



## **Models of household location and urban amenities**

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# Urban Regions in the Delta



## Models of household location and urban amenities

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NWO

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# HELP UvA-VU

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# 1. Introduction

## 1.1 Skilled workers and regional development

The research carried out in the HELP project concerns the importance of urban amenities for the location choices of highly educated workers. Why is this important? A general answer to this question is that such workers are generally regarded as being the drivers of economic prosperity and growth in cities. In this introductory section we discuss some evidence that motivates this idea.

In 'The Economy of Cities' Jane Jacobs (1970) puts forward the thesis that human interaction is a crucial aspect of urban economies. Economists such as Lucas (1988) picked up this idea, which they interpreted as human capital externalities. That is, interaction between educated individuals generates benefits for society that exceed those accruing to the individuals. The high population density in cities stimulates such interactions, which can alternatively be viewed as a kind of agglomeration economies. Cities thus become more productive places and this process works continuously and generates growth. Empirical evidence in favor of this hypothesis was provided by Rauch (1993) who estimated that an additional year of schooling of the labor force in an urban area gave rise to an increase in total factor productivity of 2.8%. Later studies include Glaeser and Maré (2001), who find that workers moving to the city realize important wage gains, especially when they are young. They do not lose these gains when they later move to rural areas, which suggests that their sojourn in the city has permanently increased their productivity.

## 1.2 Consumer city

If it is true that the interaction of highly educated workers generates substantial external effects, it is clearly important for urban policy makers to know how they can attract such workers and, when they are present, make them stay. An important contribution to the economic literature on this issue was made by Roback (1982). The basic idea of this paper is that of equilibrium: if identical workers live at different locations, they must be equally well-off in all of them. The well-being of workers depends on wages, but also on the price of consumer goods, including housing, and on the presence of local amenities. There is a trade-off between these determinants: workers can, for instance, be compensated for high house prices by higher wages or better amenities.

Workers can only be attracted to cities if there are jobs and although local labor markets may differ in many respects, it is generally the case that higher wages lower the demand for workers.<sup>1</sup> However, if a city has good amenities it may continue to attract highly educated workers even when wages are not that high. This reasoning thus suggests an important connection between urban amenities and economic prosperity.

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<sup>1</sup> The external effects generated by the interaction of highly educated workers may mitigate this effect, but should not be expected to provide full compensation.

Although urban economic theory has traditionally regarded the city primarily as the location of jobs, increasing attention is paid to the importance of consumer amenities for urban life. A pioneering contribution was Brueckner et al.'s (1999) answer to the question why central Paris is rich while downtown Detroit is poor. Amenities make the difference, according to the theory developed by these authors. When the central city is attractive high income households are willing to pay a lot for living there and contribute to a vital central city, whereas the lack of amenities make the rich choose for luxury houses in the suburbs with the risk of a desolate inner city. Another seminal study is Glaeser et al. (2001), who provide a large amount of empirical evidence that suggests that consumer amenities are important for cities. Later studies include Van Duijn and Rouwendal (2013), who show that cultural heritage – they use ancient inner cities as a proxy – is indeed an important attractor of cities. Their sorting model is of the same type as those used in this report.

## 2. The logit-based sorting model

### 2.1 The logit model with homogeneous consumers

McFadden (1973) is the seminal paper for the use of the logit model and other types of discrete choice models in applied economic analysis. The choice probabilities of the logit model can be interpreted as the outcome of utility maximizing behavior of a population of consumers over a finite set of alternatives.

Let  $n = 1 \dots N$  denote the choice alternatives. They are distinguished by characteristics  $X_n$ . The utility  $u_n$  attached by a consumer to each alternative is the sum of a deterministic part  $v_n$  and a random part  $\varepsilon_n$ :

$$u_n = v(X_n) + \varepsilon_n, \quad n = 1 \dots N. \quad (1)$$

The deterministic parts are identical for all consumers, but the random parts differ. They are regarded as random draws from a given probability distribution. Each consumer knows the draws that are relevant for him or her, but for the researcher these random draws are unobserved. The logit model thus takes into account that the researcher has imperfect knowledge of the consumer's preferences.

Although the researcher does not observe the outcomes of the draws for individual consumers, the distribution from which they are drawn is assumed to be known. If all the  $\varepsilon_n$ 's are independent draws from the extreme value type I distribution,<sup>2</sup> the choice probabilities can be derived as:

$$\pi_n = \frac{e^{v_n}}{\sum_m e^{v_m}}, \quad n = 1 \dots N, \quad (2)$$

where  $v_n$  is used as shorthand notation for  $v(X_n)$ . This is the logit model.

When applied to the location choice behavior, the alternatives are – in the simplest case – locations or – in less simple cases – combinations of locations and possible characteristics of the location. For instance, in most of the models that will be discussed below, households can choose to be a tenant or an owner-occupier in each of the locations that are distinguished. A choice alternative is then a combination of a location and a housing tenure type. If the housing stock and all its characteristics are taken as given, one may take the extreme position that all existing houses should be treated as separate choice alternatives. Although this approach is feasible<sup>3</sup> it is often more convenient to assume that the level of the housing price at each location is given, whereas households can adjust the quality of their houses to their own preferences.<sup>4</sup> The work that is reviewed below follows this approach.

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<sup>2</sup> This distribution,  $F(\varepsilon_n) = \exp(-\exp(-\varepsilon_n))$ , is sometimes also referred to as the Weibull- or Gnedenko- distribution.

<sup>3</sup> See Bayer et al. (2007).

<sup>4</sup> This ignores the costs associated with changing the quality of housing (Epple and Platt, 1998; Epple and Sieg, 1999).

It is conventional to specify the deterministic part of the utility function as a linear function of the characteristics of the choice alternative:

$$v(X_n) = \sum_{k=1}^K \beta_k X_{nk} \quad (3)$$

In this equation the index  $k$  refers to individual characteristics of the choice alternatives and  $K$  is the total number of characteristics. The characteristics may simply be included as such, but transformations, e.g. the logarithm of the housing price, or interactions can also be used.

Estimation of the model results in values for the coefficients  $\beta_k$  that reflect the importance the consumers attach to the various characteristics of the choice alternatives. The housing price is of course a relevant characteristic of each choice alternative and this provides the possibility of translating the intensities of preference into willingness to pay. In the simple case in which the characteristics are only included untransformed and without interactions, this willingness to pay is simply the ratio of the coefficient for that characteristic and that of the price. Estimating the willingness to pay for urban amenities is one of the main goals of the analyses reviewed in this report.

