RETHINKING THE CONCEPTUAL FOUNDATIONS OF NATURAL RESOURCE ECONOMICS

The Complex Taxonomy of the Factors

Natural Resources, Human Action, and Capital Goods

By FRED E. FOLDVARY*

ABSTRACT. Contemporary neoclassical economics has reduced factor analysis to two homogenous inputs, K and L. This excessive simplification has led to a deficient understanding of economic reality and a misunderstanding of concepts such as the producer surplus. This paper presents a taxonomy of the factors, including the complexity of natural resources. A better understanding of the role that factors play will enhance an understanding of economic reality and policy.

The classical categories of factors—land, labor, and capital goods—were recognized by Adam Smith and Jean-Baptiste Say and were a central element of classical economic thought. The neoclassical turn of the late 1800s melded land and capital goods into a homogenous variable, K. Textbooks still typically give *pro forma* recognition to the three factors but then proceed to ignore land in their applied topics, such as economic development, taxation, and macroeconomic policy. The near absence of land in mainstream economic analysis has been amply described (Foldvary 2005), but what has apparently also been lacking is an analysis of the complex taxonomy of the factors of production and its implication for policy.

*The author is a lecturer in economics at Santa Clara University. His book include *The Soul of Liberty, Public Goods and Private Communities*, and *Beyond, Neoclassical Economics*. Foldvary's research areas include real estate economics, social ethics and public finance.

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The foundation for the taxonomy of the factors is the distinction between "nature" and nonnature. The relevant contrast to nature is what human beings produce, and therefore also the human action that produced the goods. The apt economic meaning of *nature* is therefore "everything that is prior to and apart from human action."

Human action was analyzed by Ludwig von Mises (1949) as purposeful behavior, persons acting to achieve ends. The definition above excludes as "nonnatural" any act that is consciously, deliberately, purposefully committed by a person. Nothing that human action does is "natural." The concept of an act as "unnatural" is thus meaningless for economics; phenomena are either natural or nonnatural.

Land in economics synonymously means "natural resources." Land can be divided into three categories: (1) space, (2) nonliving matter, and (3) biological natural resources.

Spatial land (land #1) in turn consists of (a) territorial space: the surface spatial soft-shell envelope at the earth's surface in which life is located, including the space holding the waters; (b) spectral space, in other words, frequencies of the electromagnetic spectrum; and (c) routes for satellites and other spacecraft.

Material natural resources (land #2) can be categorized according to the states of matter: (a) solid substances such as minerals and coal, oil in solid substances such as shale and tar sands, and ice; (b) liquid substances such as water and oil; (c) gaseous substances such as air and natural gas, as well as properties of gas such as the capacity to carry soundwaves; and (d) other states of matter such as plasma. The last category (d) exists, but has little economic significance.

Biological natural resources (land #3) include (a) living beings; (b) the genetic base of life; and (c) the ecological relationships among living beings, including the habitat.

I

Territorial Space

EACH OF THE THREE DIVISIONS of natural resources interacts differently with the other factors. Territorial space (1a) is, for practical purposes, a fixed resource. The earth does gain in volume and mass as meteors strike it, but the annual expansion is so tiny that it is irrelevant for economic analysis. As long as the earth exists, territorial space is, for

economics, absolutely fixed in supply, as it can neither be created, destroyed, nor altered. Territorial space always remains land regardless of the matter or activity within some boundary.

Territorial space is the most important natural resource for human activity, as all activity must have a location, and productive locations are scarce. Although the fixed supply of this natural resource is often recognized in the economic literature, sometimes it becomes confused with capital goods, and land is claimed to be not really completely inelastic in supply. To understand the fixity of land, we must first clarify the other factors.

Human capital consists of the talents and capacities that human beings possess genetically and of an increase in a worker's productivity due to education, discovery, and innovation. When conceived, a human being is natural, but as the being develops during gestation and after birth, the outcome is also a product of human action, the ingestion of nutrients by the mother, the upbringing by the parents and guardians, and influences from peers and society, so that after conception, a human being is no longer a natural being and thus labor is not a natural resource.

