AN AGENT-BASED MODEL OF TRANSPORT AND LAND USE POLICY COORDINATION BETWEEN MUNICIPALITIES

Sara Levy
Institute for Management Research
Radboud University Nijmegen
s.levy@fm.ru.nl

Karel Martens
Institute for Management Research
Radboud University Nijmegen
k.martens@fm.ru.nl

Rob van der Heijden
Institute for Management Research
Radboud University Nijmegen
r.vanderheijden@fm.ru.nl

Bijdrage aan het Colloquium Vervoersplanologisch Speurwerk
24 en 25 november 2011, Antwerpen

Samenvatting

AN AGENT-BASED MODEL OF TRANSPORT AND LAND USE POLICY COORDINATION BETWEEN MUNICIPALITIES

Integratie van ruimtelijke ordening en verkeer en vervoer staat hoog op de agenda. De concentratie van arbeids- en bezoekersintensieve werkgelegenheid op stationslocaties is daarvan een concrete invulling. Het succes van een dergelijk openbaar vervoer-gericht, of Transit Oriented Development (TOD), beleid is afhankelijk van een groot aantal factoren, waaronder de mate waarin naburige gemeenten hun beleid op elkaar afstemmen. Hoewel het belang van coördinatie breed wordt onderkend, is er nog onderzoek verricht naar de ruimtelijke effecten van coördinatie.

In deze paper wordt verslag gedaan van een onderzoek naar de mate waarin de coördinatie tussen naburige gemeenten invloed heeft op het ruimtelijke patroon van kantoren en in het bijzonder op de concentratie van kantoren rond knooppunten van openbaar vervoer. Dit gebeurt aan de hand van een agent-based simulatiemodel, waarin twee naburige gemeenten concurreren om bedrijven aan te trekken om zo hun inkomsten te vergroten. Met behulp van het model worden twee scenario's onderzocht. In het ene geval voert een gemeente een TOD beleid, dat wil zeggen dat de gemeente gericht investeert in het gebied rondom het (centrale) station teneinde kantoren aan te trekken, terwijl de andere gemeente juist investeert in locaties langs de snelweg. In het andere scenario coördineren de gemeenten hun beleid en kiezen beiden voor een TOD beleid. In de simulaties kiezen bedrijven een vestigingsplaats op basis van een set van criteria: het niveau van voorzieningen op een bepaalde locatie (die dus kan worden beïnvloed door de gemeentelijke investeringen), de bereikbaarheid van een locatie, en de nabijheid van andere bedrijven (agglomeratie effect).

Het doel van de simulaties is om na te gaan in hoeverre het succes van het TOD beleid wordt bepaald door het beleid in de buurgemeente. De resultaten laten zien dat het beleid van de ene gemeente van grote invloed is op het locatiepatroon van kantoren in de andere gemeente. Als beide gemeenten kiezen voor een TOD beleid dan vestigen zich in totaal minder bedrijven in beide gemeenten, maar is er wel een toename in het aantal bedrijven dat zich nabij stations vestigt. Als gemeenten hun beleid niet coördineren en een gemeente voert een 'snelweg-beleid', dan is de andere gemeente met haar TOD beleid beduidend minder succesvol in het aantrekken van kantoren op stationslocaties. De consequentie van deze bevindingen is, allereerst, dat gemeenten zich rekenschap moeten geven van het beleid in de naburige gemeenten, en, ten tweede, dat gemeenten die streven naar afstemming tussen ruimtelijke ontwikkeling en verkeer en (openbaar) vervoer veel baat hebben bij expliciete beleidscoördinatie met de buurgemeente(n).

De simulaties zijn uiteraard gebaseerd op aannames met betrekking tot onder andere de locatievoorkeuren van bedrijven. In vervolgonderzoek zal worden nagegaan of de resultaten nog steeds opgeld doen als (1) bedrijven hun preferenties gaandeweg de simulatie aanpassen (bijvoorbeeld in toenemende mate de voorkeur geven aan stations-locaties) en (2) gemeenten informatie kunnen uitwisselen over de vestigings-plaatsvoorkeuren van kantoren.

