technology and resource endowment of the *entire economy*. This contradicts the objective of a theory of the allocative efficiency of the market mechanism, which is to demonstrate that a competitive equilibrium exists for an economy made up of individual agents, possessing nothing more than private information on a decentralized basis.

Implications for applied research and policy

A clear implication of the previous analysis is that the choice of technique paradigm should be abandoned. It not only lacks realism, as most of its critics have observed, but also, the theoretical construct in which it is embedded (e.g., the price formation mechanism) is not as solid as some researchers pretend. Choice of technique is a paradigm originating in a discussion on income distribution and price formation (e.g., the work of Ricardo, Hayek, and Hicks). It does not emanate from a theory directly concerned with the issues of technical change, growth, or technological development. Applied research on the problem of technological change has gained very little from continued use of this frame of analysis. It

should be stressed that individual firms' technological behavior must necessarily be considered as part of the pattern in which industrial branches evolve through time. The choice of technique frame of analysis does not provide a good vantage point. The internal factors of each branch must be analyzed (e.g. forms of competition, technical features of product and process technology, dynamics of market shares, and growth of individual firms). The modern theory of industrial organization shows that an individual firm's behavior does not make sense outside of the environment in which it takes place.

The choice of technique paradigm should be definitely abandoned, not substituted by more sophisticated versions of the same principle. In particular, a revival of the idea in the guise of a generalized, multifactor model should be avoided. For example, Amsalem (1983) pretends that the lack of realism of the two-factor model can be surpassed by introducing production input structures. Because we are now working with a multifactor model in which all inputs are considered (e.g., capital goods, labor skills, raw materials, and spare parts) at a given scale of production technology, selection becomes a matter of matching technology's input structure with a country's factor price structure to minimize production cost. It is then possible to evaluate the impact of factor price distortions on technology choice, and the analysis is back on the track of the traditional maximization problem. It is not possible to generalize with meaningful results a theory that is devoid of meaning in the canonical or elementary version. The problems of the theory of price formation that have been identified also apply in the case of multifactor models and input structures.

Even the most advanced use of this tool (i.e., in the theory of contestable markets) cannot be considered a theory of technical change. The most developed model (Baumol *et al*. 1982) can handle multiproduct cost functions, scope economies, and other relevant elements for a sound theory of production and competition in modern industry. The introduction of new capital goods is possible because pricing and depreciation practices can be readily incorporated into the model. The model handles cases in which exogenously determined new techniques are given (the prices of capital goods are considered to be falling when the new technique is available and infinite before this happens). It does not, however, approach the question of the economic forces behind the generation of these new techniques. In other words, the model allows for introducing new pricing and depreciation configurations when more efficient capital goods are introduced (considered as input-saving innovations). Unsustainability may occur because of a series of technology-related factors (scale economies in sunk costs, learning by doing, etc.). Much work is still needed in order to use this theory to explain the economic forces behind the generation of new technologies.

The most important policy implication is that there is no rational foundation for the belief that firms choose techniques of different factor intensities as a function of relative factor prices. There may be elements in ill-conducted empirical research that suggest this is the case; but the industrial environment and policy making are much more complex. Even if minimum wage legislation, social security charges, and legislation on job security were eliminated, the forces of intercapitalist competition (both national and international), technological features of production processes, as well as expectations and scales of production would likely all act on the decision-making process. In fact, in a period of a sharp decline in real wages in Mexico between 1980 and 1989, with a centralized and docile trade union movement, it is doubtful that firms have selected more labor-intensive production techniques better in tune with the national factor endowment.

The basic elements of the choice of technique paradigm are still advanced as a relevant frame of analysis of technology in developing countries. They crop up repeatedly in the research of influential institutions in the area of policy making. For example, in research sponsored by the World Bank, the paradigm is frequently used (Dahlman *et al*. 1987; Balassa 1988) to support the idea that social security and minimum wage measures are the causes of misallocation of resources and inefficiencies. The theory of price formation on which this idea rests is not a solid foundation. Empirical research, whether academic or policy oriented, cannot continue to ignore this basic fact.

Much applied research on issues related to technology policy (transfer, assimilation, and adaptation of technology) was carried out in Latin America during the past two decades. The issues were largely limited to the firm (or even shop) level, but experience showed that these issues had to be considered within a context in which industrial organization, expectations (both economic and technological), financial variables, macroeconomic policies, and trends in international trade and competitiveness were taken into account. Similarly, policies on technology-related issues in Latin America in the 1960s and 1970s practically ignored monetary and financial variables.[20] A strong engineering bias covered the conceptualization of firms' technological behavior (generation, acquisition, and adaptation of techniques).

The economic crisis of the 1980s revealed how shortsighted this approach had been. But in today's world of drastic adjustment programs and anti-inflationary packages (including trade and financial liberalization), technology policy is ignored altogether or reduced to a series of recipes regarding the performance of the market mechanism to guarantee efficient choice of techniques. This is another extreme view of economic policy in which efficient decisions on real-world variables are left to the invisible hand. This naive view of economic dynamics must give way to a sound perspective in which the technology and other real variables are given proper attention.

Studying the origin of the choice of technique paradigm reveals one

important lesson: there should be a minimum correspondence or affinity principle between the type of questions asked and the analytical apparatus used. For example, policy-oriented research on issues that are only intelligible at the level of an industrial branch or a complex of industrial branches should not be approached on the basis of analytical tools that are only relevant in the framework of individual firms. The answer to problems involving financial variables cannot be unraveled with the aid of analytical tools that cannot take financial or monetary dimensions into account. It is interesting to observe that much of the empirical research on technology transfer, assimilation, and adaptation in Latin America ignored the role of financial variables. With this omission, it was impossible to integrate macroeconomic policies and the dynamics of profitability into this analysis.

In the next few years, the discipline will witness a revolution that will yield exciting analytical tools for more relevant research for science and technology policy making in developing countries. There will be path-breaking work in the areas of industrial organization, resource management, mathematical applications for complex and dynamic systems, and self-organization models. In particular, results will come from new trends in evolutionary economics and from the analytical work of the new institutional economics. A new way of establishing linkages between the lessons of economic history, the history of technology, and economic theory will also offer new vantage points that may reorient applied research. Empirical and policy-oriented research should be on the alert as to the future orientation of these developments.

Concluding remarks

All theoretical statements may have universal validity, but only under restrictive conditions. Outside these conditions, theoretical utterances are unintelligible. If these conditions are ignored, there is a risk of serious confusion: the validity of theoretical statements is extrapolated and extended beyond their rational scope. When pure theory is invoked as a rational foundation of policy recommendations, it is critically important that the validity of theoretical statements be considered. As the discipline stands today, the gap separating pure theory from applied research is already enormous. Researchers must not compound this problem by the erroneous practice of invoking the results of pure theory without explicitly recognizing the boundaries of their validity.[21]

Although applied research elaborates on empirical results, it also frequently invokes pure theory. Thus, conclusions supposed to be firmly established constructions of pure theory are presented as a supplement to empirical data. Through this procedure, empirical data are frequently endowed with an apparently more coherent structure; their robustness is overstated. It is the central argument of this chapter that policy-oriented

research should explicitly consider the extremely restrictive conditions of the theoretical statements it invokes. This should be a regular habit of relevant applied research, particularly in relation to the dynamics of price-formation mechanisms and the existence of general equilibrium. Because the choice of technique assumption rests on the theory of price formation, any reference to the theoretical aspects of this notion should bring to light the restrictive conditions under which statements on the existence, uniqueness, and stability of equilibrium make sense. This is crucially important in the realm of applied research. If policy recommendations extend beyond the limits of validity of these rational foundations, they may have disastrous consequences.

Notes

1 According to this view, if distortions of relative prices of production factors last long enough, the direction of inventive activity will also be affected as biases appear in factor-saving orientations of new process technologies.

2 Ironically, much of the discussion on appropriate technology of the past decade (with all its critical flavor of the neoclassical maximization approach) rests on the same logical assumptions. Analyses that became classics of the economic development literature also relied heavily on the validity of the assumptions of choice of technique.

3 The theorem (Weierstrass) states that if f is a function from S to R, f is continuous on S, and if S is compact and nonempty, then $f(S)$ has a maximum and a minimum. The theorem is widely applied in all neo-Walrasian models for supply and demand schedules.

4 See, for example, Uzawa (1960–61) and Solow (1961–62) and, a few years later, the concept of "vintage models," which incorporates successive generations of capital goods. For a classic review of works on growth and the introduction of suppositions about "technological progress," see Hahn and Matthews (1964).

5 It is interesting to note that there is a strong analogy between the theories of the producer and the consumer. Sraffa (1925) was the first to observe this analogy in the context of his criticism of Marshall's theory of variable returns. Carrying Sraffa's observation further, as the producer, the consumer in neoclassical theory also faces the problem of choosing a vector of inputs (set of consumer goods) as a function of both relative prices and indifference curves, which represent the particular "technology" to produce a particular good called "satisfaction." In this way, consumption and production theories share a similar structure in which the position of production isoquants and indifference curves is considered an exogenous datum. The choice of technique paradigm indeed covers under its logical mantle the problem of the maximizing consumer.

6 Hayek's analysis was subjected to strong criticism, notably by Kaldor (1960), who sarcastically renamed his theorem the "Concertina Effect." In Kaldor's criticism, the "Concertina Effect" is considered to be nonexistent or insignificant and the "Ricardo Effect" is attributed to Wicksell. Kaldor makes it clear that for Hayek, the element that determines the greater or lesser use of machinery (or of labor) is the rate of profit per capital unit. For this reason, what Hayek calls the "Ricardo Effect" implies that when labor earns more profits than capital, companies then substitute machinery for workers independently of changes in the relative prices of labor and machinery. But for Ricardo, this substitution depends exclusively on this change in relative prices.

7 Some neoclassical authors have attempted to solve this problem by considering that the production function includes all *possible* designs that can be attained with the existing stock of technical information. Examples of the above are provided by Salter (1960) and, in a different context, Hayami and Ruttan (1971) through their concept of "metaproduction function." Rosenberg (1976) criticized these attempts on the grounds that statements regarding long-term movements along the production function toward points that are still unknown are extremely ambiguous, at least from the economic point of view.

8 David (1974) recapitulates the discussion about the definition of the so-called technological trajectories. In effect, David's analysis leads to the idea that, for strictly technological reasons, more of the new capital-intensive production technologies introduced during the second half of the nineteenth century were "neutral" (in Hicks's sense, that is to say, the marginal products of capital and labor factors were equally affected) than less capital-intensive technologies introduced during the same period. Surprisingly, these conclusions are frequently cited to support those theorists who regard innovation bias as induced by the relative prices of factors of production. In fact, what David's study really shows is that in some cases the flexibility of engineering parameters does not depend on relative factor prices.

9 Fellner's (1962) argument can be summarized as follows: in the case where there is no quantitative rationing of production factors and assuming that there is perfect competition, the theory is incapable of showing that the market offers incentives for finding ways to cut back on the use of a *particular* factor.

10 For Nelson and Winter (1982), movements through unexplored regions of a production function should be rejected as a theoretical concept. Furthermore, the idea that innovations are induced in an attempt to rectify the production function for remote combinations of production capital is unconvincing: it supposes that "inventing" or R&D are activities whose results can be predicted in considerable detail. In fact, there is absolutely no difference between the theory that physical investment in one type of capital (plant and equipment) causes movements through the production function and the theory that R&D investments in another type of capital (knowledge) pushes the production function "toward the outside."

11 In other words, Kennedy's (1964) central idea is that a better growth rate of the capital factor can only be obtained by decreasing the growth rate of the labor factor.

12 Nevertheless, Morishima did not provide a satisfactory analysis of the stability conditions of this equilibrium.

13 The possibility of introducing the analysis of technological choice into a system of prices of production requires a series of suppositions about the commodities that are produced in *two* systems. In trying to simplify the assumptions, Bharadwaj (1970) showed that the number of points with reswitching of technology between two systems is determined by the number of commodities that enter directly or indirectly into the production of a "reference" commodity produced in both systems. The phenomenon of reswitching techniques is not necessary to invalidate the idea of the existence of an inverse, monotonical relationship between interest rates and the arrangement of production technologies according to a criterion of "capital intensity."

14 Each level of distribution can be represented by a point on the technological frontier of income distribution possibilities. A price vector is associated with each point. The frontier is formed by the dominating segments of the income distribution possibility curves associated with each one of the techniques being compared. In fact, we can show on the technological frontier that at the same level of profit, the relative price vector of the "dominant" technique is inferior to that of the "dominated" technique. At the intersection points the price vectors are equal.

15 On the basis of Sraffa's work, even authors such as Samuelson (1966) conclude that there is no clearly defined relationship between the relative prices of factors and the intensity with which these factors are used.

16 Other problems of this theory are related to the mathematical formalization used. For example, neo-Walrasian models define a commodity space that is an isomorphism of the space R^n (i.e., copy of the space of real numbers). In this way, the dimensional problems that arise from the heterogeneity of capital goods (and of all commodities) are suppressed. Furthermore, use of the space of real numbers makes it possible to introduce perfect divisibility of all goods. Another important problem is related to the assumption of convexity required for production possibility sets. This assumption is required to prove the existence of equilibrium but rules out the possibility of increasing returns to scale.

17 Uniqueness of equilibrium is an implicit assumption in policy recommendations involving comparative statics. Because the proof of uniqueness requires such a restrictive condition as gross substitutability, this fact should be explicitly recognized.

18 In the so-called *tâtonnement* processes, no transactions are allowed before general equilibrium is reached. So-called *non-tâtonnement* models, where exchanges out of equilibrium are allowed, are pure exchange models and cannot handle production. The distinction between these two processes was first made by Negishi (1962). For a review of the history of stability analysis and the role of this assumption, see Fisher (1983).

19 In addition, these models face severe difficulties in the integration of monetary variables into their framework. In particular, as Hahn (1969) has shown, in the Arrow–Debreu general equilibrium model, solutions in which the price of money is null represent equilibrium price vectors. Thus, general equilibrium models always allow for a nonmonetary solution. For this reason, the theory of general equilibrium seems condemned to remain in the limbo of nonmonetary analysis.

20 It is interesting that the first controls of licensing contracts in the region were established in Colombia because of worries over the negative effects of royalty and overpricing practices on the balance of payments. The Royalties Committee operated in the central bank. However, this concern with macroeconomic variables was not accompanied by the introduction of financial variables in the analysis of individual firms' technological behavior.

21 There is a strong contrast between the rather modest statements found in theoretical literature on the scope and validity of results and the degree of arrogance deployed in more applied research literature involving policy recommendations. This contrast will probably diminish as the scope of validity of pure theory is explicitly recognized.

7 Existence values and priceless externalities[1]

Frank Ackerman

Introduction

Economic theory has assumed, at least since Pigou, that environmental externalities could and should be internalized into the price system. Pigou himself imagined that externalities would often be internalized through taxes or subsidies, a strategy that appeals to many environmental advocates as well as economists. Coase's much-discussed alternative approach offers a different means of internalization, through negotiation; this is plausible under rare special circumstances, but it is a means toward the same end. (On the Pigou–Coase debate, see Aslanbeigui and Medema (1998).)

The optimality properties of general equilibrium are dependent on the assumption that all economic activities relevant to utility are correctly priced. In the absence of complete, correct prices, the market generates too much of activities that cause negative externalities, and too little of those that cause positive externalities. An ambitious, prescriptive form of environmental economics suggests that if externalities are priced and internalized, the market can achieve an optimum without any further intervention. On this view, which has become influential in policy circles, all that is needed is to "get the prices right" and then let market-based policy instruments work their magic (Ackerman and Gallagher 2001).

Meaningful monetary measures of environmental damages can often be developed for individual use values; but this is only a part of the job. The argument of this chapter is that *correct* pricing of *all* externalities is impossible – both because there are too many of them, and because many of them are important but do not have prices. Both of these points pose fundamental obstacles to the completion of the Pigouvian agenda of internalization of externalities.

First, there are far too many externalities for us to imagine that all the relevant ones could ever be priced and internalized. Valuation of environmental impacts is a slow, painstaking, and expensive process, and internalization of such impacts is often politically controversial. In contrast, creation of additional externalities is easy – and often profitable, since it

shifts some of the burden of private costs onto others.[2] And if only some, not all, externalities are internalized, then the economy has not reached the theoretical optimum, even if all other market failures have been eliminated. Indeed, partial internalization of externalities (or any partial movement toward an unattainable optimum) is not necessarily a move in the right direction, as the theory of the second best demonstrates (Lipsey and Lancaster 1956).

Suppose, for example, that rich people in a developing country generally use a very polluting heating and cooking fuel, while poor people in the same country generally use a less polluting, but not pollution-free, fuel. And suppose that initially, none of the fuel externalities have been internalized. In this context, internalizing only the externalities from use of the less polluting fuel could lead to more pollution, since it creates a new incentive to switch to the dirtier fuel. Moreover, the increased price for the poor people's fuel would lead to a more inequitable distribution of resources.

The second fundamental problem with the agenda of internalization is the one that we will address in more detail here. Monetization of externalities works comparatively well for some categories of use value. Yet the value of the natural world extends far beyond its instrumental role in consumption and production – that is, far beyond the parts that are, at least in principle, easy to monetize.

Environmental economics has described the noninstrumental role of nature in terms of nonuse values. This approach first appeared in the 1960s, when Burton Weisbrod developed the concept of option value, and John Krutilla proposed a now-standard typology of several varieties of nonuse value – namely, existence, option, and bequest values (Krutilla 1967; Weisbrod 1964). Krutilla's categories refer, respectively, to the mere existence of a natural resource, the option of using it in the future, and the desire to leave it as a bequest to future generations. These aspects of nature are all potentially valuable, even for those who have never used, and do not currently plan to use, the natural resource in question.

The same techniques that often work for monetization of use values routinely fail when applied to nonuse values. This is not to say that no one has tried: existence values have been estimated for many aspects of nature, often producing numbers that, at first glance, appear gratifyingly large. But the results do not bear much resemblance to real prices. Although surrounded with an aura of technical precision, the estimated prices for the existence of nature add little to the widely accepted idea that environmental protection is extremely important. This poses a dilemma for internalization of externalities in theory, and for cost–benefit analysis of environmental policy in practice. Reliance on use values alone seriously understates the value that people actually place on nature; but monetization of nonuse values rests on flawed foundations, and may not produce numbers suitable for use in theory or in policy analysis.

The large estimates of existence value are best understood as an awkward reflection of a significant dimension of environmental passion and belief. In the absence of these values, cost–benefit analysis based on use value alone leads to a caricature of "willingness to pay," falsely suggesting that society is willing to spend little or nothing on many forms of environmental protection. The resolution of the paradox is that essential public values cannot be meaningfully quantified; nonuse values are real, but they are not really numbers. That is to say, externalities in general cannot be correctly monetized and internalized into prices.

For public policy, this implies that cost–benefit analysis, which relies on monetizing externalities, is an inadequate tool for democratic decision making. There are desirable, logically coherent public policy choices that cannot be sensibly expressed as solutions to maximization problems, no matter how much effort is spent on measuring and internalizing externalities into the objective function. For economic theory, the fact that prices cannot be adequately adjusted to internalize all externalities implies that the equilibrium of the competitive market cannot, in general, represent a Pareto optimum.

The more detailed argument for these points, presented in the following, is interwoven with stories of attempts at valuation of nature, cost–benefit analysis in practice, and clashes over environmental policy. It begins with a shipwreck.

Pricing Alaska

When the *Exxon Valdez* ran aground in 1989, spilling 11 million gallons of crude oil into the icy blue waters of Alaska's Prince William Sound, a wave of large consequences followed – for public policy, for environmental law, and even for the theory and practice of economics. At the site of the accident, the intensive, expensive cleanup took three years to complete. In the courts, as it became clear that the disaster involved a drunken captain, antiquated equipment, and a corporate attitude focused on the bottom line, legal proceedings of all kinds ensued.

In Washington, the enormous impact of the *Exxon Valdez* created an immediate political consensus about the need to prevent similar spills in the future. The Oil Pollution Act of 1990, which among other things required double hulls on new oil tankers, was passed without a single dissenting vote – long before economists finished their studies of the value of the damages due to the *Exxon Valdez*. Like most of the environmental laws that are on the books today, the Oil Pollution Act was debated and approved without benefit of formal cost–benefit analysis or monetization of environmental values.

In economics, the *Exxon Valdez* was the ship that launched a thousand surveys. The accident demonstrated that natural resource damages could run into the billions of dollars – particularly for nonuse values such as existence value. And the only way to put a price on the mere existence of a place like Prince William Sound is to ask people what they think unspoiled nature is worth. It is a difficult question to answer, since most people have had so little experience of buying and selling ecosystems.

For those closest to the scene of the accident, the value of the damages was not an abstract question. In 1994 a jury awarded almost $300 million in compensatory damages to the commercial fishermen and local residents of Prince William Sound. The compensatory damages represent the court's calculation of the actual economic losses incurred by those who have personal contact with Prince William Sound – in other words, the use value lost to the accident.

In contrast, most of the people who were outraged by the *Exxon Valdez* disaster have never been to Prince William Sound, and expect never to go there. That is, for the great majority of the U.S. population, the use value of Prince William Sound and its wildlife is zero. Still, there is a strong sense of having lost something valuable, of having been harmed by the spill. What is it worth to preserve a piece of Alaska, that most of us will never see, in its pristine, oil-free natural condition? The same question reappeared when the Bush administration proposed to open parts of the Arctic National Wildlife Reserve to oil drilling in 2002. Residents of the other forty-nine states clearly feel it is valuable to avoid oil spills in Alaska, but not for the same reasons as the fishermen in Prince William Sound.

The nonuse values damaged by the *Exxon Valdez* spill were worth as much as $9 billion, maybe even more, according to economists hired by the state and federal governments (Carson *et al.* 1992). This conclusion was based on surveys that asked people – citizens selected randomly from the English-speaking population of the United States – how much they would be willing to pay in increased taxes to put into place controls that would prevent another spill like the *Exxon Valdez* one. The average household in the United States was reportedly willing to spend almost $100 for this purpose, implying a national total of around $9 billion, or thirty times the use value of the damages to Prince William Sound. When the survey participants were asked how much money they would accept in order to allow another spill to happen, the numbers got even higher; indeed, many people said they would refuse to allow such a thing at any price.

In this case, and in many others, a lot is at stake in the calculation of existence values. Was the *Exxon Valdez* a $300 million accident, as the use values imply? Or was it a $9 billion disaster, as the existence values suggest? The dilemma is that the lower figure ignores the feelings of almost everyone who cared about the event, while the higher number rests on unsound theoretical foundations.

Questioning nature

It is not just oil spills in Alaska that elicit immense existence values. Nature in general seems to have an enormous value to the average U.S. household. Depending on which study you believe, the median household is willing to pay between $1.44 and $104 per year (in 1990 dollars) to prevent a modest worsening of visibility due to air pollution at a major park (Smith and Osborne 1996).

Many studies have explored the value of preserving rare, threatened, or endangered species. On an annual basis, the average household is reportedly willing to pay amounts (in 1993 dollars) ranging from $70 to protect the spotted owl that lives in the old-growth forests of the Northwest, down to $6 for the striped shiner, an endangered fish (Loomis and White 1996). Since there are more than 100 million households in the United States, the per-household figures imply a total of more than $7 billion a year that the nation is willing to pay for the spotted owl, and more than $600 million a year for the striped shiner. When surveys ask about one-time, rather than annual, willingness to pay, they get even larger responses. The average household would pay $216 to preserve bald eagles, $173 to protect humpback whales, and $67 for gray wolves (Loomis and White 1996). Across the whole population, that adds up to $23 billion for bald eagles, $18 billion for humpbacks, and $7 billion for gray wolves.

The technique that produces these existence values is contingent valuation. It is one of several methods available for measuring use values, but it is the only method that can estimate nonuse values. Originally proposed in 1947, contingent valuation was first carried out in the 1960s (Portney 1994; Grove-White 1997: 21–31). Its first appearance in the U.S. legal system came in the 1980s, as a means of valuing the damages from hazardous waste contamination at Superfund sites. During the Reagan and Bush administrations, the Interior Department, the agency responsible for overseeing restoration of natural resources under Superfund, placed many restrictions on the use of contingent valuation to assess environmental damages. These restrictions, however, were largely overturned by a court decision, *Ohio v. Department of Interior* – which coincidentally occurred just months after the oil spill in Prince William Sound (Binger *et al*. 1995).

In the wake of the *Exxon Valdez* and the *Ohio* decision, contingent valuation, with its potential for attaching multibillion dollar price tags to nature, suddenly looked much more important. The Oil Pollution Act of 1990 directed the National Oceanic and Atmospheric Administration (NOAA) to establish standards for damage assessments in future oil spills. A panel assembled by NOAA, including Kenneth Arrow and other distinguished economists, drafted recommendations for future contingent valuation studies. The NOAA panel recommendations, which were accepted in 1994, are now widely cited, if not always followed, as a standard for contingent valuation on topics ranging far beyond oil spills. Among many other points, the panel endorsed the calculation of nonuse values. However, the NOAA panel did not end the debate about the right way to value the environment.

