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**Conference Paper**

## Residential choice of knowledge-workers in a 'startup metropolis': the role of amenities, workplace and lifestyle

51st Congress of the European Regional Science Association: "New Challenges for European Regions and Urban Areas in a Globalised World", 30 August - 3 September 2011, Barcelona, Spain

**Provided in Cooperation with:**

European Regional Science Association (ERSA)

*Suggested Citation:* Frenkel, Amnon; Bénédict, Edward; Kaplan, Sigal (2011) : Residential choice of knowledge-workers in a 'startup metropolis': the role of amenities, workplace and lifestyle, 51st Congress of the European Regional Science Association: "New Challenges for European Regions and Urban Areas in a Globalised World", 30 August - 3 September 2011, Barcelona, Spain, European Regional Science Association (ERSA), Louvain-la-Neuve

This Version is available at:

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# **RESIDENTIAL LOCATION CHOICE OF KNOWLEDGE-WORKERS IN A "STARTUP METROPOLIS": THE ROLE OF AMENITIES, WORKPLACE AND LIFESTYLE**

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## **ABSTRACT**

Knowledge cities (KC) and knowledge-based urban development (KBUD) are rapidly gaining momentum due their potential for inducing economic growth and regional competitiveness. The current study focuses on investigating the location preferences of knowledge-workers at the intra-metropolitan level, as an essential building block in the formulation of successful KBUD policies. Specifically, this study applies multinomial and nested logit models to investigate the impact of location amenities, accessibility, housing preferences and leisure-activity pattern on knowledge-workers' residential location choice. The models are applied to 833 actual housing choices collected by means of a web-based survey. Survey respondents consist of knowledge-workers in high-technology and financial business services, who work and reside in Tel-Aviv metropolitan region, also known as the 'the startup metropolis'. The results reveal that knowledge-workers (i) prefer dense urban environments and large cities, (ii) reside in well-established knowledge communities (iii) seek abundance cultural and education opportunities, (iv) seek affordable housing, (v) reside in locations that are compatible with their housing preferences, workplace location and leisure activity pattern.

*Key words: KBUD, knowledge cities, residential choice, location model, knowledge-workers*

## 1. INTRODUCTION

The last decade has witnessed a growing interest in the concepts of knowledge city (KC) and knowledge-based urban development (KBUD) among urban planners and regional policy makers. This interest results from the potential of KBUD policies for incubating, attracting, and retaining knowledge and technology intensive (KTI) human capital and production, as means for inducing economic growth and enhancing the regional competitive edge (Chang et al., 2010; Florida, 2005; Yigitcanlar, 2010; Yigitcanlar and Velibeyoglu, 2008; Yigitcanlar et al., 2008).

The essence of KC and KBUD is to facilitate and to encourage knowledge incubation, production and flow, by promoting knowledge catalysts and incubators, and by endorsing an ambience of diversity, openness, and creativity as necessary preconditions. Among the main KBUD policies for attracting and retaining KTI workers and firms are the promotion of high education institutions, the provision of economic conditions and physical infrastructure, and the assurance of high quality, safe, secure and serene living environments (e.g., Florida, 2002; Florida, 2005; Florida et al., 2008; Yigitcanlar et al., 2008; Yigitcanlar, 2010). In particular, key enablers for attracting and retaining knowledge-workers are an affordable and high quality housing market, good accessibility and mobility, quality education facilities, and cultural, entertainment and sports facilities (e.g., Florida, 2002; Kunzmann, 2009; Lee et al., 2009; Yigitcanlar, 2010). Consequently, successful KBUD policies are strongly rooted in the residential preferences of knowledge-workers and their households.

Despite the importance of an affordable housing market, high quality of life and place as fundamental pillars of successful KBUD policies, data regarding the residential preferences of knowledge-workers is lacking (Yigitcanlar et al., 2008) and only a handful of studies focus on the residential location of knowledge-workers at the intra-metropolitan level. Evidence from the U.S. shows that high-technology workers mostly reside in the suburbs and exhibit high land consumption (Felsenstein, 2002), while studies conducted in Europe depict contradicting trends. Specifically, evidence from Amsterdam in the Netherlands reveals that finance, science and technology workers prefer suburban residential locations (Musterd, 2006), while in the whole Randstad conurbation knowledge-workers prefer to reside in proximity to city centers due to cultural amenities, although they exhibit tolerance for both commuting trips and leisure travel (van Oort et al., 2003). Evidence from North-East England reveals that real-estate as investment opportunity, lot size, security, social status, and accessibility are important for knowledge-workers residing in top-end houses in gated

communities (Tomaney and Bradley, 2007). Finally, studies conducted in Taiwan identified home ownership, housing quality, real-estate as investment opportunity, urban amenities and education facilities, job opportunities and accessibility as important in the context of knowledge-workers' residential location choice (Chang et al., 2010).

