Distances, accessibilities and attractiveness; looking at new approaches to include measures of urban form in hedonic pricing modelling?

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The population of Oslo is increasing rapidly and the corresponding housing demand presents an issue of great public, political and professional interest. Today, we can see several interesting discrepancies in the housing market, such as very high prices for dwellings with low technical standards and dwellings located in neighbourhoods very different from those planned and built today. There is a great diversity in households’ willingness to pay for housing. What are the patterns of such attractiveness in more detail and what might be the lessons to learn concerning what to build in the future? How can we plan and build housing that responds to the wide range of contemporary demands and that will also be attractive in decennials to come?

Economists and real estate businesses provide statistics on prices of dwellings, but the variables examined are usually too general for the results to be useful for actual planning and design. However, space syntax based research has shown that locations in cities can be measured more specifically and that analyses of these measurements correlate with numerous phenomena related to activities and attractiveness of cities. By applying space syntax based measurements in GIS in a comparison of housing prices with relevant measures of buildings and neighbourhoods by means of hedonic regression analysis, willingness to pay for dwellings has been examined in two unpublished studies in Stockholm and Copenhagen (Ståhle & Bernow 2011; Lundhede et al. 2013; Kummel & Andersson 2012). This paper presents the methods and some of the results of these studies, and draws conclusions from this for a future study of Oslo. In brief, we see that the more specific urban form measurements in GIS are significant in terms of willingness to pay for dwellings. The specificity of these measurements achieved by GIS analyses, applying the Place Syntax Tool, provides new and more detailed knowledge in this field.

1 Introduction
Contemporary urbanisation renders housing an acute issue worldwide. In Oslo, the capital of Norway, the population is increasing rapidly and the corresponding housing demand presents an issue of great public, political and professional interest. Even though the international financial crisis and the corresponding collapses in housing markets have also influenced the Norwegian economy, prices of dwellings are higher than ever with the number of new dwellings last year (2014) about 10% above the average since the year 2000. There is a wide range of housing prices in the contemporary liberal Norwegian real estate market, illustrating great diversity of attractiveness in terms of willingness to pay for dwellings of different kinds and in different locations. Regardless of the contemporary all-time-high dwelling prices in Oslo, there are also areas where prices are lower than even the cheapest construction costs of new housing. In other locations, prices are high regardless of a technical quality far below contemporary standards. It is also interesting to see that a well-connected street network and continuous building blocks rarely exist in new housing projects. This is a scheme proven over time to work very well for both dwellings and neighbourhoods, and that now often is very highly priced (Manum, 2006; Sjaastad et al., 2008).

Urbanisation means that people move into cities, which tend to be characterised by proximity, density and closeness. These features together lay...
the foundations for human interactions, which in turn are the main driver for invention and consequently economic growth (Florida 2003; Glaeser 2012; Jacobs 1970). Combined with the shift in moving patterns over the last few decades from jobs to housing becoming the main reason for mobility, attractive housing constitutes a major competitive factor amongst cities. While the trend used to be that people moved because of job opportunities, now employers move to the workers (Florida, 2003; Glaeser, 2012; Kim, 2014). This means the value of attractive housing is twofold: it increases the actual value of the housing stock and it supports urban growth.

An interesting question lies in the extent to which housing prices are determined by the particular dwelling, by the building and by the surrounding neighbourhood. In Norway, economists and real estate businesses provide large quantities of statistics on the prices of dwellings, but the issues concern markets and politics rather than architecture and buildings. Explicit layouts of buildings or neighbourhoods are scarcely examined, and research results that are useful to architectural design are hard to find. Jane Jacobs’ concept (Jacobs 1992) that planning and design of housing are guided by ideals and theories with little or no empirical foundation, and are contradictory to existing well-working layouts, is still surprisingly relevant.