A whale watch is not a whale

While it is difficult to put a price on the *existence* of a wilderness or an animal species, it is easy to assign prices to the *use* of wild places and animals. Tour guides and travel agents do so all the time. The human use of nature – for instance, in the form of travel to see it – is often a marketed commodity; the existence of nature is not. Measurement of use values may be challenging in practice, but it is feasible in principle. The economic losses suffered by those who work and live in Prince William Sound are naturally expressed in monetary terms, and can be calculated without elaborate surveys of hypothetical values.

It is also possible, if somewhat unfamiliar, to think of rare or endangered species in terms of use value. The only humans making direct personal "use" of whales, in countries that observe the ban on whaling, are small numbers of researchers studying them and larger number of sightseers on whale-watching boats. Commercial whale watching is a thriving industry that had 3 million customers and revenues of about $160 million nationwide in 1998 (Hoyt 2001: 15).[3] Since the national total willingness to pay to prevent the extinction of humpback whales amounts to more than $18 billion, the existence value of humpback whales appears to be more than 100 times as large as commercial whale watch revenues.

Do the prices assigned to nature accurately describe what it is worth? On the basis of these prices, can nature be treated as a commodity? Perhaps for use values, but not for existence values. Suppose that you have bought the last available ticket for a whale-watching trip, and someone offers to buy it from you for twice the price you paid. No great moral dilemmas or philosophical issues are involved; if you accept the offer, you can go another time. A seat on a whale-watching trip is a commodity that has a market price. The price expresses the value of seeing whales, and it is perfectly acceptable to think about buying or selling tickets for the trip.

But a whale watch is not a whale, and the *existence value* of whales is not a meaningful number. Suppose that a crazed antienvironmental billionaire offers to pay $36 billion for the opportunity to catch and kill all the humpback whales in the ocean. Given the estimated $18 billion existence value of humpback whales, the would-be whale killer is offering to buy the existence of the species for twice its price. If whales were commodities and existence values were real prices, this would be a good deal, just like the offer of double payment for your ticket. Nonetheless, it is inconceivable that the billionaire's offer would be accepted. Any signs that such an offer was even being considered would produce immediate, outraged protest.

A number like $18 billion is an awkward and incomplete way to describe the immense value that people place on the existence of whales. The exact number contains no useful information: what would change if a new study found that it was actually $16 billion, or $53 billion? The only answer to an offer to buy the whales – regardless of the amount offered – is, "We didn't really mean it about the price. Actually, they are not for sale." In short, the ban on whaling is based not on a cost–benefit analysis, but on a widely shared ethical judgment. That judgment is not clarified, nor made more precise, by performing a survey of public willingness to pay for something that cannot be bought or sold.

Protest votes and economic ethics

Many participants in contingent valuation surveys either refuse to answer, or give what appear to the survey managers to be unrealistically large valuations in order to express their support for environmental valuation. Such answers are typically dismissed as "protest votes," and are simply not counted. In contingent valuation surveys that put the question in the "willingness to accept" format – that is, ask how much money respondents would demand in order to allow the relevant natural resource to be despoiled – protest rates of 50 per cent or more are common (Jorgensen *et al*. 1999). In dismissing these responses, survey researchers create a danger that the valuations of nature will reflect an *ad hoc* process of censorship by economists, not a true cross section of popular attitudes.

The implicit assumption of contingent valuation practitioners is that everything has a price that can be discovered by careful questioning. On this view, it is not reasonable for people, when faced with the question of how much one would accept in order to allow another *Exxon Valdez* spill to occur, to refuse to "sell." On a broader view, though, the "protest votes" may be trying to tell the researchers something important. (On the importance of "noneconomic" influences on willingness to pay for environmental protection, see Spash (2000).) Those who refuse to value nature, or give it an "unreasonably" high value, can be interpreted as asserting that there are matters of rights and principles that are beyond economic calculation.

Setting the boundaries of the market helps to define who we are, how we want to live, and what we believe in. There are many activities that are not allowed at any price. Some businesses would undoubtedly profit from employing child labor, killing whales, or openly bribing public officials. As filmmaker Michael Moore asked, in a question that only appears to be flippant, if General Motors was trying to maximize profits, why didn't it switch to selling cocaine when its cars sold poorly in the 1980s (Moore 1996)? The magnitude of the profits that could be gained from these activities is not, for most people, an argument for changing our principles about what we do and don't allow.

Some activities not only are unpriced, but would be fundamentally changed if they become part of the market economy (Vatn and Bromley 1994). Sex and voting are two classic examples: doing it in exchange for cash, which is not unknown in either case, inherently degrades the sexual or electoral experience. The legal scholar Cass Sunstein makes a similar point with a simpler example: suppose that at the last minute you are forced to cancel a lunch date with an old friend whom you haven't seen in some time. Your friend has suffered a loss of your companionship, but it would be strange, even insulting, to offer to pay your friend for that loss (Sunstein 1997). Nature may resemble friendship, as well as sex and voting, in being changed and cheapened as soon as it is priced.

Natural capitalists

An alternative approach to economics also tries to measure the role and the value of nature, with greater, though not total, success. As Herman Daly and other ecological economists have pointed out, the economy is embedded in the natural world and constantly relies on nature to provide essential inputs such as clean air, clean water, food, fiber, and other raw materials. Since the earth and its resources are finite, there is a limit to the possible expansion of production; after a certain point, economic growth must become resource conserving rather than resource-intensive.[4]

Some of the essential natural inputs can be described as "natural capital" since they are used but not used up in production, just like produced capital. For example, fishermen "use" the population of uncaught fish in the water, whose reproduction creates the possibility of each year's new catch. Thus, uncaught fish have a use value in production, while the fish that are caught have a use value in consumption. This represents an important expansion of the conventional discussion of environmental use values, which often focuses heavily on costs and benefits to individual consumers.

Thinking about the role of nature in production also highlights the interactions of species within a habitat, which are much like the interactions of producers and suppliers within the economy. Value is produced by the system as a whole, not by the single firm (or species) that attracts the most attention. According to contingent valuation surveys, whales have a huge existence value; it seems likely that similar surveys would find much lower existence values for the plankton, krill, and other small, drab, essential parts of the ecosystem that supports whales. A consistent set of prices for nature – if they really were prices – should include values for the inputs nature uses to make whales, reflecting the contribution that the bottom of the food chain makes to the species at the top.[5]

Ecological economics, with its analysis of natural capital and ecological constraints, is an advance over standard economics in many respects. It extends the concept of the use value of the environment to encompass

uses in production as well as consumption. But ecological economics offers no new solution to the existence value problem. Many aspects of the natural world about which people care deeply, such as remote ecosystems and endangered species, are not currently used for human purposes, either as natural capital or as consumer goods; they have no discernible use value, but they are valuable. Existence values are central to the way people think about nature, and they are not the same as natural capital.

A fish story: the ones that didn't get away

Estimated values for externalities are frequently used in cost–benefit analysis, to compare the monetary costs of environmental protection with the monetized value of the benefits it achieves. Ironically, cost–benefit analysis is sometimes advertised as offering an objective, transparent standard for evaluating public policy. In practice it can achieve just the opposite, allowing partisan advocates for a particular outcome to hide behind the most opaque, technical disputes.

Nonuse values, in particular, are often decisive to the outcome of cost–benefit analysis. Yet in the absence of sufficient funding to perform a new contingent valuation study, nonuse values are often estimated with arbitrary rules of thumb, undermining any sense of scientific rigor or certainty about the resulting numbers. Consider the strange case of power plants, cooling water, and the value of the fish that didn't get away.[6]

Power plants generate electricity by boiling water and using the steam pressure to make large turbines spin. A huge coal-, oil-, or gas-burning furnace, or a nuclear reactor, is used to boil the water. The plant requires a vast, continual flow of cooling water to condense the steam back into water so it can be boiled again.

Cooling water is taken from rivers, lakes, and oceans – and often contains fish. One power plant alone, the Salem nuclear plant in New Jersey, withdraws more than 3 billion gallons of water every day from the estuary of the Delaware River. Staggering numbers of fish are killed at Salem: small ones are sucked into the plant, while larger ones are trapped against the intake grate, held there by the massive water flow. The abrupt temperature change – the cooling water is much warmer when it comes out of the plant than when it goes in – does further damage to the aquatic ecosystem.

This underwater massacre could be almost entirely eliminated with well-known, proven technologies – in particular, with the use of cooling towers. (In older facilities this was the tall structure, pinched in the middle, that defines the classic power plant silhouette; newer cooling towers are much smaller.) With a cooling tower, water, once heated, can be cooled down and then recirculated through the plant. A cooling tower reduces a power plant's water needs by more than 90 percent, and as a result saves more than 90 percent of the fish.

Salem has no cooling tower, and instead relies on a "once-through" cooling water system. Salem is not unique in this regard. More than 500 existing power plants, producing about half the electricity sold in the United States, have once-through cooling systems. They collectively use almost 300 billion gallons of cooling water every day, and kill about a billion age-one-equivalent fish per year.[7] Should all of the existing plants – or any of them – be required to build cooling towers?

The traditional approach of the Environmental Protection Agency (EPA) to such questions has been to identify the best technology available for mitigating environmental harms. This has been done, following the language of the Clean Water Act, without attempting to assign a dollar value to the resources that would be saved by the new technology. But in the case of cooling water intake systems, part way through the regulatory process EPA switched to a cost–benefit analysis, involving a lengthy and obscure inquiry into the imputed monetary value of not killing fish. Far from clarifying society's values, the new economic study represents only a temporary lull in the skirmishes between EPA's attempts to protect more fish, and industry's desire to do less. Although many other technical debates surround the numbers, the hidden assumptions about nonuse values are of enormous importance to the "bottom-line" conclusions.

What is it worth to not kill a fish? The easiest fish to value are the ones that would have been caught for commercial or recreational purposes if they had not been killed by a power plant instead. For commercially valuable fish species there is an obvious market value. For recreationally valuable fish, EPA's economists have developed elaborate models of recreational anglers' willingness to pay for the enjoyment of catching another fish.

However, even for the most valuable species, no more than 10–20 per cent – and often even less – of the fish in the water are typically caught by commercial and recreational fishing in any one year. The remaining fish represent the "natural capital" that survives to produce next year's catch. So the fish killed by a power plant can be divided into the small minority, say 10–20 per cent, that would have been caught, and the great majority that would have gotten away, in the absence of the power plant. The ones that would have been caught are readily assigned a commercial or recreational value. What is the value of the natural capital, the ones that would have gotten away? In EPA's initial attempt at cost–benefit analysis, the value was zero.[8]

The nonuse value of the fish and other underwater organisms is almost, but not completely, absent from the analysis. As often happens, the agency had no funding for a new study of nonuse value, and was thus constrained to make indirect inferences based on published studies done in other contexts. Following an idiosyncratic pattern established in a few earlier hearings, EPA's first attempt at cost–benefit analysis estimated that nonuse (existence) values are equal to 50 percent of the direct commercial and recreational value of the fish killed by the power plant. The "50 percent

rule" appears to be an empirical estimate based on a few small-scale studies done in the 1970s, long before the recent burst of analysis of environmental values. A re-examination of relevant academic literature suggests that a "200 percent rule" – nonuse value is about twice use value – is closer to the findings of studies published through the early 1990s. (Even this is far from a universal rule: recall that the existence value of Prince William Sound has been estimated at about 30 times its use value, while the existence value of humpback whales is more than 100 times greater than total whale-watching revenues.) Application of the "200 percent rule" to EPA's data on use values vastly increases the estimated benefits of regulatory options, and shifts the outcome of the analysis: judged by estimated net benefits, a regulatory option that protects more fish becomes the winner.[9]

A second round of EPA analysis, in response to criticisms of the first round, delved much deeper into fisheries data and reorganized the agency's calculation of benefits. Nonetheless, the arbitrary treatment of nonuse values remained of central importance. In the second-round study, only households that lived fairly close to the power plants (within 32 miles (50 kilometres), or in neighboring counties) were assumed to have any nonuse value for the fish killed by the plants. In this case, the results of the cost–benefit analysis are again totally transformed by assuming that the rest of the U.S. population has a nonuse value per household of just 10 percent as much as those in neighboring areas.[10]

There is no reason to think that the "50 percent rule" provides a reasonable estimate of existence values; nor are people who live more than 32 miles away always indifferent to the harm done to nature. But despite the incredible empirical detail, and months, perhaps years, of hard work that went into the cost–benefit analysis of protecting fish from power plants, one could easily argue that essentially arbitrary decisions about the estimation of existence values determined EPA's bottom-line result.

The importance of nonuse values in cost–benefit analysis is further illustrated by the dramatic reversal in the views of Robert Stavins, an environmental economist at Harvard's Kennedy School of Government. In 1984, while working for the Environmental Defense Fund, Stavins conducted a cost–benefit analysis that contributed to the defeat of a proposed hydroelectric development on the Tuolumne River in California. His conclusion that there were greater net benefits to keeping the river undeveloped and available for recreation critically depended on his substantial estimate of nonuse values. He first applied a ratio, similar to EPA's "50 percent rule," to estimate nonuse value per household; in fact, he used a 60 percent rule. He then assumed that the population who had a nonuse value for preservation of the Tuolumne consisted of the entire California membership of the Sierra Club, plus half of the membership of the Sierra Club in other states. The large resulting estimate of total nonuse value tipped the balance of costs and benefits toward preserving the river: with no nonuse value, or even a significantly smaller value, Stavins's analysis would have favored hydroelectric development (Stavins 1984).

By 2002, Stavins's analysis of the Tuolumne was long out of print, and Stavins was consulting for PG&E, the giant California energy company that starred opposite Julia Roberts in the movie *Erin Brockovich*. On behalf of PG&E, Stavins argued that EPA's cost–benefit analysis of power plant cooling water intake systems wildly exaggerates the benefits of protecting fish. As far as Stavins could see in 2002, EPA offered no rigorous grounds for assigning existence values to most of the fish killed by power plants, and indeed only limited grounds for assigning them any value at all. It is just a short distance from this point to the conclusion that it is more economically "efficient" to allow industry to continue killing fish at whatever rate it chooses.

One may have a personal preference for the Stavins of 1984, defending environmental protection, or for the Stavins of 2002, representing major corporations. As economists are fond of saying, there is no accounting for taste. Regardless of personal tastes, however, it should be clear that arbitrary estimates of existence value are crucial to both vintages of Stavins's work – and to all positions in the recent debate over regulation of power plant cooling water intake systems. Neither the big estimates of existence value favored by environmentalists, nor the small estimates favored by corporate polluters, are based on objective science. None of the estimates, needless to say, are real prices; each rests on a shaky pyramid of debatable inferences about observable market prices and unobservable, nonmarket values.

Continuing the debate about the magnitude of existence values is not a sensible way to make decisions about protection of fish and underwater ecosystems. Nor is it necessary in order to determine society's willingness to pay for regulation of cooling systems. For that determination, there is only one question that matters: are people willing to pay a small increase in their electric bills to cover the cost of cooling towers?

Although, as industry and its advocates point out, cooling towers are expensive, the plants that use them generate huge amounts of electricity. As a result, the cost per kilowatt-hour, and the average household's cost per month, are quite modest. Requiring cooling towers on all existing power plants, the strictest regulation that EPA considered, would add $0.28 to a typical household's monthly electric bill, or $3.36 per year – in round numbers, a penny a day.[11]

If, as seems likely, most households are willing to pay a penny a day to save millions of fish every year, then there is no need for the endless debates about the many ways to value a fish. On the other hand, if most households are not willing to pay that much, they will not be tricked into it by a complex, statistical fish story. Rational, democratic decision making requires information on the costs of proposed policies (the monetary cost of building cooling towers), and information on the benefits (the numbers

of fish saved) – but it does not require an artificial, implausible monetization of all benefits to force the entire discussion into the language of financial accounting. Costs and benefits of public policies will normally be expressed in incommensurable units, requiring political deliberation in order to reach a judgment.

Waiting for the Lorax

Economic analysis of health and the environment produces much bigger numbers for the existence value of nature than in any other area. If these numbers are accepted at face value, places and things that are assigned existence values are uniquely blessed. But there is a discriminatory pattern to these blessings: nature generally has an existence value, while human life and health do not.

Existence values are based on a different logic than use values or ordinary prices. In a market economy, prices are based on what individuals are willing to pay for goods and services. Use value, as perceived by individual consumers, is what creates the demand for things that are actually for sale. Valuation of human life and health, despite its numerous logical problems, attempts to follow the same pattern: the estimated values are based on economists' (often tortured and implausible) interpretations of what individuals are willing to pay to protect themselves from harm.

Nature is unable to tell us about its own values and needs for protection. There is no Lorax[12] who speaks for the trees. If whales were consumers, swimming up to the market with cash held in their fins, economists could interview them about their willingness to pay for not being harpooned. Instead, we are left with contingent valuation of the existence of whales as our only option for assigning a number to their lives.

This is, in a sense, an advance over the methodological individualism of conventional market valuation. Calculation of existence values recognizes the role of social decision making; it asks, as market economics usually does not, what the population as a whole thinks about a topic. But at the same time, the expression of social priorities through existence values attempts to replace voting with shopping. If we collectively were going to buy the existence of an endangered species, how much would we be prepared to pay?

Even in this unusual language, there are many things in addition to nature that society might want to "buy." Whales and wild places have existence values, but so do safe jobs for workers thousands of miles away, and protection from toxic chemicals for everyone's children. Most of us value the working and living conditions of people we may never meet, just as we value the natural environment of places we may never visit, such as Prince William Sound. Traditionally, society would express its concern for health and safety by passing laws on the subject, based on simple, nonquantitative ideas such as "workplaces should be as safe as possible," and

"children should be protected from toxic chemicals." But if that seems passé, too twentieth-century in its approach, economists could conduct surveys to find the existence value of other people's health and safety. It seems likely that the resulting numbers would be substantial.

Assigning monetary values to everything we care about is not a practical plan for government. Voting by shopping – using existence values to measure society's preferences in general – would bury us in a blizzard of hypothetical valuations, obscuring rather than clarifying our collective priorities. It would also raise the impossible problem of numerically "valuing" things about which people disagree. Is the "existence value" of abortion clinics a positive or negative number? It depends whom you ask. Almost no one would be happy about making a decision based on society's average monetary valuation of the right to choose abortion.

Something large and ill-defined can be seen through the dark glass of contingent valuation: the huge estimated existence values for nature suggest that the environment matters a great deal to a great many people. Nevertheless, it is difficult to maintain the fiction that surrogate prices are being calculated, suitable for use in incorporating the environment into the market economy. The problem is not the lack of coherent judgments about big or remote environmental questions. The problem is that incoherence is introduced when qualitative environmental judgments are turned into numbers.

Follow-up interviews with respondents to contingent valuation surveys elicit comments such as "I struggled with this money business," "I found the money question impossible to answer," and "I would pay the earth if I could afford to. But you can't really value it, can you?" (Clark *et al*. 2000). People who feel equally passionately about preserving a local environmental resource can make arbitrarily different decisions about how to turn that passion into a number. Similarly, legal research has found that jurors' judgments about the outrageousness of an injury and the appropriate punishment are relatively uniform in qualitative terms, but become erratic and unpredictable when jurors translate those judgments into monetary damages (Sunstein *et al*. 1998).

Moreover, the largest values are the most problematical and controversial ones. They are frequently so large that they would have little hope of being incorporated into public policy, even under a relatively liberal administration. The average estimated existence value of a member of an endangered species is forty-eight times the average fine levied for killing one of these animals in violation of the Endangered Species Act (Eagle and Betters 1998). Yet recent political debate over the Endangered Species Act has questioned whether it is already too burdensome and needs to be eased, not whether it needs to be made forty-eight times as strict.

Choices without prices

For those who support environmental protection, it would be comforting to accept the huge existence values produced by contingent valuation as quantitative, scientific evidence of the importance of nature. Unfortunately, these numbers do not withstand scrutiny. They do not behave like prices; they are so large that it is rarely possible to incorporate them into regulations; and the process of quantification creates an endless series of technical problems and debates.

On the other hand, in the absence of believable existence values, economists' best estimates of "willingness to pay" will drastically understate what society is in fact willing to pay. Cost–benefit analysis with little or no existence values will routinely justify far less environmental protection than people want, as in the case of the fish killed by power plant cooling water intake systems.

The nonexistence of meaningful, quantitative existence values poses a challenge for public policy, though not an insurmountable one. Monetary costs and nonmonetized, natural or environmental benefits can be weighed against each other in a deliberative, rather than algorithmic, process. Choosing the locus of deliberation – determining whether the decision will be made by government agencies, Congress, the courts, or the voters directly – is of great importance from a political perspective.

For economic theory, the crucial fact is the underlying reason why deliberation is needed, namely the impossibility of full quantification and monetization of externalities. The discussion of nonuse value leads to the conclusion that people cannot put meaningful dollar values on all the externalities that they care about. Thus, a model of economic activity that assumes everything of importance can be monetized and internalized – a model such as general equilibrium theory – rests on an incomplete understanding of the things people value. The typical utility function, or preference relationship (assuming that such a thing exists), must be defined not only over bundles of consumption goods, but also over variables that bear little resemblance to marketed commodities: rights and principles that are not for sale; unquantifiable but deeply significant values attached to objects and activities outside the individual's experience; the existence of whales, as well as the consumption of whale-watching trips.

Such a utility "function" or preference relationship could be better described as a catalogue of multidimensional, incommensurable values – and because its elements are incommensurable, it is not amenable to maximization. Yet the maximization of consumer welfare is the cornerstone of general equilibrium theory, the basis for the judgment that market outcomes are Pareto-optimal. If, as argued here, the price system can never capture everything that matters to people, then decisions made on the basis of prices alone can never express everything that people want.

The conclusion that emerges from this exploration of existence values is a sweeping one, with radical implications for economic theory: since no program of internalization of externalities can capture and measure the full range of nonuse values, the optimality of market equilibrium would collapse on environmental grounds alone, even if all its other problems could somehow be resolved.

Notes

1 Many parts of this chapter are based on or excerpted from "Unnatural Markets," chapter 7 of Ackerman and Heinzerling (2004).
2 For an argument that people are continually "led by an Invisible Foot" to create more externalities, see Hunt and D'Arge (1973); summarized in Ackerman *et al.* (1997).
3 The $160 million figure is for whale watch revenues alone. If indirect expenditures such as food, travel, accommodations, and souvenirs associated with whale watching are included, the total expenditure reaches $330 million.
4 One of the most accessible, nontechnical introductions to this perspective is that by Daly and Cobb (1989). The International Society for Ecological Economics and its journal, *Ecological Economics*, provide numerous other sources.
5 See the interesting proposal for a consistent set of ecological prices by Hannon (2001). Hannon proposes to extend the input–output economic model to encompass ecological services, and then use the model to impute prices to inputs. This would produce a consistent set of use values, improving on available *ad hoc* estimates; however, it would not solve the existence value problem.
6 This account draws on two rounds of my comments (prepared jointly with Rachel Massey) on the proposed regulation, prepared for Riverkeeper, an environmental group committed to protection of rivers and their ecosystems. My comments are available at http://www.ase.tufts.edu/gdae.
7 Large quantities of immature fish can be expressed in terms of the number that would have been expected to survive to the age of 1 year – or "age-one-equivalent" fish.
8 In the 2002 version of the analysis, the value placed on unlanded fish was zero. In the 2003 revision, EPA introduced a complex new set of categories, one of which included the value of the dead fish that would not have been caught in the absence of the power plant, along with other values. See my comments on the regulations (cited in note 6).
9 See my 2002 comments on the proposed regulations (note 6).
10 See my 2003 comments on the proposed regulations (note 6).
11 Synapse Energy Economics analysis of the proposed regulations, 2002; see http://www.synapse-energy.com.
12 In a Dr. Seuss children's classic, *The Lorax* (Random House, 1971), the fictional title character "speaks for the trees" and protests the destruction of forest ecosystems for short-run commercial gain.

8 Contradictions of the open economy model as applied in Mexico[1]

Alejandro Nadal

Introduction

This chapter presents a critique of the open economy model implemented in Mexico since 1987. The criticism presented here does not dwell on the deficient performance of the Mexican economy during the period in which this model was implemented; instead, it centers on the internal contradictions of the model that have prevented the policy mix applied in Mexico from delivering on its promises.[2] The model we examine here is the Mundell–Fleming model, the widely cited standard for macroeconomic analysis of open economies; that model was one of the principal accomplishments that led to the award of the Nobel Prize for Economics to Robert Mundell in 1999.

