Chapter 8

A Theory of Economic Systems, Part 3:

The Capital and Distribution Systems

Machinery industries are critical for production, and technological change in machinery industries is the most important kind of technological change. If technological innovation in machinery industries is central to economy-wide technological change, what causes machinery innovation? In order to understand this question, this chapter will use the theory of economic systems as elaborated in the previous two chapters to explain the production and design of machinery and the sources of innovation. The full description of an economic system will then be possible, integrating the distribution system with the production system.

The Capital System

Machinery does not spontaneously change itself; a person or group of people must create a new design for a new machine. Let us call these people *engineers*. Their output is a design. Generally, engineers do not actually produce the machines that they design. They hand the designs to a set of people called *skilled production workers*. These people have the ability to translate a design into a series of production steps that result in intermediate goods, and/or a complete machine, using machinery in the process. Operational managers, such as foremen and plant managers, work with the skilled workers to implement the designs of the engineer. Operational managers will therefore be considered to be functionally similar to skilled production workers.

The following sequence characterizes machinery production and design: engineer → design → skilled production worker → machine. The engineer *generates* a design, which the skilled production worker uses to produce the output, a machine.

In order to produce his or her design, the engineer draws on a *stock of knowledge* which is produced by *research scientists and engineers*, or more simply, researchers. These researchers are also often teachers. Teachers teach students to go forth into society and use a stock of knowledge, but teachers also teach more teachers. In other words, teachers self-reproduce.

We therefore have the following simplified structure of capital production and innovation:

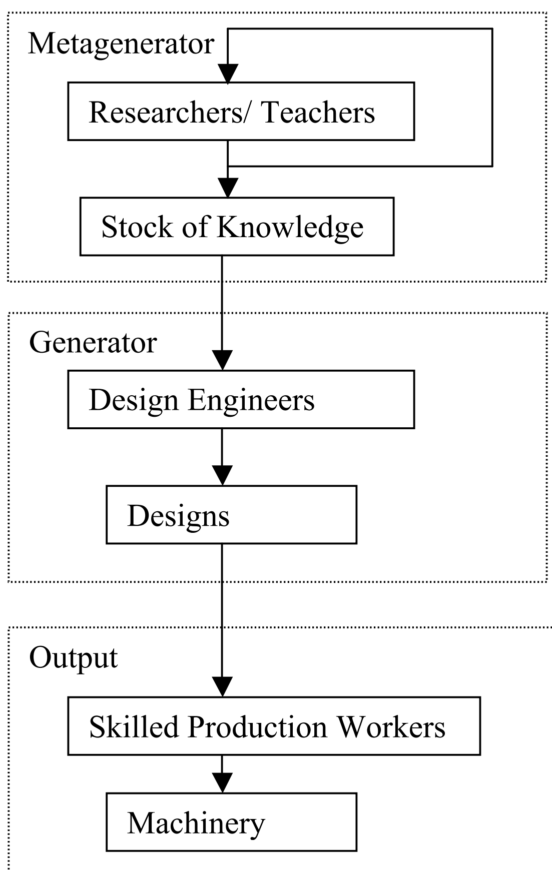


Fig. 33. The capital system.

Each stage has two elements, one human and the other a form of capital. The researcher/teachers add to the stock of knowledge, which can be thought of as a kind of capital, or asset. Using the stock of knowledge, teachers train engineers, who also use the stock of knowledge in their own work, the generation of designs. Designs are also a form of capital, or asset. Finally, skilled production workers use the designs to create machinery. This system of capital is an example of a tripartite generative system consisting of researchers/knowledge, engineers/designs and workers/machines, corresponding to a reproductive metagenerator, a generator, and an output, respectively.

This sequence reflects scholars' assessments of the requirements for development. Chudnovsky and Nagao propose, as technological requirements for competence in capital goods industries, "machine-operating skills" and "manufacturing technology", where "one basic component of this technology is the engineering knowledge of manufacturing methods and techniques, including quality control and testing", and where "another component of equal if not greater importance is the managerial and organizational know-how". In addition, "product design capacity is the ability to conceptualize and define and actually to design a product", and a "research and development capacity in the capital goods industries is clearly influenced by the claims of product design work" (Chudnovsky and Nagao 1983, 10-14).

Innovation can occur at each stage of this sequence. Innovation in an earlier step in the sequence has effects that may have an impact on processes later in the sequence. For example, a discovery made in the subfield of mechanics in the field of physics would have great import for many kinds of engineering, which would, in turn, affect all kinds of machinery production. When great strides were made in solid state physics in the 1940's with the invention of the transistor, the entire electronic revolution of later decades was made possible.

The "invention of invention", as Whitehead famously put it, was one of the great advances of the industrial age. In terms of the system of capital diagrammed in figure 33, this was equivalent to creating, or routinizing, the metagenerator stage of research. The structure of the machinery systems of the major powers changed because of the widespread adoption of research facilities (for recent studies of U.S. policy, see Branscomb 1993;Rosenbloom and Spencer 1996;Skolnikoff 1993).