However, since the 1990s, research within the field of space syntax has shown that crucial aspects of buildings and urban form can be grasped through spatial measurements and that analyses of these measurements correlate with phenomena related to activities, attractiveness of dwellings and neighbourhoods (Hanson 1998; Marcus 2000; Manum 2006). By applying continuous measures of urban form in GIS, with space syntax based measures included, and comparing these with housing prices it is possible to reveal patterns about how numerous variables concerning layouts of buildings and neighbourhood correlate with housing prices. Using this approach, the willingness to pay for dwellings has recently been examined in Stockholm and Copenhagen (Ståhle & Bernow 2011; Kummel & Andersson 2012; Lundhede et al. 2013). This paper presents and discusses methods and results from these studies. Furthermore, it draws conclusions from this for a proceeding large-scale analysis of housing and housing markets in Oslo, the focus of which is how urban form correlates to housing prices. The studies in Copenhagen and Stockholm are particularly interesting due to their extensive data on environmental attributes (more than 1000 measures in each case) and because the way they investigate urban form in itself is different from most earlier studies. The data constituting the empirical basis are numerous and reliable, ranging from household income level on address point-level (Copenhagen) to number of employees and line of business on address point-level (Stockholm and Copenhagen). Both studies have had a strong impact on urban planning in Sweden and Denmark. As an example, municipalities in Stockholm have used results in negotiations with contractors over land sales in the planning of a new subway line.

1.1 Layout of coming research
The aim of an ongoing PhD study is to examine the issues presented in the above introduction. The PhD study will investigate how urban form, architecture and location are connected to housing prices. This paper resembles a review and is a comparison of the two studies mentioned above (Lundhede et al. 2013; Kummel & Andersson 2012; Ståhle & Bernow 2011). It aims to provide an understanding of the methodological approach proposed for the similar study of the Oslo housing market, which consists of the following parts:

- Examining willingness to pay for housing in Oslo based on a hedonic price model similar to the studies described in this paper.
• Comparing the results from the Scandinavian capitals: Oslo, Copenhagen and Stockholm.
• Examining the influences of the most important parameters over time, looking at dwelling prices from the mid 1990s until now. This will likely provide results regarding the ‘economic resilience’ of different urban layouts. It is anticipated that such knowledge will be important in explaining how certain ways of designing our cities hold monetary value better than others.

2 The Copenhagen and Stockholm cases and their methodology

We now turn to the studies conducted in Stockholm and Copenhagen in more detail. This section presents the methodological approach taken by the two studies on how urban form correlates to housing prices. The first part explains the statistical analysis, the second describes the spatial analyses and the third presents the data before briefly providing an overview of the two studies, pointing out some similarities and differences.

2.1 The statistical analysis – a hedonic price model

There are numerous approaches to studying housing markets and examining what people find attractive. A relevant statistical approach is the so-called hedonic price model. Hedonic models are based on the supply of a large number of items and a market characterised by many small actors who, one by one, have negligible influence on market conditions and prices. In hedonic analyses, the heterogeneous goods or dependent variable (here, price of dwellings) are characterised by numerous properties or environmental variables (or attributes, for example closeness to city centre or dwelling size) that one by one provide benefit, i.e. affect the price. By multivariate regression analysis, the method estimates the price-effect of a change in one attribute, other attributes being constant. A prerequisite for this kind of modelling is that the sample is one housing market only. In general, this means there should be few transactions between defined housing markets and that buyers generally do not consider two different markets at the same time (Palmquist, 2005). Hedonic modelling is a powerful tool for estimating the price effects of numerous likely relevant properties in large samples (Sjaastad et al., 2008). The method estimates the impact of every statistically significant variable on price variation and thereby gives a hint of people’s willingness to pay for different particular attributes of a dwelling. However, as for any analytical tool, what is not captured by the modelling must be kept in mind before generalising the results (Maclennan 2012).

In practice, picking out the environmental measures as sketched out in Figure 3 (see Results section) is a kind of craftsmanship leaning on knowledge about the influence of urban form measures on housing prices in general and knowledge about the particular housing market examined in particular. The first stage is to choose which environmental measures to include in the model, based on presumptions of what is likely to influence the price. In the second stage, testing and elimination of measures – for example due to co-variation – is carried out and the measures to be analysed further are selected. In the third stage, the final model is composed of the variables found to be significant in the second stage.