While previous studies provide valuable input about the spatial distribution of knowledge-workers and soft qualitative data regarding possible reasons, the current study focuses on providing hard quantitative data regarding the underlying residential location determinants of knowledge-workers. The analysis is aimed at suggesting directions for developing successful KBUD policies for attracting and retaining knowledge-workers. Specifically, this study investigates prominent hypotheses from the literature regarding the influence of multiple aspects on the residential location choice of knowledge-workers in the Tel-Aviv metropolitan region, also known as the 'startup metropolis'. The aspects present a comprehensive and multi-faceted perspective encompassing scale of the city, land use structure, housing affordability, socio-economic index, accessibility to work and leisure, individual housing preferences, mobility and activity patterns. To pursue the research objective, the current study takes a disaggregate approach and employs discrete choice analysis, namely multinomial logit (MNL) and nested logit (NL) models. Interestingly, probabilistic choice models have not yet been applied for analyzing the location decisions of knowledge-workers. In fact, most residential location choice models reveal the preferences of the general population (e.g., Barrios-Garcia and Rodriguez-Hernandez, 2007; Ben-Akiva and Bowman, 1998; Cho, 1997; De Palma et al., 2007; Earnhart, 2002; Quigley, 1985), while only a few studies focus on specific population groups, in particular ethnic groups (Gabriel and Rosenthal, 1989), elderly (Duncombe et al., 2001), youth (Garasky, 2002) and university students (Kaplan et al., 2009). The model results are particularly useful for regional policy makers in formulating KBUD policies by embedding manageable city attributes that are found to influence the residential choice of knowledge-workers.

The proposed models are applied to a data sample of 833 observations of actual residential location choices of knowledge-workers in high-technology and financial business services, who work and reside in the Tel-Aviv metropolitan region. The data were collected by means of a web-based survey custom-designed for the purpose of this study.

The remainder of this paper is organized as follows. Section 2 describes the data collected to explore the residential preferences of knowledge-workers. Section 3 illustrates the

methodology and details the employed discrete choice models. Section 4 shows the estimation results. Section 5 draws conclusions and suggests further research directions.

## **2. METHODOLOGY**

### ***2.1 Research hypotheses***

The current study attempts to sketch the outline of the residential location choice pattern of knowledge-workers on the basis of the literature. This hypothesized outline serves as a basis for the model formulation in order to understand the impact of municipality attributes and individual characteristics on the residential location choice of knowledge-workers.

The current research hypothesizes that knowledge-workers are not suburbanites, but rather seek multi-functional, high-density large cities (Kunzmann, 2009; Yigitcanlar et al., 2008) that offer an abundance of cultural facilities (Kunzmann, 2009; Yigitcanlar, 2010). Naturally, as highly creative population, knowledge-workers differ in their preferences and not all seek the same activities with equal intensity. Potentially, their residential location choice is related to the main orientation of their activity pattern. In particular culture-oriented, home-oriented, sport-oriented and work-oriented activity patterns induce different residential location choices. Nevertheless, leisure opportunities are not the sole motivator for knowledge-workers' residential choice. Many knowledge-workers view their work not only as career path, but also as a vocation, and in general tend towards a workaholic lifestyle. Consequently, they seek residential environments that offer intellectual vitality and stimulation for them and their children, as well as networking and collaboration opportunities and the capability to access and join knowledge (Yigitcanlar, 2010). As a result, they are attracted to municipalities that offer a variety of excellent higher education facilities, schools and kindergartens.

While the outline so far discusses the ideal residential location to which knowledge-workers aspire, they are not without limitations. In particular, even when considering their high job mobility and the blessing of their high income level, knowledge-workers still need to consider budget constraints, especially following the burst of the high-technology bubble in the beginning of the decade. Consequently, knowledge-workers are hypothesized to be concerned about housing affordability, the opportunity to be homeowners, and the possibility to reside in single detached houses or large apartments (Chang, 2010; Felsenstein, 2002; Kunzmann, 2009; Lee et al. 2009; Yigitcanlar, 2010). Finally, despite the wide availability of company-car among knowledge-workers that reduces their monetary travel costs to a

minimum and hence increases their ability to locate further from the workplace (van Ommeren et al., 2006), knowledge-workers tend to maximize their utility by minimizing the commuting time to their workplace. Obviously, in dual-earner knowledge households the workplace location of both workers is considered (Kunzmann, 2009; van Ommeren et al., 1998).

## **2.2 The Model**

In light of the proposed hypotheses, the residential location model employed in this study examines the impact of city scale, land use structure, accessibility and mobility, workplace location, and housing preferences on the probability of knowledge-workers to locate their residence in a certain municipality within a metropolitan region. Eight groups of explanatory variables are hypothesized to influence the probability of knowledge-worker  $n$  to choose municipality  $i$  as proposed in the following general function:

$$P_{ni} = f(SC_i, LU_i, SI_i, PR_i, AC_i, MB_n, HP_n, LS_n) \quad (1)$$

Where:

$P_{ni}$  is the choice probability of municipality  $i$  by knowledge-worker  $n$ .

