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Chapter 3

Theories of Rise and Fall, Part 2: Neoclassical Economic Growth Theory

In neoclassical economics, the entire edifice of the theory of growth is built on a concept of decline – the concept of diminishing returns. Because of this reliance on the concept of diminishing returns, growth theory in neoclassical economics has left most practitioners very unsatisfied with the theory as it now stands.

The crux of the problem is that it is difficult, if not impossible, to describe how something increases if the main process used to describe the increase is a process of decreasing values. Because of this paradox, neoclassical economic theorists, like Gilpin, North, and Solow, tend to accentuate a particular set of social concepts, such as diminishing returns, and then to use technology as an explanatory variable when the other concepts are seen to not have sufficient explanatory power.

Samuelson presents “*the law of diminishing returns: An increase in some inputs relative to other fixed inputs will, in a given state of technology, cause total output to increase; but after a point the extra output resulting from the same additions of extra inputs is likely to become less and less.* This falling off of extra returns is a consequence of the fact that the new ‘doses’ of the varying resources have less and less of the fixed resources to work with” (Samuelson 1975, 27, italics in original).

Note that diminishing returns hold when one input is *fixed*, and the other input is *increasing*. As explained in the discussion of Gilpin’s work, Ricardo first claimed that if one has a particular fixed area of land, the addition of more and more labor will result in

diminishing returns to each additional unit of labor. If both land and labor are increased at the same rate, however, there may be no diminishing returns; there may be “constant returns to scale”, which is “a state where there is no reason for diminishing returns to operate, since *all* factors grow in balance, and where all economies of large-scale production have already been realized” (Samuelson 1975, 453ff). When economies of scale are being realized, then an across-the-board increase in the factors of production will actually result in *increasing* returns to investment, not decreasing returns.

In the case of the modern economy, the two factors of production most often discussed are those of capital and labor. The problems of characterizing capital will be examined later, but for now capital will be defined as the machinery and buildings of a factory which produces goods. With capital and labor as the inputs to production, we have two possibilities for diminishing returns: 1) Capital is held constant (assume that no new factories are built or expanded) and labor is increased, in which case there are diminishing returns to each additional unit of labor; and 2) labor is held constant (which might happen, for instance, in a condition of full employment), and capital is increased, leading to diminishing returns to each additional unit of capital. The first case is referred to as decreasing marginal productivity of labor, the second as the decreasing marginal productivity of capital.

At some point, in these two situations, the moment arrives when either an additional unit of capital yields only enough returns to barely cover its costs, or in the other case, an additional unit of labor yields only enough returns to barely cover the additional costs. This moment equals the price of capital and labor, respectively. In 1899, John Bates Clark therefore claimed that capital and labor receive as income that

which they contribute to production (Clark 1927). Therefore, he reasoned, we can know how much labor and capital, in the national aggregate, contributed to the economy simply by finding out how much each factor of production received, in the aggregate.

Neoclassical growth theory is based on this theoretical construction.

This model, as Clark realized, does not apply if diminishing returns do not apply. If there are returns do not diminish, then there is no point at which returns to capital or labor just equal the cost of capital or labor. If there are increasing returns, then no matter how much of labor or capital is added (in either case), the next additional unit of labor or capital will earn more and more money, without limit.

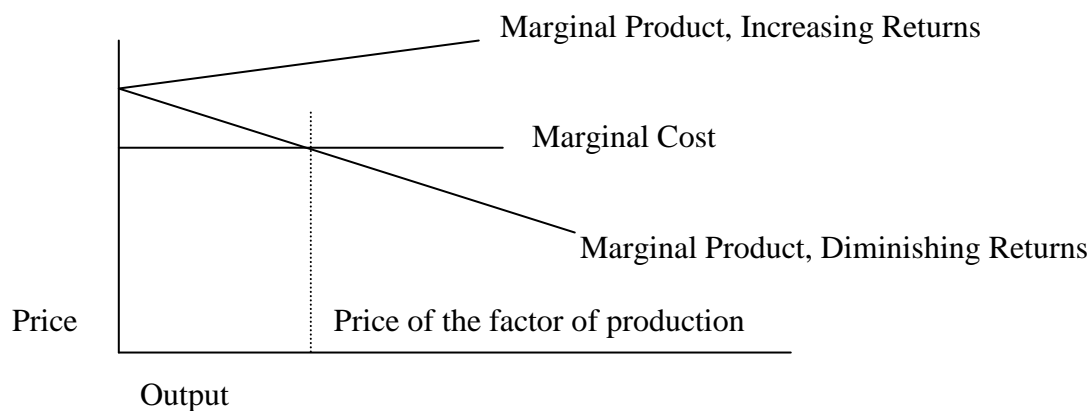


Fig. 7. Increasing and diminishing returns.