My concept of a tripartite capital system as defined above is, in part, an attempt to formalize the insights of the economist Simon Kuznets. Kuznets did not formalize his ideas in a coherent way which would be useful for further research.

For Kuznets, production and innovation are inextricably mixed. According to Kuznets, "marked rises in product per labor unit … are usually possible only through major innovations, i.e., applications of new bodies of tested knowledge to the processes of economic production. Indeed, modern economic growth is, in substance, an application of the industrial system, i.e., a system of production based on increasing use of modern scientific knowledge"(Kuznets 1959, 14-15). Kuznets goes so far as to define innovation in terms of production: "Innovation is a new application of either old or new knowledge to production process (production defined broadly)" (Kuznets 1959, 29), therefore "continuous progress and, underlying it, a series of new scientific discoveries are the necessary condition for the high rate of modern growth in per capita income combined with a substantial rate of growth in population"(Kuznets 1959, 29).

Further, “science is the base of modern technology, and … modern technology is in turn the base of modern economic growth” (Kuznets 1959, 30). My tripartite sequence mirrors Kuznets’ three steps: my stage of researchers/knowledge is similar to Kuznets’ role of science; my “engineers/designs” reflects his “modern technology”, in that engineering is based on science; and the product of “worker/machines”, which is the output which increases in economic growth, is based, like Kuznets’ “modern economic growth”, on modern technology and the work of engineers.

Kuznets defines an invention as the discovery that leads to an innovation, and he defines an innovation as the invention’s application. He claims that “many major inventions, if they are to become successful innovations, demand heavy capital investment – both in material goods and in the training of the labor force.” (Kuznets 1959, 31). The resulting accumulation of capital is necessary because “without the heavy capital investment in buildings, roads, bridges, railways, power stations, machine tools, and blast furnaces, high levels of total and per capita product are unobtainable” (Kuznets 1965, 30). Thus, innovations must be embodied in capital.

Still, “the major capital stock of an industrially advanced nation is not its physical equipment; it is the body of knowledge amassed from tested findings of empirical science and the capacity and training of its population to use this knowledge effectively” (Kuznets 1965, 35). Kuznets calls this knowledge a “stock of knowledge”, and I have used this concept as one of the outputs of the metagenerator step of the capital system, the scientists/researchers. Further, “the major source of modern economic growth, with its high rates of aggregate increase and rapid structural shifts, lies in the vast increase in the stock of useful knowledge” (Kuznets 1964, 26).

Kuznets highlights many of the themes which are present in this chapter. Innovation flows from production, is usually embodied in investment in equipment, is dependent on a stock of knowledge provided by scientists and engineers, and is central to modern economic growth.

Nathan Rosenberg has also written about the role of innovation in a manner reminiscent of Kuznets. For Rosenberg, the entire machine tool industry has a disproportionate ability to add to the "stock of knowledge": "The machine tool industry may be looked upon as constituting a pool or reservoir of skills and technical knowledge which are employed throughout the entire machine-using sectors of the economy" (Rosenberg 1976, 19). Therefore, production and especially reproduction machinery sectors have a large role to play, not only in causing technological change via their effects on later stages of production, but also on their effects on the "stock of knowledge".

Kuznets refers to "useful" knowledge, "technological" knowledge, and other kinds of knowledge. In this study, the stock of knowledge will be defined as the scientific and engineering knowledge which is useful for designing and using production machinery. This stock of knowledge will usually be available in public printed form, in research journals or books.

Engineers create the designs which are the concretization of the discoveries made by researchers. All innovation must pass through the stage of design. Skilled production workers, depending on the management of the particular factory in which they work, can also contribute important insights.

De Bresson focuses on the contribution of production workers: "There is no such thing as fixed capital stock; the stock is constantly improved, increased, and modified…Practical know-how increases the equipment's capacity…workers probably constitute the major source of all inventions" (De Bresson 1987, 64).

Thus, the process of production is also a process of innovation. The innovation that powers economic growth cannot occur without production. *Part of the cause of innovation is production*; this is the seventh hypothesis about economic systems. This hypothesis would help to explain the insight by Alice Amsden, in the case of Korea, that greater output led to greater productivity. She states that "the growth rate of output increases as the growth rate of productivity increases, and in closed-loop fashion, depending on institutional constraints, the growth rate of productivity increases as the growth rate of output increases – through investments that embody foreign designs, economies of scale, and learning-by-doing" (Amsden 1989, 323). This learning-by-doing takes place, according to the economist Kenneth Arrow, because "learning is the product of experience. Learning can only take place through the attempt to solve a problem and therefore takes place during activity" (Arrow 1962, 155). Rosenberg argued that learning-by-using is particularly important in the capital goods industries (Rosenberg 1982, 122).

By combining the processes of innovation and production, I am claiming that people in the capital system are doing more than learning-by-doing. I wish to introduce the term "innovating-by-doing", to emphasize the point that innovation is a part of the production process. "Doing" – that is, producing – is partially a question of better understanding a production process, that is, learning. Arrow (1962, 155) defines learning as "the acquisition of knowledge", which while important, is not the same as creating new innovations. As defined in this chapter, the stock of knowledge *assists* in the creation of innovations that are used to produce goods, but there is a separate output, design, which is the embodiment of innovation. As engineers (and to some extent, researchers and workers) gain expertise in the course of production, they also *create* productivity-enhancing innovations. The term innovating-by-doing is meant to focus attention on the active creation of innovations, as opposed to the more passive process of learning pieces of knowledge that already exist. Both processes are important; the difference is in the emphasis.

