



Problems with How We Do Economics Today

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3.1 Introduction [1]

The first chapter of this book summarized how we undertake economics, and our explanation for that approach in the modern Western world. The second chapter introduced the idea that this contemporary view of understanding economics is just one of many ways that humans have understood how the economy operates. The last century has seen the ascendancy, indeed intellectual dominance, of neoclassical economics (NCE, also known as Walrasian economics). The basic NCE model represents the economy as a self-maintaining circular flow among firms and households, driven by the psychological assumptions that humans act principally in a materialistic, self-regarding, and predictable way. Unfortunately, the NCE model violates a number of physical laws and is inconsistent with actual human behavior, rendering it to be an unrealistic and a poor predictor of people's actions. Recently, an array of experimental and physical evidence and theoretical breakthroughs demonstrate the disconnect between evidence and neoclassical theory. Despite the abundance and validity of these critiques, few economists seriously question the efficacy of the neoclassical paradigm that forms the foundation of their applied work, although behavioral economists such as George Akerlof and Richard Thaler have received Nobel Prizes precisely for questioning the assumptions about rationality. This is a problem because policy makers, scientists, and others turn to economists for answers to important questions. The supposed virtues of "privatization," "free markets," "consumer choice," and "cost-benefit analysis" are considered to be self-evident by most practicing economists, as well as many in business and government. In fact, the evidence that these concepts are correct is rather slim and contradictory. Thus, this chapter is a strong critique of economic theory, in this case NCE.

We offer a review and synthesis of NCE, paying particular attention to the lack of connection of NCE to biophysical reality and its inadequate characterization of human behavior. When all the criticisms are taken as a whole, it is clear that the NCE framework stands on an untenable foundation and that some other basis for interpreting economic reality must be found. NCE is very limited in its usefulness and cannot guide us in our attempts to deal with the most critical issues of

our time, such as the depletion of oil and gas, climate change, financial crises, inequality, and the destruction of much of nature. We end by sketching alternative characterizations of human behavior and economic production.

3.1.1 Economic Issues Appropriately Assessed with Conventional Economics

Before we begin we wish to emphasize that there are any number of conventional "economic" questions about which we believe that conventional economic procedures are accurate and appropriate. For example, we have no argument with cost and gain accounting procedures used by businesses and individuals. One must balance one's own accounts using just dollars, although one can think about the meaning of those dollars in terms of their energy backing. Our issue is with the theory that forms the basis for economic thinking. This theory is the basis for more complex economic thinking.

3.2 Some Fundamental Myths of NCE

The edifice of NCE is built on myths and based on an outdated worldview. These myths are not merely harmless allegories because they provide the foundation upon which economic policy is made and cultural attitudes are distilled. Thus, the worldview and policy prescriptions of most economists can only be described as "faith based" because many fundamental tenets of NCE are inconsistent with economic reality.

3.2.1 Myth 1: A Theory of Production Can Ignore Physical and Environmental Realities

Real economies are subject to the forces and laws of nature, including thermodynamics, the conservation of matter, and a suite of environmental requirements. NCE does not recognize or reflect the fact that economic activity requires the inputs and services of a finite biophysical world which is usually diminished and degraded by that activity.

3.2.2 Myth 1a: The Economy Can Be Described Independently of Its Biophysical Matrix

NCE begins with a model depicting abstract exchange relations considered only as goods and services and money within a world unrealistically limited to markets, firms, and households. Real economies also require material and energy from the natural world to allow that exchange and are limited by the material and energy transformations necessary for economic activity. Students are introduced to the *circular flow model* of the economy in the first days of principles of economics. This conceptual vision of the economy is one of a self-contained and self-regulating system independent of the biophysical system and its laws. There are but two sectors, households and firms, with goods and services going from firms to households, and productive inputs (land, capital, and labor) going from households to firms. As seen in ► Chap. 1, all human interactions take place in markets. Firms acquire the property right for land, labor, and capital in the factor market by payment of rents, wages, interest, and profit. Consumers in the household receive goods and services in exchange for money. All exchanges are seen as voluntary and made in the pursuit of self-interest. For the model, at this basic level, to be self-regulating the money that flows from firm to household (the sum of factor payments) must equal the total expenditures on goods and services. No money is saved, and no profits are retained by business for reinvestment. But more importantly from a thermodynamic point of view, the material and energy inputs required for production are simply left out of the model.

Neither monetary value nor physical materials are lost to heat or erosion as inputs are transformed into goods and services. Thus, the circular flow model represents an abstract notion of an economic system that cannot exist.

The NCE notion of scarcity is disconnected from biophysical reality for it is never absolute but only relative to unlimited wants. If we are confronted by the limits of one resource, the imaginative human mind, driven by the proper set of monetary incentives and protected property rights, we will always create a substitute. No input is critical, therefore neither absolute scarcity nor the need of any particular resource is a problem in the long run. Thus, in the NCE world the economy can simultaneously experience relative scarcity and

infinite growth. Competitive prices, formed in markets, assure that resources flow to their best use.

