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Changing concepts of ‘land’ in economic theory: From single to multi-disciplinary approaches

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Abstract

The role of land in economic theory is surveyed, both from a conceptual and historical perspective. Land has been incorporated in economic theories in various ways. Originally, land used by agriculture was the main motivation for an economic treatment of land. This was gradually extended with various other land use categories. Neoclassical economic theory gave less attention to land use, generally regarding land as a production factor of relatively little importance. Nevertheless, specialized sub-fields within economics such as regional and urban economics met the demand for explicit spatial analysis including land use considerations. Attention for environmental and resource problems has stimulated new perspectives on, and conceptualizations of, land in economic analysis. This involves the interaction with other disciplines as well as the use of spatially disaggregated methods of analysis. Awareness of the richness of ideas on land in economic theory can contribute to enhanced environmental research.

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1. Introduction

The concept of land encompasses a variety of functions that typically get classified into the categories of the environment, economics, society, and spirituality. In terms of the environment land is viewed as soil, as a sink for pollution, as a filter for drinking water, and as habitat for wildlife. It provides a link between hydrological, atmospheric, and climatic systems. In terms of economics, land can be viewed as scarce space for locating economic production activities, infrastructure and dwellings, as productive soil that provides organic and inorganic materials for agriculture, as a store of assets and resources, and as a source of aesthetic value and amenity services. On a social level the ownership of land acts as a source of prestige and an organizing principle for socio-economic relationships. For some cultures, land is a deity that exercises control over its people. (Ely and Wehrwein, 1948; Renne, 1947; Barlowe, 1986; Randall and Castle, 1985; FAO, 1995).

Virtually all resource allocation takes place on land. Misallocation of land inevitably entails misallocation of numerous valuable functions. The above list also illustrates how land in many ways is artificially separated into categories by the necessities of specialization within a modern scientific discipline: however, these categories are part of the same reality and are interwoven with each other.

At the outset, *land* in economics covered the physical universe outside of humans. As one of the three traditional primary inputs (land, labor, and capital), land was used as an inclusive term for the natural environment, covering entities such as oceans, atmosphere or solar energy. Everything that owes its usefulness to human inputs was classified under cap-

ital, and those things that owe nothing to it were classified as land. The reason that it was called land had to do with the major concerns of predominantly agricultural societies (Daly and Cobb, 1989, p. 97). However, the subsequent history of the concept of land in economics shows an increasingly narrow perception of the contribution of the natural world to human well-being. By the early 20th century interest in land was restricted to only those attributes that gave immediate economic value. With the environmental crises and increased environmental awareness in the late 20th century, various aspects of land, such as support of biodiversity or sources of non-renewable resources, have found their way back into economic discourse.

The role of land, its conceptualization, and its measurement in economic theory has changed considerably over time. Surprisingly, little research has been conducted on how land has been conceptualized in the history of economic thought. The following survey is limited to those economic theorists and theories that have triggered a change in the perception or conceptualization of land. Where necessary, references are made to general developments in economic thought. What will emerge is a view of how concepts of the ‘old economists’ reappear in today’s discourse.

The organization of this paper is as follows. Section 2 discusses the role of land in pre-classical economics. Section 3 surveys the classical school of economics. Section 4 examines neoclassical economics. Section 5 considers specialized subdisciplines, including agricultural and land economics (5.1), resource, environmental and ecological economics (5.2), and spatial (regional, urban, and transport) economics and modeling (5.3). Section 6 presents some final thoughts.

2. Pre-classical economics

In ancient and medieval economies, agriculture and other extractive industries played a dominant role in the analyses of and writings on the economy (Haney, 1964, p. 136). This changed somewhat with the rise of the commercial sector and the philosophy of *Mercantilism*. Mercantilism, the economic counterpart of political absolutism, led economic philosophy and practice in Europe from the 16th to the 18th century. It promoted governmental regulation of a nation's economy for the purpose of augmenting state power at the expense of rival national powers. According to Mercantilism, wealth was mainly based on a large population that provided a large labor supply and on the extraction of precious metals, such as gold and silver. If a nation did not possess mines or have access to them, precious metals were obtained by trade. Land was an important source of wealth, as it allowed feeding a growing population and served as a source of precious materials. In addition, it functioned as the pivotal element in the feudal order, being the stable basis of the military, judicial, administrative, and political systems. Polanyi explains this as follows: "Mercantilism, with its entire tendency towards commercialization, never attacked the safeguards, which protected the two basic elements of production, land and labor, from becoming the objects of commerce" (Polanyi, 1957, p. 69).

The Physiocrats reacted to the Mercantilists' narrow interpretation of wealth as only precious metals as well as to their support of protectionist policies. The Physiocrats' model, the *Tableau Economique*, visualizes the stationary economic process as a circular flow model. The key variable was agriculture, due to its unique ability to yield a net product ("produit net"), which is a disposable surplus over costs (Meek, 1962, p. 19). The net product introduced the idea of a surplus due to the bounty of nature (Haney, 1964, p. 182). Manufacturing and commerce, on the other hand, were considered unproductive. According to the Physiocrats, the level of agricultural output and the net product determined the general level of economic activity. An increase in the net product allowed the landowner to make investments in improving her land. The final result of this process was the attainment of the maximum level of output consistent with the country's resources and existing techniques

(Meek, 1962, p. 21). For the Physiocrats, economic surplus was attributable to land, and population growth could therefore not increase wealth, which was in contradiction to the popular Mercantilist view of people being a part of the national asset base. Physiocrats such as François Quesnay argued that human multiplication could not be encouraged beyond some point without leading to widespread poverty.

Influential for both the Physiocrats and later the Classical Economists was Cantillon's *Equation de la Terre & du Travail*. Cantillon regarded land as the only truly original or primary input. The intrinsic values of commodities were reducible to the quantity of land directly and indirectly required for their production (Aspromourgos, 1996, p. 95). In particular, he proposed that the value of labor could be measured by the quantity of food required to reproduce a worker; an idea based on the writings of Sir William Petty. Whereas for Cantillon land was the source of all value, Petty variously proposed the possibility of reducing land to labor, labor to land or both to some other denomination (Daly and Cobb, 1989, 109). Schumpeter (1981, p. 214) summarized these attempts of finding a common denominator in the following way:

...this procedure might give us the economic philosopher's stone — the unit of measurement by which to reduce the available quantities of the two 'original factors', land and labor, to a homogeneous quantity of 'productive power' that could be expressed by one figure, ... As it is, this interesting venture, like all similar ones, proved to be a blind alley.

The Physiocrats' perception of land as irreproducible reflected their thinking in physical rather than economic terms. As expressed by Quesnay, the products the artisan needs to buy are in existence before the artisan buys them but she by no means generates them. Agriculture, on the other hand, is a new production or generation because it brings these items into physical existence (Meek, 1962, p. 215, Christensen, 1994, p. 271). This view of the special role of land is very nicely explained by what Kenneth Boulding (1992, p. 320) referred to as a 'food chain theory':

The farmer produces ... more corn than the farmer and his family alone can eat. This results in a surplus. If this is fed to cattle it produces meat and milk, which

improve human nutrition and perhaps enable the farmer to produce more food. . . . Food and leather ‘fed’ to miners produce iron ore. Food and iron ore ‘fed’ to a smelter produce iron. Food and iron ‘fed’ to a blacksmith produce tools or, ‘fed’ to a machinist, machines. The tools and machines ‘fed’ back to the farmer produce more food.

The characteristic agricultural bias of the Physiocrats is reflected not only in their theoretical treatment of land but also in the stationary view of the economy. An economy’s maximum level of output is consistent with the amount of arable land available and a given state of technology (Gilibert, 1987). These positions were eventually abandoned by many writers within the tradition of classical economics.

3. Classical school

Classical economics started at the beginnings of the Industrial Revolution. This was the time of the rise of the industrialist class, and the decline of the importance of landlords. The main research agenda of classical economists was to derive the factors for the wealth of nations and the distribution of income amongst the factors of production: land, labor, and capital. The importance of technological progress and capital for productivity and thus economic growth was recognized, but many classical authors retained from the Physiocrats their special treatment of land.