Although the model applied in Mexico has not been explicitly identified with the Mundell–Fleming model, its structural components bear a close resemblance with it – and no other formal theoretical model has been proposed to explain Mexico's economic development strategy. The Mundell–Fleming model does not have strict microeconomic foundations, but its analytical structure is closely linked to the notions that markets always clear, and that trade liberalization is the best way to organize production and consumption. In fact, the close association between the Mundell–Fleming open economy model and general equilibrium theory was acknowledged by its authors (see, for example, Mundell 1968), and this close relationship has also been recognized in more recent work (see for example, Geanakoplos and Tsomocos 2001). The linchpin of the connection between the Mundell–Fleming and general equilibrium models is the market clearing assumption, which in turn depends on the postulates of perfect competition and flexible prices.

When the open economy model was first implemented in Mexico in the late 1980s, the radical change in economic policy was justified by stating that the import substitution strategy had run its course. That former strategy, it was argued, was inadequate for Mexico's economy: it no longer provided satisfactory growth rates, did not create sufficient jobs, and could not maintain balance in foreign accounts. But during the fifteen years in

which it has been implemented, the new model has not delivered adequate growth rates either, nor has it created sufficient jobs or maintained balanced foreign accounts. Further, it has not been able to maintain stability in the main domestic macroeconomic variables, such as the general level of prices or interest rates. When inflation rates have been controlled, this has been achieved at the cost of a stagnant economy and an overvalued currency. Summing up, the results of implementing the open economy model applied in Mexico are unimpressive.

However, verification of the mediocre performance of Mexico's economy is insufficient to prove the need for a significant change in economic strategy. Supporters of the open economy model maintain that it needs more time, partly because the reforms that are required for its full deployment have not been implemented. In addition, it is argued that the vestiges of the populist and interventionist regime that defined the direction of the Mexican economy from 1955 to 1982 have not been completely dismantled. For example, these supporters argue that the energy sector still needs to be privatized and that a deep-reaching labor reform is also necessary.

The corollary to this reasoning is that if the open economy model is given enough time, it will eventually lead to the desired results. The same line of reasoning maintains that the structural reforms needed by the model must be put in place: more privatizations, more deregulation, less state intervention, and less public expenditure are required in order to have healthier public finances. Only then, according to its advocates, will the model be able to deliver sustainable growth and prosperity.

Contradictions and the model: definitions

How do we know if the open economy model applied in Mexico simply needs more time? Acknowledging the poor results of its application to date is not enough. The only way to evaluate the plea to stay the course is with a detailed analysis of the model's inner logic. If (as argued in this chapter) there are internal contradictions in the way the model functions, then we can hardly expect it to turn in a good performance, no matter how much time it is granted. Thus, an analysis of the essential features of the model is required.

This point is particularly relevant because of the common belief that the problems that afflict the Mexican economy today are not the result of the deficiencies of a given model or theory, but merely reflect a series of mistakes in policy implementation. These mistakes may stem from an erroneous sequence in policy implementation or from an excessive reliance on specific instruments. It has also been argued that the mistakes arise from a deficient "early warning" system that has prevented the timely adoption of adequate corrective measures.

No doubt there have been cases of negligence, even irresponsibility, in

the management of recent economic policy in Mexico. But it is also possible that some of the "mistakes" are nothing more than logical responses to an inconsistent policy package. For example, the delay in exchange rate adjustment could be nothing more than the normal outcome of a tension that arises from applying instruments that seek contradictory goals. In fact, as we will see, the model places several incompatible constraints on exchange rates.

Internal contradictions arise when structural elements that are essential to a model simultaneously act as *obstacles* to the model's performance. In other words, a model contains internal contradictions if components that are necessary to its inner workings also hinder the functioning of the model. The resulting tension leads to a distorted process in which the model's policy mix cannot accomplish the goals that were originally established.

The analysis presented here takes the Mundell–Fleming macroeconomic model as a reference.[3] This model is an extension of the IS-LM model, which incorporates an equilibrium curve for the balance of payments and can also assimilate different assumptions concerning fixed or floating exchange rates, as well as perfect mobility of capital.[4] With a flexible exchange rate regime, there is no room for an independent monetary policy. In the Mundell–Fleming model the adjustment of the money supply is automatic, and is tied to the surplus or deficit of the balance of payments (when the monetary approach to the balance of payments prevails). A surplus in the balance of payments implies monetary expansion, while a deficit involves an adjustment due to the contraction of the monetary supply.

A review of recent Mexican experience, from the perspective of the Mundell–Fleming model, highlights five areas of internal contradiction in the model:

1 The exchange rate is expected to float freely to maintain equilibrium in the balance of trade, but it also must be changed as little as possible in order combat inflation and to guarantee risk-free currency conversion to foreign investors.
2 The domestic interest rate is expected to fluctuate to maintain equilibrium in capital markets, but is also used to regulate the money supply, the rate of inflation, and the level of economic activity.
3 Liberalization of capital markets often leads to foreign capital inflows – but these inflows may increase the financial capacity to import more rapidly than they build up the productive capacity to export.
4 Deregulation of financial institutions is said to be necessary to increase domestic savings and investment, but deregulation increases opportunities for speculative investment and flight of domestic capital to overseas markets.
5 Development under the open economy model requires the promotion of successful export sectors, a process that has historically required the active participation of the state. But the logic of the open economy model leads to a reduction and weakening of the state's capacity to intervene in the market.

The first contradiction: the exchange rate

The open economy model rests on the fundamental premise that international trade is so advantageous that any attempt at regulating and restricting it does more harm than good. That is why when there is a deficit in the trade balance, it must be corrected not with restrictions on the flow of goods and services, but by adjusting relative prices. Thus, within a flexible exchange rate framework, the adjustment through variations in the exchange rate should follow automatically.

Precisely to keep the countries that signed the General Agreement on Tariffs and Trade (GATT) from surrendering to the temptation of routinely resorting to controls on trade flows in order to tackle external disequilibria, GATT Article XII established the possibility of *exceptionally* resorting to measures such as quantitative restrictions and tariff surcharges to reestablish equilibrium in the balance of payments. It was thought that it was better to open a door just a crack, to regulate exceptional measures and impose weighty disciplinary measures to avoid abuses, than to leave GATT members at total liberty in this matter.[5]

However, the North American Free Trade Agreement (NAFTA) slammed the door shut, canceling the possibility of resorting to exceptional measures. NAFTA Article 2104 establishes that fees, tariff surcharges, import permits, or other similar measures cannot be exceptional measures, and, in effect, it prohibits the use of any such measures.[6] Under these conditions, if there is a deficit in the balance of trade, the adjustment must be made only and exclusively using the relative price system, and this means that the key variable is the exchange rate.[7]

That inflation must necessarily be reduced to the level of a country's most important trade partners is another key policy objective that prevails in the open economy model (although this is not always made explicit in discussions of the model). In the case of Mexico, this idea has led to a veritable obsession with reaching and maintaining one-digit inflation rates. One of the main policy instruments on this front has been the use of the exchange rate as the nominal anchor of the relative price system. Using the exchange rate as an instrument to fight inflation irremediably leads to an overvaluation of the exchange rate.[8] But this approach to controlling inflationary pressures entails a significant rigidity in the exchange rate, contradicting the use of a fluctuating exchange rate to maintain equilibrium in the trade balance. To the extent that exchange rate adjustments are postponed in order to keep inflation at bay, the trade balance deteriorates.

There is another force that hampers the ability of the exchange rate to act as the key variable in the adjustment of the trade balance. The open economy model incorporates perfect capital mobility as one of its central components. Capital mobility is seen as a useful instrument with which to direct productive investment to economies with insufficient domestic savings.[9] But these capital flows have many other effects besides allowing a country to finance its external deficit.

In the first place, they lead to an appreciation of the exchange rate. The demand for assets denominated in the currency of the recipient country naturally leads to this result, with the companion effect of causing further deterioration of the trade balance as imports become cheaper and exports more expensive. In addition, because capital that flows into a given economy is invested in assets denominated in the local currency, pressure builds up to maintain exchange rate stability. In general, in the world of deregulated capital accounts and interdependent financial markets, countries make efforts to guarantee exchange rate stability; this can be done through a literally fixed rate, or through a "dirty" float (very slow variation) of the exchange rate. Once foreign capital is invested in a given country, investors expect the exchange rate to remain stable; in the face of devaluation risks, a risk premium is requested by investors. If a country wants to remain attractive to these capital flows, it must try not to betray their confidence by maintaining exchange rate stability.

When capital flows are reversed, the exchange rate is depreciated as investors flee assets denominated in the local currency, and the inflation rate increases rapidly. To prevent this, the central bank offers a higher interest rate as an incentive to keep assets in the country. The effects on the interest rates are examined in the next section. The point here is that a devaluation of the exchange rate is deemed unacceptable to economic authorities, and this further degrades competitiveness. Typically, the adjustment is postponed; the adjustment is finally made when it is too late and it is implemented in a disorderly fashion, in an environment characterized by chaos, volatility, and economic collapse.

Abrupt devaluation makes local assets cheaper for foreign investors, stimulating incoming capital flows. Once again, these capital flows are placed in assets denominated in the local currency and tend to raise the exchange rate anew. This exchange rate appreciation cancels the effects of the initial devaluation and once again contributes to a deterioration of the country's trade balance. The external deficit generates a greater need for external finance, and the process becomes a vicious circle as capital flows seriously increase external vulnerability.

These three elements (using the exchange rate to stem inflation, maintaining a low exchange rate risk, and exchange rate appreciation caused by incoming capital flows) bring about an important contradiction in the model. A central feature of the model is the adjustment in foreign accounts via changing relative prices – that is, with a flexible exchange rate regime – but other elements in the model impose a high degree of rigidity on the exchange rate. The central bank is forced to intervene in the market, at times directly under the pretext of establishing order in the exchange rate market and providing liquidity, at times through other institutions with indirect investments. The goal is always the same: to keep the exchange rate stable.

Examples of the above contradiction, where exchange rate adjustment becomes necessary but difficult, abound in recent financial crises. The conflict between the goal of using the exchange rate as an adjustment variable for any external disequilibrium and the need to keep the exchange rate stable in order to benefit short-term foreign investment was clearly manifested in Mexico in 1994. Throughout that year, the overvaluation of the exchange rate had reached exaggerated levels, and the deterioration of foreign accounts demanded an important adjustment in the exchange rate. However, even after capital flight had begun, the pressure exerted by foreign investors to keep the exchange rate stable prevailed. This pressure forced economic authorities to adopt the unusual measure of indexing government bonds – held by several foreign pension funds and brokerage firms – to the exchange rate. Effectively this meant that the risk of devaluation fell on the Mexican government. This case of Treasury bonds with interest payments essentially fixed in U.S. dollars, not Mexican pesos (*Tesobonos*) is an extreme example of conflicting goals for the same macroeconomic variable in the open economy model.

How is this contradiction resolved in practice? The adjustment through exchange rate movements is delayed as much as possible, with the resulting deterioration of the country's foreign accounts. When the adjustment in the exchange rate is finally carried out, this takes place under conditions of great volatility and unrest in the financial markets. The adjustment and its effects then become disproportionate. In addition to the unrest in financial markets, the inflation rate rapidly rises and past achievements in this area are canceled.[10] Although the crisis is said to be an exchange rate crisis, it is really a structural crisis of the open economy model.

The second contradiction: the interest rate

The open economy model is based not only on trade liberalization, but on financial deregulation as well. The capital account is deregulated in order to attract and use foreign savings to increase productive investments and promote growth. Financial deregulation implies eliminating barriers to the free flow of capital, a policy measure that has profound implications for the role played by several macroeconomic policy instruments. The exchange rate is no longer the key variable that regulates contact between two relative price systems (domestic and foreign) in the goods and services market; instead, as we have seen, it becomes a variable that is more closely linked to the needs of the short-term capital flows.

In the Mundell–Fleming model, a current account deficit is financed by capital inflows. Under fully flexible exchange rate regimes, this variable adjusts so that the sum of the current and the capital accounts is zero.[11] The adjustment process is automatic. For example, consider the case of an open economy with a fixed supply of money, flexible exchange rates, and fixed prices. In this economy a current account deficit causes capital inflows, which lead to an increase in the supply of real balances and a reduction in interest rates. This reduction generates capital outflows, which provoke a depreciation of the exchange rate, making the domestic productive system more competitive and leading to an expansion of demand for exports. Total output now expands until a new equilibrium is reached for the money and the goods markets, as well as for the balance of payments.

But now consider the case of an economy that is the recipient of incoming capital flows for other reasons, perhaps because its domestic interest rate becomes higher than the prevailing international rate. In the absence of any intervention, the domestic money supply expands as demand for assets denominated in the domestic currency increases. This leads to an expansion of the money supply. At this stage, the capital account displays a surplus, the exchange rate appreciates, and the domestic interest rate is forced downwards.[12] The drop in the domestic interest rate gradually reduces the flow of incoming capital, and equilibrium is restored in the balance of payments. The drop in the interest rate and the exchange rate appreciation may or may not lead to a new equilibrium involving a greater level of output, depending on the elasticity of imports and exports vis-à-vis exchange rate variations, and of the investment schedule with respect to changes in the interest rate.

The expansion in the money supply resulting from foreign capital inflows can be an important source of inflationary pressures, threatening to bring about an even greater deterioration of the trade balance. The expansion of the money supply can be curtailed by sterilizing the effects of the influx of capital. This can be done through open market operations in which the central bank sells bonds or securities and withdraws money from circulation in an amount equivalent to the incoming capital flows. In doing this, the central bank increases its domestic indebtedness. To put it in other terms, sterilization takes place when the central bank trades foreign exchange for domestic currency but reverses the expansion of the money supply through open market operations. This permits the economy to operate with a constant money supply and to keep inflation under control.

Although limiting the expansion of the money supply may be a worthwhile objective, the central bank's intervention with sterilization interrupts the adjustment process. The automatic regulation outlined above relies critically on interest rate variations as capital flows take place. But, by maintaining a constant money supply, sterilization keeps the interest rate at an artificial level that is higher than the international rate. Capital inflows continue, reserves grow (but at an additional cost), and domestic investment continues to be confronted with a high interest rate.

In the case of Mexico, intervention with sterilization has been taking place since the crisis in 1994. This has allowed the authorities to maintain an overvalued exchange rate, bringing inflation under control but further reducing competitiveness and causing the trade balance to deteriorate. As international reserves have increased to historical levels, the central bank has continued to pursue a restrictive monetary policy, maintaining interest rates at even higher levels. This limits the economy's capacity to attain adequate growth rates, while, at the same time, maintaining high rewards for foreign capital. The capital flows that result from this further contribute to the appreciation of the exchange rate and the deterioration of the country's external accounts.

The contradiction is defined in terms of two processes in the model. On the one hand, the model requires the interest rate to fall in order to restore equilibrium in the money market in the face of incoming capital flows. On the other, a basic tenet of the model is that because an expansion of the money supply leads to increased inflation, the money supply must remain constant; this keeps the interest rate artificially high. In practice, the contradiction is resolved through intervention with sterilization, a higher interest rate and an overvalued currency.

The third contradiction: capital flows and artificial financing of imports

One of the anticipated benefits of financial liberalization is that a country can access foreign savings to finance its purchases of capital goods and intermediate products, and thereby increase productive investment. But capital flows also allow a country to finance a deficit in its trade balance. From the point of view of the model's rationale, this is a desirable outcome, as imports of capital goods can be used to increase exports. However, if the trade deficit is basically due to imports of consumer goods, the trade deficit cannot be financed by capital inflows for a long period of time.

Incoming capital flows can artificially maintain a country's capacity to import goods, without any clear relationship to the country's capacity to export (and to generate badly needed hard currency flows). From this point of view, capital flows are analogous to foreign aid, which can also artificially support a high level of imports. Some economists have noted that the use of capital inflows to maintain imports may have a contractionary effect on the domestic market and the level of aggregate activity (Bhaduri, 1998; Bhaduri and Skarstein, 1996). These authors analyze the problem in a simplified manner, starting with the basic formula of national accounts in an open economy:

$$I - S = I - s(Y) = (M - X) = A$$

where I is investment; S, savings; Y, income; s, the (constant) fraction of income assigned to savings; M, imports; X, exports, and A, foreign capital flow.[13] According to this formula, the level of national income, determined by the size of the domestic market or aggregate demand, is derived from the formula

$$Y = (1/s)\,(I - A)$$

This second equation indicates that as capital inflows take place (A increases), for any level of investment, national income is reduced by the multiplier effect.

Imports may lead to a reduction in aggregate income through a perverse effect of the well-known Kahn–Keynes multiplier: the initial impulse towards contraction is provided by the substitution effect that replaces domestic production with imports in certain branches of industry; the multiplier process leads to successive rounds of additional induced reductions in aggregate demand for domestic production, in the familiar, converging geometric series. At the beginning of the process, the substitution effect leads to a reduction in profits, wages, and jobs as the branches affected by increased imports are eliminated. But in successive phases, this initial reduction of domestic production creates additional cutbacks in aggregate demand. The overall, final reduction in profits, wages, and jobs can be significantly greater than the original drop caused by the direct impact of imports. The contraction of demand and domestic production in successive stages does not imply new or greater substitution effects directly caused by trade liberalization or by the capacity to finance imports that capital flows bring about. That is, the induced impact does not come from the lack of competitiveness of local industry.

These perverse effects are even more intense when capital inflows take place in the framework of rapid and indiscriminate trade liberalization, as was the case in Mexico in 1989–95. The contractionary effect is more pronounced when, as in Mexico at that time, fiscal policy emphasizes limiting public spending in order to achieve a primary (government budget) surplus, and when restrictive monetary policy is attempting to control inflation. In this adverse environment, the combined effect of foreign capital flows and government policy amounts to a veritable attack on domestic productive capacity.[14] And this scenario becomes still more complex because of its interaction with the first contradiction, discussed above: the overvaluation of the exchange rate encourages an increase in imports, while the need to encourage and continue foreign capital inflows requires exchange rate stability and strengthens trends leading to more overvaluation.

Capital inflows do not necessarily reflect a healthy state of the economy. In fact, they turn the capacity to import into an exogenous variable. The liberalization of the financial sector and of the capital account

opens the possibility of increased private-sector indebtedness. As a result, a country's capacity to import becomes disconnected from its ability to generate foreign currency through exports. In this context, higher levels of investment and capital flow make aggregate demand and income grow. But this expansion in aggregate demand translates into greater imports, which have a contractionary effect on domestic production. As Bhaduri points out (1998: 155), this perverse effect will appear even when a higher level of capital flow leads to greater investment and exports, as long as the marginal propensity to import associated with capital flows is larger than the corresponding marginal propensity to invest and export.

Under a floating exchange rate regime, like the one implemented in Mexico since 1995, the above conclusions are not reversed; in fact, they may even be strengthened. Despite the trade imbalance, the exchange rate appreciates as a result of capital flows; this normally means that the trade deficit becomes even worse.[15] Thus, as a result of capital inflows and increases in imports, domestic production and demand contract (ibid.).

In a framework of financial and trade liberalization, capital flows that can finance the capacity to import without generating foreign currency through exports may lead to a perverse process of cumulative causation – using the terminology from Hirschman's theory of development economics. The disequilibria in a country's foreign accounts can be financed by capital inflows, but these resources only help deepen the external imbalance and, through the effects on aggregate domestic demand, contribute to further dismantling of the domestic productive apparatus.

This contradiction is resolved by maintaining financial deregulation, and by hoping that it will somehow lead to enough investment to escape from the import trap. The problem of artificial promotion of imports is conventionally ignored; the free flow of capital is simply presented as the ideal manner for a country to access foreign savings, increase productive investment and enter a path of sustained growth.

The fourth contradiction: domestic savings and financial deregulation

The model also reveals a contradiction between events taking place in the financial sphere and processes that are present in the real economy. This contradiction arises when an economy attempts to increase domestic savings – in the hopes of leading to higher rates of productive investment – through deregulation of the bank and nonbank financial sectors.

It is assumed that the deregulation of the financial and banking sectors can lead to an increase in domestic savings, because economic agents have greater opportunities for profitable investments. In addition, it is assumed that domestic financial deregulation provides more powerful risk management instruments. However, it is difficult to ascertain that the rewards to financial savings generally bring about greater productive investment.

Because of deregulation, a growing part of domestic savings can be directed instead towards financial or speculative investments such as the stock market, various financial instruments, and even currency markets. Returns to speculative investments in currency markets, for instance, can be a powerful attractor and, even though risks do exist, they may appear to be less of an obstacle than the hazardous path of new productive investments.

The process of international financial deregulation is usually implemented at the same time as an almost complete deregulation of the domestic banking sector.[16] When this takes place, domestic restrictions on cross-market access for financial institutions are eliminated, blurring the traditional distinctions between the operations of banks, investment firms, mutual and pension funds, insurance companies, and stock exchange brokerage firms. Also, quantitative controls on various forms of loan allocation schemes are scrapped, as well as requirements for the provision of credit to specific sectors such as agriculture or housing. Perhaps even more important is the elimination of preferential interest rates for favored sectors and the slackening of cash reserve requirements for financial institutions.

In Mexico, deregulation of the financial sector coincided with the privatization of banks (1989–92); the explicit goal was to offer more efficient conditions to users of bank services. In theory, competition among banks would lead to better service, greater options for investors in terms of financial products and credit operations, and, above all, lower interest rates. These goals were not attained; instead, during the first years after the reforms were introduced, most banks started to suffer from a growing volume of nonperforming loans. In 1994–95 the financial crisis brought about the collapse of the banking system, and the government stepped in with a costly and inefficient rescue scheme.

As a percentage of GDP, domestic savings fell from 20 to 15 percent between 1988 and 1994. Even in the context of the low inflation that prevailed during those years, the measures that were adopted failed to increase domestic savings. It is true that domestic savings began to increase once again between 1995 and 1998, and that by 1999 they were approaching the levels of 1988. But this later increase in domestic savings is not related to the deregulation of the banking sector. Domestic savings increased during the 1995 crisis because of a spectacular fall in domestic consumption. Not surprisingly, this boost in savings was confined to the three highest-income deciles of the Mexican economy and was even more apparent in the highest decile. The rate of investment, however, remained stagnant and started to drop, even as this modest recovery of savings was taking place.

Here the contradiction is expressed as follows: on the one hand, domestic savings must be increased in order to promote productive investment, but, on the other hand, the deregulation of the financial sector

opens new possibilities of speculative investment for the domestic saver. These new possibilities can be more attractive than those offered by investments in the real economy, and thus the incentives for productive investment are distorted. In addition, the rate of return that comes from placing funds in financial instruments, within a framework of deregulated capital accounts and interdependent financial markets, connects resources from domestic savings with the sphere of international financial speculation.

We must also consider that to the extent that currencies from other economies become more attractive assets, especially if we consider arbitraging opportunities and the possibility of moving from one economic space to another in response to disparities in exchange and interest rates, agents may prefer to speculate on the foreign currency market. As volatility and uncertainty intensify, agents feel increasing pressure to engage in these operations. The need to seek protection from foreign competition, which becomes more intense as a result of simultaneous trade and financial deregulation, compels investors to prefer short-term rates of return.

One might guess that this contradiction – that is, the fact that deregulation designed to stimulate savings and productive investment leads to speculative investment instead – was linked to the size or level of development of the national economy. However, exactly the same phenomenon can be seen in the United States, in the mounting evidence of speculative and questionably legal investment during the boom of the 1990s – a time of rapidly expanding deregulation of financial and other markets. Deregulation of electricity markets in California led to little if any productive investment, but allowed Enron and others to "earn" billions by fraudulent manipulation of the unfamiliar rules of newly deregulated markets.

The fifth contradiction: the role of the state and competitive advantages

The standard open economy model also reveals an important contradiction between the goal of achieving an effective insertion in the global economy and that of reducing, as much as possible, both the size of the state and the degree to which it intervenes in the economy. The latter goal is tied to the notion that it is crucial to maintain healthy public finances in order to limit public indebtedness, avoid putting pressure on interest rates, and prevent a crowding out of private investment. This warning of the dangers of active fiscal policy is itself the subject of long-standing macroeconomic controversy. However, another dimension of public policy is of more immediate relevance to the path of export-led growth that is endorsed by the open economy model: reducing the role of state intervention can hinder the ability of a country's industrial apparatus to overcome the barriers to entry that exist in the international arena.

A country implementing an open economy model ultimately must rely

on a strong export sector capable of generating enough resources to finance imports (or at least to keep trade deficits under control). In many industrial branches, exporting may require overcoming the barriers to entry that exist in the world market; this has historically been attained only through a strategy involving active state intervention (see Ackerman, "An offer you can't refuse," Chapter 9 in this volume). In fact, this has been the path followed by newly industrialized economies such as Japan, the Republic of Korea, and Taiwan. The style of this public intervention varies, but in most cases it has involved adequate allocation of public resources to activities such as research and development, and some level of strategic planning or institutional support for leading export sectors. Often this has resulted in a very successful pattern of insertion in the international economy.

