Deriving the number of jobs in proximity services from the number of inhabitants in French rural municipalities

Maxime Lenormand[1], Sylvie Huet[1] & Guillaume Deffuant[1]

Cemagref, LISC, 24 avenue des Landais, 63172 AUBIERE, France
(maxime.lenormand, sylvie.huet, guillaume.deffuant)@cemagref.fr

Abstract. We use a minimum requirement approach to derive the number of jobs of proximity services per inhabitant in a municipality from its number of inhabitants. We apply this approach to four different subsets of municipalities, each defined by a specific range of distance to the municipality where the inhabitants go the most frequently to get services (called MFM). For each subset, we get satisfactory results in regression. We observe that the minimum number of service jobs per inhabitant (interpreted as jobs of proximity services) is higher in the isolated municipalities (that are their own MFM) and lower in the municipalities located close to their MFM. When the distance to the MFM increases, we find that the number of jobs of proximity services per inhabitant first increases and then reaches a plateau.

1 Introduction

How many jobs in proximity services per inhabitant can be expected in a municipality of a given size? That is the problem we have to solve when developing the microsimulation model of the demography and job dynamics of the PRIMA European project (Huet and Deffuant, 2011)[1]. Indeed, this model assumes that a part of the jobs of a municipality is devoted to everyday or very frequently needs for services - these jobs are called proximity service jobs in the following. We assume therefore that this number of jobs is strongly determined by the population size of the considered municipality. Our aim is thus to find out a simple model predicting how the number of proximity services jobs per inhabitant varies with the population size. As the French Auvergne region is one of the case studies of our microsimulation model, we work with the French data. In our study we consider French municipalities with less than 5000 inhabitants (95% of French municipalities) since the PRIMA project is interested in rural areas.

In the framework of the Economic Base Theory, our aim consists in predicting the number of non-basic or non-export service jobs per inhabitant in a municipality from its number of inhabitants, that is the jobs which satisfy the needs of the local population of a municipality and are not concerned with outside demand. Except the survey method, three main simple indirect methods have been proposed in the literature to determine the weight of the export in the total employment of an area in a given industry: assignment, location quotient, minimum requirement (Weber et al., 1986). A review as (Isserman, 1980) lists these methods and also mentions

[1] The research leading to these results has received funding from the European Commission's 7th Framework Programme FP7/2007-2013 under grant agreement n 212345.

some econometric approaches based on Mathur and Rosen recommendations. It can be useful at this stage to remind that all these methods also determine the number of jobs dedicated to the local needs.

The Economic Base Theory assumes that the dynamism of the employment is mainly fed by the exports. However, this assumption does not match some observations. In particular, in the French rural areas, the employment has increased much more around than inside urban areas. It has also increased in isolated rural areas while they are far from an urban pole and do not benefit from industries or other in-good-health productive sector. New approaches based on the residential economy point out that the dynamism of the rural area is linked to the demand for locally consumed goods and services. (Talandier, 2008) even argues that the revenues of the population should be taken into account in the Economic Base Theory to describe properly the dynamism of the municipality. To summarise, it appears that some jobs depend more on the population than on the production sectors. That is the reason why we decide to consider the population size as the determinant of the employment for proximity services jobs.

The minimum requirement approach makes sense to predict the number of jobs in proximity services per inhabitant, because one can assume that the jobs devoted to the local needs will always be found close to the targeted population, hence generally in the considered municipality. The jobs above this minimum are generated by firms or administrations of higher than local level and in our microsimulation model the evolution of these jobs is ruled by scenarios predefined by the user.

The minimum requirement (Ullman and Dacey, 1960) is based on the notion that one can make a reasonably good estimate of employment for local consumption in any economic sector by comparing the region's share of employment with the minimum region of all the regions ranked in the same size class by shares of employment in the considered sector. Suppose for instance that the minimum is five percent of the jobs in manufacturing for a given region, this method assumes that all regions in that size class require a manufacturing sector which employs five percent of the total regional employment to produce manufactured goods for local consumption. Practically, one often establishes different minimum requirements for regions of different sizes because the minimum requirement is supposed to vary with the size of the considered economy. Hence, one defines different classes of size, each represented by its median value. Under these conditions, the number of minimum employment of a class of sizes can be accurately predicted using a generalized linear model $E = \beta_0 + \beta_1 \ln P + \epsilon$. This method has mainly been applied to compute the regional multipliers giving the propensity to consume locally produced goods (Woller and Parsons, 2002; Rutland and O'Hagan, 2007; Persky and Wiewel, 1994; Moore, 1975; English et al., 2000).

