Empirical support for a theory of spatial capital: Housing prices in Oslo and land values in Gothenburg

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EMPIRICAL SUPPORT FOR A THEORY OF SPATIAL CAPITAL

Housing prices in Oslo and land values in Gothenburg

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ABSTRACT

Land is, besides labour and capital, one of the classic production factors in economic theory. However, neoclassical economics dominating the 20th century, simplified production theory to only labour and capital, treating land either as just another form of capital or as the natural resources it harbours. This hides the central role of land – in the meaning of spatial extension and location – for contemporary economies, where land rent is an essential cost and location a productive factor for most economic activities, not least since these increasingly are located in cities. Critical here is the confusion often found concerning property values and the distinction between land and improvements, the latter most often constituted by buildings, where buildings quite naturally can be treated as capital, while land cannot. Importantly, while property value can be increased by its owner through improvements, such as new buildings, she is very limited in influencing the land value, since this is a collective variable dependent on the economic development of the city as a whole. It is here proposed that improvements on land in contemporary urbanised economies to a dominant degree concern systems of centrality and accessibility generating relative locations, that are further enhanced by buildings and land division, and that this constitutes what is proposed to be called a spatial capital, which to a large degree is created through the practices of urban planning and design.

In this paper we investigate the dependency of spatial form on land value. First, we review how spatial form and the configurations of accessibility it generates on land, influences housing prices to find support for the intimate relationship between relative location and monetary market values. Second, we investigate the dominance of land values compared to improvement values in four Swedish cities of different size Third, we investigate how known parameters of spatial form correlates with land values in Gothenburg, Sweden. We see close associations between spatial form and land values, both in shape of market housing prices and as property taxation values. Land value holds a larger share of total property taxation value in larger cities, suggesting that relative location is valued higher where economic activity is greater. Furthermore, we find clear correlations between spatial form and land taxation values. Altogether, these findings indicate that spatial capital encompasses monetary value. In extension, these findings also indicate how knowledge based and skilful urban planning and design can create measurable value.

KEYWORDS

Spatial form, urban systems, land value, housing prices, spatial capital.

1. INTRODUCTION: the definition and design of land value

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Land is, besides *labour* and *capital*, one of the classic production factors in economic theory. However, neoclassical economics, dominating the 20th century, simplified production theory to only labour and capital, treating land either as just another form of capital or as the natural resources it harbours (Gaffney 1994). This hides the central role of land – in the meaning of spatial extension and location – for our contemporary economies, despite land rent being an essential cost and location a productive factor for most economic activities, not least since we increasingly live in an urbanised world (e.g. Ryan-Collins, 2017). Critical here is the common confusion concerning property values due to the common lack of distinction between *land* and *improvements*, where the latter most often are constituted by buildings, which quite naturally can be treated as capital, while land cannot. However, property values are dependent on both. Importantly, while property values can be increased by land owners through property improvements, such as new buildings, they are very limited in their ability to influence land values, since this is a collective variable dependent on the economic development of the city or region as a whole. That land and improvements are two distinct things is evident by the fact that an identical building constructed in different cities or even in different locations within the same city, give rise to different property values since land values vary. At the same time, general economic progress raises land values and can immediately be collected by land owners by rising property values, independent of whether any improvements have been made by them or not. All this have been fundamental in economic theory since the days of David Ricardo (Ricardo, 2004 [1817]).

Within the broader frame of economic development, land values were in Ricardo's times, economically dominated by agriculture, primarily dependent on soil quality, while they in the modern industrial economy primarily are dependent on *relative location* as defined by *accessibility*, which generally is recognised as related to larger infrastructural investments for different forms of transport. For the contemporary and increasingly knowledge-based economy we see this reflected in the emphasis on the proximity offered by cities where the choice of location for economic activity often is argued as crucial (e.g. Florida 2002, Porter 1998). On the urban scale, however, accessibility is not only due to infrastructural investments but equally to the *configuration of urban space*, as extensively studied in space syntax research for instance. Moreover, given the close connection between land value and location defined by accessibility, it is quite clear how the practices of urban planning and design, if properly handled, generates tremendous collective value to society but also to individual land owners.

However, the awareness of this in these practices as well as the proper knowledge and skill to fully realise this potential, can today be questioned, in particular if we separate land from improvements and public value from private value. We put forth the proposition that we today increasingly see urban development driven by private interest by way of intensified exploitation of established location in the aim to generate short term raises in property value. That is, urban development as property development, in contrast to development driven by public interest by way of urban planning and design creating new location and generating long term land values, that is, urban development as land development.