1. INTRODUCTION

A closer integration between transport and urban planning is a promising means of achieving sustainable accessibility. A number of urban planning practices such as building compact cities, promoting a rich mix of land uses and high densities around transit nodes, and increasing the number of jobs accessible by public transport are credited with reducing the need to travel and promoting a shift towards more sustainable modes of transport (1-4). Developing these integrated solutions, however, requires coordination between the policies of different actors and institutions. Policy coordination refers to efforts to increase the coherence between policies, whether between sectors (horizontal coordination), levels of government (vertical coordination) or between neighboring municipalities or other authorities with some shared interest in infrastructure and/or resources (5).

Despite numerous calls for policy coordination, it remains to be said what benefits to the land use and transport system can be expected from it. Coordination requires time, effort, resources and commitment. In this sense, it is important to understand just what its benefits can be. Literature on policy coordination tends to focus on barriers and hindrances, or otherwise in ways of encouraging coordination (for example in 6, 7), but not on its spatial outcomes. Literature on the transport - land-use connection deals with the effects of land use policies on mobility patterns, or the effects of transport investments on urban development, but rarely does it deal with coordination between policies and government levels. As a result, there is still a knowledge gap in what concerns the spatial outcomes of policy coordination. For example, it is still poorly understood how policy coordination between regional and local authorities or between neighboring municipalities affects land use or mobility patterns. What is clear is that policy decisions taken by one jurisdiction often have spillover effects on neighboring jurisdictions. This is especially true of land use and transport policies, since transport connects neighboring territories, acting as a vehicle for said spillovers. This leads to the question to what extent do different types of coordination affect transport and land use integration, and therefore sustainable accessibility. For example, can one municipality successfully pursue a sustainable accessibility policy alone, or is it crucial that neighboring municipalities pursue congruent policies?

At the level of local governments, coordination has to thrive in a mixed environment of inter-territorial competition and cooperation. On the one hand, municipalities compete for revenue, in the form of subsidies or investments from higher levels of government, and in the form of municipal taxes levied on residents or firms located within municipal grounds. In the frame of Tiebout's theory of Local Expenditures, competition between municipalities can lead to efficient outcomes if households and firms move according to their (heterogeneous) preferences concerning the services provided by the municipality. For instance, some municipalities might provide high levels of access to public transport but enforce high densities. Households and firms that value low densities will, accordingly, move out to other more suburban or exurban towns. On the other hand, there is evidence of cooperation in relations between local authorities. Economies of scale, especially at the level of (transport) infrastructure, or the management of common resources and (positive or negative) externalities can be fertile grounds for cooperation. Conversely, lack of coordination on transport and land-use policy between adjoining municipalities can end up producing patchy transport networks and car dependent neighborhoods.

In this paper, we set out to investigate to what extent policy coordination affects spatial patterns. We focus on one particular type of coordination – between two neighboring municipalities. We attempt to shed light on this relation by illustrating it with the case of municipal policies for office location. The reasons for choosing office location are manifold. First and foremost, office location is paramount for sustainable accessibility. The increase in the number of jobs accessible by public transport, through the location of office developments next to public transport nodes, is deemed to be one of the most decisive factors influencing mode choice (4, 8). Secondly, municipalities actively shape the location of offices through fiscal policies, infrastructure investments or parking regulations. Thirdly, office location decisions are well studied (see, for instance, 9, 10, 11), which allows us to readily model office location choice while focusing most of our attention on the process of coordination.