Our problem is a little bit different since we are only interested by the part of non-basic (local) jobs satisfying the ordinary needs of the residential population, i.e. we exclude the service for which it is acceptable to travel outside the municipality (hospital, university,...) and the services for businesses. We want to determine the number of jobs per inhabitant only in the proximity services sector. From the data about employment in the French tertiary sector corresponding to retail, transportations, various services, public administration, teaching, health and social action, we want to extract the number of jobs per inhabitant only dedicated to the satisfaction of the local residents. As already said, instead of looking at the minimum share of jobs for the sector in the municipality-size class, we are looking to the minimum number of jobs per inhabitant in each municipality-size class. In practice, as the observed data are only projections base of a sample representing a quarter of the population, we choose not to use the minimum but the first vigintile (20-quantile) to avoid problems due to possible outlier.

However, it is clear that the municipality size only is probably a bad predictor for the number of jobs in proximity services per inhabitant. Indeed, the French rural municipalities are close to each other; the average distance to their closest neighbour them is about 4 km. Hence people living in one municipality can satisfy a part of their proximity needs in a sufficiently close municipality. Thus the minimum is likely to be an underestimation of proximity services jobs per inhabitant. This weakness has been pointed out by (Pratt, 1968) and Ullman solved it by considering "only independent cities", thus putting apart the suburbs for example. But we would like our approach to work on all types of municipalities having less than 5000 inhabitants, hence this restriction is not appropriate for us.

To overcome this problem, we introduced a new variable: the average time to the most frequented surrounding municipality (MFM). The MFM is the municipality where residents from a given municipality usually go to consume services, leisure equipment and facilities. It can be a different municipality or the same one. We noted that this variable is significant for predicting the number of jobs in services per inhabitant in any municipality size class.

We separated the municipalities in groups classified by intervals of distance to the MFM, and we applied the minimum requirement approach to each group. With a set of four intervals, we obtain, for each interval, a satisfactory regression predicting the minimum number of job services per inhabitant. Moreover, the results correspond to one's expectations: the isolated municipalities (being their own most frequented municipality) have the highest number of proximity jobs per inhabitant. The municipalities which are close to a MFM have the lowest number of jobs in proximity services per inhabitant. Finally, when the distance to the MFM increases, the number of jobs in proximity services per inhabitant increases and reaches a plateau.

This work has been based on the data coming from the French Census of 1990, 1999 and 2006 managed by the French Statistical Institute, $INSEE$ and from the French Municipal Inventory of 1999. The variables of the Census are the *Number of inhabitants* and the *Number of jobs in the French tertiary sector* in 1990, 1999 and 2006. The variable of the Municipal Inventory is the MFM. The MFM of a given municipality is assumed to be the same in 1990 and 2006 that the one giving by the data of 1999. All this data is kindly made available by the *Maurice Halbwachs Center*. The next section presents the preliminary study showing the significance of the MFM for predicting the number of jobs in proximity services per inhabitant. Then we explain how we applied the minimum requirement method in classes of distance to MFM. We finally discuss our results.

2 Introducing a variable describing spatial interdependencies between the municipalities

In this section, we explain why we introduce the variable "time to the most frequented municipality". We start from a classification putting our municipalities in 10 clusters depending on their size in terms of inhabitants. We show that the variance in the number of jobs in the *tertiary sector* for each set of municipality can be explain by the the average time to go from the municipalities of a set to their most frequented municipality.

In the first step, we performed a $Hierarchical\ Ascendant\ Classification$ on the set of population sizes weighted with the $Ward$ distance :

$$d_W(A, B) = \sqrt{\frac{n_A n_B}{n(n_A + n_B)}} d(g_A, g_B) \tag{1}$$

with n_A and n_B the numbers of individuals in the cluster A et B, g_A and g_B their centers of gravity, and d the Euclidian distance.
This distance measures the increase of inter-cluster variance when merging two clusters, so we merge the two clusters which minimize this distance at every step of the algorithm. Using this distance maximizes the homogeneity of classes. We applied the classification method on the variable "Population in 1990", and we retained 10 clusters.