During the past twenty years, the ideology of reduced state intervention has been championed by organizations such as the IMF and the World Bank. It is based on the belief that market forces alone can achieve a more efficient allocation of resources and that, therefore, no amount of industrial or technology policy can improve on that outcome. While it has the apparent support of a narrow interpretation of conventional economic theory, it has no significant record of historical success to point to. Many studies have shown that "hands-off," laissez-faire public policy was not the path followed by successful countries embarking in late industrialization (Amsden 1989). When state intervention is ruled out as a means to generate competitive advantages, the possibility of developing dynamic, successful export-led growth may be lost, and an open economy may become heavily dependent on foreign capital flows in order to finance its chronic trade deficit.

Again, the contradiction is "resolved" in practice by forgetting one side of the problem, and hoping for the best: what if all previous historical experience was only prologue, and the true success of laissez-faire is only now about to appear on the world stage? If so, then the IMF and the World Bank are right, and the less government, the better. Some readers may prefer, as we do, more historically grounded hopes.

Conclusions

A critical appraisal of the open economy model that underlies current economic policy in Mexico needs to go beyond the analysis of the empirical data normally used for policy evaluation. Although this type of analysis is important, it is not enough. A deeper analysis of the model's structure and the dynamics of its adjustment processes is required to justify changes in economic strategy. Our investigation shows that the standard open economy model does not offer a blueprint for a viable development strategy – not only because it has failed, so far, to deliver adequate results in terms of growth and welfare, but also because it contains internal contradictions that prevent it from performing adequately in general.

In Mexico, all of the contradictions examined in this chapter coexisted during the 1990s, and they continue to affect economic performance today. The combined effect of these contradictions is a stagnant economy with a vulnerable balance of payments, crippled public finances and increased poverty. While an economic elite has prospered under the open economy model, and foreign capital has found it profitable to enter Mexico, there is no evidence of a development strategy that will raise the standard of living and welfare of the great majority of Mexicans. Unless changes are implemented in macroeconomic policy, including the introduction of some kind of capital controls, Mexico cannot hope to embark on a path toward equitable, sustainable development.

In designing an alternative economic strategy, there is no need for a dogmatic rejection of every aspect of current policy. Some aspects of the open economy model can be recovered and may become part of a very different, more robust strategy. For example, maintaining a healthy balance in public finance is not an unreasonable goal. And policies for public intervention should be based on the recognition that prices and markets also have an important role to play.

On the other hand, many aspects of the open economy model need major surgery. Monetary policy needs to be redefined. The obsession with inflation needs to be reexamined in view of the colossal social cost entailed by this policy. Although rapid or unpredictable inflation is not good, restraining growth in order to achieve inflation rates that are comparable to those that exist in highly industrialized countries does not always make sense for a country like Mexico. The monetary approach to the balance of payments and the linkages between monetary policy and the capital account also need to be reworked. The delicate subject of reregulating the capital account needs to be approached with a fresh outlook, especially after the experience of the financial crises of the past decade.

Fiscal policy is another critical element in an alternative strategy. The easy slogans concerning the need to reduce the fiscal deficit must be abandoned. In their place, more robust and well-grounded policy objectives, for both the short and the long term, need to be established. From the viewpoint of tax revenues, a new, progressive taxation scheme is needed; the well-known recipes of relying more on value added taxes need to be questioned, especially in the context of high income inequality. And on the side of expenditures, it is of vital importance to restructure the colossal liabilities (more than $89 billion) that resulted from the bailout of the banking system in the aftermath of the 1994 crisis. Unless this restructuring takes place, servicing these liabilities will continue to impose a straitjacket on fiscal policy.

And finally, the notion of a state that is not the main actor in the development process is one that needs critical evaluation, because economic history – even for Western free market societies – teaches a very different

lesson. While markets are important, markets alone are not enough to generate economic success or to redress competitive decline.[17]

The open economy model, like other conventional macroeconomic models, ultimately rests on a foundation of assumed microeconomic equilibrium. Usually the connection remains implicit, although there have been occasional (not entirely successful) attempts to spell out explicit microfoundations for macroeconomics. The Mundell–Fleming model, like other macro models, emphasizes the advantages of free market allocation of resources because it accepts the notion that the goods and services market assigns resources efficiently. Unfortunately, nothing in contemporary theory of markets and price formation provides a solid foundation for this belief.

Since Adam Smith, the goal of economic theory has been to develop a theory of the process through which the market efficiently assigns resources. In the early nineteenth century, classical economic theory was oriented around a technical model that is very different from the one developed by the neoclassical school. Still, the organizing principle was the same: the task was to prove that if left to operate freely, market forces would lead a society of greedy individuals to a point in which all agents' plans would be compatible. Twentieth-century work on general equilibrium theory continued to maintain that the greatest contribution of economics to the understanding of social dynamics is precisely this idea of the invisible hand (Arrow and Hahn 1971). Unfortunately, in spite of the deep continuity of this research program, economic theory has not been able to furnish free market ideologues with the results they expected.

The idea that markets allocate resources efficiently is valid only at equilibrium. Outside of equilibrium the world is not Pareto-optimal, and we simply cannot make a judgment about efficiency. Microeconomic theory often contrasts different states of the world in terms of comparative statics, examining portraits of different equilibrium positions. Yet the real world does not jump suddenly from one equilibrium point to another. The Mundell–Fleming model, and particularly the Mexican reality that we have examined in terms of that model, tells a story of chronic, or at least recurring, microeconomic disequilibrium. Optimality and equilibrium do not characterize the financial arrangements, nor the access to and use of technology, nor, above all, the employment of labor and natural resources, in the economy we have been describing.

The problem of disequilibrium would be a minor one if markets, in general, converged quickly to stable equilibrium points. However, general equilibrium theory has been able to prove that disequilibrium prices converge to equilibrium only under extremely restrictive and arbitrary conditions.[18] In other words, we still lack a general theory that reveals how market forces lead to equilibrium. And since efficiency is a property of equilibrium, we conclude that, in general, we cannot affirm that market forces, when left alone, allocate resources efficiently. The open economy

macroeconomic model appears to rely on a postulate that cannot find any justification, even in the most abstract model of a market economy.

Notes

1 This chapter is the result of research carried out on the project "Designing an Alternative Economic Strategy for Sustainable Development in Mexico," which received generous support from the John D. and Catherine T. MacArthur Foundation.
2 For a critical appraisal of Mexico's economic performance, see Nadal (2003).
3 See Fleming (1962) and Mundell (1964). For a description of the essential aspects of the Mundell–Fleming model, see Blanchard *et al*. (1989).
4 Perfect capital mobility implies that small changes in interest rates lead to very large capital flows. As a result, autonomy in monetary policy is lost. If the central bank wants to increase interest rates, it restricts the monetary supply, and that increases interest rates. But foreign investors flock to the economy. These capitals are placed in bonds in local currency, and the exchange rate appreciates. The monetary supply increases because the central bank has to change foreign currency into local currency. The contraction of the initial monetary supply is reverted.
5 The validity of these measures was ratified (and their reach was defined) during the Uruguay Round of trade negotiations (GATT 1994). For a discussion of these measures and the cases in which they were applied, see Nadal (1996).
6 The contents of the article on exceptions may be summarized as follows: "There will be no exceptions." While the WTO's 1994 Memorandum of Understanding carefully explains the rules that must be followed to avoid abuses when the exceptional measures are applied, it does not eliminate them, while NAFTA does. For a detailed analysis of this NAFTA article and its implications in the context of the 1994 crisis, see Nadal (1996).
7 According to this article, the adjustment of a balance of trade deficit is not only carried out through exchange rate variations. It must also be accompanied by a package of economic measures that must be established after good-faith consultations with International Monetary Fund (IMF) authorities. Much has been written about the contractionary effects of the measures recommended by the IMF when there is a balance of payments crisis (see, for example, Stiglitz 2002). It is important to point out that originally, the exceptional measures allowed in the GATT were not required to be tied to any particular macroeconomic policy package.
8 In the Mexican case, anti-inflation objectives have also been pursued through a restrictive monetary policy and containment of real wages.
9 If the components of the capital account are deregulated, capital flows can move freely in and out of a country.
10 By the end of 1994, the overvaluation in Mexico had reached 16 percent; the peso–dollar exchange rate should have been adjusted from 3.5 to 4.10 pesos per dollar, but in the chaos that followed the December devaluation, the exchange rate was established at 7 pesos per dollar. Interest rates skyrocketed, and this, in turn, led to a deeper crisis for the entire banking system as the volume of nonperforming loans exploded. Inflation, which had fallen to a one-digit level in 1993, also exploded and reached 58 percent in 1995, while GDP dropped by 6 percent.
11 When trade and financial liberalization are implemented simultaneously, capital flows can finance a deficit in the trade balance. From this point of view, the disequilibria in the balance of trade are no longer a matter of concern.

If the economy is able to finance its imports with these flows, it is assumed that a persistent (or even a growing) deficit is not a serious problem. This view is close to the so-called "Lawson approach" (named after Margaret Thatcher's Chancellor of the Exchequer), which considers that a current account deficit is not a macroeconomic problem as long as it is caused by the indebtedness of private agents.

12 In the standard Mundell–Fleming model, when the money supply grows and the level of income remains constant, the interest rate falls, reducing the cost of holding money, and this reestablishes equilibrium in the money market.

13 Bhaduri uses *A* for this flow because it is similar to a foreign aid flow.

14 Mexico's interindustrial forward and backward linkages have been badly severed as a result of the combination of rapid and nonselective trade liberalization, capital account deregulation, and exchange rate appreciation. Together with the contractionary posture in monetary policy, this process has not received sufficient attention. An indicator of the relevance of this analysis is that during the first quarter of 2000, the Mexican economy's GDP grew more than 7 percent, and the demand for domestic goods also grew 7 percent, while the demand for imported goods grew 43 percent. The balance of trade deficit experienced a 12 percent increase when compared with the corresponding quarter in 1999. During this period, exchange rate appreciation remained at approximately 25 percent.

15 Strictly speaking, the trade balance will deteriorate when the domestic currency becomes overvalued if the Marshall–Lerner conditions are met – that is, if the sum of the absolute values of the exchange-rate elasticities of imports and exports is greater than 1.

16 There are four ways to meet the need for hard currencies: (a) resorting to foreign direct investment (FDI); (b) attracting portfolio investments; (c) borrowing abroad and increasing foreign indebtedness; and (d) generating foreign currency by exporting goods and services. To the extent that the latter is not sufficient, the other three possibilities need to be considered. In general terms, FDI is preferred over the other two, but it is not always enough. To incur in public debt through loans has lost relevance for several reasons, while portfolio investments are more and more common. But flows of portfolio investments can be reversed quickly, with dire consequences. In order to maintain a steady flow, adequate real rates of return are required. Thus, short-term portfolio investments pressure the leading interest rates and the whole rate structure upwards.

17 For a lucid account, see Lazonick (1991).

18 These results were originally presented in the classic articles by Arrow and Hurwicz (1958) and Arrow *et al*. (1959). The property of stability was demonstrated only for cases where all goods are gross substitutes or those where the weak axiom of revealed preferences at the aggregate level prevails. On the basis of these results, these authors surmised that, in general, in an Arrow–Debreu economy, stability would be a property of equilibrium. Herbert Scarf (1960), in an equally classic work, proved that this was not so. Finally, in the 1970s, Sonnenschein (1972), Mantel (1974), and Debreu (1974) demonstrated that it was not possible to achieve any positive, general results regarding stability. See Ackerman, "Still dead after all these years," Chapter 1 in this volume.

9 An offer you can't refuse

Free trade, globalization, and the search for alternatives

Frank Ackerman

Rarely have such abstract ideas become so directly relevant to public life. The results of general equilibrium theory, popularized as the magic of the invisible hand, lead straight to a prescription for trade policy. The connection to economic theory invests that policy position with the aura of established, scientific truth. "This task of ceaselessly defending our scientific findings in favor of free trade (and indeed of other economic wisdom) is an obligation that I teach tirelessly to my students," says Columbia University economist Jagdish Bhagwati, one of the leading academic proponents of free trade (2002: 9).

Science, for Bhagwati and like-minded economists, begins with the observation that competitive markets lead, in theory, to optimal outcomes. As a result, expanding the scope of markets must be beneficial for all, on a global as well as national scale. All remaining barriers to free international trade should therefore be removed; the neoliberal agenda, calling for rollback or removal of all state interference in the global market, must be the fastest route to economic progress. From this perspective, when international financial agencies enforce the freedom of the unregulated marketplace on reluctant debtor nations, they are only preventing them from straying off the one true path.

As shown in earlier chapters, there are fatal flaws in the proof of the optimality of market outcomes. But the critique of general equilibrium theory can be almost as abstract as the theory itself, and does not immediately translate into an alternative. The critics of unrestricted trade and neoliberal styles of globalization have not, for the most part, found a clear expression of their position in the language of economic theory.

Yet opposition to unregulated trade cannot be ignored. The pattern first seen in Seattle in 1999 is now repeated on a regular basis around the world. As government representatives gather to negotiate further advances in free trade and economic integration, crowds of trade unionists, environmental advocates, and others gather to protest against the inequities of the global economic system, and to proclaim that "another world is possible." If market outcomes were really Pareto-optimal, would the advocates of free trade need police protection? Are the protesters no

better than flat-earth fanatics, refusing to recognize the results of science – or is it the case, as argued here, that another worldview is possible?

This chapter examines and critiques the theory of free trade, seeking to understand both the power of the theory and its limitations. The first section briefly presents the theory of free trade and offers an interpretation of its claim to scientific rigor. The second section surveys the theoretical critiques of free trade, and the third section reviews the reliance on protectionism in leading cases of industrial development in the past. The fourth section describes the neoliberal policies that have often been imposed by international institutions, and the disappointing evidence on their results. A final section offers concluding thoughts on alternative approaches to trade and development.

Economics, science, and trade

Traditional trade theory

The theory underlying free trade policies is disarmingly simple. If voluntary trades in unregulated competitive markets are always Pareto improvements, then bigger and freer markets must be better for all. In the words of *New York Times* columnist Thomas Friedman (1999: 8), "the more you let market forces rule and the more you open your economy to free trade and competition, the more efficient and flourishing your economy will be."

Theories along these lines, demonstrating the benefits of trade under particular institutional arrangements, date back to the classical economists of the early nineteenth century. David Ricardo assumed that factors of production are mobile between industries within a country but not between countries, and that all production technologies are available in all countries. Under these assumptions he demonstrated that each country maximizes this year's national income by specializing in those industries in which it currently has a comparative advantage. (In what follows, we will refer to this as "static comparative advantage," since it reflects conditions at a single moment; in contrast, the dynamic comparative advantages that might develop over time turn out to have different implications for theory and policy.)

The neoclassical economics of the twentieth century developed the same general argument in a later and more elaborate theoretical framework. Its best-known accomplishment is the *Hecksher–Ohlin theory*. Eli Hecksher and Berril Ohlin analyzed a model in which the same factors of production, such as land, labor, and capital, are combined in different proportions to make different products. They demonstrated that a country will do best by exporting products that make most intensive use of the country's most abundant factor of production. For example, a country with a lot of low-wage labor will tend to have a comparative advantage in labor-intensive industries. Although this sounds obvious, the proof of the Hecksher–Ohlin theory rests on a number of assumptions, including constant returns to scale in all industries, and the hypothesis that differences in factor endowments are the main source of comparative advantage (Cohen *et al*. 1996: 61).

Further developments of the theory spell out the implications for income distribution. The *Stolper–Samuelson theorem*, developed by Wolfgang Stolper and Paul Samuelson, shows that if factor incomes are based on their marginal products, then a move to free trade causes a gain in income for the owners of the country's abundant resources – higher wages, in a country specializing in labor-intensive industries – and a decrease in income for the owners of the country's scarce resources. A stronger result, derived independently by Samuelson and by Abba Lerner, is the *factor price equalization theorem*: in the Hecksher–Ohlin model, free trade among sufficiently similar economies leads to international equalization of factor prices. The common fear that competition with China will drive everyone's wages down to Chinese levels could be seen as an intuitive version of factor price equalization. However, the proof of the theorem is again dependent on technical assumptions, in this case including the degree of similarity between the economies in question.

What kind of truth is it?

Economists are fond of comparing their work to the natural sciences. In doing so, they often adopt a simplistic vision of science, in which statements about the world are proved to be true or false on a purely objective, entirely data-driven basis. Bhagwati's task of "ceaselessly defending our scientific findings in favor of free trade" does not suggest a picture with room for subtleties or shades of gray. Much more nuanced and complex understandings of the structure of scientific reasoning are of course available. For our purposes, one small step beyond black-and-white dichotomies will suffice: there is a crucial distinction between narrowly defined statements about how an individual physical process works in isolation, and broad statements about how a large natural system works as an interacting whole.

Some scientific statements are simply true: the hypothesis that under certain conditions, small amounts of matter can be converted into enormous amounts of energy has been amply confirmed by the performance of nuclear weapons and power plants. Equally, some statements are simply false: the "cold fusion" hypothesis, claiming that nuclear fusion can be achieved with simple apparatus at ordinary temperatures, appears to have been rejected due to the total failure, to date, to replicate the isolated initial reports of success.

These statements, whose truth or falsehood is not in doubt, refer to isolated mechanisms: ignoring or controlling for everything else, this is how

one aspect of the world works. Many statements in economics, including trade theory, are of the same type. If the assumptions made by Ricardo, or by Hecksher and Ohlin, were valid, and everything else could be ignored, then the standard conclusions of trade theory would follow. Presented this way, the economic theories are purely logical deductions, with no reference to empirical reality; but there is little doubt that selected real-world examples can be found that fit Ricardo's theory of comparative advantage, or the Hecksher–Ohlin explanation of patterns of trade. Such examples could confirm that static comparative advantage, like nuclear fission, is *among* the forces that explain reality.

The jump from theory to policy, however, lands in a different realm of discourse. Here the goal is no longer to analyze isolated causal mechanisms, but rather to explain complex, multicausal phenomena. Consider the message of free trade advocates to developing countries: "Opening an economy to international trade, and specializing in production for export based on static comparative advantage, maximizes national income and thus provides an ideal way to obtain the resources needed for development." This is not a statement about a model, or one isolated causal mechanism; it is a strong claim about what works, and what does not, under common conditions in the real world.

The scientific equivalent of such statements – the explanation of ordinary phenomena involving multiple causal factors – is also a complex endeavor. Consider an idea that countless people have learned in introductory science classes: "Gravity causes all objects near the earth to fall toward the earth with a constant rate of acceleration." Is this true or false? On the one hand, gravity is familiar, and of obvious importance, in daily experience. If one hopes to understand the dynamics of objects in the earth's atmosphere, then gravity can never be forgotten. There is a universally accepted theory that implies that in a vacuum and in the absence of other forces, gravity does cause falling objects to accelerate at a constant rate. When such conditions are created in a laboratory or museum, the predicted effects of gravity can be observed.[1]

On the other hand, it is quite unusual to observe objects directly obeying the predictions of Newton's law of gravitation, without adjustment for interaction with other forces. Those interactions can be complex and powerful: in ordinary experience, birds, Frisbees, and airplanes all seem to defy gravity for varying lengths of time. A piece of paper tossed in the air usually does fall to earth, but not at anything like a constant rate of acceleration.

The statement about gravity, like the statement about static comparative advantage, is an important partial truth that is directly, observably true only under a narrow, carefully defined set of circumstances. Understanding that single force alone would offer a very imprecise guide to ordinary experience; understanding the other forces at work is equally crucial, and in practice far more complicated.

Metaphorically speaking, the task of creating a successful development strategy may be analogous to designing a successful airplane. The gravitational force of static comparative advantage pulls low-income countries back toward specialization in producing raw materials or engaging in low-skill, low-wage industry, sectors with little promise for the future.[2] The goal is to achieve a takeoff, to sustain flight into higher-skill, higher-income activities. And in aircraft design, modeling the effects of gravity is an elementary exercise, while modeling the aerodynamics that allows large metal objects to overcome gravity is a difficult engineering challenge.

The same is true in trade theory. It is easy to understand the pull of existing patterns of comparative advantage; it is more difficult to analyze how to overcome it. For any country, there are obvious benefits to accepting trade on the terms that it is offered. Some valuable products are not physically available in every country: aluminum is used everywhere, but bauxite, the ore from which it is extracted, is mined in only a few countries. Even in manufacturing, modern industry is so complex and diverse that only the largest countries could ever hope to engage in all branches of industrial production. To obtain aluminum in most parts of the world, or to obtain goods that are not manufactured locally, trade is essential – and following static comparative advantage is usually the way to do best, at a given point in time, in trade.

Yet always giving in to the appeal of comparative advantage as it exists today would mean staying on the ground in the future, remaining trapped in resource-based or low-wage, low-skill export industries with little potential for growth. The next section examines the "aerodynamics" of trade and development – that is, theories about the limitations of free trade and static comparative advantage.

Critiques of free trade: a taxonomy

There is an extensive literature on theoretical critiques of free trade, many of them stretching back into nineteenth-century, or occasionally even earlier, debates. An in-depth survey of this literature by Douglas Irwin (1996) reveals many interesting alternatives that have been too quickly dismissed.[3] In fact, there are so many different arguments against free trade that a taxonomy is needed to organize them. Four groups of critiques can be distinguished, based on their principal causal mechanisms. One group – including two major theories – reflects the segmentation of the global market resulting from the existence of national boundaries, economies, and currencies. A second group depends on the market structures of export and import industries, including the "infant industry" argument and the once-prominent strategy of import substitution. Closely related is a third group of theories involving the nature and dynamics of technology, including the "new trade theory" or "endogenous growth" school that emerged in the 1980s. A final group, encompassing most social

and environmental critiques, highlights the effects of trade beyond the export and import product markets, such as the impacts on labor and the environment.

Boundary effects

One important early argument, originally due to Richard Torrens and amplified by John Stuart Mill and Francis Edgeworth, demonstrates that tariffs can improve a country's terms of trade. Torrens, a contemporary of Ricardo and originally a free trade advocate, later pointed out that tariffs reduce the demand for imports and thus reduce the demand for foreign currency. This boosts the value, and the international purchasing power, of domestic currency. Thanks to the terms of trade effect, tariffs can make a country better off, though at the expense of larger losses in other countries. This implies that there is often an optimal, nonzero tariff; some nineteenth-century debate focused (inconclusively) on the question of whether, under reasonable assumptions, the optimal tariff rate was quite low (Irwin 1996: 101–15).

Whatever the optimal level turns out to be, the policy implication is clearly that unilateral tariff cuts below the optimal level are not in a country's own best interests. Reciprocal, negotiated reductions are needed to bring tariffs below the single-country optimal level; such reductions can yield net gains on a global level, but not necessarily gains for each of the negotiating countries. Meanwhile, the terms of trade effect may help to explain why protectionist policies have so often proved successful in the past.

Another argument concerns the effects of international capital flows. Most theories of free trade assume that factors of production remain in the country where they are located. Thus, when capital and labor are displaced from one industry by trade competition, they are presumed to move into other industries in the same country, ending up in the industry where the country has a comparative advantage. Today, this "no migration" assumption is not entirely accurate for either capital or labor – but it is much farther from the mark for capital.

A small minority of the world's labor force does migrate to countries with higher wages, depriving developing countries of some of their most ambitious and skilled workers. However, capital is increasingly footloose, facing almost none of the obstacles to international migration that people encounter. When capital and labor are thrown out of work by trade competition, therefore, a few of the workers, and most or all of the capital, may move to other countries in pursuit of higher wages or profits. The possibility of capital flight undermines the promise of national development via openness to trade. Rather than moving into and building up industries where the host country has a comparative advantage, capital can just look for greener pastures on a global scale.

Both the terms of trade effect and the capital flight problem reflect the existence of distinct national economies – a crucial modification to the abstract model of a perfectly competitive global market. The fact that nations have their own currencies and tariff policies is the basis for the terms of trade effect and the resulting optimal tariff rates. The fact that capital is much more internationally mobile than labor undermines the classic argument that markets will shift resources toward a country's current comparative advantage. Those changes alone suffice to produce an outcome that is interestingly at variance with the standard free trade argument.

Infant industries and market structure

If textbook-style perfect competition prevailed on a global basis in export industries, then entry to and exit from these industries would be quick and costless, and firms producing the same goods would have the same costs everywhere. One long-standing critique of free trade theory stems from the failure of this assumption: often, there are important economies of scale and barriers to entry in desirable export industries. A developing country that wants to enter these industries may need to interfere with the market in order to get in.

