Price Formation
in Real Estate Markets

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This thesis includes an introductory chapter and four individual papers. The papers are held together by concepts associated with price formation in real estate markets, differentiated goods and the local character of land and housing markets. The first two papers focus on the markets for land and agricultural property and the two succeeding studies on housing markets. The first study examines regional variations of Swedish agricultural land prices. The associated empirical model follows the form of earlier literature in testing the influence of expected returns from the current agricultural use of land and the potential for non-agricultural use on prices. The use of market transacted land and the inclusion of decoupled income support to farmers, among a set of agricultural and non-agricultural factors, distinguishes this study from earlier empirical work.

The second paper relates to the first by its focus on decoupled income support, but here the analysis extends to the micro level and to the study of price formation in the market for agricultural property. The study applies a spatial multilevel model to study variations in price determinants across and within local and regional markets.

The third paper is devoted to the analysis of housing prices and their relation to open landscape amenities. The spatial analysis employs two geographical databases containing single-family home sales and preserved open spaces. In order to address the local character of urban housing markets and intraurban heterogeneity in amenity valuations the study applies a geographically weighted regression approach.

The last paper focuses on the market for second homes with a particular emphasis on urban-rural interrelations. The paper is motivated by a growing demand for natural amenities and by the awareness that urban areas are becoming increasingly attractive markets for second homes.

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Abstract

This thesis includes an introductory chapter and four individual papers. The papers are held together by concepts associated with price formation in real estate markets, differentiated goods and the local character of land and housing markets. The first two papers focus on the markets for land and agricultural property and the two succeeding studies on housing markets. The first study examines regional variations of Swedish agricultural land prices. The associated empirical model follows the form of earlier literature in testing the influence of expected returns from the current agricultural use of land and the potential for non-agricultural use on prices. The use of market transacted land and the inclusion of decoupled income support to farmers, among a set of agricultural and non-agricultural factors, distinguishes this study from earlier empirical work.

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Part I
Introduction

Introduction and summary
of the thesis

1. Overview of papers and motivations

This thesis includes four papers, which divides into two parts. The objective of the first two papers is to study price formation in markets for agricultural land and farms. Several topics are examined in these papers, such as the influences of agricultural policies, rural amenities, and urban sprawl on prices. These papers can be positioned among the studies that focus on assessing second order impacts of agricultural support payments on prices of land and farms.

In the succeeding two papers, the interest is directed towards the study of house price formation. These two contributions present spatial hedonic methods to study the influences of urban and environmental amenities on house prices. These two papers can be positioned among studies that focus on the spatial distribution of amenities, their close relation to house prices and their role in shaping the urban and regional house price surface. Although the thesis consist of four separate papers, which can be read and understood independently, they are held together by concepts associated with price formation in real estate markets, differentiated goods and the local character of land and housing markets.

It is possible to give several motivations for an interest in empirical analyses with this orientation. Land and housing have key roles in all economies. Land can be seen both as a production factor and as an asset that allows for wealth accumulation and wealth transfer between generations.

Despite the great amount of research devoted to the study of land markets, it is possible to distinguish central topics in current research. One such topic concerns determinants of agricultural land prices. In particular, does support to agriculture capitalise into land prices and rents? Moreover, who benefits from these subsides in the end? The European Common Agricultural Policy reform (CAP 2003) marks a significant change in European agricultural policy and has altered the policy environment in which landowners and farmers operate. The introduction of a single annual payment for basic land maintenance has given rise to a number of questions when it comes to understanding the responses of European land markets and individual farmers. Around 40 percent of EU´s, total budget is devoted to the CAP (56.4 billion Euros) and around 31 billion

Euros or 55 percent of the total CAP budget is disbursed to farmers through decoupled single farm payments. The Common Agricultural Policy within the EU is one of the main drivers of change in agriculture and rural areas across member states. The increased focus on rural development at the EU level implies that countries have increased their emphasis on rural development, such as reducing social and economic inequalities between regions and striving to maintain rural farming. The objectives of the CAP 2003 reform are in line with these common goals. The reform implies moving away from coupled production subsidies towards more neutral subsidies, broader issues of rural development and consumer driven agriculture. One of the key issues still lacking sufficient coverage in the literature is how these policies affect land markets across member states. The theoretical literature suggest that besides the direct first-order effect of increasing the incomes of landowners, policy-induced growth in land prices may have negative side effects. The first two studies in this thesis add empirical evidence from Sweden where literature with this focus is still scarce.

The housing market shares many features with markets for land. Many households regard their house as an insurance and an asset that allows for wealth accumulation and wealth transfer. Land and housing are both complex goods and their fixed position in space imply that price patterns are local. Another element in these markets is the extreme durability of houses. The supply of land and housing changes only by a small fraction between periods, such that their physical structure is largely predetermined in the short run. Furthermore, both house and land prices are closely tied to the presence of amenities and market interactions, such that local heterogeneity and accessibility of nearby markets are central determinants of price patterns and growth of prices in these markets.

