45 Th Congress of the European Regional Science Association

23-27 August 2005, Vrije Universität Amsterdam

TITLE - ACHIEVING A JOBS-HOUSING BALANCE IN THE PARIS REGION: THE POTENTIAL OF REDUCING CAR TRAFFIC

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THEMATIC STREAMS : B , Urban and Regional policy

SPECIAL SESSION : B4 , Effects and evaluation of spatial planning

ABSTRACT

Many experts believe that the three major urban dynamics (urban sprawl – functional and social specialization) drag along quantitative and qualitative spatial imbalances between economic and residential functions. These spatial imbalances contribute to widen the distance separating workers' homes and job places, and hence, to lengthen the trips-to-work. On the basis of this diagnosis, the re-establishment of a greater balance, on both quantitative and qualitative grounds, between jobs and housing in different areas of the city is currently emerging as a major issue regarding the car-traffic reducing goal.

This research examines the extent to which a qualitative and quantitative improvement in the jobs-housing balance in the different parts of the Parisian region could lead to a considerable reduction in car traffic. Making the explicit hypothesis that constraints exist within the housing market which affect the mismatch between the place of work and the place of residence of the working population, we investigate through a simulation approach the potential reduction in car travel distances that is provided by a housing re-assignment in which the distances between places of work and residence are reduced. We examine more directly if the housing stock in the "residential catchment areas" of the different centres of employment is sufficient in quantity and quality to be able to take all the working households living a long way from their place. The aim of our method and analysis is not to predict what the residential choice might be in other circumstances, but the upper limit of the car traffic mitigation associated to spatial mismatch reduction. Therefore we explore the "realism" of a way for more compact city.

KEY WORDS : Car commuting, Jobs-housing imbalance, Re-assignment model

ACHIEVING A JOBS-HOUSING BALANCE IN THE PARIS REGION : THE POTENTIEL OF REDUCING CAR TRAFFIC[1]

INTRODUCTION

There is no doubt that the enormous increase in motorized traffic in modern cities is closely related to the success of the passenger car, which offers a "performance[2]/cost" ratio which it is difficult to better in a context of expanding urban areas and social, functional and geographical specialization within them. However, although motorized traffic is still on the increase, with a consequential increase in oil consumption and CO_2 emissions, and opinion surveys over a number of years show that French people, even motorists, would like to see a reduction in the pressure exerted by the car on the city. This apparent contradiction between people's desires and behaviours is an important issue for public action and prompts us to ask what are the realistic margins of manœuvre with regard to controlling car use.

With regard to the organization of transport systems, public action is frequently unambitious (according to the GART/CERTU review, few urban travel plans attempt to achieve more than marginal reductions in car traffic of 2 or 3%) and the limited impacts of such action soon become apparent. Thus for example, in an area which is as exceptionally well-served by public transport as the densely populated part of the Paris Region (the City of Paris and the inner suburbs) and in conditions which are exceptionally favourable for the development of public transport supply and where car speeds are low, the potential for modal transfer from the car to walking, cycling or public transport appears to be limited to between 10 and 15% of car traffic. Most car trips are therefore captive trips [Massot et alii, 2002]. This situation is obviously worrying with regard to France's international commitments to limit CO_2 emissions.

However, there is at least one other lever that can be used to reduce motorized traffic in urban areas, namely reducing the distances that need to be travelled by car to go to work by

[1] This was funded by the French Environment and Energy Management Agency (ADEME) which we thank for its support.

[2] Both from the point of view of travel speed and practicality of use (flexibility, range, etc.)

concerted public action in the areas of transport, housing and the location of activities. Shortening the distances travelled by car by 10% would have the same effect on the total number of vehicle-kilometres travelled as transferring 10% of car traffic to public transport. This solution, which involves a variety of urban policies acting in particular on the locational structure of housing and economic activities, is provided for in the Urban Solidarity and Renewal Act (Loi Solidarité et Renouvellement Urbain) of December 2000 in order to achieve territorial cohesion and sustainable development. It is, however, in no way innovative: as early as 1965 the objective of a "jobs-housing balance" was explicitly mentioned for the inner suburbs of Paris in the structure and land use plan. This document states that the reasons for this objective include reducing the commuting distances (recognized as distressful) and reducing motor vehicle pollution, etc.

However, in France, this means of reducing travel demand has been explored little, either in the past or now, and there have been almost no studies into the limitation of travel distances, including commuting journeys, with the exception of the INRETS/ADEME travel budget-energy-environment diagnosis studies [Orfeuil,1997]. However, elsewhere, in particular in the Netherlands, the United Kingdom and California, a large number of analyses have been performed since the end of the 1970s. Thus, the Association of the State of Southern California has estimated that "directing" 9% of the jobs created in the region between 1984 and 2010 towards employment-poor regions and 4% of new housing construction during the same period towards housing-poor areas would reduce car traffic by 35% and pollutant emissions by almost as much. Although the scales of these estimates have been questioned, they are supported by a considerable body of academic work, including that by Newman and Kenworthy [1989], Cervero [1989, 1998], and Shafer and Victor [2000]. The latter has shown that the increase in long trips in the different areas of the metropolises of San Francisco and Chicago is the result of the difficulty households experience in finding suitable housing near their place of work. He suggests that effective urban policies that increase and diversify housing supply near centres of employment, which will consequently establish a better quantitative and qualitative balance between employment and housing, have considerable potential as a means of limiting motorized traffic.

The scarcity of such analyses in France is explained by professional compartmentalization that divides those concerned with housing, transport and economic

development and by the methodological weaknesses which affect transport studies (for example, provincial urban household travel surveys often fail to take distances into account).

It is also explained by the fact that French intellectual life is dominated by a discourse that affirms the increasing separation between the sphere of work and the sphere of housing. Time spent working has diminished, and work no longer governs our lives and life choices. Commuting trips have become marginal (we should mention in this context that they still account for more than half of the kilometres travelled by car in urban areas by the working population), residential location choices are becoming more and more independent of the place of work (commuting times have not changed since statistics began…).