Nicholas Georgescu-Roegen and his student Herman Daly were among the first to point out the absurdity of this depiction of production. Real economies cannot exist outside the global biophysical system, which is essential to provide energy, raw materials, and a milieu within which it can operate and assimilate wastes [2, 3]. Their first step to make an economic model consistent with reality is to put the economy *inside* the global biophysical system. Some natural scientists have gone several steps further. Several writers [4–7] demonstrate clearly that the NCE model is unacceptable because (1) its boundaries are drawn incorrectly and (2) the model is de facto a perpetual motion machine because it has neither energy inputs nor entropic loss. Many economists today, including many recent Nobel Prize winners (e.g., Paul Krugman, Amartya Sen, Joseph Stiglitz, George Akerlof, and Elinor Ostrom) have very serious reservations with the contemporary model. Most of the authors referenced in this paragraph, the authors of this book, and many other physical and social scientists are not interested in simply making corrections to the basic NCE models. Instead these scientists and others believe that the NCE model is incorrect at its core. For starters, while money may cycle seemingly indefinitely among goods and services, the real economic system cannot survive without continual inputs from, and outputs to, nature.

3.2.3 Myth 1b: Economic Production Can Be Described Without Reference to Physical Work

The neoclassical economists' model of production does not require any specific physical inputs but is solely an exchange of existing entities among firms and households. The economic process is driven not by the availability of physical resources, but rather by human ingenuity as depicted in the still widely used Cobb-Douglas function. The quantity of output produced (Q) is a function of only capital (K) and labor (L).

$Q = AK^\alpha L^\beta$ where α represents capital's share of output, β stands for labor's share, and $1 > \alpha > 0$. Moreover, $\alpha + \beta$ must add to one, so $\beta = 1 - \alpha$. The product of capital and Labor is also multiplied by some constant A , considered "pure technological change," or total factor productivity.

In this model technology is independent of the inputs of land and capital and is calculated as a “residual” left when the contributions of the measured factors (i.e. capital and labor) are subtracted from the growth rate of total economic output [8]. Not surprisingly the residue tends to increase over time. Thus, most economists believe that technology is difficult to measure but can increase the productive power of the economy without limit. With the assumption that there are no diminishing returns to technology, there is no need to worry about physical work or the scarcity of any productive input.

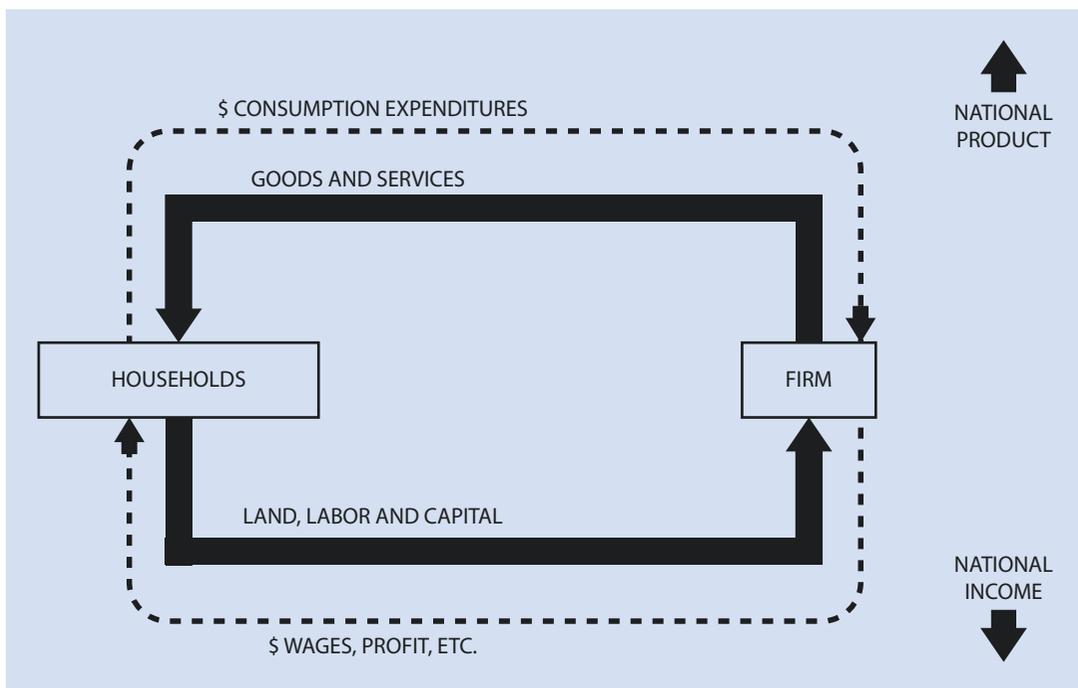
The preoccupation with pure technological change as the driver of economic growth has caused earlier neoclassical economists to virtually ignore the critical importance of energy in powering the modern economy [8]. In contrast, many natural scientists and some economists have concluded that the explosion of economic activity during the twentieth century was due principally to the increase in the ability to do work through the expanding use of fossil fuel energy. In fact, the neoclassical economist’s technology residual disappeared when energy was included as an input. Energy as a factor of production was *more impor-*

tant than either capital or labor for Germany, Japan, and the United States in recent decades [6]. Further Ayers and Warr [9] found that most improvements in “technology” have been simply an increase in the quantity of energy used or the efficiency of getting it to the point where the work is done. Although NCE models purport to show that technology alone has driven the industrial economy, historically, it has been a technology that mostly has found new sources of, and applications for, energy.

There are a number of additional, more specific, criticisms that the natural scientist can level against the basic neoclassical model as summarized in Hall et al. 2001 [6]. These criticisms are devastating to the fundamental approach taken by neoclassical economics and taken together mean that there is no possibility that we can assign any validity to the basic neoclassical model.

