A Systems-based, Production-centered Theory of Political Economy

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Introduction

Over the past thirty years, theories that have originated in neoclassical economics have been used extensively to study issues in political science. Most attempts to construct an interdisciplinary theory of political economy have been based, in one way or another, on neoclassical economy theory. This paper is an attempt to move in the opposite direction: To construct a theory of political economy based on ideas found within political science and other disciplines. The two main organizing ideas will be power and production.

Political scientists have an advantage over neoclassical economists in that political science is to a large extent concerned with issues of power. Power, its distribution and use, is a characteristic of any social system, and should be a central consideration in a theory of political economy. How can the concept of power be combined with economic concepts? In this paper, I will start with a theory of international systems, as elaborated by Kenneth Waltz (1979), that makes power a central consideration.

If power is to be truly central to a theory of political economy, then the theory must be able to explain changes in the distribution of power, whether internationally or domestically. That is, such a theory must be able to explain the relative rise and decline of particular political elements within the polity or the international political system. Neoclassical economics excels at the understanding of processes of stabilization, but in order to understand change, we need to understand the unstable processes of growth and decay.

In particular, we need to understand, in great detail, the role of production in a system of political economy. While exchange and allocation of produced goods and services is the main focus of neoclassical economics, the creation of goods and services and the causes of the long-term change in generative capacities of an economy will the be focus of this paper.

Power will have two different, but linked meanings: first, power will refer to both political power, that is, the power to make someone do that which they would not otherwise have done; second, power will also refer to the power of production, that is, the power to create wealth:

"*The causes of wealth* are something totally different from wealth itself. A person may possess wealth, i.e. exchangeable value; if, however, he does not possess the power of producing objects of more value than he consumes, he will become poorer. A person may be poor; if he, however, possesses the power of producing a larger amount of valuable articles than he consumes, he becomes rich.

"*The power of producing wealth* is therefore infinitely more important than *wealth itself*", and "this is still more the case with entire nations (who cannot live out of mere rentals) than with private individuals" (List 1885, 133, emphasis in original).

The power to create wealth underlies the changes in political power that occur both internationally and domestically, and political power underlies the creation of that wealth; further, political power can be used to either encourage the creation of wealth or lead to its decay or even destruction, as in wars.

Every theory has either an explicit or implicit theory of a system that underlies the processes and mechanisms explicated in the theory. One of the strengths of Waltz's theory of international systems is that Waltz took great care in constructing a theory of a system. Using Waltz's model, I will construct a theory of a political system and a theory of an economic system, both of which will then by used to construct a theory of a system of political economy.

My theory of an economic system will explore the structure of production. In particular, I will focus on the production machinery within an economy, which is that set of types of machinery that are used to produce all goods and services. This set of machinery sectors, I will attempt to show, contains certain self-reinforcing, positive feedback processes, which lead to a virtuous cycle of technological change; production machinery industries and their capital goods counterparts are therefore the main engine of economic growth. These positive feedback processes, fortunately, are not stable.

Neo-classical Economics

Before explaining my model, it may be helpful to discuss the neoclassical model, in order to show why a different theory of political economy should be necessary. The main reason that neoclassical economics is not adequate for constructing a theory of political economy is that the explanation of economic growth is weak to nonexistent. There are several reasons for this state of affairs: the concept is considered a "backwater" in the profession, the concept of capital has never been adequately developed, the most widely accepted theory of economic growth is actually a nontheory of sustained growth and is based on the idea of diminishing returns. In addition, the theory of comparative advantage, which has its own set of problems, has become the de facto theory of economic growth. I turn to each of these problems.

Economic growth is the single most important characteristic of modern economies; consider the changes in the level of wealth in the last century or two. For instance, the world GDP per capita has increased six-fold from 1820 to 1992, from $695 to $5,145 (Maddison 1995, 19) in 1990 constant dollars. In the U.S., per capita GDP has risen from $4,096 in 1900 to $21,558 in 1992 (Maddison 1995, 23). Yet the explanation of this fact is a "backwater" in the economics profession (Temple 1998, 39), and according to 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). Basically, the problem is that the theory of a system on which neoclassical economics is based is not amenable to the kinds of problems that one encounters when investigating questions of economic growth.

Neoclassical economics uses a theory of a system based on the subfield of physics called statistical mechanics (Mirowski 1984, 372). Classical mechanics basically deals with a system that includes two physical elements; it can explain with enviable precision the future position and velocity of two elements based on their present position and velocity. Once one moves to a system of more than two elements, however, this clarity disappears; it was only in the 20th century that a very complicated solution was found to the "three body problem". Statistical mechanics was designed to address systems that contained very large numbers of elements, such as gases and liquids. It was the crowning achievement of 19th century physics, and profoundly affected the progenitors of neoclassical economics.

Statistical mechanical systems have certain characteristics: all of the elements are the same, that is, the system is homogenous; any change in the number of elements, that is, more gas or less gas or liquid, is an exogenous event, that is, production is assumed not to exist, no new elements are created; stability is the main object of study, instability generally is disastrous, resulting in a positive feedback loop that leads to some sort of explosion. Explanations take place within a very short-term time horizon. In addition, the behavior of the system is generally linear, that is, a proportionate cause leads to a proportionate effect.

The study of nonlinear, dynamic systems is a more recent phenomenon, which gave rise to the term "chaos theory" (Holte 1993).

So it is that economists (many trained as physicists) developed microeconomics as a system of similar elements (competitive firms within one industry), treat disturbances as exogenous, must show why their models are stable, concentrate on the short-term, and rarely investigate the possibilities of nonlinear processes. This last problem leads us to consider one of the great failures of neoclassical economics, the collapse of a theory of capital.

Since Ricardo, economists have wished to explain the price or level of variables (such as interest or profit) as the result of the linear relation of independent variables. Labor is a favorite, and capital is disdained, because labor can be treated as if it was not itself a product of the economic process under consideration. Capital produces more capital; it is therefore nonlinear. There is no way to construct a statistical mechanical system in which some of the elements are producing other elements which then produce other elements, and so on.

Some scholars have attempted to circumvent this difficulty by constructing a labor theory of value, that is, claiming that all wealth, including capital, is caused, or created, by one factor of production, labor (Locke, Ricardo, Marx, Von Hayek). Capital consists of those human-made objects that are used to make more human-made objects, including tools of all kind. This definition includes the tools that were used even by the precursors of homo sapiens, homo erectus. Humans evolved along with the tools that they used; the opposable thumb and structure of the human hand is the result of the need to manipulate and create tools. Therefore, there has never been nor never will be a human community that has lived without using a large amount of capital. The production of human wealth is always multicausal: both labor and capital are necessary in order to create wealth.

Early in the 20th century, Bohm-Bawerk asserted that "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 (that is, plant and equipment). However, in order to measure an increase in productivity, one looks for a *lessening* of time spent in production, not an increase. Like much of neoclassical economics, a theory that works well when technology is assumed to not change is exactly wrong when technology is seen to be changing. No convincing theory of capital followed these attempts.

The reason this is important is that the reigning theory of growth, as designed by Robert Solow, depends on the idea of aggregating capital. But even if the idea of capital could be successfully integrated into neoclassical economics, Solow asserts that "increasing the rate of per capita growth is not only not easy in [my] 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).

The reason that his model cannot explain most of economic growth is that it relies on the idea of diminishing returns, which underlies the concept of the marginal productivity of capital and labor, which in turn is used to estimate the contribution to the economy of the factors of production. Unfortunately for the theory, labor receives most of the income in the economy, but has remained relatively stable in terms of hours devoted to production, while capital receives a much smaller part, but has followed the increase in economic growth. According to the theory of diminishing returns, the productivity of capital should diminish as capital increases and labor stays constant; but as Samuelson explains, "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…[This is] incompatible with the more basic law of diminishing returns under deepening capital. We are forced, therefore, to introduce technical innovation into our statical neoclassical analysis to explain these dynamic facts" (Samuelson 1975, 747). Thus, the term "multifactor productivity" or "total factor productivity" or even "technological progress" is used in journal articles discussing economic growth; it is actually a number used to plug up an anomaly in neoclassical economic theory. That is, instead of discarding the concept of diminishing returns and marginal productivity or exploring other concepts, the entire question of economic growth becomes insoluble.

The concept of diminishing returns explains why something decreases; it cannot be used to explain why something, such as economic wealth, is increasing. In neoclassical growth theory, the concept of diminishing returns is then coupled with an aggregate measure of capital, which is itself problematic, as Blaug explains: "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). The result is that the theory of economic growth shows that technological progress is responsible for growth, and that neoclassical economic cannot explain technological progress. No wonder economic growth theory is a "backwater".

Instead, the concept of comparative advantage reigns as the de facto theory of growth within the profession of economics and beyond. Like Boehm-Bawerk's theory of capital, the theory does well if technology is not changing. If technology does not change, and competencies in production never moved among nations, then it would make sense to concentrate on those industries in which the nation is comparatively superior, and drop the industries in which other countries were comparatively superior. But since the history of humanity can be viewed as exactly the change in technology and the change in the distribution of technological capabilities among nations, it would seem foolish to want to make the existing configuration of competencies eternal. Ricardo, applying his theory to the world in the early 1800s, stated that "it is this principle which determines that wine shall be made in France and Portugal, that corn shall grown in America and Poland, and that hardware and other goods shall be manufactured in England" (Ricardo 1970, 134).

At approximately the same time that Ricardo was making this terrible prediction, De Tocqueville (2003) was predicting that one day the U.S. and Russia would be the two most powerful countries in the world. Ricardo's failure at prediction had the advantage of being based on a formal theory; DeTocqueville's predictive success was based on his observation of the democratic and industrial capabilities of the early Americans, but he didn't have a formal model that could be used to explain his observations. The rest of this essay will be used to construct a model that can explain why democracy and industrial capability are central to power in the modern world. The first task is to offer a better alternative of a system than that presented in the domain of statistical mechanics.

What is a system?

We can start with a theory of systems as elaborated by Kenneth Waltz (1979). Like economic theory, going back to Adam Smith, his theory is based on the idea of a self-organizing, complex system. Unlike the neoclassical theorists, however, his theory is not

tethered to statistical mechanics. Influences include systems theories from anthropology, psychology, and biology (Angyal 1939, Churchill 1968).