The performance and attractiveness of regional land and housing markets is closely tied to external local conditions. In order to attract households, a regional market has to offer a certain variety and scale of consumer amenities, which depends on the size of regions (Riviera-Batiz, 1988). External local conditions relates to the supply of natural and cultural amenities, which influence the attractiveness of regions as a place to live in (Brueckner et al., 1999). Land prices are also closely associated with urban proximity, since land close to urban markets carry a higher premium based on speculation for future changes in land use (Plantinga et al., 2002)

The concept of amenities is central in the study of price formation of most types of real estate. A great deal of what is important to people in their lives relates to amenities. People value attractive elements in their surroundings, in terms of landscape qualities, consumer amenities, transportation facilities and other public goods and services. A lot of research has been devoted to hedonic pricing and the study of amenity capitalisation. As noted by Malpezzi (2002, p. 27) *"Hedonic models have been applied in every permanently inhabited region of the globe"*.

Although there exist a most extensive amount of literature in this field there are still several emerging topics within housing economics. Perhaps, one of the most exciting areas for extending hedonic models is by making use of the spatial structure of housing data and the tools provided by geographic information systems. The increased supply of geocoded data has given rise to a new set of spatially explicit hedonic models that incorporates local and parcel specific heterogeneity. Recent contributions in this field show a substantial improvement in the fit of hedonic models using spatial methods. The purpose of the hedonic papers in this thesis is to contribute to this literature.

The purpose of this introductory chapter is to provide a background to the research questions addressed in this thesis, briefly outlined above. The next section presents an overview of the theoretical framework of the thesis. Given the focus of the papers, specific attention is given to concepts surrounding land use, residential location and the influences of agglomeration effects and environmental externalities on price formation in real estate markets. Since the last three papers in this thesis use hedonic price models, the third section provide a brief review of the hedonic model. The fourth section presents an overview of the various data sources used in the empirical analyses. The last section presents a summary of the four papers and highlights their main contributions.

2.   Land use and residential location

Land as an economic resource and the advantages it may provide are central for price formation in real estate markets. Prices of land and housing are strongly influenced by their distance to urban centres, owing to job accessibility, transportation costs and potential for land conversion (Arnott, 1979; Fujita, 1989; Plantinga et al., 2002).

The development of a theoretical foundation for considering economic activities that are extended in space and use land explicitly dates back to von Thünen, (1826). The theory of von Thünen considers a homogenous plain in which land is equally fertile, which is the plain of Euclidean geometry. In this framework, the spatial characteristic of a location is its distance to a market place and land prices and location decisions are driven by the cost of transporting goods to the market. This framework was developed for the urban context focusing on the size and density of urban areas (Isard, 1956; Wingo, 1961; Alonso, 1964; Beckmann, 1969; Puu, 1977) and the economic law of market areas (Launhardt, 1882; Weber, 1909; Fetter, 1924; Christaller, 1933; Palander, 1935; Lösch, 1954).

The regional science and land use models that originated in von Thünen (1826) were later re-specified into a formal utility maximization framework by Alonso (1964), and later extended, most notably by Muth, (1969), Mills, (1972) and Fujita, (1989). This model explains residential location choices as a trade-

off between market accessibility and residential space. The main similarities with the von Thünen model is that the urban area is assumed to be mono-centric and that there is one central market place to which all economic activities are concentrated, but now the marketplace is replaced by an employment centre. This implies that the only spatial characteristic that distinguishes a location from another is its distance to this central point.

For households, high market accessibility implies easy access to jobs and lower commuting costs. For farmers and landowners, it implies easy access to markets, lower transportation costs and higher competition for land between agricultural, industrial and residential activities in locations closer to the market (Arnott, 1979; Capozza and Helsley, 1989; Plantinga et al., 2002). The model predicts higher prices of land and housing at closer distance to the central point and is based on the Ricardian assumption of short-to-medium run fixed supply of urban land.

The model outlines that households with high incomes are more attracted to locations outside the center owing to their demand for residential space and lower house prices. Households with high incomes also have a higher opportunity cost of time, in relation to households with lower incomes, and therefore value accessibility to the market more. Thus, location decisions are driven by the net effect of these opposing forces *and* the ratio of commuting cost to expenditure on housing (Alonso, 1964).

Although the model has shown to be useful for explaining location decisions in many real-world cities, it is often criticised for the assumption that urban space is mono-centric. In reality, most cities have many centres, which act as local focal points for business, employment and commercial activity (Ogawa and Fujita, 1989; Anas et al., 1998; Giuliano and Small, 1991). Studies find that assessing accessibility requires the measurement of distance to a larger set of urban spaces (Jackson, 1979; Dubin and Sung, 1987; Niedercorn and Ammari, 1987; Thériault et al., 2005).

The assumption that urban areas are mono-centric also implies that land is treated as a homogenous good and demand for housing as merely dependent on residential space and the cost of commuting to the central business district. Studies have shown that the spatial distribution of amenities is an important determinant of urban development patterns and have a major role in shaping the urban spatial structure (Schuler, 1974; Yang and Fujita, 1983; Brueckner et al., 1999).

Another type of explanation to location choices is provided by the theory of Central Place Systems (CPS), in which location patterns are driven by the size of the market, and its surroundings (Christaller, 1933; Lösch, 1954; Beckmann, 1958). According to this framework, the size of the market depends on the size of the population and the efficiency of the transportation network. Following from this, urban areas are ordered in a hierarchical system and there exist many urban areas with different population sizes, performing different functions and having different industry structures. In this context, small urban areas supply

lower order services including only the basic amenities, and higher order services become available at successively larger urban areas (Beckmann, 1969).