Central for understanding the composite character of property value better and improving professional practice in this regard, are models that can capture patterns of accessibility defining location on a detailed urban scale. Space syntax research has here broken new ground (Hillier and Hanson 1984) and has also been extended to incorporate both other variables of spatial form, such as *density* and *differentiation* (Marcus et al. 2017) and *attractions* of different kinds (Ståhle et al. 2005; Berghauser Pont et al 2017), thereby providing rich fine-scale models of the spatial form of cities. Extensive research has also firmly established how the spatial form of cities support and structure different social and economic systems and

processes in cities (Vaughan 2009; Legeby 2013; Law et al. 2013; Heyman 2018), which has led to the argument that it constitutes a *spatial capital* that can be made to enhance the value of such processes (Marcus 2010; 2017). First steps have also been taken concerning urban ecosystems in this regard (Marcus et al 2013; Berghauser Pont et al 2017).

This paper aims to give a firmer definition of spatial capital and also give further empirical proof in economic terms of the value of such a capital. First by presenting an extensive analysis of how housing prices in the city of Oslo vary according to patterns of accessibility in general as well as to accessibility to particular amenities and attractions, such as commercial services and green areas, as defined by the configuration of urban space. This indicates how spatial capital is valued in monetary terms. Second, by correlating such patterns of accessibility with property taxation values in the city of Gothenburg, where these are differentiated into land values and improvement values, indicating that the notion of spatial capital capture vital parts of the common but often evasive notion of land value. Importantly, these findings are also strong indicators of the values created by knowledge-based and skilfully performed urban planning and design.

In the following, we will first give a brief introduction to the concept of capital more generally in the aim to situate the idea of spatial capital in a broader economic context. Next, we will present a study in Oslo, relating housing prices to patterns of accessibility. Third, we investigate such patterns of accessibility in Gothenburg with property taxation values. Finally, we draw conclusion of these studies in relation to a possible theory of spatial capital.

2. THE LOST FACTOR OF PRODUCTION: a brief history of land in economic theory

In classical political economy, as theoretically developed primarily by Adam Smith (1723-1790) and David Ricardo (1772-1823), *land* and *capital* are two of the three factors of production at the side of *labour* (Brown et al.. 2007, p. 336). While labour is a fairly straightforward factor, land and capital both comprise conflicting aspects in themselves and are also often confused with each other. In the times of the classical economists, land primarily concerned land for agricultural uses but it also comprised natural resources as extracted in mining. Moreover, it could also relate to the spatial extension and location of land *per se*. As for capital, the terminology is often confusing since it relates to particular theoretical interpretation of the economy, most typically the very specific conception of capital in Marxist theory.

Smith divided capital into *fixed and circulating capital*, where the latter concerned assets used up in the production process, such as raw materials and money for wages. Fixed capital on the other hand, were assets not immediately used up in this process, such as tools, machines and buildings. Smith identified no less than four different forms of fixed capital that are useful to list since they are both explanatory and highlight a bit of the subsequent confusion (Smith 1776 (2007), p.179). He lists, first: “useful machines and instruments of trade, which facilitate and abridge labour”. Second: “those profitable buildings which are the means of procuring a revenue […] such as shops, warehouses, work-houses, farm-houses, with all their necessary buildings, granaries, stables, etc.”, where he made the interesting specification: “They are a sort of instruments of trade, and may be considered in the same light.” Third: “the improvements of land, of what has been profitably laid out in clearing, draining, inclosing, manuring, and reducing it into the condition most proper for tillage and culture.” Finally: “the acquired and useful abilities of all the inhabitants and members of the society”, which comes very close to what we today refer to as human capital and rather sort under the third factor of production, labour. The first three also fit very well the common definition of capital as *embodied work*. Summarising, we see how capital in Smith’s conception

often come very close to land, especially fixed capital of the second and third kind, which to some degree overlap. On the one hand, land is a thing in itself, at the same time, improvements of land, such as buildings, clearings, draining, inclosing and manuring, are considered capital, which helps us see how the two easily could be conflated.

However, the factors of production were not as central a theme for Smith as it became for Ricardo, who developed more stringent distinctions here, both between the factors themselves, but also within them, as between fixed and circulating capital. His most original contributions, however, concerned land where he in the aftermath of the Napoleonic wars observed how the demand for land had rapidly increased due to the tolls on corn introduced during the war, and how this in turn had increased the rents possible for land-owners to draw. This meant that despite the burgeoning capitalist economy of the time – where the productive factors capital in the form of factories and machines, and labour in the form of a growing class of workers, were the dominant drivers – increasing portions of the wealth it generated did not go to industrialists in the form of *profit* or workers in the form of *wages*, but fell into the pockets of land-owners in the form of *rent*, without these having made any contribution to the economic growth. Ricardo's remedy was to abolish tolls and open for free trade, in particular of corn, to dampen the demand for land, which in turn would reduce rents and lower the price on corn to the benefit of the poor.

It is important to note how even though all these terms also are found in Marxist theory, most prominently in *Capital* (1992 [1867]) – Marx being both a vociferous student and critique of classical political economy – but that he gives them a very particular meaning not always congruent with the terminology of mainstream economics. The reason is that Marx is adamant in stressing how he is investigating a particular form of economic production called capitalism that appears in a specific historic period and therefore is a social construct and not something naturally given, which he accuses other economists of believing. Capital, as well as many other economic terms, therefore receives a very particular meaning related to his over-all theory about the workings of capitalism. While it would be exciting to investigate the potential of our concept spatial capital in such a Marxist framework – extending David Harvey's life-long ambition to spatialise Marx – that is not the aim of this paper, which rather sticks to the terminology of main-stream economics and especially relates to the conceptions found in classical political economy.