In particular, Waltz has elaborated a theory of the *structure* of a system. The word structure is used for so many concepts that it needs a very precise definition. For Waltz, the structure defines the position and ordering of the elements in a system; it is what makes a system a system, as opposed to simply a heap of elements. For example, we can have a set of elements made up of two small circles, a big circle, and a line. If we order these elements in a particular configuration, we will have a very simple face. The positioning of the elements created a structure which is recognizable as the drawing of a face. Waltz stresses that it is not the interaction of the elements that creates the structure, but the ordering and positioning of the elements.

The definition of a structure in Waltz's theory has three parts: an ordering principle, a differentiation of functions among the elements; and a distribution of capabilities among the elements. The elements of the system and the structure of the system define the system, as well as the specification of the domain of reality over which the system applies.

In the international system, the ordering principle is one of no control, that is, anarchy, as distinct from the ordering principle in the domestic system, in which there is a hierarchical ordering within the state. There is no differentiation of functions among states in the international system, because all states must provide for their own security; but there is a distribution of capabilities among the countries that make up the international system. The system is self-organizing, to a degree; there are some countries, often called Great Powers, that have much greater capabilities than others, and therefore the international system is dominated by Great Powers. The Great Powers are the most important components, or elements, of the international system, and thus the set of Great Powers constitutes the domain of reality over which the theory holds. The internal characteristics of the Great Powers, whether they are democratic or dictatorial, aggressive or status quo, are not part of the structure of the international system. By referring to the structure of the international system, that is, the distribution of capabilities, it is possible to explain much about past and present international relations, and make broad predictions about the future. For instance, at the present time, the U.S. is very dominant; based on this observation, Waltz has argued since the end of the Cold War that the U.S. might want to use its power in a unilateral way, that unilateral action would displease other countries, and that a balance of power might develop in order to counter such overwhelming power (Waltz 1999).

Implicit in Waltz's discussion of the international system is another aspect of systems; the existence of what might be called feedback processes (feedback loops imply some form of control in a system; since there is no control in many systems, I will use the more general term feedback *processes* instead; for a discussion of positive and negative feedback, see DeAngelis et al. 1986, and Jervis 1997). A *positive feedback process* in the international system is one in which the conquest of a state by another state increases the probability that the conquering state could successfully invade yet more states; this accumulative, self-reinforcing process could go on until the entire planet was conquered, except for the functioning of the *negative feedback process* in the international system, the process of the balance of power, in which states ally and coordinate in order to prevent the accumulative process of conquest; an example is the alliance of the Soviets allied with the U.S. and U.K. in order to stop Hitler in World War II.

Thus, Waltz has defined a system as a set of elements that has a structure, which can be defined according to its ordering principle, differentiation of functions, and distribution of capabilities. The system helps to explain a particular domain of reality, and as I will stress, is

subject to positive and negative feedback processes. Once a general theory of a system has been established, then a specific theory of a system can be proposed, such as Waltz's theory of an international system. The specific theory of a system can then be used to generate hypotheses that can be tested and validated.

I want to propose two other aspects of systems that are compatible with Waltz's framework and make his definition of a system useful for constructing a theory of political economy. First, the elements within the system may themselves be systems. Thus, there may be a hierarchy of systems. A popular college biology textbook begins with a section on "Life's Hierarchical Order": "In this very first section, we introduce one of life's most distinctive features, its order. Life is highly organized into a hierarchy of structural levels, with each level building on the levels below it. As we examine the hierarchy, we will see that special qualities, called emergent properties, result from the structure at each level", as from cell to organ to organism to ecosystem (Campbell et al., 1999, 1). Just as the identifiable drawing of a face emerges from the way the lines are put together, so properties of systems that are not apparent at the component level are manifested at the system level (see also O'Neill et al. 1986). The idea of emergence is central to Waltz's conception of a system; he implies, but does not make explicit, the idea of a hierarchy of systems.

Second, I want to propose the idea that there are two general kinds of systems: generative and allocative. A *generative* system creates new elements or transforms the internal structure of an element or elements from one state to another; think of populations of different plants and animals within an evolving ecosystem. The *allocative* system distributes or organizes the elements that have been created or transformed by the generative subsystem; think of the territories of predators in an ecosystem. A complete system can be said to be composed of two elements, a generative system and an allocative system.

For simplicity, we can assume that a generative system is distinguished by a differentiation of functions among its elements, while the distribution of capabilities among a generative system's elements are less important; on the other hand, in an allocative system the distribution of capabilities is more important than the differentiation of functions for understanding structure.

Further, each kind of system has a different kind of negative and positive feedback process. In an allocative system, such as an international political system, a positive feedback process leads to a snowballing process of conquest, while a negative feedback process leads to a balance of power. In a generative system, such as an ecosystem, a positive feedback process leads to an exponential rate of creation, as in a population of animals; a negative feedback process leads a balanced rate of growth, as when the overpopulation of one set of animals upsets the balance of an ecosystem, leading to a population crash and reestablishment of balance (this is a restatement of the idea of diminishing returns, which emphasizes the need for all factors of production to increase at approximately the same rate).

The two types of systems may be diagrammed in the following manner:

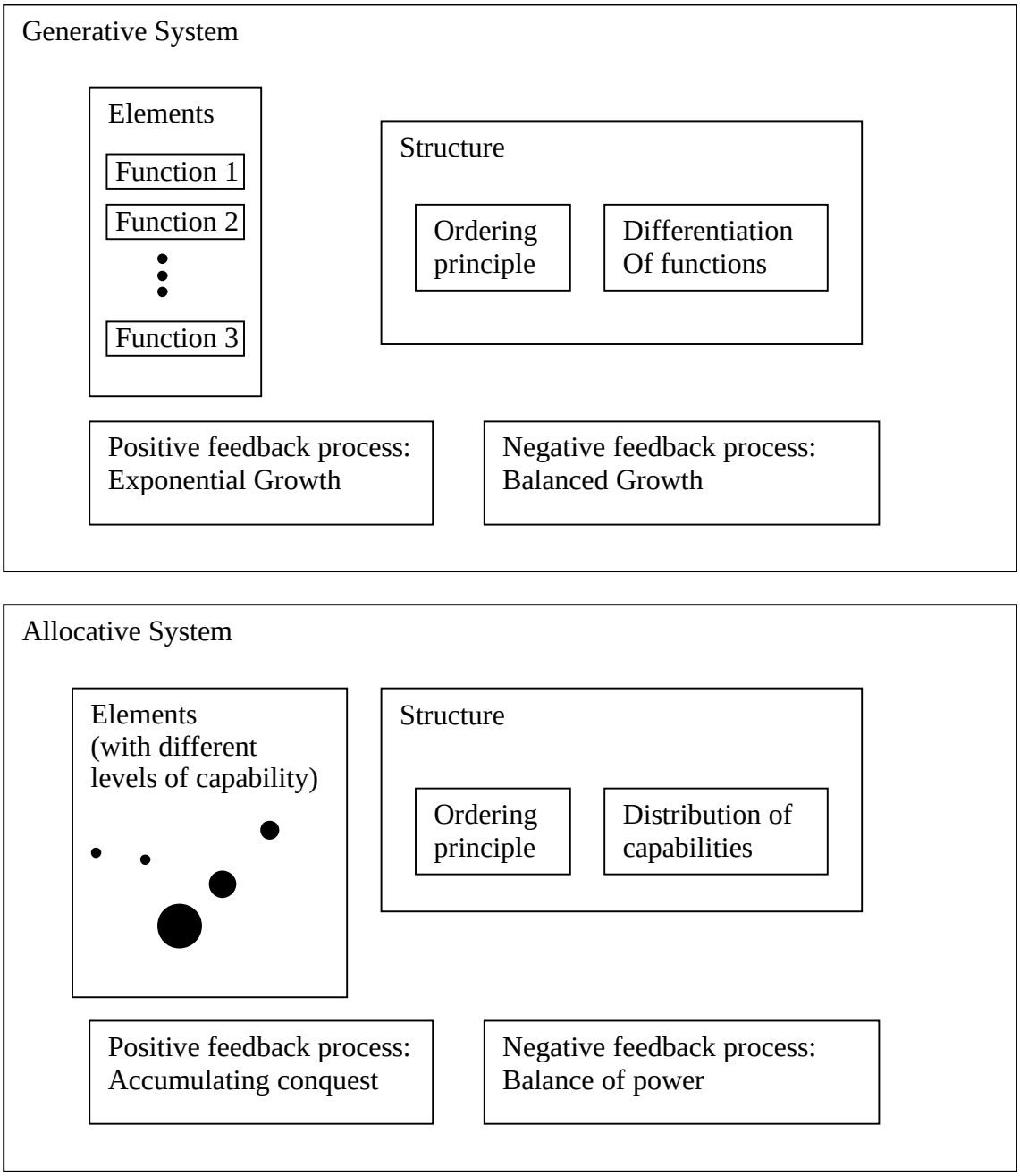

Figure 1 – Generative and Allocative Systems

The neoclassical model of the economic system is all allocation, no generation. When a situation exists that meets the assumptions of the neoclassical model, that is when there is pure competition, no technological change, and only short-term changes need be addressed, then the model works when allocation is the focus (one definition of economics is "the allocation of goods and services in a state of scarcity"). But in order to understand economic growth, rise and decline, and other important issues, it is necessary to construct a theory of political economy that includes both allocative *and* generative systems.

In order to construct a theory of political economy, it is useful to be able to construct a hierarchy of systems such that the system of political economy is composed of first, a political system, and second, an economic system; and the economic system can be seen as being composed of, first, a generative subsystem which outputs goods and services, to be called a production system, and second, a distributive subsystem, which controls the distribution of the output of the production subsystem.

The Production System

Since a production system is generative, its structure should describe a differentiation of functions. The question is how to order those functions and differentiate them in such a way as to be theoretically useful and parsimonious.

Production may be viewed as being ordered in a sequence, that is, ordered in time according to a definite set of stages of production. The stage of production that is the focus of neoclassical economics is what I will call "final production". In the final production stage, factories use the production machinery on hand to create inventories that are then distributed through the wholesale and retail systems. Viewing this part of the production system is what Alfred Marshall called the "short period" when determining prices (Marshall 1961, 379).

But how were the machines and buildings that constitute the factories created? Prior to the production of goods and services, the machinery and infrastructure that are used to create the goods and services must be produced; the means of production must be generated. This is the stage of production I will call the "production machinery" stage, in which the creation of much of this elusive stuff called "capital" takes place. Alfred Marshall called the creation of more factories and equipment the "long period" view of the price-setting mechanism (Marshall 1961, 379).