Many of the fundamental concepts and principles of classical economics were set forth in Smith’s *An Inquiry into the Nature and Causes of the Wealth of Nations* (1776). When Adam Smith wrote his treatise, only a small number of water-driven industrial establishments existed and the Industrial Revolution had barely started. This helps to explain his conviction that agriculture, and not manufacturing was the principal source of wealth (Blaug, 1997; Thomas, 1993). Smith considered the produce of the land as the principal source of the revenue and wealth of every country (Smith (1776), 1909, p. 627). For Smith agriculture was more productive than manufacturing because it has “two powers” concurring in its production, land and labor, whereas manufacturing has only one (labor). Division of labor was the main element of productivity increase.

Adam Smith’s implicit assumption concerning the returns of land (as well as for factors used in manufacturing) was that of *increasing returns*, despite the fact that two cases of decreasing returns had been fully described by Sir James Steuart (1767), *Inquiry into the Principles of Political Economy*, and Jacques Turgot (1793), *Reflections on the Formation and Distribution of Wealth*. Steuart presented what was later called the Extensive Margin: as population increases lead to uses of poorer and poorer soils, productive efforts produce smaller and smaller returns. Turgot discovered the other case of decreasing returns: the case of the Intensive Margin. This principle states that as equal amounts of capital or labor are successively applied to a given piece of land, the quantities of product resulting from each application will first increase up to a certain point, then decrease, and finally converge towards zero (Schumpeter, 1981, p. 258).

In Adam Smith’s theory of value, under competition, a costless item can never have a price. The services of land are costless in comparison to the capital invested in the land. The price paid for the use of land is, according to Smith, a monopoly rent. Smith’s theory of rent anticipated later approaches to rent, which varied with different levels of fertility, its location, and the transport system (Smith, 1909, book I, chapter XI). In the late 18th century, two concepts of rent were developed that influenced economic theory up to the end of the 19th century: Adam Smith’s monopoly rent and James Anderson’s scarcity rent. Anderson stated clearly in his article, published in 1777, *An Inquiry into the Nature of the Corn Laws, with a View to the Corn Bill Proposed for Scotland*, a concept of rent that was adopted by Ricardo and Ricardian economists:

The farmer, however, who cultivates the rich spots, will be able to sell his corn at the same rate with those who occupy poorer fields; he will consequently, receive more than the intrinsic value of the corn he raises. . . . It is this premium which we now call rent; a medium by which the expense of cultivating soils of different degrees of fertility is reduced to a perfect equality (Anderson quoted by Barlowe, 1986, p. 138).

According to this perception, which later became mainly associated with Ricardo, diversity of land is responsible for rent. In other words, if all parcels of

land were of the same quality no rent would be paid. Moreover, rent was essentially seen as a branch of income that went to a particular social class.

Even though Ricardo for his time was relatively well informed about ‘biophysical processes’ with regards to productivity of land, his theory of land and rent was based on a number of simplifying assumptions. He avidly followed chemistry and geology early on before he discovered Adam Smith.¹ In Ricardo’s theory, there are two reasons for rent: unequal fertility and scarcity of land. Ricardo assumed a giant farm producing wheat by applying homogeneous labor to a fixed supply of land subject to diminishing returns. To him, land was an inexhaustible and non-reproducible agent, unalterably fixed in supply, completely specialized in the production of one crop, and homogeneous in quality, except for differences in fertility and location (Blaug, 1997, p. 80).² These differences in fertility were the inspiration for his concept of the *differential rent*: “If all land were equally fertile there would be no rent. Rent is not the result of the generosity of nature but of her niggardliness” (Ricardo quoted in Haney, 1964, p. 297).

The second reason for rent was the scarcity of land. If land were homogeneous in quality, the limitations of supply would create only *scarcity rents*. The intensive margin would exist even if all land were of equal fertility, as long as land was in scarce supply. In Ricardo’s theory, labor and capital shift from one unit of land to another, but land itself never shifts between alternative uses. Land is supposed to be taken up freely when needed, not from another rent-paying alternative but from non-paying idleness. Resources are shifted between land and industry, never between different uses of land. As land has no alternative uses, rental payments do not affect the supply price of agricultural products: “Corn is not high because a rent is paid, but rent is paid because corn is high” (Ricardo quoted in Blaug, 1964, p. 13).

It is with Ricardo’s systematic development of the labor theory of value that rent is explained entirely in

terms of labor. The exchange values of agricultural products are determined by the capital and labor costs applied to marginal land: thus land could be eliminated from the analysis (Roncaglia, 1986, p. 86).

In contrast, Malthus tried to demonstrate that rent constitutes a genuine addition to wealth and not a mere transfer of purchasing power as Ricardo asserted (Blaug, 1964, p. 80). Starting from the same theory of rent, Malthus and Ricardo arrived at opposite interpretations. One of the points at issue was whether the rent of land owed its existence to its productivity, ‘bounty of nature’, or its scarcity, ‘niggardliness of nature’ (Schumpeter, 1981, p. 536). In any case, both ideas, Malthus’ limits to carrying capacity and Ricardo’s decreasing qualities of successive resources, conflicted with the belief in progress so prevalent during the 19th century (Costanza, 1997, p. 28).

An influential discussion of that time was related to population growth and resource scarcity. The population discussion gained new impetus sparked by Malthus’ influential *Essay on Population* (1798). He devised a theory of population growth³ in which he explained poverty as a race between growth of population and changes in the means of subsistence, thereby focusing attention on the limited supply of land. As the labor force increases, extra food could be produced only by extending cultivation to less fertile soil or by applying capital and labor to land already under cultivation, with diminishing results because of the so-called law of diminishing returns. According to Malthus, the landed class in England feared a similar threat and Malthus provided a ‘natural law’ for inequality and the misery of the masses. Malthus was criticized for his failure to acknowledge, among other things, variations in the quality of land, the specification of a time horizon, the availability of other resources, and improvements in technology and in production processes (Schumpeter, 1981; Walpole et al., 1996).

Another influential and much related political theme was the Corn Laws debate of 1814–1816. The rise of the entrepreneurial class challenged the class of landowners with divergent interests. One of

¹ We thank Paul Christensen for calling this observation to our attention.

² To Georgescu-Roegen, the mechanistic sins of modern economics can be traced to the Ricardian concept of land “which is expressly defined as a factor immune to any qualitative change we could refer to simply as space.” (Georgescu-Roegen, 1971, p. 2).

³ This idea was nurtured by the cases of overpopulation in Ireland, the agricultural and social situation in England, and the rapid population growth in America (Malthus, 1798 quoted in Ely and Wehrwein, 1948, p. 1).

these conflicts emerged around the price of corn. The protection of agriculture inspired a great number of pamphlets. Ricardo's article, *An Essay on the Influence of a Low Price of Corn on the Profits of Stock* as well as Robert Torren's *Essay on the External Corn Trade*, West's *Essay on the Application of Capital to Land*, and Malthus' *Inquiry into the Nature of Rent* were all published around that time (Blaug, 1997, p. 75). All four contributions together shaped the major theme of Ricardian economics, the notion that economic growth must come to a halt due to the scarcity of natural resources (Blaug, 1964, p. 6).

A number of new ideas on land were introduced by John Stuart Mill in his influential book, *Principles of Political Economy* (1848). Mill extended Ricardo's theory by taking into account the competing uses of land for purposes of agriculture, mining, residence, and manufacturing and applying the concept of rent to production in general. He realized that there are always better qualities of land, such as better soil and sites of remarkable beauty, or better modes of production through a patent or better business skills. These lead to extra profits, which in essence are similar to rents. As long as the owner of a new production process is not able to supply the whole market the price will stay at its natural value. Rent can never enter in the production process as a cost factor. It would only do so

...if population continued increasing, both the land and its produce would really rise to a monopoly or scarcity price. But this state of things never can have really existed anywhere, unless possibly in some small island cut off from the rest of the world; nor is there any danger whatever that it should exist (Mill (1848), 1976, p. 472).