As we can see from the figure 7, if the marginal product from one additional unit of the varying factor of production is experiencing diminishing returns, we can find one level of output which matches the cost of the factor of production. This point is the unique solution to the problem of the determination of price. But if there are only increasing (or constant) returns, no single price/output decision can be made.

Neoclassical economists tend to concentrate on short-run economic processes.

The short-run is defined as the time period before capital can be increased; that is, capital

is fixed. So in the short-run, by definition, we have a process of diminishing returns where capital is fixed and labor is increasing. We should therefore have a decreasing marginal productivity of labor. However, factories are generally designed for a specific number of a certain kind of machine, to be tended by a specific number of a certain kind of worker. There is generally no room for either decreasing or increasing the number of workers. If it takes 20 men to operate a certain section of the assembly line, then the 21st man will yield *no* return; he or she will be standing around. If a worker is taken away, the assembly line will either completely break down, or the other workers will have to scramble to make up the work, most probably leading to a more than proportional loss in output for the loss of one worker. Thus, the case of diminishing returns to labor (vis-à-vis capital) is not a very important explanation of how the economy operates.¹

In the long-run, when capital can be increased, then both factors of production (labor and capital) can be increased proportionally, and therefore constant returns may prevail. However, “in many industrial processes, when you double *all* inputs, you may find that your output is more than doubled; this phenomenon is called “*increasing* returns to *scale*” (Samuelson 1975, 28). This fact, according to Samuelson, is “not a direct refutation of the law of diminishing returns” (Samuelson 1975, 28), because of his belief that eventually diminishing returns set in, as one factor of production becomes fixed. However, if capital and labor are increasing proportionately, there may not be decreasing returns; and if in fact increasing returns occur for any level of output, monopoly could be the result, because “under decreasing Marginal Cost, the first firm to get a head start will find its *advantage increasing the greater it grows!*” (Samuelson 1975, 473)².

Since much of the economy is characterized by either monopoly or oligopoly, one would assume that increasing returns are more important than decreasing returns, at least for the structure of the market. This snowball effect, in which the unit which has an initial advantage is able to turn that advantage into a larger and larger one, has been previously analyzed in this study under the concept of positive feedback. If increasing returns to scale dominate in the economy, as opposed to diminishing returns when there is a fixed factor of production, then economists should be concentrating on positive feedback processes.

In the international political arena, an aggressor state can take advantage of the positive feedback of its conquests (as I will claim in my Chapter on Theory of Political Systems). Waltz, Morgenthau and other realists therefore stress the operation of the balance of power, which is designed to constrain this process of positive feedback. Positive feedback is important in both international relations and in economics.

Since oligopoly and monopoly have characterized much of the twentieth century, and since technological change has been so extensive, one would think that increased returns would be the focus of much economic theory (W. Brian Arthur [1997] is one noted economist who has written extensively on positive feedback and increasing returns). Instead, growth theorists have made the concept of diminishing returns central to their efforts.

In 1956, Moses Abramovitz analyzed the aggregate economic data for the United States for the period from the 1870s to the early 1950s (Abramovitz 1989). The net national product per capita grew by approximately four times in this period. This is obviously a huge increase. According to neoclassical theory, as we have seen, each

factor of production receives income according to the output it has contributed to the economy. The income of capital, defined mainly as profits and interest, has constituted only about between one-third and one-fourth of national income. Labor, in the form of wages and salaries, has received the rest, through most of American history. But capital has increased much more than labor.