Economic goods, synonymous with economic wealth, are resources, products, and services, excluding human capital, with a market value. A good has a market value if at least one arm's-length buyer will typically voluntarily purchase or trade the item.

Capital goods are goods that have been produced but not yet consumed. Following William Hutt (1974), economic consumption is the using up of economic value, i.e., reducing its market value. Consumer goods, loosely, are goods that typically become consumed within a short time after having been produced. Again following Hutt, production is the creation of economic value. Capital goods can be intangible, such as knowledge or reputation capital.

Capital goods are often defined as "the produced means of production" or "wealth devoted to procuring more wealth" (George [1879] 1975). Inventories are the "tools" and "means" used by retailers to provide services to customers, but the concept becomes murkier when households own the goods. An owner-occupied house is commonly recognized as a capital good providing housing services, just as it does to a tenant who rents from a landlord. But, likewise, an owner-occupant's car is a capital good, as is a can of corn on a shelf

in a pantry. Household inventory is just as much a capital good as is inventory in a store that sells to customers.

Ancient capital goods could be considered as land for purposes of taxation, as the producers are long gone and the taxation of the long-ago clearing, leveling, and draining of the natural materials need not apply to recently produced goods. Land could also be treated as a residual for anything that is not capital goods and not labor; for example, garbage, having no positive market value, becomes land.

But the definition of capital goods as produced but not yet consumed does not imply that the goods are economic goods or wealth. The goods can have a zero market value, or a negative value, and may be items that people would pay to be rid of. Trash is therefore a capital good with negative value. Capital goods never revert to land. Fertilized soil is not a natural resource, not land. The capital goods that fertilize land, rather than becoming land, on the contrary, convert the land into a capital good.

With these meanings in mind, we can see that claims that territorial space is not fixed are false. Those who assert that land can be increased by clearing, draining, filling, and leveling have in mind a definition of "land" as the usable solid surface of the earth, rather than a natural resource. "Landfill" is a capital good, as is any improvement to a site. Indeed, as a natural resource, land cannot be improved. Thus, the supply of territorial space is not affected by any improvement that makes the space more useful for economic activity.

Another fallacy is the belief that territorial space is not purely natural because its price depends on the demand due to population, commerce, and civic works. But what is natural is the supply, the physicality of the three-dimensional space. Demand is necessarily that of human beings, and cannot be natural.

The characteristics of spectral space (1b above) are similar to those of territorial space. The frequencies of the electromagnetic spectrum and their properties, such as light, thermal radiation, and capacity to carry transmissions, are fixed in nature and cannot be altered by human action. Labor can provide only the texts that are carried by the spectrum. It has been claimed that the scarcity and thus the

supply of the spectrum depends on technology, but this applies to territorial space as well. The concept of "supply" thus requires clarification.

The term *supply* has two meanings, which are usually not distinguished in economic analysis. Consider the shares of stock for a corporation. If no new shares are being issued, the supply-1 of shares means the total number of shares held. Supply-1 is fixed. Supply-2 consists of the number of shares offered for sale in the financial market. That supply behaves like the supply of produced goods, as, holding expectations and all else constant, more shares will be offered for sale at a higher price.

Likewise, the supply-1 of land means the quantity (measured, for example, as cubic meters or square meters) within some boundary. That supply is fixed. Supply-2 consists of plots of land offered for sale in the real estate market. Supply-2 of land is of course not fixed, and this supply curve can slope up, as with the supply-2 of shares of stock. Also, the supply of land for a particular use is supply-2, where offers to sell land increase with price.

Technology thus affects supply-2, not supply-1. Land-saving technology reduces the land needed for a particular use, such as farming, but does not affect supply-1. Likewise, technology that reduces the amount of frequency bandwidth needed for some use affects supply-2 only.

For goods currently being produced, the total supply-1 of inventory is typically offered for sale in the market, so in that case, supply-1 equals supply-2. This is the supply curve that is typically presented in textbooks and in economic analysis, where the distinction does not matter.