2.1   Urban and environmental externalities

Since the work of Yang and Fujita (1983) there has emerged a growing literature on amenities and their relation with urban growth and intraurban development patterns. Many of the models are extensions of the Alonso-Muth-Mills urban land use model and focus on explaining location decisions and the formation of the urban spatial structure resulting from interactions between environmental externalities and agglomeration (Solow and Vickrey, 1971; Arnott 1979; Rose-Ackerman, 1975; 1979; Fujita, 1989; Kanemoto, 1980; Kishimoto 1991; Nijkamp, 1999; Wu, 2001; Irwin and Bockstael, 2001; 2004; Nijkamp and Verhoef, 2002). Studies have shown that the spatial distribution of amenities and the interactions between natural amenities and agglomeration forces are significant in explaining urban development patterns and intra-urban location (Wu and Plantinga, 2003; Wu and Gopinath, 2008; Irwin et al., 2009; Wang and Wu, 2011).

Brueckner, et al., (1999) present an important point of view. They consider location decisions of different income groups as closely tied to the spatial pattern of amenities in the urban area. In their model, location by income depends on the spatial distribution of exogenous amenities such as water access, topography or historical amenities, such as monuments, buildings and parks. Their analysis shows that when the urban centre has a strong advantage over the suburbs in exogenous amenities, and when the valuation of such amenities rises with income, high-income households are likely to live in central locations. They also conclude that this effect occur regardless of the presence of endogenous amenities e.g. restaurants, theatres and other urban amenities that depend on current economic conditions.

The idea that house prices exhibit *localised* variation due to environmental externalities can be traced back to Ridker and Henning (1967). Since then, there has been a growing interest in using property value data as a source of information on the benefits of environmental externalities. The most common framework to consider housing as a traded good and the influences of externalities on house prices is based on Lancaster's characteristics approach (1966; 1979). This theory emphasises the heterogeneity of the house as a commodity, which enables evaluation of different bundles of attributes within the same total expenditure package. This is based on the Hicks-Leontief composite commodity theorem (Hicks, 1938; Leontief, 1936) and Fisher and Shell's (1971) repackaging hypothesis. The basic assumption is that households value goods by their characteristics in relation to relative cost. Rosen (1974) developed a formal model of demand, supply and competitive equilibrium and Freeman (1979) extended the model for application to environmental amenities. Since then, an extensive number of hedonic models can be found in

the literature. Due to their wide range, it is out of the scope of this introductory chapter to provide a review of this literature. However, some main conclusions from this research can be drawn. For example, it is well-established that accessibility to urban areas and their agglomerations of private and public goods and services are significant in explaining variations in housing prices across countries (Dubin and Sung, 1987; Andersson, 1997; Adair et al., 2000; Söderberg and Janssen, 2001; Thériault et al., 2005; Andersson et al., 2010). Likewise, there are many studies that empirically address housing prices and their relation to open landscape amenities in the surrounding area. Prior literature have identified positive premiums for proximity to a wide range of open spaces, such as parks, green areas, urban forest, farmlands and water covers (Cheshire and Sheppard, 1995; Tyrväinen and Miettinen, 2000; Luttik, 2000; Irwin 2002; Thorsnes, 2002; Andersson and West, 2006; Morancho, 2003; Poudyal et al., 2009a; Gibbons et al., 2011). It is also shown that the size, diversity and fragmentation of natural land covers surrounding houses are factors that influence the values that are added (Geoghegan et al., 1997; Acharya and Bennett, 2001; Cho et al., 2008; Poudyal et al., 2009b).

There has also emerged a growing literature that focus on the local character of open space amenities, addressing intraurban variations and spatial heterogeneity in value assessments (Geoghegan et al., 1997; Cho et al., 2008; Wu, 2012).

2.2 Agglomeration economies

Another part of the location theory emphasises localisation and agglomeration effects. The idea is that both firms and households can gain from agglomeration economies due to shared inputs and mutual interactions (Marshall, 1920 [1890]). The concept of agglomeration is not an unambiguous concept in the literature, but a repeated element in its definition is the benefits of joint localisation. A distinction can also be made between external scale economies that occur between firms in the same industry and referred to as *economies of localisation* (Marshall, 1920 [1890]; Ohlin, 1933) and *economies of urbanisation* when occurring across industries (Jacobs, 1969). Both of these agglomeration effects influence regional growth levels and are significant in explaining house prices (Evans, 1985; Landis and Elmer, 2002; Shapiro, 2005; Glaeser et al., 2005; 2006; Mellander, 2008). A common way to formalise agglomeration effects and the gains that may arise, is by the concept of externalities (Henderson, 1997; Kanemoto, 1980). Externalities are often categorised as one primary source of market failures and occur when consumption and production activities of individuals and firms have unintended impacts on the utility- or production functions of other individuals or firms.[1] The opposing forces of agglomeration (centripetal) and dispersion

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[1] Public goods being the other primary source.

(centrifugal) (Myrdal, 1957; Krugman, 1991; Fujita et al., 1999) influence the spatial structure of economic activities. Centripetal forces arise from the existence of positive externalities and the dynamic process in which different forms of interaction causes externalities to reinforce and increase in their scale. Dispersion, on the other hand, is the result of a trade-off where price competition and negative externalities drive firms away from each other because of product differentiation.