In the United States, this discourse is backed up by a certain amount of empirical economic research dealing with "excess commuting" or of "wasteful commuting". Giuliano and Small [1993] have shown, for example, in the case of Los Angeles, that if households were "redistributed" among the existing housing stock in such a way as to minimize average commuting distance (or time), distances would be considerably less than they are now: excess commuting is expressed by the ratio between the calculated minimum commuting distance currently travelled and whose value is of the order of one to two. Research by Hamilton [1989] on Baltimore, Small and Song [1992] on Los Angeles County, and Cropper and Gordon [1991] on Boston arrive at similar estimates for the "excess commuting ratio" and therefore consider that minimization of commuting times and distances are not a strong guidance for the residential choices of households. On this basis, some of these researchers have concluded that the increase in commuting distances is primarily the result of the residential location choices made by households and that it would be pointless to engage in planning activities aimed at bringing the life and work or the working population close together as a means of reducing car traffic. However, research applying an identical methodology to the very different urban context of Tokyo has concluded that the effective distance to work is only 10% higher than the minimum distance [Meriman et alli 1995].

The results variability encourages us to carry out specific empirical research for French cities. This work is particularly necessary because the previously mentioned research can be criticized on the grounds that it oversimplifies reality: thus, all this research apart from that of Cropper et Gordon [1991], redistributes households within the housing stock according to a procedure which does not take account of the characteristics of either the households or the housing (the size of the household and the size of the dwelling unit as well as the occupancy status of the dwelling unit are not taken into account).

More fundamentally, one can question the relevance of excess commuting measurements that are constructed on the behavioural hypothesis that people minimize their commuting time or distance when selecting their residential location. This hypothesis has been comprehensively questioned by Zahavi's empirical research [1974] into the actual daily travel behaviour of individuals, which established that individuals do not so much attempt to minimize the distances they have to cover as to maximize urban spatial potential. More precisely, this research, and other work that has stemmed from it, has shown that individuals attempt to maximize potential spatial differences (cost of housing, accessibility of various urban amenities, etc.) within given space-time and monetary budgets. This paradigm states that personal travel is the outcome of trade-offs between competing and/or more or less interchangeable objectives. Thus, every individual's time-distance to work is the result of their household's trade-off between daily travel and residential mobility; this trade-off obviously does not mean that individuals do not consider distance, but time-distances compete with other factors, in particular location within a given space-time area defined with reference to all aspects of the transport system (access to a car, speeds of available modes).

This research examines the extent to which a qualitative and quantitative improvement in the jobs-housing balance in the different parts of the city could lead to a considerable reduction in car traffic. Making the explicit hypothesis that constraints exist within the housing market which affect the mismatch between the place of work and the place of residence of the working population, we shall investigate the potential reduction in car travel distances that is provided by a situation in which the distances between places of work and residence are reduced.

Our methodology is similar to that used in research into "excess commuting". In order to measure spatial imbalances, we have developed a simulation model which reassigns the dwellings of the working population. First, however, this reassignment process has been conducted with a different behavioural hypothesis and with *explicit* rules. Our hypothesis is based neither on the primacy of proximity nor the primacy of distance reductions. It takes into account our knowledge about individual travel behaviours and limits travel to a certain time-space around the individual's work, for example 30 minutes. This time-space defines the residential catchment area for a job within which the reassignment of housing is conducted. Secondly, it involves much finer disaggregation of both household and housing types. Last, unlike previous studies, it has not been constructed with fixed housing stocks in a zone. If

needed, fictive dwelling units can be created in order to meet the fictive housing demand generated by our methodology, which means it is then possible to describe the current tensions on the housing market in different areas and show how these contribute to the creation of commuting distances. The method is based on repeated iterations of this simulation model. In our approach we made the assumption that households would accept the residentieal location proposed by the model, and that many factors (such as housing comfort or reliability and social environment of borrough), have been excluded from the substitution analysis.The aim of our method and analysis is not to predict what the residential choice would be in other circumstances, as in a conventional housing or modal choice demand models, but the upper limit of the car traffic mitigation associated to spatial mismatch reduction. Therefore we explore the "realism" of a way for more compact city.

We have conducted our empirical analysis for the Paris region; it is based on data concerning households and their dwellings contained in the one-twentieth scale file from the 1999 General Population Census performed by the French National Statistics Office (INSEE). Data concerning travel times by car from one municipality to another are derived from a matrix that was drawn up by the DREIF (Direction Régionale de l'Equipement d'Ile-de-France - Paris Region Infrastructure Directorate) that has been converted to municipality level by Wenglenski [2003].

The first section of this paper will describe our methodological approach. This will be followed by the second section which gives an estimate of the extent to which a reduction in commuting distances could reduce car traffic. Last, we shall examine more directly if the housing stock in the residential catchment areas of the different centres of employment is sufficient in quantity and quality to be able to take all the working households living a long way from their place.

I. METHODOLOGY

In order to estimate what potential there is for reducing commuting distances by measures aimed at housing, we have developed a simulation model which is based on a fictive reassignment of households to dwelling units which are nearer their place of work. Subsequent to this procedure, the potential reduction in car traffic has been estimated in terms of the number of vehicle-kilometres which would be saved if households that reside a long

way from their place of work all "rehoused" themselves within the residential catchment area of their place of work.

The hypotheses and principles on which this procedure is based were defined with reference to our understanding of the travel behaviour of individuals and with a view to explaining the extent to which the imbalance between the locations of dwelling units and jobs, and the distances associated with these imbalances, are the result of the current structure of the housing stock in the Paris region. We have measured the match between the housing stock in each zone or employment catchment area in terms of the difference between the existing stock and the fictive stock which would be required for each household to find a dwelling unit suited to its needs and desires in the residential catchment area of its place of work (we have already defined what we mean by "suited to its needs and desires"). This fictive housing stock, which corresponds to fictive demand is obtained directly from the process by which households are reassigned to a nearer dwelling.

1. The behavioural hypothesis and its implications

The procedure by which we assign households to a different dwelling unit is conducted using a locational behavioural hypothesis which is based neither on the absolute primacy of proximity (the smallest possible distance) nor on its negation. It is assumed that every household attempts to live within a radius defined by an access time "t", from its job which defines a circle in which the household will make its own locational and daily travel trade-offs on the basis of its sociocultural and financial priorities.

On the basis of this hypothesis, we have performed a fictive reassignment of the dwellings of households in the Paris region within this circle. This circle, whose radius is less than "*t* minutes" from the place of work defines the residential catchment area within "*t*" minutes of the place of work".

This hypothesis, which in practice acts as a limit, obviously means that the reassignment, and thus the potential reduction in car distances, depends on the selected radius and the associated perimeters. This radius, which can be either increased or reduced during the procedure, has been fixed at 30 minutes in the majority of the analyses presented here. The choice of thirty minutes is a direct consequence of current commuting practices in the Paris region, where the median duration of the journey to work is 30 minutes (D.R.E.I.F., 1995). This median duration is equivalent to a median distance of about 10 km.