In fact, according to Abramovitz's figures, capital per person had gone up three times (measured in constant dollars) during this time period. The number of man-hours per capita had actually gone down by 6 percent. Since labor's contribution to output is allegedly about three times the contribution of capital (because of their respective share of the national income), Abramovitz calculated that the weighted increase of the factors of production, capital and labor, was equal to 1.14. In other words, output per capita should have increased only slightly in this period, not by a factor of four. Input had hardly increased, according to the neoclassical assumptions, and output had quadrupled, so "this seems to imply that almost the entire increase in net product per capita is associated with the rise in productivity" (Abramowitz 1989, 132); that is, more output was produced with the same amount of inputs. Abramovitz famously concluded:

This result is surprising in the lopsided importance which it appears to give to productivity increase, and it should be, in a sense, sobering, if not discouraging, to students of economic growth. Since we know little about the causes of productivity increase, the indicated importance of this element may be taken to be some sort of measure of our ignorance about the causes of economic growth in the United States and some sort of indication of where we need to concentrate our attention (Abramowitz 1989, 133).

This "measure of our ignorance", as some still refer to it, has gone through several name changes, recalculations, and premature announcements of its demise. At first, it was called simply the "residual". It later came to be called "technological progress", but

currently enjoys the more scientific sounding title, “total factor productivity”. There are three main points to be made concerning neoclassical growth theory: 1) the “residual” has never been explained; 2) the core of the theory claims that “technology” is responsible for sustained growth, and this technology cannot be explained; and 3) the assumption of diminishing returns puts into question the validity of the entire theory in any case.

For 40 years, many economists have attempted to explain the “residual”. In 1957, surveying the *previous* 40 years of growth, Robert Solow estimated that “it is possible to argue that about one-eighth of the total increase is traceable to increased capital per man hour, and the remaining seven-eighths to technical change” (Solow 1957, 316). Denison, in particular, is well-known for trying to estimate factors that could account for the remaining seven-eighths (Denison 1967). But as Solow noted in his lecture accepting the Nobel prize in economics, “the main refinement has been to unpack ‘technical progress in the broadest sense’ into a number of constituents” (Solow 1988,313); Solow argues that, according to Denison’s calculations, “the growth of ‘capital’ accounts for 12 percent of the growth of output; this is coincidentally almost exactly what I found [in 1957]” (Solow 1988, 313-314). Further, according to Solow, “this detailed accounting is an improvement on my first attempt, but it leads to roughly the same conclusion” (Solow 1988, 314).

Denison is known for making the most Herculean labors in an attempt to explain the “residual”. He tries to explain productivity increase by renaming certain parts of it. In a review of Denison’s efforts, Abramovitz noted that “Advance of knowledge”, which is really the old “technical progress”, is made to account for 20% of growth from 1929-1957 (Abramovitz 1989, 162), while “economies of scale” are said to account for 37% in

that period, which, “as Denison makes amply clear, constitutes no more than his own sober judgment”, and “the fact remains that the theory on which Denison relies is no more than speculation and his special formula no more than a guess” (Abramovitz 1989, 154-5). Abramovitz concludes about this kind of effort to decompose the “residual”:

We can draw up a catalogue of the kinds of elements of which such an explanation must be composed: unconventional inputs, like labor intensity and education; economies of scale; and advances in knowledge of techniques and organization. Denison’s attempts to attach numbers to these elements, however, still falls short of success. And this unfortunate fact is just the inevitable consequence of the present state of the art. (Abramovitz 1989,164)

The second point about neoclassical growth theory is that any sustained level of growth is shown by Solow to be due *solely* to technology: “The permanent rate of growth of output per unit of labor input is independent of the saving (investment) rate and depends entirely on the rate of technological progress in the broadest sense” (Solow 1988, 309). This conclusion flows from a particular kind of equation, called an aggregate production function, and follows from the way Solow combined this function with the fact of depreciation and population growth.

The aggregate production function is the staple of neoclassical discussions of growth³. It has the general form $Y = F(K,L) = K^\alpha L^{1-\alpha}$, where α is the contribution of capital to output for the entire economy, that is, between 25% and 33%, and therefore $1 - \alpha$ is the contribution of labor, between 75% and 67%. K is the amount of capital, usually measured as the dollar value of the plant and equipment of an economy, and L is the amount of labor, usually counted as total man-hours used in an economy over the course of one year. Y is the national output, usually defined as the gross domestic product (GDP).

Recall that the national income of a factor of production is supposed to match the marginal productivity, in the aggregate, of the particular factor of production. In other words, each factor of production receives as income that which it contributes to production. The particular form of the aggregate production function, $Y = K^\alpha L^{1-\alpha}$, is popular among economists because of two properties it possesses. First, when both K and L (capital and labor) are multiplied by the same amount (say, doubled), then Y will be doubled; that is, there are *constant returns to scale*. For example, if the plant and machinery of a country doubled and, at the same time, the number of man-hours doubled, the GDP would exactly double, according to the aggregate production function. The second aspect of the equation is that the two exponents, α and $1-\alpha$, add up to one. Since the factors of production are supposed to reap exactly that which they sow, the equation encompasses all of national income⁴.