Regarded from the supply side, localised intra-industry spillovers arise from the sharing of inputs and knowledge and influence the production functions of firms. Externalities can also be *pecuniary* taking the form of by-products of market interactions and affect firms that are involved in interactions facilitated by the price mechanism (Fujita and Thisse, 1996). This base on the idea that externalities are localised and decay with distance and that geographical proximity induces personal interactions and face-to-face contacts. Following from this, geographical proximity facilitates the diffusion of knowledge (Andersson and Mantsinen, 1980; Jaffe et al., 1993) and enables the distribution of information of changes in input and output markets and the development of new technical or organisational innovations (Andersson and Johansson, 1984; Duranton and Puga, 2004).

Another gain on the supply side is that agglomeration effects may cause a decline in transactions costs. This means improved matching between skills and job requirements that reduces the search costs of workers with differentiated skills and employers with differentiated demands for labour (Helsley and Strange, 1990; Acemoglu, 1996). On the demand side, it means that new firm formation may attract workers because they may anticipate better job matching and, therefore, higher wages. This in turn makes large and dense urban areas more attractive for firms since they expect to find the types of workers and services they need, as well as new consumers of their products.

From the perspective of household utility and residential location, several gains from agglomeration arise on both the demand and the supply side. A cornerstone in early spatial equilibrium models is that household utility depends on the consumption of traded goods, housing and a variety of local goods. Among other things, these models emphasise that a greater variety in local goods has a greater impact on household utility (Rivera-Batiz, 1988).

In large and dense urban areas, localised intra-industry spillovers facilitate scale economies in the provision of public goods and services (Artle, 1959; Andersson, 1985). Economies of localisation also enable the production of more differentiated consumer goods and services (Rivera-Batiz, 1988).

Besides consumer amenities, many of the gains that arise on the demand side are in the form of *pecuniary* externalities, which are often relevant in cases when markets are imperfect. For example, shared inputs in consumption also include networks for spreading knowledge about activities (e.g. culture, retail), as well as the facilities for such activities (Quigley, 1998).

It is also well established that the inclination to interact with others is a fundamental human attribute (Andersson and Karlquist, 1976; Lucas, 2001). Thus, geographic proximity to other people increases the likelihood for social interactions and the possibility to interact with others to exchange ideas (Fisher, 1982). In these perspectives, large and dense urban regions can be thought of as public spheres and public arenas as described in Habermas (1962) *The Public Sphere*, or as in Featherstone (1998) *The Flâneur, the City and Virtual Public Life*. Since access to urban areas is required for the possibility to consume such amenities, they can be regarded as *local public goods*.

Andersson and Andersson (2006) define *the city as a territorial public good*. In their definition, large and dense urban areas are not only viewed as agglomerations of people and consumer amenities, but also agglomerations of cultural infrastructure, architecture and other historical amenities. These tangible structures constitute important amenities since they capture the various ways in which history influences the quality of life in urban areas. Since these are both congestible and excludable, they can be regarded as local public goods. The amenities discussed above are all part of the urban amenity premium, which enhances the attractiveness of urban areas and add value to housing within and beyond their borders (Des Rosiers et al., 2000; Glaeser et al., 2005).

2.3   Local public goods

The theoretical framework for considering individual preferences for local public goods as revealed through location choices was developed by Tiebout (1956) and Buchanan, (1965). In the model outlined by Tiebout, rational individuals exit communities that offer less attractive bundles of local public goods in favour of those providing bundles that are more attractive. In line with this, Buchanan's (1965) theory of clubs emphasise that *if* different bundles of local public goods are offered at different locations, a spatial division of the population into clubs of homogenous tastes would arise.

The awareness that public goods simultaneously benefit a group of people can be traced back to classical economics (Smith, 1976 [1776]). Although the meaning of public goods and their implication for welfare was discussed much earlier, the development of a formal definition can be assigned to Samuelson (1954; 1955), discussing them and comparing them with private goods.

The definition of pure public goods as goods that are consumed without rivalry and without the possibility for exclusion is well established, what is more interesting is how distance and congestion can alter their nature. For the case of local public goods, distance serves as an exclusionary devise when the consumption requires that one is at a certain location (Tiebout, 1956). Moreover, the benefits of congestible public goods are shown to increases until they are eroded by crowding (Buchanan, 1975).
Samuelson (1954) emphasised that a collective voice or a nonmarket decision process is necessary to reveal individual preferences and achieve Pareto

efficiency in the provision of pure public goods. However, many goods are public only in a limited sense and the non-exclusion principle and/or the jointness of supply principle may not be applicable over the full range of possible distribution and production alternatives (Mueller, 2009). For these quasi- or local public goods, it is more relevant to study individual preferences through their *entry* or *exit* decisions than through their *voices* (Hirschman, 1970).

In these perspectives, hedonic pricing provide an approach to study *actual* market behaviour and provides an intuitive general modeling framework for assessing how households value different local public goods. While hedonic models are useful primarily for the analysis of market behavior and *use values*, the alternative method of stated preferences is useful for studying *non-use values* of local public goods (Drake, 1992; Lindhagen and Hörnsten, 2000; Fredman and Emmelin, 2001; Carlsson et al., 2003; Hasund et al., 2011). Economic research on the relationships between local public goods and household utility using the methods of stated and revealed preferences can provide important information for policymakers in the formation of local and regional policies. Empirical results may also play an important role in the evaluation of policy alternatives.