Mill mainly emphasized the two primary factors of production: land and labor. After noticing the fact that the economic process of every period also depends on the stock of goods, he added capital as a distinctive factor of production (Schumpeter, 1981, p. 560). For Mill the factors of production were incommensurable:

The part which nature has in any work of man is indefinite and incommensurable... When two conditions are equally necessary for producing the effect at all, it is unmeaning to say that so much of it is produced by one and so much by the other; it is like attempting to decide which half of a pair of scissors

has most to do in the act of cutting; or which of the factors, five and six, contributes most to the production of thirty (Mill (1848), 1976, p. 26).

For Mill land was not merely a factor of production, he also introduced the function of land as a provider of amenity services. He emphasized its importance for the quality of life and the opportunities for experiencing solitude and natural beauty. The necessity of keeping undisturbed land was his argument for a stationary economy:

...with every root of land brought into cultivation, ...every flowery waste or natural pasture ploughed up, all quadrupeds or birds which are not domesticated for man's use exterminated as his rivals for food, every hedgerow or superfluous tree rooted out, and scarcely a place left where a wild shrub or flower could grow without being eradicated as a weed in the name of improved agriculture. If the earth must lose that great portion of its pleasantness which it owes to things that the unlimited increase of wealth and population would extirpate from it, ... I sincerely would hope, for the sake of posterity, that they will be content to be stationary, long before necessity compels them to it (Mill (1848), 1976, p. 750).

Nassau William Senior analytically distinguished three agents of production: labor, natural agents, and abstinence. Natural agents encompassed land – mines, rivers, forests and its wild inhabitants – as well as the ocean, atmosphere, light and heat, and physical laws, such as gravity and electricity. Capital was not a simple productive instrument, but the result of all the three productive agents combined. Land was the most important of the natural agents as its possession carries with it the command of all the others. But his major addition was knowledge. For him, the mere knowledge of the operations of nature creates revenue to its possessor analogous to the rent of land (Senior (1836), 1938).

Karl Marx accepted many of the views of the classical economists. Karl Marx's theory of value was heavily influenced by Ricardo's value theory of labor. For Marx, labor is the only source of exchange value: "Commodities, therefore, in which equal quantities of labour are embodied, or which can be produced in the same time, have equal value" (Marx, 1967, Vol. 1, p. 39). A closer look at his writing

reveals that he was a serious student of agriculture. He realized that production requires both labor and nature. The labor process for Marx was the transformation of natural resources into objects of utility for humans (Perelman, 1979).

Labour is, in the first place, a process in which both man and Nature participate, and in which man of his own accord starts, regulates, and controls the material reactions between himself and Nature. He opposes himself to Nature as one of her own forces, setting in motion arms and legs, head and hands, the natural forces of his own body, in order to appropriate Nature's Productions in a form adapted to his own wants (Marx (1867), 1967, Vol. 1, p. 177, quoted by Gowdy, 1988).

Marx distinguished two ways of viewing a commodity: the *use-value*, as an embodiment of useful attributes and qualities, and the *exchange-value*, as an embodiment of a certain quantity of labor time. Marx's often misinterpreted notion of natural resources as "free gifts of nature" has to be understood as 'free' in terms of its effect on exchange value. Nature in this logic is subsumed within the concept of use-values. As his concern was to explain the inner logic of the capitalist economy, he abstracted from the sphere of use-values, focusing instead on exchange values (Smith and O'Keefe, 1980, p. 34).

Unlike many of his contemporaries, he did not see land as a fixed entity since the fertility of land can be affected by human labor (Marx (1867), 1967, p. 139). He thought that in the capitalist system there is an inherent tendency to decrease the fertility of land. One reason for this is the fact that most land at his time was rented by farmers, who tried to increase their return on investments before expiration of the lease (Marx (1867), 1967, p. 274). The other reasons are the unpredictability of returns from land and the variability of nature, both of which threaten return on capital investments (Marx (1867), 1967, p. 20; Marx and Engels (1846–1895), 1942, p. 270).

Like many other classical writers, Marx kept natural capital and human-made capital separate in his analysis. His starting point is a theory of class, distinguishing between landlords and capitalists, where the first one is parasitic and the latter exploitative. Consequently, their revenues in the form of rent and interest constitute distinct categories (Bryan, 1990, p. 180). For Marx rent is "a product of society and not of the soil" reflect-

ing assertion of power rather than different degrees of fertility. The first element of power was farmers in having to rent their land had to accept the rent as part of their production costs. The second element of power next to the monopoly rent was the power of the farmer over agricultural labor, which is a source of surplus value and potential basis of rent (Perelman, 1979, p. 703). Since the level of rent depends on monopolistic powers rent does not become an efficient allocator of resources (Perelman, 1979, p. 703). Marx's treatment of land was not primarily an ecological one, in the sense of dealing with the availability of resources, but a Ricardian one, that is, concerned with how rent paid to the owners of natural resources would alter the pattern of distribution of income, savings, and investment (Massarrat, 1980 quoted in Martínez-Alier and Schlupmann, 1987, p. 218).

A new dimension to land was presented by Johann Heinrich von Thünen.⁴ Whereas Malthus, Ricardo and others focused on different qualities of land, von Thünen ((1826), 1966) in his book, *The Isolated State*, used distance as the central concept. He was interested in the pattern of agricultural production around the central town in an isolated state, in a homogenous featureless plain of equal fertility. He sought the principles that would determine the prices that farmers receive for their products, the rents that are earned and the patterns of land use that accompany such prices and rent. He developed a system of concentric circles, in which bulky or perishable goods are produced closer to the city and valuable or durable goods are imported from further distance.⁵ In this central town the price of a product like grain is determined by the production and transportation costs from the most distant farms whose produce is required to satisfy the town's demand. Since grain must sell at the same price irrespective of its location of production, ground rent is highest in the first concentric ring and decreases

⁴ Spatial economics and geography claim von Thünen as one of their fathers of their discipline. His concept of diminishing returns is also perceived as a precursor to the marginalist approach of neo-classical economics (Samuelson, 1983).

⁵ Weber applied von Thünen's theory to the optimal location of the manufacturing facility. His theory resulted in materials-oriented or market-oriented types of production dependent on whether factors and products were weight losing or weight gaining in the various stages of the production process (Pearson, 1991, p. 9).

with distance. Von Thünen arrived at similar conclusions as Ricardo in observing that differences in the quality of soil will determine the ground rent in the same manner as its proximity to the central town (Blaug, 1997, p. 597).

For most of the above authors, land occupied a special role in the production process while questions of productivity of land and the distribution of its proceeds received most attention. But the special role of land as a means of production came slowly under pressure from various sides. For Daly and Cobb (1989) the decline of the importance of land had much to do with the political demise of the landlord-class. With the further development of industrialism, capitalists and industrial labor became the dominant classes and the discipline of economics shifted its attention to industry. Important technological developments driving the Industrial Revolution contributed to change the perceived importance of land, notably in the eyes of British economists. The cotton industry, which was one of the dominant features of this development, benefited from land-saving structural change in production in England. This was the shift from wool of good quality, but dependent on land in England, to cotton of poor quality, but abundant in India and America. Therefore, an increase in the production of cotton was easy without causing the problem of land shortage in England. Further, cotton production was itself less land-intensive than the wool industry based on grazing sheep (Kawamiya, 1984, quoted by Mayumi, 1991, p. 43). In addition, technical innovations such as Whitney's cotton gin allowed using cotton as a raw material by drastically reducing the cost of preparing cotton for spinning.