2.2 The measurements applied

There are two kinds of properties that influence the price, or monetary value, of real estate. The first is the physical properties of the particular real estate object being purchased, such as the actual building (or part of building) and the ground, the nature/vegetation and the other physical elements that belong to it. The second is the properties of the particular real estate object in relation to the surrounding neighbourhood, landscape, city or district. The studies examined in this paper focus on the
latter, captured by the real-estate business mantra “location-location-location”, and which concern distances and accessibilities from a specific location to exterior attractions as well as to disadvantageous features of the surroundings.

In the studies presented here, the price effect of ‘location’ is examined by two kinds of measurements. One kind is measurements simply counted within an area, the ‘area’ being the building, the block or a part of town. The issues measured are number of residents, number of people at work, floor area of buildings and other kinds of ‘density measurements’ within an area. The other kind is so-called accessibility measures. These are measured as ‘distance to’ such as distance to children’s playground or distance to motorway, or as ‘number or amount within a certain distance’ such as number of restaurants or area of parks within a certain walking distance (Manum & Nordström 2013; Ståhle & Bernow 2011). Figure 1 illustrates such measures represented in the GIS model.

In the studies presented here, distances are measured in three ways. One is straight line distance, which is simply distance measured as the horizontal shortest route. The second is distance along route of real movement, such as walking or bicycling distances along safe/useful routes. The third is cognitive distance as grasped by the space syntax measurement axial steps, often applied in combination with metric distance along a route (Ståhle et al. 2005). Apart from straight line distance measures, the measures are based on network distances. When calculating bicycle route distances, roads where bicycling is prohibited are excluded.

When analysing the price effect of noise and pollution from a motorway, straight line distance will likely be the most useful measurement. Regarding other issues, such as the price effect of distance from a dwelling to a children’s playground, metric distance along safe walking routes will probably be more useful, maybe in combination with axial steps grasping cognitive aspects related to orientation and way finding.

Figure 1:
Two variables illustrated as map-images. Left: percentage of streets accessible within a 500m straight line distance that have a speed restriction of 30km/h or less. Right: functional compactness, measured as number of dwellers multiplied by workers within a 500m walking distance. The latter measure is an attempt to capture both the mixture of workers and dwellers, and the population density at the same time. Adapted from Heyman (2012).
2.3 Data
The total number of measures examined was about 1,000 in Stockholm and 1,300 in Copenhagen. This extensive amount of measures was possible due to the supply of precise and reliable GIS-data, important for the aim to test as many measures presumably significant for housing prices as possible. The GIS-data were provided by, or gathered in close collaboration with, local authorities. They ranged from incomes and average grades in elementary schools to sizes of parks and locations of amenities and services.

There was also a large quantity of price data. In Stockholm, the data included all sales of apartments in the first half of 2010 and all sales of single family houses in 2011, in total about 7,000. In Copenhagen, the time period ranged from 2007 to 2010 and the numbers were approximately 18,000 apartments and 10,000 single family houses.

2.4 The cases
The first study was conducted in 2011 for apartments in Stockholm, and later completed with a study of single family houses in 2012. The Copenhagen study in 2013 included apartments and single family houses.

The Stockholm and Copenhagen studies are especially interesting due to the specificity of the measurements regarding accessibilities and distances, and because the measures are continuous rather than discrete variables. In both studies, the consultancy firm Spacescape performed the GIS-analyses applying the Place Syntax Tool; in Stockholm together with the consultancy firm Evidens and in Copenhagen/Aarhus together with researchers from the University of Copenhagen (Ståhle & Bernow 2011; Kummel & Andersson 2012; Lundhede et al. 2013).

The two studies have similar setups in terms of spatial measures. Figure 3 lists the main groups of measures examined. The measures were chosen for reasons of likely significance, and for their relevance to the practices of urban planning and architecture in the sense that planners and architects might have an actual impact on the phenomena captured by the measures (Lundhede et al. 2013; Ståhle & Bernow 2011).

The methodological approach of the two studies differs in some respects. In Stockholm, the whole metropolitan area was considered as one market, only distinguishing between markets for apartments and single family houses. In Copenhagen, several markets were defined according to revealed differences in impact of location and geographical barriers such as expressways or green belts. Subsequently, three markets were defined for apartments and four for single family houses in Copenhagen.