3. The hedonic price model

Hedonic models are among the most common models applied to explain local variation in house prices. The basic theory developed by Lancaster (1966; 1979) and Rosen (1974) provides a framework for assessing how different attributes influence prices. The hedonic approach applied to housing assumes that the price of a house is a smooth, differentiable and continuous function of its attributes. Thereby, housing is treated as a heterogeneous good, differentiated into a bundle of quality attributes $Z = z_1, z_2, ..., z_n$, and the hedonic price function $P(Z)$ gives a functional relationship between observed expenditure and quality characteristics contained in the vector Z. In accordance with Rosen (1974), $P(Z)$ is the maximum bid price of a given bundle and the marginal implicit price of any quality attribute z_n are obtained by partial differentiation $p_z (\equiv \partial P(Z)/\partial z_n)$. The interaction between consumers and producers within the market gives the hedonic price schedule and the cost function facing producers is given by $C(M, Z, \beta)$ where M denote the number of units produced, Z the vector of product attributes and β the vector of firm-specific technologies and factor prices. Thus, the marginal implicit for each attribute equals the marginal unit cost of the attribute price, which is given by the first order condition of the solution to the profit function $\pi = MP(Z) - C(M, Z, \beta)$ (Palmquist, 1991).

Hedonic price theory does not provide any guidance on the functional relationship between observed expenditure $P(Z)$ and quality characteristics. In most cases, the cost of adjustment gives rise to nonlinearities and constant marginal prices can only be justified if there are constant returns to scale in production or costless repackaging of two or more bundles (Rosen, 1974; Goodman, 1989). Since these conditions are highly unrealistic with regards to housing, the linear form is usually rejected (Andersson, 1997). Many different functional relationships have been suggested in the literature, such as the log-linear (Dubin and Sung, 1990; Follain and Malpezzi, 1980), the translog (Christensen and Manser, 1977, the Box-Cox transform (Halvorsen and Pollakowski, 1981; Andersson, 1997) and the logarithmic (Heikkila et al., 1989; Andersson, 1994). Introducing flexibility is generally recommended since it allows the value added to vary proportionally with size and quality, such that the price of an additional unit of an attribute will depend on the quantity already supplied and in some cases the quantity of the other attributes (Andersson, 2000).

As indicated in the previous sections, many different factors influence house prices. To this, one can also add their durability and fixed position in space, implying that houses with equal physical characteristics at different locations should be treated as different commodities. Problems of unobserved spatial heterogeneity and spatial dependencies are common problems in estimations that involve durable goods that are fixed in space (Anselin, 1988). This implies that besides inherent quality characteristics, house prices are highly dependent on spatial variation at the local scale, such as characteristics of the neighborhood, externalities surrounding a given location and the local price surface (Goodman, 1978, Schnare and Struyk, 1976; Hårsman and Snickars, 1975; Wilhelmsson, 2002; Sandberg, 2004).

A consequence of the hedonic price model is that there are natural tendencies toward market segmentation, in the sense that consumers with similar price functions purchase products with comparable characteristics (Rosen, 1974). Similar points are raised in Tiebout's (1956) analysis of the implicit market for neighborhoods and by Ellickson (1971), showing that neighbourhoods tend to be segmented by income and taste.

There is generally little agreement on how to identify the correct geographical extent of local markets and how to segment housing markets to enhance hedonic predictions. Several different approaches with varying spatial scale have been suggested in the literature (Schnare and Struyk, 1976; Linneman, 1980; Hårsman and Quigley, 1995; Mills and Simenauer, 1996; Bourassa et al., 2003; Straszheim, 2008). Another common problem is how to deal with spatial dependencies and spatial spill over effects resulting from local externalities or the quality and structure of surrounding property (Anselin, 1988; Can, 1992). Spatial autocorrelation is often linked to the processes of spatial diffusion that occur in geographical space (Griffith, 1992) and to the spatial distribution of externalities which produces urban distance gradients

(Anselin, and Can, 1986). Many different models to deal with spatial heterogeneity have been suggested in the literature and studies have found substantial improvements in the fit of hedonic models using spatially explicit approaches (Can and Megbolugbe, 1997; Basu and Thibodeau, 1998; Fotheringham et al., 2002; Willhelmsson, 2002; Bitter et al., 2007).

3.1 Characteristics of land in the hedonic framework

While most of the theoretical and empirical work have been focused on housing as a differentiated consumer good, hedonic pricing has also been developed to model the dynamics of characteristics of land on the price of land (Orishimo and Morishima, 1985) and land as a differentiated factor of production (Palmquist, 1989).

Palmquist (1989) show that enhancements made by individual land owners, or as a result of public policies, is reflected in the equilibrium hedonic price schedule given that a sufficient number of parcels are affected. Orishimo and Morishima (1985) develop a model, in which they model the shadow pride of land as a function of its environmental characteristics and its accessibility to urban areas and their agglomeration economies. In their model, land quality characteristics enhances by public expenditure, such that their outcome ties to their supply origin. Following from the basic assumptions underlying their model, the dynamics of characteristics of the land and the dynamics of private investment, under the condition of income identity, the following Hamiltonian function can be expressed:

$$
\begin{aligned}
H = U(c, z_a, z_e) &+ P_k\left(f(k) - \eta k - c - g_a - g_e\right) \\
&+ P_a\left((\beta - \eta)z_a + m(g_a)\right) \\
&+ P_e\left(-\eta z_e + n(g_e)\right)
\end{aligned}
\tag{1}
$$

where c denote a composite numéraire consumer good, z_a denote accessibility and z_e denote environmental conditions. Moreover, P_k, P_a and P_e are the implicit price functions of k, z_a and z_e. From Equation 1 it can be seen that the price of land is influenced by government expenditure on accessibility (g_a) and environmental conservation (g_e). Moreover, β is a coefficient denoting the added benefit of improvements in accessibility through agglomeration or by improvements in direct accessibility.