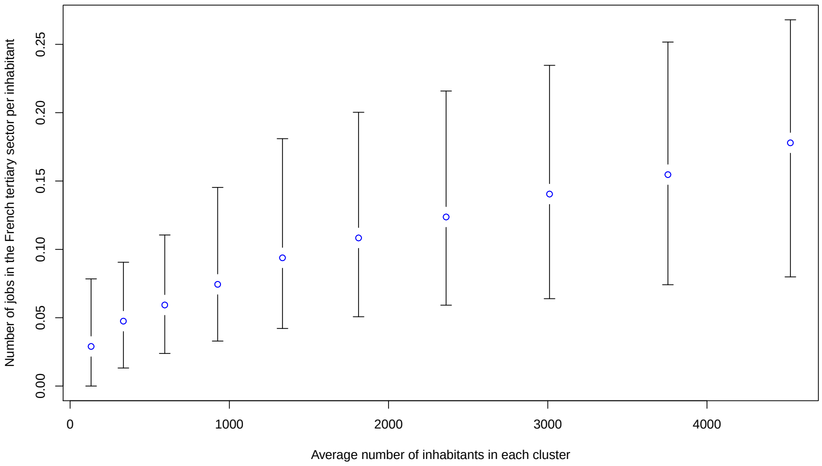

Fig. 1. Number of jobs in the French tertiary sector per inhabitant in term of the average number of inhabitants for each cluster; circles represent the median value of the number of jobs in services per inhabitant in each cluster and the confident interval is composed by the first and the ninth deciles

The figure 1 represents our municipality structure. The clusters of municipality-sizes are represented in x-axis through their average number of inhabitants. The y-axis is the number of jobs per inhabitant for each municipality of the cluster in the tertiary sector. We observe for each municipality-size cluster, the distribution of the number of jobs in services as a function of the mean number of inhabitants in the cluster with, represented by a circle, the value of the median and a confident interval composed by the first and the ninth decile. There is a clear dependence between the number of jobs and the mean number of inhabitants that we can fit through a generalized linear model. The Table 1 describes our municipality clusters with more details about the number of inhabitants and jobs.

We also observe a large discrepancy of the number of jobs per inhabitant in a given municipality-size cluster. Then we consider a new variable from the data of 1999 census: the average time to the most frequented surrounding municipality (MFM). Assuming a part of this variance can be explained by the distance of the municipality to its MFM where its residents can easily satisfy their needs. We test if there is a relation between the distance of the municipalities to their MFM and the number of jobs. If it is the case, the distance to the MFM should be taken into account to make a good estimate to the number of employments dedicated to the local residents services satisfaction. In each cluster, we test if the correlation coefficient is significantely different of 0. All the p-value are significant (see Table 1).

Table 1. Population cluster and proximity service jobs per inhabitant and the p-value of the relation to the distance to the MFM

Population mean	**Cluster length**	**Job services p.i. median**	**Job services p.i. min**	**Job services p.i. max**	**p-value**
131.73	12571	0.0290	0	4.2025	0
334.40	8170	0.0475	0	4.3682	0
594.28	5087	0.0593	0.0168	6.4323	0
926.61	3123	0.0744	0.0258	1.4342	0
1333.76	1884	0.0938	0.0340	1.4288	0
1811.62	1288	0.1084	0.0409	17.0166	0.0276
2361.52	882	0.1237	0.0510	1.6220	0
3011.08	691	0.1405	0.0544	7.6829	0
3754.56	430	0.1547	0.0647	0.6970	0
4523.89	365	0.1779	0.0688	0.9363	0

Our assumption about spatial interdependency is confirmed for the job in the tertiary sector. We assume this relation also exists for the subpart of jobs corresponding to the proximity service jobs. Indeed, a French family, to satisfy an ordinary need as bread for example, can go to the next municipality which is very close on average, about 4 km. Then we can apply a particular derivation of the minimum requirement method to solve our problem. The next section gives details about this derivation taking into account the distance to the MFM.