This first rule as regards the reassignment of dwelling units in order to calculate potential reductions in commuting distances results in two principles which differentiate our research from that which deals with "excess commuting".

- The first principle is that all the workers and their households are not relocated; the procedure is only applied to those persons living outside the residential catchment area of their place of work, that is to say persons who live more than 30 minutes away from where they work and whom we shall describe as long-distance commuters.
- The second principle is that we do not reassign households to employment catchment areas which have been identified on the basis of normalizing urbanistic hypotheses (number of jobs and /or minimum job densities) which lead to a reassignment of dwelling units either to an excessively small number of centres of employment each of which covers too large an area, or to too many centres of employment which cover too small an area. In our methodology, the residential catchment area for the job is associated with each job, and therefore with each worker..

These two principles situate our approach within a conceptual framework that describes the residential behaviour of households with reference to a time-distance to work.

2. The rules for reassigning households within the employment zone.

2.1. The populations which are subjected to do the procedure

In the study, we have considered households in the Paris region with at least one working member and whose working member(s) work in the Paris region. Some of these households have two working members, either one or both of whom may be long-distance commuters and therefore subject to the reassignment procedure within the residential catchment area of their place of work.

Only households with two working members both of whom are long-distance commuters are subjected to the housing reassignment procedure. We therefore make the inverse hypothesis that a household in which at least one of the two working members is not a long-distance commuter is not moved closer to its place of work, based on the assumption that such a household has already optimized its location in favour of the place of work of at least one of its two working members.

Depending on whether the household has one or two working members, the rules of the procedure are as follows:

- Any household with a single working member whose place of residence is more than 30 minutes away by car or public transport from its place of work is subjected to the procedure; the household's dwelling unit is relocated within a 30 minute commute by car or public transport from its municipality of work.
- Any household with two working members both of whom work more than 30 minutes away from their respective jobs is considered to be a household that lives a long way from its place of work. The dwelling unit of these households is relocated within a 30 minute commute from the municipality in which the partner lives[3].

2.2. The rules for reassigning households to dwelling units

Reassignment is guided by two principles:

- The first involves the social, economic and familial characteristics of the households and the type of dwelling unit that they are looking for with reference to these characteristics.
- The second is the hypothesis that households which are relocated within the residential catchment area of their job "demand" or "will be content with" the same kind of dwelling as the households with the same profile which already reside in this residential catchment area.

The second principle would obviously tend to oversimplify with regard to the number of items which are considered by households when making a residential choice if the number of household profiles and types of dwelling unit was not large enough to take full account of the diversity of present-day situations. For this reason we have established the profile of the households on the basis of three criteria: (i) – its socio-occupational group (six categories))[4], (ii) – the number of workers in the household (three categories)[5]; and (iii) – the family profile (eight categories)[6]. Combining these three criteria gives 108 different household types. The types of dwelling unit are also defined using three criteria: (i) – the nature of the dwelling unit (two categories: house or apartment); (ii) – ownership status of the dwelling (three

[3] The reason we prefer to move these households closer to the partner's place of work rather than that of the reference individual is because we have generally observed that when both partners work the dwelling is usually located nearer the wife's work than the husband's.

[4] Senior executives and liberal professions; intermediate professions; employees, artisans and shop-keepers; skilled workers; unskilled workers; unemployed. The socio-occupational category of the household is that of the reference person if this person is employed, and that of the partner if not. [5] Two jobs, One job, No jobs.

[6] Single person; single-parent family with one child, with two children, with three or more children; childless couple, couple with one child, with two children, with three or more children. [7] Owned; private sector rented; public sector rented.

categories)[7] and – (iii) the size of the dwelling unit in number of rooms (six categories ranging from "one room" to "six or more rooms"). By combining these three criteria, we define 36 types of dwelling unit.

Housing demand is thus ultimately characterized by relating the 108 types of household to the 36 types of dwelling unit.

3. The conduct of the procedure

The reassignment procedure takes place in the following manner :

1. We identify the households with profile "*i*" working in municipality "*j*" and which live outside the residential catchment area 30 minutes away from municipality "*j*" (which includes all the municipalities within a 30 minute commute by car or public transport from municipality "*j*");
2. We determine the structure of the housing occupied by the households with profile "*i*" which live in residential catchment area "*j*" (this structure is the distribution of the households between the 36 types of dwelling unit we have defined);
3. We attribute dwelling units to the households with profile "*i*" which have been relocated within the residential catchment area "*j*" such that the structure of the housing occupied by these households is identical with that of the households with the profile "*i*" already living in the residential catchment area "*j*".

$$MR_{ijk} / \sum_k MR_{ijk} = MA_{ijk} / \sum_k MA_{ijk} \quad for\ any\ i,j,k$$

where

MR_{ijk}: denotes the households with profile "*i*" which have been relocated within the residential catchment area "*j*" in a type "*k*" dwelling unit

MA_{ijk} : denotes the households with profile "*i*" already living in residential catchment area "*j"* in a type "*k"* dwelling unit.

4. The households with profile "*i*" which have been relocated in the residential catchment area "*j*" in a type "*k"* dwelling unit are distributed between the different municipalities making up this catchment area such that their distribution between the municipalities is identical with that of the households with profile "*i*" already living in the residential catchment area "*j*" which occupy a type "*k"* dwelling unit.

$$MR_{ijkb} / \sum_b MR_{ijkb} = MA_{ijkb} / \sum_b MA_{ijkb} \quad for\ any\ i,j,k,b$$

where :

MR_{ijkb}: denotes the households with profile "*i*" which have been relocated within the residential catchment area "*j*" in a type "*k*" dwelling unit located in municipality "*b"*,

MA_{ijkb}: denotes the households with profile "*i*" already living within the residential catchment area "*j*" in a type "*k*" dwelling unit located in municipality "*b*";

5. The operation is reiterated for each profile "*i*" and for each municipality of work "*j*".

At the end of the reassignment procedure, for each municipality "*b*" in the Paris region we know the number of "new" resident households with each profile "*i*" and the number of dwelling units of each type "*k"* they "demand". On this basis, by adding together the dwelling units that are demanded by the households that have been reassigned to the municipality "*j*" and the dwelling units that are occupied by households already residing in municipality "*b*", we can obtain the number of dwelling units that are required to satisfy the entire "fictive demand", for each type of dwelling unit "*k*" in each municipality "*b*".

