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Insularity and Urban Hierarchies: the Case of La Reunion

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Insularity and Urban Hierarchies :
The case of La Reunion

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Introduction

Modern urban landscapes are characterized by the progressive separation of the location of jobs, houses and amenities, which inexorably leads to the increase of urban travel and transit. This is the beginning point for some recent research programs in regional economics which adopt a new line of reasoning based on the study of the commuting trips that characterise contemporary urban life. Different aspects of these trips, such as the volume, the pathways and the travel modes of the commuters, are examined with regard to mass transport (Pugh, 1998; Mignot, 1999; Zénou, 2000), local public services (Glaezer, Kolko and Saiz, 2002; Gaschet and Lacour, 2004) and the increasing diversification of rural and urban amenities (Brueckner, 2000; Glaezer, Kolko and Saiz, 2002). This allows one to explore some original aspects of the recent transformations in both modern cities organisation and regional urban hierarchies and identify institutional and policy responses to new urban problems such as traffic congestion (Fujita and Thisse, 2003) or residential segregation (Brueckner, Thisse and Zenou, 2002; Mauer and Ott, 1999).

Despite their strongly heterogeneous nature, these research programs seem to agree, from both a theoretical and methodological point of view, that the great complexity and interdependence of the forces influencing the firms and households' choices of localisation make it difficult to reach hasty conclusions about a spatial behaviour model, as recommended by the micro-economic foundations of some new popular spatial theories. Instead of trying to define a general households' residential model, it seems then more appropriate to investigate the relationship between a given urban organisation and its regional macro-economic environment (Gabaix, 1999; Axtell and Florida, 2000). This point of view defends the hypothesis of a principle of structural dependence involving the action of long-term macroeconomic effects on the puzzling geometry of an urban economy (Marsili and Zhang, 1998; Simpson, 2000).

This type of research has so far mainly concerned European and North American urbanisation. This paper aims to apply it to peripheral and insular regions. By studying the case of Reunion, a French overseas department with 750,000 inhabitants, it intends to assess the impact of insularity on the development of a regional urban hierarchy and stress its

consequences on the commuting patterns which characterise heavy traffic congestion between the island's various urban and economic centres.

In the first part of the paper, we present a simple rank-size model, applied to the study of Reunion's urban hierarchy in order to measure the 'tensions' and interactions between its different urban and economic centres. In the second part, we highlight the structural effects connected to insularity, which, in Reunion, strongly influence the spatial organisation of cities, the firms and households' localisation as well as the commuting transit.

I. Urban hierarchies in Reunion Island

A. Reunion's urban infrastructure according to a rank-size rule

Zipf's law (1949) was the first stylised representation of the 'urban mystery' which, according to Krugman (1996), describes the self-organisation of the geography of urban agglomerations and the spatial distribution of households and activities¹. This law introduces a log-linear relationship between the size T_i of a town and its rank R_i such as :

$$R_i^q \cdot T_i = C_0 \Leftrightarrow T_i = C_0 \cdot R_i^{-q}$$

where C_0 is a constant and $q > 0$ is a hierarchy index. When $q > 1$, the agglomeration effect is strengthened and large towns take on a greater importance than they should. Conversely, if $q < 1$, there is a poly-centric space in which several urban centres of roughly equal size co-exist (Suire, 2002).

Even if, originally, Zipf's stylised construction was intended to describe urban geometry in the European and North American continents ($q=1$), some recent studies (Makse *et al*, 1995) have shown that the rank-size rule is also applicable to smaller levels of aggregation, such as regions or counties. Following on from this work, therefore, we aim to investigate the rank-size relationship of the Reunion island², despite the small sample size available to us (24 towns).

¹ For a literature review of the many applications of Zipf's law, see Carroll, 1982; Suh, 1987; Glaeser *et al*, 1995; Le Bras, 2000; Dobkins and Ioannides, 2001; Gabaix and Ioannides, 2004; Henderson and Thisse, 2004).

² On average, the population of the *communes* in Reunion is 17 times that of French mainland *communes*. The Reunion *department* is the only French *department*, apart from the ones of the *Ile-de France* (Paris, Seine Saint Denis and Val de Marne), which has no *commune* with less than 2000 inhabitants (INSEE, 1999).