$SC_i$  are city scale variables, namely size and density indicators including population, total built area and residential population density. These variables are obtained from the Israeli Central Bureau of Statistics (CBS, 2005).

$LU_i$  are land use structure characteristics including percent of built area dedicated to education, culture and public open spaces. These variables are obtained from the Israeli Central Bureau of Statistics (CBS, 2005).

$SI_i$  is a public-record national index that expresses the socio-economic status of municipalities in Israel as a proxy variable to the possibility of knowledge-workers to network, join and access knowledge within their community. The 10-point scale consists of sixteen indicators which represent demography (e.g., dependency ratio), education (e.g., share of university graduates, average years of education, share of matriculation certificate holders), employment (e.g., unemployment rate, share of salaried employees earning minimum wage, share of employees in prestigious occupations) and standard of living (e.g., income and motorization level). The index is obtained from the Israeli Central Bureau of Statistics (CBS, 2008).

$PR_i$  represents housing affordability and is the average purchase price per square meter in Israeli New Shekels (NIS) in the municipality. The price is obtained from the Israeli Central Bureau of Statistics and the Israeli Tax Authority (CBS, 2006; CBS, 2011; ITA, 2011).

$AC_i$  are accessibility measures, including morning peak-hour commuting travel time by car from municipalities to the workplace location, and morning peak-hour travel time by car to the metropolitan core as a measure of accessibility to the central business district. These variables are based on traffic assignment results obtained from the TAM transport model. The workplace location of the knowledge-workers and their spouse is obtained from the survey conducted for the purpose of this study.

$MB_n$  are mobility indicators for knowledge worker  $n$ , namely car ownership, number of cars and company-car availability. These characteristics are obtained from the survey conducted for the purpose of this study.

$HP_n$  are the revealed housing preferences of knowledge-worker  $n$  consisting of ownership, dwelling unit size and building type (single detached house versus multi-storey building). These characteristics are obtained from the survey conducted for the purpose of this study.

$LS_n$  are the lifestyle factors that represent the leisure activity pattern of knowledge-worker  $n$  (i.e., culture and entertainment, sport and home-oriented activities), in agreement with Florida (2002). These factors are synthesized from the attitudinal survey conducted for the purpose of this study.

In order to investigate the impact of the aforementioned variables, MNL and NL models (Ben-Akiva and Lerman, 1985) are estimated in the empirical analysis for the choice among municipalities in the research region. According to the MNL model, the probability of knowledge-worker  $n$  to choose municipality  $i$  from a set of  $J$  mutually exclusive municipalities is given by the following expression:

$$P_{ni} = \frac{\exp(\beta' X_i)}{\sum_{j \in S_q} \exp(\beta' X_j)} \quad (2)$$

where  $X_i$  and  $X_j$  are vectors of explanatory variables attributed to the municipalities  $i$  and  $j$ , respectively, and  $\beta$  is a vector of parameters to be estimated.

Assuming the existence of similarities across municipalities, the choice is represented by the NL model (Ben-Akiva and Lerman, 1985). The model differentiates between municipalities that are located either in the center of the metropolitan region (i.e., metropolitan core and inner ring) or in the outer suburbs (i.e., middle and outer rings). According to the NL model, the probability of knowledge-worker  $n$  to choose municipality  $i$  is as follows:

$$P_{ni} = \frac{e^{(\beta'X_i/\lambda_r)} \left( \sum_{j \in B_r} e^{(\beta'X_j/\lambda_r)} \right)^{\lambda_r - 1}}{\sum_{l=1}^N \left( \sum_{j \in B_s} e^{(\beta'X_j/\lambda_s)} \right)^{\lambda_s}} \quad (3)$$

where  $X_i$  and  $X_j$  are vectors of explanatory variables attributed to municipalities  $i$  and  $j$ , respectively,  $B_r$  and  $B_s$  are nests,  $\lambda_r$  and  $\lambda_s$  are measures of the degree of independence in unobserved utility among the municipalities in nest  $B_r$  and  $B_s$ , and  $\beta$  is a vector of parameters to be estimated.