II. THE POTENTIAL FOR REDUCING COMMUTING DISTANCES BY REDUCING JOBS-HOUSING IMBALANCES

1. A comprehensive approach to jobs-housing imbalance as measured by long-commuting distances

Reducing the commuting distances of households living more than 30 minutes away by car or public transport from their place of work would affect 767,000 households in the Paris region. These households, which accounted for 27% of the households with at least one working member in 1999, account for 46.7% of all travel distance. Long-distance commuting is therefore an important phenomenon in the Paris region, and this importance is more due to the distances involved than the number of households or workers. The average commuting distance for those persons who are considered to be distant from their work is 23.5km as opposed to 8.7km for those who reside within a 30 minute commute from their jobs (Table 1).

More long-distance commuters use public transport (58%) than the car (42%). This is hardly surprising, and it must neither be forgotten nor minimized when we consider the

potential reduction in car dependency that can be achieved by reducing commuting distances. Since the beginning of the 20th century, track-guided public transport (trams to begin with and then the metro and regional express networks more recently) has played a major role in decentralizing populations and jobs. It is still the case today that long-distance commuting is more associated with fast public transport than car use, not only because the people making long journeys tend to use public transport more often, but also because of the commuting distances encouraged by this transport mode (60% of the commuting distances of distant households are on public transport). This means that the average commuting distance of long-distance public transport commuters is considerably higher (30.6 km) than of someone who commutes by car (25.3 km). However, here too we should not minimize what has been observed elsewhere concerning the dynamic of long-distance commuting which is characterized by equally large increases in car use and public transport use (Massot, Roy, 2004). The large-scale decentralization of work that has taken place in the Paris region in the last 10 years, which is marked both by a movement of jobs to new centres in the new towns, La Défense and Roissy and a spreading of jobs throughout the rest of the Paris region, certainly explains both the continuing importance of public transport but also the increasing proportion of commuting distances which are travelled by car.

2. The sensitivity of the potential reductions to the hypotheses used in the procedure

The procedure described above applies a necessarily arbitrary threshold to decide which households are engaged in long-distance commuting and in order to define the residential catchment area of relocated households. Obviously, both the populations affected by long-distance commuting and the reductions in commuting distances depend on the value of the threshold.

To evaluate the sensitivity of population sizes and commuting distances to the time threshold, we have made two different hypotheses concerning the reduction of the distance between the residential location and the place of work. These are a more constraining hypothesis in which the households that are relocated are those which make a commuting trip of at least 20 minutes by car or at least 30 minutes by public transport, and a less constraining hypothesis in which the households that are relocated are those which have a commute of less than 45 minutes by car or public transport.

The simulation results show the sensitivity of the field of analysis to the definition of the distance threshold (Table 1). We can see that once the commuting time exceeds 45 minutes,

the percentage of households involved in long-distance computing and affected by the relocation procedure is relatively low (9%) as the vast majority of households take less than 45 minutes to travel to work. However, this definition of long distance still covers a high percentage of all commuting distances (21%) and although the percentage of the total distance which is covered by public transport (65%) is greater than in the "median scenario" (30 minutes), a non-marginal percentage of distances (35%) are travelled by car by a non-marginal percentage of households (39%). On the other hand, reducing the definition of long distance to a 20 minute commute by car instead of 30 minutes in the "median" scenario while keeping public transport commuting time at the same level (30 minutes), considerably increases the number of households and the commuting distances (410,000 additional households and 10 million additional kilometres).

Table 1 - : Populations and commuting distances according to the threshold used to define the "residential catchment area" of a worker

	VP <20mn et TC < 30mn		**VP <30mn et TC < 30mn**		**VP <45mn et TC < 45mn**	
Type of household	% of households	% of total commuting distances	% of households	% of total commuting distances	% of households	% of total commuting distances
Living <u>more than</u> 30 minutes away from their place of work	42,1	63 ,8	27,4	46,7	9,0	21,0
Living <u>less than</u> 30 minutes away from their place of work	57,9	36,2	72 ,6	53,3	91,0	79,0
Total	100,0	100,0	100,0	100,0	100,0	100,0

Source: Figures calculated by the authors from the 1999 General Population Census and the DREIF travel time matrices

3. Jobs-housing balancing and the reduction of commuting distances by car

3.1. An approach which defines the lower bounds

Evaluating the reduction in car commuting distances that would occur if people's residential locations were brought closer to their places of work on the basis of different hypotheses concerning the distance threshold allows us to gain a rough idea of the stakes. The method, which is admittedly somewhat brutal, provides the lower bound for reductions in car commuting distances. This is because our proposed method for evaluating the reduction for

households with at least one working member who commutes by car in the initial situation is calculated by subtracting the commuting distances of these households before relocation from their commuting distances after relocation. The commuting distances of these households after relocation have been evaluated by assuming that once they are inside the residential catchment area, the working members of these households will still travel to work by car and that their distance to work will be, on average, the same as that of the households that are currently residing in the residential catchment area. In other terms, the reductions in commuting distances do not take account of the performance of public transport and any possible modal transfer that could result from it.

3.2. The stakes involved in limiting commuting distance

If all the workers in the Paris region lived within a 30 minute commute by car or public transport from their places of work, commuting distances would be reduced by 31%, from 49 millions to 33 millions of kilometres (Table 2). With our hypotheses, this reduction would involve something like 27% of households with at least one commuting member, i.e. 767,000 households. As more long-distance commuters use public transport than the car, 53% of the reduction in commuting distances (15,4 million of km) is relevant to pubic transport users.

Table 2 – The reduction in Car and Public Transport (PT) kilometres travelled with the hypothesis of a relocation of households within a 30 minute commute from their work.

	Before housing' re-assignment		**After housing' re-assignment**	**Households Re-assigned**	
	No. of households	Total communing Distances In Million km	Total communing Distances In Million km	No. of households	Commuting distances Reduction In Millions km
Car Users	1,453,000	23,2	16,0	321,000	7,2
P.T Users	1,346,000	25, 8	17,6	448,000	8,2
Total	2,799,000	49,0	33,6	767,000	15,4

Sources: Figures calculated by the authors based on the 1999 General Population Census (INSEE) and the Travel Time Matrices produced by the DREIF(Direction Régionale de l'Equipement d'Ile-de-France)

3.2. The stakes involved in limiting car commuting

If all the workers in the Paris region lived within a 30 minute commute by car or public transport from their places of work, commuting distances with current levels of car use among

the working population would be reduced by 31% (Table 3). With our hypotheses, this reduction would involve something like 22% of those households with at least one member using the car to travel to work, i.e. 320,000 households out of the 1.4 million car users.