The problem now becomes one of infinite regress (Solow 1962, 207); we can always trace production back to another level and another level, because some set of machines was used to create the factory equipment, which themselves were created by yet another set of machines, until we go back to the first humans. However, the construction of theory requires a certain amount of simplification, if that simplification is useful for understanding a system. In order to understand economic growth, we need not throw up our hands and worry that "there is no there there". Instead, I will propose that there is an initial stage in the sequence of production, which I will call the "reproduction machinery" stage.

Reproduction machinery produces production machinery and also produces more reproduction machinery. This concept is a simplification of the reality of the complexity of production in an economy. Machine tools are a good example. Machine tools were one of the first technologies invented in the Industrial Revolution, and have been critical ever since. Machine tools are the machines that cut, stamp, and grind metal so that the metal component acquires a particular shape. Any product that is made of metal has been put together out of pieces of metal that were shaped by a machine tool or set of machine tools. And of course, any *machine tool* has been created using parts made by other machine tools.

Any particular machine tool did not create itself; it is only as a *class* of objects that machine tools can be said to reproduce, just as humans do not create themselves, but the species of homo sapiens propagates via reproduction. Machine tools reproduce because some set of machine tools is used to create some other set of machine tools.

This reproductive stage of production technology has a second function, besides producing more of itself; reproduction machinery is used to generate production machinery; and production machinery is then used to create final goods and services. I am therefore

proposing a tripartite sequence of production, starting with the stage of reproduction machinery, followed by a stage of production machinery, followed by a stage of final production.

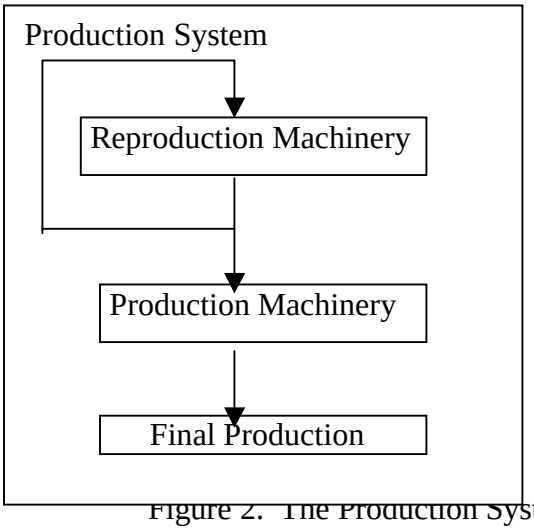

Figure 2. The Production System

Human beings are set apart from all other animals, not because they make tools, but because they use tools to make other tools. Early humans used a hammer stone, which was a tool, to make the flint pieces that were used to make the final tool. This final tool was then used for "final production", to butcher meat or other activities. In more abstract terms, the initial tool can be called a "metagenerator", and the secondary, or production tool can be called the "generator". The generator creates the final output of the system.

Thus, humans have always used a three-stage sequence of production. The industrial revolution can be defined as the process of transforming the initial stage of production, the metagenerator, into a fully reproductive process (there was some aspect of reproduction in medieval technologies; see Diderot 1959).

Because of this simplifying concept of a reproductive stage of production, it is possible to discover the most important cause of growth; as in a biological population, the potential for reproduction leads to the potential for exponential, self-sustaining growth. Like a group of rabbits, once one has a group of machine tools, for instance, one can expect to have an explosion of machine tools at some future point in time. The process of reproduction must be unstable if growth is to occur.

There are several other technologies of reproduction, and their enumeration will be useful in discussing the rest of the structure of production. Since the end of the nineteenth century, steel-making has been critical for the production of machines, because the most critical material in machinery is steel. Steel-making equipment is therefore used to make the steel for production machinery, reproduction machinery such as machine tools, and for more steel-making machinery. Also since the turn of the last century, electricity generation has been the most important form of energy conversion within the production process, allowing for the development of motors (most critically, in machine tools), the use of electric lances in steel-making, and most famously, the development of eletronic machinery. Computers, the most important form of electronic equipment, are dependent, since the introduction of integrated circuits in the 1960s, on a form of equipment called semiconductor-making equipment. All of these forms of machinery possess three qualities: first, they are used to

make more of themselves; second, they are used to make more of other forms of reproduction machinery; and third, technological advances in one form of reproduction machinery accelerates technological development in all other forms of reproduction machinery (and other sectors of the production system as well).

The history of technology is replete with the positive feedback effects of change in one class of machines affecting change in a large set of different machines. The most critical type of semiconductor-making equipment, for instance, is optical lithography equipment. Advances in this kind of machine allow for denser and denser central processing units (e.g., CPUs – the difference between a Pentium I and a Pentium 4). Advances in computers led to advances in machine tool design, in particular, numerically and then computer-controlled machine tools. Better machine tools then lead to better precision glass cutting, among other things, which lead to better optical lithograpthy equipment. Better computers lead to more automated, highly-efficient steel factories; better kinds of steel lead to better machine tools (the industrial engineer Federick W. Taylor first became famous for explicating the relationship between different kinds of steel and their cutting properties in machine tools (Taylor 1906)). Better machine tools made mass production possible, because mass production is dependent on the ability to produce interchangeable parts, which can then be assembled in a final product using an assembly line, as opposed to custom-fitting each car or machine. The declining cost of electricity-generation, itself a by-product in advances in machine tools, steel-making, and information-processing, led to better and cheaper machines and goods.

If the system of production within the economy is perceived as being ordered by a tripartite sequence of production then one can clearly see that there is a virtuous, self-reinforcing cycle of technological change leading to more technological change. The idea that there is a part of the economy that leads to exponential growth is not new; see Lowe 1987, and Domar 1957 on Marxist ideas. My model is more explicit about the role of machinery, and uses a different underlying model of a system than the other models.

There is another set of orderings, hinted at above, which when combined with the stages of production, can fully describe the ordering of the structure of a production system: categories of production.

In order to create something, four kinds, or categories, of production must take place: first, a material or materials must be created out of which the produced thing is fashioned, that is, there is a material-making function, whether that material be steel, chemicals, textiles, etc; second, a shape or form or structure must be created out of the material or materials, which may include creating parts and putting the parts together, so that there must be a structure-forming function, carried out by a machine tool, assembly line, construction equipment, etc; third, energy must be converted from one form to another, for instance, a waterfall or coal converted into electricity using electricity-generating steam turbines, in order for the work of production to take place; this function I will call the energy-converting function; and finally, information must be processed in order to fulfill the design of the object as a whole, whether by detailed plans or embedded microprocessors, in other words, there is an information-processing function (these four functions mirror the structure, elements, processes, and system-level of the theory of systems outlined above).

Thus, there are four examples of reproduction machinery (steel-making equipment, machine tools, electricity-generating steam turbines, and semiconductor-making equipment) which correspond to the four categories of production (material-making, structure-forming, energy-converting, and information-processing, respectively). Each stage of production can be modeled as containing four categories of production; thus, the production machinery stage

has four categories of production. For example, textile-making equipment, construction machinery, trains, and broadcast equipment are classes of production machinery within material-making, structure-forming, energy-converting machinery (in which I include transportation) and information-processing equipment. A diagram of industrial sectors and their location in this structure is shown in appendix 1.

The production system is thus formed out of twelve elements, three stages each divided into four categories of production, ordered according to the principles of the stages and categories of production as laid out above. Each element I will call a production system niche, or simply niche. A niche is a term used in ecology to denote a part of the ecosystem that has a particular function, so that for instance carnivores on the open savannah serve to keep the population of savannah herbivores in check. In the same way, each production system niche serves a particular function within the overall system of production.

One advantage of this view of the structure of the production system is that technological change can be more readily explained. Instead of trying to create aggregate measures of "technology", we can look at the structure of the production system and note that the technologically most important sectors are the reproduction machinery sectors, followed in importance by the production machinery sectors, followed by final production sectors. Since the machinery sectors are quite small, political science research can be focused on the dynamics of technological change within and among these sectors. My theory can be used to generate hypotheses concerning the links and processes that accelerate the effects of innovations within the production system.

Each element, each niche, within the production can be seen to be made up of three factors of production; an *unskilled/semiskilled labor* factor of production, corresponding to the labor factor of production in neoclassical analysis, which may be aggregated because the workers have little skill and so are easily substitutable; a *physical capital* factor of production, which equals the plant and equipment, or fixed capital, to use Adam Smith's term; and finally, a *human capital* factor of production. This human capital system is also made up of a tripartite sequence of stages. First, *scientists* at the metagenerator stage produce research, which to use Simon Kuznet's phrase (Kuznets 1965, 35), contribute to the global *stock of knowledge*. Scientists teach other scientists, thus leading to a possible exponential increase in scientists. Second, *engineers* , using the stock of knowledge created by scientists, create *designs* for machines and factories; engineers also teach other engineers. Third, *skilled production workers and operations managers* implement these designs and produce the *machinery and output* of the production system niches.