According to neoclassical economics, when one factor of production is held constant, and another is increased, the latter factor will yield diminishing returns. The aggregate production function can be transformed into the equation $Y/L = (K/L)^\alpha$, which means that output per worker man-hour increases in proportion to the increase of capital per worker, but at a diminishing rate ($Y/L =$ output per worker man/hour, and $K/L =$ amount of plant and machinery per worker man-hour, and $\alpha =$ percentage of national income received by capital, i.e., interest and profits) . There are two main aspects to this form of the equation.

First, more capital per worker leads to more output per worker. If one worker has a more expensive piece of equipment to work with, the worker will be producing more

output. The worker that tends a modern textile machine, with, say, 100 spindles, produces much more output than a preindustrial worker with a spinning wheel.

Second, the exponent, α , is less than one, because it represents the percentage that capital receives of the national income, and this exponent describes a process of diminishing returns. For example, an aggregate production function might be of the form $Y/L = (K/L)^{1/3}$, which is the cube root of (K/L) . Let's say capital per worker (K/L) is 8; the cube root of 8 is 2. So output per worker in such a situation will be 2. Now, assume that capital per worker increases to 64; the cube root of 64 is 4; therefore, output per worker has only doubled, while capital per worker has increased by 8 times. *There are diminishing returns to capital*, and therefore this equation is accepted by the mainstream of economics because it is consistent with the idea of marginal productivity and diminishing returns. Because each new addition of capital per worker yields less and less addition to output, the capital-output ratio (K/Y) is supposed to go up. In other words, a large increase in capital will yield a smaller proportional increase in output, because of diminishing returns to capital; if K increases more rapidly than Y , the ratio K/Y increases.

The problem is that this process of diminishing returns is contradicted by the data; *the ratio of capital to output has remained constant*. As more and more capital has been added, even with about the same amount of labor, the output keeps going up at the same rate as capital. The data show no diminishing returns:

Table 3: Capital and Output, 1930 to 1995

Year	1930	1940	1950	1960	1970	1980	1985	1990	1995
Capital (billions)	316	361	974	1,676	3,239	10,323	13,737	18,283	22,608
Output (billions)	90	100	287	527	1,036	2,784	4,181	5,744	7,254
Ratio	3.48	3.61	3.39	3.18	3.22	3.71	3.29	3.18	3.17

The capital figures, in billions of current dollars (that is, not adjusted for inflation), are taken from the article “Improved Estimates of Fixed Reproducible Tangible Wealth, 1929-95”, in *Survey of Current Business*, May 1997, Table 1, “Current-Cost Net Stock of Fixed Reproducible Wealth, 1929-95”, p. 77, as private and public equipment and structures. The output figures, in billions of current dollars, are taken from GDP figures of the United States Statistical Abstract of 1997, p.447. The ratio is the fixed wealth divided by the GDP.

Economists refer to an increase in capital per worker (K/L) as “capital deepening”; as Samuelson puts it:

Instead of observing a steady rise in the capital-output ratio as the deepening of capital invokes the law of diminishing returns, we find that the capital-output ratio has been approximately constant in this century...A steady profit rate [that is, share of capital in national income] and a steady capital-output ratio are incompatible with the more basic law of diminishing returns under deepening of capital. We are forced, therefore, to introduce *technical innovations* into our statical neoclassical analysis to explain these dynamic facts. (Samuelson 1975, 747, emphasis in original).

A consistent and obvious contradiction of an integral part of economic theory has been brushed aside by Samuelson by invoking a *deus ex machina*, technology. We are not “forced” to question the underlying theory, according to Samuelson; we are “forced” to introduce an exogenous variable, technology, in order to save the underlying theory.

When data contradict a theory, there are two possible responses: one can question the underlying theory, or one can try to augment the theory by adding another variable. The neoclassical economists have chosen the second alternative. However, the new variable, technology, is not independently measured. It continues to be, in Abramovitz’s phrase, simply a “measure of our ignorance”, or a “residual”. It is the number which is necessary in order to save the theory, not a number whose existence is independently confirmed. Sometimes scientists temporarily postulate a missing factor which will make up the difference between the theory and the observed data. However, the theory is considered unproven until the existence of the missing factor is confirmed.