Map 1: The Reunion island

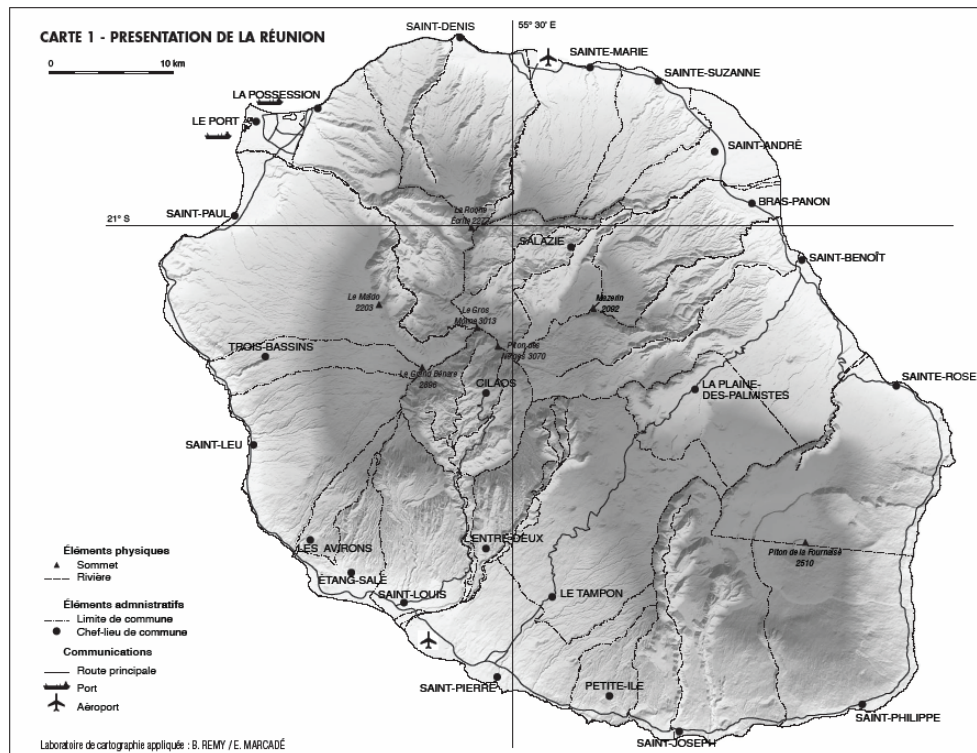
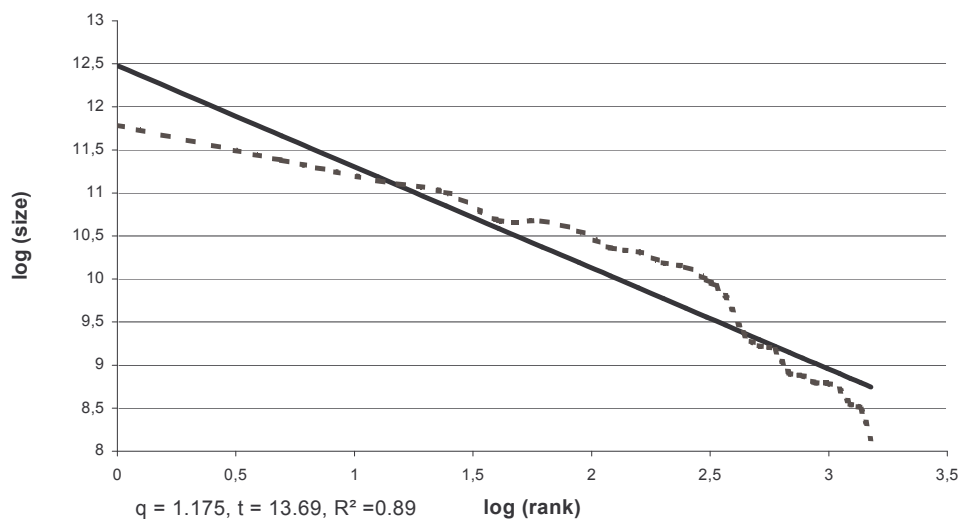


Chart 1 shows that Reunion's urban infrastructure has a fairly strong hierarchy ($q=1.17$); indeed, 50% of the population live in towns of over 50,000 inhabitants, whereas for the other overseas *departments* the figure is 21%, with 23% for mainland France.