### 3. DATA COLLECTION

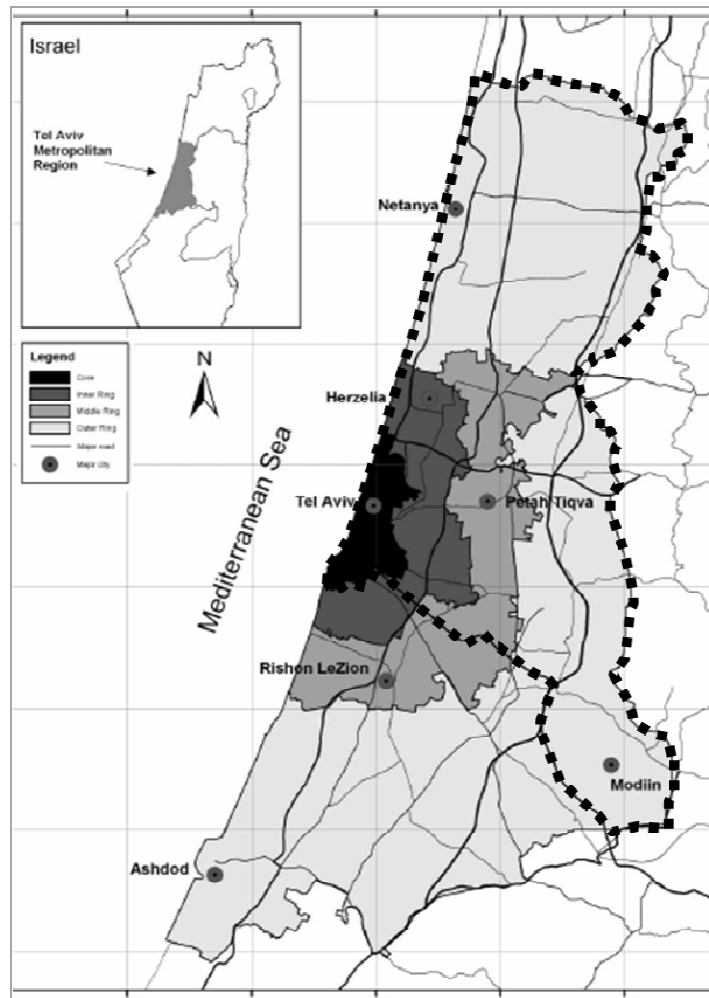
#### 3.1 Research region and population

The empirical study took place in the Tel-Aviv Metropolitan (TAM) region, which is Israel's largest and most central metropolis, and the country's cultural and financial center. The TAM encompasses the Tel-Aviv district and the Central district, covers 1,518 square-kilometers and hosts 3.0 million inhabitants, roughly over 40% of the country's population. The TAM has a classical concentric structure, with the city of Tel-Aviv as the core of the metropolitan region, surrounded by three concentric rings known as the inner, the middle and the outer ring. The city of Tel-Aviv is the residence of 400 thousands inhabitants and provides 1.0 million jobs.

The TAM, a world city in evolution and a cosmopolitan metropolis, is known as the 'startup metropolis', as in the late 1990's it was hosting 86% of Israel's high-technology firms and three of its main industries: communication, information technology, and the Internet. In addition, the core area and the inner ring, which supply 49% of the jobs in the TAM, are characterized by a high level of specialization in finance and business activities and they function as the country's financial and administrative center. Finally, the TAM serves as the center of the 'creative class' and the bohemia including world-known musicians, actors, dancers and visual artists (Kipnis, 2004; Frenkel, 2007).

This study focuses on the population of knowledge-workers who reside and work in the metropolitan core and the north-eastern sector of the TAM, as this area hosts a large concentration of 78,000 finance jobs and 115,000 high-technology jobs (CBS, 2009). The research region is defined in figure 1.





**Figure 1 - The metropolitan core and the north-eastern sector of the metropolitan region**

The target population consists of business-oriented knowledge-workers in the high-technology services (e.g., computer science, electrical engineering, biotechnology) and financial business services (e.g., banking, market analysis, and investment consultancy), according to Schwartz's (2006) classification. The sample was recruited through 1,500 relevant firms, whose main offices and facilities are located in the TAM. The firms were drawn from the Dun and Bradstreet database and the Israel Venture Capital Research Center database that include information regarding activity sector, number of employees and year of establishment of each firm. The sample covered a wide range of high-technology and financial activity sectors, as well as firm sizes and ages.

### ***3.2 Questionnaire design***

The data were collected by means of a web-based revealed-preferences survey that was conducted between June 2009 and February 2010. The survey consisted of questions about the housing choice of knowledge-workers, their socio-economic characteristics, their employment characteristics, their car-ownership and their activity patterns.

Questions about the housing choice of knowledge-workers investigated residence location by municipality, building type, dwelling size and home ownership. Socio-economic characteristics concerned gender, age, marital status, number of children, car ownership and monthly income. Employment characteristics included education level, workplace location, spouse's workplace location, employment sector and status.

An attitudinal survey regarding activity patterns addressed four leisure activity dimensions that are considered relevant to residential location choice. The four activity dimensions were culture and entertainment, sport, home and overtime-work. The attitudinal survey was chosen instead of a traditional one-day activity travel diary, in order to capture general long-term activity patterns, to avoid the problem of under-reporting of low-frequency and short-distance trips, and to reduce to respondents' burden. The attitudinal survey comprised 28 items concerning the frequency of engaging in activities related to each dimension.

The survey design was web-based, since its benefits in comparison with traditional survey forms (e.g., home interviews and phone surveys) are the minimal disturbance to knowledge-workers due to schedule and location flexibility, and the modest operational costs. A web-based environment is particularly advantageous with respect to survey administration among knowledge-workers who use the Internet media on a regular basis. The survey design was conducted with OPINIO software (ObjectPlanet, 2010). Although advantageous, a major challenge in conducting web-based surveys concerns sample reliability, due to their high degree of anonymity. In order to control for sample composition, the recruitment of respondents was conducted through human resources offices in knowledge companies, and the workers provided their name and contact details. A follow-up contact by e-mail on July 2010 verified the identity of the respondents.