In absolute terms, as is always the case in the Paris region, this percentage would result in a considerable reduction, of the order of 7,2million kilometres, which makes a total of 14,4 million kilometres a day with the hypothesis that each worker makes one return trip a day and 11,5 million kilometres a day with the hypothesis that only 80% of the working population actually works on a given day (data obtained from the INSEE 1999 Time Use Survey). The figure of 11,5 million kilometres represents 9% of the total daily car traffic in the Paris region as calculated from the comprehensive transport survey (Enquête Globale Transport, 2000), 14% of the commuting distances covered by all modes and 30% of car commuting distances.

This reduction is without doubt high enough for us to consider that the reduction in car traffic that would result from jobs-housing balancing is significant. It is even more so if we consider that for those households affected by the residential relocation procedure, the reduction in the commuting distances travelled by the working population would be 63%. Their average commuting distance would fall from 20.7 km to 7.8 km, thereby becoming almost equal, for example, to the average commuting distance of the population that lives and works in cities with more than 300,000 inhabitants in France.

Table 3 - Populations and reduction in car commuting distances according to the threshold used to define the "residential catchment area" of a worker

Threshold defined The residential area of a worker	Households Re-assigned		Reduction in car commuting distances		Reduction in daily car traffic in Paris region*
	Number	In % of daily car users for commuting	In Million km	In % of car commuting distances before reassignment	
VP < 20mn - TC < 30mn	578,000	39 %	10,7	47%	14%
VP <30mn -TC <30mn Scenario Median	320,000	22 %	7,2	31%	9%
VP <45mn - TC < 45mn	99,000	7 %	3,1	14%	4%

Sources: Figures calculated by the authors based on the 1999 General Population Census (INSEE) and the Travel Time Matrices produced by the DREIF (Direction Régionale de l'Equipement d'Ile-de-France)

This reduction in commuting distance affects 320,000 households which is an enormous figure too, amounting to the population of a large provincial city. However, we do not necessarily need to be overawed by the size of this number of households "to be moved": we should simply bear in mind that of the 1.7 million of the 3.9 million household heads who were resident in the Paris region between 1990 and 1999 moved home during that time.

The sensitivity of the reduction in car commuting distances to the radius which defines the "residential catchment area "for reassigning households is as great as it was previously (table 3).

- With the threshold of 20 minutes by car or 30 minutes by public transport, 39% of households with at least one car commuter would be affected by the car commuting distance reduction procedure and there would be a 47% reduction in the commuting distances travelled by car;
- With the threshold of 45 minutes by car or public transport, 7% of households with at least one car commuter would be affected by the car commuting distance reduction procedure and there would be an 14% reduction in the commuting distances travelled by car.

While these results of course confirm the high sensitivity of measurements to the "closeness" threshold, we can nevertheless observe that even when the thresholds are relatively high (45 minutes by car or public transport), there is still a substantial reduction in the distances travelled by car – particularly when we compare this reduction with the objectives that have been stated by the public authorities in various planning documents concerned with reducing car traffic.

III. THE STRUCTURE OF THE HOUSING STOCK IN THE PARIS REGION AND COMMUTING DISTANCES

1. The approach

The influence of the quantitative and qualitative spatial imbalances that affect the housing stock in the different parts of the Paris region on the creation of long commuting distances has been analyzed by relating the housing stock in the thirty minute residential catchment areas in the different employment zones to the "fictive housing demand" of workers who at the present time live a long way from their place of work.

Following the procedure described above, we have relocated all the households that live a long distance from their place of work within the residential catchment area defined by a 30 minute commute. Last, for the area within a 30 minute commute from a municipality of work "*j*" and for each type of dwelling unit "*k*", we have measured the difference E_{jk} between the housing supply in the catchment area and the housing supply "that would be necessary" for each household working in municipality "*j*" and requiring a dwelling unit of type "*k*" to be housed within a 30 minute commute from municipality "*j*".

$$E_{jk} = Oc_{jk} - O_{jk}$$

Where :

E_{jk} is the difference between the supply of type k dwelling units that is necessary within a 30 minute commute of the municipality of work j and the existing supply of type k dwelling units;

Oc_{jk} is the supply of type dwelling units that is required within a 30 minute commute of the municipality of work j;

O_{jk} is the supply of type k dwelling units which exists within a 30 minute commute of the municipality of work j.

We have made the implicit hypothesis that if demand for type k dwelling units within a 30 minute commute of a municipality *j* is significantly higher than the existing supply, we can suspect that the households which have decided to live outside this catchment area have done so because of spatial jobs-housing imbalances which mean the type of housing they desire is scarce near their place of work. Then, extending this first hypothesis, we can think that within the entire Paris region a large number of households live a long way from their place of work because of the scarcity of the type of housing which they "demand" near their place of work (as defined above), we can hold the view that spatial jobs-housing imbalances effectively generate long commuting distances in the Paris region.

We have constructed a typology of municipalities of work *j* for each type of dwelling *k* on the basis of the value of the indicator defined above (E_{jk}). This typology identifies five types of municipalities of work. In this typology, the municipalities of work "*j*" which are classed in the first category are, of course, those municipalities whose residential catchment area within a 30 minute commute provides the number of type k dwelling units that is necessary to meet all the demand from households working in these municipalities and which currently reside a long way from them: these are municipalities of work with no deficit as regards the supply of type k dwelling units within a 30 minute commute ($E_{jk} \leq 0$). At the other extreme, the

municipalities of work "*j*" in the last two categories are those whose residential catchment area within a 30 minute commute is far from providing enough type k dwelling units to cope with all the demand from households working in these municipalities and which currently reside a long way from them: these are municipalities with major supply/demand imbalances for type "*k*" dwelling units within a 30 minute commute . Between these two extremes are the municipalities of work "*j*" where the supply of type "*k*" dwelling units within a 30 minute commute exceeds current requirements but to a less marked degree.

2. **A housing stock which partially matches estimated needs…**

How are the municipalities in the Paris region distributed according to this typology? What proportion of them have a major housing supply deficit within a thirty minute commute? What proportion of them have a sufficient supply within a 30 minute commute to be able to satisfy all the demand from the households which are reallocated to them?