If the physical sciences were to operate by consistently integrating forces which had not been confirmed, they would be much less successful. For instance, the response of the Ptolemaic astronomers to the development of sun-centered astronomy by Copernicus,

Kepler, Galileo and Newton could have been the following: “Well, we can make all of our calculations match the observed data by adding an X variable that is equal to the difference between the Ptolemaic system and the data”. Scientific progress is not possible if all theories can be “fixed” in this way.

One reason that this contradiction has not made more of an impression on the economic community is that growth theory is not central to the profession. Jonathan Temple has gone so far as to call growth theory a “backwater”(Temple 1998, 39); for Nicholas Stern, growth theory “has, however, been a popular topic for those involved in formal economic theory only for short periods, notably from the mid 1950s to the late 1960s” (Stern 1991, 122), which is basically the era of the elaboration of the Solow model and discussion of the “residual”. The economics profession has concentrated on equilibrium, stability, the allocation of a given set of resources, and the determination of price. None of these concepts is helpful in understanding the very dynamic process of the long-term growth experience of an industrial economy. For growth theory to instigate a fundamental discussion of core neoclassical theories would be like the tail wagging the dog for economists. Indeed, the accomplishment of Solow and others is to create a model of growth which is consistent with the assumptions of neoclassical economics – *not to explain growth itself*. A fuller explanation of Solow’s model will show that it is actually a model explaining why, without technology, there is no sustained growth.

Recall that we have a function of the form $Y/L = (K/L)^\alpha$. As Solow points out, capital per worker will decrease, in this model, if we add more workers without adding more capital. Alternatively, capital per worker will decrease if there is less capital, which is what happens when plant and machinery depreciate; capital does not exist forever, but

eventually breaks down and disappears. In either case, there is a decrease in the capital-to-labor ratio, which is bad for the economy, because a smaller capital-to-labor ratio translates to less output per worker.

Solow uses the term $(n + d)k$ to model this decrease of capital per person, where n is the rate of labor expansion, d is the depreciation rate, and k is capital per worker. As long as the increase in capital just offsets this $(n + d)k$ value, there will be no deterioration in the income per person in the society. The amount of new capital will just offset the amount of depreciation, on the one hand, or will just accommodate the new additions to labor, on the other hand. The economy will be at equilibrium; it will not become richer, and it will not become poorer.

The following diagram will be used to show how Solow's model works.

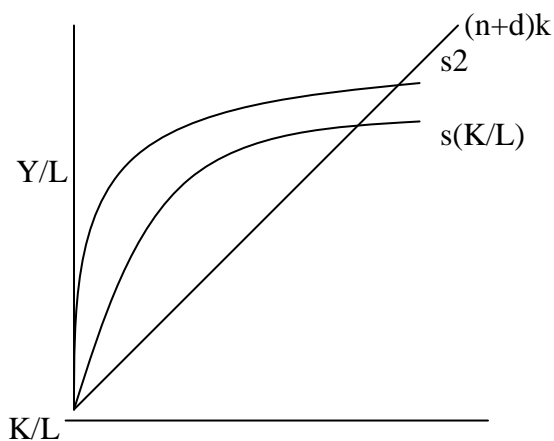


Figure 8. Solow's growth model.

The curve $s(K/L)$ represents the amount of investment in new capital per man-hour; s is the savings rate. s is usually around 10% to 20% of the economy. More capital translates into more output, but since there are diminishing returns, the curve flattens out after a while. The point at which the $s(K/L)$ curve crosses the line $(n+d)k$ is the equilibrium point; the amount of added capital (in the form of investment per worker) just

cancels out the amount taken away by the addition of new workers and/or depreciation. There is no growth per person, but neither is there any decrease.

The important part of the model is the process that takes place if the economy, for whatever reason, is not investing just enough to offset either depreciation or added workers. Like any accepted economic model, Solow had to show that the economy would move *automatically* back to the equilibrium point, and would stay there, unless something pushed the model off of equilibrium.