Spatial routes are not all fixed in supply-1. Airline routes can depend on the locations and size of airports, as well as the air-travel technology. These routes are thus produced by the technology of the aircraft and the production of landing places. Airline routes are capital goods. However, satellite orbits (land 1c) are natural, as they must orbit the earth in the limited space surrounding the earth. Some routes, such as geosynchronous orbits, stationary above a location on the surface, are even more limited. These routes are not a product of the locations of satellite signal transmission and reception.

All three types of spatial land are fixed in supply-1, and therefore the tapping of their economic rent for community or public revenue has no deadweight loss (i.e., excess burden). The second consequence of a fixed supply is capitalization. An increase in the demand for spatial land can increase only the value of that land, as it cannot affect the quantity.

But the works that increase value are capital goods, so the increase in the yield of the space is not natural. The return on land is termed "rent" in economics, and "rent" will refer here to only the return on the land factor. The rental of a capital good can be referred to as the "yield" or "rental" of the capital good. When a house is rented to a tenant, only the portion of the rental that pays for the space is rent, the rest being a yield of the capital goods and wages for the labor services of providing the real estate.

Thus, the rental of a site is actually a payment for three factors: rent, the yield of capital goods, and wages. Likewise, the increase in real estate rentals due to public goods such as streets, security, and public transit are yields of those capital goods, not of the natural land. Land rent excludes the rental added by nonnatural factors such as civic goods and security services.

The rent of a television frequency is that which one would pay for a new or abandoned portion of the spectrum. Once the spectrum is in use, its value may rise due to the activity of the enterprise using the spectrum, just as a location in a city might increase in value due to the fame of the firm occupying a site. These increases in value are a return to capital goods.

Given the natural features of a site and the capital goods attached to a site, a greater population can increase the demand to be located there, and thus raise the site values. As noted above, demand does not affect the characteristics of the supply of land, so the greater demand simply due to population is land rent and does not affect the natural characteristic of spatial land.

II

Speculation for Space

THE CHARACTERISTICS OF TERRITORIAL SPACE make speculation outcome different from that of commodities. Speculation is the purchase or short-

sale of an item with the expectation of a favorable shift in supply or demand. Speculators buy futures contracts for wheat, for example, expecting the demand to rise or the supply to shrink. Land speculators expect the demand for land to rise due to new infrastructure or development or growing population or increasing commerce.

Commodity speculation makes the price of commodities in the present rise, which reduces current use, shifting more use to the future and reducing future shortages. But the quantities of land cannot be so shifted. Land rent can rise due to population movements to fringe areas with less productivity, increasing the rent of the more productive areas. Speculation extends and quickens this movement. Speculators tend to be those most optimistic about future prices, so they can push land prices higher than current use warrants. Higher costs for real estate reduce profits, so investment can fall, leading to lower demands for other goods and even to a recession.

If site owners have to finance civic goods and services, this reduces the gains from land speculation and reduces, if not eliminates, the destabilizing effects of spatial speculation.

III

The Nonproducer Surplus

SINCE NEOCLASSICAL ECONOMICS melds land into capital goods, it masks the income from nonlabor resources as returns to homogenous "capital" rather than explicitly separating land's share. Land rent cannot be so easily hidden in microeconomic theory, so it is assigned another name. This creates a contradiction that is seldom confronted in the economics literature.

In the models of perfect competition and monopolistic competition, the long-run equilibrium is zero economic profit. If marginal costs rise with increasing production, supply curves slope up, creating a producer surplus of price minus marginal costs. But the producer surplus is an economic profit. So how can there be no economic profit? The owners of firms do not receive it; therefore, the surplus must flow to the owners of factors. But if the labor market is atomistic, highly competitive with replaceable workers, then wages obtain only normal returns with no surplus. Likewise, competitive producers of capital goods also have zero profits.

The only other factor left is land, and since territorial space cannot expand, land rent can persist as economic profit. The economic cost of land is zero, and thus all land rent is a surplus. The producer surplus is thus site rentals, aside from the minor surplus of monopoly labor and monopoly capital goods. If labor has a common wage and all capital goods of a type are equal in price, then the differing costs of production are generated by differences in the productivity of locations. Site rentals thus absorb these greater productivities, a combination of land rent and the rentals of the capital-goods infrastructure tied to land.