This factors of production may be diagrammed as follows:

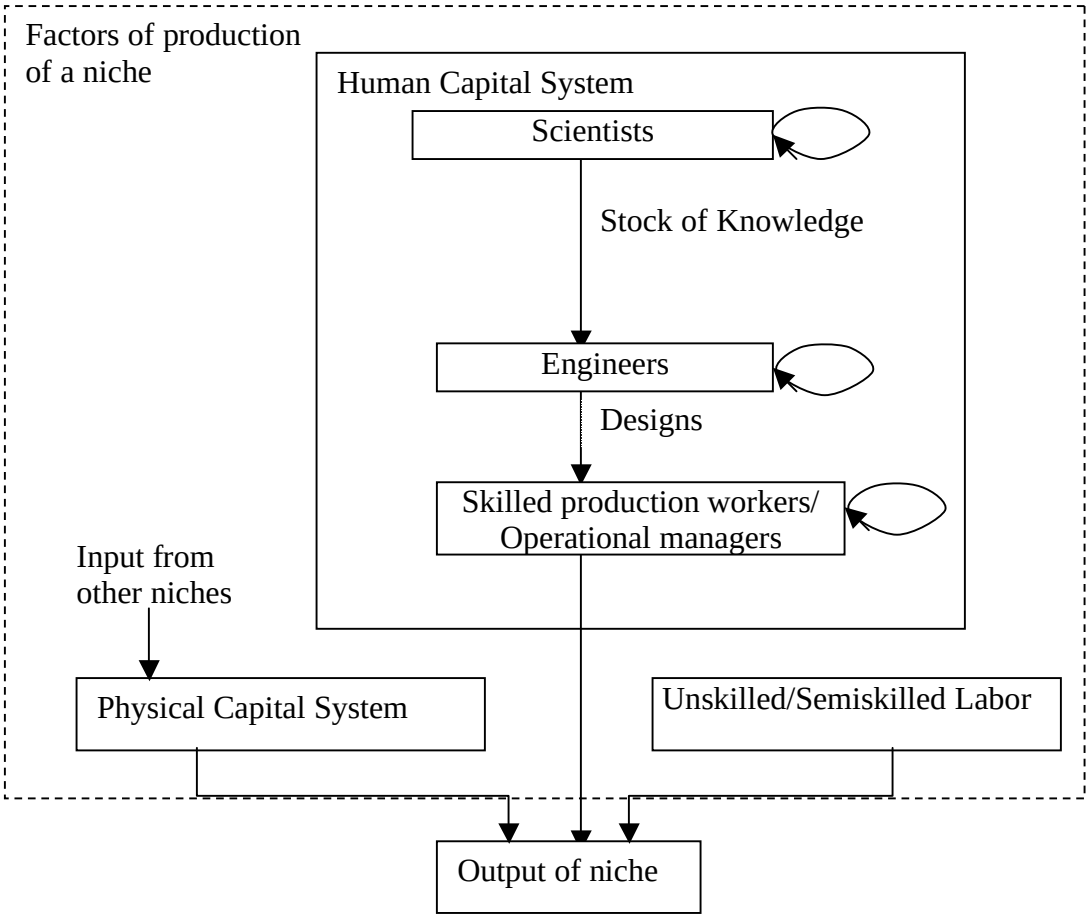

Figure 3. Subsystems of a production system niche

The structure of the production system has now been specified based on the principles of a system as described by Waltz. There are two ordering principles, the stages of production and the categories of production, as well as a differentiation of functions. The production system is the generative system of the economic system. A proposed simulation model for stages and categories of the production system is shown in Appendix 2.

The state and the rest of the economy depend on the production system, which is the source of wealth and growth. How are these others systems constructed, how do they fit together, and what are their dynamics?

The Financial System

I proposed that a complete system would consist of two subsystems, one generative and one allocative. The production system is the generative subsystem of the system that encompasses it, the economic system. The allocative subsystem we may term the distributive subsystem of the economic system. Retail and wholesale are the sectors that distribute the final goods to consumers. These sectors are important, but for understanding economic growth and for the purposes of constructing a theory of political economy, the financial system, a subsystem of the distribution system, will be the focus of discussion.

The function of the financial system is to distribute the surplus created by the main engine of economic growth, the production system, back into the production system. The financial system may do this very well, by distributing capital to important, technologically-emerging sectors, such as in the field of computers; it may also do a wasteful job, as in the Internet stock market bubble. Ultimately, there is no return on investment, in terms of the economy as a whole, if eventually finance capital does not return to the production system.

Since the financial system is allocative, according to my model, it is not the main engine of growth. I am not proposing that the financial system is useless, only that its usefulness derives from its ability to allocate and control capital. According to my simplified model the production system has no control over the disposition of its surplus, or of its final output, which are controlled by the financial system and retail/wholesale sectors, respectively. It is dependent on these sectors, and in particular, it is dependent on the financial sector for its renewal, maintenance, and expansion. Dependence over a group implies power over that group. Therefore there is an inherent tension, or at worst, contradiction within any economic system; the subsystem that generates the wealth does not have control over it. The subsystem that controls the surplus does not generate it.

The financial system is capable of diverting, back to itself, some of the capital that it is in the business of recycling; the profits and salaries in the financial sector are quite large because of control over the flow of surplus. This diverted capital is not available to the production system. An accumulative positive feedback process usually is present; the more powerful the financial system becomes, the greater part of the economic system as a whole will be controlled by the financial system, leading to greater control, etc. As the production system becomes capable of generating ever more wealth, it sets up the conditions for its own decline and depletion by providing the surplus that enables the financial system to slowly strangle the production system of sustenance (see Kindleberger 1996 for a history of the movement from commercial to financial dominance within leading economies).

On the other hand, from the invention of financial instruments by the Italians in the Middle Ages to venture capital funds in Silicon Valley and Boston, finance has been used as part of the larger positive feedback system of economic growth of the economic system. That is, without a financial system, it would be very difficult, if not impossible, to recycle the surplus of the production system back to itself. If auto companies had to barter for plant expansion by trading cars for buildings and machinery, expansion and growth would be much slower.

Thus, there are two subsystems which together make up the economic system. The production system generates wealth; the engine of the increase in wealth creation is the set of positive feedback processes that lead to exponential growth. At the same time, the negative feedback processes that are occurring within the production system constrain some niches

from growing much faster than others, as was seen in the telecommunications industry in the 1990s. The financial system allocates the resulting surplus, but accumulative positive feedback processes can work to undermine the economic system as a whole. Since the financial system is mainly an allocative system, positive feedback for the financial system leads to the stronger conquering the weaker, which in the case of the economic system means that the financial system will eventually deplete and weaken the production system.

The economic system has the function, within the wider system of political economy, of generating and distributing goods and services through time. How can the political system be modeled so that a useful model of a system of political economy can be constructed from the proposed models of political and economic subsystems?

The Political System

Any definition of a system includes, implicitly or explicitly, the specification of the domain of reality that the system is designed to model. Ideally, any subsystem will model its own exclusive section of the domain of reality (the subdomains will be disjoint). The total of all subdomains will equal the entirety of the domain of the system.

The domain of reality that the model presented here will encompass will be the social use of the *physical* world. This is one way to create a simplified domain of social reality. The advantage is that the physical world can be divided into the concepts of matter, energy, space, and time, to borrow concepts from physics. By dividing reality into these four concepts, the economic subsystem can be seen to involve the concepts of matter and energy, that is, the generation of goods and services involves the transformation of configurations of matter and energy into different configurations of matter and energy, through time. The political subsystem can be seen to involve the control, and generation of control, over space through time (see Easton 1957 for a specification of a political system as an allocative system). Time is crucial in both subsystems.

Of course, the transformation of matter and energy involves the use of space, and the control of space involves the use of matter and energy. By isolating these concepts, certain features (for example, positive feedback processes) become clearer. By focusing on the transformation of energy/matter, a system of production and distribution has been constructed. Now I turn to space and time.

The discussion of the state, both in political science and sociology, has usually had as one of its central concerns the concept of a territory that is controlled by the state. Most famously, Weber defined a state as "a human community that (successfully) claims the monopoly of the legitimate use of physical force within a given territory" (Weber, 1946, 78). Tilly adds some qualifiers (differentiation, autonomy, centralization, coordination), but defines a state as " an organization which controls the population occupying a definite territory" (Tilly 1975, 70). For Michael Mann, "The state is, indeed, a place – both a central place and a unified territorial reach (Mann 1985, 70). There are many other statements of a similar kind (Poggi 1990, Chapter 2; Weiss and Hobson 1995; Skocpol 1985).

By concentrating on space as the domain of a political system, however, I am ignoring a huge array of political functions – laws of all kinds, in particular. However, I want to suggest that the control of space is the paramount responsibility of the state. Without such control, as even recent history suggests, the state is considered "failed"; with such control, other forms of political life become possible.

In particular, the control of space means the control of a person's (or thing's) *position* in space. A system in space is specified by the elements that the space contains and the

position of the system's elements. The state must be able to control the position of people and things within its territory. There have historically been two primary methods for the state to handle criminals and others that it wants to tightly control; by controlling their position in space by incarcerating them, that is, making their position in space constant; or by removing them, either through execution or expulsion. The state can also limit the movement of people within the territory of its control or limit the movement of people into or out of its territory. These are considered "sovereign" rights of any state.

If the political system controls space and the population and things within that space, then the state is the subsystem that generates the violence or force that is the means used for controlling space. Just as the last stage in the production system is the stage of the final production of goods and services, so the last stage of generation in the state is the violence used to impose enforcement on the population, that is, the police powers of the state. Just as the production machinery stage in the production system provides the means for generating final goods and services, so the bureaucracy in a modern state is the means of generating violence. The bureaucracy is often referred to as a form of "machinery", not only because it mechanically follows rules and regulations, but also because it generates an output, that is, violence and enforcement. Weber saw bureaucracy as the modern form of legitimation, so that the phrase "the monopoly of the *legitimate use* of violence" can be translated into the phrase " the monopoly of the *bureaucratic generation* of violence."

The state elites – heads of state such as presidents, dictators and kings, plus any authoritative body such as a ruling committee, parliamentary body or powerful court of justice – are the equivalent, in the political system, of the reproduction machinery stage of the production system. The state elites generate the bureaucracy, which generates the control of space.

In dictatorships of various kinds, the state elites reproduce themselves, either literally in the case of monarchy, or figuratively in the case of juntas, Politburos, or even in the case of a dictator appointing his successor from a pool of state elites. In democracies, on the other hand, the state elite stage of the control of space is made to be *non*reproductive. The *sequence* of control, from state elite to bureaucracy to population, turns into a *cycle* of control, from state elite to bureaucracy to population and back to the state elites, and so on. The structure of the state is changed, because the ordering of the components has changed from a line (sequence) to a circle (cycle).

The allocative function of the domestic political system is therefore the choice between two structures of the state – democratic or dictatorial. This is a vast simplification of the range of political structures within a country, but I have given a precise definition of each form of allocation of political power. We can say that there is a constitutional subsystem, which is the allocational subsystem, which in a democracy specifies how power is distributed in this cycle of the generation of control (the bureaucracy is never controlled directly by the population under its control, but is instead controlled indirectly by the control of state elites).

Thus, a domestic political system is made up of a generative subsystem, the state, a population, and an allocative subsystem, the constitution. Now I will relax the simplification that a political system is only concerned with position in space, and add another function: the generation of laws. The state elites generate laws, the bureaucracy generates modifications to laws called regulations, and the population is controlled in terms of its position in space and also in terms of its adherence to laws. This second function of creating laws fits in well with the function of control of space, because incarceration and removal are generally carried out with reference to a particular law. So without loss of generality, the domain of the domestic political system can be extended to laws, as shown in the diagram below.