The need to protect a nation's small, newly started ("infant") industries, so that they can grow up to compete on a world scale, is one of the most popular grounds for tariffs, import quotas, and other forms of protection. Political advocacy of protection for infant industries dates back at least to Elizabethan times in England (Irwin 1996: 116). Adam Smith rejected the infant industries argument, but influential thinkers, including Alexander Hamilton in the United States, Friedrich List in Germany, and John Stuart Mill in Britain, all accepted and developed it. If there are steep economies of scale, high start-up costs, or significant "learning by doing" effects, unit costs will be high at first. Costs will then drop sharply as the industry moves beyond infancy, at which point it might no longer need protection from international competition.

There is obvious potential for abuse of infant industry protection; industries and their supporters will be eager to win protection, but less enthusiastic about ending it when the industry is objectively ready for international competition. However, the infant industry problem is a real one for countries beginning to industrialize. As is explained in the next section, protection of infant industries has been a feature of virtually every successful case of industrialization to date.

Some industries may never entirely shed their "infant" status – that is, economies of scale may remain significant at all levels of production. The world market may not be large enough to support more than a few optimal-sized producers of commercial airplanes, for example. In such cases, protection of national industries may lead to larger sales volumes

and hence lower-cost, more efficient production. Here again, the potential for abuse of the idea is obvious, but so is the reality of the problem.

The presence of massive economies of scale implies that there are enormous costs to participation in an industry such as aircraft production. As a result, there may be a role for the public sector in choosing which industries the nation should enter. The very visible hand of government intervention has been a continual factor in aircraft production: Airbus was a creation of the British and French governments, dependent on public subsidies since its birth; Boeing has enjoyed a steady stream of U.S. military contracts (which, in effect, subsidize civilian aircraft design and production) and other forms of preferential treatment from its government.

Since industries with substantial economies of scale are typically oligopolies – nearly a duopoly, in the case of large commercial airplanes – market prices depend on strategic interaction among producers. Thus, there is no determinate market outcome against which public or private decision-making can be judged.

Import substitution, a development strategy based on selective use of protection for infant industries, was popular in the years following World War II, particularly in Latin America. Raúl Prebisch (1950) and Hans Singer (1950) argued that the terms of trade had a long-term tendency to shift against primary products. This Prebisch–Singer effect implied that countries that exported agricultural or mineral products and imported manufactures would fall steadily farther behind the industrial world, able to buy less and less with their export earnings. (Fear of being trapped in a "dead-end" specialization in primary product exports has arisen at other times and places, including a debate in Australia in the 1920s (Irwin 1996: 172–79).) To escape from this trap it was necessary to diversify away from traditional exports and overcome the barriers to entry into manufacturing. The import substitution strategy called for the targeted use of tariffs or import restrictions to protect new domestic producers in an industry the country was ready to enter. Prices would be high at first but would come down as the industry matured, at which point import restrictions could be lifted on that industry and applied to the next target for economic development.

While import substitution has gained a tarnished reputation in recent years, it was far from a total failure. In the 1950s and 1960s, the heyday of national policies based on import substitution, many developing countries grew at faster rates than in the years before or since then. Yet during the 1970s a series of problems emerged that led to a shift away from import substitution. The terms of trade did not continue to shift against primary products, as predicted by the Prebisch–Singer effect. Due to the adoption of capital-intensive, "Northern" technologies, the new, import-substituting industries employed only a small minority of the labor force. After an initial era of success, government planners often stumbled in their attempts to pick the next round of industries to target. Moreover, protected industries gained political clout and were reluctant to give up protection as they matured. Despite import restrictions, balance of payments problems emerged because imports continued to rise, often for capital goods and other inputs needed by the protected industries. When the oil crises were followed by soaring interest rates and debt crises, the need for a new economic strategy became painfully apparent.

In political and economic debate, the alternative to import substitution was typically assumed to be openness to trade, market-based policies, and export-oriented development – in short, a return to the classic prescriptions of free trade. Henry Bruton's thoughtful review (1998) of the import substitution experience offers a different explanation: import substitution faltered, particularly in Latin America, because it had ceased to create an environment in which learning and accumulation of knowledge about production could occur. These issues are addressed in the next group of critiques of free trade.

Imperfect knowledge, technology, and productivity

In general equilibrium theory, as in the elementary theory of perfectly competitive markets, the same information is available to all market participants without cost or delay. Technological possibilities are therefore identical for all: the same combination of capital and labor will produce the same output, regardless of the firm or country in which production occurs. The critique of this unrealistic assumption has become increasingly prominent in recent innovations in economic theory. It can also be seen in an early challenge to free trade orthodoxy.

One well-known objection to the Hecksher–Ohlin theory is the *Leontief paradox*. In 1954, Wassily Leontief pointed out that although capital was abundant and labor was scarce in the United States, compared to the rest of the world, U.S. imports were more capital-intensive than U.S. exports – exactly the opposite of the prediction of the Hecksher–Ohlin theory. Leontief's own explanation was that U.S. labor was far more productive than its counterparts in other countries; in productivity-adjusted terms, perhaps the United States had a relative abundance of labor after all. While many responses have been offered, one of the latest contributions to the extensive literature on the paradox supports a version of Leontief's explanation (Trefler 1993). The need to adjust the quantities of labor for national differences in productivity, however, undercuts the assumption that the same production technologies are available everywhere.

In general, it is obvious that the same information about technology is not available everywhere; the transfer of new technologies is neither costless nor instantaneous. Being "behind the curve" in technological terms is a central component of the common image of underdevelopment. Overcoming technological disadvantages is a central goal of the development

process. A theory that assumes the problem away by definition is unlikely to provide appropriate policy advice.

Education and technology are recognized as factors of production in the "new trade theory" and "endogenous growth" models that emerged in the 1980s. The production of technology is often modeled as a process with increasing returns to scale, or positive externalities that benefit other industries; in such models, the inputs required for growth become partially endogenous. Thanks to increasing returns, a small initial advantage may expand into a growing technology gap between leading and lagging nations (Lucas 1988; Grossman and Helpman 1991). If the North has a comparative advantage in innovation, it can continually stay ahead by introducing new products, even if the South eventually catches up and gains a comparative advantage in low-cost production of each old product over time (Krugman 1979).

From this perspective, what matters most is not static comparative advantage at any one moment in time, but the ongoing pattern of dynamic comparative advantage: the ability to follow one success with another, to build on one industry by launching another, again and again. Since the process of technology development is characterized by increasing returns, many models will have multiple equilibria. It is easy to specify a model in which the choice between multiple equilibria is not uniquely determined by history; rather, it becomes possible for public policy to determine which equilibrium will occur (Krugman 1991). If, in such a model, the multiple equilibria include high-tech, high-growth paths as well as traditional, low-growth futures, then public policy may make all the difference in development. This of course means that there is room for industrial and technology policies, something systematically forbidden in trade agreements since NAFTA and the Uruguay Round.

Broader harms from trade

A final family of critiques looks beyond the markets for imports and exports, examining the effects of trade elsewhere in the economy. Traditional objections have concerned the impacts of free trade on wages, employment, and the equitable distribution of resources and welfare within a country; an analogous newer critique considers the impacts of trade on imperfectly internalized environmental problems. These questions could not arise in the ideal world of general equilibrium. In theory, any undesired indirect effects of trade could be resolved by eliminating all imperfections in labor and other markets – or by creating the "missing" markets in environmental goods, thus putting a price on all externalities. But since this is impossible in practice, the indirect effects of trade on imperfect markets cannot be ignored in real-world discourse.

One of the most striking oversimplifications of general equilibrium models is the assumption that unemployment, beyond the voluntary or

frictional level, is essentially impossible. The reality of involuntary unemployment is one of the sharpest challenges to conventional economic theory: the supply and demand for labor do not follow simple textbook models; labor markets do not always clear; and wages are often inflexible downward, even in the presence of unemployment. It is no surprise, therefore, that the effects of trade on labor have prompted discussion of the need for government intervention.

John Maynard Keynes argued that tariffs to protect employment could be beneficial, under the conditions faced by the British economy at the start of the Great Depression. In the presence of rigid wages, high unemployment, and fixed exchange rates, tariffs could be helpful; if labor does not move freely between industries, free trade could increase unemployment. Free trade theory, according to Keynes, depends on the assumption "that if you throw men out of work in one direction you re-employ them in another. As soon as that link in the chain is broken the whole of the free trade argument breaks down."

Another critique concerns the effects of trade on wages. If wages differ in two sectors of a national economy, free trade could harm the country by driving labor out of the high-wage sector. A tariff to protect high-wage jobs could therefore be desirable. First formulated in theoretical terms in the 1920s by former Romanian government minister Mihail Manoilescu (Irwin 1996: 153–71), this argument is often cited by politicians, trade unionists, and others. It has drawn a rebuttal from free trade advocates: theoretically, the preferred response would be a labor market policy designed to address the inequality of wages; trade policy is, in theory, an inferior response to a non-trade-related market failure. Yet in the meantime, until the theorists succeed in banishing market failure from labor markets, policy makers will have to consider the effects of trade on labor.

A comparable problem arises, and elicits a comparable response, in the case of the impacts of trade on the environment. If two industries cause different degrees of (uninternalized) environmental harm, trade that favors one industry over the other could lead to increased damages. For instance, if export industries are more damaging than subsistence agriculture, then opening a developing country to foreign trade and moving labor into production for export could intensify environmental degradation. Again, the theoretical answer is that it is a better idea to internalize the externalities; but we have seen that the theory does not guarantee gains for everyone unless *all* externalities can be internalized. Again, the practical reply is that since this will not happen in the foreseeable future, the impacts of trade on market externalities must be taken seriously.

In view of these issues, it is no wonder that the general evaluation of the impact of trade on the distribution of income and welfare remains uncertain. The distributional impacts of trade can be undesirable even if incomes go up. There is little value to hypothetical compensation tests, showing that any aggregate income gain is a "potential Pareto

improvement" because the winners could choose to compensate the losers. All too often, the winners choose to keep their winnings, not to compensate anyone else.

Do as we say, not as we did[4]

History, as well as theory, confirms the limited applicability of the free trade ideal. Today's industrial powers did not rely on laissez-faire policies, low tariffs, and openness to the world market in the critical stages of their development. While Britain advocated free trade in the nineteenth century, as did the United States in the late twentieth century, this reflected their national interests at a point when they had come to dominate the global economic system. On their way up, Britain and the United States were actively interventionist and protectionist – just like virtually every country that has successfully industrialized to date.

The Industrial Revolution, it is well known, began with the English textile industry exploding into dominance of the world market in the late eighteenth century. Less famous is the English response to foreign competition in the early eighteenth century. In the decades before the industrial takeoff, England did not look like the world's leading textile producer. Paul Mantoux's classic history of the Industrial Revolution documents the fact that English protectionism was crucial to the rise of the domestic industry (Mantoux 1962). Competition from a nearby country with lower wages, Ireland, threatened English weavers – but having conquered Ireland in the seventeenth century, England was able to impose export duties that effectively cut Ireland off from foreign and colonial markets.[5]

Perhaps more serious was the threat from the leading textile producing nation, India. Printed calico (cotton) fabrics, almost all imported from India, became fashionable in England in the seventeenth century. In response to protests from the domestic woolen industry, Parliament prohibited imports of printed fabrics from India, Persia, and China in 1700, and strengthened the prohibition on all imports of printed or dyed fabrics in 1719. The rise of the English cotton textile industry became possible only after the import prohibitions took effect (Mantoux 1962: 199–201). Shortly thereafter, England went on to conquer India, an event which ensured that India, like Ireland, would not be able to compete with England in world markets.

Reliance on protectionism did not vanish during the early stages of England's industrial success. Imports of printed fabric remained prohibited throughout the eighteenth century; the few specialty fabrics that were imported faced high and rising tariffs; and English manufacturers received an export subsidy on calico and muslin exports (Mantoux 1962: 256–57). As Mantoux says, summarizing the state of the industry in the 1780s and 1790s,

> Nothing is less accurate than to say that the English cotton manufacture grew up without any artificial defence in the face of foreign competition.. . . If it be true that the history of the cotton industry can provide arguments for the doctrine of laissez faire, these will certainly not be found during this early period.
>
> (Mantoux 1962: 256–58)

Every country that has industrialized since Britain has had to deal with the existence of more advanced industrial powers – countries that were already exporting large volumes of low-cost manufactured goods. A strategy of openness to world markets, and focus on static comparative advantage, would have led many of the later-industrializing nations to stick to agricultural and mineral exports. Certainly this would have been true for the nineteenth-century United States, which had much greater natural resources, but initially much less industry, than Britain. Yet the infant industries of the United States were protected from British competition by the high costs of ocean transport at the time, as well as by tariffs, extensive subsidies, and other government policies designed to promote industry.

Throughout much of the history of U.S. economic development, high tariffs were taken for granted. The average U.S. *ad valorem* tariff rate exceeded 25 percent from 1821 (the first year of reliable data) through 1945, with only two brief interruptions. For long periods, the rate was even higher: the average tariff rate exceeded 37 percent in every year from 1865 through 1914.[6] Tariffs not only provided protection for U.S. industries, but also financed the government. Customs revenues exceeded all internal revenue collection in every year from the beginnings of the federal government through 1910, with the sole exception of 1864–68 (when high taxes were imposed in order to pay Civil War debts).[7] In other words, during the crucial stages of industrialization that many developing countries are now approaching, high tariffs were a reliable, long-term feature of U.S. economic and political life.

Government protection and direction of industrial development was even more explicit in the rise of the German and Japanese economies. The World Trade Organization's rules for the twenty-first-century world economy would never allow a repetition of the Japanese and German post–World War II economic "miracles," nor their impressive record of prewar industrialization, because both countries' miraculous outcomes rested on active government management of exports, imports, choices in technology development, and strategy for industrial investments. Japan is now an active advocate of strong patent protection, but its climb up the technology ladder involved copying and reverse engineering of existing technologies, activities now forbidden by the global patent system.

Latter-day advocacy of free trade by countries with this history amounts to "kicking away the ladder," as the German economist Friedrich List described it in 1841:

> It is a very common device that when anyone has attained the summit of greatness, he kicks away the ladder by which he has climbed up, in order to deprive others of the means of climbing up after him . . . Any nation which by means of protective duties and restrictions on navigation has raised her manufacturing power to such a degree of development that no other nation can sustain free competition with her, can do nothing wiser than to throw away these ladders of her greatness.
>
> (quoted in Lind 2002)

The countries that have most successfully begun to develop in recent years have been climbing the same ladder. According to Alice Amsden (2001), the East Asian success stories of post–World War II economic development, as well as the leading Latin American economies, relied on an extensive system of government involvement and support. Tariff protection was only one part of public-sector assistance to industry; governments also offered help in financing, support for research and development, strategic planning and coordination of industrial investment, and a variety of nontariff barriers that effectively blocked many imports. In Amsden's view, government intervention is essential, due to the lack of perfect knowledge – i.e., the fact that the same technologies are not available everywhere – and the need to create large firms in order to achieve the minimum efficient scale of production in many industries. As a development strategy, says Amsden,

> free trade appears to have been limited to Switzerland and Hong Kong. That is, whatever the historical time period, these are the only two obvious "countries" that managed to achieve high per capita incomes without tariff protection or export promotion . . . *both Switzerland and Hong Kong enjoyed extraordinary assets by neighboring country standards*, rendering protectionism and other forms of government support unnecessary. [Emphasis in original]
>
> (Amsden 2001: 185)

Compulsory freedom

The paths that led to development in the past, the ladders once climbed by today's developed countries, are increasingly closed to newcomers. Participation in the world of free trade and free markets has become compulsory; the freedoms foreseen by Adam Smith have become an offer you can't refuse.

Indeed, the theory of free trade has moved from philosophical ideal, to favored prescription for growth, to mandatory requirement for international economic relations. International bodies created to promote trade and eliminate tariffs and other barriers – first GATT, now WTO – have grown steadily more prescriptive, claiming an expanding right to dictate the conditions of production and overturn national regulations that interfere with trade. The International Monetary Fund and the World Bank, which are principal sources of international financial assistance, particularly for countries in emergencies, impose strict and detailed political requirements in exchange for their loans.

The "Washington consensus," shared by these institutions and by most of the U.S. government, amounts to free trade run rampant: not only goods, but also services, financial investments, and intellectual property rights must be allowed to cross international boundaries without hindrance. To allow the global market to work its unregulated magic, the role of government must be minimized everywhere; laissez-faire is the only approved political philosophy for the neoliberal era.

The impact of the new regime on national governments is far from benign. New trade measures such as NAFTA's Chapter 11 allow corporations to sue foreign governments in secret tribunals organized by international financial institutions; the corporations can win substantial damages if regulations are found to unfairly limit their actual or potential profits. A case in point is Metalclad, a small California-based company that bought a landfill in the Mexican state of San Luís Potosí and planned to turn it into a hazardous waste disposal site. The company obtained permits from the national and state governments, but the municipal government at the site vetoed the project on the basis of the health and environmental damages that it was likely to cause. Although Metalclad's investment in the project was worth no more than $4 million, it won a judgment under NAFTA's Chapter 11 of some $16 million for the loss of future income it could have earned from its planned waste disposal business, plus interest. Mexico's national government paid Metalclad in 2001, and also accepted responsibility for the expensive cleanup of the site (Bejerano 2003).

There are two broad exceptions that highlight the hypocrisy of the neoliberal approach to globalization. First, labor is not free to follow goods, services, capital, and intellectual property across international boundaries. As we have seen, capital flight may leave workers in a developing country worse off, undermining any hopes of growth through free trade and static comparative advantage. The developed countries that insist on free movement of goods and capital also insist on limiting immigration and policing their boundaries, sometimes at great cost, to block unauthorized entry. In any theoretical model, the resources that are allowed to move around the globe are likely to have more bargaining power and win a better deal than the resources that are required to stay where they are.

Second, the industrial countries themselves are not rushing to follow the same rules that are enforced on those of lower incomes. Massive and apparently politically untouchable agricultural subsidies in the United States, Europe, and Japan distort world food markets and lower the

incomes of developing country farmers. Selected industries, such as steel, textiles, sugar, and orange juice in the United States, continue to receive protection from imports despite the ever-escalating rhetoric of free trade – and needless to say, these industries are long past their infancy. There is no theory, aside from cynical models of rent seeking, that justifies such behavior. Free trade is alive and well as an ideology to enforce on others, but not as a universal principle that everyone has agreed to live by.

The rigors of contemporary trade policies have not led to better results; the evidence suggests that free trade has not been reliably helpful for growth in recent years, any more than in the past. Several empirical studies using large international datasets have claimed to find a positive relationship between a country's openness to trade and its rate of economic growth. However, a review of this literature by Francisco Rodriguez and Dani Rodrik finds that the research is unpersuasive:

> *Do countries with lower policy-induced barriers to international trade grow faster, once other relevant country characteristics are controlled for?* ... Our main finding is that [the recent empirical] literature is largely uninformative regarding the question we posed above. There is a significant gap between the message that the consumers of this literature have derived and the "facts" that the literature has actually demonstrated.... Our bottom line is that the nature of the relationship between trade policy and economic growth remains very much an open question. The issue is far from having been settled on empirical grounds. [Emphasis in original]
>
> (1999: 2–4)

According to Rodriguez and Rodrik, the "false positive" correlations that have been reported between trade openness and growth are largely based on poorly constructed or misinterpreted measures of openness. For example, one published measure of openness to trade, which correlates well with growth rates, turns out – through accidents of its construction – to be little more than an indicator of location outside of sub-Saharan Africa. There are many possible explanations other than trade policy for the slow growth of African countries.

Another theory is possible

Economic development has had its success stories, amid many disappointments. There are a number of formerly poor countries that grew rapidly in the second half of the twentieth century; there is an enormous range of policy experiments and differential outcomes from which to learn. However, there are no grounds for concluding that free trade theory offers the one true answer. The abstractions of general equilibrium do not fit the data; the details that were lost in the process of abstraction turn out

to be the details that matter. The belief in a single true path to development, guided by abstract economic theory and the ideology of free trade, is ready for retirement, unsupported by evidence or logic.

The alternative is not a similarly abstract counter-theory, nor a similarly absolute, one-size-fits-all policy prescription. Neither central planning nor vintage import substitution policies will do the trick: while both contributed more to the early stages of development than it is fashionable to remember, both failed to provide an ongoing, viable strategy for the stages that followed. Development, as Amsden (2001) describes it, is an inductive process of experimentation and learning from past successes, not a deductive policy of proving and applying theorems. Rodriguez and Rodrik conclude that free trade may be neither good nor bad across the board: "We are in fact skeptical that there is a general, unambiguous relationship between trade openness and growth waiting to be discovered" (1999: 4). Bruton's review of import substitution concludes that the successful development of Japan, Korea, and Taiwan is attributable to active experimentation, flexible intervention in the market, and governments that were able to learn from their past mistakes, rather than any unique formula for development that they applied (Bruton 1998: 924–25).

A review of the theories discussed above will lead to a sketch of an alternative approach. To begin with, it is impossible to ignore a basic point of free trade theories, namely the short-term benefits of exports based on static comparative advantage. In the terms of our earlier metaphor, this is the gravitational force that can be felt at all times, the force that the more complicated aerodynamics of development are attempting to overcome. But it is one thing to remember the force of gravity, and another thing to insist on mentioning nothing else. Imagine the impact on airplane designers if international institutions could demand, as a condition of funding, that their designs be based on gravity alone, or force a rewrite of those designs if any hint of the influence of countervailing forces was detected: under those rules, no one would leave the ground.

Less metaphorically speaking, no country can afford to abruptly stop producing its traditional exports, and no sensible development strategy would suggest doing so. But much more than continuing those exports and bending to market pressures has to be done, as suggested by the four categories of critiques of free trade theory.

First, national boundaries and institutions make a difference, and controls over capital flows are important to national welfare. Chile, one of the fastest-growing Latin American economies after 1980, and advised by University of Chicago economists of impeccable conservative credentials, nonetheless instituted controls over destabilizing short-term capital flows into and out of the country.

Second, economies of scale are real, and quite large in some desirable export sectors. Hence, infant industries do need protection from foreign competition, and support from the public sector. As Amsden explains, this

support can take many forms other than tariff protection – but the historical record shows that high tariffs have been part of most success stories of development to date. The fact that the argument for industrial protection has been abused, in the United States as well as in developing countries, does not imply that the idea should be abandoned.

Third, education and technological innovation are increasingly essential to development. Minimizing the role of the state will not help, in this or other areas; there is a need for bold public-sector initiatives to improve education and foster new technologies. The creation of dynamic comparative advantage in modern sectors of the economy involves increasing returns and positive externalities, rendering the predictions of traditional economic theories ambiguous at best. In a situation with multiple equilibria, public policy can be decisive in achieving the preferred outcome.

Finally, labor markets are highly imperfect, and countless environmental externalities have not been internalized. There is no hope of achieving the economic theorists' recommendation – that is, eliminating these market imperfections – in the real world. Therefore, trade and development policies will have to be "second best" in theoretical terms, modified to improve their impacts on employment levels, income distribution, and environmental quality.

Policies addressing these concerns should be welcomed, not regretted. Industrialization in the past has been a brutal process; in England it devastated the environment and lowered the living standards of much of the population below preindustrial levels for several generations. The eclectic, experimental approach to development advocated here involves, above all, learning from past mistakes, and trying to do better next time. Neither the historical experience nor the abstract economic theories that have emerged from today's industrial countries provide fully appropriate guidance for this path.

Notes

1 A striking exhibit at the Boston Museum of Science, years ago, involved simultaneously dropping a rock and a feather inside two tall glass tubes. As expected, the rock falls rapidly while the feather drifts slowly downward. Then the air is pumped out of the tubes and the demonstration is repeated. In a vacuum, the rock and the feather fall at identical, rapid rates – which are accurately described by Newton's law of gravitation because air resistance has been eliminated.

2 This metaphorical use of gravity is not related to the so-called gravity model of trade, which predicts that the volume of trade between two countries is proportional to their size and inversely proportional to their distance from each other.

3 This section frequently relies on Irwin's account, though with a different organization and conclusion, as well as a number of additions. Irwin himself concludes that the critiques are valid only under exceptional circumstances, and "the idea of free trade, the conceptual case for free trade, has survived largely intact against the tide of repeated critical inquiry" (1996: 8).

4 I was not aware, when choosing this heading, that Michael Lind (2002) had used nearly the same title for an excellent article on the same subject.

5 The export duties were passed in 1699, and penalties for violation were strengthened in 1732 (Mantoux 1962: 86).

6 U.S. Census Bureau (1975: Part 2, series U212, on 888). Notes on 879 describe this series as "similar to, but not identical with" figures published elsewhere on average *ad valorem* tariff rates. The rate fell below 25 percent in 1857–61 and 1918–20.