## 2.2 The logit model with heterogeneous consumers

An important property of the logit model is the independence of irrelevant alternatives. It says that the ratio of the choice probabilities of two alternatives does only depend on the deterministic utilities of these two alternatives.<sup>5</sup> This property of the model has implications for the way the consumer is willing to substitute one choice alternative for another that are generally regarded as unrealistic. Researchers have therefore tried to find more flexible models that relax this property. An important development in this respect was the generalization of the logit model to situations in which the parameters  $\beta_k$  are random variables. This so-called mixed logit model can be interpreted as referring to a population of consumers that are not only heterogeneous with respect to the relevant values of the  $\varepsilon_n$ 's, but also with respect to those of the  $\beta_k$ 's. In a mixed logit model the latter are also regarded as draws from a distribution function. Although in a mixed logit model the independence of irrelevant alternatives is still present at the level of the individual consumer, it no longer holds for the population. Indeed, McFadden and Train (2000) show that under mild conditions *any* random utility maximization model can be approximated arbitrarily close by a mixed logit model, which suggests that the logit model is completely general if only one is allowing enough flexibility in the functions  $v(X_n)$ .

McFadden and Train's (2000) result suggests that the key to relaxing the restrictiveness of the multinomial logit model is to allow for heterogeneity among the actors. Even if one does not specify a completely flexible mixed logit model, taking into account that actors differ in preferences when estimating the model makes it more flexible and realistic. One obvious possibility, that will be used here, is to allow the coefficients of the utility function to differ with household characteristics. Taking the specification (3) of the deterministic part of the utility function as our starting point, this generalization allows for consumer specific values of the coefficients. That is, instead of  $\beta_k$  we should now use  $\beta_k^i$  which is the realization of the coefficient for the  $k$ -th characteristic of the choice alternative for consumer  $i$ . It seems natural to allow for the possibility that these coefficients are related to consumer characteristics  $Z_i$ .

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<sup>5</sup> It is easy to verify that  $\pi_n/\pi_{n'} = e^{v_n}/e^{v_{n'}}$ .

Assuming linearity, we specify:

$$\beta_k^i = \alpha_k^0 + \sum_{l=1}^L \alpha_k^l (Z_{li} - \bar{Z}_l), \quad (4)$$

where  $Z_{li}$  denotes the value of characteristic  $l$  for consumer  $i$  and  $\bar{Z}_l$  is the average of  $Z_{li}$  in the population.<sup>6</sup>

The formulation just discussed can be related to a mixed logit model in which the distribution of the parameter  $\beta_k^i$  in the population is determined by the distribution of the consumer characteristics. Randomly drawing a consumer from the population results in a realization of  $\beta_k^i$ .

The coefficient  $\alpha_k^0$  give the value attached to characteristic  $k$  by the average consumer in the population, while the deviations from this average are determined by the coefficients  $\alpha_k^l$ . When the latter coefficients are all equal to zero, we return to the logit model with homogeneous consumers that was discussed in the previous subsection. A notable consequence of the generalization of that model implied by (4) is that the willingness to pay for characteristics of choice alternatives becomes also dependent on household characteristics. For instance, if education is included as a relevant consumer characteristic, the estimated parameters reveal its impact on the willingness to pay for location characteristics.

### 2.3 Estimating the model

Logit models can be estimated on individual data with the maximum likelihood method. McFadden (1973) showed that the likelihood function is globally concave. In practice the logit model is the only discrete choice model that can be conveniently used when the number of alternatives is large (hundreds or even thousands).

An important issue in estimating logit models, that was brought to the fore by Berry et al. (1995) is that in practice researchers have incomplete information about the choice alternatives. They proposed to take this into account by adding an unknown alternative-specific variable  $\xi_n$  to the utility function. With this additional variable and allowing for individual-specific coefficients, the utility attributed to alternative  $n$  becomes:

$$v(X_n) = \sum_{k=1}^K \beta_k^i X_{nk} + \xi_n \quad (5)$$

Since the impact of unobserved characteristics of alternatives in (5) is not actor-specific, this formulation may still be regarded as restrictive. Nevertheless, its introduction was a major step forward in the application of logit models. The problem for estimation posed by (5) is that the new term  $\xi_n$  cannot be observed. To solve it, Berry et al. (1995) propose to rewrite (5), using (4), as the sum of an alternative-specific constant and a number of cross-terms:

$$v(X_n) = \delta_n + \sum_{k=1}^K \sum_{l=1}^L \alpha_k^l (Z_{li} - \bar{Z}_l) X_{nk} \quad (6)$$

with

$$\delta_n = \sum_{k=1}^K \alpha_k^0 X_{nk} + \xi_n. \quad (7)$$

Estimation then proceeds in two steps: first a logit model is estimated with the utility function specified as in (6) and then the estimated alternative-specific constants are analyzed further by

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<sup>6</sup> Note that the consumer characteristics  $Z_{li}$  may be transformations or cross-products of elementary consumers characteristics.

linear equation methods using (7). The unobserved heterogeneity terms  $\xi_n$  are the residuals of the estimating equation.

In the second step endogeneity concerns can also be addressed. An important one is that the housing price in a neighborhood is likely to be correlated with its unobserved characteristics. Ignoring this problem implies the risk of underestimating the consumer's price sensitivity and it is indeed generally found that instrumenting prices results in substantially larger price coefficients. Other endogeneity issues arise when the demographic composition of a neighborhood has an impact on its attractiveness.

Finding instruments for the endogenous variables is not an easy task. Berry et al. (1995) suggested the use of characteristics of competing alternatives as an instrument for the price in their model of the automobile market, but in the context of neighborhood location choice, the appeal of this argument is not so strong. Bayer and Timmins (2007) suggest computing an instrument using the logic of the model. The idea, for the case of prices, is to use the equilibrium prices that are predicted by the model in the counterfactual case in which the unobserved heterogeneity terms are all equal to 0. This procedure is used in the studies reviewed here for the housing price as well as for population shares when they enter the utility function.