An agent-based model is developed in which two neighboring municipalities compete to attract firms to locate within their municipal boundaries. Municipalities can adopt either a transit oriented policy or a road oriented policy. Coordination is conceptualized as "coherence between policies", and in the model it equates to the scenario where the two municipalities adopt a transit oriented policy. This policy determines that the municipality will in areas near transit stations to improve the level of amenities, and therefore the site's attractiveness to firms. Conversely, when one of the municipalities adopts a road-oriented policy, it invests in areas near the road. The goal is to understand to what extent coordination between the two municipalities' policies affects the pattern of office location in transit and road areas. This model incorporates several assumptions that greatly simplify the context of political decision-making, and it should be viewed as a first step in trying to understand the complexity involved. One such simplification is that our operationalization of such a complex and elusive concept such as policy coordination inevitably narrows it down. Another assumption is that municipalities' investments are determined by policy alone. A third simplification is the reduced number of actors involved in decision-making in the model. In future research, we plan to overcome these limitations.

2. THE MODEL

2.1 Environment

The model is set on a m x n rectangular cell lattice, which is divided into two equal size areas that represent the jurisdictional space of two neighboring municipalities. The cells with coordinates y = 0 represent the border between the two jurisdictions, and stay empty throughout the simulation. To each side of the municipal border there is a town. The two towns are symmetric to each other, developing monocentrically around a railway station. The pattern of houses is fixed, and it is generated at the beginning of each simulation through a random function that determines if a given cell will be occupied by a building. The urban core is surrounded by suburbs, in which densities are much lower. Densities, measured in floor area ratios, are approximately 42,5% in the urban core and 2,5% in the suburbs. At every run of the model, a new system of two towns is generated, with random form but constant core and suburb densities. At the edge of each urban core there is a road access to a highway that connects the two towns. Travel time by road between the two road exits is set to 15 minutes. Travel time by rail between the two train stations is a parameter that can be varied between different runs of the model.

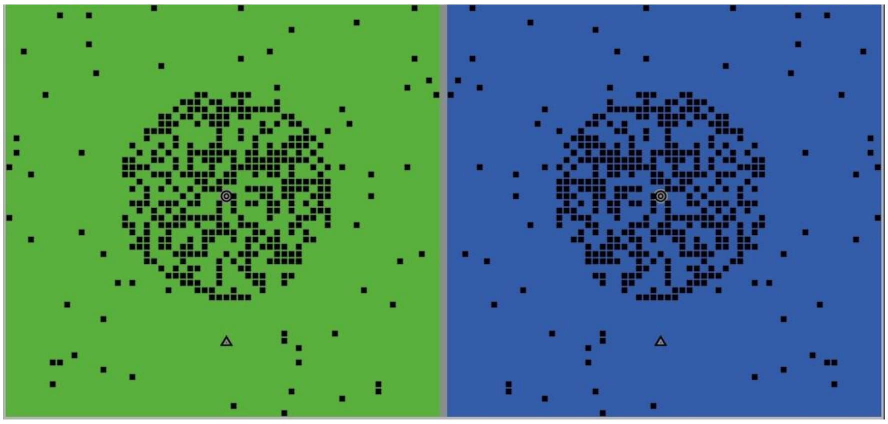

FIGURE 1 Initial setting for the model.