The capital system is both the source of the *machinery* contained within a sector, and the source of technological *changes* associated with the use of those assets. The capital system is one element in the system that constitutes a niche in the production system. As explained above, physical structures are also part of a niche, as are the intermediate goods created within the niche. In addition, unskilled labor is usually conceived of as another element.

The Production System Niche as a System

Thus we have the following diagram, showing a niche as a system, composed of a capital system, physical structure and unskilled labor. Input from other niches constitute the interaction from other elements in the system:

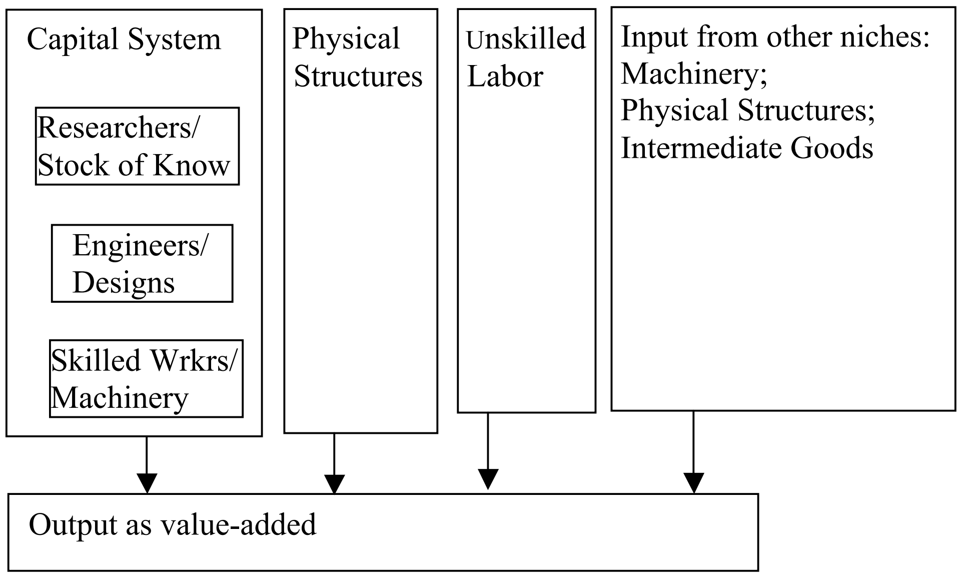


Fig. 34. The production system niche as a system.

Output moves to other niches. Output is measured in terms of the value-added that was generated by the originating niches.

This model is similar in some ways to the characterization of production as put forth by neoclassical economists, who usually reduce production to the factors of production called capital and labor (and occasionally, land). I have restricted the term "capital" to what Adam Smith called "fixed capital", by which he meant machinery and physical structures. Inputs from other niches constitute what Smith called "circulating capital", or intermediate output. Capital as shown above also incorporates a significant portion of the workforce, that is, skilled workers, engineers, and researchers. Economists recently have called this human input "human capital", and I will use the same term to refer to skilled workers, engineers, and researchers. The term "labor" is here restricted only to unskilled labor. In neoclassical discussions, labor is considered one homogenous group; homogeneity holds only in the case of unskilled labor.

Alfred Chandler offers a similar assessment of the importance of human capital to the one offered here. In describing the basic workings of mass production, he states that "organizationally, output was expanded through improved design of manufacturing or processing plants and by innovations in managerial practices and procedures required to synchronize flows and supervise the work force. Increases in productivity also depend on the skills and abilities of the managers and the workers and the continuing improvement of these skills over time" (Chandler 1977, 241). Further, "the potential economies of scale and scope, as measured by rated capacity, are the physical characteristics of the production facilities. The actual economies of scale or of scope, as determined by throughput, are organizational. Such economies depend on knowledge, skill, experience, and teamwork – on the organized human capabilities essential to exploit the potential of technological processes" (Chandler 1990, 24).

Chandler emphasizes the organizational capacity of managers. Managers (such as factory superintendents) who directly control production are considered a form of skilled production worker in my scheme. The operational manager is trying to fulfill a design, and the orders emanating from the operations manager are ideally part of the design. The operations managers and skilled production workers are part of the implementation of the design as specified by the engineers.

The role of middle managers and top managers is ignored in my conceptualization of the production process. These administrative managers, as well as the rest of the administrative overhead of the firm, are generally involved in nonproduction activities, as will be explained in the next section.

Technological change within a niche is the result of two main factors. First, *internal change* will occur within the capital system of the niche, and that change will be the result of a change made by a combination of the researcher, engineer or skilled production worker elements.

Second, *external change* will result from the first kind of change, because the inputs from another niche may enable further technological advances in a niche further down the sequence of production. This will occur when a type of production machinery is improved, or an intermediate input is better adapted for the destination niche.