Another difference between the studies is how variance is handled. In Copenhagen, dwelling and building-specific features, such as number of bathrooms, balcony or not, and façade material, were included in the model, with the aim to cover as many features assumed to be relevant for the price as possible. In Stockholm, another approach was used: the market was divided into geographical areas, 319 for apartments and 475 for single family houses, which were then appointed the mean value of the dwelling- and building-specific measures for all dwellings in the area. These mean values were then compared with the sale prices within the areas. In Copenhagen on the other hand, the measures were individually addressed to every sold dwelling. With this procedure in the Stockholm study, it was assumed that the variability of dwelling-specific measures was equally distributed over the area, and therefore could be excluded from the model due to lack of variance within each sample.

3. Results and discussion
The tables in Figure 2 show the categories of measures examined and the main results in terms of variables found to be significant. In the study of
The working procedure for the hedonic model. First: selecting variables assumed to influence housing prices. Second: statistically testing the variables for co-variation, significance, and impact on housing prices, and accordingly grouping or indexing the variables to better explain the variation of prices. This stage iterates with the first stage. Third: the revised set of variables is examined by regression analysis. The table lists the variables found to be significant.
Copenhagen, the main results are presented as 10 “rules of thumb” (bottom list in Figure 2). In addition to the results in common for the studies, such as the significance of accessibility to public transport, there are some interesting differences. One result is that typical factors of urbanity, such as accessibility to urban amenities and walking distance to city centre, are highly valued by apartment owners while single family house owners value typical rural factors, such as proximity to open water and to green spaces.

Another general remark is that no ‘negative’ variables transpired as significant in the models in Stockholm. For example, noise was found significant in Copenhagen but not in Stockholm.

Axial integration emerged as significant, both locally and globally. It was significant in markets for apartments in both Copenhagen and Stockholm, but not for single family houses. This is an interesting result, considering that the model consists of some very strong determinants for housing prices. Not surprisingly, walking distance corresponds better to price variations than straight line distance.

As previously explained, the hedonic model should use measures that correspond as closely as possible to how people actually perceive the phenomena (Palmquist 2005). For instance, accessibility to green space through axial steps has shown to correlate better to perceived access compared to metric walking distance, and hence should be included in the distance measurement when examining accessibility to parks (Ståhle 2008). So, even if the statistical suitability might be better for one measure, it is not a given that it is the one that should be included in the model.

Another issue regarding hedonic price models is the definition of a market, as a price model is only valid if it corresponds to one market and one market only. Markets can be defined in different ways and the definitions differ between the studies in Copenhagen and Stockholm. Stockholm was considered as one single market and Copenhagen was divided into submarkets. An advantage of hedonic price models is that they are considered as practice-friendly in terms of transparency and clarity, much due to the generality of the model, which makes the results applicable in general policies for a city or region (Whitehead 2012). Since the city of Copenhagen was divided into several markets, based on geographical statistical differences, some generality of the results is lost. For variables occurring in all markets, some general conclusions should still be valid. For variables that only occur in one market and not in the adjacent one, results can only be considered valid in that particular area. In general, a market should be defined as one (separated from other) only when there are few or no transactions across the border (Palmquist 2005). We doubt this is the case for two areas distinguished in the very centre of Copenhagen. The fact that a variable can be valued on one side of a street but not the other makes the model lose some generality. On the other hand, it can also be questioned whether people looking for apartments in Stockholm actually consider the whole city. Often markets are defined through statistical measures, such as clustering analysis, but a recent study by (Law et al. 2015) looks into how submarkets can be defined through spatial configuration and how these submarkets have an impact on housing prices.

3.1 Space syntax measurements and housing prices

Chiaradia et al. (2009), examining price differences in a northern borough of London, point out the importance of measures that correspond to actual urban conditions and argue that space syntax based methods are highly useful in this respect. In the studies in Stockholm and Copenhagen, results point towards the same conclusions, i.e. that spatial accessibility in itself has an impact on housing prices. Spatial accessibility seems less...
important for people living in single family houses than for people living in apartments, perhaps due to lifestyles being more dependent on private cars and consequently less so on a well-integrated local street network.