2.2 Office location

Agents in the model include firms and planners. Each firm is searching for a suitable location for a new office. Any empty cell in the lattice (with no houses, stations or roads) is a potential candidate for office location. In their choice of a new office location, firms have no a priori preference for any of the municipalities. They make their location choice based on a set of attributes of a location, namely: the level of accessibility of the site, the level of amenities at the site and level of agglomeration. Consideration of these three factors is based on literature suggesting that these are amongst the main attributes influencing firms' location choices. In an exhaustive study of firms’ location choices, Bodenmann and Axhausen (11) group the factors influencing firms' location choices in four groups: production factors (production costs, wage levels, human capital), economic environment (agglomeration effects, accessibility), municipal interventions (infrastructure, attitude of the administrative authorities) and residence location factors (surroundings, quality of life). De Bok and Sanders (9) explain firm migration on the basis of the firms' mobility profiles and the characteristics of the locations, such as the distance to train stations and to motorway onramps. Shukla and Waddell (12) explain firms' location choices based on three groups of variables, the first relating to distance to the central business district, the second pertaining to space availability and the third group pertaining to agglomeration effects. Considering the scale of our model, that includes only the space of two municipalities, it is reasonable to assume that production costs, wage levels and human capital are homogenous. Agglomeration effects refer to a general preference for proximity to other firms, and it is documented in the literature as being an important component of firms’ location choices. We measure agglomeration by considering the amount of office firms that already exist in the Moore neighborhood of the cell, which is defined as the 8 cells around it. Accessibility is mode specific so that rail accessibility depends on the distance to the train station and on the travel time on the rail network, and road accessibility depends on distance to the road access ramp and on the travel time on the road network. This term is further elaborated in the next section. The influence of municipal interventions is included in the Amenities term. Amenities refer to a bundle of site's characteristics, such as quality of public space, internet access options and level of provision of other infrastructure. These are the sites' characteristics that can be controlled by the planners. In the beginning of the simulation, the level of amenities is higher in the town centers than in the suburbs. This reflects the fact that town centers are usually better served in terms of a number of these amenities. The location choice of firms will be based on an evaluation of the utility offered by 50 randomly chosen locations. This represents a rational decision process, but because only a finite number of locations is considered, agent rationality is bounded by incomplete information. The utility of a location i for a firm k is given by:

$$\text{Utility}_{ki} = \text{Uamen}_{ki} + \text{Uagglom}_{ki} + \text{Uacc}_{ki}$$

$$\text{Uacc}_{ki} = \beta_{1k}\text{Railacc}_i + (1-\beta_{1_k})\text{Roadacc}_i$$

$$\text{Uamen}_{ki} = \beta_{2_k}\text{Amen}_i$$

$$\text{Uagglom}_{ki} = \beta_{3_k}N_8$$

The firms' profile is the vector of weights β1 β2 and β3, which reflect the strength of firms' preferences concerning each of the three factors above. The weights vary between 0 and 1 and are drawn from a random distribution. This means that companies entering the model can have any kind of preference profile. The preferences of firms concerning accessibility are mode specific, and assumed to be inverse, i.e., the more a firm values rail accessibility the less it values road accessibility.

2.3 Accessibility

Both road and rail accessibility are computed using a potential accessibility measure (or gravity-based measure). The potential accessibility measure estimates the accessibility of zone i with respect to opportunities in all other zones, in which smaller and/or more distant opportunities provide diminishing influences. When computing rail accessibility, the two railway stations are considered as possible destinations, whereas destinations outside a threshold radius of the railway stations are neglected. Similarly, when computing road accessibility, the areas around the two highway accesses are considered as possible destinations, whereas destinations far from the road exit are considered inaccessible for the purposes of the model. The attractiveness of a destination refers to the amount of opportunities at the location. In the model, attractiveness is proportional to the amount of office firms located at or near that location. As the simulation runs, accessibility tends to increase, although the transport network remains the same, because firms are entering the model and increasing the attractiveness of certain locations. As for the impedance part of the function, we use a negative exponential form, which is considered in many ways the most suitable (11) approach to modeling accessibility and anyway the most often used and most closely tied to travel behavior theory (13). The accessibility measure has the following form:

$$\text{Accessibility}_i = \sum_j \text{Att}_j \cdot f\left(\text{dist}_{ij}\right)$$

$$\text{Att}_j = \gamma \cdot N_r$$

$$f\left(dist_{ij}\right) = \exp\left(-\theta \cdot dist_{ij}\right)$$

in which:

i is the cell for which accessibility is being computed,

j = 1, …, n refers to possible destinations,

Att is the attractiveness of destination j,

N_r is the number of firms located within a radius r of destination j

γ is a scale parameter relating the attractiveness of a location with the number of firms at that location