With the neo-classical school taking the place of the classical school during the second half of the 19th century, the ontological foundations of economic theory became far more abstract. Ricardo's theory of value for instance, in which value only could be created by labour – an idea taken up by Marx but typically given a different meaning – was ousted in favour of marginal theory where value increasingly came to be equated with the price set by supply and demand – a transition echoing Oscar Wilde's remark about the cynic: a man that knows the price of everything but the value of nothing. Similarly, it meant a less material interpretation of the factors of production, where the firm, which now increasingly was conceived of as the central agent in production, altered the composition of factors in its production depending on market prices set by supply and demand; for instance, exchanging capital for labour in times of rising wages. Hence, capital received a far more abstract and generalised definition, where it rather than as "embodied work" now was defined as "assets that may generate future income streams".

This meant that all factors of production could be interpreted as forms of capital, which however hid their particular properties. While this led to a rather heated debate about the degree to which labour actually is exchangeable with capital, land more quietly came to be subsumed as capital, not least since the two often seemed to overlap as in Smith's list above, leaving capital and labour as the two factors in modern

production theory. This echoes Marxist theory, where the central theme is the struggle between capital and labour, although again, his argument is set in a very different theoretical framework.

Hence, land disappeared from economic theory in the 20th century, broadly speaking, also since it primarily was concerned with the industrial economy, where land seemed an outdated factor related to agriculture. More recently, however, land has for several reasons started to return as a vital issue in economic theory. On the one hand in the meaning of natural resources, where the abstract understanding of these as a form of capital that simply can be added to the production process according to prices set by the market, has proven an increasingly problematic conception, since markets have demonstrated great ineptness in setting prices that support environmental sustainability (e.g. de Perthuis and Jouvet 2015). On the other hand, as already touched upon, modern knowledge-based economies are highly dependent on location, drawing as they do on the insight by Alfred Marshal, who explained the kind of aggregation economies found in cities by spatial proximity, so that: “the mysteries of the trade become no mysteries; but are as it were in the air”. In extension, land is not only central for modern knowledge-based production, but also as the location of attractive housing for employees. Hence, housing can be said to have taken on the role of agriculture as the most common and valuable use of land. Thereby, it has also come to play a central role for the economy in general and has not least been identified to play a critical role in our recurrent economic crises (Harrison 1983, 2010; Ryan-Collins, 2017).

3. SPATIAL CAPITAL: bridging capital to land

While land and capital may be confused, especially when speaking of fixed capital, at closer scrutiny it is obvious that land constitutes something very different from capital. The list can be made long but we may settle for three decisive differences underlined by Mason Gaffney, an economic scholar that consistently has emphasised the central role of land also for modern production (Gaffney 1994). First, land cannot be produced, it is something given and limited to the spatial extension of the surface of our planet. It can certainly be enhanced and intensified by human construction, including tall buildings and recovery of land from the sea, but then we move into the area of improvements, which traditionally sort as capital. Capital on the other hand is by definition produced, whether it concerns buildings, machines or tools, and is often defined as “that which is produced but yet not used up” (Gaffney 1994). Second, while capital typically depreciates over time as it wears or becomes out-dated, land neither wears or becomes out-dated, but rather appreciates over time, due to the fact that land becomes scarcer as populations and economies grow. Third, land is fixed and not mobile as most capital, why it cannot be moved to where it is needed, something even a lot of fixed capital, such as machines and even buildings can be.

These fundamental differences clearly indicate that it is problematic to treat land as interchangeable with other productive factors such as labour or capital. For instance, if the demand for land increases, it is not immediately possible to produce more, which generally is the case for capital and labour – the latter by training rather than breeding. It may be possible in the sense that one may find land of a demanded type in a new location or that one may improve land to satisfy such demands, but demand of land often concerns land at particular locations, for instance the CBD of large cities, which cannot be produced, the reason land typically is regarded as monopolistic. Hence, in such locations we often see huge investments in improvements of land in the form of tall buildings. We may say that such buildings are a way of exchanging capital for land, but this is not really true since this capital is still reliant on the location of land. Moreover, the monopolistic character of land means that it is only the owner of this land that can draw the benefits of the land itself as well as its improvements – a reason for the continuing debate about the rights to own land (Linklater 2014).