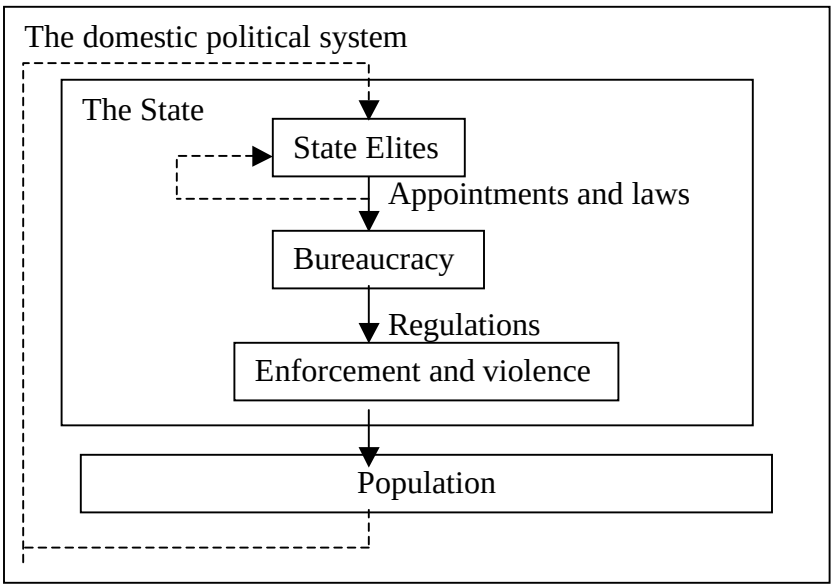

Figure 4. The Domestic Political System. Dotted lines indicate that either state elites or the populace choose the state elites, in dictatorships or democracies, respectively

The international political system, as opposed to the domestic political system, has no generative subsystem – it is all allocation. The function of the international political system is to allocate space, or territory, among domestic political systems, that is, among states. Since the space of the earth was created 5 billion years ago, and the present structure of the position of the continents has been fairly constant the past few million years, then there is no question of generating territory. In addition, as the unenforceability of international law shows, there is no global generation of violence in order to control space; those functions are the jealously guarded prerogative of states.

To say that the international political system allocates territory is to say that it is anarchic, and that the structure is defined by the distribution of capabilities among states, as elaborated by Waltz. If there is no generation of output, there is no differentiation of function, and only the distribution of capabilities can be used to ascertain structure.

There is one group of states, however, that has often been singled out as being more important than the rest of the states put together, that is, those states often referred to as Great Powers. The definition of who was a Great Power at a certain point in time has never been agreed upon or satisfactorily defined (see Appendix 3). By defining the international political system as the allocation of territory, it is possible to define the Great Powers as those states that control the *reallocation* of territory among states. There are two kinds of reallocation that Great Powers would want to prevent: first, a change that resulted in the creation of a new Great Power (see Lustick 1997 concerning the prevention of a Great Power in the Middle East) ; second, a change that would lead to one Great Power obtaining too much power (such as the Allies in World War II). One sees this reallocation capability most clearly at the end of major wars, as in the conferences at the end of the Napoleonic wars and the World Wars, in which territory is literally divided up with strokes of a pen. In addition, the fact that the five Great Powers during World War II – the U.S., U.S.S.R, U.K., Germany and Japan – controlled virtually the entire globe in 1943 shows the domination that Great Powers have the capability to exert.

Great Powers, if they wish, control the changes in the allocation of territory, and they can do this because of their great economic capability to generate military power. To make such a statement, however, requires the specification of a system of political economy, to which I now turn.

Systems of Political Economy

Now that economic and political subsystems have been specified, I can turn to a discussion of systems of political economy. New characteristics should emerge from a combination of the two subsystems – the whole should have more explanatory power than the two subsystems added together, both domestically and internationally. For a domestic system of political economy, for which I will use the term *polity*, the following will serve as an explanatory diagram:

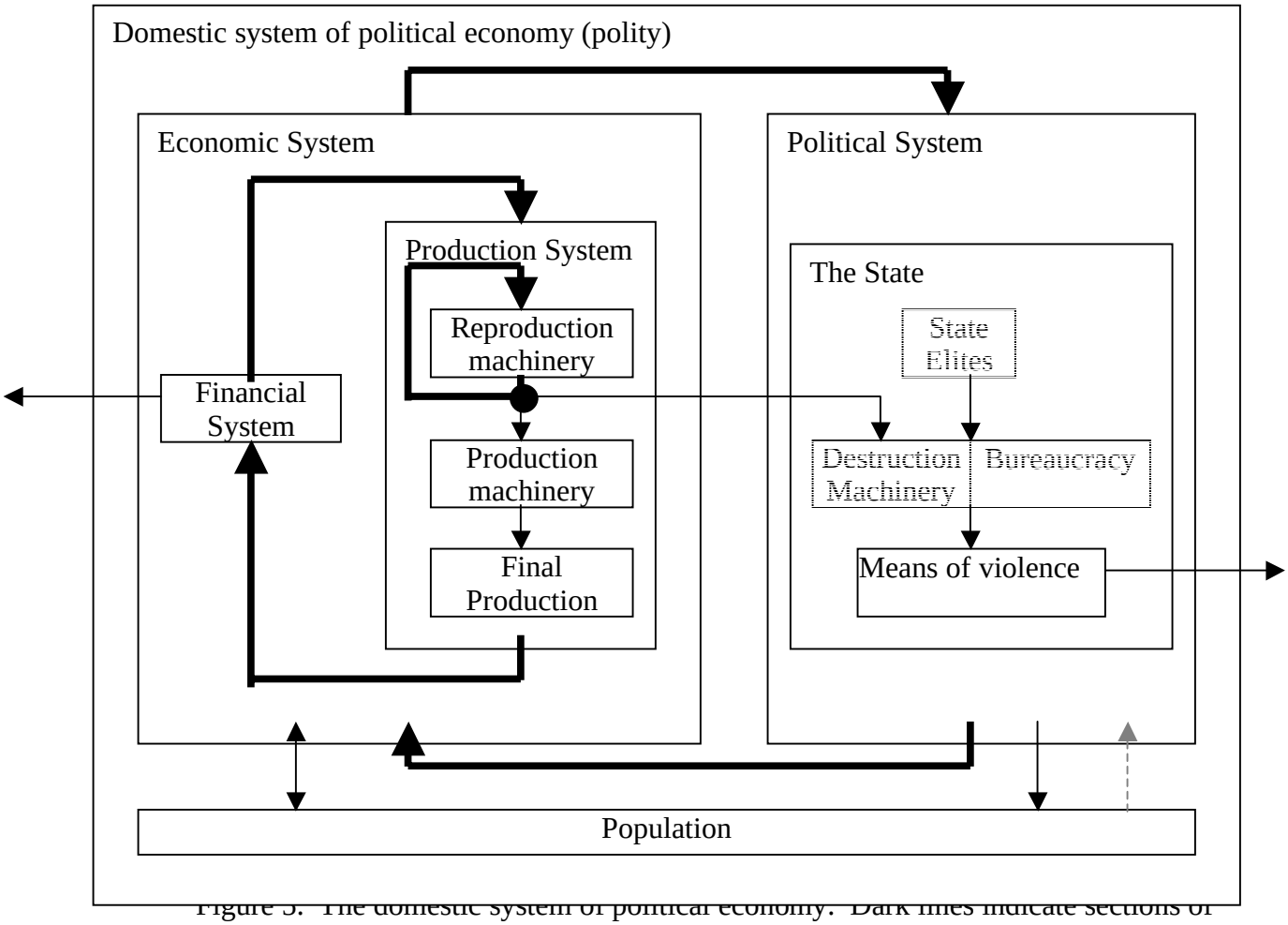

Figure 5. The domestic system of political economy. Dark lines indicate sections of positive feedback processes; arrows indicate direction of causality or control; arrows pointing outside of the diagram indicate movement into international system. The gray dashed arrow represents popular control of the state, but only in a democracy.

Figure 5 represents a model of the domestic system of political economy. Several parts of this system emerge from a combination of the economic and political: first, there is another positive feedback process in this model that can be used to describe the dynamics of rise and decline; second, a new element, destruction machinery, has been added; third, the position of the population has been moved; and finally, there are two links to the international system of political economy.

There are now three positive feedback processes in the model. The first positive feedback process, the reproduction machinery stage, is central to the system as a whole, and is always generative; the other feedback processes effect this stage either negatively or positively. When they contribute to the self-reinforcing virtuous cycles in the production system, the financial and state systems add to the positive feedback processes of growth of the system. When they deplete the production system, they decrease and even destroy the positive feedback growth processes of the polity.

The second feedback process involves the economic system as a whole, as explained previously. The financial system may recycle capital in a balanced way back into the production system, in which case a positive feedback process of exponential growth is encouraged, which leads to a larger financial system, and so on. On the other hand, the financial system can cease to play this function, and thus there will be a positive feedback process in reverse; the production system will be depleted, either by diverting capital into the financial system itself, leading to a smaller and smaller production system, or also by diverting capital outside of the polity, indicated in the diagram by an arrow leading outside the box marked "polity".

The third feedback process, which emerges only in a system of political economy, involves the interaction of the political and economic systems. The state may support the positive feedback processes, both production-based and financial-based, within the economic system, in which case the state will have more resources available to it because of the greater capability of the economic system to generate goods and services. The state may do this by aiding either the production system directly or indirectly through the financial system. But like the financial system, the state may create a positive feedback system in reverse; it may deplete either the financial system, production system, or both, in order to increase its short-term capabilities. A depletion policy will lead to eventual decline as the production system declines (see Ashtor 1978 for the effects of overtaxation on the preindustrial Middle East).