If the civic goods that get capitalized into site values are not paid for by the site owners, the site owners receive a surplus for goods they did not pay for. The title holders of land are in that case nonproducers, and the surplus they receive as rentals should be called the "nonproducer surplus." Instead, neoclassical theory masks the rent of natural resources by calling it a "producer surplus," as though it was going to the producers, the workers, and owners of capital goods.

IV

Material Land

UNLIKE SPATIAL LAND, material natural resources can be altered by human action, and then they are no longer land. Solid natural substances such as minerals and coal (land 2a) are subject to depletion, since these were created in the past and, as far as is known, there is no new creation. Natural ice, however, can expand, as water turns to ice during the winter. These natural materials become capital goods when they are altered by human action.

Extraction alters minerals and coal by transporting them and by isolating them. Human action also is involved in exploration for these materials. But such action does not alter the physical capital good, which remains natural until physically changed in form or location, just as spotting an eagle with a telescope does not transform it into a domestic animal. What is affected by exploration is the yield from the extraction. Part of the yield is rent for the scarcity of the resource; part is a return on labor, including exploration; and part is a return to the capital goods used in the extraction and exploration.

The use of minerals and coal necessarily involves depletion, as they are nonrenewable resources. If there is no government intervention, a free market efficiently allocates the amount of extraction. Speculation in material land is similar to that in produced commodities, and while it can carry prices to a level not warranted by actual rents, it does not have the greater impact of speculation in territorial space, since the particular commodities have a narrower use.

The price of minerals such as copper is global, so the local infrastructure will not affect the local price of copper. Thus, while the public collection of spatial rent is market enhancing in avoiding capitalization subsidies to landowners, it does not hold this economic effect for material land. The collection of the land rent from material land can serve a moral purpose, but not an allocation purpose. Indeed, the taxation of extractions of coal and minerals needs to be carefully crafted to avoid inducing too fast or too slow extractions relative to the nontaxed market rate. There needs to be a combination of ex ante charges for leaseholds, current charges for extraction, and ex post charges based on the estimated economic profit. The firm also should be required to pay the social cost of environmental damage, which would induce it to prevent such damage if the cost of prevention were less than that of pollution.

For liquid material land (2b), namely, water and oil, there is a potential problem of dividing the extraction among separate owners of the pool. There needs to be an organization or agreement among the owners of the pool to avoid turning the resource into a common good that becomes too quickly exhausted.

Material land may be fixed in supply-1 like oil or renewable like water. The current literature on "peak oil" suggests that the supply-1 of oil will in the future decrease as ever more oil is extracted and few new sources are found. But there are also large quantities of oil that can be extracted from shale and tar sands, land 2a, which will substitute for liquid natural oil at higher prices. Uranium, as land 2a, will increasingly substitute for oil as a source for the generation of electricity, including the energy used in producing hydrogen for fuel cells.

The supply of water is to a great extent controlled by governments, which subsidize its provision to agriculture and allow large areas to

become contaminated. The efficient provision of water prices is at the social cost, which includes the provision of sufficient amounts for fish and other wildlife preservation and extraction at sustainable levels, with pollution at the amounts for which the social costs of additional pollution equals the social benefits of additional pollution prevention. Given such conservation, the economically efficient charge for water is the marginal cost of a unit of water, if the fixed costs generate an equal or greater amount of site rentals. If the water infrastructure does not generate site rentals, this indicates that the amounts of the capital goods are excessive.

Water is a negative natural resource when its supply is excessive, causing crop failure and flooding. The economics of natural resources has to account for a resource as a good and as a bad. In a free market, bad waters reduce land values, and the incentives of communities are to protect lives and property with controls to prevent flooding. When these functions are shifted to national governments, the protection becomes vulnerable to national politics, and the moral hazard is created of residents not bearing the cost until there is a catastrophe, such with Hurricane Katrina in New Orleans.

Gaseous substances such as air and natural gas (land 2c) have pool characteristics similar to liquid natural resources. As a nonrenewable resource, natural gas's extraction is similar to that of oil. If natural gas is liquified, it becomes a capital good. Indeed, as soon as oil and gas are extracted, they become capital goods.