3.2.4 Specific Criticism 1: Thermodynamics

Contemporary economics and its fundamental household-firm-market model (■ Fig. 3.1) pays



■ Fig. 3.1 The neoclassical view of how economies work. Households sell or rent land, natural resources, labor, and capital to firms in exchange for rent, wages, and profit (factor payments). Firms combine the factors of production

and produce goods and services in return for consumption expenditures, investment, government expenditures, and net exports. This view represents, essentially, a perpetual motion machine. See also ■ Fig. 1.1

only minimal attention to the first law of thermodynamics, and none at all to the second. In fact, the second law is completely incompatible with the conceptual model known as the circular flow. In the circular flow diagram, there is never any value lost to waste or entropy. Specifically, there is no dissipation of the useful work of energy as it is used, and hence no requirement in that model for an input of new energy. This is a serious conceptual flaw and an obstacle to designing economic policies that can meet the challenges of pollution, resource scarcity, and depletion successfully. In effect, the two laws of thermodynamics say, “Nothing happens in the world without energy conversion and entropy production.” The consequences are: (1) Every process of industrial and biotic production requires the input of energy. (2) Because of the unavoidable entropy production, the valuable part of energy (called exergy) is transformed into useless heat at the temperature of the environment (called anergy), and usually matter is dissipated, too. This results in pollution and, eventually, the exhaustion of the higher-grade resources of fossil fuels and raw materials. (3) Human labor, powered by food, can be, and was, replaced by energy-driven machines in the course of increasing automation. This has allowed an increase in the productivity of labor, as each worker can do more real work. But it also makes much of labor increasingly superfluous.

Although the first and second laws of thermodynamics are among the most thoroughly tested and validated laws of nature and state explicitly that it is impossible to have a perpetual motion machine (i.e., a machine that performs work without the input of exergy), the basic NCE model *is* a perpetual motion machine, with no material requirements and no limits (■ Fig. 3.1). Most economists have accepted this incomplete model and have relegated energy and other resources to unimportance in their analysis. Rather than placing the economy within the confines of nature, this approach relegates all the limits of nature to a minor position within a system of self-regulating markets. This attitude was cemented in the minds of most economists by the analysis of Barnett and Morse [34], who found no indication of increasing scarcity of raw materials (as determined by their inflation corrected price) for the first half of the twentieth century. However, their analysis, although cited by nearly all economists interested in the depletion issue, was seriously incomplete. Cutler Cleveland showed that the only reason that decreasing con-

centrations and qualities of resources were not translated into higher prices for constant quality was because of the decreasing price of energy [10]. Thus, it is only because of the historic abundant availability of many natural resources that economics can assign them low monetary value despite their critical importance to economic production.

3.2.5 Specific Criticism 2: Boundaries

The basic model used in neoclassical economics (■ Fig. 3.1) does not include boundaries that in any way indicate the physical requirements for, or effects of, economic activities. We believe that at a bare minimum ■ Fig. 3.1 should be reconstructed as ■ Fig. 3.2 to include necessary resources and generation of wastes. Taking this assessment one step further, we believe that something like ■ Fig. 3.3 is the diagram that should be used to represent in more detail the physical reality of an economy’s working. It shows the flow of energy and matter across the boundary separating the reservoirs of these “gifts of nature” from the realm of cultural transformation within which sub-boundaries indicate the different stages of their further transformation into the goods and services of final demand. Such a diagram should be presented to every student in an introductory economics course so that the ways the economic process operates in the real world are properly understood. Another way of reflecting the necessary changes is that ■ Fig. 3.4 shows the standard economist’s view of one person’s role in the economy, while ■ Fig. 3.5 gives the biophysical perspective of what biophysical materials are actually needed to operate the economy for one person for 1 year. Superior, and more detailed conceptual models of the biophysical perspective will be found in ► Chap. 5.

3.2.6 Specific Criticism 3: Validation

Natural scientists expect theoretical models to be tested before applied or developed further. Unfortunately, economic policy with far reaching consequences is often based on economic models that, although elegant and widely accepted, are not validated. Economists test regularly many hypotheses. Topics such as the effects of income on consumption or the tax rate on economic output are regularly subjected to the rigors of linear regres-

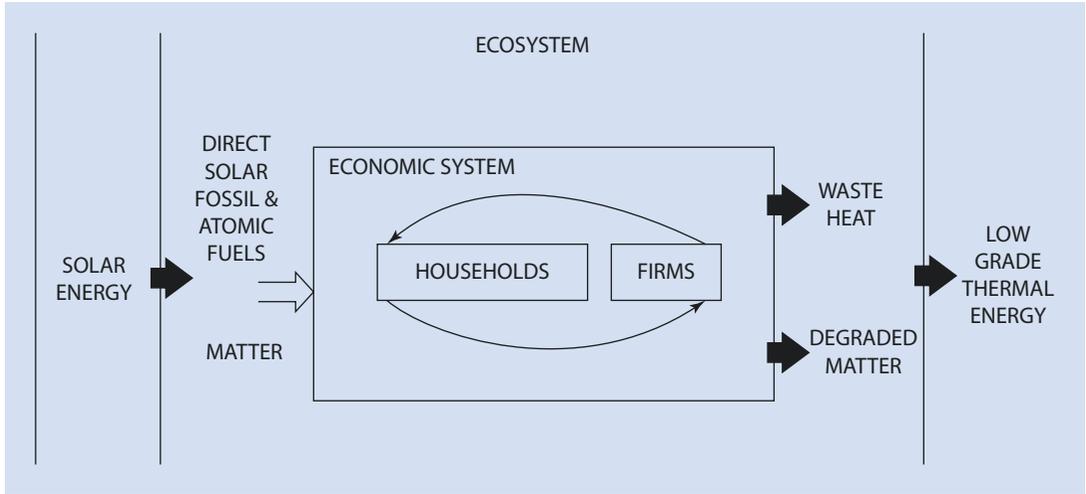


Fig. 3.2 Our perspective, based on a biophysical viewpoint, of the minimum changes required to make Fig. 3.1 conform to reality. We have added the basic

energy and material inputs and outputs that are essential if the economic processes represented in Fig. 3.1 are to take place (Source: Daly [3])