The Hamiltonian in Equation 1 is equivalent to a basic optimisation problem in which the time integral of utility is maximised subject to dynamic constraints. Orishima and Morishima (1985) conclude:

"Based on these derivations and standard assumptions, we may conclude that a rise in the shadow price of land is indeed the result of public expenditure on such factors as transportation and environmental conservation."

Orishima and Morishima (1985, p.98)

3.2 Measuring accessibility

The influence of distance with regard to a relevant set of opportunities is central in hedonic models of land and house price formation. Accessibility relates to the possibility of individuals to travel and participate in activities at different locations in an environment (Thériault et al., 1999). Measuring accessibility requires a framework that considers spatial and temporal factors and comprises individual behaviour in commuting patterns and location choices (Nijkamp et al., 1993). Such a framework can be found in the concept of time geography developed by Hägerstrand (1970). The concept of time geography emphasises the importance of factors that constrain the possibility to interact, where time is regarded as one of the fundamental constrains. Thus, geography matters for households not because of the physical distance, but because traveling is time- and resource consuming.

Following Hansen, (1959), Ingram, (1971), Wilson (1971) and Weibull (1976), accessibility to a given opportunity D_j can be expressed using the following gravity-type index:

$$A_i^D = \sum_{j=1}^{n} D_j \exp\{-\lambda t_{ij}\} \tag{2}$$

where A_i^D denotes the accessibility to opportunities D_j, defined as the size of possible opportunities that can be found in location *i* and the n-1 surrounding locations. Travel-time between location *i* and *j* is represented by t_{ij}. Moreover, λ is a parameter reflecting time-sensitivity and can be viewed as a distance discount operator, which reduces accessibility as travel-time efforts increases. In this thesis, we use the type of time-distance accessibility defined in Equation (2).

Is accessibility a useful concept in economics? The answer is yes. Accessibility can be a useful variable in profit as well as utility or welfare functions. Furthermore, a spatial general equilibrium, driven by accessibility, exists as demonstrated by a theorem:

THEOREM: *If the welfare of households in a region is an increasing function of accessibility to households in other regions and of space per household in the region, then there exist a state of general equilibrium with equalised welfare for all households in all regions, provided there is no moving cost of households between regions.*

This is explicitly proved for the case of Cobb-Douglas welfare functions (Andersson and Karlqvist, 1976, p.191-192).

3.2.1 Distance in the Euclidean space

Hedonic studies commonly use Euclidean metrics to measure proximity to various types of amenities. In most cases, minimum distance may not serve as a useful approximation. There are some cases where the straight-line distance has shown to work as a reasonable estimate. One such case is within cities that have Manhattan like street networks. Since those types of networks have more shortcuts, the closer can straight-lines be approximated since the random elements in the formation of a street system tend to average out the directional element (Puu, 2003).[2]

The second case relates to the localised variation in house prices and the close link between location-specific amenities and house prices. For example, minimum distance may serve as a useful proxy for walking distance, for enjoying the view of, or consuming the environmental benefits of local amenities (Kestens et al., 2004). Indeed, most hedonic studies have used Euclidean distances to measure the influence of externalities on house prices or the influence of distance to urban areas.

The Euclidean space can also be used to calculate a cost-distance or the shortest path given a predefined transportation network. Thériault et al. (1999) and Des Rosiers et al. (2000) use a GIS distance and a trip duration modelling procedure and show that measurements of actual road distances and travel times significantly improve hedonic modeling. The nearest location from a house in terms of shortest route distance or in terms of trip duration can be expressed as (Beckmann and Puu, 1985):

$$\theta(\underline{x}) = \int_{\underline{x}^0}^{x} ds = \int_{\underline{x}^0}^{x} \left(dx_1^2 + dx_2^2 \right)^{1/2} = \left[\left(x_1 - x_1^0 \right)^2 + \left(x_2 - x_2^0 \right)^2 \right]^{1/2} \qquad (3)$$

where $\theta(\underline{x})$ denote the value of minimum transport cost to $\underline{x}$ from a given origin $\underline{x}^0$ and the coordinate points in Euclidean space is given by $\underline{x}^0 = \left(x_1^0, x_2^0 \right)$ and $\underline{x} = \left(x_1, x_2 \right)$.

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[2] Illustrated in Puu (2003 p. 33-38).