3 Assessing the number of jobs of proximity services per inhabitant for different types of municipalities

The significant role of the distance to the most frequented municipality is taken into account by considering several sets of municipalities corresponding to sets of values of MFM. In the following, we chose four sets (values expressed in minutes): $MFM = 0$, $0 < MFM \leq 5$, $5 < MFM \leq 10$, $MFM > 10$. In each set, we performed a hierarchical ascendant classification as the one described in the previous section. Each set is composed from clusters of city-size.

Within a cluster, we assume that a given quantile corresponds to the number of jobs per inhabitant satisfying the local resident needs for proximity services, and we associate it with the mean population of the cluster.

Let E be the number of jobs per inhabitant corresponding to the minimum or a chosen quantile and P the mean number of inhabitants in the cluster. We consider the following GLM:

$$E = \beta_0 + \beta_1 \ln P + \epsilon$$

where β_0 and β_1 are parameters and ϵ the residual vector. We determine β_0 and β_1 with the *Ordinary Least Square* method.

For each set, we perform a regression predicting the first vigintile (20-quantile) of the number of jobs per inhabitant with the average population of the cluster. Indeed, in this case, as the observed data are only projections base of a sample representing a quarter of the population, we choose not to use the minimum but the first vigintile. The parameter values of the function for each set are presented in the Table 2. The adjusted R-Squared are quite satisfactory and give confidence in the model. Figure 2

Table 2. Parameter values of the GLM predicting the number of jobs per inhabitant satisfying the local resident needs for service depending on the distance to the MFM for municipalities having less than 5000 inhabitants

Distance to MFM (in min)	Intercept	Slope	Adjusted R-Squared
0	-0.170901146	0.033121263	0.94
$]0, 5]$	-0.130158882	0.025111874	0.99
$]5, 10]$	-0.141049558	0.026983278	0.98
> 10	-0.162030187	0.031165605	0.97

shows the relation given by the model for 1990 comparing the observed data (circles) to the model data (line). As we can see in the graph, we obtained a really good fit of the model for each MFM cluster. To determine if the relation in each MFM cluster is time invariant we repeated the complete procedure in 1999 and 2006. The Figure 3 and 4 present the comparison for the 1999 and 2006 observed data to the model obtained with the data of 1990 in each MFM cluster. As we can see in these graphs the relations seem to be time invariant.

The Tables 3, 4, 5 and 6 present the characteristic of each cluster of each set of municipalities and the observed versus the estimated vigintile representing the number of job in the service sector satisfying the local resident needs for 1990. Figure 5 shows the error detail. The median errors varies from 4 to 11 %. The larger relative prediction error is 25 %. For the objective value 0 for which it is not possible to compute a relative error, the maximum absolute error is 0.0082.

The model shows an interesting relation between the distance to the MFM and the number of proximity service jobs per inhabitant. Figure 6 illustrates this relation for three different sizes of municipalities (500, 1000 and 3000 inhabitants). One can see that the number of jobs per inhabitant is higher for time 0 to MFM and decreases for $\leq$ 5 minutes to MFM, then increases the time MFM $\leq$ 10 minutes and reaches a plateau at a time $>$ 10 minutes. Indeed, we also studied the two subsets of municipalities situated at $>$ 15 minutes to the MFM and we observed that the number of jobs per

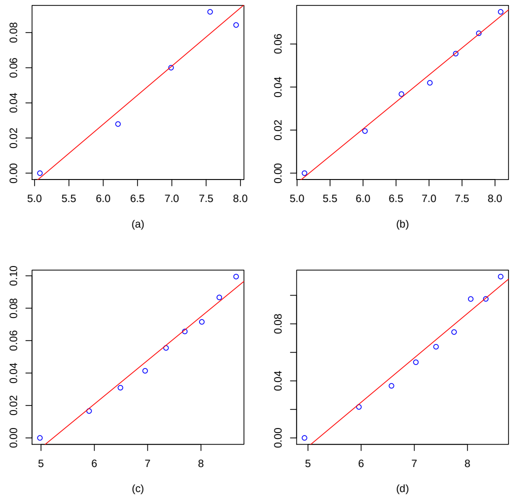

Fig. 2. Evolution of the minimum of the number of jobs in proximity services per inhabitant in term of the average number of inhabitants by population cluster for each MFM cluster in 1990; (a) $MFM = 0$; (b) $0 < MFM \leq 5$; (c) $5 < MFM \leq 10$; (d) $MFM > 10$