## **4. THE EMPIRICAL RESULTS**

### ***4.1 Sample characteristics***

The survey yielded 1181 questionnaires of knowledge-workers who reside and work in the TAM, of which 833 complete records (70.6%) are analyzed in the current study.

The respondents' socio-economic characteristics are presented in table 1. The wage level of the sample population is higher than the average wage of 15,800 NIS and 14,200 NIS in the high-technology and finance sector (CBS, 2008c). The motorization rate of the sample population is high although not surprising considering the high-share of company-car owners (61%) among high-technology workers in Israel (Keinan, 2007). In terms of workplace location, More than half the respondents work in the core and inner ring and so do roughly 40% of the spouses. Among respondents, 38.7% reside and work in the same metropolitan ring, while an additional 35.5% reside and work in adjacent metropolitan rings. For 21.5% of the married respondents, the two spouses work in the same metropolitan ring.

**Table 1: Respondents' socio-economic characteristics**

VARIABLE	CATEGORIES (%)			
<i>Gender</i>	<i>Male</i> 71.8	<i>Female</i> 28.2		
<i>Marital Status</i>	<i>Married</i> 80.4	<i>Non-married</i> 19.6		
<i>Number of children</i>	<i>None</i> 25.4	<i>1 child</i> 16.5	<i>2 children</i> 28.4	<i>More than 2 children</i> 29.7
<i>Age</i>	<i>Mean</i> 38.0	<i>Standard deviation</i> 8.4		
<i>Monthly wage (NIS)</i>	$\leq 12,500$ 14.2	<i>12,500-20,000</i> 25.4	<i>20,000-30,000</i> 31.9	$\geq 30,000$ 28.5
<i>Level of education</i>	<i>High-school</i> 8.1	<i>B.Sc.</i> 47.4	<i>M.Sc. or Ph.D.</i> 44.5	
<i>Residential location</i>	<i>Core</i> 26.9	<i>Inner ring</i> 27.7	<i>Middle ring</i> 23.9	<i>Outer ring</i> 21.5
<i>Workplace location</i>	<i>Core</i> 32.8	<i>Inner ring</i> 24.1	<i>Middle ring</i> 32.1	<i>Outer ring</i> 11.0
<i>Spouse's workplace location</i>	<i>Core and inner ring</i> 38.9	<i>Middle and outer ring</i> 27.5	<i>Unknown</i> 33.6	

Four leisure activity pattern factors labeled "culture and entertainment activities", "sport activities", "home activities" and "work activities" were obtained by means of exploratory factor analysis. A detailed description of the factors is provided in the Appendix.

The distribution of the residential preferences is presented in table 2. Most respondents are home owners and most respondents reside in multi-storey buildings in relatively populated cities. The housing preferences are related to the residential location. Respondents who reside in the core and inner ring tend to reside in relatively small apartments in highly populated cities. Respondents who reside in the middle and outer ring tend towards home-ownership, and reside in large apartments or single detached house in small suburban communities.

**Table 2: The distribution of respondents by residential preferences**

Inhabitants	Metropolitan core and inner ring (%)	Middle and outer ring (%)
<i>Home-ownership and building type</i>		
Rented apartment	24.1	5.4
Owned apartment	22.1	18.0
Rented house	1.7	5.1
Owned house	6.5	17.1
Total	54.4	45.6
<i>Dwelling unit size</i>		
Up to 60 m <sup>2</sup>	14.3	2.0
60-100 m <sup>2</sup>	20.7	9.6
100-140 m <sup>2</sup>	10.8	14.2
Over 140 m <sup>2</sup>	8.6	19.8
Total	54.4	45.6
<i>Municipality size</i>		
up to 2,000	0.2	0.2
2,000-10,000	0.0	2.2
10,000-20,000	7.0	8.2
20,000-50,000	10.6	10.5
50,000-100,000	0.4	16.3
100,000-200,000	9.4	8.1
Over 200,000	26.8	-
Total	54.4	45.6

#### **4.2 Model estimation results**

Table 3 presents the parameter estimates for the MNL and the NL model formulations. The final parameter estimates were obtained following an iterative estimation procedure with

various variable combinations, and hypothesis tests for variable significance. The results show that most of the variables contribute significant explanatory power to the model.

The dependent variable in the choice model is the probability to reside in 33 municipalities in the research region. A comparison between the MNL and the NL model formulations by likelihood ratio (LR) test cannot reject the null hypothesis of an independent error structure across alternatives ( $LR=4.35 < \chi^2=5.99$  with 2 degrees of freedom at the 0.05 level). In addition, the NL collapses to the MNL model form since the nesting coefficients do not significantly differ from one (t-test for testing the hypotheses  $\lambda_1=1$  and  $\lambda_2=1$  equal -0.35 and 0.81, respectively).