So, what do we more specifically mean by spatial capital in this context. First, we must consider the rather dim distinction between land and capital in the particular meaning of land improvements. If we put aside the understanding of land as natural resources possible to extract from land, for instance in mining or fishing, the difference between land as given and land as improved by humans, may prove difficult to detect. Today most land, whether urban or rural, is decisively influenced, for better or worse, by human activity. Land in its pure state may today prove difficult to find, something perhaps less true in the times of Smith and Ricardo, especially if we think of the colonial view on the Americas at the time. We may therefore choose to stick to a definition of land as strictly location and spatial extension. However, we also need to acknowledge that the character of land as given by nature also varies. Very large parts are for instance covered by water and other large parts have dramatic variations in height. We also find great varieties in soil quality that give rise to an equally great variety in vegetation and in extension also in animal life. Moreover, depending on location on the globe, land exists under very varying climatic conditions. All these variations are independent of direct human intervention.

Acknowledging the above, we argue that spatial capital concerns fixed capital used for improvement of land but of a particular kind constituting a sub-group that only partly overlaps with the rather motley types listed by Smith. It certainly includes buildings and some of the improvements he lists, such as clearing and inclosing, but perhaps not draining and certainly not manuring, that is, we look for land improvements close to what we recognise as architectural interventions, which can enhance the function, meaning and value of land. Importantly, however, we want to extend beyond Smith's list and as fixed capital include also systems of accessibility, as facilitated by roads and streets for instance.

If land on the most basic level is spatial extensions with particular locations on the surface of our planet, keeping in mind the much-varied character and conditions of this land, spatial capital would concern how such spatial extension and location may be altered by humans. An important distinction here is then between *absolute location* and *relative location*, where the first concerns different geographic locations on the globe, which we for instance may describe using the coordinates given by longitudes and latitudes. This sets all land within a neutral isometric grid independent of any local qualities or conditions. Relative location, on the other hand, concerns the relation between locations. On a fundamental level such relations can be said to already be described by an isometric system of the kind above, but we may also describe such relations from some particular perspective. A common and for humans most useful approach is to describe relations between locations from the point of view of accessibility for humans. This can be done in many ways, including describing different forms of infrastructure for transport. This gives rise to very different and far more differentiated descriptions of land than isometric grids, it may for instance take the form of road maps.

If we take this to the urban level, we recognise typical street maps as doing the same thing, describing relations between locations from the point of view of human accessibility. We then realise that cities are situations of very intensely improved land, where these improvements constitute an extensive capital related to human use that enhances its function, meaning and value. We therefore primarily include both buildings and streets in spatial capital where the configuration of streets create strictly defined relations between locations by means of accessibility, while buildings enhance the potential land use of these locations producing more space in these locations than given by nature. To this we also want to add the possibility to differentiate land by land division into systems of plots that can be designated to particular owners or proprietors, whereby the diversity of actors and uses may be increased. Hence, we here define spatial capital as improvements of land, using the architectural means of spatial form and more

particularly the variables distance (streets), density (buildings) and differentiation (plots). Open space, such as parks and squares, then represent locations with low density in the absence of buildings. An important remark here is that spatial capital in the sense we discuss it here, is not an entity where an increase in any of these variables in itself is something good or valuable, but rather how they are combined and designed into an urban landscape related to particular human uses. Hence, borrowing and extending on an apposite remark made by Brent Toderian, former planning director of Vancouver: “it is not how dense, accessible and differentiated you make it, but how you make it dense, accessible and differentiated”.

4. SPATIAL CAPITAL: empirical investigation

Now, to examine the existence of such a capital that enhances the value of land we on the one hand, briefly investigate some previous empirical studies on accessibility and property values, and on the other hand, perform a new empirical investigation more specifically concerning accessibility and land values, which we consider a tentative investigation of the value of spatial capital.

That there exists a relation between location and property values is nothing new, if anything it has become common wisdom through the saying that what determines property values are three things: location, location and location, and there is a great magnitude of studies applying a series of approaches to support this wisdom. However, there are two entry points to studies of this relation; one is to try to build predictive models for property values, the other is to estimate monetary values for non-market goods, such as parks or public transit, through the property market. In both cases it is known that prices vary over time and space, hence, these factors are controlled for in the analyses. However, the different entry points give different incentives for the description of location.

In the case of property price prediction models, the description of location that explains prices better is preferably used. Consequently, studies of this type often rely on different descriptions of absolute space, most often area based. While this generally explains price variation over space well, it also carries inherent problems. First, the way areas are defined in these spatial descriptions are often arbitrary in relation to most urban processes as well as actual urban life. What often is used are administrative areas, census areas or zip code areas, since these often are the spatial units where data are collected or at least made accessible, but they rarely have a natural relation to urban processes or urban life; there are no processes of particular importance taking place within zip code areas beyond mail delivery and as individuals we typically do not have any particular relation to census areas and neither to particular city districts as they may have been spatially defined; most often we do not even know their exact boundaries. Second, being descriptions of absolute space, they are weak in capturing relations between locations, for instance between an urban area and its adjacent areas, even though we realise that such relations may have great influence on urban processes and urban life, for instance when it comes to property values. Finally, since these descriptions have an arbitrary relation to the processes they contain, they do not help us identify any spatial means that may influence these processes; that is, it is difficult to turn such studies into policy or professional intervention. It should be mentioned that there is a brand-factor to property values that is bound to the absolute description of location. An example is a neighbourhood with good reputation, which will reflect in higher selling prices for dwellings in that area simply because the dwellings are located in the absolute location of that neighbourhood. This is tested by Heyman and Sommervoll (submitted manuscript) by adding relative attributes of location in an economic valuation model that is based on absolute descriptions of location. It turns out that the relative location predicts the

prices better than the absolute and consequently makes the absolute locations lose their significance in the model. However, this is not true for all absolute locations, which suggests that there is a brand-factor.