θ is the distance decay parameter

$dist_{ij}$ is the topographical distance between i and j

2.4 Planners

The planners' goal is to attract companies to their municipality. In order to do this, planners can invest in a given site. Investing in a site means that the level of amenities at the site and its Moore neighborhood increases. The neighborhood in which to invest is chosen according to the municipality's Policy. The municipality can have either a TOD or a ROAD Policy. TOD means that investments will be made in places where rail accessibility is already high, usually in the urban core or near to it. ROAD means investments will be made where road accessibility is high. Investing in a site costs the planners part of the budget they raise on taxes. Namely, at each time step, the planners' budget is

$$Budget_t = Budget_{t-1} + n_t \cdot Tax - Investments - Costs_t$$

in which
Tax is a lump sum tax per company
nt is the number of companies in the planner's municipality
Investments is a lump sum to be paid each time the planner invests in a new site
Costst is the maintenance costs for sites where planners have invested and that remain empty.

Planners collect taxes on the firms that are located in their municipalities. The level of taxes raised each year is directly proportional to the number of firms. With the money collected the planner is empowered to invest in its municipality, in order to make it more attractive for firms. When a planner invests in a neighborhood, he has not only to pay for the investment, but also to support the maintenance costs of his investment as long as the site remains unoccupied. There is no rule that prevents the planner form investing several times in the same neighborhood. However, when the level of amenities increases and cells remain empty, maintenance costs increase. Namely, if a planner has invested once in a cell, he pays a certain amount of maintenance costs, whereas if he has invested twice or more times in a cell, he pays double that amount.

TABLE 1 Cost Level for Different Amenity Levels

Costs = 0	if amenities level is standard (planner has made no investment) or site is occupied
Costs = a	if amenities level is high (planner has invested once) and site is empty
Costs = 2a	if amenities level is very high (planner has invested twice) and site is empty

2.5 Dynamics

The model is run for 100 time steps. At each time step, 10 new firms enter the model. When firms enter the model, they evaluate 50 randomly chosen empty cells for their utility, and choose to locate at the site that maximizes their utility. One cell can support only one firm, so firms are allocated to a cell on a first come - first served basis. There is thus no competition for the same locations and a firm cannot be outbidden and driven out of a location. A firm can, however, fail to survive and be driven out of the model. Firm survival depends on the utility that their office location offers them. At each time step, firms recalculate the utility of their office location. After a certain number of firms has entered the model, competition drives firms with low values of utility out of the model.

As the office location choice process develops, a second process takes place concurrently. At each time step, each of the planners evaluates their budget. The initial budget for each planner is 0, but it soon increases due to the fact that firms have to pay taxes to the municipality. Planners' can only invest when their budget is above a minimum threshold. Whenever this happens, planners can make their investments according to their policy.

The model was run using the parameter values in TABLE 2. At the end of each run the outputs in

TABLE ***3*** are collected. We run the model 30 times for each scenario, so that in the end we have a sample of 30 values for each of the variables. The model is run in Netlogo 4.1.3.

TABLE 2 Parameters Used in Simulation

Time parameters	
Length of simulation	100 time steps
Rate of firm arrival	10 firms per time step
Accessibility parameters	
distance decay parameter	0,25
Attractiveness scale parameter	100
Travel time by road	30 minutes

TABLE 3 Outputs Collected

offices@total	total number of offices in the model after 100 time steps
offices@transit	number of offices located at travel time ≤ 15 minutes from a railway station
offices@road	number of offices located at travel time > 15 minutes from a railway station
offices@green	number of offices located in the green municipality
offices@blue	number of offices located in the blue municipality
offices@green_transit	number of offices at travel time ≤ 15 minutes from the green municipality railway station
offices@green_road	number of offices at travel time > 15 minutes from the green municipality railway station
offices@blue_transit	number of offices at travel time ≤ 15 minutes from the blue municipality railway station
offices@blue_road	number of offices at travel time > 15 minutes from the blue municipality railway station
U aggregate	Aggregate utility of the firms located in the both municipalities
U average	Average utility of the firms located in both municipalities

3. SIMULATION

3.1 Scenarios and Hypothesis

The goal of the model described is to test the effect of coordination between municipal policies and the spatial distribution of office locations in the two municipalities. More specifically, we are interested in the distribution of office locations between transit locations (town centers) and road locations (out of the town centers). The underlying idea is that the success of a transit oriented policy in bringing more offices near transit nodes depends (among other factors) on the neighboring municipality's policy. In order to test this proposition, we run the model for two different policy scenarios. In the first scenario, both municipalities adopt a transit oriented policy, which we refer by saying there is coherence between the municipal policies. In the second scenario, one of the municipalities (so called blue municipality) adopts a road oriented policy, while the other municipality (so called green municipality) maintains its transit oriented policy. Each scenario gives rise to a different urban development pattern.