The city scale variables, namely the logarithm of the total built area and the residential population density, are positively related to knowledge-workers' residential location choice, thus confirming the hypothesis that knowledge-workers are urbanites and are attracted to high-density environments and larger cities.

The residential location choice of knowledge-workers is positively related to the land use dedicated for culture and education facilities, thus confirming the hypothesis regarding the importance attributed by knowledge-workers to cultural, higher education and children's education amenities as reflected by the amount of developed land for these facilities. Interestingly, the land use dedicated to public open spaces is not significantly correlated with knowledge-workers' residential location choice, possibly due to high travel tolerance for outdoor activities in natural areas, as suggested by findings from the Netherlands (van Oort et al., 2003).

The residential location choice of knowledge-workers is positively related to the socio-economic index of the municipality, as a proxy for the population share in the municipality of highly educated population employed in prestigious occupations, providing an abundance of networking and collaboration opportunities with other knowledge-workers. This result confirms the proposed hypothesis indicating that knowledge-workers tend to be attracted to knowledge communities, which are characterized by highly educated population.

The residential location choice of knowledge-workers is negatively related to average housing price per square meter. Knowledge-workers who are home owners or reside in large dwellings and single detached houses show increasing tendency to reside in suburban locations and the metropolitan fringe. This preference in the search for home ownership, large apartments, and single detached houses, is likely associated with lower land values and higher supply of such dwelling units in the outer suburbs. These results confirm the

hypothesis regarding the importance of housing quality and affordability to knowledge-workers. Notably, both the dwelling prices and the socio-economic index in the TAM region are among the highest in the country, so trade-offs occur within a limited range of relatively high values.

Morning peak-hour commuting time by car to the workplace is negatively correlated to the residential location choice of knowledge-workers. Namely, knowledge-workers prefer to reside in proximity of their workplace location. Interestingly, the preference to reside in the outer suburbs and the metropolitan fringe (middle and outer rings) increases when the spouse's workplace is located there. These results confirm the hypothesis that knowledge-workers tend to minimize their commuting time, although a balance exist between the preferences of knowledge-workers as individuals and their need to satisfy the welfare need of all household members.

Morning peak-hour travel time by car to the metropolitan core is negatively related to the residential location of knowledge-workers. Hence, knowledge-workers prefer to reside in proximity to the metropolitan core.

Knowledge-workers who frequently engage in cultural activities prefer by large to reside in the metropolitan core and the inner ring. Knowledge-workers who actively participate in sports also prefer to reside in the core and inner ring. Probably, these findings are related to the abundance of fitness centers, the proximity to the sea shore and the metropolitan park located in the core. In contrast, knowledge-workers who lead a home-oriented activity pattern exhibit growing preference for the middle and outer ring, likely related to the serenity involved in residing in suburban communities. A workaholic activity pattern does not significantly influence the residential location, possibly since the knowledge-workers in general lead a workaholic life. This result confirms the hypothesis that the residential location choice of knowledge-workers is related to the main orientation of their activity pattern.

Car-ownership is not significantly related to the residential location choice of knowledge-workers, likely since 97.2% of the respondents are car owners, and the average number of cars per household is 1.7. Knowledge-workers who have a company-car significantly tend to have longer commute travel times, thus confirming the hypothesis that the availability of a company-car is related to the residential location choice of knowledge-workers further from the workplace.

**Table 3: Location choice model estimation results**

Variable	MNL model		NL model	
	Estimated coefficient	Student t-test	Estimated coefficient	Student t-test
<i>Scale: city size measures</i>				
Logarithm of the total built-area	0.709	10.96**	0.750	4.71**
Residential population density	0.027	2.31*	0.026	1.97*
<i>Land-use structure variables</i>				
Fraction of educational land-use	0.131	3.12*	0.104	1.96*
Fraction of cultural land-use	0.185	2.23*	0.224	2.41*
Fraction of public open spaces	0.002	0.06	0.005	0.18
<i>Intellectual vitality and networking opportunities</i>				
Socio-economic index	0.578	7.75**	0.616	4.29**
<i>Housing affordability</i>				
Average monthly rent price	-0.192	-5.78**	-0.216	-4.05**
<i>Accessibility variables</i>				
Average morning commute time by car	-0.091	-12.04**	-0.090	-6.11**
Interaction between company-car and average morning commute time by car	0.039	3.29*	0.036	2.97*
Average travel time by car to the CBD	-0.021	-3.37*	-0.019	-2.42*
Preference to reside in the middle and outer ring, conditional on the spouse's workplace	1.328	6.23**	1.342	6.29**
<i>Housing preferences (base category: core)</i>				
Home ownership - inner ring	0.786	3.55*	0.930	2.91*
Home ownership - middle ring	0.967	3.73*	1.092	3.67*
Home ownership - outer ring	1.055	3.33*	1.190	3.46*
Large dwellings - inner ring	0.720	2.65*	0.859	2.40*
Large dwellings - middle ring	1.302	4.48**	1.411	4.18**
Large dwellings - outer ring	1.444	4.02**	1.557	3.87**
Single detached house - inner ring	1.342	3.92**	1.629	3.14*
Single detached house - middle ring	1.800	4.99**	2.013	4.96**
Single detached house - outer ring	4.125	10.23**	4.203	6.62**
<i>Activity pattern factors (base category: core)</i>				
Cultural activities - inner ring	-0.608	-5.46**	-0.731	-3.57*
Cultural activities - middle ring	-0.892	-6.74**	-0.934	-6.14**
Cultural activities - outer ring	-1.602	-9.27**	-1.611	-6.31**
Sport activities - inner ring	-0.090	-1.08	-0.112	-1.02
Sport activities - middle ring	-0.309	-3.05*	-0.292	-2.72*
Sport activities - outer ring	-0.288	-2.43*	-0.273	-2.20*
Home-oriented activities - inner ring	0.108	1.13	0.102	0.90
Home-oriented activities - middle ring	0.245	2.26*	0.303	2.52*