If technological change is guided by researchers, engineers, and skilled production workers, why are some nations able to experience more technological change than others? First, *innovation by people depends on the level of resources directed toward the innovators, in the form of income, educational facilities, and research/work facilities*; this is the eighth hypothesis about economic systems.

Second, *innovation is encouraged by the wide distribution of access to the various forms of capital, be they the stock of knowledge, designs, or machines, or their human counterparts, researchers, engineers, and skilled production workers. In other words, the free flow of people and ideas is an important determinant of technological innovation*; this is the ninth hypothesis of economic systems. When the power to control this flow is concentrated, for example, in certain organs of a dictatorial state, then the rate of innovation will slow down. When a populace is well-educated and allowed to express and communicate their ideas, and when they are allowed to travel and visit production facilities, then innovation will flourish. As postulated in chapter 6, the speed with which innovations spread is an indication of the power of the system of production, and free access to people and ideas allows innovations to spread more quickly. Thus, a democracy will tend to encourage more innovation than a dictatorship, as will be commented on in Chapter 10.

Therefore, an explanation of technological innovation on the level of the capital system involves resources and the free flow of people. An explanation of technological innovation on the level of the production system includes two other sources. First, the structure of the economy enables or constrains innovation. There is an ordering of the innovative potential of sectors of an economy, such that reproduction machinery sectors have the greatest potential, followed by production machinery sectors, followed by final production. More generally, according to Rosenberg, "a small number of industries may be responsible for generating a vastly disproportionate amount of the total technological change in the economy" (Rosenberg 1982, 76).

Second, there is a complementarity of the various categories of production, which is also the result of the structure of the production system. Rosenberg highlights this complementarity:

> Inventions hardly ever function in isolation. Time and again in the history of American technology, it has happened that the productivity of a given invention has turned on the question of the availability of complementary technologies…Technologies depend upon one another and interact with one another in ways that are not apparent to the casual observer, and often not to the specialist … The growing productivity of industrial economies is the complex outcome of large numbers of interlocking, mutually reinforcing technologies, the individual components of which are of very limited economic consequence

> by themselves. The smallest relevant unit of observation, therefore, is seldom a single innovation but, more typically, an interrelated clustering of innovations…The importance of these complementarities suggests that it may be fruitful to think of each of these major clusterings of innovations from a systems perspective. (Rosenberg 1982, 56-59)

In sum, "Technological progress in one sector of the economy has become increasingly dependent upon technological change in other sectors" (Rosenberg 1982, 73).

Strassmann also points out the importance of complementarity: "The interrelatedness of innovation in key industries by 1850 set the basis for an accelerated pace of mutually reinforcing changes. This pace continued through wars and depressions into the twentieth century" (Strassmann 1959, 208). The structure enables certain pathways of innovation.

To these two sources of innovation at the production system level I have elaborated three at the capital system level. First, the actual process of production itself, in the form of well-supported capital systems, encourages innovation; I called this process "innovation-by-doing". The sources of innovation in a capital system come from the researchers, engineers, and workers (including operational managers). Thus, the structure of the capital system also enables innovation.

Second, a capital system needs resources in the form of income and educational and research facilities. This support may need to come from outside the niche of which the capital system is a part.

Third, a wide distribution of access to various forms of capital, both physical and human, leads to greater technological change, implying that democracies have greater potential for economic growth than dictatorships. Thus, the structure of the political system may have an influence on national rates of innovation.

The capital system has now been described. The capital system is the most important element in the system that is the production system niche. The hierarchy of systems is therefore the following:

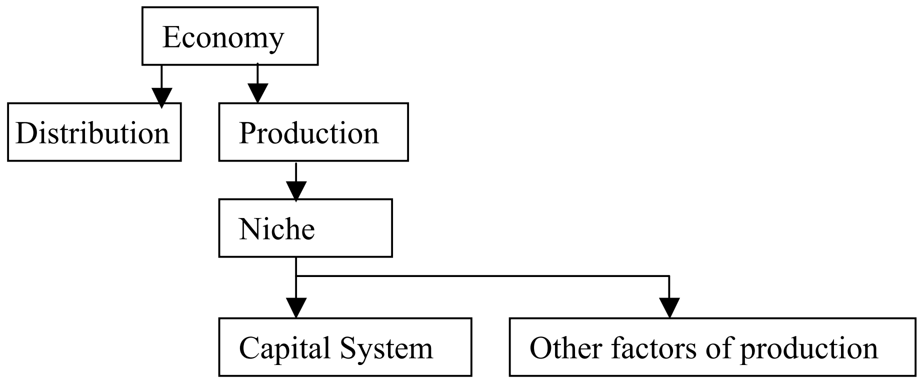


Fig. 35. The hierarchy of the economy including the capital system.

The economic system is composed of two subsystems, distribution and production. The production subsystem is composed of niches. Each niche is made up of factors of production, the most important being the capital system. In addition, niches can be further decomposed into individual industries, which may be characterized according to their factors of production.