Chart 1: Distribution of 24 towns in Reunion Island according to a rank-size rule, in 1999



This chart shows that below a certain threshold (for small to moderate sized towns), the discrepancy between observation and the Zipf distribution is quite significant. According to Gabaix (1999), this is because in general, the variance of urban growth is greater in small towns than in large agglomerations. This would confirm the hypothesis of a certain inertia slowing both migration behaviour and relocation, which decreases as the size of the urban units diminishes (Ioannides and Overman, 2003; Suire, 2002).

Such an interpretation seems plausible in Reunion, where between 1990 and 1999 the average peripheral towns featured quite varied annual population growth rates (3.3% in La Possession, Etang-Salé and Sainte Marie, 1.8% in St.Joseph, St.Louis and St.Benoît), unlike the bigger economic agglomerations which featured smaller but comparatively homogeneous rates (1,2% in St.Denis, Le Port and St Pierre). This divergence in growth for the small agglomerations leads, inevitably, to a temporal instability in the slope (Brakman *et al*, 1999). In the case of Reunion, the slope has tended to increase over the last twenty years (q equalled 1.18 in 1990 and 1.22 in 1982), which expresses a weakening in the agglomeration effect.

B. A model of social gravitation based on commuting trips in Reunion Island

To understand Reunion's urban geometry, from the point of view of a rank-size rule, one must study the 'tensions' between the various towns. These tensions, measured by the daily flow of exchanges and commuting trips, are studied in some social gravitation models, initially built by Stewart and Reilly (1949). Based on Newtonian mechanics, these models emphasise the attraction effects of the various urban centres, as a function of their size and the distance between them (Le Bras, 2000).

In the case of Reunion, it seems appropriate to apply a model which allows the evaluation of the interactions between two towns i and j , through the calculation of the daily commuting trips F_{ij} :

$$F_{ij} = (P_i \cdot P_j)^k \cdot (g + D_{ij})^{-b}$$

where P_i and P_j are the active working populations in the two respective towns, g corresponds to intra-communal transit, D_{ij} is the distance between the two towns, k is a measure of the active population and b measures the 'curbing effect' of distance.

The choice of such a model is justified by the fact that 55,000 people, that is one third of the active working population in Reunion, have to leave their *commune* each morning to go to work³, and because managing this growing mobility is the greatest challenge in transport infrastructure facing local authorities today.

Table 1 gives the results of a theoretical approximation of the flows F_{ij}^* which would be observed if they only depended on the active populations in the towns, which expresses their capacities to ‘generate’ and to ‘receive’ urban transit, and the distances between them. Calculated using a sample of 276 daily interactions between the various *communes*⁴, this approximation reveals the importance of distance ($b = 1.56$) in determining commuting mobility in Reunion Island.

Table 1: Approximation of daily commuting journeys in Reunion using a gravitation model

Parameters	Values
k	1.01 (20.84)
b	1.56 (20.45)
R ² adj	0.82
F-Ratio	429.6
DW	1.77

The variables are in logarithmic form. Between brackets, the Student test statistics (significance level at 5%).

Chart 2 shows the relationship between intensity of exchange and distance in Reunion. The curve representing the cumulative theoretical distributions (for all locations) is compared to that for the three economic centres of the island, namely St. Denis, Le Port and St. Pierre, which account for more than 75% of trips (coming and going) recorded in the island.