## 2.4 Relation with hedonic analysis

To discuss the relationship between sorting and hedonic price models, we assume that the price is the first location characteristic and write:  $P_n = X_{1n}$ . We can now invert the utility function (5) into something that looks like a hedonic price equation, apart from the fact that utility is one of the variables on the right-hand side. If individuals with the same characteristics would all reach the same utility level, no matter which location they choose, we could consider this as a 'fixed effect.' The logit model does not have this property, but there is a closely related property which guarantees that the distribution of the expected maximum utility of actors with a given set of characteristics is independent of the alternative that has been chosen.

Weijsschede-van der Straaten et al. (2014) show that this property implies that we derive the following equation for the housing price at location  $n$ :

$$P_n = \sum_{k=2}^K \frac{\bar{\beta}_k}{-\beta_1} X_{nk} + \frac{1}{-\beta_1} \xi_n + C_n \quad (8)$$

where  $\bar{\beta}_k$  is the average value of coefficient  $\beta_k^i$ ,  $k = 1 \dots K$  in the population<sup>7</sup> and  $C_n$  is a term that reflects the heterogeneity of the actors and the supply of housing at  $n$ . The ratios  $\frac{\bar{\beta}_k}{-\beta_1}$  give the average willingness to pay for characteristic  $k$  in the population, expressed in terms of the housing price. That is, they indicate how much the average actor is willing to pay for one unit of characteristic  $n$ . This agrees with the conventional interpretation of the coefficients in a hedonic price equation. Equation (8) thus establishes a link between sorting models and conventional hedonic price equations. Nevertheless, the two are not completely equivalent because the term  $C_n$  differs over the locations and may be correlated with the  $X_{nk}$ s, which suggests that hedonic analysis may lead to biased results. On the other hand it should be observed that the problems with endogeneity of the housing price that are present in the logit model do not occur in the hedonic price equation.

<sup>7</sup> That is,  $\bar{\beta}_k = \sum_i \beta_k^i / N$  where  $N$  denotes population size.

# 3. Applications

## 3.1 Introduction and overview

In this section we discuss a number of applications of the modeling framework outlined above to questions concerning the relationship between educated workers and urban amenities. We start in subsection 3.2 with an investigation into the locational preferences of various household types in the Netherlands. The focus in this work is on housing in relation to jobs and other amenities. One important idea is that households with higher incomes, often related to more education, have better possibilities for realizing a satisfactory housing work arrangements than otherwise comparable households with lower incomes. A second consideration is that this is especially important for households with two workers, since the higher income allows them to solve the co-location problem, which has been shown to be an important driver for the choice in which metropolitan region to live in the U.S. (Costa and Kahn, 2002). The third and – for the purposes of the HELP project – most important aspect of this study was the investigation of the importance attached to other (non-work) urban amenities, relative to unemployment accessibility. The results confirm that households do not only appreciate the city because of its labor market advantages, but also attach substantial weight to consumption amenities, thus confirming the main idea behind the HELP project.

In section 3.3 we delve a bit deeper into this issue by elaborating the role of conservation areas, which is our main indicator of urban attractiveness, in our sorting model. It is certainly true that the cultural heritage that is abundantly available in many historical Dutch cities is an important amenity in itself. However, the presence of this amenity also makes it more attractive for other amenities like shops, restaurants, café's, theatres and music halls to locate in these cities. This is indeed the case and we can therefore conclude that our estimates of the strong preference for cities with historical districts does not only reflect the value attached to the monuments and old buildings *per se*, but also to the endogenous amenities that are overrepresented in its vicinity. Our findings thus confirm the importance of 'consumer city,' especially for the higher educated workers.

To provide an international perspective, subsection 3.4 discusses some results of the estimation of a sorting model for the Greater Copenhagen Area, which can be considered as the Danish equivalent of the Dutch Randstad. The results confirm that also in Denmark consumer amenities play an important role next to labor market considerations. Another issue, to which we return in other work for the Netherlands, is the unequal distribution of income groups over the area. The higher incomes are overrepresented in the northeastern part of the area, whereas the lower incomes tend to live more often in the west. We link this phenomenon to preferences of households over the composition of the population in residential areas. This composition is thus, on the one

hand, an important outcome of the choice process, but on the other it is also one of its driving forces. This interdependency has been taken into account when estimating the model and the importance of this 'social interaction' phenomenon is clearly demonstrated. It suggests the possible existence of multiple equilibria and path dependence. Further investigation of these issues was, however, outside the scope of the Copenhagen study.

Before elaborating the social interactions issue for the Netherlands we turn to two other issues concerning the interpretation of the sorting model. The first one, discussed in 3.5 concerns the question if job accessibility is the appropriate indicator for labor market attractiveness. With competitive labor markets the wage would be a sufficient statistic for the attractiveness of a particular residential location. Although we know that labor markets are not perfect, the wage remains of course an important aspect and recent research (see Groot et al. 2001) has confirmed that there are non-negligible geographical differences in wages within the Netherlands. Using these research results, we investigated the robustness of our earlier investigation. The results show that wage differences can alternatively be used as a labor market indicator and that the results with respect to urban amenities remain qualitatively unchanged. Wages and job accessibility are strongly correlated, and this phenomenon can be attributed to agglomeration effects.

Our finding that urban amenities are important drivers of location choice behavior raises another question: can good amenities substitute for a strong labor market? This seems to be unlikely for *a priori* reasons, but our results do not exclude this interpretation. To investigate the issue in some detail we have extended the sorting model with a cross term for job accessibility and conservation area. A positive coefficient for this cross term tells us that the impact of urban amenities is larger if the labor market is also strong, whereas a negative coefficient suggests that consumers attach less value to these amenities when the labor market is strong, for instance because there is not so much time to enjoy the consumer amenities. The results are clear: consumer amenities are appreciated more in areas with a strong labor market. Without jobs, amenities are unable to add much to the attractiveness of a city. In subsection 3.6 we discuss this result and its extension to a more general, non-parametric specification.

In subsection 3.7 we return to the importance of the demographic composition of neighborhoods for their attractiveness as a residential location. It is well known that in US cities the higher incomes tend to live in the suburbs, whereas in European cities the pattern is different: the rich are also overrepresented in the city centers, especially when there are many amenities. In the Amsterdam metropolitan area this pattern is also clearly visible in the owner-occupied sector. Including the share of high income households as a possible attractor in the sorting model confirms the hypothesis that social interactions are also important here. This leads to interesting questions with respect to possible equilibrium configurations. The presence of cultural heritage and associated endogenous amenities attracts higher educated households to the city center. Since these households often have higher incomes. This further increases the attractiveness of the center. The 'social interaction' (people like to live where the rich live) therefore has a multiplier effect on the attractiveness of the center. Moreover, simulations suggest that, depending on the initial situation and the parameter values, the social interactions help to determine the equilibrium configuration (where the rich can either concentrate in the suburbs or in the center). These findings shed light on the successful policy of large cities to increase their attractiveness by targeting housing construction on high income households.