Most of the fictive housing demand, that is to say 75%-80% of the 760,000 dwelling units required within a 30 minute commute from their municipality of work by households currently residing a long way from their place of work, is located, with our hypotheses, in areas with enough dwelling units for all the households "wishing" to reside in them. So the deficit in current housing supply is estimated at 160,000–190,000 dwelling units : the dwelling deficit should be moderate and should account for 4,5% of the total currently housing supply in the Parisian region. To this, we can add that a non-negligible number of households (36%, table 4) have been reassigned where the supply deficit is particularly high (greater than 10% of current supply) while 29% should "demand" a type of dwelling unit for which there is a high level of supply near their place of work. The remaining large third are in an intermediate position: they are looking for a type of housing for which there is a "moderate" shortage near their place of work.

Table 4: Distribution of fictive demand from households living a long way from their place of work between the categories of municipality according to the level of imbalance within a 30 minute commute

	Housing demands (thousand)	Cat. 5 – Deficit of more than 20%	Cat. 4 – Deficit of 10 - 20%	Cat. 3 – Deficit of 5 -10%	Cat. 2 – Deficit of 0 - 5%	Cat. 1 – Surplus	Total
Total	759.5	***8.0***	28.0	20.3	15.0	28.7	100.0
Paris	334.3	**17.4**	**46.9**	25.1	8.6	1.9	100.0
Inner suburbs	269.8	1.1	**20.5**	**24.1**	24.2	30.2	100.0
Agglomerated outer suburbs	134.4	0.0	0.5	3.5	**14.3**	**81.8**	100.0
Periurban suburbs	20.8	0.0	0.0	0.7	**2.5**	**96.8**	100.0

Sources: Figures calculated by the authors based on the 1999 General Population Census (INSEE) and the Travel Time Matrices produced by the DREIF(Direction Régionale de l'Equipement d'Ile-de-France)

3. Imbalances between current housing supply and "fictive" demand which vary greatly within the Paris region and according to the segment of the housing stock

3.1. The spatial dimension of jobs-housing imbalances

The jobs-housing imbalances have a pronounced spatial dimension. The residential catchment area of the City of Paris has a widespread and large-scale shortage of the dwelling units that would be necessary for the households working there to live nearer their work: more than 65% of the households that would be relocated within this catchment area would be looking for types of housing with shortages in excess of 10% (Table 4). The housing supply deficits within a 30 minute commute for the municipalities in the inner suburbs[8] are considerable as 70% of households would be relocated to areas with a shortage of the desired type of dwelling unit. Nevertheless, fictive housing demand is better distributed between the different levels of deficit than is the case for the residential catchment area of the City of Paris. Outside the inner suburbs, the imbalances take the form of surpluses: 82% of the households relocated in the municipalities of the agglomerated outer suburbs[9] would be

[8] We define here the inner suburbs as the area corresponding to the '*petite couronne*' (small crown) of the parisian region. This area gathers a hundred boroughs located close to Paris intra-muros. *Cf.* map in annex.1.

[9] We define the agglomerated outer suburbs as the area corresponding to the part of the parisian '*grande couronne*' (big crown) that is within to the urban agglomeration of Paris. We define the periurban suburbs as the

reassigned to municipalities where current housing supply is greater than demand, this percentage rises to 97% for the municipalities in the urban periphery. We can conclude that the structure of the housing stock in Paris is responsible for the large commuting distances of a large part who work there and that the structure of the housing stock in the municipalities of the inner suburbs also contribute to this phenomenon. On the other hand, the structure of the housing stock in the municipalities in the outer suburbs does not.

We can therefore conclude, as readers will no doubt have already noticed, that the reduction in the commuting distances of households which live a long way from their place of work that we have simulated in the study involves 44% of households with at least one member working in Paris (334,000 demands for dwelling units out of the estimated 760,000) and 35% of households with at least one member working in the inner suburbs.

3.2. Jobs-housing imbalances according to segments of the housing stock

The jobs-housing imbalances are also distributed very unequally between the different types of dwelling unit. Among the shortage of 160,000-190,000 dwelling units, 28% are relevant to apartments belonging to the *social rented accommodation sector,* 44% are relevant to apartments belonging to the rented and private sector, 27% to apartments or houses in owning sector. As it should be a dwelling units shortage after housing re-assignment, there should be also a located dwelling units surplus : 50% of the surplus is relevant to individual house in owning. In the Parisian context, owning an individual house is probably a major source of long commuting distances but not the only one. In fact, in a less aggregated analysis on 18 types of dwelling unit (which on their own represent 93% of the total number of dwelling units in the Paris region), a high concentration of very marked shortages in housing supply (>20%) is apparent and affects only 3 segments of the housing stock (Annex 2) ; the 3 housing segments which exhibit the greatest deficits (>10%) are first large apartments (4 or 5 rooms) belonging to the social rented accommodation sector, followed by medium-sized dwelling units (between 1 and 3 rooms) belonging to the social rented and private sectors. For these types of dwelling unit, strong quantitative inadequations between housing current supply and demand might have stimulated long commuting distances generation. In case of the most other housing types, housing supply shortages are quite generalized but don't reach excessive levels.

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area corresponding to the part of the parisian '*grande couronne*' that is outside the urban agglomeration of Paris. *Cf.* map 1 in annex.

These observations lead us to conclude that the imbalances between current supply and fictive demand are specific to each segment of the housing stock, but that for most types of housing the imbalances appear to be not excessive and relatively uniform. The imbalance is very high for only three segments.