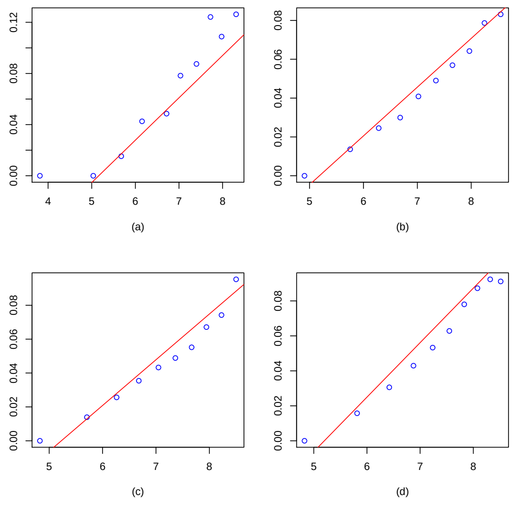

Fig. 3. Evolution of the minimum of the number of jobs in proximity services per inhabitant in term of the average number of inhabitants by population cluster for each MFM cluster in 1999; (a) $MFM = 0$; (b) $0 < MFM \leq 5$; (c) $5 < MFM \leq 10$; (d) $MFM > 10$

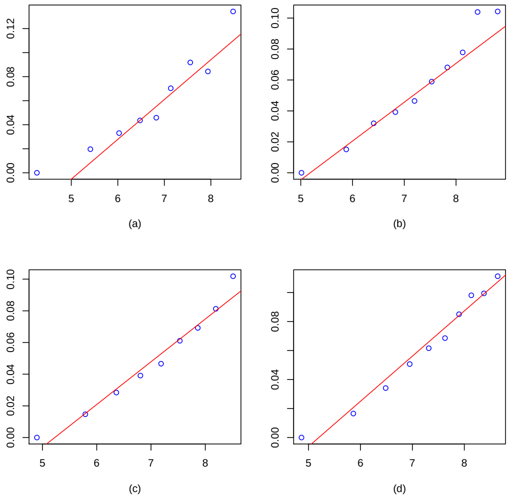

Fig. 4. Evolution of the minimum of the number of jobs in proximity services in term per inhabitant of the average number of inhabitants by population cluster for each MFM cluster in 2006; (a) $MFM = 0$; (b) $0 < MFM \leq 5$; (c) $5 < MFM \leq 10$; (d) $MFM > 10$

Table 3. Table giving the characteristics of the municipalities having a distance to MFM = 0 in terms of proximity service jobs per inhabitant (p.i.)

Cluster	Average number of inhabitants	STD number of inhabitants	Number of munici-palities	Jobs p.i. 1^{st} vigintile (Observed)	Jobs p.i. 1^{st} vigintile (Estimated)
1	160.32	89.60	41	0	-0.0027
2	500.32	129.64	22	0.0280	0.0350
3	1083.96	189.57	25	0.0600	0.0606
4	1915.46	210.96	13	0.0918	0.0794
5	2798.00	334.47	16	0.0843	0.0920

Table 4. Table giving the characteristics of the municipalities having a distance to MFM =]0,5] in terms of proximity service jobs per inhabitant (p.i.)

Cluster	Average number of inhabitants	STD number of inhabitants	Number of munici-palities	Jobs p.i. 1^{st} vigintile (Observed)	Jobs p.i. 1^{st} vigintile (Estimated)
1	166.08	69.80	2668	0	-0.0018
2	415.22	80.43	1845	0.0196	0.0212
3	721.73	98.27	1100	0.0367	0.0351
4	1110.57	131.78	660	0.0420	0.0459
5	1643.05	170.29	385	0.0555	0.0558
6	2331.39	226.60	249	0.0650	0.0646
7	3247.64	277.66	177	0.0749	0.0729

Table 5. Table giving the characteristics of the municipalities having a distance to MFM =]5,10] in terms of proximity service jobs per inhabitant (p.i.)