Subsection 3.8 relates an exercise that investigates the consequences of a standard assumption in the sorting models literature: the absence of mobility costs. In the conventional setup, that has also been used in the work discussed thus far, households are assumed to be able to locate everywhere. History does not matter. In practice, it is likely that high costs of mobility (in monetary as well as in social and psychological terms) tend to stick households to locations that have been chosen in the past. Making unrealistic assumptions is not necessarily a bad thing: model building is useful exactly because it simplifies reality by neglecting many aspects that are irrelevant. However, treating immobile households as if they are perfectly mobile may well have implications for our estimates of the location preferences and this is the reason why we investigated this aspect in a separate (pilot) study for the Eindhoven region in the Netherlands. Our results show – not surprisingly – that mobility costs are large. What is more important: including mobility costs has an impact on the estimated parameters of the utility function, both of the average household and of specific groups. Hence willingness to pay estimates are also affected, which implies that policy recommendations based on sorting models may also be biased. Further investigation of the importance of mobility costs in the logit model is therefore a relevant topic for future work.

Subsection 3.9 concludes our sequence of studies by an exploratory investigation into the relevance of making a distinction between technical, creative and other (highly educated) workers. The relevance of this distinction is suggested by geographical literature, e.g. the stated preference survey conducted within this project. To see if the suggested differences in location behavior can be verified in revealed preference research as well, we have used a classification of occupations to detect 'technical' as well as 'creative' occupations. Since occupations are – at least to some extent – chosen by the workers, we base the orientation of workers on their education directions, which are usually given once the worker enters the labor market. On the basis of this investigation we distinguish three groups of (highly educated) workers and estimate a sorting model. At the time of writing this report, results were not yet available.

### 3.2 Employment and amenities in the Netherlands

Weijsschede-van der Straaten et al. (2014) study the locational preferences of various types of households in the Netherlands. Municipalities are their basic geographical unit of analysis and their focus is on the role of household heterogeneity. A main finding of their analysis is that education is an important determinant of differences in willingness to pay for urban amenities among households. Table 1 gives the main results.

The first line of Table 1 refers to the estimated willingness to pay of the average Dutch households for a number of amenities. Accessibility to jobs is measured as the shortest distance within which 100,000 jobs can be found. The table shows that the average Dutch household is willing to pay almost €3,000.- less for a standard house if this distance is increased with 1 km. The figures referring to distance to a highway ramp and an intercity station also reflect – at least partly – the importance that households attach to the accessibility of jobs. Column 4 of Table 1 refers to the attractiveness of the city as a place to live. The area of the historical district is used as an indicator for this amenity. The Dutch Agency for Cultural heritage (RCE) has listed many of these districts for their outstanding value as cultural heritage and we have used the size of this listed area as our indicator for urban attractiveness. Dutch households are on average willing to pay €5,000 for a standard house when it is located in a municipality that has an additional km<sup>2</sup> of such a historical district. The figure reflects not only the cultural heritage itself, but also the vivid city life

that is usually associated with it as visitors are attracted to these districts which makes it also a preferred location for shops, restaurants, theatres and other urban amenities. The last column of the table gives the willingness to pay for an additional percent of the municipality's area that qualifies as nature.

**Table 1** Average marginal WTP for location characteristics and deviations by household type

	Distance to 100,000 jobs (km)	Distance to high-way on-ramp (km)	Distance to intercity station (km)	Protected historical inner city (km <sup>2</sup> )	Nature (percent)
Average marginal willingness to pay	- 2970	- 697	- 438	4785	952
WTP of lower educated single with average age	- 2927	- 492	- 572	5234	953
	Relative to lower educated single with average age				
Single, higher educated	- 309	- 376	- 180	+ 316	- 25
Couple, both lower educated, no children	+ 179	+ 69	+ 126	- 688	- 46
Couple, both lower educated, at least one child	+ 227	- 128	+ 241	- 943	+ 7
Couple, one lower and one higher, no children	+ 1	- 127	+ 110	- 352	+ 47
Couple, one lower and one higher, at least one child	+ 33	- 100	+ 88	- 549	+ 43
Couple, both higher educated, no children	- 205	- 179	- 62	+ 158	+ 74
Couple, both higher educated, at least one child	- 422	- 318	+ 13	- 346	+ 58
Lower educated single, 10 years older	+ 44	+ 24	+ 29	- 60	+ 40

Source: Weijsschede-Van der Straaten et al. (2014)

Note: these results, as all other WTP results in this report, are based on the revealed preferences for owner-occupiers only. Rent control invalidates the revealed preference methodology for the rental segment of the housing market.

The table illustrates that cities are not only important because they provide access to dense labor markets, but also because city life is attractive in itself. This should – of course – not be interpreted as implying that cities can thrive without jobs; the point is rather that the inhabitants of cities are not only workers but also consumers and that they also take into account the consumption possibilities when choosing a residential location in the vicinity of their job.

The other lines in the table show that households differ in the value they attach to the urban amenities. Singles and higher educated couples in particular appreciate the inner cities with a large amount of cultural heritage and the associated atmosphere. Note that such 'power couples' also attach a higher than average value to this typically urban location aspect when they have children. This points to a potentially important aspect of location choice: it is not – perhaps we should say: no longer – self-evident that the inner city is the wrong place to raise children. The times in which young households moved *en masse* to the suburbs may well belong to the past.

### 3.3 Shops and cultural heritage

In the previous subsection we argued that the willingness to pay for historical urban districts that we estimates should be interpreted as referring not only to cultural heritage *per se*, but also to the shops, restaurants, bars, theaters, music halls, et cetera that are attracted to historical districts either because the ancient building provide an appropriate surrounding for the kind of services they offer or because large numbers of visitors are attracted to these areas (or both). In Van Loon et al. (2014) we have focused on the relationship between historical districts and the number of shops. Table 2, which is taken from this paper, shows that there all more shops of all types in neighborhoods that qualify as historical districts than in otherwise comparable neighborhoods. The overrepresentation of antique, art and culture is especially striking. The catering services include bars and restaurants. It should also be evident that theatres, music halls and museums are also overrepresented in historical districts.