In the case of this model, there are two possible nonequilibrium situations. If the economy is investing too little, then the economy is at a point on the $s(K/L)$ curve to the left of the $(n+d)k$ line. In this case, because the returns to investment are *greater* than the depreciation or population growth rate, more capital per man-hour will be furnished to the economy by entrepreneurs; $s(K/L)$ will go up, and the economy will automatically move along the $s(K/L)$ curve, eventually reaching its equilibrium point where it crosses the $(n+d)/k$ line. The economy will have been in disequilibrium, but will have moved back to equilibrium.

On the other hand, if the economy is investing too much, then the economy will be on a point to the right of the $(n+d)k$ line. In this case the economy will be adding much more capital than it is getting back in the form of greater output. It will be running faster and faster just to advance a little bit. But in this situation, there will be huge amounts of capital piling up; and because the depreciation rate is still the same, large quantities of machinery will be retired. Entrepreneurs will not want to invest in capital, capital will decrease because of depreciation, and so the economy will automatically slide back to the equilibrium point.

Thus, the model has a stable equilibrium. It is the kind of model in which, even if the economy is out of equilibrium, the economy moves back to equilibrium automatically. It is the same situation as a marble at the bottom of a cup; move the ball up the wall of the cup, and as soon as you release the ball, it will be pulled back down by the force of gravity to a resting point. In Solow's model, rational decision making is analogous to the force of gravity.

According to this model an economy can grow in one spurt, and then stop growing, if the investment level is increased. The curve marked s_2 on the graph above is the same curve as $s(K/L)$, except that the s factor is increased. So if a society *permanently* increases its savings rate from, say, 10% to 14%, according to this model, its output will grow, but then the economy will reach equilibrium and stop growing. This is why Solow says that the growth rate is *independent* of the investment rate (the savings rate is assumed to be the same as the investment rate). Countries can achieve a one-time increase of their GDP by increasing their savings rate, but the economy can not enjoy continuous, or *sustained*, growth.

There is only one way of sustaining growth in this model: technological progress. In order to have continuous growth, at every point on the $s(K/L)$ curve, the Y/L , or output per worker-hour, would have to be greater. The same amount of machinery per worker would have to yield more output per worker than before, and therefore labor productivity would increase, if technology improved. This will come about because better machinery has been developed, or the means of production have been organized more efficiently, both of which are considered to be technological progress, and more properly within the realm of the engineer than the economist. If the investment rate stays the same, and the

engineers maintain the rate of technological progress (that is, increasing the amount of output per worker), the economy will grow continuously.

Solow has therefore succeeded in completely removing all possible sources of sustained growth from his model, other than technological progress. Put another way, there is no sustained growth without technological progress, according to Solow's model. Obviously, there has been tremendous, sustained growth in the last two centuries. Solow concludes that "increasing the rate of per capita growth is not only not easy in this model, it is impossible unless the rate of technological progress can be altered deliberately. This reversal of conclusions has led to a criticism of the neoclassical model: it is a theory of growth that leaves the main factor in economic growth unexplained" (Solow 1994, 48). He continues that "there is some truth in that observation, but also some residual misconception", which seems to consist of pointing to the work of the Endogenous Growth theorists, which will be discussed below.

Neoclassical growth theory has explained growth by showing how growth cannot be explained by neoclassical growth theory. The unknown, "residual" element has never been satisfactorily specified, and the main conclusion of the theory itself is that technology creates growth. This, in itself, would indicate that an understanding of technological change would be the appropriate focus of research into the rise and decline of Great Powers.

But there is a second reason to doubt the usefulness of neoclassical theory. Since the theory cannot explain why the prediction of diminishing returns has not taken place, except to postulate an invisible variable, the entire theory is on shaky ground. Thus whether diminishing returns are plausible, or whether they are not significant, the theory

fails to provide a convincing base from which to analyze rise and decline. Recently, however, there has been an attempt to deal with the problem of diminishing returns, and this theory has been named “endogenous growth theory”, to underline the idea that technology can be explained from within the model.

Romer (1986 and 1990) attempts to work around the problem of diminishing returns by invoking a new factor of production, knowledge. In addition to the factors of production of capital and labor, as in the Solow model, Romer postulates that the knowledge of how to design and organize production is itself a factor of production. Unlike capital and labor, however, we can never have “too much” knowledge. There are no diminishing returns to knowledge, in other words.