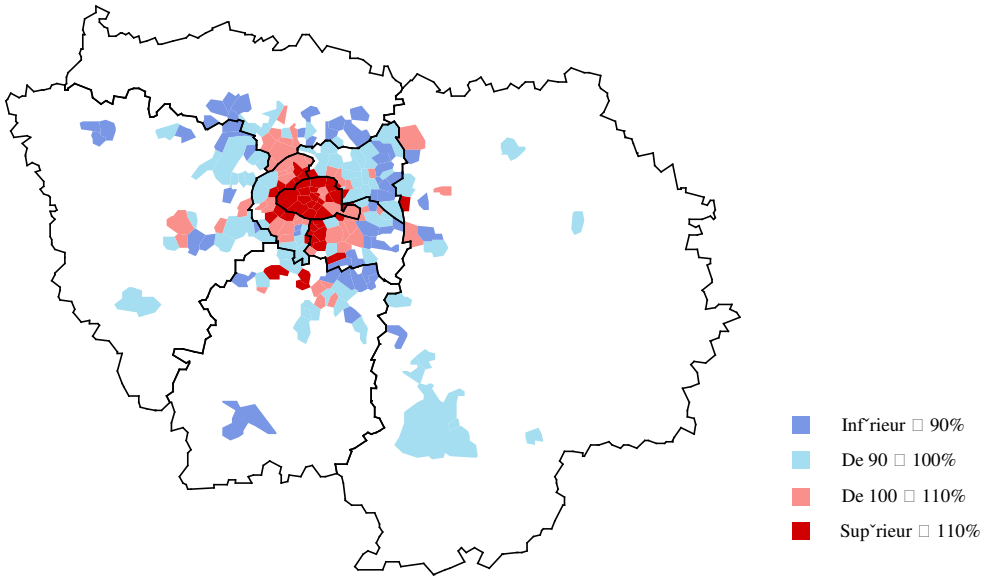
This brief survey raises important issues, particularly with regard to the imbalances that affect social housing, as this sector is the main segment of the housing stock on which local authorities can (or should) take action at the present time. Currently, 25% of the households which commute long distances (200,000 dwelling units) are in social housing of all types. If we consider this segment of the housing stock spatially, the shortage in social housing sector dwelling units is considerable in the city of Paris (18% of current supply or 35,000 dwelling units), while there is a surplus in most other administrative Departments that reaches 10% in the Départements of Yvelines and Val d'Oise (table 5 and figure 1). Given that households residing far from their workplaces and who are renters in the social sector represent 10% of car daily commuting distances, achieving for these people a better housing localisation through a specific housing policies could produce significant effects on car traffic.

Table 5 - Imbalances between fictive demand and current supply for social rented apartments

Administrative Departments of Parisian region	Fictive housing Demand	Current housing Supply	Imbalances demand In % of current housing supply
Paris Intra Muros	217,800	183,500	**+ 18,7**
Hauts-de-Seine	170,800	136,200	**+ 4,7**
Seine - Saint-Denis	177,100	183,300	- 3,4
Val-de-Marne	147,000	143,500	**+ 2,5**
Seine et Marne	75,000	79,600	- 5,9
Yvelines	91,800	100,300	- 8,5
Essonne	79,900	85,700	- 6,8
Val d'Oise	90,000	99,000	- 9,1

Sources: Figures calculated by the authors based on the 1999 General Population Census (INSEE) and the Travel Time Matrices produced by the DREIF(Direction Régionale de l'Equipement d'Ile-de-France)

Figure 1 :Imbalances between fictive demand and current supply for social rented apartments



Sources: Figures calculated by the authors based on the 1999 General Population Census (INSEE) and the Travel Time Matrices produced by the DREIF(Direction Régionale de l'Equipement d'Ile-de-France)

IV. CONCLUSION

This research examines the extent to which a qualitative and quantitative improvement in the jobs-housing balance in the different parts of the Parisian region could lead to a considerable reduction in car traffic. Making the explicit hypothesis that constraints exist within the housing market which affect the mismatch between the place of work and the place of residence of the working population, we investigate first the potential reduction in car travel distances that is provided by a re-assignment of households residing far from their workplace to a location closer to it. Second we examine more directly if the housing stock in the "residential catchment areas" of the different centres of employment is sufficient or not in quantity and quality to be able to take all the working households living a long way from their place. Therefore our work potentially allows to explore the "realism" of a way for more compact city.

From a methodological point of view, the re-assignment procedure we developed is not only innovative but heuristic with regard to our questions.

Our analysis shows that jobs-housing balancing for households with at least one member who is both in work and a long-distance commuter could lead to reductions in car commuting traffic included between 43% and 14%. While these results show the great sensitivity of the reduction in car commuting distances to the radius which defines the "residential catchment area" for reassigning households, we can nevertheless observe that even when the radius is relatively high (45 minutes by car or public transport), there should be still a substantial reduction in the distances travelled by car – particularly when we compare this reduction with the objectives that have been stated by the public authorities in various planning documents concerned with reducing car traffic (5%).

We also show that there are genuine spatial jobs' housing imbalances, both quantitative and qualitative, in the Paris region and that achieving jobs' housing balance is synonymous of housing shortages with regard to current housing supply in some central municipalities. If the housing shortages within a maximum thirty minute commute are very spatially concentrated, the housing shortages should be quite enough limited (between 4 – 5% of the regional current housing supply). That is a "good news" if one day we have to constrain the space occupancy to limit CO_2 emissions.

Still, housing supply shortages nearby job places are particularly high for the social rental sector, which concerns, among others, the poorest households. Given that households residing far from their workplaces and who are renters in the social sector represent 10% of car daily commuting distances, achieving for these people a better housing localisation through a specific housing policies could produce significant effects on car traffic. The quite enough limited housing shortages are social and spatial concentrated. Therefore one of the most important effect of achieving jobs' housing balance is to reduce the social segregation in inner Paris and in the department of Hauts de Seine. For example in inner Paris, achieving a jobs' housing balance should increase the part of the poorest workers (from 33% to 39%), the inhabitants density should increase about 3%.

The analyses in this paper have principally dealt with households and dwelling units within a 30 minute radius from the place of work. This radius was selected on an *a priori* basis, but seems to be reasonable for jobs-housing balancing in view of the current structure of the housing stock and the current location of jobs: although a large number of relocations would be necessary no massive restructuring of the housing stock would be required.

However, in terms of the reduction in car commuting distances and France's commitments under the Kyoto agreement, the outcome can seem somewhat limited. For jobs-housing balancing to lead to greater reductions in car traffic, the radius must be made smaller, with the likely consequence that the current housing stock would be found to be less adequate. The jobs-housing balancing that we have performed, which is based on a functional approach towards the city, encourages a debate (and research) that examines its potential contribution to sustainable development.

Further analysis are also required in order to clarify the causes of long commuting distances for those households for which the structure of housing would seem to encourage long commuting distances less. An exploratory comparative analysis of property prices in the area these households are currently residing and those in the area near their jobs allows us to some extent to separate those households which obtain cheaper housing by living a long way from their work ("economic distancing") from those which have more expensive housing by moving further away ("sociological distancing"). Although a full analysis has not yet been conducted, we can state at this stage that "economic distancing" behaviour is, in absolute terms, slightly more common than "sociological distancing" behaviour.