**Table 2** Ratio of type of stores within and outside conservation areas for 2012

	Within conservation areas	Outside conservation areas	Ratio inside / outside
Food stores	5.29	3.68	1.44
Fashion stores	9.19	2.63	3.50
Catering services	15.83	5.32	2.98
DIY	0.53	0.47	1.13
Antique and art stores	1.02	0.14	7.20
Sports and game stores	1.41	0.52	2.73
Flower and pet stores	1.18	1.03	1.15
Electronic stores	1.50	0.67	2.23
Furniture stores	2.67	1.35	1.98
Culture stores	2.16	0.54	4.00
Recreation facilities	0.94	0.54	1.75
Craft stores	5.99	3.03	1.97
Financial institutions	1.33	0.97	1.38
Private services stores	3.72	1.58	2.36
Vacant stores	4.80	2.18	2.20

Note: these values are adjusted for population size and population density. Thus the figures 'within and outside conservation areas' are comparable to each other. The figures are the average number of stores per neighborhood. An average neighborhood in this particular sample counts 2500 inhabitants and it has a population density of around 4000 inhabitants per square kilometer. We do not include neighborhoods with a population below 100 and a population density below 500. Source: Van Loon et al. (2014).

All this suggests, of course, that consumption patterns of urban citizens differ from those living elsewhere. The greater supply and variety of all kinds of services and commodities in urban areas has an impact on the way consumers spend their budget. Consumers who like the urban amenities are attracted to the city, but have to face the generally higher housing price prevailing there. See Rouwendal and Möhlmann (2014) for an analysis using consumer expenditure patterns.

### 3.4 Employment and amenities in the Copenhagen metropolitan area

A similar sorting model as discussed in 3.1 has been estimated for the Greater Copenhagen Area (GCA).<sup>8</sup> The GCA is the political, administrative, and educational centre of Denmark and accounts for more than 40 % of Denmark's GDP, one third of the Danish population, and 1 million jobs. Estimation is based on administrative register data for all Danish households with residence in the GCA for the year 2008, spread over 167 zones designed for the purpose of detailed traffic modelling. The study area is thus substantially smaller than that of the study discussed in the previous subsection.

A 20% sample of the population living in owner-occupied housing was used,<sup>9</sup> which gave us 41,099 observations. These consumers are distributed over 167 zones in which they can choose to live either in an apartment or other housing types (detached, terraced). In some zones we observe only other housing types (mainly at the outskirts of the study area) and in some zones only apartments (in the center of the GCA), and the total choice set includes 302 elements.

We focus on 8 local amenities: i) standardized house price, ii) coastline (km), iii) employment access, iv) distance to the nearest motorway ramp (km), v) distance to the nearest metro station (km), vi) number of listed buildings per sq.km., vii) distance to the CBD, and viii) share of higher educated population. We include 10 socioeconomic variables: i) age of the head of the household, ii) squared age of the head of the household, iii) a dummy indicating male head of the household, iv) three dummy variables indicating highest education obtained by the head of the household, v) a dummy indicating a single-person household, vi) the number of children in household, vii) household income, viii) a dummy indicating the head and his/her partner have the highest level of education (power couple).

In Table 3 we present the results of the second step of the estimation procedure. The first column shows the OLS results, the second those of instrumental variables regression. The set of explanatory variables (location characteristics) differs somewhat from those used for the Netherlands, which is partly due to differences in available data. We used the number of conserved (protected, listed) building as an indicator of cultural heritage and – indirectly – also for other urban amenities like shops, restaurants, theatres, and the length of the coastline of a zone as an indicator for natural amenities.

We also included the share of higher educated in the population as an indicator of an endogenous amenity. It is often argued in the literature that the attractiveness of living in a particular area is partly determined by the demographic composition of that neighborhood. For instance, in sociology the phenomenon of *homophily*, that households interact preferably with other households that are similar, is well-known. In the urban economics literature the importance of this for location choice within the San Francisco Bay area was documented by Bayer et al. (2007). In this study we use a similar formulation.

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<sup>8</sup> For details see Mulalic and Rouwendal (2014).

<sup>9</sup> We ignore renters. This can be motivated by a nested logit approach in which the housing tenure choice is on the top of the utility tree and the choice of the combination of housing type (apartment or other) and the geographical area refers to the lower level.

As we noted earlier in this report, the demographic composition of location is as much the result of choice behavior as it is one of its determinants. This means that we have to deal with the probable endogeneity of the share of higher educated. The price should, for reasons that have also been detailed above, also be treated as endogenous. Table 3 shows that dealing with the endogeneity makes a huge difference for the estimation results.<sup>10</sup> We find a much larger (in absolute value) price coefficient and the coefficient for share of higher educated becomes significant and also much larger once it is instrumented. This large value suggests that in the Copenhagen region the higher educated tend to concentrate in particular areas. Maps show that this is indeed the case: the share of the higher educated is much larger in the north-eastern parts of the metropolitan region than elsewhere.

**Table 3** Second step estimation results: decomposition of the mean indirect utilities

	OLS	IV (2SLS)
Log (standardized house/apartment price)	-1.408*** (0.552)	-3.606*** (0.577)
Coastline (km)	0.087** (0.042)	0.115*** (0.043)
Employment access	0.879*** (0.233)	0.840*** (0.235)
Log distance to the nearest motorway ramp (km)	0.064 (0.099)	0.108 (0.100)
Log distance to the nearest metro station (km)	0.113 (0.116)	0.111 (0.117)
Number of conserved/protected buildings per sq.km.	1.847*** (0.291)	1.852*** (0.294)
Distance to the CBD.	0.019 (0.021)	0.015 (0.021)
Share of higher educated	0.516 (0.887)	3.094*** (0.919)
Dummy variable indicating non-apartment	1.896*** (0.326)	3.094*** (0.339)
Constant	-1.879*** (0.334)	-1.195*** (0.340)
R-squared	0.327	
No. of observations	302	302

Note: standardized house/apartment price and share of higher educated are instrumented.