3.2 Location, location, location

Urban amenities, defined as shops, excluding convenience stores, restaurants, cafés, bars and cultural amenities, were found to be significant in Stockholm. More explicitly, accessibility to urban amenities correlated with housing prices both for apartments and single family houses, within 1000m and 500m walking distances respectively. In Copenhagen, the result was more nuanced, showing that restaurants, bars and cafés within 100m correlated negatively to housing prices whereas accessibility to shops within 1000m correlated positively. Moreover, variety in businesses, measured as number of different branches within distances between 800m and 1200m walking distance, correlated positively with housing prices. The results in Copenhagen indicate that restaurants, cafés and bars close to the dwelling are not appreciated by residents (because of noise or other disturbances), whereas the results in Stockholm suggest they are appreciated at some larger distance. The suggestion that correlation of some variables alters from positive to negative depending on the distance is discussed by Heyman & Ståhle (2013) and will be elaborated in further research.

In Copenhagen, distance to schools weighted by their average grades emerges as a significant variable, whereas in Stockholm it does not. This could be a matter of data supply. Alternatively, a school’s average grades may function as a substitution for socioeconomic indexes, household income and parents’ education level – factors that were significant in Stockholm.

3.3 Urban typologies versus continuous measures

The environmental variables in Stockholm and Copenhagen are constructed to supposedly measure only a single phenomenon. In contrast, a study by (Dittmar et al. 2007) collects several measures relevant for sustainable urbanism, such as mixed use, walkability etc. into one typology called “sustainable urbanism”. This is then compared to “old urbanism” and “standard urbanism” regarding correlation with dwelling prices. Even though the study indicates that such kinds of typologies might grasp some monetary issues, the urban form characteristics are too general for the results to be applicable for architecture or urban planning.

On the matter of typologies, the study by (Sjaastad et al. 2008) in Oslo is relevant. It takes the same basic approach as the studies in Stockholm and Copenhagen but does not have the space syntax based measures and GIS-tools were not applied. Instead, neighbourhoods were categorised by urban typologies based on the idea that people are able to ascribe the properties they are looking for to urban typologies. This categorisation of neighbourhoods into a few types does not capture any variations within neighbourhoods of the same type. A practitioner is consequently unable to differentiate which characteristics of a neighbourhood are preferred, or not preferred, from this study. Some characteristics within a typology (for example “postmodern blocks”) might be well correlated to housing prices whilst some are not. However, the study describes several interesting results. For example, the distance to parks in the centre correlates positively to housing prices whereas distance to “un-programmed green areas”, a kind of area often found in post-war neighbourhoods, correlates negatively. In the studies in Stockholm and Copenhagen, these typologies are instead disaggregated into variables not associated with only one typology. However, a combination into an index may be more accurate to a person's
perception. Consequently there might be cases in which a typology could fit better into a model, but one should be careful of what can go unnoticed in such a measure.

3.4 Measures not captured by the analyses
In hedonic modelling, measures that are constant across the sample will not be found significant by the analysis but might very well be relevant in reality. One example is measures that are not present in the sample, such as the price effect of adding a park in a city with no parks. Another example is measures that are equally distributed all over the market. An example of the latter is the fact that neither of the studies found food stores to be significant. Accessibility to a food store is most likely to be relevant for people buying a dwelling. However, since the stores are evenly distributed, giving little diversity in accessibility, this factor does not result in any differences and is not captured by the analyses. This means that some measures can ‘disappear’ in the statistical model even though they are, in reality, important for the willingness to pay for housing.

In our future research in Oslo, we expect that accessibility to public transportation in the central parts of town might be one of those ‘invisible’ variables that has an impact on price in reality but does not show up in the model, due to the even distribution of bus routes, light rail and subways in large parts of the city.

3.5 Prices, attractiveness and needs
In liberal real estate markets, such as the contemporary Norwegian housing market, the demand is often equalled with people’s needs. This is misleading; the demand in terms of the market’s willingness to pay for dwellings represents nothing more than the sum of requests of the households wanting and intending to buy a dwelling and does not capture needs or preferences of households wanting a better dwelling without being able to afford to buy one (Aarland & Nordvik 2009; Anderson & Duncan 2011).