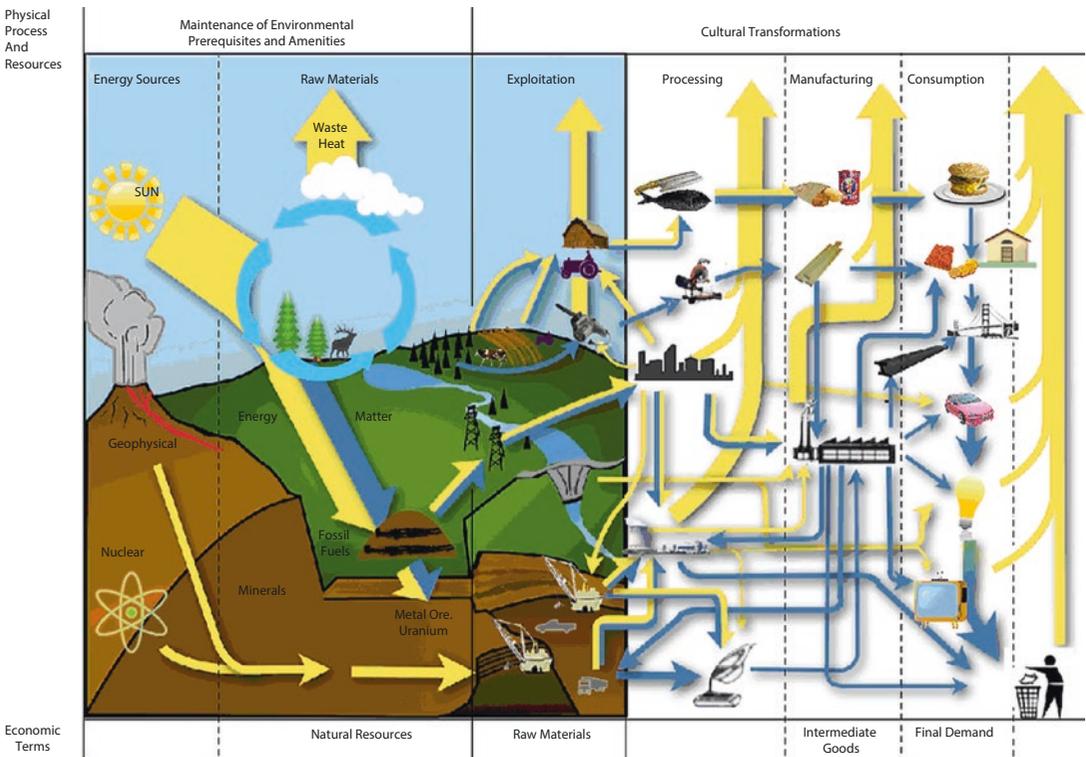
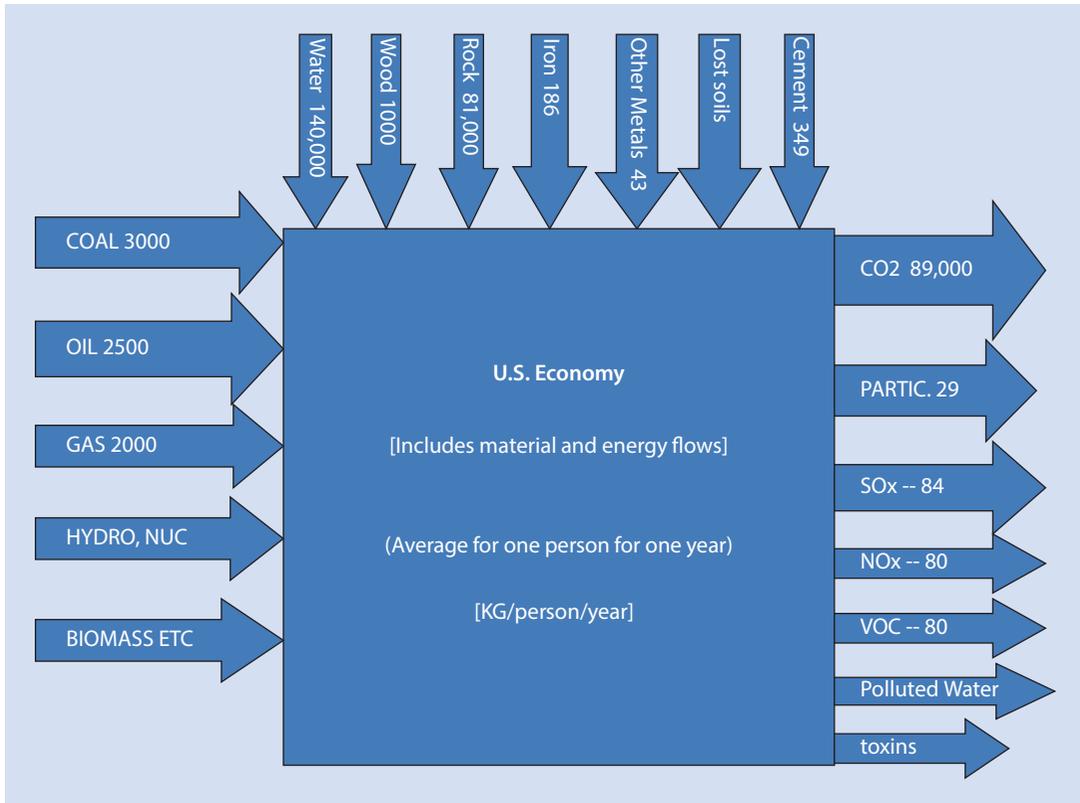


