Land as a production factor

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Paper to be presented at

45th Congress of the European Regional Science Association in Amsterdam

23-27 August 2005

Abstract:

In this article we explore to what extent land can be regarded as a production factor. We do so at the macro and at the micro economic level. At the macro level, the available amount of industrial land could be a factor in national economic growth, just like growth of the labour force. At the micro level we consider whether the theory of individual firms' production function is able to incorporate the amount of land as production factor. We commence with an economic argument for intensive land use, before we present a historical overview of the treatment of land in economic theory. The paper concludes with a comparison of the various conceptualisations of land as a production factor.

Keywords: Land use; Production factors; Land demand

JEL codes: R14, R33.

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The authors wish to acknowledge the assistance of the Dutch government through th Habiforum Program Innovative land Use

1 Introduction

Land leads a marginal existence in modern mainstream economics. To an outsider, this lack of interest might seem odd as land is an indispensable necessity for all economic activities. Manufacturing industries need space for factories, the service sector requires land for offices, transport and logistic companies need roads, sea and airports, etcetera. While most firms optimise production and minimise costs with respect to the use of labour and capital, they seem to refrain from this practise with respect to the plot size of their business. Surely, firms have some idea about the plot size they need for their business, considering their desired level of production. However, there exists no empirical literature to support the argument that they indeed calculate in such a systematic manner that it results in the most efficient and optimal amount of land. Apparently, the production factor land is not a factor of economic concern for non-agricultural firms. This thought, however, does not seem odd when confronted with data that show that land costs are fairly little. In the Netherlands for instance which its high density of economic activities, land costs are only around two percent of total fixed capital investments[1]. So, with respect to costs, there is no compelling need for firms to economise on the amount of land they use.

Hence, the question is: why should economists be concerned with the amount of land that firms use for their production process? The answer originates from fact that many people highly value the amenities of untouched landscapes (either rural or natural), especially in densely populated countries. Build up land for housing, business sites and transport networks create externalities such as the loss of open space, the loss of a nature like environment and the loss of scenic views. Therefore, governmental agencies have developed spatial policies to prevent or restrict urban sprawl. These policies fit in wider debates about sustainable development, which has triggered economist and has (re)introduced land into the economic discourse (Hubacek and Van den Berg, 2002).

The spatial planning policies towards the supply of land may have effects that are of economic concern. Cheshire and Sheppard (2005), for instance, observed that inflexible restrictions on the supply of land for offices, manufacturing and housing create land price differentials in the long run that reflect the relative land scarcity of different land uses.

[1] According to data from Statistics Netherlands http://statline.cbs.nl.

However, even with this scarcity premium, land costs of firms are still minor. So, there still seems to be no incentive for firms to optimise their plot size. Therefore, it seems that spatial planning only thwarts urban sprawl but does not necessarily stimulate the use of less land per se. Moreover, it has even been argued that the established planning practise of industrial sites in the Netherlands propagates inefficient land use. As a result this practice stimulates the development of more sites (Louw et al, 2004). An explanation of this mechanism is that the factors that influence the demand for industrial land are hardly known, so local governments plan and develop industrial land well in advance of demand because they think a shortage of industrial building land will limit their economic development. That is also why, some of the scarce studies on industrial land manly focus on restrictions on the development of industrial land (see for instance Adams et al., 1994). In general it can be argued that the supply side of the industrial land market, as far as the amount of land is concerned[2], has had much broader attention than the demand side.

Better understanding of land use of firms, with respect to plot size and the aggregated demand for land, might help to improve land demand models that are used for the spatial planning of industrial sites. The aim of this paper is to survey the role of land in economic theory and to look for possible conceptual leads to understand the demand for industrial land. In this attempt we focus on the way mainstream economic theory has conceptualised or still conceptualises land as a production factor. This implies that we will not go into detail on the economics of land use change (although it is in some way related) and other main subjects of regional and urban economics (such as location). Instead we will operate at the fringe of these specialized sub-fields within economics. Within the literature we hope to find leads that help us to build an conceptual framework to explain industrial land demand, which will guide or empirical research.

This paper is organised as follows. In the next section we present an argument for intensive land use. In section three we review the history of economic thought regarding the production factor land. In section four we address land use from the firm's perspective. The last section concludes and presents an overview of the various ways in which economics have treated land as a factor of production and argues which theoretical leads are useful in explaining the quantity of land used by firms.

[2] As will be argued later in this paper the main focus on the demand side of land in regional science and geography is about its location.