This knowledge is itself the product of a sector of the economy which Romer calls the “research” sector. However, as Stern puts it, “it is extremely difficult to identify anything approximating to a knowledge-producing sector in real economies” (Stern 1991, 127). According to Howard Pack, “the long-term imprint of any growth theory must ultimately depend on the extent to which it generates a productive empirical literature. In this task, endogenous growth theory has led to little tested empirical knowledge” (Pack 1994, 69).

Solow’s model, the Endogenous Growth theory, and the concept of an aggregate production function suffer from a similar problem: they are attempting to aggregate a factor of production, capital, that is more profitably used in a disaggregated state. Worse, economics – classical and neoclassical – do not have models of how the economy works which include representations of the plant and machinery that make modern industrial economies possible. As Kurz asserts,

“capital theory is notorious for being perhaps the most controversial area in economics. This has been so ever since the very inception of systematic economic analysis” (Kurz 1990, 79)⁵. How can one construct a theory of rise and fall in the twentieth century without including plant and machinery?

Adam Smith (1994 [1776]) first pointed out the importance of capital. In his schema, there are two types of capital: circulating capital are those goods which move from producer to producer, that is, they are ordinarily intermediate goods which are in the process of being turned into final products; and fixed capital, which is comprised of “all useful machines and instruments of trade which facilitate and abridge labour” (Smith 1776, 305), commercial buildings, improvements of land, and the “acquired and useful abilities” (Smith 1776, 306) of labor. For Smith,

To maintain and augment the stock which may be reserved for immediate consumption, is the sole end and purpose both of the fixed and circulating capitals. It is this stock which feeds, clothes, and lodges the people. Their riches or poverty depends upon the abundant or sparing supplies which those two capitals can afford to the stock for immediate consumption. (Smith 1776, 307)

In other words, capital generates the goods that comprise the substance of the economy.

Later theorists, however, took a step backward in their treatment of capital. The problem started with Ricardo. Ricardo was not trying to understand “The Wealth of Nations”, which is the focus not only of Adam Smith but of the present study, but the distribution of income of the nation. Ricardo wanted to know how profit could be understood in terms of wages, rent, and output. In order to keep his models simple, he resorted to the extreme position of considering seed corn as both the wage of labor and the capital to be used to create output. While this made the model easier to construct, fixed capital, that is, plant and machinery, disappeared from his model of the economy.

Later in the nineteenth century, the neoclassical economists developed what came to be known as the “Austrian theory of capital and interest”. The two main neo-classical expositors were Bohm-Bawerk and Wicksell. For Bohm-Bawerk, “the role of capital in production is to permit adoption of more productive but also more time-consuming ‘roundabout’ methods of production” (Blaug 1996, 480). The more ‘roundabout’ a production process was, the more ‘capital’ was involved, because “all of Bohm-Bawerk’s work and most of Wicksell’s was concerned with ...continuously applied circulating capital” (Blaug 1996, 489), but not with fixed capital. Capital turns into a fund from which to support the workers while they produce; capital is no longer something which is directly involved in production. The longer a production process took, the more capital was needed to support the employees who were working on production (Blaug 1996, 482).

But taking more time to produce something is an indicator that the process is a *less* efficient process, not more efficient, as Bohm-Bawerk wanted to show. As Blaug asks, “Is it never possible at a given state of technical knowledge to increase the total product by investing in less time-consuming methods of production?” (Blaug 1996, 481). Indeed, most of the technological progress that is supposed to explain growth in the Solow model is of the form of *decreasing* the period of production.

For example, while the tools that Adam Smith describes for the production of the pin factory were relatively crude, the machines available to make pins today have enormously speeded up production. According to Pratten (1980), “Adam Smith estimated that each person ‘might be considered as making 4800 pins in a day’”, while in 1980 “approximate output per employee for one of the U.K. companies is 800,000 pins

per day. An increase of 167 times in 200 years” (Pratten 1980, 94) occurred, caused by improvements in production machinery. According to the “roundabout” theory of capital, these machines are worth less than the crude 18-century tools, because they decrease the time involved in production!

Thus ended the attempt to rigorously define capital in the aggregate. Yet, as we have seen in the case of the aggregate production function, economists continue to aggregate. There were tremendous debates over this problem in the 1960s, retold, for example, by Harcourt (1969). Samuelson admitted that there was a problem, but economists have tended to proceed as if there were no difficulties.