A new niche within the political system, called "destruction machinery", has appeared as a result of the combination of the political and economic systems. Military prowess depends on many things, but machinery and equipment which can destroy the opponent's men and equipment has been the most important source of military power. The word "destruction" is used to underline the fact that this equipment has the opposite purpose as production machinery: destruction, as opposed to creation. Destruction machinery appears on the same level as production machinery in figure 5, because they are both produced by reproduction machinery. Indeed, reproduction sectors such as machine tools, steel, engines, and computers have been financially supported by military establishments. Figure 5 shows an arrow leading from reproduction machinery to destruction machinery

The state needs the economic system in order to support the people within the state: its elites, bureaucracy, destruction machinery sector and means of violence. The state needs the reproduction machinery sector in order to support the production of military equipment. Thus, I have modeled a sequence of causation that has often been hypothesized, but never within a general theoretical framework, that is, that economic capability leads to military capability. For instance, Paul Kennedy concluded in his study of the rise and decline of the Great Powers:

> It was as clear to a Renaissance prince as it is to the Pentagon today that military power rests upon adequate supplies of wealth, which in turn derive from a flourishing productive base, from healthy finances, and from superior technology. As the above narrative has shown, economic prosperity does not always and immediately translate into military effectiveness, for that depends

> on many other factors, from geography and national morale to generalship and tactical competence. Nevertheless, the fact remains that all of the major shifts in the world's military-power balances have followed alterations in the productive balances; and further, that the rising and falling of the various empires and states in the international system has been confirmed by the outcomes of the major power wars, where victory has always gone to the side with the greatest material resources. (Kennedy 1987, 439)

My model formalizes this assertion, and provides a model of the rise and decline of Great Powers and other polities. The model also addresses several other important questions of political economy: the role of the state, the advantages of democracy, state formation, and the evolution and definition of Great Powers. I address these issues in turn.

The role of the state in the economy is central to the growth or relative stagnation of a national economy. There are three main roles of the state: to manage the production system, to manage the economic system as a whole, and to create the space necessary to encompass a complete production system.

The first main role of the state is to manage the production system. It can intervene directly into the production system, both in order to increase its military capabilities and to increase general economic output. The history of industrial development is replete with examples of successful, direct state intervention into the production system in order to catch up to other countries, from Federal support in the U.S. for machine tools that could create interchangeable parts for nineteenth century rifles, to Imperial Germany's establishment of apprenticeship and technical school systems, to the Soviet Union's wholesale creation of machinery industries in the first Five-Year plans, and Japan's successful catching up and surpassing of the U.S. in machinery technology in the post War period.

The state provides the bulk of the funding for training the scientists, engineers, and skilled production workers that are the human capital component of each production niche. The resources for this education are received from the production system; just as the financial system recycles capital into the production system, the state recycles capital into the production of human capital.

The second main role of the state is to manage the economic system as a whole. Just as the financial system can be a source of growth for production as well as a source of depletion, so the state can encourage or discourage production. By providing control over space, as has often been noted, the state provides the security necessary for production and finance to take place, and enforces the contracts and property rights that allow markets to exist (North 1990). It is the state's responsibility to prevent the financial system from gaining too much control over the production system, a problem I posed earlier. U.S. anti-trust legislation can be seen as state management of the financial system. The system of codetermination in Germany after World War II, in which all employees have decision-making power over the conduct of the firm, was partly an attempt to prevent the enormous concentration of corporate power that took place before the war. The state can also encourage the financial system by not overtaxing.

The third main role of the state is to create the space for the development of a *complete* production system, and to strive to develop a complete suite of industries within its territory. Ideally, an economic system will include all production niches because of the positive feedback processes that develop among them. The territory over which this suite of industries occurs must be populous enough that all these industries can coexist. One of the advantages of the United States was that it was large enough to encompass, not only all

niches, but for much of the 20th century the best production system in the world. In "The Precarious Balance", Dehio (1962) chronicles the attempts of countries, in particular France, Germany, and Japan, to become large enough in size to compete with "satiated" countries such as the U.S., Russia, and even China (and one might add, India today). The cause of many major wars can be explained by reference to this need to create enough space to encompass a complete production system.

On the other hand, the question currently is whether or not the optimum economic system is "global". I discussed economic systems in general without reference to size because I separated out the spatial aspect from the economic. In a system of political economy, the question of size can be addressed. Because of the nature of human capital, I hypothesize that the optimum size of an economy should not be global, because of the need for interaction among human capital workers and between human capital workers and machines. Industrial districts, such as Silicon Valley and Wall Street are clear examples of the usefulness of close proximity in one industry. Industries must be near their counterparts in the production system in order to maximize the benefits of technological change and in order to create technological change.

Because of the structure of the production system, the human capital workers and industries that reside in the reproduction machinery stage are very important in transmitting technological development from one part of the production system to other parts. Engineers in production machinery industries interact with engineers in reproduction machinery industries, who then talk to other engineers, both within other reproduction machinery industries but also with other production machinery sectors (Rosenberg 1976).

This Goldilocks-type principle, not too small and not too big, does not give a clear answer to the question of what the most efficient size of a polity might be. As the technologies advance, the optimum size may increase, because transportation and information technologies in particular lead to a greater range for the production system. In particular, continental or subcontinental size would seem to be an appropriate size at this point in history; the European Union, U.S., China and India are examples.

The neoclassical formulation of the need for size is summarized by Adam Smith in the statement, "The division of labor is limited by the extent of the market" (Stigler 1951). Since the division of labor, according to Smith, is to a large extent the consequence of machinery (Smith 1994, 7), then not only is the dependent variable, the division of labor, effected by technological change in machinery, but the extent of the market, the independent variable, is affected by technological change in informational and transportation equipment as well. Optimal size is to some extent a function of level of machinery technology, and is the consequence of state action.

The state is not a junior partner to the market. The state actively manages the production system, the economic system, and the political economic system. An advantage of creating a truly *political* economic model of a system is that both the market (i.e., the production and financial systems) *and* the state (i.e., the political system) can be seen as central partners in the processes of the system.

The state can also mismanage the polity. The state can deplete the production system to an even greater extent than the financial system. The financial system must eventually put some capital back into the production system. States can squeeze the production and financial system with overtaxation that leads to lavish lifestyles, or more commonly, divert massive amounts of resources into the military sector.

Like the financial system, the state as an allocative subsystem of the polity can initiate a positive feedback process of accumulating greater and greater control. If it diverts

too much of the output of the production system, either to build a large military-industrial complex or for state elite consumption, then the production system will begin to whither, leading to an accelerating process of decline as more and more of the output of the smaller and smaller production system is depleted in order to maintain state resources.

As an example of the usefulness of my framework, I can explain both the rise *and* decline of the Soviet Union. The Stalinist state in the 1930s created a means of production, including a full suite of production and reproduction machinery industries, which propelled the U.S.S.R. to superpower status. But because the Soviet state was completely unconstrained, it completely depleted the production system in order to build up a destruction machinery sector (Shmelev and Popov 1989, Rowen and Wolf 1990); the former countries of the Soviet Union are heir to a crumbling production system. The example of the Soviet Union points to an important hypothesis about the internal structure of the state: Over the long-run, a democracy is more efficient economically than a dictatorship.

Because the structure of the democracy is a cycle, that is, the controlled population chooses the state elite, the state is constrained from completely siphoning off the resources of the production system. There may still be a depletion process by the military, as many believe has happened in the U.S.(Melman 2001), but the state will not be able to warp the production system (and financial system) to the degree that dictatorships such as the Soviet Union were able to do.

In addition, as discussed above, a democracy may more easily be able to constrain an accumulative financial sector. Post-war Germany and Japan were able to break up the holding companies that had been partners with the dictatorial regimes of both countries.

The power to create wealth is the key to international power as well as economic growth, because economic growth leads to a relative rise in power compared to countries that are experiencing less growth. The model elaborated in this essay should have some predictive capability as well as explanatory power.

The logic of my model leads to the hypothesis that the U.S. is currently declining. Manufacturing, and in particular the machinery industries, are declining relative to other countries (Rynn 2003). This is partly the result of an accumulative financial sector and a state that gives highest priority to expanding it destruction machinery sectors. China, and to a lesser extent India, are rising because of their embrace of manufacturing and computer technologies. A prediction generated by my model is that India should eventually become stronger than China because India is a democracy.

If the most powerful nations are those that are democratic, that have an optimal size, that is, on the scale of a subcontinent or continent, and that contain a complete production system, then one would expect to see an evolution of the elements of the international system of political economy such that all polities, or at least all Great Powers, would have these three characteristics. Just as ecosystems evolve as their organisms change, so the international system of political economy will change as the domestic systems of political economy change. The United States was the first polity that met all three requirements of democracy, size, and a complete suite of industries; my model thus explains the American rise to dominance, since no state has yet to combine all three characteristics. The closest to this ideal is Japan, which is stronger in terms of industrialization than the U.S. but contains only half the population. Europe would automatically join the club if it was truly one polity, as would a democratic and industrialized China, and an industrialized India.

The three positive feedback processes in a system of domestic political economy lead to the main positive feedback process of the international system of political economy, namely, the snowballing accumulation of power that results from the fruits of conquest (see

Liberman 1993 on the usefulness of conquest). Another hypothesis generated from my theory is that if all peoples were members of large, democratic, complete polities, a balance of power would develop that would improve chances for global peace. Each state would be powerful enough to deter attack from other states; the international political system would be more stable because there would be no weak polities to fight over.

The acquisition of a large territory by a nation-state can be explained using my model of political economy. The formation of the nation-state, and of most present day nation-states, was the result of the snowballing accumulation of territory, a positive feedback process. The state took territory by conquest, and the new territory yielded the productive power necessary to provide revenue for the state bureaucracy and to provide resources for more conquest. As Tilly observed:

> The building of an effective military machine imposed a heavy burden on the population involved: taxes, conscription, requisitions, and more. The very act of building it – when it worked – produced arrangements which could deliver resources to the government for other purposes…It produced the means of enforcing the government's will over stiff resistance: the army. It tended, indeed, to promote territorial consolidation, centralization, differentiation of the instruments of government and monopolization of the means of coercion, all the fundamental state-making processes. War made the state, and the state made war. (Tilly 1975, 42)

We can see observe this pattern in the history of the major nation-states. The U.S.overwhelmed the Native Americans, both because of industrialization and constant conquest; the Prussians moved from control over Berlin to an eventual German Empire; the French state slowly gained control from Paris to the other provinces; Russia used gunpowder and a constant expansion from the Muscovite center to obtain central Eurasia; China first unified by the snowballing conquests of the Ch'in; Japan was remade in the Meiji restoration by peripheral provinces; India was conquered with gathering steam by the British. In many cases of state formation we can detect the interaction of the production, financial, and state systems which led to an "explosion" of the relevant national center over the rest of its eventual domain (see Cederman 1994 and Cederman 1997).

Each of these cases of national expansion were eventually stopped by a balance of power or satiation because an optimal size was reached. Territorial allocation can move in the opposite direction, to loss and fragmentation, as in the former Soviet Union or the collapsed monarchies of World War I. The relative rise and decline of various Great Powers and small ones can be explained by examining the interaction of the domestic political and economic subsystems.