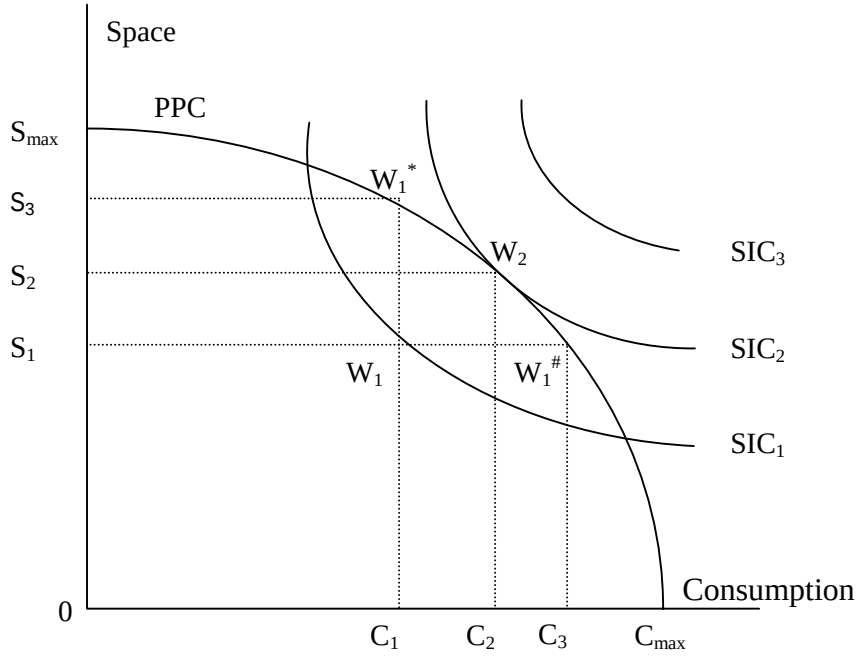
2 An economic argument for intensive land use

Nation wide, the spatial dispersion of residences and firms covers a lot of land. From this perspective land resources are in fact a production factor that in the end serve consumption. Demographic growth and increasing economic activity have lead to urbanised regions. Increasing prosperity of citizens has come at the cost of depleting the production factor land. As a consequence many people are becoming conscious of the amenities of untouched nature. The aggregate preferences of the country's inhabitants towards preserving open space have lead to restrictive land use policies. On the other hand, citizens demand the government to facilitate economic activities in order to increase employment. However, most economic activities consume land. Clearly, there exists a trade off between environmental preservation and economic activity.

Welfare theory is an economic analysis of conflicting preferences on the aggregate or social level. This theory confronts any feasible set of commodities with the preferences of a group of individuals[3]. In our case these commodities are open landscape and economic activity. More precisely, economic activity serves consumption, including the consumption of land. Thus, there is a trade off between consumption and space. In figure 1, the production possibility curve (PPC) envelops all possible combinations of space and consumption. Social indifference curves (SIC_1, SIC_2, SIC_3) depict the preferred bundles of space and consumption for which the society experiences equal utility. The more society is able to consume, the higher is its utility or welfare, so $SIC_3 > SIC_2 > SIC_1$. The highest attainable welfare is the consumption bundle at the indifference curve (SIC_2) that is tangent to the production possibility frontier at point W_2. At that point consumption is C_2 and space is S_2, implying that the amount of land that serves consumption is S_{max} minus S_2.

[3] It is, however, a great leap from individual preferences to societal preferences since individual preferences widely diverge and may not easily aggregate to the societal level. Nevertheless, for sake of the argument, we ignore this fact.