Even though these deficiencies do not always matter, depending on the aggregation or purpose of the study, we below turn to descriptions of relative location in an effort to remedy them for studies when these things do matter. Moreover, as argued above, we here understand such descriptions to have the ability to capture what we have discussed as spatial capital. In recent decades we have also seen a development where both the generation of geographic data and increase in computer power has made it possible to refine and extend spatial descriptions to also capture relative location. In principle, one can categorize these measures into accessibility measures and centrality measures. Both have many forms and shapes, but the difference is that pure centrality measures only uses its own network, of whatever format, to calculate the centrality. Accessibility, on the other hand, can be conceptualized to be to or from something, for example access to public transit or from work places (Handy and Niemeier, 1997). Combined, one could argue that they can explain what is in a location. This is what we refer to as the relative location, a place in relation to other places, as opposed to the absolute location, which is just the notion of where in space a place is located.

Another fundamental matter in the empirical investigation of this is what we mean by value. This is a discussion that could be extended very far, even if we keep to value in economic theory (Mazzucato 2018). In this study, we are specifically interested in land value, which is hard to isolate from the value of improvements, since improvements, such as buildings, most often are attached to land. For the rare cases of properties without improvements, such are typically sold too seldom to build up a large enough sample for empirical analysis. In the Scandinavian context, this empirically present two options; using housing prices or land taxation values as dependent variable. The former provides market values, which make the inference to preferences clear, but it has no separation between land value and improvement value. The latter has a clear separation between land and improvement value, but is partly modelled, which gives a weaker connection to market preferences. It is also clear that the building value and land value are highly correlated in the Swedish land taxation values.

4.1 Relative location and housing prices

The most common approach to estimate effects of relative location on property values is by regression analysis with property prices as dependent variable and characteristics of the property as independent, also referred to as a hedonic price model (Kain and Quigley, 1970; Rosen, 1974). Although not referred to as relative location, a number of studies have used accessibility measures as descriptions of relative location to estimate revealed preferences in the property market and the monetary value of individual attributes of the relative location. On a fundamental level the estimations of monetary values are sensitive to the specifications of relative location variables, not least with regards to spatial aggregation (Lee et al., 2016). Furthermore, the specification of accessibility varies greatly between studies and consequently corresponds more or less well with the consumer and seller perception, which influences the interpretability (Law 2018; Heyman et al., 2019).

We define relative location as accessibility and centrality, where both have many different shapes. It is evident that access to places is well reflected in the property market (Law 2018; Heyman et al., 2019). Generally, access to green spaces, water, urban amenities and public transit is highly appreciated in the housing market, but the relationship varies both with quality of the place and with distance. For example, the willingness to pay for access to park depends on the size (Czembrowski and Kronenberg, 2016), but

the relationship between the distance and housing prices is highly non-linear (Heyman et al., submitted manuscript).

It has repeatedly also been shown that centrality, in terms of network integration as applied in space syntax methodology, has a significant impact on prices (Heyman et al., 2017; Heyman and Manum, 2016; Law et al., 2013; Law 2018; Shen and Karimi, 2017). It is, however, not always straight-forward to interpret the relationship. Generally, the global or large radius integration measures are associated with higher prices, while local lower radius integration has a negative impact (Chiaradia et al., 2013, 2009; Heyman et al., submitted manuscript). This can be interpreted as if central locations in cities as a whole are preferable, but immediate adjacency to local high streets are not. That is, homebuyers prefer central locations but at a distance from busy streets. However, the relationship between network integration and housing prices becomes more difficult to interpret when a spatial factor is added to the hedonic model. Heyman et al. (submitted manuscript), finds that the estimated relationship between local integration and housing prices switches from positive to negative, and global integration loses its significance when a spatial gradient is included. One interpretation of this is that the network integration is collinear to the spatial gradient but less fit for the statistical model and therefore gets the coefficient estimations changed. This could paradoxically strengthen argumentation of the importance of network integration as a preference in the property market.

4.2 Relative location and land values

Land taxation values in Sweden

In Sweden, ownership of land and buildings is administered using a complete subdivision of all land areas into “properties”. A property is in the normal case made up by a single polygon, but in certain situations it can comprise several polygons. For all properties The Swedish Tax Agency have determined a taxation value which is normally updated each third year. By law,[3] taxation values are required to correspond to 75% of the current total market value (land and buildings) for the property, but partial values must also be determined for land and buildings separately. The tax agency has established detailed procedures for how to accomplish these assessments of market value. When such data is available the taxation values are based on representative sales prices and rental values. Properties are classified by type code, based on the usage of the land, and the type codes determine which sales events that are deemed representative for a certain property. Land usage and type codes are in most cases the effect of local planning restrictions.