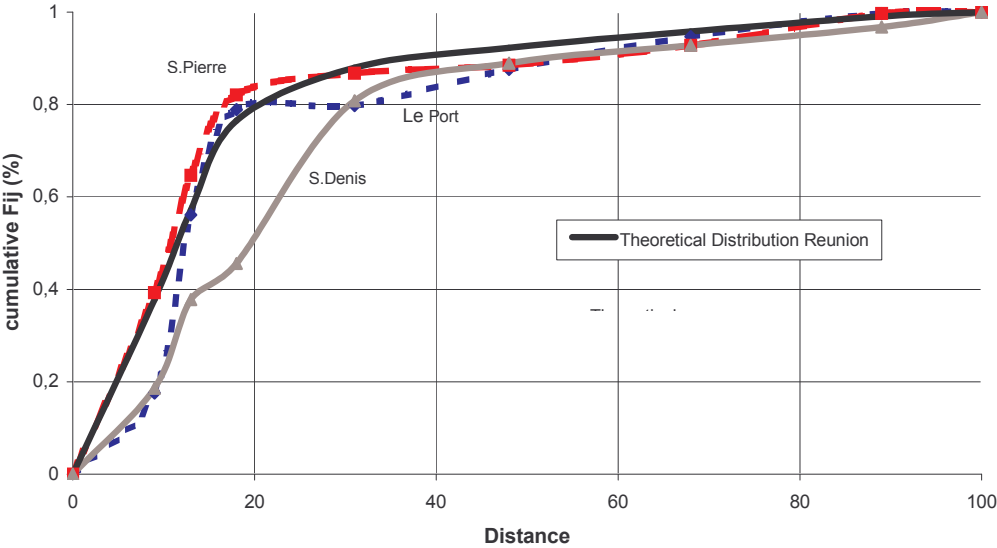
The convergence between the theoretical distribution for the whole of Reunion and the empirical observations for the towns of St. Pierre and Le Port, confirms that the attraction and/or interaction threshold between two towns is generally at 20 km. Above this distance, the daily mobility between towns becomes much less significant. Only the administrative capital,

³ In terms of distance covered, these trips are even longer, because the average *commune* in Reunion is eight times larger than its equivalent in mainland France (104 km² compared to 15 km²), which means that even trips within the *commune* can be long.

⁴ As an example, all the commuting trips between St. Paul and St. Denis are counted as a single trip, regardless of the direction.

St. Denis, which exerts multi-faceted attractions on the population, breaks the rule, pushing the limit to 30 km.

Chart 2 : Cumulative frequency of commuting travel



The residues of the spatial interaction model allow us to spot which part of the migratory flows is due neither to the dissuasive effect of distance, nor to the importance of the ‘home’ and ‘destination’ locations. The residues are positive when the flows observed are greater than the approximated flows, and thus correspond to a migratory preference. On the other hand, if the observed flows are lower than the theoretical ones, the negative residues bear witness to barrier effects between the towns.

In this respect, the Reunion space exhibits a distinct asymmetry : the residues are in general negative between the capital St. Denis and the *communes* of the West and North-West. However, this is the region where traffic congestion is higher within the whole island. This result is related to the atypical proximity of St. Denis, which is the island’s administrative centre, and the town of Le Port, its economic centre. During rush hours, two different types of commuters share the same highway, blue collars getting to the Port and white collars going in or out of St. Denis. Insularity seems to be one of the main reasons of such an atypical proximity between two organically independent economic centres.

2. How insularity affects Reunion's urban organisation

Three factors specific to insularity seem to play an important role in the spatial distribution of activities and in the firms and households' choices of localisation: the distance from world markets, the small scale of the local economy and the specific localisation of amenities and public equipment.

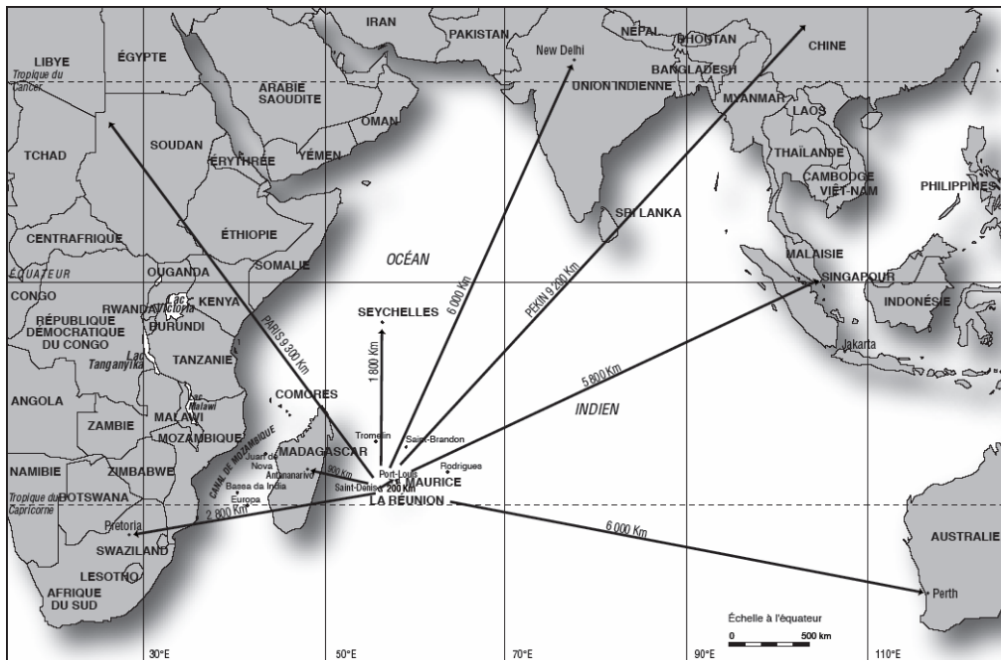
A. The distance from world markets and its consequences for the location of economic activities