Figure 1



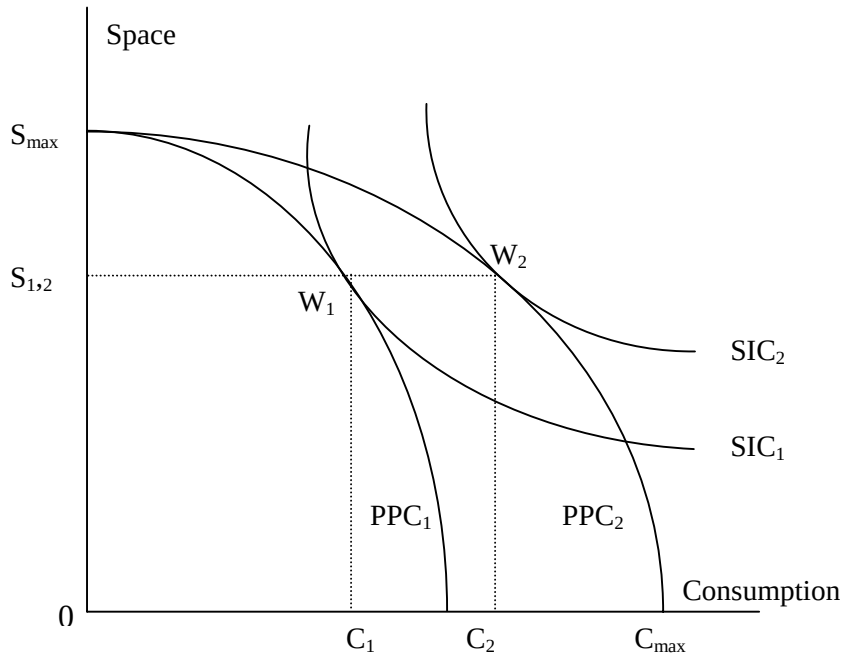
It is possible that society produces a bundle of goods that is not optimal. In figure 1 the bundle of space S_1 and consumption C_1 lies below the production frontier at W_1. This production outcome is inefficient because with the same amount of economic activity society might enjoy more space (S_3) or with the same amount of space more consumption (C_3). In other words, economic activity at C_1 uses too much space ($S_{max} - S_1$) while it could use less instead ($S_{max} - S_3$). Therefore, the bundles W_1^* and $W_1^\#$ are called *technically* efficient production outcomes because they are positioned on the production frontier. At the same time these points yield more welfare because they are on a higher indifference curve. However, these bundles are not *economically* efficient because they do not yield the highest possible welfare. Indeed, as stated before, maximum welfare is achieved at point W_2, the technical and economical production outcome.

This analysis illustrates that economic growth and land preservation are both possible if society organises its economic activity through efficient land use. In reality moving to the production possibility frontier (at W_2) is probably not an easy task. This transformation requires a reorganisation of the production process towards more intensive land use. Furthermore, the amount of land previously used for economic activity has to be converted back to greenfields ($S_2 - S_1$). Both processes require a lot of investment and time. These investments improve societies welfare but may not be profitable from the investor's

perspective. Hence, these investments may not be made. Therefore, government regulation, intervention or incentives may be necessary to stimulate investment in intensive land use.

Even if society is operating at the optimal efficiency on the production possibility curve, economic growth and higher welfare are possible if technological progress allows for more intensive land use. In figure 2, W_1 is the initial situation of the economy at the tangent of I_1 and PPC_1. At that point society enjoys consumption C_1 and Space $S_{1,2}$. Now, technological progress is represented by an outward shift of the production possibility curve (from PPC_1 to PPC_2). With unchanged preferences higher welfare is possible in W_2 at the tangent of SIC_2 and PPC_2. At that point society's economic output has grown from C_1 to C_2, while the available space remains the same ($S_{1,2}$). At the same time the amount of land used in economic activities remained the same (S_{max} minus $S_{1,2}$), which is a clear illustration of more intensive land use and sustainable.

Figure 2



The above presented welfare analysis has illustrated that preserving the landscape and the application of land intensive production processes may increase society's welfare. Unfortunately, with respect to space and consumption, we do not know the indifference curves and production possibility frontier of our society. Thus, we do not know at which point relative to the PPC our economy is operating. However, we do know that many people

appreciate untouched landscape, according to the increasing number of contributors to environmental organisation and the resistance of citizens against, for instance, public works in the country side. This resistance may be due to a ‘not in my backyard mentality’ as there is evidence from hedonic house price analysis that residents value environmental amenities close to their home higher than further away (Luttik, 2000). Nevertheless, these examples of public concern for environmental issues provide sufficient reason to stimulate intensive land use, as long as it does not hamper economic activity too much.

In this section we have established that intensive land use may improve society’s welfare. However, although the government in the Netherlands has the means to assign land for different uses (e.g. housing, business and agriculture/environmental preservation), the amount of land use is still at the firm’s discretion. Therefore, in the next section, we address land use intensity from the firm’s perspective.

If one is to study land use intensity from an economic perspective, one can not circumvent the concept of land as an indispensable production factor for economic activity. With *production factor* we refer to the plot size of the firm or the amount of land used in aggregate economic activity. We do not refer to the physical qualities of the land for agriculture or mining, nor do we focus on the amenities of the location of a certain lot. So, the productive quality of land from our perspective is the space it provides for economic processes. With respect to the above analysis, the question is what quantity of land is optimal for economic activities. With *economic perspective* we refer to the economic agents who decide on the space they deem fit for their production process. So, this angle excludes planning regulations - and the process behind it - that directly restrict, allocate or intensify land use. Nevertheless, this demarcation does not exclude the fact that some planning policies might affect land use decisions of firms. Under a restrictive planning policy, for instance, an under supply of building sites might affect a firm’s decision in two ways: through the available amount of land and/or through higher land prices. Understanding the factors that influence this decision is our ultimate goal. However, before we are able to reach that goal, we think that it is prudent to start with a brief review of the economic literature to get a grasp of the concept land as a production factor.