An important similarity between the results for the Netherlands discussed above and those for Copenhagen is the strongly significant role of cultural heritage and the endogenous amenities associated with it. Although the size of listed historical districts may be a better indicator of this

<sup>10</sup> An important message of this result is that the neglect of endogeneity issues may result in misleading conclusions. For instance, the smaller (in absolute value) size of the price coefficient tends to lead to *larger* estimates of the willingness to pay for all amenities.

urban attractor than the number of monuments, the two are strongly correlated and we have also used the number of monuments per municipality as an alternative indicator in robustness analyses for the Netherlands. We always found strongly significant coefficients, as is the case for the Copenhagen metropolitan region.

### 3.5 Wages and job accessibility

The studies discussed above use job accessibility as an indicator of the quality of the local labor market. This is not necessarily the best indicator. Van Duijn and Rouwendal (2013) also use wage differentials between municipalities to deal with the attractiveness of the labor market in an alternative way. In their model they include many amenities (e.g. the area of historical inner cities, the area of nature, distance to the nearest intercity station) to make a clear distinction between employment and different types of amenities. The results of this residential sorting model show that wages and urban amenities are important determinants for the location choice of Dutch households. The results confirm the high willingness to pay of households for urban amenities and the presence of substantial heterogeneity of households. For instance, highly educated singles are willing to pay around 15% more than the average household for living in a municipality where wages are 1% higher.<sup>11</sup> In general, the higher educated prefer to live in municipalities with higher relative wages compared to households with children and older households. Wages thus play a similar role as the job accessibility measures used in other studies. Wages also tend to be higher at places where job accessibility is good. In practice the two local labor market indicators can therefore be taken as substitutes, although they clearly measure different aspects.<sup>12</sup>

### 3.6 Jobs and consumer amenities are complements

In the introduction we have briefly discussed the Roback model, which suggests that there is a trade-off between the wage, the housing price and urban amenities. Each of these variables has an impact on the utility of the consumer who is – according to standard economic theory – willing to accept (for instance) a lower wage if this is compensated by cheaper housing or better amenities.

An interesting related question is whether consumers are also willing to trade of job accessibility for urban amenities. Put differently, are consumers still attaching a high value to cultural heritage and the related endogenous amenities if a city is located in an area with a smaller density of jobs? The results discussed above for the Netherlands and Copenhagen are unable to provide a detailed answer because the models do not contain the interaction between job accessibility and cultural heritage. The question has therefore been investigated separately in an extension of Van Duijn and Rouwendal (2013), using job accessibility as an indicator for the local labor market. We introduced the interaction between the indicator for cultural heritage and the proxy for employment opportunities - the distance to the nearest 100 000 jobs – as a new variable into the model. Figure 1 shows the relationship between the average marginal willingness to pay for an extra square kilometer protected historical area and the distance to the nearest concentration of jobs. The graph shows that protected historical areas are valued especially in combination with good accessibility of jobs. The results thus show that investing in urban amenities is especially beneficial in

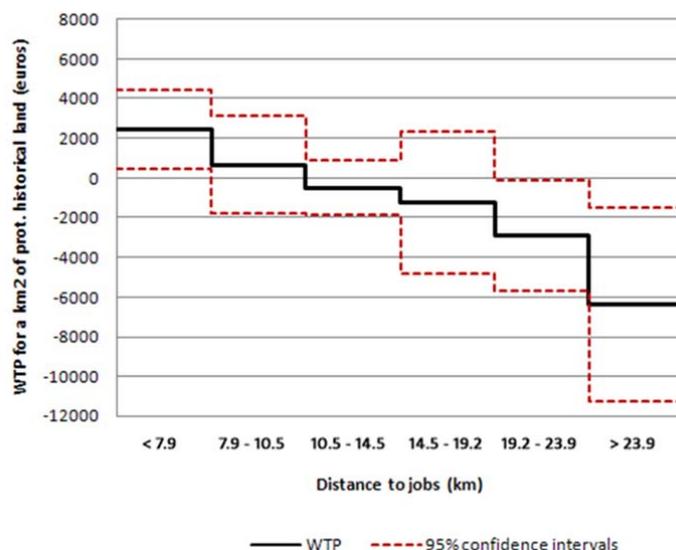
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<sup>11</sup> The average household is defined as a household where all characteristics are equal to the average values.

<sup>12</sup> Further investigation of their relationship would require the development of a spatial labor market model with search.

areas where the labor market is dense. This can be interpreted as confirming the primacy of jobs in the preferences of households. It also suggests that strategies to fight population decreases with better amenities are risky. Urban amenities are especially important in combination with and as a complement to a strong labor market.

**Figure 1** The interaction between protected historic areas and the nearest concentration of 100,000 jobs



### 3.7 Cultural heritage and social interactions

Earlier in this report the importance of the demographic composition of neighborhoods was discussed and illustrated with estimation results for Copenhagen. In economics this phenomenon is often referred to as social interactions, because the behavior of some individuals influences that of others in their peer group directly, instead of only indirectly via the market mechanism and prices. In the case considered here it the location choice of households is influenced by that of other households. Heterogeneity is essential for this phenomenon since it is especially the behavior of one's peers or the members of one's reference group that matters.

The phenomenon has been investigated in some detail in Van Duijn and Rouwendal (2014) where the focus is on the impact of the share of higher income households on the attractiveness of urban neighborhoods. The study refers to the Amsterdam metropolitan area and uses administrative (register) data for all households in the year 2008. Household characteristics include i) gross primary household income, ii) household composition, iii) socioeconomic category, and iv) age of the head of the household. In addition to the standard exogenous neighborhood characteristics (e.g. comparable house prices, employment, cultural amenities, transport facilities) we include the share of high income households (those belonging to the highest quartile of the overall income distribution).

The results regarding the attractiveness of a historic inner city differ from the earlier studies as we now have neighborhoods – instead of the much larger municipalities - as our spatial units of

analysis. Table 4 reports the marginal willingness to pay for a limited number of local amenities. We find that historic inner cities are an important factor in the location decision of households in the Amsterdam area and that the willingness to pay figures of historic inner cities are reflected in the high house prices of the Amsterdam city center. The average household pays around 40 000 euro more in terms of house prices for an extra square kilometer of historic city center in the neighborhood of residence. The higher the income of households, the more they are willing to pay to live in the historic city center. Household that earn 10 000 euro more than the average on a yearly basis are willing to pay 2000 euro more for an additional square kilometer of historic city center compared to the average household. We also find that social interactions are important. The average household prefers to live in neighborhoods with a concentration of high income households, and higher income households prefer even more to live in such areas. According to our estimates, the average household is willing to pay almost 1500 euro for an additional percentage point of high income households in the neighborhood population. Households that earn 10 000 euro more, are willing to pay 137 euro more, i.e. almost 10% more than the average household for an additional percentage-point of high income households.