The first and most important characteristic of insular and ultra-peripheral regions is the great distance which separates them from world markets and alters both the nature of economic exchanges and human mobility. The relative geographical isolation of these regions means access is an important issue, which explains the great dependence of production activity on maritime and air transport (Péraldi, 2002; Levratto, 2002; Dimou, 2004). This dependence has a fundamental effect on the spatial distribution of firms and industrial activities, because it makes them tend to collect around airport zones where, along with all the activities directly linked to air and sea transport, there is a concentration of all the logistical services for stocking, treating and distributing goods.

Because of the distance involved and its relative isolation, the Reunion Island is very dependent on its import/export activities, as evidenced by the volume (the openness ratio of the economy is 0.43) and above all the structure (the ratio of exports to imports is 0.11) of its external trade. Despite this dependence, the island is endowed with only one commercial port (Le Port) through which practically all goods have to pass, and, until quite recently, only one airport, on the outskirts of St. Denis⁵. This strongly influences the locality of firms and production activities.

⁵ A second airport was opened in 2000, at St. Pierre in the south of the island, but its scope remains limited.

Map 2: Reunion Island in the world



There are three main centres of economic activities and sources of employment: in the North, the town of Le Port, where locates the main harbour and the transit, treatment, stocking and distribution infrastructure for goods, and St. Denis, the island’s capital, home to numerous government offices; in the South, St. Pierre, home to many medium sized companies and craftsmen specialising in food processing and building industries. Today, 75% of the island’s active population live in the surrounding areas for these three economic centres (50% of Reunion’s households are located in the northern suburbs areas centred on the cities of Le Port and St. Denis, and 25% in the southern suburbs areas around St. Pierre).

As one can see in the following table, during the last decade the attraction of these centres grew stronger, particularly in the case of Le Port, which saw the most spectacular development thanks to its near-monopoly of harbour facilities but also because of the introduction of a policy of advantageous land-rending rates for firms.

Table 2: Labour attraction rates
(base 100 - job attraction rate in Reunion in 1999)

<i>Commune</i>	1990	1999
Le Port	154.2	184.7
Saint Denis	119.4	123
Saint Pierre	134.2	138.7
Other communes	77.8	78.5

Source : Insee (1999)

The two towns in the northern catchment area are surrounded by a single ring of suburbs (La Possession, Ste Marie, Ste Suzanne)⁶, which has experienced strong demographic growth (at an annual average of 5%) over the last fifteen years. These suburbs are for the most part made up of blue collar workers' homes and households on average income (blue collar and other worker households account respectively for 30% and 20% of the 80000 inhabitants of these suburbs); their occupants commute daily into other *communes* to work, as one can see from table 2.

Table 3: Number of commuters (%) in each *commune*'s population

<i>Communes</i>	Number of people (%)
La Possession	70.6%
Sainte Suzanne	60.3%
Sainte Marie	59.7%
Etang-Salé	58.9%
Le Tampon	41.2%
Other <i>communes</i>	31.5%

Source : INSEE (1999)

The relative proximity of St. Denis and Le Port and the concentration of economic activity into the latter – strongly linked to Reunion's insular state – are the main reasons for the barrier effects which characterise exchanges and daily movements between the other towns and the ring of *communes* in the west and north-west of the island. Of course, this explanation on its own is insufficient to explain the evident asymmetry in the urban development between the western and eastern sides of the island, because the type and locality of amenities also play an important role. Nevertheless, it allows one to understand the geography of the congestion and traffic saturation of the road system which today appears to be a significant negative externality, as much for households as for firms.