7 Ibid: series Y353 and Y354, on 1106.

10 Computable abstraction

General equilibrium models of trade and environment[1]

Frank Ackerman and Kevin P. Gallagher

General equilibrium theory, with its abstract axioms and topological theorems, seems to live in a world apart from applied economic analysis. Economists who crunch numbers and engage in policy debates are often out of touch with the latest work by economic theorists (and vice versa). Yet the language of general equilibrium finds a distinct echo in the analytical apparatus of empirical economics. So-called computable general equilibrium (CGE) models have become common in many policy applications – including an area we have been involved in, namely the analysis of the environmental impacts of international trade.

CGE models bear only a modest resemblance to the grand theories of general equilibrium. What distinguishes these models from other ("partial equilibrium") approaches is their attempt to represent the interacting web of supply and demand balances in all sectors of the economy, not just the ones of immediate interest. A policy that changes the demand for housing will induce changes in the demand for wood, bricks, steel, glass, and many types of labor. This will lead to price and quantity changes that will continue to ripple through other markets, affecting supply and demand in, for instance, other wood-using sectors. Like general equilibrium theory, CGE models assume that equilibrium is reached simultaneously in all sectors, based on the explicit representation of sectoral interactions.

This comprehensiveness is the good news about CGE models: they automatically encompass the entire economy, offering a systematic framework for analyzing price and quantity interactions in all markets. The bad news about CGE models also stems from their comprehensiveness: they draw on general equilibrium theory, with all its flaws, to complete their picture of economic interactions; and in practice they are forced to rely on opaque and arbitrary approximations of numerous poorly understood relationships. Their predictions have frequently been far from accurate. For empirical work in areas such as trade and environment, we conclude that there is a need for exploration of alternative modeling approaches that would avoid the limitations we have seen in CGE models in practice.

Background: the need for models

Negotiations to liberalize trade have become an increasingly frequent part of international diplomacy, including the "Doha Round" of negotiations in the World Trade Organization (WTO), the proposals for a Free Trade Area of the Americas (FTAA), and numerous bilateral talks between individual countries around the world. Critics have objected that expanded trade may harm the natural environment (see Ackerman, "An offer you can't refuse," Chapter 9 in this volume). In response, some countries, including the United States and Canada, have established a process of environmental reviews of trade agreements.

Environmental reviews date back to the early 1990s, when the U.S. and Canadian governments conducted environmental assessments of the North American Free Trade Agreement (NAFTA) and the Uruguay Round of world trade negotiations (Montgomery, 2000; Beale, 2000). In Canada, environmental reviews that have recently been conducted, or that are scheduled for completion in the near future, include reviews for the Canada–Chile, Canada–Singapore, Canada–Central America, and Canada–Costa Rica Free Trade Agreements, the FTAA, and the Doha Round of global trade negotiations. For the United States, recent and forthcoming reviews include the U.S.–Jordan and U.S.–Chile Free Trade Agreements, the FTAA, and the built-in agenda on agriculture and services at the WTO.

There is widespread interest in the environmental impact of these agreements, but there is less agreement on the methods that should be used to analyze those impacts. Typically, studies have assumed that environmental effects are proportional to some economic activity, such as the output of a particular industry. Most of the analytical effort therefore goes into modeling the *economic* impacts of trade agreements. These results are then converted into *environmental* impacts by the application of a simpler, supplementary model, in some cases little more than the use of environmental multipliers tacked onto the economic model results.

Methodologies for environmental reviews

The level of methodological sophistication that is involved in predicting the potential economic effects of a trade agreement depends on the scale of economic activity between the proposed trading partners. For smaller bilateral agreements such as the Canada–Chile FTA or the U.S.-Jordan agreement, fairly simple economic techniques may be sufficient. Larger agreements that have potential economy-wide effects, such as the proposed FTAA and the Doha Round of world trade talks, are more likely to involve more complex economic modeling techniques.

When proposed agreements are relatively small in scale, analysts often consider only what are sometimes referred to as the "primary" effects of

the agreement, or changes in sectors directly affected by the terms of the agreement. Such an approach is justified because the level of activity between the potential trading partners will not be large. Analyses of the primary effects essentially ask how exports and imports in key sectors will expand or contract as a result of the proposed agreement. Such estimates can be a derived from simple examinations of historical trends and tariff rates, or by more sophisticated partial equilibrium models. An example of the former approach is the draft environmental review for the proposed U.S.–Chile FTA that was conducted by the U.S. Trade Representative. To examine the potential effects of that agreement, analysts simply examined the historical record of the top twenty-five imports and exports and their respective tariff rates between the United States and Chile (United States Trade Representative, 2001). From such an examination it became fairly easy to predict which sectors might expand or contract due to trade liberalization between the two nations.

A partial equilibrium model focuses on certain sectors of the economy, but does not attempt to represent the full range of interaction among all sectors. Such an approach allows policy analysts to isolate the effect of trade liberalization on particular sectors, commodities, or pollutants in an economy and to test the significance of the relationship between trade policy and the examined variable. Partial equilibrium assessments have been used, for example, to examine the potential economic impacts of the U.S.–Jordan agreement. These models assume, in effect, that the interactions between the modeled sectors and the overall economy can be ignored in order to focus greater attention on the workings of the particular sectors themselves.

When a proposed trade agreement, such as the FTAA or a new round of world trade negotiations, has the potential for substantial effects throughout the economy, environmental reviews often rely on estimates from CGE models. In contrast to the partial equilibrium approach, which looks at changes in one or a small family of sectors, a CGE model attempts to present a quantitative picture, at a point in time, of the interaction of the full range of markets and industries throughout an economy. Like partial equilibrium models, the CGE approach involves an analysis of the primary effects of the proposed agreement, but then adds two other layers of analysis. We will refer to the new layers as "secondary" and "tertiary" effects.

The secondary effects are the indirect, interindustry consequences of the primary effects, as calculated by input–output models. The tertiary effects are the economic equilibrium effects resulting from the primary and secondary effects. For example, when Mexico opens its markets to U.S. corn under NAFTA, the primary effect on the United States is the increase in corn exports; the secondary effects include increased purchases of farm inputs by corn growers; and the tertiary effects include shifts in consumer spending and employment patterns throughout the economy as a result of the changes in incomes and prices in the farm and farm input sectors.

The three stages of effects are conceptually distinct, even if in practice they are often simultaneous. All three should be included in an assessment of the effects of trade agreements. First, there is the estimate of the primary economic effects of trade liberalization. What exports and imports expand, by how much, in each country? What changes in production technology, organization, and ownership will occur? Second, there are input–output effects, as changes in final demand ripple through supply chains and intermediate goods producers. If a policy change leads to the production of fewer cars, input–output analysis can calculate the resulting decrease in auto industry inputs from other sectors of the economy. Finally, there are equilibrating changes, as markets readjust to changed conditions, prices rise and fall, and labor (at least in theory) moves from declining industries to expanding ones.

Some modeling problems reflect the fact that environmental reviews are necessarily *ex ante* evaluations, performed before the proposed changes have occurred. Thus, they are inherently different in methodology from *ex post* analyses. After the fact, it is possible to use actual historical data to ask, "What happened when a trade agreement was adopted?" However, environmental reviews clearly cannot use historical data, since they are anticipating the results of future trade agreements.

For use in analyzing a trade agreement, the CGE model is run twice: once as a benchmark, representing actual conditions in a recent "base year" without the proposed agreement; and again for that same year, making the counterfactual assumption that the agreement was in effect but other conditions remained unchanged. In other words, the only difference between the two model runs is that the proposed agreement is assumed to be in effect in the second one. The difference between the outputs of the two model runs is then taken to be the impact of the proposed agreement. Note that this is a comparative statics analysis, contrasting two snapshots of economies in equilibrium. It does not attempt to describe the time path of adjustment following adoption of a trade agreement.

CGE models, pro and con

As trade agreements become more complex, involving many countries and sectors of an economy, efforts to predict their economic outcome become more controversial. In contrast, the simpler modeling techniques used in environmental reviews for smaller trade agreements are relatively straightforward; our discussion here concerns the economic models used to assess the largest trade agreements. Such reviews inherit the many controversies surrounding the predictive capability of CGE models, and therefore their utility for policy makers is more limited.

CGE models are attractive to analysts for several reasons – but they

have important weaknesses as well. The attractions of CGE models include their theoretical rigor, their ability to represent the direct and indirect interactions among all sectors of the economy, and their precise, detailed quantitative results.

CGE models are rigorously derived from economic theory; they assume that a simplified version of general equilibrium applies to the economy being modeled. Thus, the models appear to bear the imprimatur of established economic analysis – though of course they may reflect the flaws in the underlying theory for the same reason. (Most practitioners of applied economics, in this or other fields, do not dwell on possible challenges to the accepted, conventional approach to economic theory.)

CGE models incorporate the interactions among all sectors of the economy. Some interactions result from supply chains: more demand for automobiles implies more purchases of tires and window glass by auto companies. Others result from price and income effects: higher prices for cars imply that fewer people will buy them, while higher wages for autoworkers imply more spending on consumer goods. CGE models provide consistent sets of equations to analyze all such interrelationships. Once constructed, the models can run different simulations to consider alternative policies. They incorporate multiple markets (for factors of production, final goods and services, or even marketed environmental instruments), and are able to quantify efficiency and distributive impacts of economic and/or environmental policies (de Miguel and Nuñez 2001).

Another contribution of CGE models to environmental reviews is that they respond to the need for quantitative tools (Waverman 1992). Trade agreements can potentially affect all economic sectors, and create a mix of positive and negative effects on labor markets, consumer welfare, and environmental media including air, water, land, and biodiversity. It is important to improve the understanding of the linkages between trade policy reform and the environment, and quantifying their significance is an important part of the analysis. It also allows a more specific debate about the potential costs and benefits of a proposed trade-related reform (Anderson and Strutt 1996).

Yet CGE models also have a number of less familiar but important limitations. We can group these limits into four categories: high information costs and lack of transparency; controversial assumptions regarding model relationships; the inability to capture "nontrade" aspects of trade liberalization; and finally (in part as a result of the other factors), a poor track record of economic prediction in practice.

High information costs and lack of transparency

At its core, building a CGE model is a cumbersome and expensive task, requiring a great deal of time, substantial effort from a team of specialists, and considerable resources, especially with respect to data. Given the large data requirements, disaggregated models become problematic, because for every sector it is necessary to examine its direct relationship with every other sector. In a model with n sectors there are $n(n-1)/2$ distinct pairs of sectors to consider. Even in a highly aggregated, 25-sector model there are 300 distinct pairs of sectors whose relationships must be considered; with 50 sectors there are more than 1,000 pairs to consider; with 100 sectors there are nearly 5,000 pairs. In short, adding a level of disaggregation causes a more than proportional increase in data and parameter requirements (Munk 1990).

The expense of building adequate data sets means that they can only infrequently be updated; the resulting reliance on outdated data puts policy analyses at risk of being outdated before they are even completed. For example, as of 2001 the most recent version of the GTAP data set (GTAP 5) used 1997 as a base year. Other models have been known to use base years as much as ten years out of date; GTAP is probably as current as possible, given the size of its data set. However, analyses that use the GTAP 5 data, for instance, can only tell policy makers what would have happened if the policy change had occurred in 1997, not in the present or future. That is, an *ex ante* analysis of the effects of the FTAA using such a data set does not actually project what will happen, in 2005 or later, if the FTAA is adopted. Rather, it is examining what would have happened if the FTAA had somehow been transported back in time, and dropped into the economy of 1997 (Ackerman *et al*. 2001).

This inescapable obsolescence can be a serious problem. In an *ex ante* situation, proposals during trade negotiations are always changing, as are the base conditions for creating the model. As a result, any economic assessment is in constant danger of being rendered irrelevant, should the direction of negotiations or economic conditions change (UNEP 2001). This was an issue for early NAFTA modelers, because in the late 1980s and early 1990s the Mexican economy was changing so rapidly that models calibrated to any fixed base year soon became inaccurate (Waverman 1992).

A modeler's analysis is only as good as the quality and quantity of data available. However, due to the large data requirements, it has become commonplace to synthesize data from multiple published data sources. Although these data sets are assembled carefully, there is always a risk that some of the data sources employ assumptions or definitions that are incompatible with the model scenarios. Use of incompatible or biased data sources can create a host of problems, potentially even undermining model calibration and the relevance of the model results (Laird 1997; Waverman 1992).

High information costs lead to a lack of transparency in CGE models; ironically, the problem can arise from either too little detail or too much. On the one hand, cost constraints and the desire to keep models simple can lead to highly aggregated models with relatively few sectors, relying on

numerous simplifying assumptions. Models of this variety can be difficult to interpret since their results are shaped by the degree of aggregation and the nature of the simplifying assumptions (Gallagher and Ackerman 2000). Moreover, a simple, highly aggregated model often lacks the detailed forecasts that policy makers need.

On the other hand, a more disaggregated model, with sufficient detail for policy analyses, can be difficult for anyone but an expert in the field to follow. The number of intersectoral relationships, as we have seen, grows much faster than the number of sectors. Comprehending and evaluating a model with hundreds of sectors and thousands of potential interactions is a challenge even for another expert on CGE models, and essentially impossible for nonspecialists.[2]

It is not obvious that there is any happy medium between too little disaggregation and too much; instead, there is some danger that both problems could occur at once in a medium-sized model.

Controversial assumptions regarding model relationships

While CGE models pride themselves on their rigorous grounding in economic theory, this does not mean that they have escaped from controversy about their economic assumptions and relationships. Economic theory unfortunately does not provide clear, unambiguous guidance on how to model a complex, modern economy; on the contrary, theory suggests several reasons to question standard CGE approaches. Questions that will be addressed here include the limitations of the static framework, the reliance on textbook-style "perfect competition," and the lack of established empirical estimates for key relationships.

Limitations of static analysis

As we have seen, most CGE models rely on comparative-static analysis, contrasting a scenario representing a hypothetical policy change to actual conditions in a fixed base year. Both the base year and the policy scenario are represented as static snapshots, with no provision for gradual adjustment or change over time. When the new policy is introduced, the model jumps directly to the resulting new equilibrium.

In practice, however, the process of adjustment following introduction of a new policy is extremely important. If labor is eventually going to end up in different industries (in a new "general equilibrium") following a shift in economic structure, it makes a great deal of difference to know whether it takes ten weeks, ten months, or ten years for workers to move to their new, equilibrium occupations. Lacking the ability to model the pace of change, in labor markets or elsewhere, comparative static analyses have proved most useful for examining short-term issues (Munk 1990; see also Tims 1990).

To address such questions, a dynamic model would be needed. Unfortunately, CGE models are poorly suited for dynamic analysis. The data requirements are significantly greater for a dynamic analysis, and dynamic models are much more unstable and difficult to solve (i.e., iterative solutions do not always converge), even for the best computers.

The issue goes beyond the practical limitations of existing computers. The abstract theoretical rigor of general equilibrium is limited to static analysis, and is silent on questions of adjustment over time. Economic theorists have known since the 1970s that general equilibrium is seriously flawed as a model of economic dynamics, with the apparently inescapable potential for unstable or chaotic outcomes (see Ackerman, "Still dead after all these years," Chapter 1 in this volume). Ironically, many advanced theorists have moved away from the general equilibrium framework at the same time that it has become the norm in applied economics.

Reliance on perfect competition

Economists have a strange relationship with the familiar theory of "perfect competition," in which markets are populated exclusively by very competitive firms, all of which are too small to exert any independent power over prices. On the one hand, the theory is easy to analyze; in perfect competition the market leads to ideal outcomes, which cannot be improved on by government intervention. On the other hand, it is obvious that the theory does not describe the market economy as it actually exists; perfect competition among small, powerless firms does not characterize the likes of Microsoft, General Motors, AOL Time Warner, and ExxonMobil.

In building CGE models, the mathematical convenience of familiar theories such as perfect competition has often won out over realism about market imperfections. A study of the CGE models used for economic analysis of NAFTA found that many were arguably erroneous and easily challenged when compared to the real world (Stanford 1993). The models' debatable assumptions include the idea that factor markets, including labor markets, are perfectly competitive and will always clear (i.e., markets always return to equilibrium, or full employment, after an external shock). The models tend to ignore the impacts on income distribution of socio-economic institutions such as trade unions, minimum wages, and social programs. Conversely, they assume that the distribution of income has no effect on aggregate economic performance. A common assumption is that the aggregate economy is supply-constrained, so that output is limited only by the availability of productive factors; this makes it impossible to model unemployment and recessions. Some NAFTA models even assumed that there is no capital mobility between North American countries, only within a country; no country in such a model can be threatened with a loss of capital, and all gains in foreign investment come from outside of the region.

The literature on critiques of perfect competition is itself extensive, raising many reasons why these theories are inappropriate or inaccurate representations of real economies. Among the most important recent contributions is the analysis of the economics of limited information. Three economists who have worked in this area shared the Nobel Prize in economics for 2001. The best known of the three is Joseph Stiglitz, formerly the chief economist for the World Bank, and the chair of the President's Council of Economic Advisors in the Clinton administration. Stiglitz argues that the fatal flaw of traditional economic theory is its assumption that everyone has perfect information about all goods and services (see Stiglitz 2000 and numerous sources cited there). No one could possibly have that much information, Stiglitz points out, let alone update it as the market changes. An economy of limited information behaves very differently from the traditional theoretical model; Stiglitz demonstrates that the theory of perfect competition and perfect information (the standard basis for CGE models) is not even a good approximation to the behavior of a realistic, limited-information economy.

Lack of established empirical relationships

One of the important strengths of CGE models is their explicit treatment of the interactions between different economic sectors. It is this feature that allows analysis of indirect, intersectoral effects of trade policies. However, the models' estimates of indirect effects inevitably rest on assumptions about the exact shape and strength of numerous relationships, such as the price elasticities of supply and demand in various industries, or the speed and completeness with which markets adjust to external shocks. The economics literature does not provide a single set of widely accepted estimates of these parameters; CGE model relationships cannot be based on a professional consensus about the empirical strength of price elasticities and market responses, because there is no such consensus. Indeed, many of the models that predicted the effects of NAFTA used elasticities estimated on the basis of U.S. trade with the whole world in the 1980s (not with Mexico and Canada in the 1990s), averaged across separate industries where necessary due to mismatched SIC code lists, etc., and arbitrarily rounded upward in some cases because the model is unstable with low elasticities (Hinojosa-Ojeda *et al*. 2000).

This is the opposite of the situation in many areas of physical sciences and engineering, where physical relationships are based upon well-established natural laws and have withstood repeated empirical tests. Everyone doing rocket science uses exactly the same model of gravity – but economics is not rocket science, and every CGE model has its own picture of labor and product markets. The key assumptions differ in detail from one model to the next, precisely because there is no one model that has proved to be reliably more accurate than others in practice.

Inability to capture "nontrade" aspects of trade liberalization

Multilateral trade agreements are increasingly moving beyond the traditional agenda of reducing tariffs and dismantling the obvious nontariff barriers to trade. The new trade agenda also focuses on trade-related issues such as international property rights, investment, government procurement, and services. Although the economic impacts of these provisions will be significant, it is difficult to model them in a CGE framework. This is especially problematic for environmental reviews if these "nontrade" provisions will create environmental impacts.

Most important in this respect is the inability of CGE models to capture investment effects. Proposed changes in investment rules could have a significant impact on economic activity throughout the hemisphere. According to the World Bank, annual net foreign direct investment (FDI) inflows into Mexico more than tripled after NAFTA was passed, reaching over $10 billion in 1998. In addition to altering the composition and output of different sectors in Mexico, such inflows have altered the trade orientation of many sectors as well. Changes in investment rules under NAFTA have reshaped intra- and interindustry trade in North America, and changes in future investment regimes are likely to do the same. Increases in FDI have direct impacts on technology choice and environmental quality. Investment-related changes to trade patterns of this kind are of potentially great importance, but are beyond the scope of CGE models.

Inaccurate predictions of economic performance in practice

One of the dangers in using CGE models for economic analyses is that they are oversold as definitive predictors of how the *entire* economy may change after a trade agreement. In fact, the accomplishments of such models are quite modest. A CGE model is only analyzing how (in a counterfactual, comparative statics sense) a proposed agreement might affect an economy via changes in trade barriers, while holding everything else, including policy toward investment and services, constant. If the limitations of the modeling exercise are kept in mind, it may provide limited but useful information; if it is presented as the beginning and end of economic analysis of a trade agreement, it is more likely to prove misleading.

Scott (2001) notes that in many of the *ex ante* analyses of NAFTA, the authors pointed to the growth in U.S. exports without adequately highlighting the concurrent growth in imports. In a 1992 study designed to highlight some of the expected economic benefits from NAFTA, the Michigan model predicted that U.S. exporters would benefit more than their Mexican counterparts. Exports from the United States to Mexico were forecast to increase by $4.2 billion per year, while imports from Mexico would grow only $3.5 billion per year (Brown *et al*. 1992). A later *ex post* assessment showed that these forecasts were gross underestimates,

and wrong about the balance of trade as well. U.S. exports to Mexico grew by an average of $8.3 billion per year, while imports from Mexico grew by $13.5 billion per year. The result was that the U.S. trade deficit with Mexico almost quadrupled, jumping from $16.6 billion in 1993 to $62.8 billion in 2000 (Scott 2001). Although NAFTA was not solely responsible for these changes, the results dramatize the extent to which CGE model outputs can provide misleading forecasts.

The impact on labor in the U.S. from Mexican imports was another highly charged pre-NAFTA debate, which even today generates ongoing controversy among economists. For example, one *ex ante* model showed that U.S. employment would fall by 234,000 workers after NAFTA; most of this was assumed to be a return flow of illegal immigrants to Mexico, since Mexican employment was predicted to increase by 273,000 (Hinojosa-Ojeda and Robinson 1992). At first glance this looks close to some views of what actually happened: a later *ex post* model, with the same lead author, showed that in the United States, 259,000 jobs were lost as a result of increased Mexican imports, and the U.S. Department of Labor reported that 238,051 workers were certified under the NAFTA-Transitional Adjustment Assistance Program (NAFTA-TAA) to have lost their jobs due to trade with Mexico (Hinojosa-Ojeda *et al*. 2000).

However, these *ex post* results refer to different workers than the *ex ante* model: illegal immigrants who returned to Mexico did not get certified under NAFTA-TAA for job loss in the United States. If, in addition to 238,000 certified job losses by U.S. workers, there were other U.S. job losers who did not get certified, and a large number of undocumented Mexican immigrants who lost their U.S. jobs and returned to Mexico, then the true employment impact must have been much greater (and surprisingly hard to measure). A different *ex post* analysis of U.S.–Mexican trade since NAFTA found that what we have called the primary and secondary effects of that trade caused the loss of 766,030 U.S. jobs, though the impact was of course offset by the growth of the U.S. economy in the late 1990s (Scott 2001).

The disparity between these numbers shows that even after NAFTA, there is no agreement on the full effects, due to methodological issues of the studies, as well as the other economic factors that impacted U.S. employment. Before future economic analyses are conducted with the same models that were used to predict the outcomes of NAFTA, a thorough evaluation of their NAFTA predictions should be undertaken.

Deductive theories for applied research

Whereas CGE models are derived from an inductive theory of the economy, general equilibrium, there are a wider variety of modeling approaches that have been derived by using more deductive approaches. Deductive models take as their starting point the actual workings of an economy and are thus much more appropriate for environmental reviews. The theories of Marshall, and much later Leontief, form the basis for two deductive approaches that could make environmental reviews much more useful in terms: partial equilibrium and input–output analyses. Such approaches rest on less controversial theory and can provide policy makers with a range of much more concrete economic estimates from which to base their decisions on.

Recall that standard CGE approaches involve three conceptually distinct layers of analysis. First, there is the estimate of the direct economic effects of trade liberalization, such as increased trade in sectors where tariffs are reduced. Second, there are input–output (I–O) effects, as changes in final demand ripple through supply chains and intermediate goods producers. Finally, there are equilibrating changes, as markets readjust to changed conditions, prices rise and fall, and labor moves from declining industries to expanding ones.

There is a strong tendency for studies to publish and focus on the combined results of all three stages, including the more controversial, equilibrating effects. Analyses of the primary and secondary effects are often embedded in the larger CGE models – but receive far too little analytical attention on their own, and are rarely even separately discussed in the presentation of CGE results. Simpler, more standardized partial equilibrium and I–O analyses can estimate these primary and secondary effects. I–O analysis is a well-established, straightforward process, resting on nothing more theoretically complex than matrix multiplication (yet still rigorous and very data-intensive).

I–O analysis was initially developed, and can easily be used, in a partial equilibrium framework. For instance, if analysis of the primary effects of a tariff change in the automotive sector provides estimates that indicate that there will be the production of fewer cars, I–O analysis can calculate the resulting decrease in auto industry inputs from other sectors of the economy. After such analyses have been carried out, it can be determined whether CGE modeling is desirable to provide supplementary information.