A similar perception of the unimportance of land was developed by contemporary American economists, but for different reasons. The American School tended to deny the classical law of diminishing returns and the Malthusian doctrine of population, since they seemed to contradict the facts in the 'new world': abundance of land⁶, flexible ownership and tenure-

ship, and value related through competition and the market (Haney, 1964, p. 877; Marshall (1920), 1961, p. 171). These facts greatly influenced their perception of the form of the production function. For example, Hamilton suggested that land is inferior to other capital and could be subsumed under capital, arguing that labor is more productive in manufacturing than agriculture (Haney, 1964, p. 316).⁷ Henry Carey, an American theorist emphasizing protectionism, argued against the existence of decreasing returns on the extensive margin. For him, settlers progress from the worst soils, on the mountain tops, occupied for security reasons, to the superior soils of the valleys below. Once these soils are occupied it is a moral responsibility to maintain their fertility through wise agricultural practice, for otherwise they would become depleted. He argued for a localized economy with cooperation between manufacturing and agriculture. Carey was in close exchange of ideas with the interesting but not widely known economist Peshine E. Smith. Smith sought to develop a political economy "... of purely physical laws, and thus to obtain for its conclusions that absolute certainty which belongs to the positive sciences" (Smith (1853), 1974, p. iii). His firm grounding in the work of Justus Liebig and other agricultural chemists of the 1840s combined with the observable depletion of American soils by one-crop farming ('mining the soil'), led Smith to attack Ricardo's notion of the "original and indestructible powers" of soil. For Smith, soil was essentially a converter like all other forms of capital, here transforming chemical matter into crop output. The soil's fertilizing elements could either be withdrawn or augmented. Fertility, therefore, was a product of human-made capital investment. Unlike British economists, who viewed capital as a form of embodied labor, Smith portrayed capital in a way similar to the Physiocrats, namely the unique factor that tapped nature's productive powers (Smith (1853), 1974; Hudson, 1974).

⁶ Liebig showed in his *Naturwissenschaftliche Briefe* (1859, p. 169) that yields were rapidly decreasing from 1840–1850: for example, Connecticut: from 87,000 to 41,000 bushel of wheat, Massachusetts 157,923 to 31,211 bushel. But for him the reason was rather in the lack of agricultural methods: "The general knowledge of agriculture in all parts of the country is so poor that the soils get depleted year by year." (Liebig, 1859, p. 168, own translation).

⁷ Many eminent earlier economists were convinced of the law of diminishing returns to land and an opposite law of increasing returns in manufacturing (West (1815), 1934, § 25; McCulloch, 1825, p. 277; Senior (1836), 1938, p. 82).

Henry George⁸ was one of the major figures of nineteenth-century American economic thought (Solow, 1997). He was considered to be the last classical economist (Dwyer, 1982). For Henry George capital and land were distinct entities. He saw capital as a form of labor, produced by labor to complement labor, whereas land was given and as such restricted in supply (Gaffney, 1987). Due to this constraint useful land was considered to be monopolistic in the sense that future generations or competitors would not have access to these productive resources on the same terms as the owner (Dwyer, 1982, p. 367). Since economic progress would entail a growing scarcity of land, the landowner would reap ever-increasing returns at the expense of the productive factors, capital and labor. The result would be social inequality, depression, and poverty. Since speculation would override the full use of land Henry George proposed to transfer the rent from the landowner to the community. This idea became well-known as the so-called ‘single tax’, an add-valorem tax on land, similar to the Ricardian rent as a return to a non-reproducible natural resource. The rationale behind this tax was that land values are mostly social creations, such as the advantage of a certain location, and can therefore be socially appropriated (Bromley, 1997).

Classical economists laid the foundation for modern economics. The move toward an increasingly homogenous measure of output allowed for a simple aggregation of all output into total product. But in most of their analyses, land retained its special role. As fertile land was considered to be limited in supply, most classical economists believed that agricultural output would be subject to diminishing returns. On the other hand, industrial machines, although lacking independent productivity, could be replicated and could be extended indefinitely, given appropriate

resources. The aggregate production function as conceptualized by this stream of classical economists can be represented in the equation: $Y=f(L, K, N)$, where Y =aggregate output, L =land, K =capital, and N =labor. This ‘classical triad’ developed from the recognition of the three categories of participants in the economic process – landowner, workers, and capitalists – associated with a triad of incomes – rent, wage, and interest. But we have seen in the previous discussions that the triad of production factors was not unanimously accepted.⁹ Approaches limiting the production function to only two factors, as in the case of Senior, or to only one factor, as in the case of Ricardo and Marx, existed throughout.

The unifying approach of classical economists was their analysis of values embodied in the product to determine its price. Even though utility was seen as a precondition for goods to have value, classical economists were led by their orientation towards the long-run, where relative prices were only determined by costs of production. Hence their search for a labor or land content establishing values and prices. A very different orientation was adopted by the new neoclassical school, triggered by Jevons, Marshall, Menger, and Walras, in their search for interdependencies between utilities in consumption and costs in production.

4. Neoclassical economics

Although much can be said about how changing environments influence the content of theories, no simple explanation can be given for the change of perception that led to the ‘neoclassical revolution’. The distinguishing characteristics of neoclassical economics were probably shaped by the longevity of the industrial revolution, the pace of technological devel-

⁸ His book *Progress and Poverty* ((1880) 1971), became an instant success but was heavily disputed if not disregarded by many economists: “Be it as it may, *Progress and Poverty*, a wonderful example of old-style classical economics, was thirty years out of date the day it was published” (Blaug, 1997, p. 88). His book lies on both side of the divide between classical and neoclassical economics written during a period of momentous economic transition (Perelman, 1997). In any case, George’s ideas have enjoyed enthusiastic support up to the present day, and that there are societies, institutes and a journal founded in his name to diffuse his ideas.

⁹ Christensen (1980, p. 544) criticizes the triad as follows: “. . . the neoclassical version involving a simple partial derivative where land area and use are held constant is incorrect. In the case under discussion, land area is held constant but other inputs (sunlight, nutrients, ground water, gases, etc.) are *implicitly* allowed to vary. More output is obtained because more matter and energy are being transformed by the agency of labor and capital employed on the land.” He interprets the classical production function to include an environmental agent E : $Y=f(E, L, K, N)$.

opments, shifts from food and fiber-based economies to mineral and fuel-based economies, and economies in the industrialized world that seemed to be almost independent of extractive industries.

However, the turn of the 20th century was also the time of the beginnings of the conservation movement in the U.S., with its emphasis on efficient use of resources and on sustainable growth (e.g. Hays, 1959; Martínez-Alier and Schlüpmann, 1987, p. 163). The reasons for this new emphasis lay in a dramatic increase of the U.S. population and its related effects in the second half of the 19th century. At the beginning of the 20th century, food prices and farmland values increased and forests and minerals once considered inexhaustible were discovered to be limited. World War I, with its extraordinary demand for food and fiber, increased the pressure further. As John Maynard Keynes (1920) remarked, “the ‘Malthusian devil’, chained for more than half a century, was unleashed again” (quoted in Ely and Wehrwein, 1948, p. 10).

In his discussion of capital, in *The Theory of Political Economy*, Jevons (1970) completely ignored raw materials, despite his earlier insistence on the importance of coal as the industrial source of power driving the industrial revolution and despite his understanding of coal representing stored energy that imposes strict and calculable limits on industrial activities (Jevons, 1865; Geddes, 1884). Later economists saw his pessimistic treatise on the limits to growth in Britain as being refuted by empirical facts such as the emergence of new technologies and oil as a substitute, which added to mainstream economists’ arguments against resource depletion (Spash, 1999, p. 415).

Even though Jevons had a theory of interest based on individual time preference – economic agents prefer consumption today to consumption tomorrow – it was only with Lewis C. Gray that the pattern of use of exhaustible resources over time was related to the interest rate (Martínez-Alier and Schlüpmann, 1987, p. 163). In his article *The Economic Possibilities of Conservation* Gray (1914) introduced the interest rate as an instrument for inter-temporal allocation of resources. He also identified external effects as responsible for the “lack of correlation in individual expense and social cost” (p. 514). Building on Gray, Ise (1925) discussed the effects of different prices and

discount rates on quickly exhaustible resources. Hotelling (1931) developed an algorithm for optimal non-renewable resource depletion over time. His finding shows that an efficient allocation price is equated to marginal extraction cost plus the shadow price – also called the royalty or scarcity rent – of the resource in the ground. And, over time, this royalty grows at a rate equal to the rate of interest. Menger discussed the importance of raw materials and intermediate products in the production of goods of ‘higher’ and ‘lower’ orders, similar to consumption and inputs to production, respectively (Menger (1871), 1923, pp. 21). He emphasized that the value of a good is derived from its importance for the user, a ‘teleological connection’, rather than from an inherent attribute.¹⁰ He recognized the existence of fixed proportions between inputs. His theory of prices requires a theory of substitution in order to assess the difference made by the presence or absence of an individual factor. In his theory, input quantities can be varied: more land or more fertilizer can be employed to produce the same output (Christensen, 1989, p. 24).