Fig. 3.3 A more comprehensive and accurate model of how real economic systems work. This is the minimal conceptual model that we would accept to represent how real economies actually work. Natural energies drive geological, biological, and chemical cycles that produce natural resources and public service functions. Extractive sectors use economic energies to exploit natural

resources and convert them to raw materials. Raw materials are used by manufacturing and other intermediate sectors to produce final goods and services. These final goods and services are distributed by the commercial sector to final demand. Eventually, non-recycled materials and waste heat return to the environment as waste

3.2 · Some Fundamental Myths of NCE

■ **Fig. 3.4** A conventional economist's view (or perhaps a caricature of that) of one person's inputs and outputs to the process of economic production for 1990 (Source: Hall et al. [32])



■ **Fig. 3.5** The actual material and energy flows associated with one person's involvement in the economy for the same year (Source: Hall et al. [32])

sion, and even nonlinear statistical methods. However, questions about the ideological worldview of NCE are not often tested. Behavioral assumptions such as rationality, self-regarding preferences, and the connection between higher levels of material consumption and happiness are not always, if ever, tested. Neoclassical economists consider them to be “maintained hypotheses” that do not require empirical verification. Validation also proves difficult or impossible because both classical and neoclassical theories were originally developed using concepts of production factors as they existed in preindustrial and agrarian societies

[14]. These theories have been transferred more or less unchanged to applications in the modern industrial world. No provisions have been added to the basic theory for industrialization and its consequences. As the Nobel Laureate in Economics Wassily Leontief noted [12], many economic models are unable “to advance, in any perceptible way, a systematic understanding of the structure and the operations of a real economic system”; instead, they are based on “sets of plausible but entirely arbitrary assumptions” leading to “precisely stated but irrelevant theoretical conclusions.”

While we have no argument with the development of theoretical assumptions or models, they normally should be put forth as hypotheses, that is, as a good assumption or guess as to how something operates. This is how the scientific method works, and this is the most powerful way that we have to find out how the world actually works. Then the hypotheses can be tested, and if it stands up well can be advanced to a theory or perhaps eventually a law. But although there are some economists who appropriately use hypotheses, there has been no attempt to build up the main theoretical model of economics as a set of testable and tested hypotheses. Instead economics is constructed as a series of logical constructs that make a certain sense (from a limited perspective), but hardly encompass how real economic systems operate. We believe economists should adopt this perspective and test the supposedly maintained hypotheses, instead of treating belief in the self-regulating market as a matter of faith!

Most noneconomists do not appreciate the degree to which contemporary economics is laden with arbitrary assumptions. Nominally objective operations, such as determining the least cost for a project, evaluating costs and benefits, or calculating the total cost of a project, normally use explicit and supposedly objective economic criteria. In fact, such “objective” analyses, based on arbitrary and convenient assumptions, produce logically and mathematically tractable, but not necessarily correct, models.

The authority economists often assign to their “physics-based” models, starting with the basic neoclassical model of the economy, are somewhat curious. In neoclassical production theory, the price vector is given by the gradient of the output in the space of the production factors just as the vector of a conservative physical force is given by the gradient of potential energy in real space [13]. The quite imperfect economic analogy should not be confused with the thermodynamically rigorous model in physics, and unavoidably fuzzy economic models should not become more precise simply because they distantly share concepts.

3.2.7 Myth 2: A Theory of Consumption Can Ignore Actual Human Behavior

The second main way that conventional neoclassical economic models are unrealistic is that the model assumes that humans behave as individuals

and do not care what others think of them. These are referred to as “self-regarding preferences.” Yet, we have known since the time of Aristotle that humans are social animals. Few of us would want to live in total isolation, no matter how many creature comforts we might possess. Interestingly enough, most economists pay homage to Adam Smith, but few have ever read him in the original. If you chose not to follow this path, we suggest you read Smith’s *Theory of Moral Sentiments*, in which he spends hundreds of pages detailing how social approval governs our behavior, and that humans have an altruistic side as well as an individualistic one. But just as NCE production assumptions violate principles of physics, its assumptions about human behavior are inconsistent with both a large body of psychological and neurological research and even everyday human experience. It is well established that real human beings are other regarding, that is, how one person values a certain economic outcome depends on how much it is valued by others. It is also well established that the consumption of market goods cannot be equated with an individual’s happiness. Nevertheless, the fundamental behavioral assumptions of NCE require self-regarding consumers whose happiness depends essentially, or even only, upon their consumption of market goods. The cultural context of behavior is deemed irrelevant to neoclassical economic analysis as the emphasis is entirely on the behavior of the isolated individual.