Blaug comes to the conclusion, as do many others, that “in the real world in which we live, capital like labor is as heterogeneous as output and there is no such thing as *the* marginal product of the total stock of capital in the economy, just as there is no such thing as *the* marginal product of the labour force” (Blaug 1996, 450). Part of the reason is that “A whole class of well-behaved microeconomic production functions, having all the properties economists favor... simply will not aggregate into a well-behaved macroeconomic production function” (Blaug 1996, 452).

Capital is problematic in the theories of neoclassical economists, particularly as capital applies to problems of growth theory. Both neoclassical and endogenous growth theory are based on the aggregation of capital and labor, in an unrealistic way, and both assume diminishing returns which may not in fact exist. In addition, both theories rely on an exogenous force, technology, which they can not explain.

As two prominent scholars of innovation have put it:

For most economists, assessing technological change appears something of a puzzle, far removed from economic reality. The main reason for this goes back to the traditional economic framework, within which technology is reduced to an 'exogenous' external factor whose impact on, for example, economic growth can be best described...in terms of a particular parametric value: a 'black box' variable, not to opened except by scientists and engineers (Freeman and Soete 1997, 426).

It would seem natural, then, to focus on the exploration of this crucial force, technological change in the service of production.

Conclusion

Three mainstream theories have been reviewed, and all three have major weaknesses when used for fulfilling the task of explaining rise and decline of Great Powers. Gilpin and North try to use property rights to explain the position of societies in the international system, but their expositions show that technological change and the distribution of power within the state might have greater theoretical power. For North, technological change seems to be the main cause of the change in property rights, but the change in the distribution of power seems to be more important than property rights as a cause of change of behavior. For Gilpin, the internal ordering of the state is a mix of property rights and distribution of power, without clearly indicating the role of either variable. Technological change for Gilpin has an ambiguous role as well.

Neoclassical theory gives the central role in growth to technology. But theorists such as Solow rely on the process of diminishing returns to construct their theory, even though diminishing returns on an aggregate level does not seem to have an empirical

basis. The various theories of the functioning of the economic system either do not acknowledge the existence of machinery, or try to use an aggregated measure of machinery, even though such a measure has not been shown to make theoretical sense. There is no clear sense of what technological progress is, other than as an increase in labor productivity.

North's theory concentrates on the reasons for the relative ranking of various countries, but does not investigate the reasons for *changes* in these rankings. Gilpin concentrates mainly on internal causes of decline (and to some extent rise), but he does not focus on the reasons for the relative ranking of countries. Neoclassical theory cannot explain why technological levels are different among countries, or why the technological prowess of countries changes through time. Thus, there is currently no consistent and empirically-based theory of relative rise and decline.

There are grounds, therefore, to try to construct a theory of relative rise and fall which is not based on any of the existing, mainstream theories. The theories reviewed here have tried to use various combinations of the ideas of property rights and diminishing returns. They have all implied, in various ways, that technological change and the distribution of power are more powerful ideas with which to approach the inquiry into the causes of relative rise and decline. In order to investigate these two concepts, in the next chapter I will construct a systems-based framework for understanding the complexity of the processes of the rise and decline of Great Powers.

¹ There is another current of neoclassical economics which ignores the idea of diminishing returns and marginal productivity, called general equilibrium theory, but this theory has its own problems. General equilibrium theory has never been used to even

attempt a theory of growth. Mark Blaug, the respected historian of economic thought, gave this assessment:

After a century or more of endless refinements of the central core of general equilibrium theory, an exercise which has absorbed some of the best brains in twentieth-century economics, the theory is unable to shed any light on how market equilibrium is actually attained... We must perforce conclude that general equilibrium theory as such is a *cul-de-sac*: it has no empirical content and never will have empirical content... [general equilibrium theory] has proved in the fullness of time to be an utterly sterile innovation (Blaug 1996, 570)

² The graph shows increasing marginal productivity, but we can also have constant marginal productivity with decreasing marginal costs, particularly when both factors increase, which leads to the same process of increasing returns.

³ The following discussion is based on the textbook by Charles Jones (1998, Chapter 2).

⁴ This form was developed in an article by Cobb and Douglas (1928).

⁵ Freeman and Soete (1997, 328) comment that “capital too in the usual sense is absent in most of the ‘new’ growth theories. It is either assumed that physical capital is absent, and only investment in knowledge matters (Romer 1986) or, in more sophisticated models, that there is only an intermediate good which, contrary to physical capital in the usual sense, does not accumulate”.