3 A history of thought on the production factor land

The purpose of this section is to shed light on the concept of land as a production factor by means of a brief review of the history of economic thought. We commence our review in the eighteenth century and work our way up through the ages. For two reasons the eighteenth century seems a reasonable starting point: (1) many economists regard this period as the dawn of modern economic science and (2) land had a dominant position in the society and economic thought of that time.

In the eighteenth century, a main concern of philosophers on economic issues was the source of wealth. They had realised that more goods were produced than were needed to pay the real costs of producing those goods. Hence, a surplus was generated. In the predominantly agricultural society of that age, it may come as no surprise that the produce of land played a major role in the subsequent analysis of the origin of this surplus. Moreover, in the view of this early economists, agriculture was the only sector capable of producing a surplus. This thought is reflected in the opening sentence of Richard Cantillon's essay:

> "The land is the source or matter from whence all wealth is produced. The labour of man is the form which produces it: and wealth itself is nothing but the maintenance, conveniences, and superfluities of life." (1755).

The Physiocrats, a French school of economists who were influenced by this work (Hayek, 1985), held a similar view on macro economic growth. Their intellectual leader, François Quesnay, developed a circular flow model – the *Tableau Économique* – to show the relations between three sectors of the economy. In this model only the agricultural sector produced the surplus that was necessary to sustain growth for the entire economy. On the contrary, manufacturing and other non-agricultural economic activities were considered "sterile," because they created no net product. The Physiocrat's reliance on agriculture may be explained by the fact that they focused on physical productivity rather than value productivity. However, because large-scale industry had not yet developed in France in the middle of the eighteenth century, the productivity of industry was not apparent to them (Landreth and Colander, 1994).

In the course of the nineteenth century the pivotal role of land was gradually diminishing in the writings of the Classical economists. First, it was Adam Smith (1776, bk. IV, ch. IX. par.

4) who stated that the industry of towns was under-valued in the Physiocratic economy. Smith emphasised the division of labour and capital accumulation in his analysis of the origin of wealth. Nevertheless, he maintained the idea that the labour of farmers was more productive than the labour of industries, because the former "over and above the stock which maintains and employs them, reproduce annually a net produce, a free rent to the landlord" (bk. IV, ch. IX. par. 30). However, Smith's main concern about land is the relation between the produce of land and rent to the landlord and not the produce of land as source of wealth. Then, hardly two decades after Smith, Jean-Baptiste Say (1803) definitely closed the argument against the Physiocrats by stating "…that wealth consists, not in matter, but in the value of matter..." and that "… if the value of matter constitutes wealth, wealth is to be created by the annexation of value." Moreover, Say argued that value, and consequently wealth, is produced by no other than three sources: human industry (i.e. labour), capital and natural agents, of which land was the chief component. Hence, all sectors of the economy, agriculture, manufacturing and commerce, were able to create value (book 1, chapter 2).

The role of land in the creation of wealth was about to decline even more when Say defined the productive power of natural agents as "…a process performed by the soil, the air, the rain, and the sun, wherein mankind bears no part, but which nevertheless concurs in the creation of the new product that will be acquired at the season of harvest." However, Say pointed at the fact that "The productive faculty of capital is often so interwoven with that of natural agents, that it is difficult, or perhaps impossible, to assign, with accuracy, their respective shares in the business of production." (book 1, chapter 4). Moreover, the presence of land as a natural agent of production is not necessary in manufacture and commerce that use foreign grown products. Thus, only in the most strict definition land enters production as the area on which this business of industry is carried on. Nevertheless, following this definition, "it must at least be admitted, that, with aid of a large capital, an immense manufacturing concern may be conducted upon a very trifling spot of ground. Whence this conclusion may be drawn, that national industry is limited, not by territorial extent, but by extent of capital." (book 1, chapter 5). In plain words, Say meant that the plot size of the firm is of minor importance relative to capital. This notion, so early in the history of economic thought, is relevant to our present study on the role of land as the amount of land used in business activities is our main concern.