I can identify Great Powers using the following rule: Great Powers are the polities that control reallocation of territory among states because Great Powers are those states that collectively control the global reproduction and production machinery industries. Great Powers have the destruction machinery or the potential to create the destruction machinery needed to project military power because of their relative capabilities in machinery production (see Appendix 4).

Conclusion

The logic of neoclassical economics leads to conclusions about how the political system should interact with the economy: as little as possible. Besides preserving property

rights and security, the state should stay out of the economic system, as for example, by expanding free trade to all goods and services and all countries. If this happens, then comparative advantage will work its magic, countries will specialize and the market will move toward stabilization. And economic growth will grind to a halt.

The logic of a system-based, production-centered theory of political economy leads to the conclusion that prosperity is the result of two main causes, the productive power of a country and the actions of the state. This is a multicausal system. Policies evolving from this model would not be oriented towards expanding the freedom of trade or specialization, but instead would move toward the creation of subcontinental/continental economic spaces that are based on a democratic political system and a complete production system The main function of trade among such entities would be to transmit technological innovations, not to provide essential goods or services. Multiples centers of innovation as would exist within, say, ten major political economic systems, would yield greater global technological change than if each industry had only one center of innovation, as would occur in an idealized world of global specialization and comparative advantage. The state would have to create production niches if they did not already exist in order to insure the existence of a complete production system.

The processes of economic growth, rise and decline, democracy and dictatorship, development and economic policy, can only be understood if both economics and politics, production and power, can be woven into a theory of political economy. The world is multicausal; social science should be as well.

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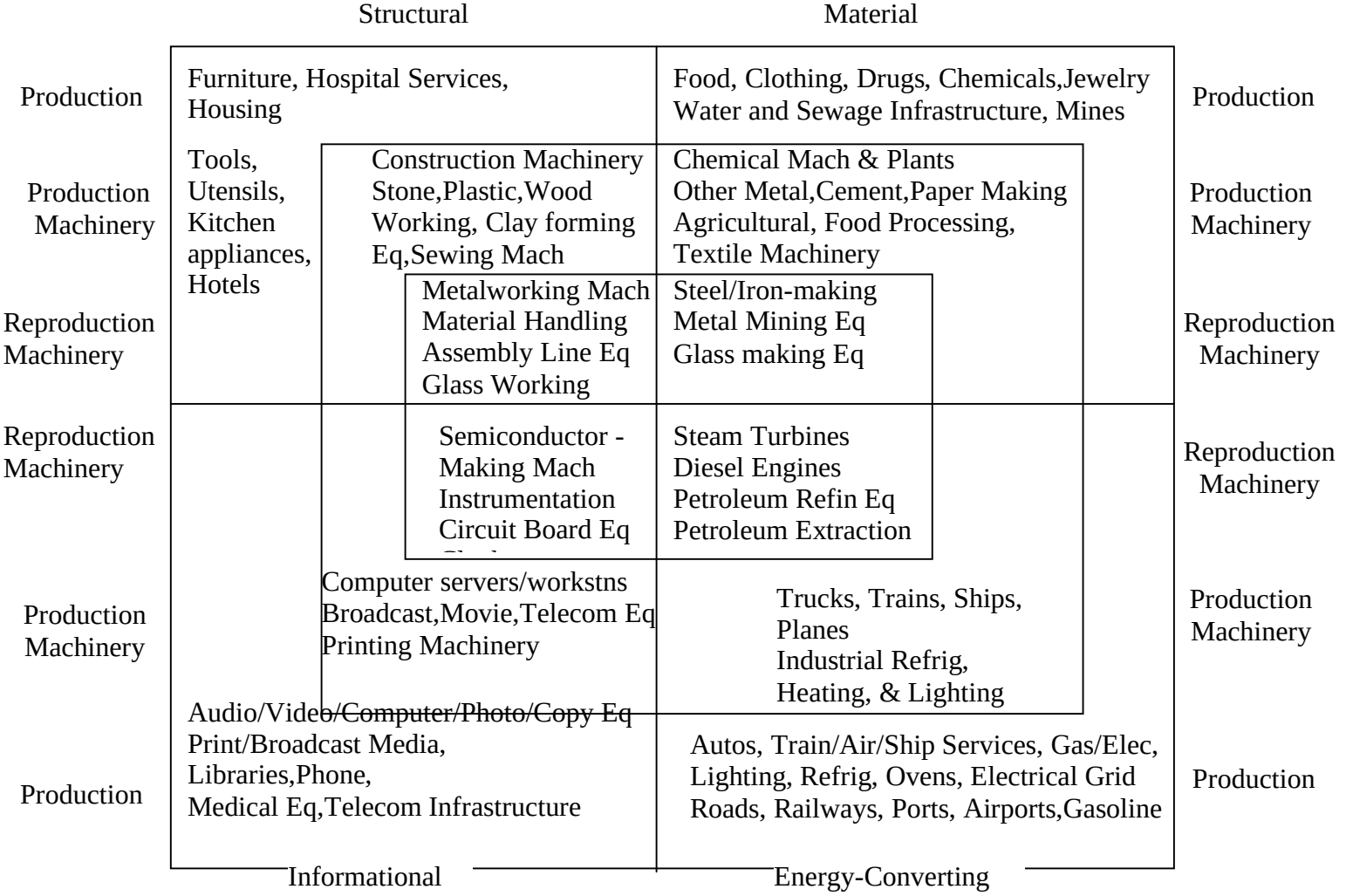

Appendix 1. Detailed structure of production

The innermost four quadrants represent the reproduction machinery niches, the middle ring of quadrants represent the production machinery niches, and the outermost ring represent final production quadrants. The upper left hand quarter of the diagram represents structural production, the upper right hand quarter represents material production, the bottom left hand quarter represents informational production, and the bottom right hand quarter represents energy-converting production. All industry names were taken from the Standard Industrial Classification, 1987, U.S. Department of Commerce

Appendix 2. Tripartite Input-Output System

In the diagram on the next page, a proposed input-output methodology is modeled. In a standard input-output chart, there exists a matrix with all industries under consideration having a row as well as a column. Each row of the industry shows which part of its output goes to which industry. The column of each industry shows the inputs from all other industries. There is no place to show the equipment that is being used to produce the output; the inputs all consist of circulating capital, that is, the output of the industrial equipment (see Leontief, Wassily. 1986. *Input-Output Economics*. 2nd ed. Oxford: Oxford University Press).

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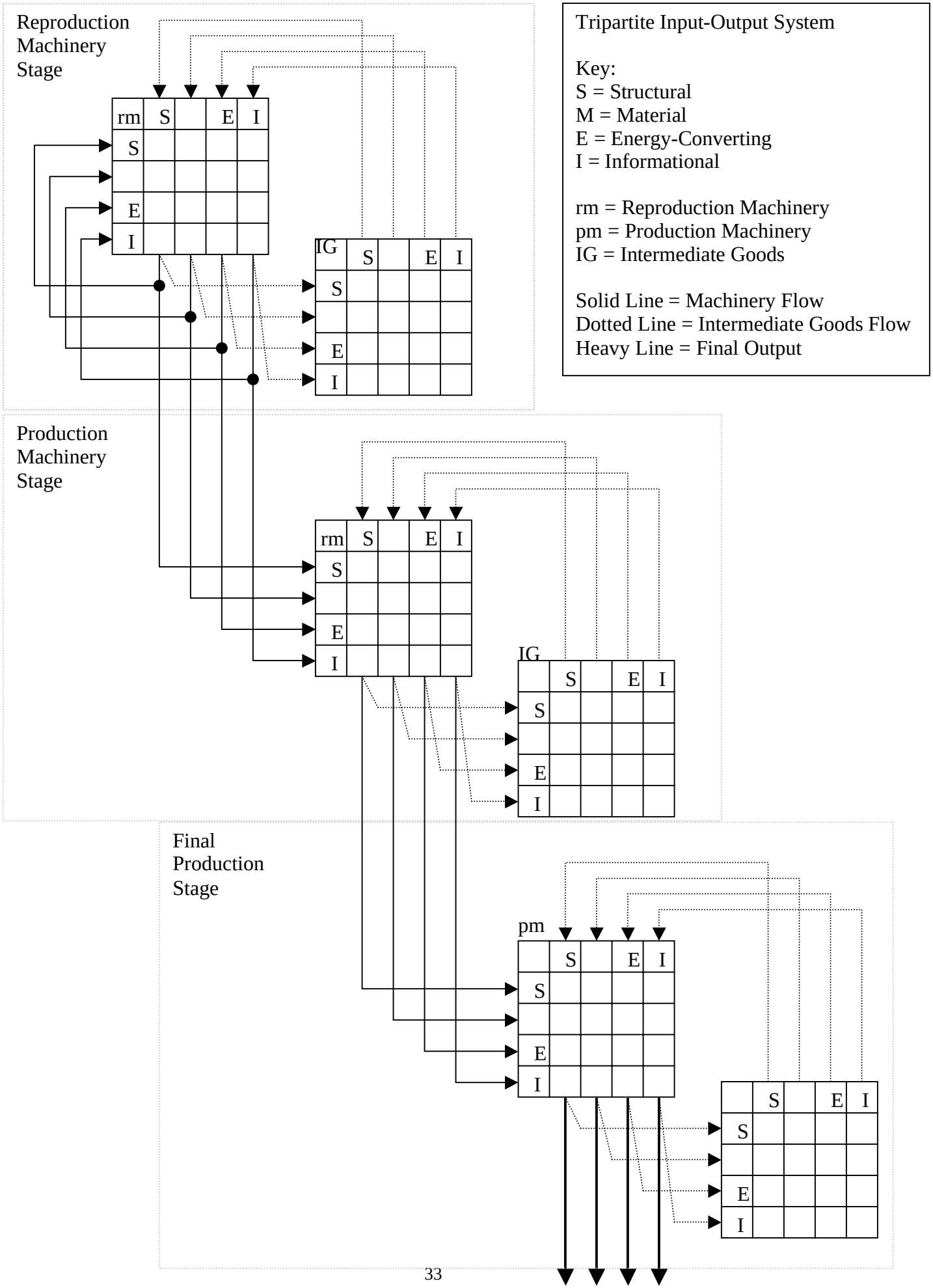
My diagram contains two input-output matrices for each stage of production (reproduction machinery, production machinery, and final production). Each matrix has rows and columns for the categories of production within the particular stage, not an industry as defined by the government; that is, structural, material, energy-converting, or informational categories. The matrix on the lower right of each pair represents the standard input-output matrix, as takes place within that stage of production. The arrows coming in to the left side of an intermediate goods matrix is the input for that production niche's production category. The arrows coming from the top of each column indicates the output of each production niche category.