**Table 4** Marginal willingness to pay results from the SLS estimation

	(1) Mean	(2) Income (x10,000)	(3) Employed	(4) Retired
Historic city center (+km <sup>2</sup> )	40,274	2,175	1,300 (ns)	1,838 (ns)
Historic city center in surrounding neighborhoods (+km <sup>2</sup> )	9,842	91	-84	-193
High income households (+%)	1,414	137	55	161
Distance to nearest 100,000 jobs (-km)	644 (ns)	10 (ns)	-41	174

Note: the values are in euros, (ns) means not significant at the 5% level. The significance levels of Column 2 to 4 are based on the first step estimation procedure of the residential sorting model.

An interesting implication of these findings is that they suggest that urban amenities – indicated by cultural heritage – may have cumulative effects on household location. We discussed earlier that the willingness to pay for cultural heritage and associated other urban amenities is higher among the better educated workers, who often have a relatively high income. This group therefore tends to become overrepresented in areas that are relatively rich in cultural heritage, like the Amsterdam canal zone. The large share of high income households contributes further to the attractiveness of the neighborhood, especially for higher income households. The social interaction effects thus tend to stimulate segregation between income groups in the metropolitan area. Interestingly, we see that the rich are overrepresented in the ancient city center – as in Paris – as well as in the suburbs close to the open space of the polders – which is similar to Detroit. A typical Dutch aspect is that this location pattern is especially present in the owner-occupied sector, as almost all rental housing is rent-controlled and accessible to low-income households, although waiting lists for social rental housing in the Amsterdam city center are extremely long.

### 3.8 Costs of mobility

One of the assumptions of the sorting model is perfect mobility of agents. Mobility costs do not play a role in the model and earlier location choices thus have no impact on current choices. Since mobility costs are in fact substantial it is important to investigate the possible bias introduced by this assumption. Households might be restrained from choosing the location that would be optimal in the absence of mobility costs and neglecting these costs may thereby lead to biased inferences about their location preferences.

We investigated this issue by analyzing households' residential sorting behavior within the local housing/labor market of Southeast North-Brabant (SNB), the region surrounding Eindhoven.<sup>13</sup> The SNB economy is highly specialized in knowledge-intensive production, such as high-tech manufacturing, making future regional growth heavily dependent on the ability of the region to retain and attract human capital intensive firms, and the associated skilled labor.

The locational characteristics considered are housing prices, natural amenities (natural and water coverage), urban amenities (the number of catering services) and various measures of accessibility. Household characteristics are highly educated households, marital status, presence of children, and age of the head of the household. We capture the impact of mobility costs by introducing dummy variables in the utility functions of all residential locations except the one in which the household was living five years ago. If mobility costs are important, we expect a significant negative coefficient for this dummy, implying a reluctance of households against moving. The cost of mobility is treated as a neighborhood characteristic – albeit one that differs over households - and its coefficient is allowed to differ with household characteristics.

**Table 5** Descriptive statistics on movers and sub-categories of movers

	Mean	Std. Dev.	Min	Max
Move within SNB to a different municipality	0.031	0.173	0	1
Move within original municipality	0.093	0.290	0	1
Move from outside SNB	0.028	0.164	0	1
Move but previous location unknown	0.114	0.318	0	1
Mover (total)	0.265	0.442	0	1

Source: Gatto (2013), based on WoOn 2012. Number of observations is 1732.

In Table 5 we report some descriptive statistics on movers. Slightly more than a quarter of the households observed in SNB in 2012 moved between 2007 and 2012, implying that almost 75% stayed. The 10% who moved within the boundaries of their original municipality are treated by us as non-movers, since our model does not distinguish between locations within a given municipality.

Table 6 reports the two sets of results of the first step estimation of the sorting model (Gatto, 2013). The columns labelled (1) are the estimation results obtained when moving costs are not

<sup>13</sup> This application is based on a master thesis, "Locational Choice and Preferences with Costly Relocation", by M. Gatto supervised by J. Rouwendal and M. van Duijn in 2013.

included in the estimation, and the columns labelled (2) are the estimation results obtained when moving costs are included. Since moving costs are individual-specific, they are only included in the first step estimation of the sorting model. The impact of moving on utility is negative – as expected – and significantly different from zero. The loss in utility associated with moving is estimated to be higher than those of renters which is plausible. Table 6 also shows that the higher educated, younger households and couples have lower utility losses when they move than the average household. In contrast, older households and households with children under 18 have significantly higher mobility costs.

Comparison of the columns (1) and (2) suggests that moving costs is an important variable when we consider household location choice and that their incorporation can have substantial impact on the coefficients estimated for other location characteristics, confirming our conjecture that willingness to pay estimates may be sensible to the inclusion of this variable.

Moving costs are also included in an application of the sorting model by Möhlmann et al. (2014a). Their sorting model is also based on WoOn 2012, but applied to 118 regions within the Netherlands. In the survey, households indicated whether they moved within the last two years. About 11 percent of the relevant households indicated that they moved at least once in that period. These households also indicated the municipality of their previous home. Based on this information, Möhlmann et al. (2014a) included a binary variable for moving as well as a distance variable in the logit specification. This allows the estimation of the fixed moving costs as well as the additional moving costs that households experience for moving over larger distances. The distances are calculated as Euclidean distances between the centers of the regions.

Preliminary results indicate that the fixed costs of moving to another region are about 57,000 euro for an average homeowner. Note that this is measured as a willingness to pay for staying in the current region instead of moving to another region. This does not only include the monetary costs of moving – which are probably much lower – but also all other costs that people experience from changing their region. Also note that this is based only on moving between one of the 118 regions in the model. Households that moved within the same region are not modelled as movers. The additional costs of moving to regions that are further away are preliminary estimated as about 500 euro per kilometer for homeowners.