If one asks students for an example of a free good, they will often answer "air." But one does not breathe air in the abstract. One uses air in particular places. If the location in which one is breathing is scarce, then so is the air there. So if the site has a rent, the air there is not a free good; one must pay to be located there, or the host must pay.

Clean air is also not free if resources are used to prevent pollution. Advancing technology enables communities to directly charge for air pollution from automobiles with remote sensing devices. The benefit of clean air is subjective as, aside from the costs of illness, there is an aesthetic benefit to clean air, as well as the benefit to wildlife. Demand revelation could be used to measure the subjective benefits, as each person reveals his or her value and has to pay the social cost of changing the outcome. But atmospheric pollution can have an

immense global social cost if it causes the warming of the earth, so the avoidance of pollution is not just a matter of local choice.

It has been claimed that the cost of avoiding air pollution is so high that it would stifle economic development and even crush current industry. This argument ignores the current excess burden of taxation. If current taxes were shifted away from income and sales and value added and toward site values and pollution charges, the added cost from pollution charges would be offset by reducing the cost imposed by current taxes on production. This shift would involve transition costs but no long-term costs on industry.

Air is a negative resource when it has a high velocity, as with hurricanes. As with flooding, when governments provide aid after a disaster, the short-run benefit has the long-run cost of a moral hazard, as the cost of residing in the location is borne by others, inducing excessive locating in the areas prone to disaster.

V

Living Beings

THE SUPPLY OF WILDLIFE (land 3a) can grow or be depleted depending on the habitat and the weather. As a renewable resource highly valued by many people today and surely in the future, the morally justified use is only of the annual yield, leaving the principal intact. The rent from fishing is similar to that of oil extraction, except that governance can limit the extraction to the yield based on the current wildlife population, with consideration to the age and sex of the animals.

Some animals, such as elephants, live in government-owned lands such as national parks where hunting is prohibited, while others of the same species are private property or the communal property of villages. Poaching is common for state-held elephants, while private and local communal owners have an incentive to protect their elephants and thus profit from foreign tourism and hunting. The population of elephants and other wildlife in private or communal reserves has been growing while that in government parks has been reduced.

Harmful wildlife—viruses, bacteria, protozoa, rats, mice, and mosquitos—has always been a plague on humanity and can now spread diseases quickly as human beings travel the globe. Currently,

the bird flu virus is being spread by migrating birds such as ducks to poultry and then to other animals and human beings around the world. Prevention is less costly than curing the plagues after they hit, but the problem is the uncertainty of the future damage and the psychological tendency to weigh visible problems more than hypothetical ones.

The genetic base of life (land 3b) consists of the variety of organisms and their current and potential contributions to human welfare. Many drugs originated in wild plants, and there are potential scientific and health benefits in preserving the genetic heritage. This is complementary to conserving the wildlife (3a).

Ecology means the relationships among the interdependent species of wildlife, creating an overall structure of complementarities. Prey needs predators to keep their numbers in check and to prevent overgrazing the vegetation. The entire habitat requires preservation in order to maintain the viability of each particular species (3a).

VI

Human Action in the Production of Wealth

THE LABOR FACTOR can be regarded as human exertion in the production of wealth, although "exertion" implies applying oneself energetically, whereas a wage could conceivably be earned just sitting there looking pretty. (Sitting still is a choice, and thus also a human action.) The more general definition of labor is "human action that produces economic wealth."

The reason that labor is a separate factor is the moral and biological autonomy of human beings. If there is no slavery, the worker has not just consumer sovereignty but also production sovereignty. It is his or her choice to engage either in labor or in leisure, each being the opportunity cost of the other. A worker buys leisure by foregoing extra wages and the consumer goods it buys. In contrast, a capital good is directed by its owner. If slavery were accepted, then a human slave would function economically like a horse, a capital good. With no slavery, unlike capital goods and land, labor has no purchase price but only a rental if employed by others, and an implicit rental as well as economic profit if self-employed.