Marshall, one of the fathers of neoclassical economics, introduced time as a factor in analysis reconciling the classical cost-of-production principle with the marginal-utility principle formulated by William Jevons. Marshall formally introduced organization (e.g. division of labor and management) as a fourth factor of production, while maintaining land as a distinct factor of production. For Marshall, land had certain features that justified its special role in production since it is sometimes impossible to augment the supply of land by draining swamps or irrigating deserts. Therefore, the supply of land is much less elastic than the supply of capital goods (Blaug, 1997, p. 82). He further argued that “...there is this difference between land and other agents of production that from a social point of view land yields a permanent surplus, while perishable things made by man do not” (Marshall (1920), 1961 quoted by Daly and Cobb, 1989, p. 111).

On the other hand, his concept of quasi-rent brought the two concepts capital and land closer in

¹⁰ Based on this understanding he criticized Ricardo’s concept of rent, which is based on the inherent differences of various types of land (Menger (1871), 1923, p. 162).

an analytical sense.¹¹ In the short-run, the time span during which the production capacity is fixed, there is no difference between rent and quasi-rent. For Marshall quasi-rents are price determined and exist because of the failure of complete adjustment in any given amount of time, which will disappear in the long-run as all costs become variable.

Joan Robinson disentangled some of the confusion of earlier writers concerning the fixity of land and the role of rent by distinguishing between the level of the society, an industry, and a single company. In studying the supply of a factor to one industry the focus is not on the total supply of the factor, but on the transfer price necessary to induce units of the factor to be transferred from other uses to the industry in question. The concept of rent as the earnings from the ‘free gifts of nature’ – which are present and do not need to be produced or paid for – was not limited to land anymore. Rent in an economic sense was considered the surplus earned by a particular part of a factor of production over and above the transfer price, which are the minimum earnings necessary to induce the factor to do its work (Robinson, 1934, p. 102). The factors were defined in such a way that their efficiency units (output in relation to inputs) could be substituted by one another without altering physical productivity. Efficiency units were later replaced by the concept of the value of the marginal product, which was entirely defined in monetary terms and allowed to formulate measures of substitution between the factors of production.

There were a number of controversies surrounding the concept of capital. The majority of writers still kept to the triad of factors — of which land was one. Even though ‘physical’ concepts still enjoyed greater popularity, non-physical ones began to intrude.¹²

¹¹ Quasi-rent is the short-term economic surplus due to unexpected supply and demand conditions, which in the long-term are expected to come into balance again. Therefore, it represents a disequilibrium concept. The basic assumption is that every existing resource (or even supply of a product) is unresponsive to a change in price for at least some period of time.

¹² As Schumpeter remarked: “We may, however, note in passing that monetary concepts of capital carry the no doubt minor advantage that they bear a relation to capitalism which physical concepts do not” (Schumpeter, 1981, p. 899).

The trinity of factors was by some seen as an arbitrary grouping of homogenous goods. Frank Knight described “the entire notion of ‘factor of production’” as an “incubus on economic analysis that should be eliminated from economic discussion” (Schumpeter, 1981, p. 900). Instead, he proposed an indefinite variety of factors among which there were no economically significant differences. He was inclined to subsume all the factors under capital (Patinkin, 1973, 794). Very influential was Knight’s perception of land (Patinkin, 1973, p. 39). For Knight, land had no unique role in the productive process. Agricultural land had to be developed and maintained, just like any other capital good (Patinkin, 1973, p. 794). Land transformed from being a primary input to both input and output of production.

Land, as a factor of production, has no unique characteristics which should cause it to be set aside by itself in economic analysis. The principles defining the optimum use of land are those drawn from the more general production economics principles. ... Land perhaps takes on unique importance only in respect to its use and allocation over time. Even here the tools of analysis and basic economic principles are identical with those which apply to any other production or resource use problems over time (Heady, 1952, p. 763).

By the second half of the 20th century land or more generally environmental resources, completely disappeared from the production function and the shift from land and other natural inputs to capital and labor alone, and from physical to monetary and more aggregated measures of capital, was completed.

Likewise, it became a common practice in international trade theory to exclude natural resource-intensive products from consideration. For example in the factor proportions theory, which explains the pattern of comparative advantage by inter-country differences in the relative endowment of primary factors of production, the two primary factors of production were capital and labor (Ohlin, 1933; Heckscher, 1949; Kim, 1983).

Solow, (1956) in his paper, “A Contribution to the Theory of Economic Growth”, did not include land in the production function, which took the form $Y=f(K,N)$, where K is capital and N is labor. In a later model, Solow (1974), inquiring about the long-

term prospects for an economy that uses exhaustible natural resources, gives the production function the form $Y=f(D,K,N)$, where D =exhaustible natural resources. The specific production function he used had the property of constant unitary elasticity of substitution among inputs, which does not assign any special role to natural resources.

Later developments reduced the production function to only one input factor: $Y=f(K)$. This means that no fundamental distinction between capital and labor is assumed. Labor productivity is dependent on investment in training and education. For others, knowledge is the ‘ultimate resource’ (Simon, 1981). This view is often the basis for a belief in the possibilities of technological development as expressed by Barnett and Morse (1963): “... the accumulation of knowledge and technological progress is automatic and self-reproducing, and obeys a law of increasing returns” (p. 236).

The methodology of economics underwent substantial changes which had started in the second half of the 19th century. It came increasingly under the influence of analytical mechanics and its maximization model, which led to shifts from production dynamics to an analysis of exchange value. The resulting static optimization theory was mainly concerned with efficiency and equilibrium. Its inputs – land, labor, and capital – and the preferences of customers were considered as given. The theory of production was replaced by a theory of allocation and prices. Physical realities disappeared from the theoretical view. Land, resources, and energy became treated like any other factor of production or lost their status as unique factors of production. The physical and technical assumptions that were made about economic activities have been argued to be in conflict with the basic physical principles governing material and energy transformation (Ayres and Kneese, 1969; Georgescu-Roegen, 1971; Christensen, 1989).

Parallel to an increasing reductionism within mainstream economic theory, neoclassical economists were readily available to extend their mathematical armory designed for market transactions to questions of land and resource use. Empirical facts as well as theoretical considerations led to new specialization within mainstream economics. The classical concept of land as a factor of production was considered too restrictive since significant demand exists for the direct con-

sumption of land. At the same time, land as encompassing all of nature that is of economic significance was too broad to be useful for economic analysis.

The quantity of land, as it is commonly described, is such a heterogeneous aggregate as to have little or no economic meaning, and very little has been done in applying economics to land. ... Whereas the task is a difficult one, all too little has been done to measure land as an economic variable (Schultz, 1953 quoted by Castle et al., 1980, p. 419).

Consequently, different concepts of land, such as productive soil in agriculture, environment, resources, and space for infrastructure, transport and buildings, became subdivided among various sub-fields and many of the ideas developed by classical economists were incorporated into these. The common feature of these sub-fields is that they make a particular aspect of land the central focus while their methods closely follow the assumptions of neoclassical economics. The basic premise underpinning neoclassical economic theory is that (all) economic agents show utility-maximizing or profit-maximizing behavior. Private production decisions, such as the allocation of land or resources between alternative uses, are taken with the objective of maximizing profits accruing to the individual producers, subject to constraints imposed by prevailing technology, resources, and policies (O’Callaghan, 1996, p. 24). In the case of environmental resources or amenities, indirect market methods are used to exploit the relationships between environmental quality and marketed goods (Cropper and Griffiths, 1994, p. 677). This information is used to adjust price imperfections in order to provide proper market signals for economic agents. In a competitive economy, each factor of production receives the value of its marginal product and under the ‘adding-up theorem’ the total output will be exactly exhausted, leaving no surplus to be expropriated. Land and related resources are thus treated like any other factor of production (Fischel, 1985, p. 15). In the neoclassical paradigm, the same logic is applied to all aspects of land or resource use.