Nevertheless, the productivity of land remained a major issue in the advances of Classical economic theory of the early nineteenth century, especially in theories on land rent. These

theories depended on the assumptions that (1) the total area of land available is fixed and cannot be augmented, thus land supply is not dependent on the return obtained from it and (2) that land costs nothing to produce and has no alternative uses, implying that there are no opportunity costs of holding land. Thus, land is just idly waiting for production and land rent is pure profit to the landowner. As a consequence, the total available land is the ultimate constraint on output and, as long as the population is growing, the cause of diminishing marginal returns to labour and capital. Based on these assumptions, Ricardo (1817) developed a theory of agricultural rent based on differences in the fertility of land or - as he called it - "the original and indestructible powers of the soil" (ch. 2, par. 1). The rent on the most fertile or productive land is based on its advantage over the least productive. Competition among the farmers ensures that the surplus of production goes to the landowner in the form of rent. Although Ricardo, like Smith before him, recognised that land that is nearer to the market bears lower transport costs and has a location advantage over more distant land, he focused his attention to fertility differentials. A decade later, Von Thünen (1826) developed a theory of rent based on transport costs and distance to the market place. In his approach farmers compete in acquiring land as near as possible to the market place. As a result, land rent at any location is equal to the value of its produce at the market minus the production and transport costs. The advances of Ricardo and Von Thünen paved the way for the Marginal Revolution in the second half of the nineteenth century and are still bearing relevance to contemporary issues on rural and urban land values.

At first, the insights of the Marginal Revolution left the three-part division of the agents of production intact. Marshall (1890, p. 138), viewed by many economists as the prime exponent of this paradigm shift, followed the Classical economists in defining land as "the material and the forces which Nature gives freely for man's aid, in land and water, in air and light and heat." Marshall recognised that land as such "owes much of its character to human action; all that lies just below the surface has in it a large element of capital, the produce of man's past labour. But it is different with that is above the surface. Every acre has given to it by nature an annual income of heat and light, of air and moisture; and over these man has but little control (1890, p.147)". Therefore, these "original and indestructible powers of the soil" remained a determinant of agricultural land rent along with the location of the lot.

However, in applying the logic of marginal cost and production to land, Marshall concluded that "land is but one form of capital to the individual producer (1890, p.430)". This

conclusion is even more valid to urban land, where the productive forces of land are not needed. “So again a manufacturer or trader, owning both land and buildings, regards the two as bearing similar relations to his business (1890, p.431)”. In practise, confronted with the need to extend his factory, an entrepreneur will equate the cost and income derived from spreading the building over more ground with the investment and return of building an extra floor. Therefore, Marshall states that “if land is cheap he will take much of it; if land is dear he will take less and build high (1890, p. 448)”. This means that in a Neo-Classical context the intensity of economic activity on the firm’s plot size depends on the price of land and the industry specific construction costs.

The notion that land in many features resembles the production factor capital led economists to subsume land altogether with capital at the beginning of the twentieth century. The reason was that the distinction between capital and land made no sense when substituting the production factors at the margin of their productivity.

> “It will be well at this point to note how very unsatisfactory, from the theoretic point of view, is the popular division or classification of the factors of production as land, labour, and capital. The distinction between land and capital is obviously arbitrary. What we mean by land in practical life is something which admittedly consists very largely of the accumulated result of human effort, and accordingly it is usually regarded in books of Political Economy as capital, the term land being reserved for the "original and inalienable" properties of the soil. And these it has been found practically impossible to define or separate. Just where we have an area of the earth's surface which, physically speaking, owes little or none of its value to anything that has been done to it or on it,—for instance a bare site in the centre of a great city,—we find that its value depends more than ever upon capital, that is to say, upon the results of accumulated effort. Only it is the capital that has been expended not upon the site itself but upon the surrounding areas. Land, therefore, even as economically defined, cannot be considered in isolation from capital. And since, as we have seen, the principle on which things balance each other in the market is independent of whether they have been accumulated or not, the distinction between land and capital, which it seems difficult or impossible to draw, would be theoretically worthless if drawn.” (Wicksteed, 1910, bk I, ch 9, par 11).

In spite of its logic, this view was not universally accepted over night. Until the thirties of the last century economist were still debating whether land is sufficiently different from capital to grant it a separate treatment (Cannan, 1930, Brown, 1930 and Souter, 1932). Nevertheless, mainstream Neo-Classical economics ignored this debate and moved on in developing theories of production, income distribution and growth that are based on the assumption that there are no fixed, non-augmentable factors of production. According to this view the area of land available for agriculture or other forms of production can be augmented at a cost by extending communications, or by clearing, irrigating, draining, fertilizing, fencing less fertile

areas and even land reclamation projects. Land is then just another form of capital and not an effective limit on economic growth.