3.3 Prices in a competitive market

In accordance with urban economic theory, the hedonic price theory is formulated by Rosen (1974) as a problem in the economics of partial equilibrium, such that the entire set of implicit prices guides consumers and producers locational decisions in characteristics space. Transactions in products are viewed as bundles of characteristics and market-clearing prices are determined by the distributions of consumer tastes and producer costs. The studies in this thesis are all focusing on analysing market prices of tangible assets. What distinguishes the first two papers in the thesis from most empirical work is the focus on prices rather than rental prices. Analysing market prices have some advantages in that competitive forces imply that prices of most goods adjust to changes in the market and to changes in policy. Adjustment of rental prices is generally slow due to long-term contracts (Ciaian and Kancs, 2012). Market prices of land and housing (although not the rent) also reflect expected future capital gains, which are highly influenced by location. In a competitive land market, land values will reflect returns from the most profitable use. If the most profitable use of land is non-agricultural, but instead residential, then prices determines by the profitability of urban housing. There may also be speculations of potential non-agricultural use of the land in future. In such cases, the current land price will reflect the sum of the discounted stream of rents from agriculture up to the date of conversion, and expected rents from potential use after conversion (Capozza and Helsley, 1989; Plantinga et al., 2002). Thus, speculation based on changes in land use is closely linked to both market accessibility and amenities.

4. Databases

The hedonic approach is demanding in terms of data requirements. In Sweden house and land transactions data have restricted public access and large samples are rather costly to obtain.[3] The data used in this thesis have different sources and the empirical analyses in the studies have varying geographical scale. While the first two studies are based on nation-wide transactions data, the two succeeding studies are based on geographically delimited samples.

The first two studies are based on Swedish farm transactions provided by The Swedish Mapping, Cadastral and Land Registration Authority (MCLRA). These data hold detailed information on farm sales across the country including spatial references and characteristics of the residential units and their pertaining land. Farm transactions data includes all sales of land and agricultural property for the period 2007-2008. In the first paper, these data are used to calculate the

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[3] The Swedish Mapping, Cadastral and Land Registration Authority is the main provider of these data in Sweden.

average municipal price of agricultural land, which is the dependent variable in a cross-regional analysis of Swedish agricultural land prices. In the second paper, these data are used in a farm-level analysis. In both these papers, farm- and regional-level data are combined with data on decoupled support payments disbursed to farmers and characteristics of the local and regional agricultural sector. The Swedish Board of Agriculture and Statistics Sweden provide these data.

The third study combines two geocoded datasets: (i) property data (single-family homes) provided by the Municipal Housing and Development Office, and (ii) open space amenities (parks, green spaces, forest areas and farmlands) provided by The Municipal Housing and Development Office. Property data includes the total number of single-family homes sales in the studied region during the time period 2000-2011. Besides these data, economic and socio-demographic census tract data is used to measure neighbourhood quality.

The last study combines three geocoded datasets; (i) property data (second homes) attained from the MCLRA, (ii) climate data provided by The Swedish Meteorological and Hydrological Institute, and (iii) natural amenities (waterscapes, and open space amenites) provided by The Swedish Meteorological and Hydrological Institute, The Swedish Environmental Protection Agency and The Swedish Board of Agriculture. Property data includes the total number of second home sales located in the nine southern counties in Sweden for the year 2008. As a general method in both paper three and four, distance to amenities are calculated using spatial joins (ArcView 10.1) and road network layers (Geodataportalen).

5.   Summary of papers and contributions

The purpose of the first paper *Location Determinants of Agricultural Land Prices (co-authored with Sara Johansson)* is to analyse determinants of Swedish agricultural land prices focusing on location specific factors. An asset pricing model that decomposes prices into expected returns from land in its current agricultural use and its potential use is applied. The use of market transacted land parcels and the inclusion of decoupled support payments, among a set of other key explanatory factors, distinguishes this study from earlier empirical work with this focus. In Sweden, prices of agricultural land have been steadily increasing during the last decade and explanations are likely to be related to both agricultural and urbanising factors. Since Sweden entered the EU and the European Common Agricultural Policy a lot of focus has been directed to institutional factors, particularly after the decoupling reform in 2003. A combination of several factors can be thought to explain the observed growth in land prices. During the last decades, countries throughout Europe have witnessed a growth in non-agricultural markets in their rural parts of their

economies, suggesting that owners of agricultural land are faced with a growing set of opportunities for alternative use of their land. Thus, accessibility to nearby markets and rural amenities are likely to explain a significant part of the observed growth in land prices. This is where the first study positions itself in the literature. In this paper we focus on the role of location as an important prerequisite for the potential of diversification and non-agricultural use of land. One important element that is analysed in this study is that, besides traditional agricultural land price determinants that relate to land fertility and income support to farmers, non-agricultural factors, such as accessibility to services, employment opportunities and rural amenities are likely to be key determinats of prices.

To analyse the stated objectives we estimate an asset-pricing model in which the price of agricultural land is a function of the expected returns from its current agricultural use and its potential non-agricultural use (Cappozza and Helsley, 1989; Plantinga et al., 2002). In this study, spatial characteristics that influence the potential use of land is measured by population accessibility, designed to reflect urbanity of the own and neighbouring regions. The analytical approach to geographical distances used in most previous studies with this focus is relevant mainly for land located at the urban fringe. This study contributes to the literature by providing empirical estimates based on a measure of accessibility that captures the spatial relation of each location to all urban centres across the country.

Two types of decoupled payments are included in the analysis. The first is the single farm payment, which gives a fixed direct payment to farmers conditionally only upon preservation of the land in an arable state. The second are agri-environmental payments, which are conditional upon the protection and preservation of natural and cultural values found in the agricultural landscape. From the results of this study one can conlude that besides the single farm payment, population accessibility and the potential for diversification and non-agricultural use of land is the primary factor influencing land prices. These results suggest that the single farm payments scheme benefit farmers in cases when they own their land, in other cases non-operators may capture an important share of the agricultural support. Another finding is that agri-environmental payments appear not to have the sufficient size or the type of design that result in inflated land prices.