These conceptual divisions of land have proven to be efficient and useful for allocating land resources in the short-run. Yet, neoclassical economic approaches to land have received a number of criticisms: for example, the inadequate treatment of aspects such as

irreversibility, non-substitutability of production factors, and the pervasiveness of external effects. These deficiencies inspired advancements both within neoclassical economics and in new approaches. New fields such as ecological economics emerged, claiming a new paradigm; but the distinction to neoclassical economics is not clear-cut. Many economists in these field areas have received training in neoclassical economics and apply their methods based on the same set of assumptions. An agreement of what makes the fields distinctly different has not yet fully emerged.

5. Treatment of land in specialized sub-disciplines in economics

5.1. *Agricultural, land and real estate economics*

Out of the concern for soil depletion and future agricultural productivity a vast literature emerged in the sub-field of *Agricultural Economics*, which became firmly established in the 1920s. The original farm management tradition developed to help farmers gain a satisfactory income from their land (Fox, 1987 p. 56).

Land suitable for agriculture is not constant over time. Human intervention, notably the creation and cultivation of nature areas, have increased the (potentially) available agricultural area, while erosion, flooding and transformation to other uses have reduced it. The quality and productivity of land has been vastly influenced especially through the use of mechanized management practices and chemical inputs, pesticides, insecticides and the like. This has had an impact on the way economists model the production relations of agricultural activities.

Land economics can be regarded as having split off from agricultural economics. It retained the classical view of the uniqueness of land resources, and stressed the factor land, rather than its management (Renne, 1947, p. 250). But the focus was not exclusively on land, as by itself land has little economic value until used in conjunction with other inputs as well as institutional factors (Randall and Castle, 1985).

One of the early research questions focused on how to best bring unused lands into agricultural production. With an apparent oversupply of agricultural land, the interest shifted to the more general concern for

situations in which land, its use, or its limitation was of strategic importance. Salter, (1942, p. 229), who created a first summary statement of land economics, focused on changes in “major land uses” and their effects on social well-being. As Steele (1942, p. 254) recognizes, the question of social well-being is defined by multiple benefits, in addition to monetary values, and cannot be derived by arithmetic addition of individual returns. Salter, (p. 246) sees the use of physical data as a common feature of research in land economics.

In Schultz’s, (1951) paper “A framework for land economics — the long view”, the physical properties of land are of minor importance. The decisive attributes are either technical or institutional in character. As Randall and Castle (1985, p. 577) assert, land economics has been a product of diverse influences: the basic paradigm was evolutionary and its methods of analysis have been holistic, historical, and practical. To summarize, one can say that the heritage of land economics is both in institutional analysis as well as neoclassical economics.

In *real estate economics*, land is a factor of production as well as a product. The theoretical basis for this branch of economics was developed by von Thünen and Alfred Weber. A central element is location and its associated transport costs. Whereas von Thünen focused on agricultural production, Weber’s emphasis was on the location of the manufacturing facility. His theory resulted in materials-oriented or market-oriented types of production dependent on whether factors and products were losing or gaining weight in the various stages of the production process (Pearson, 1991, p. 9). A real estate location is a fixed point in space that is linked to other locations. These linkages and the surrounding uses, commonly referred to as neighborhood effects or externalities, influence the productivity of the location. Distinct from the location are the physical attributes of real estate: land is physically *immobile*; land as space is *indestructible*; and land is *non-homogenous*, that is, no two parcels are alike (Dasso et al., 1995, p. 8). These physical properties refer to the *raw land*. However, what an owner of land really owns is not raw land but *real estate*. Therefore, the existence of parcels of land or real estate is entirely a matter of human institutions (Zaibert, 1999, p. 279). This dichotomy of raw land and real estate is where the methodological

approaches of land economics and real estate economics overlap in applying neoclassical economics tools with strong consideration of the institutional factors and physical attributes of land.

5.2. *From resource and environmental economics to ecological economics*

Both environmental economics and resource economics have partly responded to the way mainstream economics in the 1950s and 1960s treated land and the environment. The focus of these two disciplines has been on pervasive external effects, irreversibility, non-substitutability, and distributional questions. Relatively little attention has been given to the spatial aspect of environmental problems, environment policy, and environment–economy interactions. It is now recognized that a spatially more explicit approach would better allow including information and concerns from natural sciences like hydrology, ecology and physical geography. Only in this way can peculiarities of spatial mismatches between environmental, economic and policy systems and processes be analyzed (see van den Bergh et al., 2001, 2004). Within the neo-classical framework, especially Siebert, (1985, 1995) has emphasized the inclusion of spatial dimensions in environmental economics.

Ciracy-Wantrup, in his seminal book *Resource Conservation*, proposed a ‘safe minimum standard of conservation’ so as to avoid undue losses through irreversibility (Ciracy-Wantrup, 1968). He argued that this safety approach entails costs, either use foregone or positive efforts invested: “The losses are similar to the costs of flexibility in private economics. The similarity is more than formal: as implied above, a safe minimum standard of conservation is essentially an increase of flexibility in the continuing development of a society” (p. 253). The safe minimum standard may be defined in terms of a certain flow rate and a corresponding use rate or, in other words, as a ‘state of conservation’. His interpretation of conservation is redistribution of use rates into the future, whereas depletion is a shift of use rates towards the present (p. 51). Yet, conservation does not mean non-use. Conservation of non-renewable resources, in the sense of leaving the stock undiminished, is a meaningless concept, as this would be logically inconsistent with what is meant by the term resource (Ciracy-

Wantrup, 1968, p. 48). In the case of renewable resources, the concept of sustained maximum yield reflects that use is adapted to the growth buffering capacity or regeneration rate of a resource.

Amenities and related values, such as recreation, or biodiversity, are a different kind of non-renewable resource. Unlike resources extracted at a site, amenities are unlikely to have a close substitute. The value of extractive resources can be reduced through recovery and substitutes, whereas natural environments represent assets of appreciating value. In addition, due to the public good character of the resource, private and social returns to the use of an environmental resource are likely to diverge significantly (Krutilla, 1967, p. 777; Fisher and Peterson, 1976, p. 2). It was argued that in addition to the current use value of a resource, there might be a value for having the option to use a resource in the future: “If an option value exists for rare or unique occurrences of nature, but there is no means by which a private resource owner can appropriate this value, the resulting resource allocation may be questioned” (Krutilla, 1967 p. 780).

This option value represents a potential benefit as opposed to actual present use values. In addition to these two kinds of value, the concept of intrinsic values was stipulated to measure values, which are independent of human beings (and monetary valuation) altogether (Pearce et al., 1989, p. 60). Land as a means of producing useful products, as in agricultural economics, has come to be treated separately from land as a resource, renewable or exhaustible. The latter case is concerned with the implications of exhaustibility of an essential resource on the economy as in the theories of Malthus (1798) for the case of agricultural resources, Jevons (1865) for coal, Gray (1914), and Ise (1925) and Hotelling (1931) for inter-temporal allocation of resources. A body of literature since the 1970s addresses different variations of the same basic question of optimal resource use over time (Solow, 1974; Nordhaus, 1973; Dasgupta and Heal, 1974). Recent writers have considered the same question in an endogenous technology or growth setting (Smulders, 1999). A general understanding is that ‘Malthusianism’ is refuted with the main arguments being technical progress (e.g. Barnett and Morse, 1963) and substitution (e.g. Hartwick, 1977, p. 213).

Certain aspects of the wider concept of land returned into the public discussion in the late 1960s and early 1970s due to the fact that system modelers and natural scientists pointed out the apparent limits of the Earth's resources facing the growth of human population and changes in consumption and production patterns (Meadows and Club of Rome, 1972; Ehrlich and Ehrlich, 1990). Following the cycle of public awareness for environmental problems, the attention ebbed after the oil crisis in the mid-1970s. A renewed discussion of natural resources in mainstream economics was instigated when the notion of *sustainable development* was put forward by the International Union for the Conservation of Nature in 1980 (IUCN, 1980) and the World Commission on Environment and Development (1987).