Arriving at this point in history we come to the preliminary conclusion that, in the course of around hundred and fifty years, land has become from being the sole productive factor to just another kind of capital. Moreover, land is even less than a kind of capital as modern textbooks only mention labour and capital (such as machines, buildings or monetary funds) as production factors and make no reference to land. Two plausible reasons for this neglect are the low share of land costs in total firm expenditure and the low share of the agricultural sector in the total economy of industrialised countries.

Another striking development in theories on land is the shift in economic orientation; from macro economic growth to micro economic production. It is, therefore, inconvenient to our case that the logic of Neo-Classical economics rendered land as a separate production factor obsolete because the concept of marginal productivity and marginal costs are useful in determining the optimal plot size of a firm. Alas, we did not find any empirical work approaching the plot size from this perspective. Moreover, land issues seem to have led a subdued existence in the first half of the twentieth century, except for some interest in land rent and agriculture. However, the second half of last century has shown renewed interest in land issues from various perspectives – some new, some related to historic theories – that have spurred theoretical and empirical work in ever increasing quantities.

The seminal work of Alonso (1964) may be seen as the birth of a new discipline in urban economics. In theorising about the determinants of urban land values, Alonso reinterpreted the Von Thünen model by substituting commuters for farmers and a central business district for the market place in the isolated town. To the present day many theoretical and empirical studies about industry and residential location, traffic issues and industrial and residential land values are based on his work. However, some aspects of his work are overlooked. In reviewing Marshall's work with respect to urban values, Alonso (1964, p.5) stated that

> "..it would seem that later theorists have not studied Marshall's analysis with care, for the question of size of the site is almost universally ignored. Yet the market equilibrium must concern itself with quantities as well as with prices. Later writers, however seem content with considering a location as a dimensionless point, and speak of bidding for a site, paying no attention to its size. The matter can be made very clear at the level of the firm. If two firms realize the same location advantages with respect to a location, but one requires a site only half the size of that required by the other, the former will be

> able to bid a price per square foot of land at that location twice as large as the latter. Thus, for the purpose of a theory in which the land market is cleared, and for the purposes of determining the bids per unit of land, the size of the site must be considered, and the point of location must be given the attribute of extension."

Consequently, acting on this deficiency in existing knowledge, Alonso devoted ample attention to the land use of firms. However, scholars that followed his footsteps and did only applied his thought about land use on residential land and barely to industrial land. Among others Muth (1969) and Fujita (1989) have theorised on determinants of residential land use. In their models equilibrium land use is achieved through optimising a production function for housing that incorporate the production factors land and capital. The optimal demand for land depends on the distance to the central business district and on the four rules of derived demand first formulated by Marshall (1890). According to this rules, the forces influencing the elasticity of demand for a productive factor such as land are the elasticity of demand for the final product, the elasticity of supply of other factors, the ease of substitution in production, and the relative importance of the factor. Marshall argued that the greater any one of these the greater the elasticity of derived factor demand. Scholars have conducted empirical research on the demand for and capital land substitution of residential land (Muth, 1971, Sirmans and Redman, 1979, Sirmans and Kau, 1981, and Needham, 2000) but method could be applied to industrial land as well. These studies suggest that the elasticity of demand for the production factor land for housing is quite low and averages around -0.5. The elasticity of demand for industrial land is even less and is calculated for the Netherlands between -0.1 and -0.2 (Centraal Planbureau, 1999). The reason may be that, in comparison with residential housing, the elasticity of demand for the final product (e.g. the building), the ease of substitution between land and other factors of production and land costs relative to the costs of other production factors are low.

So far, this literature review shows that there are no studies that focus on the quantity of land as an *independent* factor of production (from other inputs). In some handbooks such as Alonso (1964) and Barlowe (1958) there is attention to the amount of land that is used for economic activities, but other researchers have hardly picked this up. To some extend the intensity of land use can be seen as an approximation of the amount of land. Barlowe (1958: 143-144) defines intensity as "the relative amounts of capital and labor combined with land in the productive process". In empirical research however, it is hard to distinguish between various land uses, so land is used as a homogenous entity, in which no distinction is made between land for industry, housing and recreational uses. This makes empirical research in

terms of differences in density possible but the concept of land a separate factor of production is lost because it is unknown which amount of land is involved in productive processes (see for example Ciccone and Hall (1996) and Ciccone (2002)).