Fundamental urban economic theory (Alonso, 1964), as well as empirical data on Swedish taxation values clearly shows that market values for land is significantly higher per unit of land area in more dense and central parts of urban regions and cities. Using a data set with taxation values for all properties in Sweden we have created maps with the relative ratio of land taxation to total taxation value for four cities of increasing size (Figure 1).

The smallest of the cities, Skara, is situated in a rural region of West Sweden. For most properties in this city, the building values dominates the taxation value. However, gradually shifting the focus towards larger cities reveals that land value becomes a larger part of the total value. For the parts of Stockholm that are shown in the map, it is clear that land value represents the largest part of the total taxation value.

[3] https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/fastighetstaxeringslag-19791152_sfs-1979-1152

This trend is visible both for single-family residential properties as well as apartment and commercial properties, and indicates that centrality disproportionately drives land value, compared to building value.

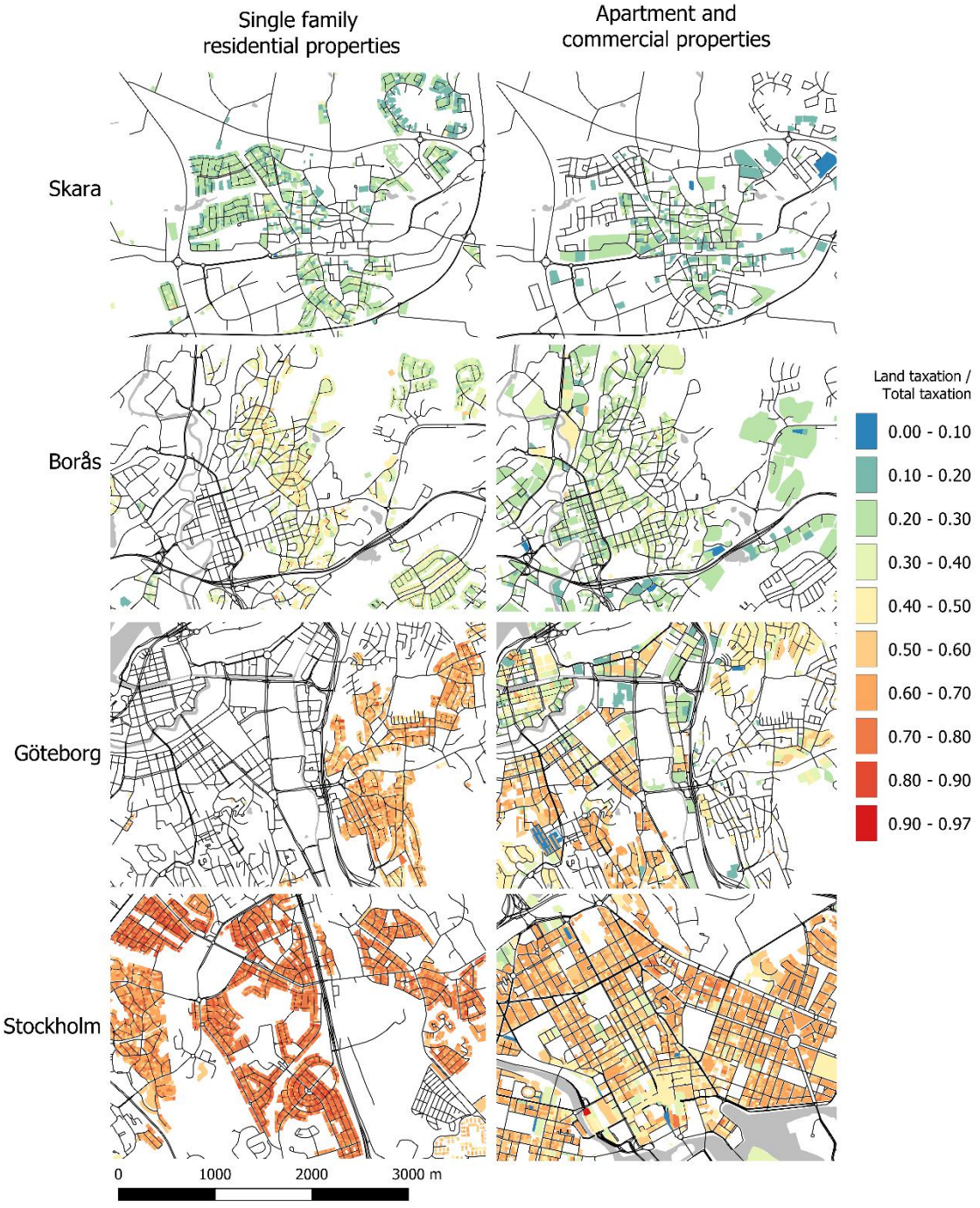

Figure 1. Ratio of land taxation value to total taxation value, for parts of four different Swedish cities of increasing size from top to bottom. Approximate populations (2015) are: Skara – 11 000, Borås – 71 000, Gothenburg/Göteborg - 570 000 and Stockholm - 1 500 000. The left column of panels shows properties consisting of single-family residential housing units. The right column shows properties consisting of apartment and commercial buildings. Properties with mixed type codes are excluded as well as industrial, agricultural and other special property types. Also excluded are those properties with a building value below 200 000 kr.