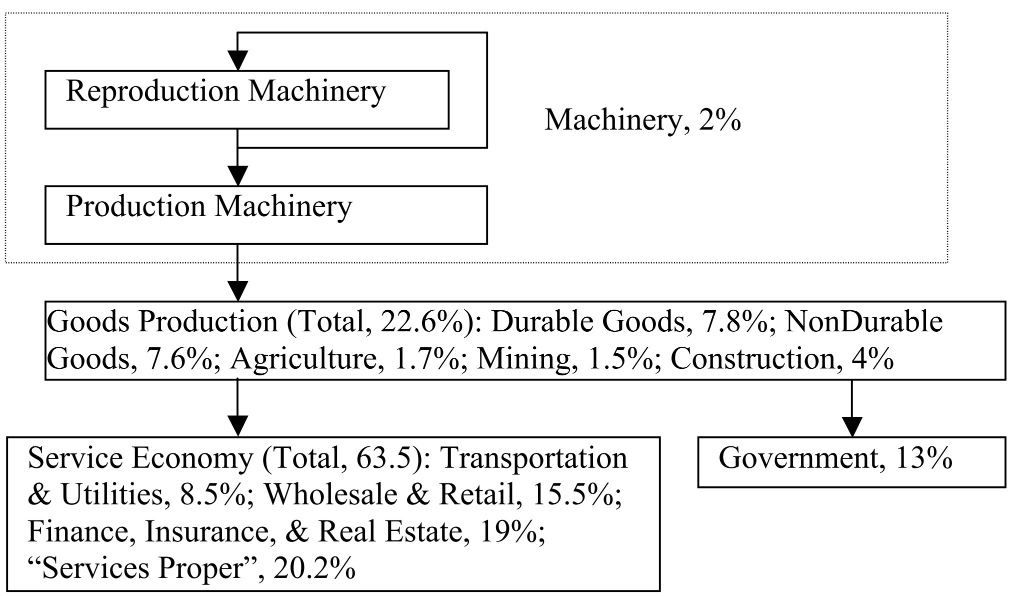
The theory of the production system has now been explained. The distribution system, and the economic system as a whole, must now be modeled.

Distribution system

Once the production system has generated its output, the distribution system receives the output and distributes it to three destinations: 1) the population, in the form of income; 2) back to the production system in the form of finance capital; and 3) into the distribution system, because the distribution system's power to allocate includes a capability to allocate a large segment of the output to itself.

The distribution system is a large part of the economy. In 1996, retail and wholesale activities constituted 15.5% of the U.S. GDP, by value-added. The same year, finance and insurance held 8.4% of U.S. GDP (Lum and Yuskavage 1997, 28). Advertising and other distributive business services may constitute another 1%, thus yielding a total for the distribution system of approximately one quarter of the economy.

We can diagram the U.S. economy as follows, where the percentage indicates the percentage of the economy as a whole (in terms of value-added in 1996):



Source for percentages: *Survey of Current Business*, "Gross Product by Industry, 1947-96", 11/97

Fig. 36. Percentage distribution of value-added in economy.

The arrows indicate the direction of production. The service economy receives 63.5% of the national product. The goods sector constitutes about 25% of the national product, including the machinery industries – which are only 2%, although about half of machinery is imported into the U.S. Note that much of what constitutes the "service" economy is dependent on goods production. The retail and wholesale sectors are retailing and wholesaling the production of the goods sector. Utilities, including transportation services, are based on production machinery, either electrical, communications, or transportation machinery. Real estate and some of the "services proper", such as hotels, rely on physical structures such as buildings. Other "services proper", such as engineering consultants or computer software, are integral parts of production processes. Repair services make up almost about 4% of the economy, and involve structural change to machinery. Health services, which make up about 6% of the economy, can also be seen as another kind of "repair", but to human "machinery", and involve the use of various classes of production machinery such as instrumentation and drug-making machinery. Thus, virtually all nondistribution service industries are based, in one way or another, on production machinery.

The retail/wholesale sectors can be divided into the same categories as the categories of production. The role of the retail/wholesale sectors is to distribute the goods and services produced by the production system. Every industry that exists in the structural, material, energy-converting, or informational final production sector that is destined for human consumption has a corresponding sector in the retail/wholesale part of the distribution system.

In addition to the entire industries which make up the distribution system, a large percentage of the personnel of most firms is devoted to the activities of marketing, advertising, sales and distribution of products and services, and to internal finance and accounting activities. According to David M. Gordon, in the U.S., 13% of employees were managerial and administrative in 1989 (Gordon 1996, 43), and received 22.4% of national income in the same year (Gordon 1996, 82). These parts of firms also constitute a part of the distribution system. I would therefore classify office buildings and automobiles, for example, as “distribution physical structures” and “distribution machinery”, respectively. I claimed in the previous section that middle and upper managers should not be included in a description of human capital.

The financial sector interacts with the economy almost exclusively in terms of money, but the allocation function of the financial sector can be considered in terms of products and services instead of being measured exclusively in money terms. The benefit of using money is that a mass of different products and services can be represented with one measure. Therefore, when people participate in exchange, they do not have to worry about which of a huge number of things, or portion of things, is being traded. But sometimes it is convenient to measure the goods and services that are flowing within the economy, instead of the money. After all, the money represents goods and services. When money is exchanged, ultimately, real goods and services are being exchanged.