Cluster	Average number of inhabitants	STD number of inhabitants	Number of munici-palities	Jobs p.i. 1^{st} vigintile (Observed)	Jobs p.i. 1^{st} vigintile (Estimated)
1	145.38	62.27	4742	0	-0.0067
2	365.74	72.97	3171	0.0166	0.0182
3	658.01	97.77	2031	0.0310	0.0341
4	1045.74	126.25	1169	0.0414	0.0466
5	1547.60	165.31	712	0.0555	0.0571
6	2201.60	213.82	424	0.0657	0.0666
7	3029.82	287.78	252	0.0716	0.0753
8	4204.47	381.93	172	0.0867	0.0841
9	5759.88	1815.39	57	0.0995	0.0926

Table 6. Table giving the characteristics of the municipalities having a distance to MFM > 10 in terms of proximity service jobs per inhabitant (p.i.)

Cluster	Average number of inhabitants	STD number of inhabitants	Number of munici-palities	Jobs p.i. 1^{st} vigintile (Observed)	Jobs p.i. 1^{st} vigintile (Estimated)
1	139.00	65.20	5525	0	-0.0082
2	386.88	82.72	3058	0.0217	0.0237
3	713.80	105.22	1865	0.0365	0.0427
4	1129.58	133.11	1234	0.0531	0.0571
5	1650.07	168.33	850	0.0639	0.0689
6	2316.64	224.02	633	0.0742	0.0794
7	3169.97	266.20	474	0.0974	0.0892
8	4207.90	336.32	321	0.0975	0.0980
9	5568.02	659.41	130	0.1131	0.1068

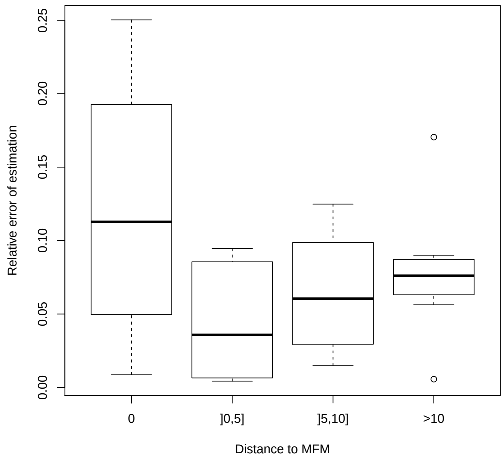

Fig. 5. Error of prediction of the number of proximity services jobs per inhabitant ($\frac{|Observed-Simulated|}{Observed}$). The large black line is the median while the box goes from the first quartile to the third quartile of the error distribution. The length of the horizontal line goes from the first decile to the nineteenth one. Circles represents the value above the nineteenth decile.

inhabitant does not continue to increase with the distance to the MFM (not presented in the figures).

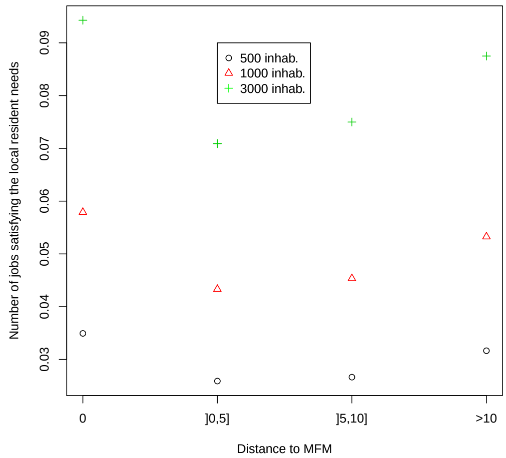

Fig. 6. Number of jobs per inhabitant satisfying the local resident needs (ordinate) of municipalities having 500, 1000 or 3000 situated at a distance to the MFM of 0, ≤ 5, ≤ 10, > 10

4 Discussion

Starting from the postulates of the residential economy, we assume it is possible to derive the number of proximity services jobs per inhabitant in Auvergne municipalities, using the principles of the minimum requirement approach. We consider indeed that proximity service jobs per inhabitant are driven by the presence of the population rather than by businesses. We proposed a Generalized Linear Model (GLM) built on data associating the average value of population of a municipality size class with the minimum number of jobs in the service sector per inhabitant for the class. Practically, instead of using the minimum, we use the first vingitile since the precision of the data is not so high (they are projection of a quarter sample). To take into account the dependence of the municipalities, especially to possible offers of services in close by municipalities, we build such a GLM for four different subgroups of French municipalities. Each subset is defined by a range of time to most frequently visited municipality (from 0 to higher than 10 minutes). The most frequently visited municipality is likely to offer proximity services to people visiting it, hence this variable provides important information about the likelihood that jobs of proximity services are located in an other municipality.