The second study in this thesis *Capitalisation of Single Farm Payments on Farm Prices: a Spatial Multilevel Analysis (co-authored with Joel Karlsson)* continues to examine the farm data used as a basis for calculating regional land prices in the first paper. In this study, the data is analysed at the micro level, focusing on farm prices. Similar to the first paper, the single farm payment scheme is included among the variables as a key explanatory factor. Unlike the first paper, that examines the influence of decoupled payments on the price of productive land, this paper focuse on the influence of single farm payments on farm prices. The use of market transacted farm-level data and the focus on small and

medium sized farms, spatial heterogeneity and spatial spillover effects, at local and regional level, distinguish this study from earlier empirical work.

Land development in response to local and regional land use spillovers is a spatial dynamic process that results from the interactions of various agents (Irwin, 2010). Regional policies, land management and the actions of landowners and land developers may influence the price of land and farms at both a local and regional level. This implies that the price of farms and land lots are not only determined by their inherent quality characteristics, but also reflect interdependencies between other factors at varying spatial scale. From the viewpoint of policy, the main problem is that public considerations may influence local land market mechanisms (Latruffe and Le Mouël, 2009). In this study, we address these sources of unobserved heterogeneity by introducing a hierarchical structure of the data, in which farms are nested into local areas, which in turn are nested into regions. To address the relation between the single farm payment scheme and land quality, we impose a cross-classified structure at the third level in our hierarchy, defined as local areas nested in both regions and different harvest areas. Using this approach, we are able to mitigate unobserved heterogeneity at all levels in the proposed hierarchy and address the identification problem discussed above.

The main conclusions from our analysis are that farm markets are local and prices vary significantly at local and regional levels. Spatial heterogeneity is found for both local, regional and harvest area levels and the spatial spillover contribute to a substantial share of the total spatial variation on the average price of a farm. Results also show that decoupled single farm payments have no influence on farm prices; rather, prices are profoundly influenced by residential characteristics and accessibility to urban amenities.

In the third study *Natural Amenities in Urban Space: a Geographically Weighted Regression Approach* the focus is on the market for single-family homes and the relation between intraurban variation in house prices and open landscape amenities. The preservation of natural amenities in urban areas has become a matter of growing importance with increasing urbanisation and altered lifestyle choices in cities around the globe (Brueckner, 2000; Wu and Plantinga, 2003; Irwin and Bockstael, 2004). Sweden, as many other countries, has witnessed a decay in the variety of differentiated landscapes including ecosystem services, such as urban forests, cultivated lands, wetlands and other open landscape amenities (Ihse, 1995). The increased focus on preservation efforts stems from a growing awareness of the large number of aesthetic and environmental benefits generated by open landscape amenities (Irwin and Bockstael, 2004; Hasund et al., 2011). It is shown that local ecosystem services have a significant influence of the quality of life in urban areas and should therefore play an important role in urban land-use planning.

Recent literature highlights that there is significant intraurban variation in the marginal effect of open landscape amenites on house prices depending on local development patterns, differences in resource endowments and resource

policies (Palmquist, 1992; Roback, 2007). Previous literature on open landscape amenities and house prices predominantly focus on estimating average marginal effects at the regional level. Compared to this there is less information on how value assessments differ within regions and how this influences the relative demand for housing. This is where this study positions itself in the literature. For studying intraurban variability in the benefits of living close by preserved open landscape amenities, the paper applies a geographically weighted regression model. In this model, housing prices are modelled according to their spatial nature and marginal attribute prices are allowed to vary across the market area. The results from this analysis show significant intraregional heterogeneity in how open landscape amenities are valued by urban residents. Marginal valuations are relatively high in central areas where undeveloped land is relatively scares and where population and home densities are relatively high, whereas marginal effects are either low or insignificant in rural and peripheral areas. The results in this paper highlight the need for local land use planning and development in the provision of local public goods.

The focus of the last paper *The Influence of Urban and Natural Amenities on Second Home Prices* is on the market for second homes. Growth in income and leisure time, increased mobility and a growing demand for amenities are some of the factors that have contributed to the observed growth in second homeownership. Recent studies show that this segment of the housing market is emerging rapidly in many of the European countries, as well as in the US (Müller, 2011; Biagi et al., 2012). It is also noted that an increasing number of households purchase second homes as a part of a life-cycle planning and investment strategy. Despite its growth, this segment of the housing market has not been widely addressed in regional economics, or in the housing literature. One important element that is examined in this paper is the variation in amenity effects across regions of different type. This is based on the argument that natural amenities are valued differently depending on regional characteristics, such as the supply of urban amenities, regional size and commuting patterns. In accordance with prior findings and the Central Place System (CPS) framework the paper asserts that there are reasons to believe that amenities do not affect house prices homogenously across regions. Specifically, a hierarchical spatial economic system is likely to alter the importance of amenities in the surrounding areas.

By estimating a spatial hedonic model on Swedish house price data, the paper shows that the hierarchical structure is indeed reflected in the structure of spatial dependencies. The relative importance of amenities is shown to be higher in regions with low position within the hierarchy. The influence of natural amenities on second home prices is shown to be relatively more important in rural and urban regions, whereas access to an attractive local house market is more important for prices of urban second homes.

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