Thus, when finance capital is directed in investment, for example, to build a new factory, the process can be described as the redirection of a certain amount of money. It can be said that the materials that were bought with the money were used to build the factory; it can also be shown that those same materials were redirected from one part of the economy to another. One could also view the pay of the workers who built the factory and the wear and tear on the machinery used in the construction of the factory as being redirected from one production sector to another. In other words, people and machines and goods have been taken from the output of a set of production industries and allocated to another point in the production system, that is, invested. Thus, the financial system allocates the output of the production system, and directs the output according to the wishes of the decision-makers who control the output.

Therefore, the financial system can be said to mirror the production system. While the retail/wholesale sectors only mirror the categories of production (with the trivial exception of the selling of machinery), the financial system can be modeled as having the same twelve niches as the production system. These financial niches can be viewed as taking output from each production system niche – not as money, but as real goods and services. These goods and services are transferred to other financial niches, and then the destination financial niches transfer the real goods and services to their mirror production system niches.

For example, assume a new car factory is being built with financing from a bank or a stock offering, and a set of machine tools is needed. In terms of the flow of goods and services, the output of the machine tool maker is being transferred from the structural production machinery *production* niche to the structural production machinery *financial* niche. An intra-financial system transfer then takes place, as these machine tools are transferred to the energy-converting *financial* niche. Finally, the machine tools are moved to the energy-converting *production* niche (transportation is considered within the energy-converting niches).

This example is shown in skeleton form below:

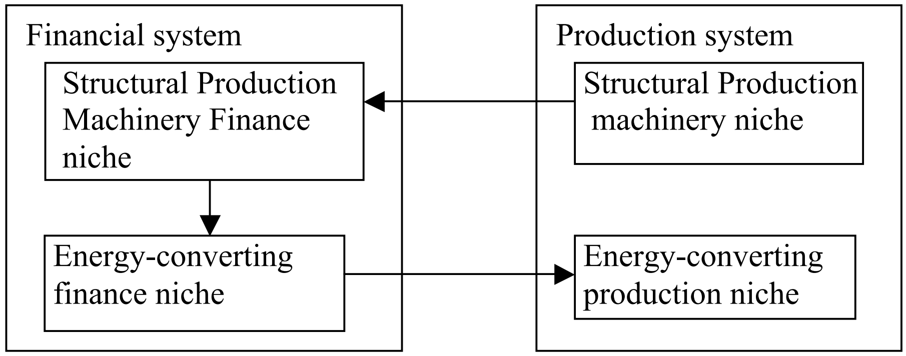


Fig. 37. Financial system interacting with production system.

The arrows follow the movement of output from one niche to another. At some point, the energy-converting production niche has to give something back to the energy-converting finance niche, and so on, but the goods sent back and forth do not have to be identical.

Generally, when finance capital is involved in this way, the providers of capital expect, not simply the receipt of an equivalent money value, but a *return* on their investment. According to the model offered here, this return on investment (ROI) is the result of the greater output of goods and services that is made possible by the provision of various resources and production machinery to the receiver of the financial asset. In the example above, the bank or stock holders receive more money value, that is, more claim to goods and services, as a result of their investment, because the car factory was able to create additional value by using the machine tools to produce automobiles. The ROI may be reinvested elsewhere, at which point the goods and services obtained may be recorded. The financial system is being modeled here as a repository, in which goods and services are flowing in, goods and services are flowing out, and some goods and services are being used up by the people and firms that make up the financial system.

A full specification of the economic system is diagrammed in the following:

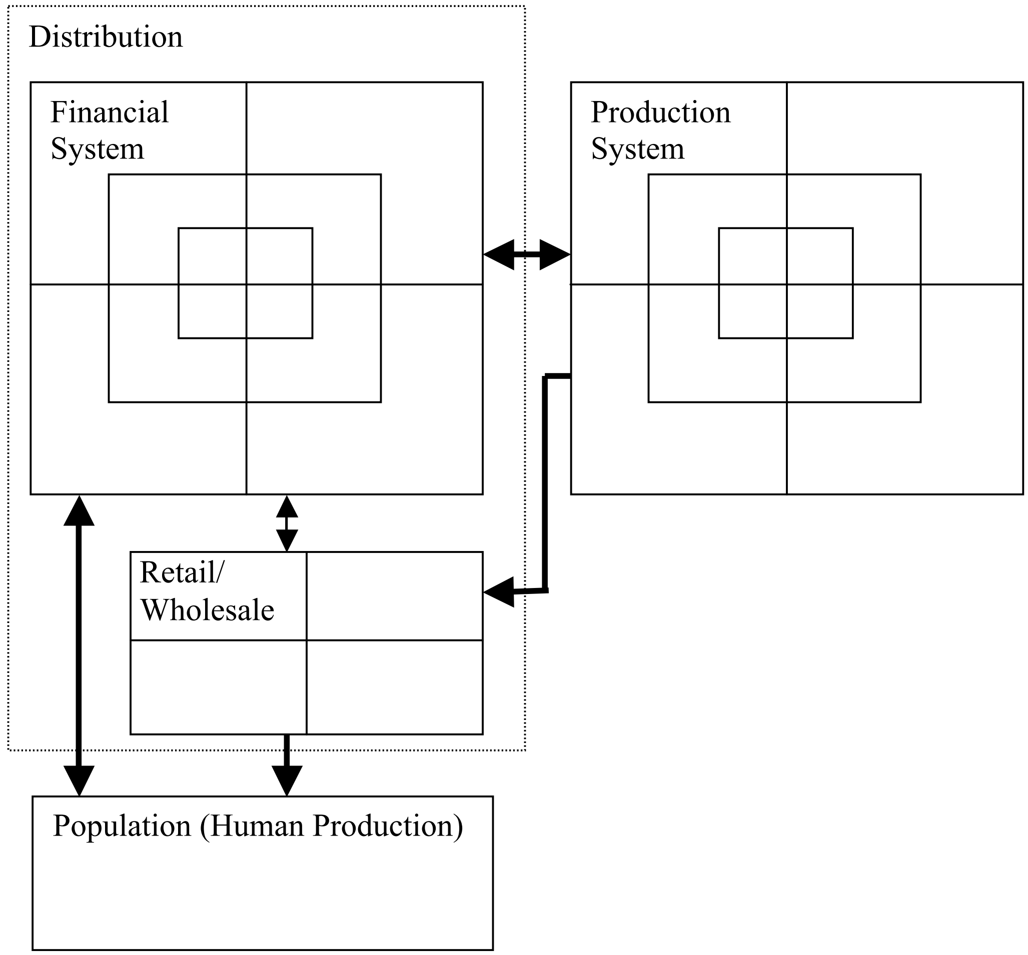


Fig. 38. The economic system.

The arrows indicate that the output emanates from a subsystem to the appropriate corresponding component. Thus, the output from the production system moves either to the corresponding niche in the financial system, or to the corresponding category in the retail/wholesale system. The different categories of goods and services move from the retail/wholesale system to the population, as do resources from the financial system; in turn, the population may send resources into the financial system, and the financial system may send resources to its corresponding niche in the production system.

The population is shown as separate from both the production and distribution subsystems. As explained in the previous chapter, the population constitutes its own production system. Humans are the objects which are being produced; like any population of organisms, the population of any nation has the potential to grow exponentially. By separating the population from the other components of the system, it will be easier to combine the economic and political systems in the next chapter, because they both share a population.

As a production system of a nation continues to grow and generate more and more output, more and more economic power accrues to the financial system because the financial system is able to control a larger and larger amount of output; this is the tenth hypothesis about economic systems. This "power" is not the same as productive power. The financial system controls a larger and larger amount of resources. I will define this power as *distributive power*, the ability to move a particular amount of previously produced goods and services a certain distance in a certain period of time. Thus, modern financial firms have a large amount of distributive power because they can move billions of dollars around the world in seconds. On the other hand, as claimed in the previous chapter, the machinery industries have little distributive power because they generate relatively little money value.

Economic power, then, will be seen to be a combination of productive and distributive power. Economic power is the capability to generate goods and services, diffuse productive innovations, and move the resulting goods and services a particular distance in a particular period of time.

It is also the case that in a rising economic system, the interaction between the financial system and production system is mutually self-reinforcing. The financial system improves the production system, in a rising economy, by directing resources back into the appropriate niches of the production system. The economy starts to decline when this mutually beneficial interaction turns into a one-way flow from the production system to the financial system.

It has been a repeated pattern throughout history that nations that develop into powerful producers eventually become financial centers, because the production of output gives rise to the expansion of the nation's financial system. Charles Kindleberger postulates that "the usual progression in the national cycle is from trade to industry to finance" (Kindleberger 1996, 212). The industrial stage may lead to decline, he feels, because the sector becomes "large, resistant to change, defensive", partly because institutions such as guilds and monopolies, which were once beneficial, have become burdensome. He is worth quoting at length:

> "The cycle in finance starts with promotion of trade and industry through short- and sometimes long-term capital lending, and ultimately moves to trading assets and preoccupation with wealth rather than output. Merchants and industrialists graduate from risk-taker to rentier status, and conserve flagging energy. Consumption out of given incomes rise, savings decline. Various interests push their concerns at the political level, and if enough do, they block effective action. Income distribution tends to become more skewed, the rich richer, the poor poorer. With greater access to the reins of political power, the wealthy are likely to resist some ethically appropriate sharing of national burdens, such as the costs of defense, reparation, infrastructure, and other public goods". (Kindleberger 1996, 213)

Carried too far, the focus of the entire economic system shifts to the financial system. This can become positive feedback process, because the finance capital accumulated in the finance center can be used to accumulate even more finance capital by controlling generators of output, both domestically and internationally. A financial "imperialism" may evolve, which may be destructive to the originating country as well as possibly distorting of the recipient country.