3.2.8 Myth 2a: *Homo Economicus* Is a Scientific Model That Does a Good Job of Predicting Human Behavior

At the heart of standard neoclassical economic theory is the model of human behavior embodied in *homo economicus* or “economic man.” Economic texts usually begin with a very general statement about human nature that is soon codified into a set of rigid mathematical principles resting upon the idea that “people maximize their well-being by consuming market goods according to self-regarding, consistent, constant, well-ordered, and well-behaved preferences.” However, the assumption that people are entirely, or mostly, self-regarding has been shown to be false by considerable contemporary work in behavioral economics, neuro-economics, and game theory [15–17]. For

example, Henrich and colleagues, after examining the results of behavioral experiments in 15 societies ranging from hunter-gatherers in Tanzania and Paraguay to nomadic herders in Mongolia concluded: “[T]he canonical [NCE] model is not supported in any society studied.” In experimental settings and under real-world conditions, humans consistently make decisions that favor enforcing social norms over ones that lead to their own material gains [18]. Gintis describes several experiments showing that humans are both far more altruistic and far more vindictive than the NCE “rational” actor model allows. They will make decisions to punish persons they will never again encounter if those people “cheat” in experimental transactions, even if this means considerable monetary loss to themselves. Rather than humans being simply self-regarding, they have a high regard for seeing that others “follow the rules” and treat other people decently.

The centrality of the behavior of isolated individuals is reflected in the notion that consumers are sovereign, meaning independent in their behavior, in a market economy. Ackerman and Heinzerling [19] point out that the rise of economic orthodoxy put consumers at the center of analysis. The idea is that producers respond to consumer preferences rather than the reverse. Yet we all know that, in fact, consumer tastes are both grossly and subtly manipulated and that firms barrage us with advertising to increase their market share. Nonetheless, the centrality and preeminence of the individual in orthodox economic analysis precludes any analysis or emphasis on the context of individual behavior.

3.2.9 Myth 2b: Consumption of Market Goods Can Be Equated with Well-Being and Money Is a Universal Substitute for Anything

Most economic texts simply equate utility with happiness and assume that utility can be measured indirectly by income without any substantive or formal discussion of the matter [20]. The higher the income, the better off an individual (and hence society) is supposed to be. Yet there is considerable evidence that, past a certain point, income is a positional good; that is, if everyone’s income goes up there is little or no long-term gain

in social well-being. This implies that policies designed merely to increase per capita income may have a negligible effect if the goal is to improve social welfare.

Psychologists have long argued and documented that well-being derives from a wide variety of individual, social, and genetic factors. These include genetic predisposition, health, close relationships, marriage, and education—as well as income [20]. It is generally true that people in wealthier countries are happier than people in poorer countries, but even this correlation is weak, and the happiness data show many anomalies [21]. For example, some surveys show that people in Nigeria are happier than wealthier people in Austria, France, and Japan [22–24]. Past a certain stage of development, increasing incomes do not lead to greater happiness. For example, real per capita income in the United States has increased sharply in recent decades, but reported happiness has declined [25].

When economists equate utility with income in the NCE model, this affects the policy recommendations of economists which in turn impact the natural world. According to Arrow and colleagues [26], “sustainability” means simply maintaining the discounted flow of income over time. Leaving future generations with the same or greater real income than the present leaves them at least as well-off no matter what happens to specific features of the natural world. By this reasoning if the present discounted value of a rainforest is \$1 billion in ecosystem services if left intact, but can generate a discounted investment flow of \$2 billion if it is clear cut and sold, then it is the moral responsibility of the present generation to cut down the rainforest. With \$2 billion the future generation could buy another rainforest or something of equal value and have \$1 billion left over. This is the logic used by some economists to justify the destruction of a substantial portion of the planet’s ecosystems and species [27].

3.2.10 How the Neoclassical Model Fails to Deal with Distributional Issues

A different but extremely important and pungent critique of the neoclassical model comes from recent work by John Gowdy [27, 28]. Gowdy takes as his starting point the welfare model of John

Rawls. (Here “welfare” is the same as “utility.”) The basis of *welfare economics* is that each individual gains welfare proportional as his or her real disposable income increases. Thus, a given individual will be “better off” by a factor of two if he or she has 2000 rather than 1000 dollars to spend (or if prices are half as much). This concept also uses the idea of Pareto optimization. Both the Rawlsian and the Pareto approach assume that there is a linear relation between individual welfare and money. Thus, if one individual becomes five times wealthier (say from \$1000 to \$ 5000), that is as great a social good as five people becoming twice as wealthy (say from \$1000 to \$2000 each). This is an important concept that lies behind welfare economics and has been used incessantly as a logic for developmental plans that tend to pay most attention to increasing GNP and relatively little attention to *who* gets the proceeds. This of course avoids the contentions within the developing world that development tends to enrich those who have, while doing little, or even impoverishing, those that have not. By the Rawlsian-Pareto logic, or at least as employed by most contemporary neoclassical economists, if the total wealth is increased the distribution is not important, or at most is quite secondary. The entire economic perspective is often associated with social notions that people are well-off or not in accordance to their own efforts rather than due to factors outside their control.

Gowdy argues against the economists’ position that distribution is not an important issue by summarizing considerable recent psychological investigation that shows that human welfare and happiness does not increase linearly with income, but rather is curved downward. Hence supplying poor people with the basic necessities of life generates a greater deal of happiness and welfare with a given amount of money compared to much less happiness or well-being generated by the same amount of money in the hands of someone who is well-off. Curiously this is a conclusion also reached by thinking about the concept of marginal value—that the first units of something have much more value than additional units—a fact conveniently ignored by marginalist neoclassical economists! Instead the marginal utility of money is assumed to be constant. If it were not, the neoclassical theory of income distribution could not produce efficiency and equity. Finally, according to Gowdy and Gintis, the extensive social research

done in recent years has completely undermined the “value neutral” assumptions that are the base of welfare and neoclassical economics and calls into question all the basic tenets of neoclassical economics.