What drives land value in an urban system?

Land taxation values on the national level in Sweden are power law distributed (Andersson, Frenken, Hellervik, 2006), which points towards an underlying process of random multiplicative growth (Gabaix, 2016). In network terminology, these types of processes are often framed as "preferential attachment". However due to the fundamental spatial nature of land value, there are strong spatial decencies in the growth process, making it less plausible that it would be totally random. By combining a spatial interaction model with a preferential attachment process of growth and redistribution, a new type of centrality measure can be computed. This "preferential centrality" has been shown to correlate with property taxation values in Gothenburg, which is an indication that property values are strongly influenced by the accessibility afforded by the underlying physical road network (Hellervik, Nilsson, Andersson, forthcoming).

In the following analysis we show that land values also correlate with centrality measures used in space syntax research, angular integration and angular betweenness centrality (i.e. angular choice).

Land taxation values in Gothenburg - correlations

Using models of both the motorised and non-motorised street network for Gothenburg, basic correlations were conducted with land values from The Swedish Tax Authorities, as described above (Figure 2).

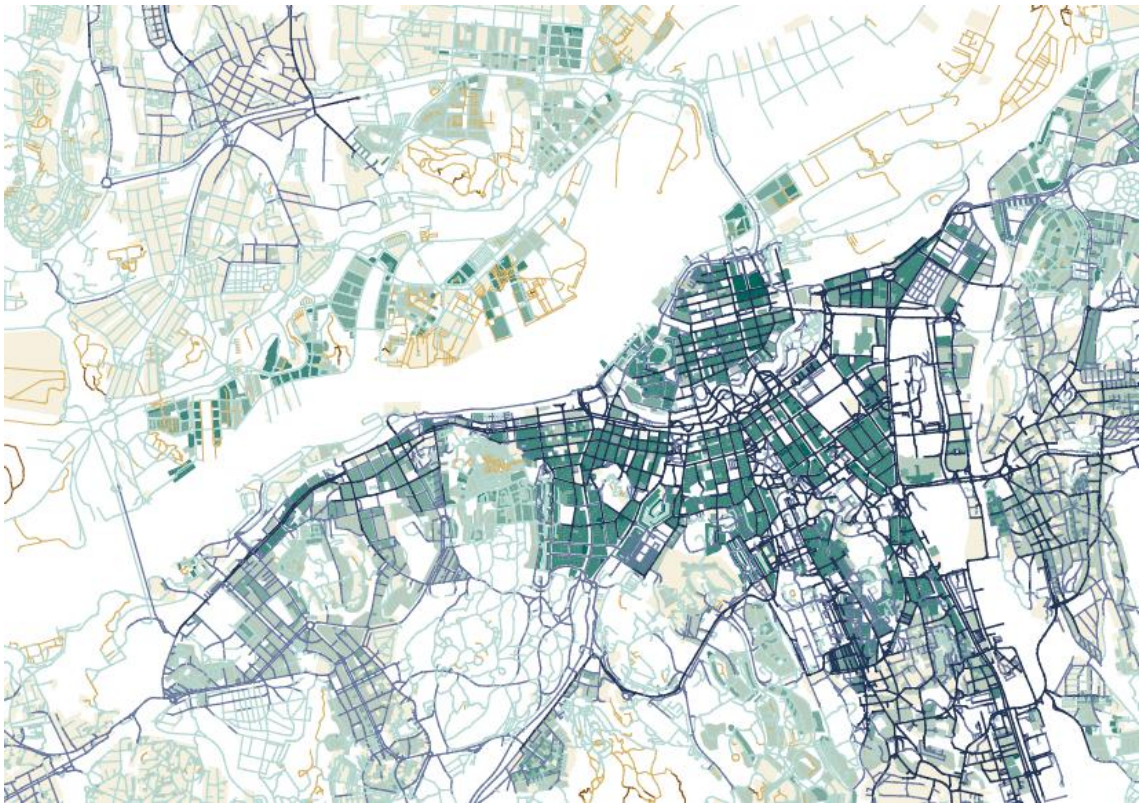

Figure 2. Accessible land values within 500m (plot system) and integration 5000m (street network), using the non-motorised network of Gothenburg.

More specifically, what is correlated is both accessible land and building values within 500m from every street segment, divided respectively by the accessible property area within 500m. That way we controlled for the different size of the properties, that also affects their land and building value.