Apart from the discussions about land as an *independent* factor of production, there is, however, general agreement about land as a *distinct* factor of production. Land has unique characteristics and this uniqueness arises from its distinct physical or natural and institutional properties (see for overview: Hubacek and Vazquez, 2002). The natural resource component consists of innate land conditions such as soil and topography and its man made improvements. Other distinct attributes or characteristics are land its physical immobility, its indestructible nature and its non-homogeneity. No two parcels of land are alike. "Differences may arise due to unique locations, size, shape, topography, buildings, infrastructure and other location-specific attributes. Parcels might be past of an 'assemble', of a specific region with certain wind an weather conditions or exposed to positive or negative influences (externalities) from other parcels or its associated land uses." (Hubacek and Vazquez, 2002: 9). Differences in locations cause otherwise similar parcels to have different use-capacities and thus values.

Not only are use-capacities of land determined by these physical properties, but also by institutions regarding land use. As Hubacek and Vazques (2002: 9) states: "..what an owner relly owns is not raw land but *real estate*. The existence of parcels of land or real estate is wholly a matter of human institutions. Real estate comes into existence and is maintained in its existence as a result of complicated networks of institutional facts, whereas raw land is not. Institutional factors set the frame influencing (economic) behaviour." Several public regulations, such as land use plans, subdivision regulations and building codes shape the development and use of real property and a great variety in property rights. This also makes real estate markets differ from other type of markets. Due to the physical characteristics of land, and the institutional features of the transactions, real estate markets are less efficient than other markets. Immobility and heterogeneity cause real estate and land markets to be area-specific. Negative externalities of land use together with in in-efficiency of markets have been an important argument for regulation in the form of spatial planning. Our understanding about the influence of regulation on the market and visa versa is limited (Cheshire and Shephard, 2004), which again underlines the distinct character of land as production factor.

It seems that, apart from the Neo-Classical concept of marginal productivity and marginal costs, there is little theoretical lead for investigating the quantity of land as an independent production factor. However, as land is considered a distinct factor of production, it remains viable to pursue this matter further in order to gain insight into the intensity of land use.

4 Productivity and efficiency of land

Production is the transformation of one set of resources (inputs) into a second set, e.g. output of intermediary or final commodities (Grubbström, 1995). With respect to the physical transformation of production factors, it is clear that the amount of land in use for production, the plot size of the factory, is not a production factor[4]. However, in a broader sense the production process includes more than just physical transformation. Production also needs immaterial production factors such as labour services, knowledge and financial resources. One can argue that the transformation process consumes a certain amount of land at a particular location. From this perspective land provides productive services to a firm, which include the size of the plot and location-specific attributes. Since land has a price, part of the firm's financial resources are used to obtain the necessary amount.

Because we regard land as a production factor such as labour and capital, it is conceivable to apply the concepts of productivity and efficiency to the spatial dimensions of land. We name these concepts spatial productivity and spatial efficiency. The two concepts are related but not identical. We conceive land productivity as the firms' output produced on a certain amount of land[5]. This concept is closely related to Barlowes' (1958: 143-144) definition of 'intensity of land use': "the relative amounts of capital and labor combined with land in the productive process". Spatial productivity is a merely descriptive expression and is defined as the added value produced per square metre.

Spatial efficiency, on the other hand, reveals information about the efficiency of land use the production process. A firm is spatially inefficient when it is using more land than necessary given the level of output, the input of labour and capital (production factors) and the production possibility curve (technology). In other words an inefficient firm is operating

[4] The obvious exceptions are, of course, agriculture and mining.
[5] The term 'spatial productivity' can be used interchangeable with 'land productivity'. 'Land use intensity' is another related term. This term relates the concentration of other production factors to the plot size.

below the production possibility frontier that incorporates the production factor land. Barlowe (1958) called such a firm an extensive user because they own large land areas relative to the amounts of capital and labour used. This is not to say that the firm is inefficient in its use of the traditional production factors (labour and capital) per se, just that it uses more land than strictly necessary.

The minimum required amount of land for spatial efficient production can be derived from the desired output level and the production technology, e.g. the combination of labour and capital. However, it is expected that firms almost never operate in a spatial efficient manner because of the fixed nature of land as a production factor. Following Alonso's (1964) model of land use, Daly and Webber (1973) incorporate firm's investment decisions with respect to location and relocation. In essence they state that when a factory site can no longer accommodate growth, meaning the combination between the fixed size of the site and an optimum combination of labour and capital is stretched to the limit, a new location is sought involving relocation costs. In their line of reasoning, a firm will only relocate when the net gains from increased sales and economics of scale outweigh the friction cost of staying put and the cost of relocation. Furthermore, they argue that every relocation involves an increase in the plot size and sub-optimal site use. The reason is that expected growth lead firms to reserve considerable areas of for future requirements, which may never be used when expected growth rates are not met (Van Haveren et al., 1999). However, as land costs are a very small portion of total fixed capital investments; these extra costs are small compared to costs of relocation. Balowe (1958: 137) has pointed at the same mechanism by stating:

> "Individual producers always operate in a series of short-run periods during which they are limited by various fixed factors such as land. But when these periods are treated together as part of the long-run situation, all fixed factors become variable. The supply of land resources available to individual operators over this longer run can change with individual adjustment."