Partial equilibrium and I–O analyses can also be used to estimate the primary and secondary effects of a policy in an *ex ante* framework as well. For instance, researchers can estimate the *ex post* effects of a particular range of trade policies on a given sector or sectors of an economy. The specification based on such analysis that best explains the historical past can then be used to forecast *ex ante* changes for the same sectors. The secondary effects may be estimated by feeding the results of the *ex ante* predictions into an I–O model. Such a deductive approach ties the analysis much more closely to economic reality, and is also grounded in less controversial theory.

If CGE work is conducted, the results should be published with full disclosure of the embedded assumptions, and alongside the results from

analyses of the primary and secondary effects. It is important for policy makers and for analysts evaluating the models to know the answers to questions such as: How large are the relevant price elasticities? How rapidly does the model assume that labor, capital, and product markets move back toward equilibrium when perturbed? How is government assumed to respond to changing economic conditions, and how does the government response affect the economy?

Finally, it is important to stress that estimates of the potential economic impacts of a trade agreement should include an examination of effects triggered by events beyond changes in trade and tariffs. Increasingly, "trade" agreements deal with capital flows and investment, intellectual property rights, government procurement, and a host of other issues. International capital flows, for direct foreign investment and other purposes, account for vast sums of money; many observers see the expansion of capital flows as a key objective and rationale for new trade agreements. However, the dominant modeling techniques are not constructed to predict the outcomes related to these issues.

General equilibrium theory has numerous abstract flaws, as earlier chapters have demonstrated. When notions of general equilibrium leave the ivory tower and enter the world of practical politics, these flaws are not overcome. Instead, a new layer of problems is added on top of the theory. Model results often reflect the dilemmas of overwhelming information requirements and related aggregation issues; the limitations of comparative statics and counterfactuals using dated base year information; and the lack of agreed-upon price elasticities and other adjustment parameters. It is not surprising, therefore, to find that *ex ante* forecasts differ widely from one model to another, and, moreover, diverge widely from *ex post* reality. If this is a successful theory, what would a failure look like?

Notes

1 This chapter is based on Luke Ney, Kevin P. Gallagher, and Frank Ackerman, "Economic Analysis in Environmental Reviews of Trade Agreements: Assessing the North American Experience," GDAE Working Paper 02-01 (2002), prepared for the North American Commission on Environmental Cooperation, and available at http://www.ase.tufts.edu/gdae/publications/working_papers/02-01SustAssessments.pdf. Thanks to Regina Flores for research assistance, and to John Audley and Scott Vaughan for comments on earlier drafts of the original paper.

2 It is important to note that many of the data in the United States that derive from the ITC are classified by an act of Congress and cannot be examined by the public (and in some cases other agencies).

11 Freedom and submission

Individuals and the invisible hand

Alejandro Nadal

The building housing the Chicago Board of Trade, the world's most important futures market, is topped by a faceless cast-aluminum statue of Ceres, the Roman goddess of agriculture. The statue is said to have been left faceless by the building constructors in the 1930s because nobody would be able to see the statue's face from street level anyway. However, the faceless statue suggests a deeper feature of markets, namely their anonymity. Underneath the apparent confusion and turmoil of the frantic transactions taking place in the big commodity trading pits of the Board, a smooth, well-regulated, albeit cryptic, market process is supposed to be occurring. The individuals who make up the market do not control this process, although they must endure its impersonal forces. At the same time, individual agents are liberated from personal responsibility toward any larger social goals, and are free to pursue narrow self-interest as they carry out their daily transactions.

More than two hundred years ago, a new vision of society was born – a vision in which individuals were not controlled by divine or other central authority, but rather functioned as independent, yet predictably interacting, parts of a system. This was the time of the genesis of economic thought, a process in which Adam Smith played a crucial role. He is best known, of course, for introducing the notion of the invisible hand as a device capable of producing an unintended but socially desirable outcome out of the uncoordinated actions of individuals.

The invisible hand has been described by Arrow and Hahn (1971) as the most important single contribution of economic thought to the understanding of social processes.[1] The idea of the invisible hand has also been linked to the accomplishments of a free society by Hayek, and plays a key role in the theories of Rawls and Nozick. General equilibrium theory, for all its twentieth-century complexity, is nothing more than the mathematical elaboration of Smith's eighteenth-century metaphor.

This chapter examines and compares the logical structure of the invisible hand metaphor as it appears in Smith's two most important works, the *Theory of Moral Sentiments* (1982) and the *Wealth of Nations* (1937). We will argue that Smith developed the idea of an invisible hand process

coordinating individual decisions in his earlier work, *Moral Sentiments*, in describing morality, conscience, and the sources of society's ethical judgments. Thus, the invisible hand as a social structure is separable from the market mechanism in which it is embedded in *Wealth of Nations*. Moreover, the invisible hand of *Moral Sentiments* does not imply that individuals are reduced to narrow, self-centered profit-maximizers with a limited understanding of society – that is, individuals need not be "degraded" by the operation of the invisible hand.

This is an important point, because markets have been frequently linked to freedom of choice. Recently, however, an opposite view has been advanced by Rothschild (1994) on the position of individuals in the invisible hand process.[2] According to this view, Smith did not have a lot of respect for the notion of the invisible hand, and the agents involved in those processes were described as puny, debased individuals. In this chapter we show that this is not accurate, for two reasons. First, Smith strives to build a theory of two different kinds of invisible hand processes in his *Theory of Moral Sentiments* and *Wealth of Nations*. Thus, the invisible hand per se may be of greater importance and broader validity than the problematical theory of the market to which it has been attached.

Second, in the invisible hand process in *Theory of Moral Sentiments*, individuals are depicted as very complex entities, capable of analyzing intricate social situations, and are therefore free to choose from a vast array of possible social conducts. However, when theory has attempted to present a mathematical representation of this process, the models that have been used have not been able to incorporate this freedom in their archetypes of individual agents. And when a degree of freedom is introduced, making these agents "cunning individuals," the model is unable to show that the invisible hand process leads to a desirable outcome.

There is a long literature of debate about Adam Smith's writings. The old "Adam Smith problem," originally identified by German authors, claimed that there was a blatant contradiction between Smith's two most important works, since sympathy was the pillar of society in the *Theory of Moral Sentiments*, while self-interest was the center in *Wealth of Nations*.[3] This view was considered a pseudo-problem by many, and dismissed long ago as a product of a superficial reading of Smith's works (Viner 1966; Raphael and Macfie in Smith 1982; Wilson 1976; Sen 1987). However, the problem has been reformulated in at least two relatively recent works, by Rothschild (1994) and Minowitz (1993).

The resilience of the Adam Smith problem derives from its relevance to the analysis of relations between ethics and economics. This chapter examines the commonalities and discontinuities between *Moral Sentiments* and *Wealth of Nations* in relation to the invisible hand process, highlighting the surprising extent to which Smith developed the logic of the invisible hand in *Moral Sentiments*, prior to his analysis of markets in *Wealth of Nations*. The first section centers on Smith's conception of society as a system of hidden interdependencies in which individual members play a modest part, a conception that is common to both *Moral Sentiments* and *Wealth of Nations*. We will show that this did *not* necessarily imply condescension or contempt for the individual components of the system in Smith's *Moral Sentiments* (see Rothschild 1994). The second section identifies the underlying relations of the social system in *Moral Sentiments* as a network of interlocking jurisdictions, governed by the "impartial spectator" of individual conscience, which leads to an unintended outcome. In contrast, in *Wealth of Nations* the role of the impartial spectator is replaced by the system of market prices and exchange. Third, we focus on similarities between the system in *Moral Sentiments* and the theory of the market in *Wealth of Nations*, showing how the latter is the continuation of a research program advanced in the former. In the fourth section we summarize results and examine some of the problems raised by contemporary stability theory and market theory. Our concluding remarks focus on the issue of freedom and submission in the status of individual agents in invisible hand processes.

Society as a mechanism

The image of the invisible hand is explicitly mentioned three times by Smith, once each in his *History of Astronomy*, in *Moral Sentiments*, and in *Wealth of Nations*. Only in the latter two does it have its modern meaning, referring to a process of uncoordinated individual actions leading to an unintended, desirable social outcome. However, too much attention has been paid to the few places where Smith literally used the words "invisible hand," and not enough to the underlying logic of his work that supports the image. In this section we will argue that in his *Moral Sentiments*, Smith held a conception of society in which individuals are part of a machine-like system – but this did not necessarily imply for him a view of devalued individuals.

The idea of society as a mechanical system is not only present in, but in fact dominates, the *Theory of Moral Sentiments*. This mechanistic vision may come from the influence on Smith of Stoic ethics, which went along with a view of nature as a cosmic harmony (Raphael and Macfie in Smith 1982); see, for example, in *Theory of Moral Sentiments* (TMS) VI.ii.3.4–5, 236, the reference to "the immense machine of the universe." The "all-wise Architect and Conductor" is portrayed as responsible for the system (TMS, VII.ii.1.37, p. 289):

> As all, even the smallest of the co-existent parts of the universe, are exactly fitted to one another, and all contribute to compose one immense and connected system; so all, even apparently the most insignificant of the successive events which follow one another, make parts, and necessary parts, of that great chain of causes and effects

> which had no beginning, and which will have no end; and which, as they all necessarily result from the original arrangement and contrivance of the whole; so they are all essentially necessary, not only to its prosperity, but to its continuance and preservation.

This view is less like one of a biblical Creator of the Universe than one of a deistic God who rules over a system without genesis, and without anger and punishment (Minowitz 1993). Smith's terminology almost implies a secular view of this supreme entity, who is variously described as creator (Author, Architect) but more frequently as a bureaucratic authority (Superintendent, Conductor, Administrator). This role of *fonctionnaire* really inaugurates a more functional view of the force behind the "immense machine of the universe." And this is consistent with a view of society as a mechanism (TMS, VII.iii.1.2, 316):

> *Human society, when we contemplate it in a certain abstract and philosophical light, appears like a great, an immense machine, whose regular and harmonious movements produce a thousand agreeable effects*. As in other beautiful and noble machine that was the production of human art, whatever tended to render its movements more smooth and easy, would derive a beauty from this effect, and, on the contrary, whatever tended to obstruct them would displease upon that account: *so virtue, which is, as it were, the fine polish to the wheels of society, necessarily pleases; while vice, like the vile rust, which makes them jar and grate upon one another, is as necessarily offensive*. [Emphasis added]

Viewing society as a system was part of Smith's heritage from what Meek (1967) described as the Scottish school of sociology, with John Millar, Adam Ferguson, and William Robertson as some of its most distinguished members. According to Meek, these authors inaugurate the view of society as a sort of immense machine-like system that would, like all machines, function in an orderly and absolutely predictable manner.[4] Because the conception of society as a system presupposes a certain rationality, Smith must have seen that it provided access to more powerful insights and analytical instruments than, say, a simple taxonomy or classification of seemingly isolated elements.

The individual components of the social machinery have only a faint notion of the complex interconnections that make up the system. They are the precursors of agents in modern microeconomics with their individual (production and consumption) possibility sets (TMS, VII.ii.1.44, 292):

> By Nature the events which immediately affect that little department in which we ourselves have some little management and direction … are the events which interest us the most, and which chiefly excite our desires and aversions, our hopes and fears, our joys and sorrows.

However, these individuals are capable of sacrificing their interests for the benefit of the system's welfare. The wise man[5] recognizes in the perfection of the immense machine of the universe that the ultimate goal of the Superintendent is "to produce the greatest possible quantity of happiness" (TMS, VI.ii.3.5, 236). This is why he can readily sacrifice the interests of his own little department for the sake of the general interest. The idea is developed in Smith's admiring description of Stoic philosophy (TMS, VII.ii.1.20, 276):

> A wise man never complains of the destiny of Providence, nor thinks the universe in confusion when he is out of order. He does not look upon "himself" as a whole, separated and detached from every other part of nature, to be taken care of by itself and for itself. … He enters, if I may say so, into the sentiments of that divine Being, and considers himself as an atom, a particle, of an immense and infinite system, which must and ought to be disposed of, *according to the conveniency of the whole*. [Emphasis added]

Submission to the necessary precepts of the system is not a sign of futile conduct on the part of devalued individuals. Rather, it is the sign on the part of an individual that he or she has acquired wisdom and accomplished self-command, which is described by Smith as the virtue from which all others "seem to derive their principal lustre" (TMS, VI.iii.11, 241).

The wise man has acquired a modest and unassuming attitude vis-à-vis the intricate system of which he is only a modest part.[6] On the contrary, the proud and vain man is constantly dissatisfied. This idea is a structural element of Smith's *Moral Sentiments*, underlying a conception of society as a system ruled by laws that only a few (if any) can grasp. The critical reference comes, once again, from the chapter "Of Universal Benevolence":

> The wise and virtuous man … [i]f he is deeply impressed with the habitual and thorough conviction that this benevolent and all-wise Being can admit into the system of his government, no partial evil which is not necessary for the universal good, he must consider all the misfortunes which may befal himself, his friends, his society, or his country, as necessary for the prosperity of the universe, and therefore as what he ought, not only to submit to with resignation, but as what he himself, *if he had known all the connections and dependencies of things*, ought sincerely and devoutly to have wished for.
>
> (TMS, 235–6) [Emphasis added]

The key item here is that the wise individual in question normally does not know the connections and dependencies of the social system, and thus is incapable of deciphering the operation of the invisible hand.

Indeed, in his last writing,[7] Smith introduced and criticized the image of

a reformer who attempts to comprehend and control the system as a whole (TMS, VI.ii.2.16, 233–34):

> The man of system, on the contrary, is apt to be very wise in his own conceit; and is often so enamoured with the supposed beauty of his own ideal plan of government, that he cannot suffer the smallest deviation from any part of it. . . . He seems to imagine that he can arrange the different members of a great society with as much ease as the hand arranges the different pieces upon the chess-board. . . .
>
> Some general, *and even systematical*, idea of the perfection of policy and law, may no doubt be necessary for directing the views of the statesman. But to insist upon establishing, and upon establishing all at once, and in spite of all opposition, every thing which that idea may seem to require, must often be the highest degree of arrogance.

In this passage, taken from his final revision of *Moral Sentiments* in 1790, Smith is reacting to the French Revolution (Raphael and Macfie in Smith 1982: 18–19); in no way is this a contradiction of his notion that society behaves like a system. More specifically, what Smith says in this passage is that the reformer cannot measure up to the complexity of the task. Why does Smith criticize the "man of system"? Because his "ideal plan of government" cannot even attempt to approximate what the natural system or order (the "invisible hand") can do.[8]

In several passages of *Moral Sentiments* the idea of individual submission to a system carries a ring of degraded resignation in face of an unstoppable destiny.[9] However, before jumping to this conclusion we must identify and analyze the nature of the system that characterizes *Moral Sentiments*. This will be the focus of the next section.

The system of interlocking jurisdictions

Society is conceived as an intricately interconnected system in the *Theory of Moral Sentiments*, through a set of relations binding the individual components of the system together. The system is not simply traced via metaphors but is explicitly described in Part II, "Of Merit and Demerit." Here Smith introduces the notion of the *impartial spectator*, an inner voice of conscience, which will become the basic foundation for the construction of the system (TMS, II.ii.2.2, 83):

> Though it may be true . . . that every individual, in his own breast, naturally prefers himself to all mankind, yet he dares not look mankind in the face, and avow that he acts according to this principle. . . . When he views himself in the light in which he is conscious that others will view him, he sees that to them he is but one of the multitude in no respect better than any other in it. If he would act so as that the *impartial spectator* may enter into the principles of his conduct, which is what of all things he has the greatest desire to do, he must, upon this, as upon all other occasions, humble the arrogance of his self-love, and bring it down to something which other men can go along with. [Emphasis added]

Smith pursues the development of the impartial spectator as the key element of the system in Part III of *Moral Sentiments*. In contrast with the previous parts, here Smith concentrates on the origin and foundation of our judgments concerning our own conduct, instead of that of others. Smith tells us that (TMS, III.i.2, 110) "[w]e endeavour to examine our own conduct as we imagine any other fair and impartial spectator would examine it." The impartial spectator thus plays a key role in how we relate to the conduct of other individuals, and in how we can approve or disprove our own. The impartial spectator permits society to flourish on the basis of a proper comparison between individual interests (TMS, III.iii.1, 134):

> But though the approbation of his own conscience can scarce, upon some extraordinary occasions, content the weakness of man; though the testimony of the supposed *impartial spectator*, of the great inmate of the breast, cannot always alone support him; yet the influence and authority of this principle is, upon all occasions, very great; and it is only by consulting this judge within, that we can ever see what relates to ourselves in its proper shape and dimensions; or that we can ever make any *proper comparison between our own interests and those of other people*. [Emphasis added]

It is the impartial spectator that allows Smith to introduce some measure of objectivity in a world of otherwise self-contained individuals; and it helps structure a system of related individuals that rests on a secular principle.[10]

The central place of the impartial spectator rests on its relation with the notion of sympathy. Smith defined sympathy as something more general than benevolence (TMS, I.i.1.3, 10) and related to the sense of propriety. In turn, the sense of propriety depends crucially on the impartial spectator. In criticizing theories according to which "virtue consists in propriety," Smith states (TMS, VII.ii.1.49, 294):

> None of those systems give . . . any precise or distinct measure by which this fitness or propriety of affection can be ascertained or judged of. That precise and distinct measure can be found nowhere but in the sympathetic feelings of the impartial and well-informed spectator.

But the impartial spectator may have been something more than just part of Smith's theory of conscience. It may have been part of an attempt to

approach the question of interpersonal comparability, and even to solve the problem of impartiality of moral value judgments (Hausman and McPherson 1993: 692–93). Smith is in this sense the forerunner of the "imaginative empathy" used by Harsanyi (1988) in the analysis of interpersonal utility comparisons, a controversial step that Harsanyi describes as unavoidable in the field of ethics.[11] Although the procedure of imaginative empathy poses insoluble problems in modeling, the important point here is that it involves in *Moral Sentiments* a network of interdependent relations and a system.

The notion of the impartial spectator is closely related to the idea of *jurisdiction* introduced in *Moral Sentiments*. Each man has been rendered the immediate judge of mankind, but he has been so rendered only in the first instance, and an appeal can go to a much higher tribunal, the tribunal of individual conscience, "to that of the supposed impartial and well-informed spectator, to that of the man within the breast, the great judge and arbiter of their conduct." The key description of jurisdictions is as follows (TMS, III.2.32, 130):

> The jurisdictions of those two tribunals are founded upon principles which, though in some respects ressembling and akin, are, however, in reality different and distinct. The jurisdiction of the man without, is founded altogether in the desire of actual praise, and in the aversion to actual blame. The jurisdiction of the man within, is founded altogether in the desire of worthiness, and in the aversion to blameworthiness.

The jurisdictions overlap and act reciprocally as mirrors reflecting each other's images. If all men are judges, then no one is superior to others. In society, men act as mirrors of each other (TMS, III.1.3, 110), and in isolation the impartial spectator acts as "the only looking-glass by which we can . . . with the eyes of other people, scrutinize the propriety of our own conduct" (TMS, III.1.5, 112). Every man is a small component of the whole, but he is made up in this complex manner. Although he may appear to be a small element, this internal structure does not allow us to see him as an insignificant part of the system, and certainly not as a debased individual. In fact, as Minowitz (1993: 214) says, "Smith wants to complete the liberation of the conscience from 'ecclesiastical powers' by subordinating it to nature [via the impartial spectator] rather than to the sovereign."

The social system of *Moral Sentiments* can be described as a network of *interlocking jurisdictions* in such a way that "[e]very faculty in one man is the measure by which he judges of the like faculty in another" (TMS, I.i.3.10, 19). Through the impartial spectator and the network of interlocking jurisdictions, the system of Smith's ethics seems to move through self-enforcing rules or laws described in a tone worthy of the Old Testament (TMS, II.ii.2.3, 84):

> The violator of the more sacred laws of justice can never reflect on the sentiments which mankind must entertain with regard to him, without feeling all the agonies of shame, and horror, and consternation. . . . By sympathizing with the hatred and abhorrence which other men must entertain for him, he becomes in some measure the object of his own hatred and abhorrence. . . . The thought of this perpetually haunts him, and fills him with terror and amazement. He dares no longer look society in the face. . . . Every thing seems hostile, and he would be glad to fly to some inhospitable desert, where he might never more behold the face of a human creature. . . . But solitude is still more dreadful than society. His own thoughts can present him with nothing but what is black, unfortunate, and disastrous, the melancholy forebodings of incomprehensible misery and ruin.

Although Nature did not impose upon human beings the enforceability of justice's mandates by the "terrors of merited punishment," it did implant "in the human breast that consciousness of ill-desert, those terrors of merited punishment which attend upon its violators, as the great safeguards of the association of mankind," without which "an assembly of men" would be like a "den of lions" (TMS, II.ii.86).

The notion of unintended outcomes from social interactions appears in a discussion of conscience and the sense of duty. Smith's striking language on the subject (TMS, III.3.5, 137) seems to foreshadow the famous invisible hand passage of the *Wealth of Nations*:

> It is not the soft power of humanity, it is not that feeble spark of benevolence which Nature has lighted up in the human heart, that is thus capable of counteracting the strongest impulses of self-love. It is a stronger power, a more forcible motive, which exerts itself upon such occasions. It is reason, principle, conscience, the inhabitant of the breast, the man within, the great judge and arbiter of our conduct. It is he who. . . . calls to us, with a voice capable of astonishing the most presumptuous of our passions, that we are but one of the multitude, in no respect better than any other in it; and that when we prefer ourselves so shamefully and so blindly to others, we become the proper objects of resentment, abhorrence, and execration. . . .
>
> It is not the love of our neighbour, it is not the love of mankind, which upon many occasions prompts us to the practice of those divine virtues.[12]

As in the *Wealth of Nations*, the society analyzed in *Moral Sentiments* is not exclusively cemented together through feelings of friendship or the spark of benevolence. It is because the impartial spectator maintains everyone in order that the assembly of men does not fall apart. But Smith hints at two possible principles that allow the impartial spectator to do

what it does. First, the impartial spectator shows the propriety of generosity and the deformity of injustice; it reveals the propriety of resigning our own greatest interests for the yet greater interests of others. Second, it is not the love of our neighbor which prompts us to practice these virtues, but fear of the judgment and punishment that may be imposed by the impartial spectator which makes individuals "dare not, as self-love might suggest to us, prefer the interest of the one to that of the many" (TMS, III.6, 138). It is not for love of mankind that society is cemented together and can continue to exist. The social system described in *Moral Sentiments* as a *system of interlocking jurisdictions* shares with the one studied in *Wealth of Nations* a rationality driven by an unseen force or mechanism.

The whole purpose of the system is to attain justice, which is "the main pillar that upholds the whole edifice. If it is removed, the great, the immense fabric of human society ... must in a moment crumble into atoms." But Smith is even more specific in his analysis of the sources of justice: in the section "On the Nature of Self-Deceit," Smith states that the entire process based on the network of interlocking jurisdictions leads to the formation of the "general rules of morality" (TMS, III.4.8, 159). The relevant paragraph concludes that only when the general rules of morality have been formed and are universally acknowledged and established by "the concurring sentiments of mankind" can they be cited as the foundation of what is just and unjust. This has misled many eminent authors, continues Smith, to build a system in which the original judgments of mankind with regard to right and wrong are derived from the application of a preexisting general rule. The importance of the invisible hand in Smith's moral theory is clear at this point: *these authors are wrong, the rules are the outcome of a process which no one foresees and is beneficial to all*. Therefore, in the *Theory of Moral Sentiments*, moral rules are the object of what Nozick (1974, 1994) has called an invisible hand explanation.

The impartial spectator, the cornerstone of the social system in *Moral Sentiments*, has not been adequately studied.[13] The conventional view is that the appearance of the invisible hand in *Moral Sentiments* is limited to the famous passage in Part IV where the rich, moved by a desire to gratify their "own vain and insatiable desires," are led, without their knowing it, to "advance the interest of society." But in the main body of Smith's book every individual member of society is led to curb his excessive self-love, not by "love of neighbor or mankind," but by regard for the impartial spectator. Each individual may avoid the harsh judgment of the impartial spectator either by love of justice, or by fear of the astonishing voice of the "inmate of the breast." The result is the same: actions seeking to avoid a negative judgment bring about justice, which keeps the fabric of society together. The desirable final outcome is not intentionally sought by each individual, partly because they have only a limited understanding of the system's connections.

How is the system kept together in *Wealth of Nations*? A common answer is that it is "self-love" that cements the system in Smith's economic

theory, in contrast to the ethical system developed in his earlier work. But this interpretation is incomplete. For one thing, the network of interlocking jurisdictions bonding the system together in *Moral Sentiments* is already based "not on love of humanity," but in something resembling self-love, so this would not be enough to distinguish *Moral Sentiments* from *Wealth of Nations*. The key element distinguishing these two works is that in the latter, Smith examines society from the vantage point of a *price system*.[14] The critical difference is that the interlocking jurisdictions of *Moral Sentiments* are substituted by a matrix of relative prices. The impartial spectator is absent because the nature of the price system ensures enforceability of economic laws.