In the following correlation analysis land with two different types of land-use were investigated. On the one hand land with villas, separate family houses, vacation homes etc. On the other hand, land with multi-storey apartment buildings, offices, commerce etc. This means that land with water, parks, industrial, agricultural, public buildings (hospitals, universities etc.) and other property types of specific kinds. were excluded. We also need to keep in mind that land values and building values are strongly correlated (R^2=0.835).

Angular centrality measures in ten different radii, ranging from 500 to 5000m with intervals of 500m, were tested. The following results correspond to the highest R^2-values.

Non-motorised network and land values: Angular Betweeness centrality 500m (R^2=0,195), Angular Integration 4000m (R^2=0,231).

Motorised network and land values: Angular Betweeness centrality 1000m (R^2=0,309), Angular Integration 5000m (R^2=0,145).

All correlations are significant at 0.01 level.

We conclude that for Gothenburg, there is a significant correlation between centrality measures used in space syntax research and land values. This correlation may look weaker than expected, but the study is to be seen as preliminary and far from ideally designed for its purposes. First, we do not deal with market prices but partially modelled land taxation values. Second, the selections include rather distinct land-uses that will influence the correlation. Third, the relation is not necessarily linear as also demonstrated in hedonic studies of housing prices. Hence, we see this as a promising result that reveals that what here has been defined as spatial capital does represent an economic value. The other way around, we may conclude that spatial capital seems to have a significant impact on land value. However, the results also clearly ask for further and more precise studies.

Land taxation values in Gothenburg – regression models.

Above, we defined spatial capital not only as centrality as created by urban street networks but also enhanced by the distribution of density generated by buildings and differentiation created by land division. We therefore also investigate the impact of these variables on land value by creating a multiple regression model that includes them. Again, we did this both for the motorised and non-motorised network. In both cases, the dependent variable was Accessible land value within 500m/Accessible property area within 500m. The explanatory variables were: Angular Integration (r=5000m), Angular Betweenness (r=500m), Accessible FSI (r=500m) and Accessible number of plots (r=500m), where accessible FSI is a location based way of measuring building density and accessible plots concern how many plots you access within a certain radius. The natural log (ln) was used for all variables except Angular Integration, because of their non-linear distribution. The results are summarized in the tables below.

Model summary for non-motorised network[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.702[a]	.492	.492	.76565

a. Predictors: (Constant), Int5000, LnBet500, LnFSI, LnPlots

b. Dependent Variable: LnLandValuebyLandArea

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	-.249	.014		-17.888	.000		
	LnBet500	.081	.001	.107	65.811	.000	.845	1.184
	LnPlots	.132	.002	.131	74.640	.000	.724	1.380
	LnFSI	.486	.002	.518	301.620	.000	.753	1.328
	Int5000	1.763	.021	.141	84.109	.000	.787	1.271

a. Dependent Variable: LnLandValuebyLandArea

Model summary for motorized network[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.757[a]	.573	.573	.75896

a. Predictors: (Constant), LnBet1000, LnPlots, LnFSI, Int5000

b. Dependent Variable: LnLandValuebyLandArea

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	-2.395	.028		-84.625	.000		
	LnFSI	.470	.002	.493	195.336	.000	.751	1.332
	LnPlots	.143	.003	.130	51.887	.000	.763	1.311
	Int5000	1.016	.026	.109	39.698	.000	.633	1.580
	lnBet1000	.497	.005	.270	91.134	.000	.544	1.838

a. Dependent Variable: LnLandValuebyLandArea

Regarding the regression model we conclude that in both cases spatial capital as defined here, to a significant degree explain land value. The model based on the motorized network explains better (R^2=0,57) than the one for the non-motorized (R^2=0,49). In both models, all variables also significantly contribute. Centrality and density have the largest influences, but importantly differentiation through land division is also significant in both models. Again, we understand this as indications that there are convincing connections between what we have defined as spatial capital and land value, worthy of further investigations.

5. SPATIAL CAPITAL: towards a theory about land

Relative location is more important in urban areas, where urban processes drive economic growth and thereby land values. Furthermore, relative location is reflected in the housing market, suggesting that it is not only underlying urban economic processes that drives property values, but it is considered by homebuyers. From previous studies, we can also conclude that relative location is superior to absolute location in predicting housing prices, which supports the argument that the reflection of relative location in the housing market is causal, not only correlational. From the empirical support presented in this paper we can conclude that a monetary value of spatial capital can be captured in land. This is due to land's character of spatial extension and location, which conceptualized as relative location creates and accumulates collective value.

Hence, we in the practices of urban planning and design identify practices that generate substantial value by improving land through systems of centrality and accessibility that in turn may be enhanced by building density and land division, creating landscapes of locations that in different ways support and direct urban processes. The degree to which this is handled in an informed and skilful way naturally varies, but we do see the central role of these practices in generating urban values of both a qualitative and monetary kind.

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