Home-oriented activities - outer ring	0.322	2.58*	0.374	2.70*
Work activities during leisure - inner ring	0.029	-0.32	0.019	0.17
Work activities during leisure - middle ring	0.021	-0.21	0.075	0.66
Work activities during leisure - outer ring	-0.055	-0.47	0.003	0.03
<i>Nesting coefficients</i>				
Core and inner ring ( $\lambda_1$ )	-	-	0.932	-0.35
Middle and outer ring ( $\lambda_2$ )	-	-	1.203	0.81
Number of observations		833		833
Number of parameters		32		34
Log likelihood at zero		-2912.6		-2912.6
Log likelihood at estimates		-2044.8		-2042.6
McFadden's adjusted R-square		0.287		0.287

\*\* Significant at the 1% level

\* Significant at the 5% level

## 5. CONCLUSIONS AND FURTHER RESEARCH

The current study focuses on understanding the determinants of knowledge-workers' residential decisions, with the aim of suggesting directions for developing KBUD policies for attracting and retaining knowledge-workers. The importance of this issue derives from the growing attention of urban planners and regional decision makers to the KC and KBUD concepts and from the key-role of housing and urban amenities in successful KBUD policies. Interestingly, despite the importance of affordable housing market, high quality of life and place as fundamental pillars of KBUD policies, data regarding the residential preferences of knowledge-workers are scarce.

The empirical results obtained in this study indicate that knowledge-workers are attracted to dense urban environments and large cities, seek communities that offer an abundance of culture and education facilities, and prefer to reside in well-established knowledge communities in order to enjoy networking and collaboration opportunities. Housing price and housing preferences play a central role in the residential location choice of knowledge-workers, especially for knowledge-workers who seek to be home-owners, or to reside in larger apartments, who prefer therefore to reside in the metropolitan fringe and suburban settlements. Mobility and accessibility influence the residential location choice of knowledge-workers, as they prefer locations that are highly accessible to both their workplaces and the metropolitan core. In dual-career households of knowledge-workers, both workplaces are considered. The availability of a company-car expands the commuting range



of knowledge-workers, possibly due to commuting travel expenses reimbursement. Finally, the residential location choice of knowledge-workers is related to the main orientation of their activity pattern. Culture-oriented and sport-oriented activity patterns increase the tendency to reside in the metropolitan core, while a home-oriented activity pattern increases the propensity to reside in the outer suburbs and the metropolitan fringe.

The empirical findings of the current research are in agreement with hypothesized residential choice decision portrait that is revealed from multiple studies in the literature. The current study broadens the literature by providing a multi-faceted perspective encompassing multiple aspects of knowledge-workers' residential choice, and by presenting hard quantitative data regarding the magnitude of different municipality attributes on the residential choice of knowledge-workers. The empirical results may serve as tools for successful KBUD policies by enriching the knowledge regarding the residential preferences of knowledge-workers and the reasons leading to their spatial distribution within the metropolitan region. Although the estimated parameter values are relevant to the research region, this study supplies sufficient evidence regarding the residential preferences of knowledge-workers, likely transferable to other knowledge regions and metropolitan areas of a similar scale.

In terms of KBUD policy implications, the empirical results suggest that municipalities that wish to attract knowledge-workers need to invest in culture and education infrastructures, and to provide either affordable high quality housing or housing incentives in order to attract and retain knowledge-workers. Naturally, since knowledge-workers seek communities with high socio-economic index values, slow gradual change is expected, and municipalities should continuously strive to attract and retain knowledge-workers.