TABLE 4. Scenario Description

Scenarios	**Policy Green Mun**	**Policy Blue Mun**
Scenario 1	Transit oriented	Road oriented
Scenario 2	Transit oriented	Transit oriented

The hypotheses that we seek to test are:
H1: Coherence between municipal policies leads to an increase in the total number of offices near transit nodes.
H2: Coherence between municipal policies leads to an increase in the total number of offices.
H3: Coherence between municipal policies leads to an increase in the average utility of firms, regarding their locations.

3.2 The Effect of Policy Coordination

H1: Coherence between municipal policies leads to an increase in the total number of offices near transit nodes

Hypothesis H1 was tested by comparing the results of scenarios 1 and 2. The results are compared using Pearsons' r, a measure of the linear correlation between the sample values of the variables of interest. In this case, the variables are offices@transit and a dummy variable standing for policy coherence. The correlation is positive and very significant, which confirms hypothesis H1. The increase in the number of offices near transit locations is due not only to an increase in the center of the blue municipality, but also to the increase in the center of the green municipality (where policy did not change). In fact, there is a highly significant correlation between policy coherence and offices@green_transit. Whereas as the effect of coherence in the number of offices in the blue municipality is straightforward - a change in policy from road to transit oriented is likely to succeed in attracting more firms to the center of the blue town - the effect of the blue municipality's change in policy on the green municipality spatial development is a spillover due to increases in rail accessibility.

H2: Coherence between municipal policies leads to an increase in the total number of offices

Hypothesis H2 was tested by comparing the results of scenarios 1 and 2. Our model does not confirm this hypothesis. On the contrary, the total number of offices is higher in average when the blue municipality adopts a road oriented policy. A road oriented policy attracts more companies than a transit oriented policy, due to the more space available near road locations. This difference is more than enough to compensate for the losses suffered by the green municipality due to the lack of policy coherence.

H3: Coherence between municipal policies leads to an increase in the average utility of firms, regarding their locations.

Hypothesis H3 is not confirmed by our model. The average utility of firms correlates negatively with policy coherence, which means it is higher when the blue municipality adopts a road oriented policy.

TABLE 5 Output variables statistics and correlation with policy coherence

	Pearson's r	p-value	Mean		Minimum		Maximum	
			scen 1	scen 2	scen 1	scen 2	scen 1	scen 2
total	-0.496**	0.000	486	466	434	424	533	503
near transit	0.956**	0.000	298	418	256	374	333	451
near road	-0.988**	0.000	189	48	165	36	219	61
green	0.568**	0.000	206	232	174	200	249	267
blue	-0.780**	0.000	280	234	240	190	318	273
green transit offs	0.473**	0.000	187	207	155	177	233	250
green road offs	0.566**	0.000	19	24	11	17	30	31
blue transit offs	0.965**	0.000	110	210	79	171	124	244
blue road offs	-0.990**	0.000	170	24	148	15	208	34
aggregate utility	-0.544**	0.000	62153	58484	54182	52202	69518	63832
average utility	-0.475**	0.000	128	126	124	121	131	131
green transit utility	0.434**	0.001	23889	26424	19668	22492	30357	32162
green road utility	0.560**	0.000	1945	2566	1151	1815	3303	3390
blue transit utility	0.966**	0.000	12871	26989	8774	22176	14411	32325
blue road utility	-0.986**	0.000	23448	2505	19748	1478	29687	3616