The matrix on the upper left, however, represents the machinery used in each stage. The arrows pointing toward the left hand side of the machinery matrix represents new machinery for that kind of production niche category. The arrows pointing into the top of each machinery matrix represent the input of intermediate goods, from the intermediate goods matrix. Finally, the output of each machinery matrix is the combination of the use of intermediate goods and machinery.

Note that the source of machinery for the reproduction machinery stage is the output of the reproduction machinery stage machinery matrix. The output of each machinery stage points from the bottom of the matrix. The output of the reproduction machinery stage also points to the production machinery stage. The output of the production machinery stage machinery matrix is the input for the final production machinery matrix; that is, the production machinery stage creates the machinery used in the factories and offices making final goods and services. The output of the final production machinery matrix is the output of the production system as used by consumers plus physical structures such as buildings.

This system can be modeled using computer simulation, where each cell in the machinery matrices would be composed of both the equipment assets for the corresponding niche category and the intermediate goods input into the cell; and the cells in the intermediate goods matrices would operate as does the classic input-output system. In addition, different countries' models could be linked together to form a three-dimensional, spherical model. The computer simulation would be similar to that used for ecological or other biological types of modeling. The data can be taken from the U.S. Department of Commerce's Bureau of Economic Analysis, in particular, their surveys of fixed reproducible assets, gross domestic product by industry, and input-output studies.


Reproduction Machinery Stage
rm S E I
S
E
I
IG S E I
S
E
I
Tripartite Input-Output System
Key:
S = Structural
M = Material
E = Energy-Converting
I = Informational
rm = Reproduction Machinery
pm = Production Machinery
IG = Intermediate Goods
Solid Line = Machinery Flow
Dotted Line = Intermediate Goods Flow
Heavy Line = Final Output
Production Machinery Stage
rm S E I
S
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I
Final Production Stage
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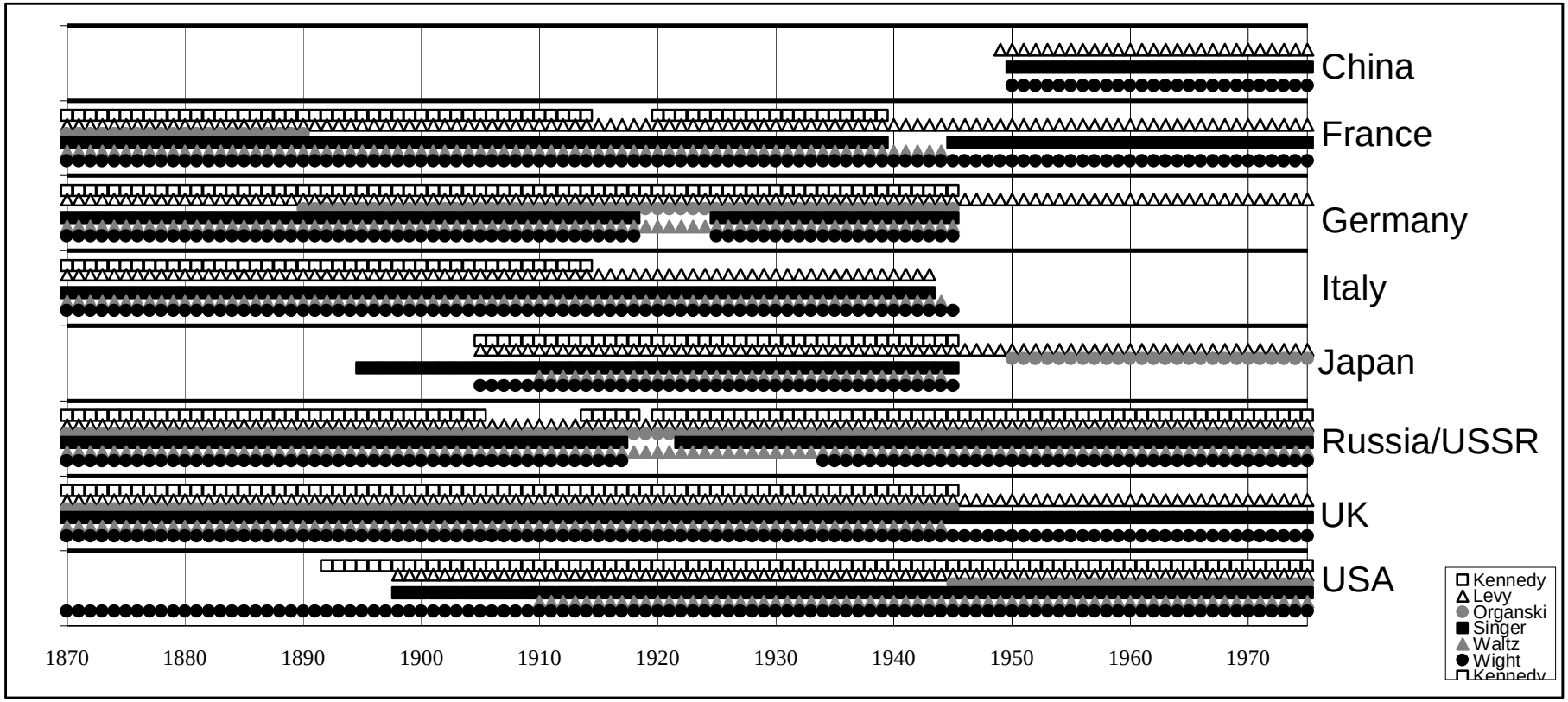

Appendix 3. Scholars' estimates of when various countries were Great Powers. The following were the main sources:

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Levy, Jack. 1983. *War in the Modern Great Power System 1495-1975*. Lexington: University of Kentucky Press.
Organski, A.F.K. and Jacek Kugler. 1980. *The War Ledger*. Chicago: University of Chicago Press.
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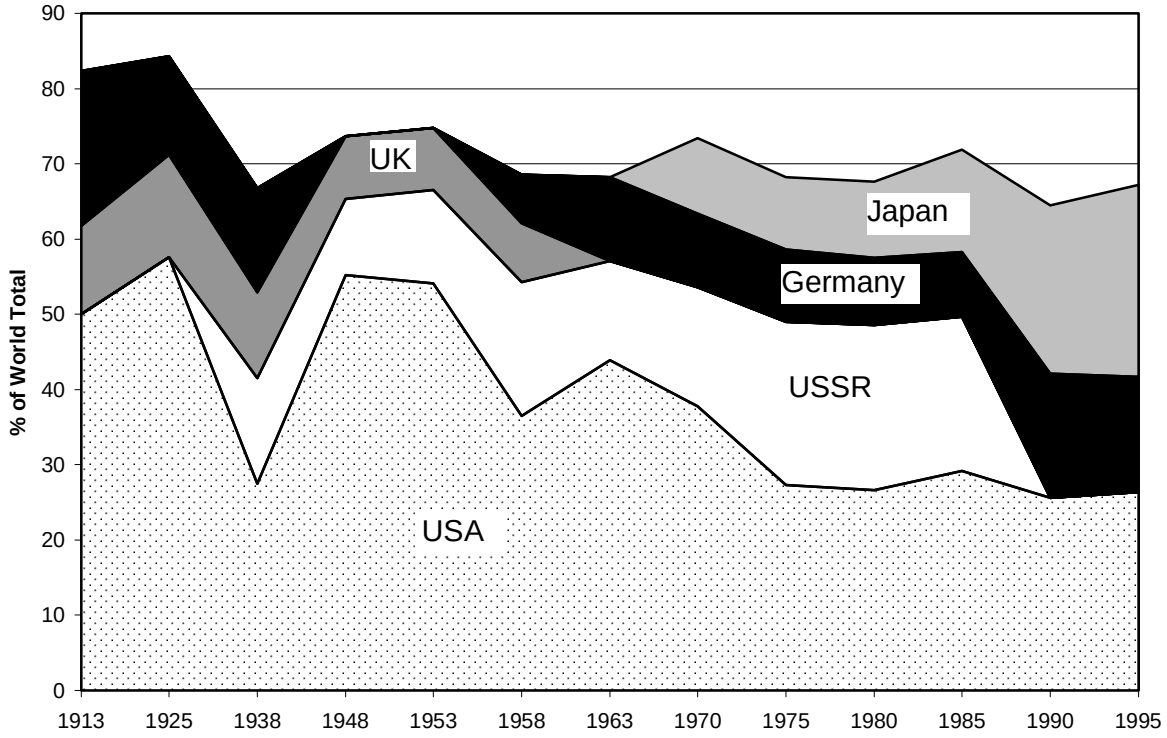
The analysis and methodology used to obtain the values for this chart can be found in Chapter 1, "What is a Great Power?", in my dissertation (Rynn, Jonathan. 2001. "The Power to Create Wealth: A systems-based theory of the rise and decline of the Great Powers in the 20th Century", Department of Political Science, City University of New York)

Appendix 4.The production machinery capability of the Great Powers from 1913-95

The chart shown at the bottom of the page is based on the table of data shown below, all percentages. The data for the table was obtained from the list of sources on the following page. The detailed analysis of the data sources and methodology used to construct the percentages are available in the Statistical Appendix of my dissertation (Rynn, Jonathan. 2001. "The Power to Create Wealth: A systems-based theory of the rise and decline of the Great Powers in the 20th Century", Department of Political Science, City University of New York

Year/Country Production Machinery % World Total	USA	Germany	UK	USSR	Japan
1913	50	20.6	11.8	3.5	0.3
1925	57.6	13.1	13.6	1.8	1
1938	27.5	13.9	11.4	14	1
1948	55.2	3.8	8.4	10.1	0.8
1953	54.1	4.7	8.3	12.4	1
1958	36.5	6.5	7.8	17.8	1
1963	43.9	11.1	6.1	13.2	4.9
1970	37.8	9.8	6	15.8	10
1975	28.8	9.9	5.1	12.1	9.8
1980	26.6	8.9	5.4	22	10.1
1985	29.2	8.6	3.8	20.5	13.6
1990	25.6	16.5	5.3	3.9	22.4
1995	26.4	15.3	4.3	0.5	25.5



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