Just as a natural resource can be positive or negative for human welfare, an employee can reduce economic value by being wasteful and destructive, but in that case, this was not what he or she was hired to do. Thus labor implies an ex ante anticipation of a positive marginal product. When a worker destroys property, this is not *economic* labor. Labor is therefore always ex ante productive. A thief, for example, exerts effort in stealing, but this is not economic labor. The employee who steals is a thief, not a laborer. There are negative natural resources and negative capital goods, but not negative labor. The deliberately destructive worker ceases to engage in labor.

Some production functions split labor into the quantity of labor and the amount of human capital. Investment is then on human capital, rather than the quantity of labor. But in actuality, even "unskilled" work involves human capital, so in application, labor cannot be separated from human capital.

The wage of an ordinary worker is generally that of the worker's marginal product, but with variances due to personal relationships, arbitrary discrimination, union rules, and government law. Unions with the power to strike tend to raise union wages but depress nonunion wages, as the higher union wages reduces labor in the union sector, shifting the supply to the nonunion sector.

The responsiveness of labor supply to a change in the after-tax wage has to account for many margins: working extra hours, taking a second job, whether a spouse is employed, when to retire, and how much to invest in human capital. The elasticity of labor should be applied to the most elastic margin, just as the marginal utility of water is for its least important use.

Entrepreneurs also engage in labor, but they do not earn a marginal product. Their wage is rather a residual of revenue minus all costs, the entrepreneurial profit. This is a second residual, after the locational residual of land rent.

VII

Capital Goods

AS NOTED ABOVE, neoclassical theory homogenizes capital goods into the factor K. The deficiency is not just the melding of natural

resources into capital goods, but also that even the homogenous treatment of capital goods alone leaves out important aspects of that factor.

Austrian School economists have recognized that capital goods have a structure based on two elements: stages and time. Production proceeds in stages. To make bread, production has to first raise the grain, then make the flour, and then bake the bread and sell it. The time involved in the stages for a product is the "period of production."

The time element also consists of the rate of growth of the value of the capital goods. This can be illustrated with planted trees. Some planted trees take many years to mature, while others, such as small Christmas trees, turn over quickly. Inventory in a retail store has a very small period of production; it is also referred to as circulating capital, as opposed to the long-lasting fixed capital.

A low rate of interest induces investment in slower-growing capital goods with a long period of production. A high rate of interest induces less higher-order investments and more in circulating capital, which is not as affected by the interest rate (Hayek 1931).

If the funds for investment come from savings, then the interest rate serves to allocate goods between investment and consumption, since savings equals investment. But when money is artificially injected into the banking system by a monetary authority, it acts like greater savings, reducing interest rates and inducing investment in slower-growing long-lived capital goods. But intended consumption has not been reduced, resulting in price inflation. Prices then rise, including land prices, which accelerate with speculation. Interest rises again as the monetary authority reduces the growth of the money supply. Rising costs reduce investments, which reduce demands for other goods, resulting in an economic downturn.

The land factor is thus linked to the capital goods factor and the financial markets in creating the boom-bust cycle (Foldvary 1997). Central banking has an inherent knowledge problem, as the future is too uncertain to be able to provide the optimal growth of the money supply. An alternative is free market banking, or "free banking," where the monetary base is a commodity (which today could be a frozen supply of government money), with future expan-

sion with private bank notes convertible into the base money (Selgin 1988).

Various capital goods can be substitutes and complements. Complementary capital goods, like software and hardware, enhance their mutual productivity. Network externalities can increase the productivity of the individual items as more are used, as with fax machines. Thus, contrary to models of growth such as that of Robert Solow, where an increase in K with constant L has a diminishing marginal productivity of K, complementarities can make an increase in capital goods exhibit increasing returns.

Advancing technology is embedded in both human capital and in capital goods. The power to make the same inputs more productive comes from a better harnessing of the power of nature, using a better knowledge of the laws of physics, chemistry, and biology to produce more, so at bottom, nature is the foundation of technological advancement.

VIII

Conclusion

THE FACTORS OF PRODUCTION are much more complex than the simple two-factor neoclassical models suggest, or even the classical three factors. Land, for example, comes in multiple forms, each with its own characteristics. There is also a complex ecology of factor interaction. The inclusion of all the factors of production in their full complexity provides for a more complete understanding of economic reality, with important policy implications.

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