High price indicates that a number of people with a certain capability to pay find the actual commodity attractive and therefore worth the high price. People with lower income, such as average students or the unemployed, might agree that a highly priced dwelling is attractive (in terms of inheriting features to be appreciated), without ever considering buying the dwelling themselves. Concerning their own choice of dwellings, low-priced dwellings are likely to constitute the attractive ones, if we understand attractiveness as being sought for and purchased or rented.

The overall issue as well as the methodological approach of the studies presented in this paper are about built form and housing prices. This is a useful focus for carrying out certain works of research, but is at the same time a limitation that must be kept in mind before generalising the results of this research to people’s needs for housing. Our further research will include elaborations on these kinds of relationships between housing prices and needs for housing, keeping in mind what is not captured by the applied methodology and being aware of the tacit contemporary conception equalling people’s need for housing with the demand of the liberal market.

4 Conclusions
The aim of this paper is to draw conclusions from the previous studies examined for a proceeding analysis of Oslo’s housing market. Since the studies in Copenhagen and Stockholm are unpublished reports, they are not completely transparent regarding method and are also lacking in the presentation of complete results. Having said this, we are able to draw some main conclusions and learn some valuable lessons from them.

Firstly, and maybe most importantly, we believe these studies show that the used measures of urban form can and should be a fundament when
searching for the willingness to pay for housing. For example, the study favours measures of proximity using walking distance over the ones using straight line distance. The exception is distance to railroads and highways, which probably corresponds to noise which travels as the straight line distance. Instead of leaning on statistical suitability of the measures, we are convinced that choosing measures known from urban design theory to have an impact on people’s behaviour will make the study for Oslo more reliable (in the sense of being able to present a model where the variables are more likely to connect the correlation with cause).

Secondly, the studies show two different ways of defining a market. Although the reports describe little of the motivations for the different approaches, their results give us something to draw on. The results from Copenhagen make a pretty strong case that their approach fails to deliver a clear picture of the willingness to pay for housing in Copenhagen, because there are so many different submarkets. The variables that emerged as significant in the different markets are perhaps statistically more suitable. However, if the question is which are the aspects of housing and its environment that affect price, the study does not present a clear answer. On the other hand, the results from Stockholm leave us wondering if one can really look at the whole metropolitan area as one single market. Although we are unable to conclude which approach is preferable overall, we find that in terms of transparency, the approach in Stockholm is favourable.

Thirdly, we note that both studies offer high degrees of explanation but have different ways of including building or apartment-specific measures, such as number of bathrooms or balconies, as discussed in section 2.4. In general, we prefer the more transparent procedure in Copenhagen, where all measures were included individually in the model, but which is also dependent on large amounts of data - maybe more so than is accessible in Oslo.

4.1 Further description of the study in Oslo
Thanks to the extensive data on the housing market, containing key data on all dwelling purchases in Oslo over the last 20 years, we are able to examine both the price effects of different variables in the contemporary market, similarly to the studies in Stockholm and Copenhagen, and to study the development of prices over time. The time aspect hopefully can capture both fluctuations in demand for specific variables as well as differences among particular neighbourhoods’ attractiveness over time. Such results might shed light on essential urban development issues related to gentrification. We hope to find patterns in price fluctuations that can be linked to urban form and consequently provide insights into how urban design, in addition to political and economic instruments, can be used to distribute monetary value of real estate more equally among the population. Through the methodological approach, we hope to reveal new knowledge about what could be attractive urban developments in the future. The studies in Stockholm and Copenhagen, perhaps due to their nature as consultancy reports, do not discuss people’s needs versus ability or willingness to pay. This matter is briefly mentioned in previous sections and will be elaborated on in our ongoing study of the housing market in Oslo.

Although there are differences between the cities that will likely make the Oslo results somewhat different from those obtained in the studies of Copenhagen and Stockholm, an important part of the Oslo study will be to synthesise the results with those of Copenhagen and Stockholm, looking for a general platform from which urban form can achieve a more central position in the economical valuation of housing. Leaning on analytical theory of spatial capital as proposed by (Marcus 2007), we might be able to provide new knowledge regarding variations of economic value due to spatial variability in cities. This knowledge should be useful for a wide range of actors, including politicians, local authorities,
urban planners, architects, real estate businesses and contractors, who are participating in housing design and development.

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