These individual adjustments are in most cases relocations (including new plants, opening branch plants of mergers with other firms). Thus, in the long run land is a variable factor of production. Nevertheless, because relocation decisions are not taken that often the amount of land held by a firm "…becomes relative fixed and the costs of acquiring and holding the land may be treated as a fixed or 'sunk' cost'" (Barlowe 1958: 137).

Clearly, there exists a trade-off between spatial efficient production and the adaptability of the production site to possible growth. This trade-off is biased towards inefficient land use because, as stated before, extra land costs are marginal compared to costs of relocation.

However, this does not imply that more extensive land use is an inefficient decision from the firms' perspective. As long as the expected cost of holding idle land is lower than the expected cost of relocation, there are good reasons to do so.

5 Final remarks

For various reasons a society may pursue the preservation of open land. In order to achieve this goal, the production factor land for economic activities should be used in an efficient way. The aim of this paper was to find leads in past and present conceptualisations of the production factor land that will enable us to study the quantity of land used by firms within a theoretical framework.

The role of land in mainstream economic theory has disappeared. Only in the early ages of economic science as a science land played a significant role because of its evident role in the prime economic sector of that time, that is agriculture. As soon as the importance of agriculture diminished relative to trade, industry and services the attention for land decreased sharply. Although, many economist tried to incorporate land into their analysis the role of land became marginal compared to other factors of production as capital and labour. In many cases land is just another and less important kind of capital.

Land only plays a major role in specialized sub-fields within economics such as regional and urban economics. In these fields there seems to be agreement on location is the *significant* factor in determining both land use and land values. If land has any distinctive quality it is the location. Traditionally, regional scientists have captured the idea of location by appealing to one-dimensional measures such as access or distance measures. Because every location is unique, land is by its very nature heterogeneous. Another attribute that make land heterogeneous is that no two parcels are alike. Differences may arise due to size, shape and topography. Beside these physical of natural properties, the uniqueness of land also arises from its institutional properties which frame economic behavior (Hubacek and Vazquez, 2002). For these reasons, according to Hubacek and Vazques (2002), land is a distinct factor of production and consumption.

From our literature review it appeared that land was used as a factor of production in three different ways in micro and macro economics (see table 1):

1. Land as a natural resource. In this context land has a resource component related to innate conditions.
2. Land as location. Because land is physically immobile it remains fixed in space and has location-specific attributes, which makes it well or less suitable as an industrial production site.
3. Quantity of land. Land as a production site is not a point in space, but an amount of land on which productive resource allocation takes place.

Table 1 Elements of land as production factor in micro and macro economic theory.

	micro perspective	macro perspective
Land as natural resource	Agricultural economics	Physiocrats. Classical economists Environmental economics/ sustainable growth.
Location	Mainstream urban economics and regional science on housing and firms	New economic geography
Quantity of land	Housing economics. Implicitly existent in neo-classical logic. Mentioned by Alonso but no empirical work on firms.	Intensity of land use

We can conclude that the demand for industrial land in economics in general and in regional science in particular leads a marginal existence. That is strange when because the attention of environmental economics and urban sprawl is increasing. From our review it seems that there are two ways forward that are applicable for empirical research into productivity and efficiency of land use. The first is the standard Neo-Classical concept of equating the marginal costs and marginal productivity, meaning that a firm will obtain the amount of land that is optimal from cost and productivity perspective. However, we have to recognize that land is a fixed factor of production in the short run. Therefore, firms are likely to hold,

initially, more land than strictly necessary. Although a rational decision for the firm, on societal level this is inefficient land use. Therefore we have to find a way in which we can identify the difference between actual land use by firms and its most efficient land use, that is the land use in which on a fixed amount of land the other production factors are used to its maximum capacity.

The second way forward is to measure the actual productivity of industrial land (or intensity of land use) in a more aggregative way and to compare different regions in their land use. This closely resembles the way economists and regional scientist study differences in the production factor labour.

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