4. CONCLUSIONS

The model presented in this paper explores the extent to which policy coordination between neighboring municipalities can affect spatial patterns. The model tests hypothesis concerning the effects on the spatial distribution of office buildings of the coherence between municipal policies. We find that the policy of a municipality greatly affects the spatial distribution of offices in its neighboring municipality. If both municipalities adopt a transit oriented policy the total number of firms in the model area decreases, but the number of firms in the transit areas in both municipalities increases. On the other hand, if one of the municipalities adopts a road oriented policy, thereby providing attractive areas near the road, the other municipality will not be able to attract as many firms to its transit locations. The implications of this finding are that municipalities seeking to attract offices to transit areas should be aware of their neighboring municipalities' policies concerning office location, and have a lot to gain if their neighbors also adopt a transit oriented policy.

The validity of these findings depends on the assumption that firms have no a priori preference for one or the other municipality. The model assumes that the two municipalities do not differ significantly in terms of size, labor availability or any other relevant factors for firms' location choices. In addition, the results depend on the firms' preferences in terms of the attributes of different locations. In the present model, firms attribute random weights to their preferences for rail and road accessibility, site amenities and agglomeration. A natural extension of this model is to test for the case where there is a changing pattern for firms preferences (for instances, firms increasingly prefer rail to road locations) and municipalities can exchange information about the structure of firms preferences.

REFERENCES

1. van Wee, B. and K. Maat. Land-Use and Transport: a Review and Discussion of Dutch Research*.* In *EJTIR*, Vol. 3, No. 2, 2003, pp. 199-218.
2. Handy, S., Smart Growth and the Transportation-Land Use Connection: What Does the Research Tell Us? In *International Regional Science Review*, Vol. 28, No. 2, 2005, pp. 146-167.
3. Leck, E., The Impact of Urban Form on Travel Behavior: A Meta-Analysis*.* In *Berkeley Planning Journal*, Vol. 19, No., 2006, pp. 37 - 58.
4. Ewing, R. and R. Cervero. Travel and the Built Environment - A Meta-Analysis*.* In *Journal of the American Planning Association*, Vol. 76, No. 3, 2010, pp. 265 - 294.
5. Geerlings, H. and D. Stead. The integration of land use planning, transport and environment in European policy and research*.* In *Transport Policy*, Vol. 10, No. 3, 2003, pp. 187-196.
6. Hull, A., Integrated transport planning in the UK: From concept to reality*.* In *Journal of Transport Geography*, Vol. 13, No., 2005, pp. 318-328.
7. Te Brömmelstroet, M. and L. Bertolini. Integrating land use and transport knowledge in strategy-making*.* In *Transportation*, Vol. 37, No. 1, 2010, pp. 85-104.
8. Cervero, R., Office Development, Rail Transit, and Commuting Choices*.* In *Journal of Public Transportation*, Vol. 9, No. 5, 2006, pp. 41-55.
9. De Bok, M. and F. Sanders. Firm Relocation and Accessibility of Locations Empirical Results from the Netherlands*.* In *Transportation Research Record: Journal of the Transportation Research Board*, No. 1902, Transportation Research Board of the National Academies, Washington, D.C., 2005, pp. 35-43.
10. Elgar, I. and E. Miller. How Office Firms Conduct their Location Search Process? Analysis of a Survey from the Greater Toronto*.* In *International Regional Science Review*, Vol. 33, No. 60, 2010.
11. Bodenmann, B. R. and K. W. Axhausen, *Synthesis report on the state of the art on firmographics*. 2010, Institute for Transport Planning and Systems, IVT ETH Zurich.
12. Shukla, V. and P. Waddell. Firm location and land use in discrete urban space: A study of the spatial structure of Dallas-Fort Worth*.* In *Regional Science and Urban Economics*, Vol. 21, No. 2, 1991, pp. 225-253.
13. Handy, S. and D. Niemeier. Measuring Accessibility: An exploration of issues and alternatives*.* In *Environment & Planning A*, Vol. 29, No., 1997, pp. 1175 - 1194.