In the subsequent academic discussions, two alternative interpretations of sustainability emerged: strong and weak sustainability. The advocates of weak sustainability maintain that the aggregate stock of artificial and natural capital (including land) should be non-decreasing; the elasticity of substitution is unitary and natural resources can be replaced by human-made capital (Pearce and Atkinson, 1993). Advocates of strong sustainability argue that a minimum necessary condition for sustainable development is that the stock of natural capital be maintained (Pearce and Turner, 1990; Gowdy and McDaniel, 1999). In between is the viewpoint that certain stocks of 'critical natural capital' have no substitutes, so that they must be maintained in addition to the general aggregate capital stock (Victor, 1991). Common to the latter two approaches is the perception of the unequal role of technological progress with regard to human-made and natural capital: "... technological progress can enhance the capital stock of the economy and hence the economy's capacity to produce commodities. However, it is far less capable of enhancing the supply of wilderness" (Victor, 1991, p. 196).

In neoclassical economics, substitution is elevated to the central principle on the basis of which both the price system and the production system are explained. The neoclassical approach ignores the essential complementarity between different factors of production or different types of activities; or as Kaldor pointedly puts it: "Indeed, it is, I think, the concentration on the substitution aspect, which makes

'pure' equilibrium theory so lifeless and motionless" (Kaldor, 1975, p. 348).

Similarly, Boulding (1992) criticized neoclassical production theory for using only 'contributive' factors. This is what he calls the 'cookbook theory' of production: "we mix land, labor and capital and out come potatoes". For Boulding the limiting factors are energy, appropriate material, time, and space. What can be realized depends on which in any particular situation is the most limiting factor.¹³ The elementary economic principle of efficiency requires that we maximize the productivity of the scarcest factor (pp. 52). For Daly and Cobb (1989, p. 116) the scarcest factor, in the long-run, is increasingly natural capital. Similarly, for Daly natural capital and human-made capital are complementary rather than substitutes. "But standard economic theory is so dedicated to the idea of substitution that it can hardly say the word 'complementary' any longer, and without complementarity there can be no limiting factor" (1998, p. 23). This "dedication" may be due to the fact that assuming a degree of complementarity will cause complications in the sense that it makes mathematical analysis more tedious and less elegant, while generally fewer analytical results can be obtained. In contrast, the focus of the young field of ecological economics is on production and on how material well-being is created through the use of productive inputs, especially natural resources (Martínez-Alier and Schlüpmann, 1987; Gowdy, 1988, p. 34). This shift in 'pre-analytic' vision (Schumpeter, 1950) has been instigated, among others, by Kenneth Boulding's classic *The Economics of the Coming Spaceship Earth* (1966) with his metaphoric description of the transition from 'cowboy economics', with its focus on growth in material consumption, to the 'spaceship economics', characterized by economic use of limited material, energy, and food supplies. This represents a shift from resource allocation in an economic system to the interdependency of ecological and economic

¹³ A concept that goes back to Liebig's 'law of the minimum' (Liebig, 1859): "no single element of the indispensable minerals is superior to any other, but all have equal value for the life of the plant. Therefore, if one element is missing from the soil, the others cannot produce a properly developed plant until the missing element has been supplied" (quoted in Mayumi, 1991, p. 43).

systems (Costanza, 1997). This view has been extended with the notion of “hierarchies of systems”, where the economic system is a subsystem of the social system which itself is embedded in the ecosystem (Gowdy and O’Hara, 1995). Also, new is the notion of co-evolving processes, which help us understand how natural and social systems interconnect and change (Gowdy, 1994; Norgaard, 1994).

These concepts of co-evolving economy and environmental systems and non-substitution is often more visible when these systems are cast in physical rather than monetary terms. A number of physical concepts have been applied in ecological economics, which try to capture the dependency of economic and social systems on the natural world, such as ‘throughput’ (Boulding, 1966; Ehrlich and Ehrlich, 1990), ‘entropic flow’ (Georgescu-Roegen, 1971), economy–ecology input–output models (Cumberland, 1966; Daly, 1968; Isard, 1972), ‘human appropriation of net primary production’ (Vitousek et al., 1997), ‘environmental space’ (Moffat, 1996), and ‘ecological footprint’ (Wackernagel and Rees, 1996). The major difference between these biophysical approaches and neoclassical economics is an overall systems view in contrast to marginal analysis. On the other hand, some of these biophysical approaches have been criticized for being dogmatic about the source of value, implying energy or land theories of value which resemble the labor theory of value that was popular among classical economists (Daly and Umaña, 1981; van den Bergh and Verbruggen, 1999).

It is the question of defining and measuring meaningful social and ecological scales that distinguishes ecological economics from neoclassical economics. The notion of scale has a direct relationship with land and space use. According to Daly, a good scale is one that is sustainable, that does not erode environmental carrying capacity (Daly, 1992, p. 186). Yet, the carrying capacity of humans is quite distinct from the carrying capacity of other species, since the former is culturally and technologically determined (Blakie and Brookfield, 1987). Therefore, carrying capacity is far from being a given universal constraint: it is rather a complex normative concept influenced by ecological dynamics, human values and aims, institutional settings, technology and management practices (Seidl and Tisdell, 1999, p. 395).

5.3. Land in spatial economics and spatial modeling

Land is an important element in the field of spatial economics. This covers *regional*, *urban* and *transport* economics as well as spatial informatics — mainly the application of geographical information systems (GIS; see Scholten and Stillwell, 1990). Various linkages exist between these research areas and environmental economics, focusing, for example, on location choice, diffuse pollution, land use, and transport. Often, land is not referred to explicitly in spatial economic studies, even when it is the focal point of attention. Instead, terms like space, location and region are used.

In an economic perspective an essential feature of land is that it is scarce and subject to competing uses. This is reflected by the existence of positive prices for land, by price gradients according to scarcity, or by rent surfaces if land prices follow a more complex two-dimensional pattern. The latter is most clearly illustrated by cities and urban regions, where land prices increase from the rural areas through the city edge to the city centre. As suggested by the von Thünen model, price gradients affect location choices in such a way that zones result with dominance of certain types of land use, for instance, housing, offices, industry, forestry, grazing, or crop growing. In cities, residence and offices are the dominant land use categories, whereas in rural areas this role is occupied by agriculture.

The optimal zonation, as implied by the von Thünen model, has changed over time in response to consumer demand and technological conditions (Hoover and Giarratani, 1984). For instance, whereas forestry used to be an important supplier of energy (firewood), this has now been replaced by fossil fuels (non-forest products). On the other hand, there is increased demand for outdoor recreation in forests. Other factors, which have affected zonation include changes in modes and speed of transportation, changes in core industries, and regulations on buildings, or more generally, on the intensity of land use.

Land prices are typically regarded as reflecting the total sum of capitalized expected future rents (Hoover and Giarratani, 1984). Land markets do not, however, always function as perfect markets. The reasons are manifold: regulations, historical contingencies, positive and negative externalities, asymmetric information (real estate agents), and speculation. Negative or

positive externalities operate in subtle ways, for example, when the use of a parcel of land affects the quality and value of surrounding parcels. In addition, the presence of a large number of agents and variety in the land market creates additional complexity. These agents include residential owners, land owners, farmers renting land, real estate agents, real estate developers and speculators (Buurman, 2001).

Prominent in regional economics is the idea that land is the dimension of spatial interactions and exchange among economic agents (producers, consumers) in spatially separated locations. In line with this, multiregional approaches consider regions as spatially separate entities. This allows the analysis of interregional trade, spatial price patterns, differential growth, freight and passenger transport, and communications resulting from differences in characteristics between regions. Land use inside regions as such receives little attention in such multi-regional contexts. On the other hand, in economic analyses of single regions or urban areas land use is a central concern. Especially land use by infrastructure is regarded as an important prerequisite and motor of regional development (Rietveld, 1989; Rietveld and Bruinsma, 1998).

Urban economics has probably devoted more explicit attention to land than regional and transport economics (of course the boundaries between the three disciplines are vague). According to Mills and Nijkamp (1987), Alonso's (1964) book *Location and Land Use* can be considered as the starting point of urban economics. Further back, urban economics has its roots in the work of von Thünen. An early and ambitious effort to provide for a link between urban and regional issues was undertaken by Isard (1956), in which attention was given to the role of land use.