Eventually, the original production system which led to the creation of the financial system is depleted, and because of this neglect, the means of production begin to decline. In a sense, the goose that lays the golden eggs is starved. The entire economy then starts to decline, except for the financial sector, which may be able to retain its international role as a distributor of capital. Such is the state of the United Kingdom currently.

According to this model, in order for the economy to grow, a production-centered financial system must redirect capital back into all production niches, since a well-functioning production system requires that all niches be well-supported. This is the negative feedback character of the production system; no niches will do well unless all or most niches grow.

In particular, in a growing economic system, the financial system must be able to redirect capital into the vulnerable machinery industries. But if the machinery industries are not well-funded, the investment opportunities of the machinery sectors will seem less and less desirable, and less and less capital will be directed toward them, leading to an even weaker production sector. A vicious cycle, a form of positive feedback, will result. Neglect of production leads to declining production competence which leads to even less investment in production. The very success of the production system may lead to a decline of the production system, because of the relative rise of the financial subsystem within the wider economic system.

For the most part this imbalance takes place because of the functional differentiation between the generative and allocative subsystems of the economic system. Since the financial system reallocates resources, the generative sectors are at their mercy. The imbalance may be exacerbated by the relative imbalance in the distribution of capabilities between the two systems, particularly when the resources of the financial system become large vis-à-vis the production system. In such a case, both the distribution of capabilities *and* the functional differentiation tend to lead to depletion of the production system; in other words, at a certain point both aspects of the structure of the economic system as a whole lead toward an unbalanced situation. At this point, a positive feedback process may take over, leading to financial hegemony within the economic system.

Historically, the state is the outside force which must step in to correct an imbalance between the financial and production systems. The state that steps in is often an outside state. For instance, when Germany and Japan were defeated by the Allies, the power of the German and Japanese banks, industrial elites and military were heavily circumscribed by the United States. This helped the German and Japanese states to reorient their economies to civilian industrial production.

The United States was able to restrict its financial titans early in the twentieth century, partly through the mechanism of antitrust legislation. This was done partly because of the democratic nature of the political system. Theodore Roosevelt and other progressives were able to rally public opinion behind their efforts. These solutions were not possible for Germany and Japan for much of the first part of the twentieth century because of their authoritarian structure.

Conclusion

The production subsystem of the economic system contains the engine of growth which causes the rise of a national economy. Reproduction machinery is capable, collectively, of creating exponential growth, and both production and reproduction machinery sectors are the most important sources of technological change. In addition, the structural, material, energy-converting, and informational categories of production participate in a mutually symbiotic amplification of technological advance.

The nature of the capital subsystem of each sector is another source of innovation and growth. The researchers/teachers act as reproductive metagenerators, training engineers and generating knowledge, which the engineers then use to create better designs of production machinery and production processes. These designs are then turned over to skilled production workers and operational managers, whose competence is crucial for a well-functioning economy.

These capital-generating people need the support of high income levels, good educational facilities, and research facilities. In addition, innovation is encouraged by the free flow of information, people, and capital.

The role of the financial sectors in a rising nation is to encourage these processes of innovation and growth within the production system. In particular, because the distribution of value-added is much different than the distribution of causal capability – in other words, because the machinery industries have much less allocative power to redirect resources than productive power to generate resources – the financial sphere must compensate.

However, there is a tendency in any economic system for the financial system to accumulate resources to itself instead of redirecting resources to the production system. As the financial system gains more and more power over resources as a result of the success of the production system, the financial system is able to lock-in its hold over the economic system as a whole. The entire system is then in danger of decline, as the production system is depleted.

Thus, the rise and decline of economic systems depends on the management of the production and financial systems. The positive feedback processes of the production system encourage growth; the positive feedback processes of the financial system may encourage either rise or decline.

It is within the political economic system that the outcome of this struggle is often decided, because the state and the nature of the state is crucial to the enfolding of these processes. The interaction and combination of the political and economic systems must be considered in order to pursue a full understanding of the rise and decline of Great Powers.

A systems approach is necessary for understanding the complexity of these national economic processes. John Hobson argued for a holistic understanding almost 100 years ago. Speaking of economists at the turn of the last century, he wrote:

> Each piece of the mechanism [in an economy] is clearly described, and the reader is informed how it fits into the parts which are most closely related to it, but no simultaneous grasp of the mechanism as a working whole is attained. When we graft upon the idea of a mechanism that character of continuous self-development which transforms it into an 'organism', the synthesis of the changing phenomena is still more difficult to comprehend…To understand the

> evolution of the system of modern industry we must apply to the heaps of bare unordered facts those principles of order which are now recognized as the widest generalizations or the most valid assumptions derivable from other sciences. (Hobson 1902, 8-9)

The chapters on the theory of an economic system (Chapters 6 through 8) have been concerned with fitting the “bare, unordered facts” together in a way that is consistent with a wider array of scientific thought than is normally used by neoclassical economists. My general theory of systems has been used to construct a specific theory of economic systems, and my theory of economic systems has been used to generate hypotheses which can be tested. The political and economic domains have now been explored; the level above these systems, the level of systems of political economy, will be investigated in the next two chapters. Rise and decline are phenomena at the level of systems of political economy.