3.2.11 What Economists Think of These Ideas

Mostly conventional economists do not think at all about these problems with conventional economics but stick very closely to the accepted neoclassical model. But there are some partial exceptions. The Nobel Laureate in Economics Robert M. Solow considered the possibility in 1974 that “The world can, in effect, get along without natural resources” because of the technological options for the substitution of other factors for nonrenewable resources [11]. More recently, Solow stated “It is of the essence that production cannot take place without some use of natural resources.” Clearly, there is need for more analytical and empirical work (some of which we provide in later chapters) on the relation between economic production and natural resources, especially energy, and how much of the resources are actually needed. Many economists today, including many recent Nobel Prize winners (e.g., Akerlof, Krugman, Sen, Stiglitz) have very serious reservations with the contemporary model, although none has explicitly endorsed the biophysical alternative.

We might ask why economists pay so little attention to the biophysical alternative. The conventional neoclassical view of the low importance of energy and materials goes back to the early days of neoclassical economics. Initially, the focus was not so much on the generation of wealth but rather on the “efficiency of markets” and the distribution of wealth. The model of pure exchange of goods starts without considering their production. With a set of mathematical assumptions on rational consumer behavior, it was shown that through the exchange of goods in markets, an equilibrium situation results in which all consumers maximize their utility. This benefit of (perfect) markets is generally considered the foundation of free market economics. It shows why markets, where greedy or at least “self-regarding” individuals meet, work at all. Later, when the model was extended to include production, the problem of

the physical generation of wealth had to be inseparably coupled to the problem of the distribution of wealth. In the neoclassical concept of equilibrium, the activity of profit maximizing entrepreneurial behavior generates the situation where factor productivities (e.g., the respective contribution of capital, labor, and energy) equals factor prices. This means that in conventional economic analysis, the weights which the production factors contribute to the physical generation of wealth are determined by, and evaluated by, the factor cost shares. Thus, energy's importance is assumed by most economists to be equal (only) to its cost, which typically is small, only 5–10% of the cost of all goods and services.

Unlike their classical predecessors, neoclassical economists do not even bother to include the process of how things are actually made in their analyses. They just take the input prices and put them into a function, and the price and quantity of output are automatically generated. Here lies the historical source of the economists' underestimation of energy as a production factor, because in industrial market economies energy cost, on the average, is only 5–6% of the total factor cost (and of GDP). Therefore, economists either neglect energy as a factor of production altogether, or they argue that the contribution of a change of energy input to the change of output is equal only to energy's small cost share of 5–6%. This has led to a long-lasting debate on the impact of the two energy price explosions in the years 1973–1975 and 1979–1981 when the cost of energy increased to 14% of GDP even while supplying less physical energy. As we show below, and more explicitly in Hall et al. (2001), energy is more important in production than either labor or capital, although all three are needed. Curiously energy's low price is the reason for its *importance, not its unimportance*. For 200 years the economy has received huge benefits from energy without having to divert much of its output to get it. This is because basically we do not pay nature for energy, but only the cost of exploiting it. Likewise, the finite emission absorption capacity of the biosphere is more important to future economic growth than its present (nearly vanishing) price seems to indicate.

Neoclassical models built on the assumptions of  Fig. 3.1 cannot explain the empirically observed growth of output by the growth of the

factor inputs. There always remains a large residual (i.e., a statistical “leftover” that is not explained by the factors used in the analysis, in this case, capital and labor). This is formally attributed to what economists call either “technological progress” or improvements in “human capital,” which are long-term increases in skill and education of workers. Even Robert Solow stated, “This ... has led to a criticism of the neoclassical model: it is a theory of growth that leaves the main factor in economic growth unexplained” [11]. As we will argue below, weighting a factor by its cost share is an incorrect approach in growth theory.

In fact, the human economy uses fossil and other fuels to support and empower labor and to produce and utilize capital. Energy, capital, and labor are then combined to upgrade natural resources to useful goods and services. Therefore, economic production can be viewed as the process of upgrading matter into highly ordered (thermodynamically improbable) structures, both physical structures and information. Where the economist speaks of “adding value” at successive stages of production, one may also speak of “adding order” to matter through the use of free, or unbounded and available, energy (exergy). The perspective of examining economics in the “hard sphere” of physical production, where energy and material stocks and flows are important, is called biophysical economics. It must complement the social sphere perspective.

3.2.12 Why Theory Matters

It is in the policy arena that the ideological nature of NCE reveals itself most completely. Most economists substitute the mythical NCE world of rational agents, certainty, and perfect information for the complex reality and uncertainty of real economies. Where reality and the neoclassical model disagree, reality is increasingly forced through policy to conform to the neoclassical model [29]. Neoclassical economists generally assume that people always respond rationally and consistently to price signals; therefore, the goal of economic policy is to assign property rights and “get the prices right.” The corollary assumption is that things of value to people have a price, and anything without a market formed price must lack value. Prices are theoretically capable of reflecting all the relevant attributes of any good or service

and all that people value. The rest of us are asked to take the validity of these assumptions and analyses on faith and to turn our complex decision-making increasingly over to barely regulated markets and cost-benefit analyses. This emphasis frequently leads to fundamental policy-related failures and problems that include the following:

1. The ultimate policy goal of NCE is not to correct any particular problem directly but rather to correctly value the problem in terms of everything else so that the “calculating machine” of the market can establish the pecking order of priorities. The focus on establishing “general market equilibrium” frequently means neglecting essential details of the policy problems under consideration, especially those for which it is difficult or impossible to determine a price (i.e., oil depletion, environmental degradation, and global climate change). Hence when we purchase a gallon of gasoline, we pay only for getting that gallon to the pump, not for finding a new gallon to replace it, or something else if oil depletion makes replacement impossible.
2. The NCE model makes no qualitative difference between needs and wants, or among commodities produced, or among specific productive inputs, including energy. Everything we find useful is treated like an abstract commodity substitutable for and by anything else. Absolute scarcity does not exist nor, within certain broad limits, are any specific conditions deemed necessary for human existence. Value is a relative matter expressed in relative prices. Because no single thing is essential, substitution among resources and commodities will occur until the marginal value of a commodity is the same for all commodities. At this point, rational individuals have made optimal choices, and the sum of all optimal choices leads us to the “best of all possible worlds.” Thus, the tastes of affluent teenagers in malls for unnecessary but heavily advertised clothes or gadgets are given as much weight per dollar spent as health care or education for the less affluent.
3. The model assumes that aggregate income is a complete and sufficient measure of well-being. Operationally this means that total costs and benefits of policies can be determined by merely adding the monetary changes in the incomes of all isolated individuals affected. This implies that relative income effects don’t matter to the individual—for example, a loss of \$1000 to a poor person can be more than compensated for by a gain in \$1100 to a billionaire. Similarly, neoclassical economists consider preferences to be exogenous to social context. Yet numerous studies have found that relative income effects matter and sometimes these effects can completely cancel out increases in total income which is always the primary goal of NCE. How much one person values a gain or loss depends on what others get, the income of each person relative to others, the “fairness” of the income change, and a variety of other social factors which are not included in the NCE model.
4. “Sustainability” in the NCE model means sustaining only the discounted flow of per capita income, not anything else such as biodiversity, oil stocks, human health, or social cohesiveness. This is known as weak sustainability. However, to live within nature’s limits, we need to arrive at the conditions of strong sustainability, which requires that the profits from the depletion of a resource or degradation of an ecosystem are reinvested in developing alternatives or restoring degraded systems. This entails looking at the bigger picture of how market systems function and interface with the biophysical world [29–32]. Consequently one cannot arrive at a social decision to achieve an optimal macroeconomic scale by merely aggregating many separate efficient market outcomes.
5. Perhaps most importantly the neoclassical model has nothing to say about the relative power of diverse groups of people to influence the “free market” through influencing politicians with expensive contributions, through supporting advertisements in the media, or simply through their own massive purchasing patterns. The consequence has been to increasingly make the rich richer and the poor poorer. The advertising campaign against the role of government has undercut many programs that have helped alleviate somewhat the difference between the rich and the poor. There is a rich literature on this subject [33], much of it extremely critical of the neoclassical model, but much of the public still believes that markets are the best way to distribute economic goods and services

despite the lack of compelling evidence that this is true. For example, Sekera has demonstrated clearly that government can deliver services more efficiently than private entities, but few citizens seem to understand that. The work of Piketty and Sekera, along with that of other income distribution scholars, will be developed in more detail in ► Chap. 23.

NCE dominates policy making yet provides an inadequate toolbox for confronting the major problems of the present world: global climate change, biodiversity loss, oil depletion, loss of wilderness, and the recalcitrant problems of poverty and social conflict. It has been used as the basis for “the Washington Consensus” which has been and continues to be exported to the developing world with essentially no assessment of its effectiveness or basis in reality and with enormous social and environmental problems [30, 31]. We are led to believe that our most pressing environmental and social problems can be dealt with by simulating efficient market outcomes as if this alone provides the elixir for all that ails us. Yet we know that the concept of market efficiency rests on an untenable and faulty foundation and that the real market economy is not best described in this framework. The perpetuation of neoclassical economics, usually to the exclusion of other possible approaches, is essentially the substitution of faith for reason, science, and empirical testing in many areas of economics. We must move beyond this “faith-based” economics and find a more illuminating way of understanding economic activity and informing decision-making so that our policies will amount to something more than window dressing for the status quo.

? Questions

1. What are some of the “myths” of neoclassical economics? Do you agree that these are myths? Why or why not?
2. Why is the circular flow model of the economy inconsistent with the laws of thermodynamics? Is that possible?
3. Nicholas Georgescu-Roegen and his student Herman Daly are economists. Why are they such critics of conventional economics?
4. Economic productivity in neoclassical economics is usually represented as a function of capital and labor. Do you agree with that perspective? Why or why not?
5. What, in your opinion, should be the proper boundaries to be used in economic analysis? Can you draw a picture of how you would represent these boundaries?
6. What does validation mean? Why is this often difficult for economic models?
7. What are thought to be (within conventional economics) the main characteristics of *homo economicus* (or “economic man”)?
8. Do you think that having greater amounts of money to spend will make you happier? Why or why not? Do you think wealthier people that you know are happier than poorer people?
9. Does an increase in income of, say, 1000 dollars have the same meaning for a wealthy person as for a poor person? How does that relate to the usual economist’s position on Pareto optimality?
10. Why have neoclassical economists attempted to generate a “value neutral” approach to economics? To what degree have they succeeded, in your opinion?
11. Why does theory matter in economics?
12. What does sustainability usually mean within conventional economics? What might be some problems with that definition?

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