The findings also suggest policy implications regarding the conflicting role of knowledge-workers in inducing both processes of urban revitalization and urban sprawl. On the one hand, knowledge-workers are envisioned as a catalyst to revitalization and regeneration of urban core areas (e.g., Lee et al., 2009; Kunzmann, 2009; van Winden, 2010). On the other hand, knowledge-workers are viewed as contributors to encouraging urban sprawl (Felsenstein, 2002). Regarding urban sprawl, the results of the current study suggest that knowledge-workers are attracted to large cities and dense urban environment and some knowledge-workers actually prefer the metropolitan core due to their activity pattern. In fact, knowledge-workers who lead a culture-oriented and sport-oriented activity patterns prefer to reside in the core. From the findings of the current study, the main reason for locating in suburban communities seems to be housing affordability and desire for home-ownership

subject to budget constraints. This desire, in combination with large scale provision of company-cars, eventually leads to sprawl. Regarding urban revitalization processes, the results of the current study suggest that, although some knowledge-workers are attracted to the metropolitan core, they cannot be viewed as natural contributors to gentrification since they are drawn to well-established knowledge-communities. Consequently, they may be reluctant to locate in urban areas that need revitalization, unless a knowledge community is already established. Hence, knowledge-gentrification is limited, and incentives are required in order to attract a minimum threshold population of the creative class for gentrification processes to occur.

Further development of the current research includes three main directions. Firstly, an interesting further research direction includes investigating the demand for residential and auxiliary land consumption of knowledge-society and its implications on the spatial structure in metropolitan regions. Second, as the residential location is related to the activity pattern of knowledge-workers, it would be interesting to understand the characteristics of Hägerstrand's (1970) time-space prism of knowledge-workers and its linkage to their residential location choice. Last, cross-cultural comparison is beneficial in order to understand the transferability of the results to other world regions.

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## APPENDIX

Individual activity patterns were identified by means of factor analysis. Tests of internal consistency and sample adequacy constituted the necessary preliminary conditions for conducting factor analysis and obtaining meaningful results. Exploratory principal axis factor analysis with subsequent orthogonal rotation produced four factors. The factor loadings are presented in table A1. In order to facilitate factor labeling, the dominant items, marked in bold in table A1, were defined as those with an absolute value of the loading greater than 0.35. The first factor (F1) is labeled "culture-oriented activities". The second factor (F2) is named "sport-oriented activities". The third factor (F3) is identified as "home-oriented activities". The last factor (F4) is defined "work-oriented activities".

**Table A1: Activity pattern factors**

Item	F1	F2	F3	F4
<i>Work-related activities</i>				
My work schedule allows me to dedicate time for leisure activities (R)	-0.282	-0.219	-0.087	0.161
Promoting my career is currently the most important thing in my life	0.141	0.018	-0.069	<b>0.423</b>
I participate in many conferences and professional courses	0.236	0.068	0.160	<b>0.388</b>
I have flexible work hours (R)	-0.042	-0.070	-0.094	-0.210
I work until late in the evening and also on weekends	0.018	0.015	-0.039	<b>0.751</b>
I am highly available for my employer outside of my work hours	-0.028	0.020	0.035	<b>0.684</b>

*Culture- and entertainment-related activities*

I frequently go to restaurants and coffee shops	<b>0.626</b>	0.039	-0.028	0.106
I frequently hang out in discotheques, bars and clubs	<b>0.476</b>	0.075	-0.129	0.024
I frequently go to the theatre and music shows	<b>0.632</b>	0.120	0.158	0.070
I frequently go to operas and concerts	<b>0.382</b>	0.155	0.144	0.100
I frequently go to museums, exhibitions and galleries	<b>0.525</b>	0.116	0.194	0.103
I frequently go to courses and seminars	<b>0.368</b>	0.059	0.208	0.161
I frequently go to the cinema	<b>0.607</b>	0.134	0.069	0.098
I enjoy living in an urban area that offers abundance of opportunities and population diversity	<b>0.634</b>	0.021	-0.170	0.047

*Home-related activities*

I frequently gather with friends at home	0.144	0.039	<b>0.427</b>	0.075
I like to walk around the neighbourhood	0.135	0.296	<b>0.392</b>	-0.038
I like to read, watch TV or listen to music quietly at home	0.050	0.041	0.203	0.025
I like to work in the garden, design the house or engage in other hobbies at home	-0.073	0.176	<b>0.458</b>	0.050
I have social relations with people who live in my neighborhood	-0.038	0.030	<b>0.694</b>	-0.025
I am socially involved in my community	-0.109	0.046	<b>0.682</b>	0.022
I prefer to live in a quiet neighbourhood	-0.381	0.098	0.283	0.096

*Sport-related activities*

I frequently dedicate time to outdoor sport activities	0.132	<b>0.809</b>	-0.038	0.079
I frequently jog or walk in parks and public open spaces	0.102	<b>0.666</b>	0.144	0.025
I frequently use sport facilities near my residence	0.100	<b>0.514</b>	0.120	0.167
I frequently engage in outdoor activities in parks, gardens and open spaces	0.067	<b>0.394</b>	0.293	-0.051
I frequently engage in outdoor sport activities such as cycling	0.106	<b>0.751</b>	0.058	0.095
I frequently go to camping	0.062	0.337	0.289	0.005

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