Anticipating the theory of the merchant society

The "connections and dependencies of things" that form the system in the *Theory of Moral Sentiments* are not for everyone to grasp or understand:

> The administration of the great system of the universe, however, ... is the business of God and not of man. To man is allotted a much humbler department, but one much more suitable to the weakness of his powers, *and to the narrowness of his comprehension*.... [T]hat he is occupied in contemplating the more sublime, can never be an excuse for his neglecting the more humble department.
>
> (TMS, 237; emphasis added)

Even the virtuous and wise will have difficulties trying to understand the complexity of the system. At most, they will submit to whatever calamity befalls them *as if* they had full comprehension of the necessity of these calamities arising from the interconnectedness of things. But when the wise and virtuous perceive the connections and dependencies, they may also realize that the end result is the greatest possible amount of happiness. The question is not whether individuals understand the process, but whether they are led to a desirable outcome.[15]

What about other men – those who are not wise and virtuous – in different types of societies? There is a passage on this subject in *Moral Sentiments* that builds a bridge with Smith's later work (TMS, II.ii.3.2, 85–86):

> though among the different members of the society there should be no mutual love and affection, the society, though less happy and agreeable, will not necessarily be dissolved. *Society may subsist among different men, as among different merchants*, from a sense of its utility, without any mutual love or affection; and though no man in it should owe any obligation, or be bound in gratitude to any other, it may still be upheld by a mercenary exchange of good offices according to an agreed valuation. [Emphasis added]

In these societies, "exchange according to an agreed valuation" plays the role that the impartial spectator and the interlocking jurisdictions have in *Moral Sentiments*. It also raises the key problem tackled by Smith in the *Wealth of Nations* through his value theory, namely the question of the dynamics of the price system. This is the introduction of the research program that Smith developed after 1776: when the division of labor has been established, every person must exchange the surplus which is of no use to its producer (WN, 22): "Every man thus lives by exchanging, or becomes in some measure a merchant, and the society itself grows to be what is properly a commercial society."

The rules by which *this* society is regulated must still be unraveled, and this is the objective of the *Wealth of Nations*. Why should the laws and rules (of exchange and valuation) regulating the system be identified and analyzed? Can't we be, like the wise and virtuous, satisfied with the system, knowing that the great Superintendent of the universe manages the system and takes every part of it to a state of universal prosperity where the greatest possible happiness is produced? Smith was clearly intrigued by this different society in which no sense of wisdom is present, and benevolence and the impartial spectator are absent. Surely he must have seen that the invisible hand process was much more interesting in the case where the impartial spectator is entirely absent: in a society of monks, in a monastery, there is no need for an invisible hand explanation of social harmony.

As he wrote his *Moral Sentiments*, Smith may have already been looking for the rules and laws that determine the dynamics of the "connections and dependencies of things," and he mentions some of the indirect mechanisms that lead to final unintended outcomes which are desirable from the economic standpoint. The relevant passage is molded in language that is familiar to the reader of *Wealth of Nations* (TMS, IV.1.11, 185):

> When a patriot exerts himself for the improvement of any part of the public police, his conduct does not always arise from pure sympathy with the happiness of those who are to reap the benefit of it. It is not commonly from a fellow-feeling with carriers and waggoners that a public-spirited man encourages the mending of high roads. When the legislature establishes premiums and other encouragements to advance the linen or woollen manufactures, its conduct seldom proceeds from pure sympathy with the wearer of cheap or fine cloth, and much less from that with the manufacturer or merchant. [T]rade and manufactures ... make part of the great system of government, and the wheels of the political machine seem to move with more harmony and ease by means of them.

Thus, the manufacturer and the merchant, attracted by premiums and other rewards, end up working towards a more harmonious system, most probably without knowing it.[16] But these references to indirect or unintended consequences were not enough for Smith's inquisitive inclinations. They merely defined a new problem area for a future research program that would animate his *Wealth of Nations*. It is true that Smith was preoccupied with practical problems in political economy and was concerned with the key policy question lurking behind all of this: how can we get rid of obstacles that impede the *natural* process of the economy from following its course? If the virtuous man could understand and recognize the connections and dependencies of things, he would clearly see that every partial evil is necessary for the universal good. He would then not only submit with resignation, but in fact would wish that the outcome be realized as soon as possible.[17]

Naturally, the reciprocal of this proposition is that if the outcome is undesirable (e.g., if it is poverty for the many, or downright exploitation for some), we must be ready to combat it.[18] So, proving the desirability of the final outcome is a very important chapter of the research program. Smith could not advance much in this direction because of the limitations of the price theory in his *Wealth of Nations*. His theory of cost-based "natural prices," and market prices that fluctuate around them, did not allow him to make a rigorous argument that market outcomes would be desirable; rather, this crucial point remained a casual, metaphorical assertion in his work. Still, Smith asserted that the desirable outcome is implied in the harmonious state of affairs produced by the invisible hand and described in terms of the "progressive" state of society.

At this point, another "Adam Smith problem" makes its appearance, in the discovery that there is a conflict of interests between the three orders of society (proprietors, workers, and capitalists), which is briefly explained at the end of Book I of *Wealth of Nations*. The invisible hand process may lead to prosperity in a progressive society, but this coexists with a situation in which the interests of one order of society ("those who live by profit") do not coincide with the interests of society as a whole (WN, 250): "the interest of the dealers ... in any particular branch of trade or manufactures, is always in some respect different from, and even opposite to, that of the public."

The conflict arises from Smith's particular concept of prices (as the sum of cost components) and the role of capital accumulation and competition. The resolution of this conflict of interests is not explicitly described by Smith. In Ricardo, the invisible hand process will be upheld, while at the same time a fundamental conflict over distribution will be introduced. How can we think of an invisible hand process, leading to a desirable social outcome, in the context of such a fundamental social conflict? How can we reconcile social harmony stemming from the invisible hand process (based on the compatible plans of individual agents) with social conflict in the "sphere of distribution" (based on the inverse relation between the rate of profits and wages)? This is carried to the extreme in Marx's

account of the invisible hand, where the unintended outcome is associated with class exploitation.[19]

In *Wealth of Nations* Smith examines (through the spectacles of value and price theory) how social harmony can still be upheld "by a mercenary exchange of good offices according to an agreed valuation." Smith now takes the extreme hypothesis required by his theory: individuals do not engage in reciprocal assistance out of "fellow-feelings," but rather are moved by self-love. And with the impartial spectator completely absent, the critical role of the market in achieving social harmony (i.e., the compatibility of individual plans) becomes the central object of analysis. But to perform the trick of harmonization in the midst of a community of self-interested individuals, without the intervention of the "inmate of the breast" and in a decentralized framework, is the new challenge. This is the true nature of the assumption of self-love: it is the strong hypothesis under which it is pertinent to analyze the performance of the allocative functions of the market's invisible hand. The idea that the invisible hand would work in the presence of wise and virtuous men is not relevant; these agents would either perceive the nature of the laws that are involved, wisely submitting to their command, or they would draw up a special compact to guarantee social coherence. The only case where it is important to prove that the invisible hand is able to perform its task is precisely the case of proud, vain, and unwise men.[20]

Shrewd individuals and witless agents

When we shift our attention to modern general equilibrium theory, or even to newer theoretical developments such as multi-agent models, we find that the question of freedom and submission under the invisible hand is closely related to some of the crucial assumptions in contemporary price theories. In the modern modeling context, are agents allowed to do more than wait for the equilibrium price vector to be announced? In Smith's terms, are the individuals subject to the invisible hand allowed to be other than wise, virtuous, and passive?

Pride and vanity may coexist in cunning and shrewd individuals. Therefore, the individuals involved in Smith's account of the invisible hand (under the extreme self-love assumption, without the impartial spectator) need not submit wisely and passively to the workings of the process. In fact, one would expect that if they are smart enough to be aware of disequilibrium opportunities, they will try to engage in arbitraging operations that will translate into greater gains. Rothschild is right: agents in new approaches to dynamic processes may be "more Smithian" and closer to "the complicated merchants of Smith's theory" than the well-behaved agents of traditional general equilibrium models. But so far (given the limitations of general equilibrium theory discussed in this volume), we do not have a theory in which socially desirable situations arise as the unintended outcome of individual actions of agents who are self-aggrandizing *and* astute. This section comments on some of the problems encountered in contemporary economic theory in its attempt to provide a comprehensive invisible hand theory.

In fact, what is often referred to as the "theory of the invisible hand" does not constitute a rigorous interpretation of market processes. Its problems are not limited to the status of the individual agents involved in the invisible hand, but rather cover the entire price formation process. The theory of stability formulated between 1950 and 1970, and known as *tâtonnement* price formation, shows that it is possible to build theories about dynamic processes leading to optimal unintended outcomes. But the results of this theory are unsatisfactory. As is well known, this contribution to stability theory has relied on the quite *visible* hand of the Walrasian auctioneer as an authority lurking behind the adjustment process, centralizing information and adjusting everyone else's prices.[21]

Moreover, the theory of general equilibrium has constructed a model in which the individual agents present very negative characteristics. As Rothschild's interesting essay puts it, "the *tâtonnement* of general competitive equilibrium is a (blind) groping in the dark." Agents cannot see the Walrasian auctioneer aggregating data and adjusting prices according to the sign of excess demands. But in addition, agents in *tâtonnement* models are also autistic because they do not have any communication with other individual agents of the system, amnesic as they cannot recall past price vectors, naive as they believe every price vector is an equilibrium price vector, and shortsighted as they are prevented from anticipating future price movements. They are also passive agents because they cannot carry out transactions outside of the equilibrium, and wait for the auctioneer's signal before they proceed to realize their exchanges. As a result, individuals in these models are indeed devalued, partly as a consequence of concentrating sight and memory in the incarnation of the invisible hand: the auctioneer must be able to aggregate information, calculate excess demands and adjust prices in order to reach a competitive equilibrium; in short, human capabilities denied to the agents are granted to the auctioneer alone.

The crucial point here is that in spite of all of these restrictive assumptions (which are needed to reach a Pareto-optimal equilibrium), stability theory has not yielded good results. When some of the restrictive assumptions in these general equilibrium models are relaxed, as in the Hahn–Negishi non-*tâtonnement* process allowing trade to take place in disequilibrium situations, the central figure of the auctioneer is still needed to play the critical price-adjustment function. The fictitious auctioneer is not only a restrictive assumption, but one that contradicts the object of an invisible hand theory, the possibility of price formation in decentralized market processes. In a sense, this continues to be the single most important unsolved problem in stability theory, in the context of both

tâtonnement and non-*tâtonnement* models. In the more advanced models, for example that of Fisher (1983), with trading opportunities perceived by individual agents and without an anonymous price adjustment process, additional restrictive assumptions are required. The worst part is that the outcome may not be a competitive equilibrium; this poses a deep problem. If the outcome of the invisible hand process is not desirable, we may have to engage in actions to guide the process towards a different outcome. The stakes are extremely high, and yet, as of today, we still lack a satisfactory theory of invisible hand processes replicating market dynamics and yielding desirable outcomes.

We are still far from having a convincing model of the truly relevant invisible hand process: a case in which the interaction between self-aggrandizing individuals who are also aware of disequilibrium opportunities and engage in strategic behavior leads to a socially desirable outcome. Agents involved in Bayesian learning processes, aware of the fact that they may get close to influencing final outcomes and even modifying the rules of games, may be a perfect example. But the lack of an explicit, economically meaningful dynamic price adjustment process in these models still leaves them far from constituting a satisfactory theory of the market.

The invisible hand remains popular, in academic as well as political life: "[Nozick's] proposition that 'Invisible hand explanations of phenomena ... yield greater understanding than do explanations of them as brought on by design as the object of people's intentions' has made progressive headway and now enjoys widespread support" (Williamson 1994). It is intriguing to see how this enthusiasm and widespread support can coexist with such negative results of the theory of market processes.[22] Stability analysis is widely recognized as unsatisfactory, and the theory of *N*-person noncooperative games has still to deliver definitive results, so the solid foundation for the faith in the outcomes of processes where "groping individuals move towards more efficient institutions" is nowhere to be seen.

The bottom line is that we still lack a good theory of dynamic invisible hand processes leading to a socially desirable outcome, however the model is specified. At the heart of this problem lies the status of the individual agents involved in the process. The impartial spectator allowed Smith to define a social system (interlocking jurisdictions) and an invisible hand explanation for social harmony and the emergence of moral norms. But Smith must have remained unsatisfied with this partial result. After all, introducing the figure of the impartial spectator in each individual is almost equivalent to assuming away the problem of social harmony. Dropping the assumption of the impartial spectator and working with the extreme hypothesis of unbridled self-love was needed in the attempt to perfect the invisible hand explanation of social harmony through the performance of the market. Some experiments in contemporary theory are continuing the search for increased realism and allowing individuals to

perceive favorable opportunities outside of equilibrium positions. This is analogous to endowing them with the ability to perceive part of the "connections and dependencies of things" (TMS, 235–36), but without the countervailing weight of the impartial spectator's "astonishing voice." Building a model along these lines which leads to a socially desirable outcome has not been an easy task.

Concluding remarks

Stephen Jay Gould (1993) has reminded us that Darwin's theory of evolution and Adam Smith's theory of the invisible hand are structurally similar. In his description of the invisible hand in economic theory, "the inefficient are weeded out and the best balance each other to form an equilibrium to everyone's benefit." Biology is already in debt to economic theory through Malthus's influence on Darwin, and economists are correspondingly beginning to browse in biological analysis and borrow ideas to illuminate the structure of social systems.[23] Consider, for example, Gould's (1990) discussion of the geological evidence of the fossil record. He chooses the example of the decimation of the Burgess Shale fauna to affirm that it may be "a grand scale lottery, meaning it would not happen the same way again if you replayed the tape and decimated it a second time in different ways." Thus, *the future does not control the present*; the accidental and contingent are the dominant themes behind evolution.[24] Whatever happens makes sense after the fact; it is not random and chaotic, but it is utterly unpredictable in advance.

And now consider the implications for economic theory. Are certain outcomes of invisible hand processes predictable? Stability theory in path-dependent processes says no: as in evolutionary processes, there are numerous possible trajectories in the dynamics of state variables. If we rewind the tape and play it again, the outcome will be different every time.

If agents are modelled as active individuals, they may become more realistic replicas of real-life agents, and the models may become more relevant to modern economic reality. However, so far, models incorporating these features do not necessarily lead to socially desirable outcomes. The predicament can therefore be stated as follows: to obtain more realistic and relevant models of individual agents, contemporary models lose the crucial property of having the invisible hand reliably lead to a socially desirable outcome.

In Smith's view, freedom of the individuals coexists with their submission to the forces of the system. But a conclusion regarding the status of individuals will depend critically on several things. It will depend on the relative position of each individual agent (or class of agents) within the system's nontrivial laws. It will also depend on their relative position in the final outcome (e.g., whether or not it is socially desirable). In fact, it may also depend on whether the invisible hand process being considered is

an economic process or not, and on whether the individual agents are introduced with due consideration to their *agency* dimension (Sen 1987) or the degree of positive and negative liberty accorded to them.

As economic theory moves into the world of evolutionary models and self-organization environments, it is important to remember the unfinished business in the theory of the invisible hand. One crucial element here is that belonging to a system, in itself, does not necessarily transform individuals into degraded beings. Smith's description of the social system in *Moral Sentiments* clearly shows there are alternative ways of thinking about the relation between individuals and social systems which do not imply degrading the individual. In terms of invisible hand processes that are economically meaningful, the problem has to be viewed from a different perspective.

In the end, we may never get close to the dream of a general theory of the market (i.e., countless uncoordinated individuals acting in interdependent markets to reach an outcome sought by none but blissful to all). As agents are allowed to be aware of disequilibrium opportunities, and to play with terms of trade in their quest for advantages, the outcome is influenced by their actions. Of course, awareness of disequilibrium opportunities and possibility of engaging in arbitrage operations for individual gains may be closer to economic reality. But models incorporating these features involve a hysteresis or path-dependency effect. And although path-dependent processes may shed more light on real-life economic processes, contemporary models reveal that the final outcome is not necessarily a Walrasian equilibrium. Finally, self-organization models may reveal how power relations (strategic behavior and bargaining power) influence the final outcome of economic structures. But the profile of possible aggregate results seems to open the door for a seemingly unSmithian conclusion: the need for more (and better), not less, public intervention.

The resolution of the "Adam Smith problem" is that his two major works present models of society with different content – but with the same underlying structure. The invisible hand coordinates individual actions to produce an unintended yet desirable social result – in the realm of morality in *Theory of Moral Sentiments*, and in the competitive marketplace in *Wealth of Nations.* While provocative and insightful, neither version of the theory quite stands on its own as a description of society: the model in *Moral Sentiments* relies on remarkably strong assumptions about the power and universality of individual conscience, while the model from *Wealth of Nations* – as more than two hundred years of subsequent research has shown – cannot prove the optimality of market outcomes without adding unrealistic or arbitrarily restrictive assumptions.

The faceless statue of Ceres, goddess of agriculture, is not an adequate symbol for the Chicago Board of Trade, or for the global market system of which it is a focal point. Agents intervening in the market are shrewd and cunning, not passive and anonymous calculators lacking a vision of the future. In this sense, the forces of market exchange should be symbolized by a statue with a face. Let's hope that, in the spirit of the *Theory of Moral Sentiments*, that figure may one day be Minerva, the goddess of wisdom.

Notes

1 With the term "invisible hand" we follow conventional usage, describing a process in which the actions of many individuals produce an unintended outcome. This implies that agents can be seen as connected in a system whose dynamics lead to the unintended result. Because individuals do not perceive the laws regulating the system's dynamics, it is said that the process is invisible to them. Not all invisible hand processes are economic or market processes.

2 Rothschild has returned to the topic in a more recent work, expanding on the arguments presented in her earlier article (Rothschild 2001; see especially chapter 5). The original version of this chapter was published in 1998, when only Rothschild's earlier work was available.

3 Smith's *Theory of Moral Sentiments* was first published in 1759 and was revised several times. The sixth and last revision was carried out in 1790, fourteen years after publication of his *Wealth of Nations*. The sixth edition incorporated important additions (particularly the inclusion of section VI) but no major changes in fundamental theses. In what follows, all references to *Moral Sentiments* are from the Raphael–Macfie edition reprinted in 1982.

4 According to Smith (TMS, I.i.4.2, 19) the "immense machine of the universe" is continually exhibiting the most diverse appearances, even in the conduct of a third person. This reinforces the idea that wise men recognize their modest role in society.

5 Smith's language assumed that the typical individual was male. It seemed simpler to us, in a detailed discussion of his texts, to follow his wording when referring to his concepts, rather than repeatedly correcting it to gender-neutral terminology. Our apologies: we are well aware that half of the individuals in society are not "men."

6 The wise and virtuous man never forgets "for one moment the judgement which the impartial spectator would pass upon his sentiments and conduct. He has never dared to suffer the man within the breast to be absent one moment from his attention." (TMS, III.3.26, 147).

7 Section VI was introduced in the last revision of *Moral Sentiments* in 1790.

8 This is nothing but a development of the last passages of *Moral Sentiments*, where Smith states that "[e]very system of positive law may be regarded as a more or less imperfect attempt towards a system of natural jurisprudence, or towards an enumeration of the particular rules of justice" (VII.iv.34, 340). And: "In no country do the decisions of positive law coincide exactly, in every case, with the rules which the natural sense of justice would dictate. Systems of positive law ... can never be regarded as accurate systems of the rules of natural justice" (TMS, VII.iv.37, 341). Work along these lines was promised by Smith at the end of *Moral Sentiments* but could not be accomplished. Smith's position here has an echo in modern general equilibrium theory, where the outcome of market forces cannot be improved by anyone.

9 See, for example, this description of Stoic philosophy (TMS, VII.ii.1.38, 289): "Whoever does not cordially embrace whatever befalls him, whoever is sorry that it has befallen him, whoever wishes that it had not befallen him, wishes, so far as in him lies, to stop the motion of the universe, to break that great chain

of succession, by the progress of which that system can alone be continued and preserved, and, for some little conveniency of his own, to disorder and discompose the whole machine of the world."

10 The passage is followed by a reference to a hypothetical devastating earthquake in China that only generates insignificant sympathy in Europe. Only the impartial spectator can prevent these superficial feelings. Raphael and MacFie suggest the example may have been inspired by the Lisbon earthquake of 1755. The passage reveals Smith's strong commitment to a secular explanation of the world, a view that pervades Smith's work.

11 Harsanyi (1988) traces this unavoidability to formal reasons surrounding the definition of individual social welfare functions, a procedure that faces the intractable problem of accessing a common utility unit. Of course, Smith's individuals are far from Harsanyi's agents, who try to base their social welfare functions on conversion ratios between the various agents' utility units. The sentiment of approbation and propriety in Smith is not determined in this fashion because welfare is not identified with utility. Smith's impartial spectator is also presented by Wilson (1976) as a special case of interdependent utility functions.

12 Compare with the well-known passage in chapter II of *Wealth of Nations* (p. 14): "We address ourselves, not to their humanity, but to their self-love, and never talk to them of our own necessities but of their advantages." Hirschman (1977) has shown how the conception of human beings as a unit where interests curb passions was not uncommon before Smith's time, and there is a clear echo of this idea in many of the passages describing the "impartial spectator."

13 This is ironic, because, as Raphael and Macfie point out, the frequency of passages referring to Smith's conception of the universe as a system "leads one to think that commentators have laid too much stress on the 'invisible hand'" (p. 7).

14 This point requires clarification. To a first approximation it could be said that the social system in *Wealth of Nations* is structured as a set of branches (or "employments," in Smith's terminology) of economic activity. Although the branch is Smith's unit of analysis in many important sections of *Wealth of Nations*, the notion of interdependent branches as the foundation of the economic system had to wait until Ricardo's "Essay on Profits" and later his *Principles*. This view introduced new difficulties in the theory of the invisible hand process as we comment below (see note 16).

15 The importance of this question was well understood by none other than Walras (1969) himself in his debate with the followers of Proudhon. If the outcome of the invisible hand process is not desirable, we might even have to think about stopping it or counteracting its thrust.

16 Smith criticizes policies aimed at this in other parts of *Moral Sentiments* as hindrances to the free operation of the natural system. The passage quoted here belongs to Part IV which is largely devoted to describing and criticizing Hume's theory of propriety and utility.

17 And like Demetrius's citizen he would say, "I have only one complaint to make to you, immortal gods, that you did not make your will known to me before; for I should then have come the sooner to the state in which I now am after summons." Reported by Seneca and quoted in TMS (IV.2.1.20, 276).

18 The "desirability" of the outcome in general equilibrium theory is defined in terms of a Pareto optimality criterion. Sen (1987) addresses a lucid criticism to general equilibrium theory on this point.

19 Of course, the interest of this question may be restricted to classical and Marxian political economy because, in contrast with neoclassical (general equilibrium) theory, distribution is not determined simultaneously with prices. The state of price theory, in the context of the classical theory of gravitation of market prices, or in a Marxist context, is far from providing a satisfactory explanation of an invisible hand process.

20 Smith did not think that this was the best way to live in society, but the assumption is crucial for market theory. Smith's belligerent debate with Hobbesian thought helps explain this: even in the context of a society full of selfish and egotistical individuals, the social device called the market arranges things in such a manner that individuals do not cut each other's throats. The market will make individual plans compatible with each other, achieving social harmony. So there is no need for Leviathan; and in fact, we can say that Smith identifies economic relations as the one dimension of social life where passions do not have to be curbed by the power of the state or any other central authority in order to attain social harmony. On the contrary, in economic relations self-love can remain unbridled because it will lead to social harmony by the grace of the market.

21 Additional restrictive assumptions are required to ensure stability in this model. Either of the following is sufficient: all goods are gross substitutes, or the weak axiom of revealed preferences at the market level must be introduced. The first is, of course, extremely restrictive, and the second does not have any economic sense.

22 Nozick (1994) himself seems unaware of these difficulties in stability theory and continues to believe that "equilibria within markets" are the product of invisible hand processes.

23 An early inspiration here is Nelson and Winter (1982), in their borrowing of conceptual tools from biology to build their evolutionary model of economic change.

24 This is Darwin's argument, and evidence suggests he got it from Smith (Gould 1990: 22): the publication of Darwin's notebooks shows that his reading of Dugald Stuart's work on the life of Adam Smith provided a key input into the theory of natural selection. Our analysis shows that Smith had a different view of the typical invisible hand process, namely, one in which the final outcome is indeed preordained, although the individuals involved do not perceive this. However, if there is one lesson to be observed from contemporary developments in market theory, it is that as soon as multiple equilibria, disequilibrium opportunities, and arbitraging are introduced, it is not possible to think that the present is preordained by some future state of events.

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