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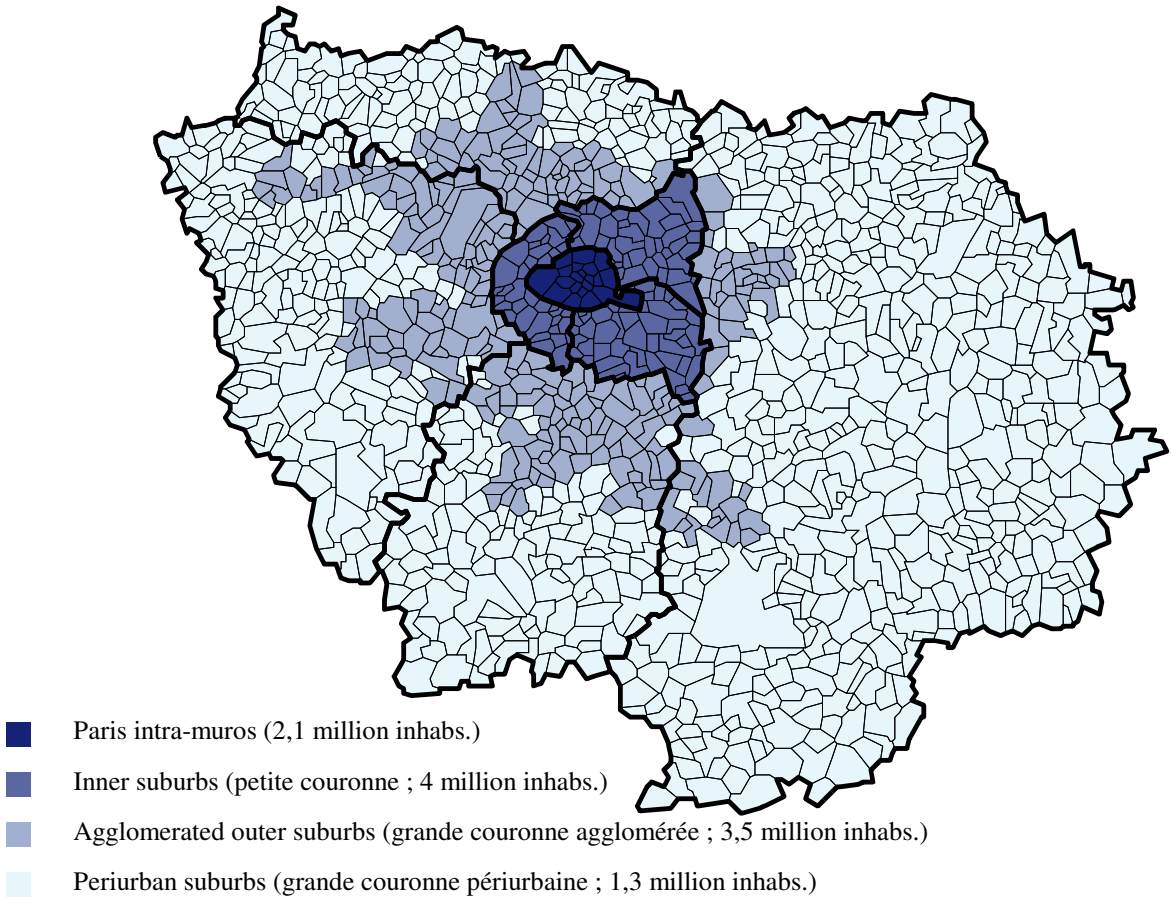
ANNEX 1

Map 1 – Parisian region : Paris intra-muros, inner-suburbs, agglomerated outer suburbs, and periurban suburbs (population in 1999)



ANNEX 2

Analysis of housing supply current deficits and surpluses within a 30 minute commute from the municipalities of work – by type of dwelling unit

Type of housing *k* (thousand dwelling units in the Paris region)	Distribution of the region's jobs between categories of municipalities according to the level of imbalance within a 30 minute commute for type of housing *k*					
	Cat. 5 – Deficit of more than 20%	Cat. 4 – Deficit of 10 - 20%	Cat. 3 – Deficit of 5 - 10%	Cat. 2 – Deficit of 0 - 5%	Cat. 1 – Surplus	Total
Apart-SocialR-3P (384.7)	**9.1**	**22.9**	17.6	14.9	35.5	100.0
Apart-PrivR-2P (354.0)	0.0	**30.4**	16.6	18.8	34.2	100.0
Apart-Owner-3P (302.1)	0.0	10.0	29.2	16.4	44.4	100.0
House-Owned-4P (300.5)	0.0	11.8	11.2	**26.4**	**50.6**	100.0
House-Owned-5P (296.9)	2.1	11.1	12.4	**19.2**	**55.2**	100.0
Apart-SocialR-4P (262.7)	**18.3**	**14.8**	19.3	15.4	32.2	100.0
House-Owned-6P (258.2)	2.1	12.8	9.1	**18.2**	**57.9**	100.0
Apart-PrivR-1P (254.3)	0.0	**26.6**	23.5	20.4	29.5	100.0
Apart-PrivR-3P (240.6)	1.5	**38.2**	11.8	11.4	37.1	100.0
Apart-Owned-4P (230.6)	0.0	**28.5**	18.9	13.4	39.3	100.0
Apart-SocialR-2P (218.4)	0.0	19.5	23.7	17.8	38.9	100.0
Apart-Owned-2P (209.8)	0.0	0.0	31.9	**15.0**	**53.1**	100.0
House-Owned-3P (163.1)	0.0	0.0	12.5	**32.9**	**54.5**	100.0
Apart-PrivR-4P (103.8)	**21.4**	**24.4**	7.3	11.0	35.9	100.0
Apart-Owned-5P (94.6)	**3.5**	**34.5**	9.7	8.2	44.2	100.0
Apart-SocialR-1P (71.4)	0.0	10.9	23.2	**28.9**	**37.1**	100.0
Apart-SocialR-5P (64.6)	**25.8**	**18.6**	8.4	13.0	34.3	100.0
Apart-Owned-1P (58.6)	0.0	5.0	25.9	**19.9**	**49.0**	100.0

Sources: 1999 General Population Survey – Institut National de Statistiques et d'Etudes Economiques (INSEE); The *Travel Time Matrices produced by the DREIF(Direction Régionale de l'Equipement d'Ile-de-France*
Each type of housing (*k*) is characterized by 3 criteria[2]: (i) type of dwelling unit, house [House] or apartment [Apart]; (ii) ownership status, owned [Owned]- Private Sector rented [PrivR]; Social rented [SocR]), and (iii) The size of the dwelling unit is measured by the number of rooms from one room [1R] to six or more rooms" [6R]
Interpretation: For three room apartments in the private rented sector (first line of the table), the municipalities where the supply of dwelling units that is necessary to satisfy fictive demand from relocated households is in excess of 20% of the current supply provide 9.1% of the region's jobs.