The estimated moving costs are heterogeneous across different types of households. Couples, households with children and higher educated households all experience higher fixed moving costs. The difference is about 6 percent for couples versus singles, 10 percent for households with versus households without children, and 7 percent for higher versus lower educated households. Additionally, older households experience higher fixed costs of moving of about 1.3 percent per year of age. The costs of moving over larger distances are higher for households with children (+ 29 percent) and lower for couples (– 33 percent), higher educated households (– 39 percent) and older households (– 0.4 percent per year). This implies that the last three groups are less inclined to move, but if they move they tend to move over largest distances. Households with children move less and also over smaller distances.

**Table 6.** First stage results for homeowners: estimated parameters for interaction terms and moving costs

Municipality characteristics	Household characteristics		Age (+10 years)		Households with children below age 18		Couples	
	Highly educated households							
	(1)							
Standardized house price (€)	5.67419 ***	(0.2581)	0.12215 ***	(0.00749)	4.71692 ***	(0.22943)	1.12390 ***	(0.25863)
No. of shops	-0.00221 ***	(0.00007)	-0.00006 ***	(0.000002)	-0.00095 ***	(0.00006)	-0.00083 ***	(0.00007)
Nature (km2)	0.00150	(0.00095)	-0.00001	(0.00003)	-0.00136	(0.00094)	-0.03230 ***	(0.00098)
Water (km2)	-0.23157 ***	(0.01262)	-0.00625 ***	(0.00038)	-0.01054	(0.01153)	0.01036	(0.01291)
Distance to 100,000 jobs (km)	0.06046 ***	(0.00615)	0.00065 ***	(0.00018)	0.03751 ***	(0.00536)	0.05015 ***	(0.00614)
Distance to intercity station (km)	-0.14177 ***	(0.00602)	-0.00164 ***	(0.00015)	-0.04968 ***	(0.00469)	-0.02767 ***	(0.00545)
Distance to motorway ramp (km)	-0.12346 ***	(0.00386)	-0.00216 ***	(0.0001)	0.01156 ***	(0.00307)	-0.02543 ***	(0.00359)
	(2)							
Standardized house price (€)	8.63042 ***	(0.57764)	0.04759 ***	(0.01801)	5.57008 ***	(0.55125)	-5.72724 ***	(0.63647)
No. of shops	-0.00641 ***	(0.00017)	-0.00024 ***	(0.000005)	0.00096 ***	(0.00017)	-0.01291 ***	(0.00226)
Nature (km2)	-0.04449 ***	(0.00214)	-0.00096 ***	(0.00006)	-0.00580 ***	(0.00201)	-0.0051 ***	(0.00019)
Water (km2)	-0.52348 ***	(0.02836)	-0.02777 ***	(0.00095)	0.30245 ***	(0.02689)	-0.13824 ***	(0.03265)
Distance to 100,000 jobs (km)	0.02150	(0.0134)	0.00187 ***	(0.00043)	0.12216 ***	(0.01299)	-0.31002 ***	(0.01519)
Distance to intercity station (km)	-0.07974 ***	(0.01192)	-0.00233 ***	(0.00037)	-0.06955 ***	(0.01095)	0.21477 ***	(0.01301)
Distance to motorway ramp (km)	-0.05929 ***	(0.00759)	-0.00819 ***	(0.00025)	0.05815 ***	(0.0072)	0.06260 ***	(0.00841)
Moving costs homeowner (mean is 8.35545)	0.61625 ***	(0.04016)	-0.09212 ***	(0.0014)	-1.54301 ***	(0.04191)	0.24813 ***	(0.04173)
Moving costs renter (mean is 7.12496)								

Source: Gatto (2013).

### 3.8 Technical and creative higher educated workers

A key feature of the sorting model is that it allows for heterogeneous preferences of households. The sorting models discussed so far distinguished households based on household composition (couples versus singles and households with or without children), age and education level. Research on stated preferences suggests that location preferences differ strongly between creative and technical orientated households (Boterman and Sleutjes, 2014). This can also be tested with a sorting model, provided that we have data on the education orientation of workers. The previously discussed sorting models for the Netherlands are based on data from the housing surveys WoOn 2009 and WoOn 2012, which do not include data on the type of education. An alternative data source that does include these data is the labor survey (*Enquête Beroepsbevolking*) from Statistics Netherlands. These data can be linked with municipality register data (*GBA*) from Statistics Netherlands in order to determine household characteristics and the household location.

In Möhlmann et al. (2014b) three groups of households are defined: creative households, technical households and other households. Households are allocated to each group based on their field of education. The labor survey has information on the level of education, the field of education and the occupation. They used the field of education rather than the profession since the former is believed to be a better indication for the intrinsic orientation of the worker, while occupations also depend on labor market conditions. Additionally, the field of education usually stays the same once a person is graduated, while the occupation may change several times.

Preliminary results of the sorting model by Möhlmann et al. (2014b) show that location preferences are different between households with a technical or a creative field of education. For all five interaction terms between the location characteristics that were included in the model, the two dummies had the opposite sign. The initial results suggest that households with a creative field of education are willing to pay less than the average household for nature and more than the average household for proximity to jobs, proximity to an intercity train station, proximity to a highway onramp, and urban amenities. The exact opposite applies for households with a technical field of education.

## 4. Conclusion

This report has summarized the results of several sorting models as well as some additional research, that has been carried out in the HELP project. The investigations have further established the usefulness of the logit-based sorting model for empirical research and the connection with hedonic pricing analysis has been clarified. The estimated models have clarified our understanding of the role of urban amenities for the attractiveness of residential locations. Cities are not only important for work, but also for consumption and our research has resulted in estimates of the willingness to pay for these consumption amenities. The values reached for these figures depend on the geographical scale and the specification of the model. For instance, the implied willingness to pay for an additional km<sup>2</sup> of conservation area is lower if the model refers to municipalities than if it is estimated on neighborhoods within the Amsterdam metropolitan area. We have shown that consumption amenities are not a substitute for an attractive labor market, but that both variables must be seen as complements. Another important observation is that the attractiveness of neighborhoods is not only a determinant of choice behavior, but – at least partly – also a consequence of this behavior. This underscores the importance of policies referring to, for instance, the construction of new housing. The research has also identified some loose ends. A potentially important one is the incorporation of moving costs, which calls for a generalization of the model to a dynamic setting. A second interesting issue that should be further investigated is the importance of heterogeneity within the group of highly skilled workers, notably the distinction between technical, creative and other high skilled workers.

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# Urban Regions in the Delta

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