The model gives us quite accurate prediction of the first vingitile (median error varies from 4 to 11 %). The results correspond to one's expectations: the isolated municipalities (being their own most frequented municipality) have the highest number of proximity jobs per inhabitant. The municipalities which are close to a MFM have the lowest number of jobs in proximity services per inhabitant. Finally, when the municipality gets further from the MFM, its number of jobs in proximity services per inhabitant increases and reaches a plateau.

Moreover, we observed that the relation is stable in time. We could have certainly made a much more complex model, considering for example the interesting hypothesis on the local dynamics from (Talandier, 2008) with a decomposition of the residential economy based on the number of retired persons, the number of commuters and the tourists for example but it was not our aim at this stage. On the other hand, some researches try to better understand the interactions between the population and the employment on the economic growth: does it come more from employment or population presence (Boarnet et al., 2003; Hoogstra et al., 2005). Here also, we make the choice of simplicity to begin our microsimulation study. Our result appears as a good compromise to be included in the microsimulation model that motivated our work: its accuracy appears satisfactory and it remains relatively simple with an almost direct relation between the municipality population size and the number of jobs satisfying the local resident needs.

Bibliography

Boarnet, M., Chalermpong, S., and Geho, I. (2003). Specification issues in models of population and employment growth. *Unpublished manuscript. Irvine, California: Department of Urban and Regional Planning, University of California, Irvine.*

Brodsky, H. and Sarfaty, D. E. (1977). Measuring the urban economic base in a developing country. *Land Economics*, 53:445–454.

Dissart, J.-C., Aubert, F., and Truchet, S. (2009). An estimation of tourism dependence in french rural areas. In Matias A., Sarmento M., N. P., editor, *Advances in Modern Tourism Research II*, chapter 17. Springer.

English, D., Marcouiller, D., and Cordell, H. (2000). Tourism dependence in rural america: Estimates and effects. *Society & Natural Resources*, 13(3):185–202.

Hoogstra, G., Florax, R., and van Dijk, J. (2005). Do "jobs follow people" or "people follow jobs"? a meta-analysis of carlino-mills studiess. *ERSA Congress Amsterdam*, page 25.

Huet, S. and Deffuant, G. (2011). An abstract modelling framework implemented through a data-driven approach to study the impact of policies at the municipality level. *ESSA 2011 Conference, september 2011*, page 22.

Isserman, A. (1980). Estimating export activity in a regional economy: a theoritical and empirical analysis of alternative methods. *International Regional Science Review*, 5(2):155–184.

Moore, C. L. (1975). A new look at the minimum requirements approach to regional economic analysis. *Economic Geography*, 51(4):pp. 350–356.

Persky, J. and Wiewel, W. (1994). The growing localness of the global city. *Economic Geography*, 70(2):129–143.

Pratt, R. (1968). An appraisal of the minimum requirements technique. *Economic geography*, 44:177–224.

Rutland, T. and O'Hagan, S. (2007). The growing localness of the canadian city, or, on the continued (ir)relevance of economic base theory. *Local Economy*, 22(2):163–185.

Talandier, M. (2008). Une autre géographie du dveloppement rural : une approche par les revenus. *Géocarrefour*, 83-4:259–267.

Tiebout, C. (1962). *The Community Economic Base.* Committee for Economic Development.

Ullman, E. and Dacey, M. (1960). The minimum requirement approach to the urban economic base. *Papers and Proceedings of the Regional Science Assn.*, 6:192.

Weber, B., Smith, S., Faas, R., and Smith, G. (1986). Understanding your local economy. Economic base analysis and local development strategies. *Community Economics*, January(WRDC 29):12.

Woller, G. and Parsons, R. (2002). Assessing the community economic impact of nongovernmental development organizations. *Nonprofit and Voluntary Sector Quarterly*, 31(3):419–428.