Spatial interactions can also take the form of relocation of firms – known as capital flight – and migration of people – acting as consumers and employees. Both processes have received much attention, although migration is typically studied more outside than inside economics (for an overview of the economics angles see Gorter et al., 1998). Location of firms has recently received much attention in the area of environmental economics, where attention is devoted to optimal environmental policy subject to endogenous location of firms, giving rise to multi-nation game theoretic approaches (Hoel, 1997).

Despite the above examples, according to Costanza (1997, p. xxii) the integration of economics and ecology within environmental economics and science is hampered by widespread lack of considering space in economic theories and models. While it is true that mainstream economics has largely assumed away space and spatial externalities of economic agents, the statement neglects the whole field of spatial economics. GIS applications are nowadays often considered an essential input to integrated models, because they permit linkage of economic and ecological phenomena at a detailed spatial scale. It is not beforehand clear, however, that using a high spatial resolution will always be fruitful. Whereas many ecological and hydrological processes are amenable for a grid-based description, most economic processes operate at multiple scales. This explains, for instance, why cellular automata have been more popular in landscape ecology than in spatial economics (Engelen et al., 1995)¹⁴. Whereas in physical and biological systems such immediate neighborhood influences in space dominate, this is not necessarily the case in social and economic systems. Here 'spaceless' information is crucial to individual and public decisions. Moreover, many spatial interactions in an economic context extend beyond the scope of directly 'neighboring cells' — the extreme examples being international trade and communication, or more generally globalization of production chains, product and financial markets, and communication networks aided by new information and communication technologies. Nevertheless, agent-based approaches, such as cellular automata, could be used to address issues in social science that depend on the physical and network interactions between people in local neighborhoods. Cellular automata have already been applied in studies of urban growth, infrastructure development, and deforestation and land use patterns, notably in conditions where physical planning and land regulation are not well developed.

¹⁴ Cellular automata in the pure form describe discrete time transformations of discrete cell states in a regular n -dimensional space (usually $n=2$), where the transformation is completely determined by the states of the cell itself and of its immediately neighbouring cells (a generalization of the well-known 'game of life'). Given the initial states of all cells a spontaneous spatial evolution will take place.

An example of an integrated model with cellular automata for analyzing land use patterns is [White and Engelen \(1997\)](#). This model combines various types of suitability (environmental, institutional, neighborhood) and accessibility indicators to trace land use patterns in the context of a regional economic – environmental system. Important for the applicability of such an approach is that institutional controls are not such that they completely dominate land use patterns, as is the case in many western countries nowadays. In the latter case no degree of freedom exists for spontaneous spatial evolution. Application of cellular automata in social science seems thus rather limited, unless generalizations and extensions are developed that allow for direct interactions between non-bordering cells (see [Couclelis, 1985](#)).

Urban and regional economics have, next to macroeconomics, provided inputs to integrated modeling, evidently focusing on explicit spatial approaches ([Nijkamp, 1979a,b](#); [Hafkamp, 1984](#); and [Brouwer, 1987](#)). These may be linked with landscape and spatial ecology. Applications are usually at the ecosystem or regional scale, rather than the global scale, so as to limit the level of detail and the size of models.

Landscape ecology, originating from an interaction between ecology, geography and land use planning, has developed into a field that can provide important spatial information to integrated modeling involving social and natural science elements ([Turner, 1998](#)). It studies the linkages between ecological processes and spatial patterns, taking account of spatial heterogeneity of land cover, i.e., vegetation and habitat types. The spatial patterns of nature and environment change over time through various mechanisms: (1) regular and short-term natural causes like ecosystem succession, sedimentation, erosion, and less regular causes like fires, pests and storms; (2) long-term evolution caused by local systems developing in different directions as a result of being spatially isolated for long periods of time; and most important nowadays (3) through land use and human activities. An important question is whether the spatial structure or mosaic, i.e., the spatial organization of land cover viewed from above, will after some time converge to a steady state or be continuously changing. Cellular automata have been used to model spatial ecological processes such as the movement of species or

dispersal of materials. Other applications have compared different ecosystem management strategies, for instance, small dispersed versus large concentrated cuts in forest harvesting. Landscape ecology takes a grand perspective at a local or sometimes regional level, using models and GIS. It thus allows for concrete interaction with economic land use oriented models, and in particular to link the different spatial scales at which models in ecology and economics are commonly defined ([van den Bergh et al., 2004](#)). Landscape ecology can provide useful information for ecosystem management, land use planning, and biodiversity conservation.

The issues of spatial scale and level are important for the integration of economics and natural sciences in modeling studies. Economics usually distinguishes between micro, regional (meso) and macro levels. Although economics usually adopts a coarser spatial scale than ecology, both can and need to address the entire range of spatial scales, from micro to global. Nevertheless, economics has traditionally been oriented towards larger scale issues, from the national or international level. The field of spatial economics, comprising regional and urban economics, adopts a spatial scale that is closest to the scale of analysis common in environmental science and ecology. When searching for methods to incorporate land use into economic as well as integrated economic–environmental analyses, one therefore should expect to find most inspiration in the field of spatial economics, which continues a long and respectable, though somewhat neglected, tradition in economics.

6. Conclusions

In ancient and pre-industrial times the products obtained from land constituted the majority of total output, and land productivity thus was the major determinant of a country's standard of living. Soil of low productivity could, and in many agricultural societies still does, mean poverty for its inhabitants. It is, however, no longer generally believed that a country's economic well-being is inevitably tied to the productive capacity of the land. The productive potential of the land is not fixed. On the contrary, it is greatly expandable through the adequate use of modern agricultural inputs and management. Moreover, industri-

alization and trade have reduced people's dependence on local conditions of the soil.

It was only with the environmental crisis of the recent decades that land came back to the attention of a large audience. Anthropogenic land transformation is as old as humanity itself but only in the last two centuries have land-cover changes become truly global in scale and now occur at unprecedented speed. Even though these changes are undertaken at the local or regional level, they are so widespread that their consequences reach global dimensions. To meet human needs for fibers and foods, wilderness areas have been converted into managed land. Human activities, rather than natural processes, have become major forces in shaping the environment. Research shows that human induced changes in land use and land cover have significant effects on the functioning of ecosystem components, such as the nutrient, carbon, and hydrological cycles, at a regional as well as the global level.

The different development phases and structural change are reflected in economic theory. Land as the principal source of wealth in classical economics lost its central role in neoclassical economics. A basic premise of neoclassical economics is substitutability between human-made and natural capital. Treating land like any other commodity or factor of production means neglecting the unique services land provides, which are not traded in markets. The metaphor of sustainable development has triggered a renewed discussion and has also reintroduced land into the economic discourse.

Land use is an important indicator of tensions between the economic system and the environment: first, productive land is a good approximation for natural capital. Second, ecosystem productivity is governed by primary production, which principally depends on land use. Finally, the most important interaction between humans and other biological communities is the competition for land being the basic source of biomass, energy and mineral reserves (Mayumi, 1991; Darwin et al., 1996; Wackernagel et al., 1999).

Land has been of great importance for many economists of various schools of thought. Much theory and method has been dismissed over the course of the centuries. Yet, a closer look at present-day criticism of mainstream economic theory shows that it is worthwhile to re-evaluate these 'old treasures' in the light of tools and theoretical advancements of today's econom-

ic discourse. Economic analysis of land should not be solely preoccupied with price signals and shadow prices. It also has to include historical, institutional, and biophysical factors. Land is as much a social construct as a physical reality. Recent developments in spatial economics and spatial modeling offer new opportunities to bring economic ideas on land use in contact with physical realities as reflected in environmental science and models. The collection of large amounts of spatial data and the evolution of computing power and GIS foster this trend. A large array of theories has been identified, including theories of land value and pricing, zoning, location of firms, spatial interaction – trade, transport and migration of people –, and physical planning. A wide range of methods is available to operationalize these theories, using data in GIS or other formats.

The challenge to economists is to engage in a transdisciplinary dialogue. The solution to a next step is not a *theory of everything* but rather a framework achieved with an enhanced understanding and consideration of the complexities and manifold factors involved, and improved ways of translating disciplinary information between natural and social sciences. From an economic perspective it means in any case linking the concept of externalities to the real spatial dimension of land. Against this background, one is tempted to say that the future of land in economics looks brighter than ever.

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