B. The reduced dimension of the economy and the malfunctioning work market

A second characteristic of insular and ultra-peripheral spaces is the size of their market economies, which is determined by the reduced local market, the limited stock of human and natural resources, and an energy dependence on the exterior, all of which implies in a general way the lack of a 'critical mass' to undertake a process of sustainable development (Peron,

⁶This phenomenon also exists in the south (Etang-Salé, Le Tampon) but is less pronounced than in the north.

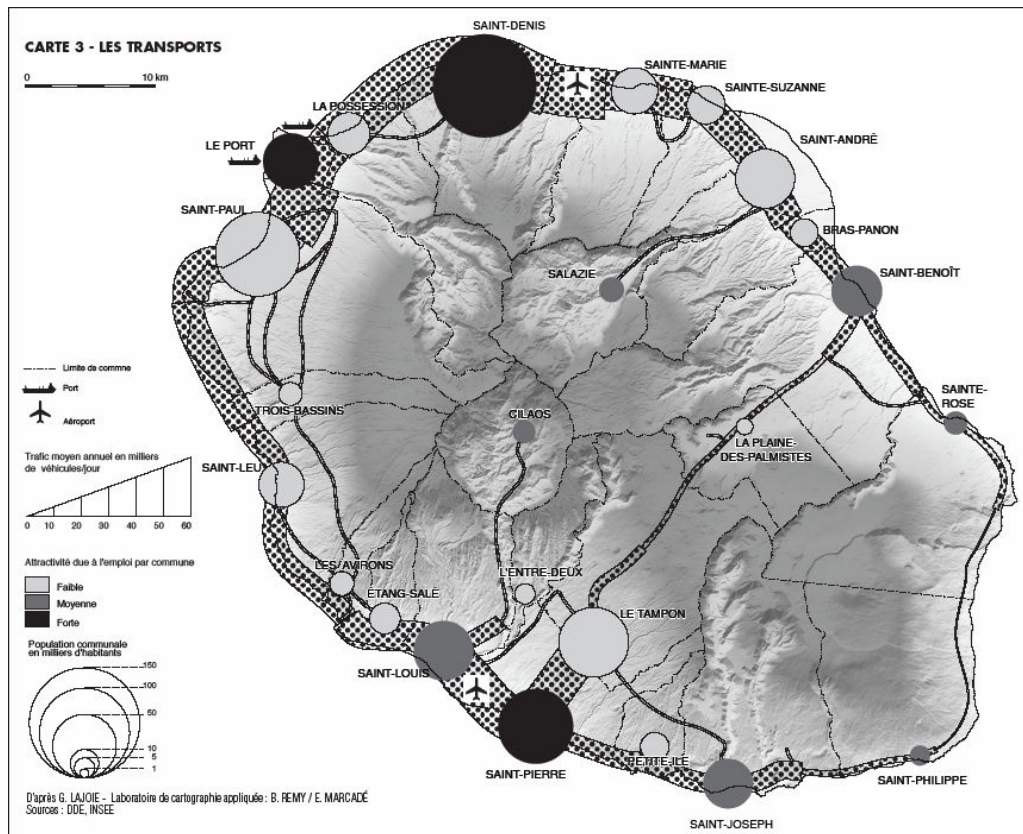
1993 ; Dimou, 2004). This dimensional aspect involves a structural mismatch between supply and demand for qualifications within a ‘fragmented’ local labour market, which exhibits a lack of specialisation, low confidence, lack of job security, an over-rigid system of work training, and resultant weakness in positive, financial or technological externalities.

At first sight, Reunion seems to have been spared this problem, because the island has enjoyed considerable economic growth: from 1982 to 2000, the annual growth in GDP by volume was 4.8% (Dimou, 2004b), a much higher rate of growth than in the majority of French mainland regions. However, this economic growth has been accompanied by several huge demographic changes: an annual population increase of about 2% and a massive influx of young people and women into the local labour market. Between 1990 and 1999, the number of jobs increased by 19%, which is roughly equal to the population increase in the same period. However, the active population increased by 39% over that period, which seriously affected the local labour market: in 1999 the number of unemployed, which had been going up steadily over the previous 20 years, exceeded 100,000 persons. This led to an unemployment rate of 41.6%, the highest within the European Union !

The huge unemployment which affects above all young job-seekers and the poorly qualified, is nevertheless not particularly due to the island’s demographic changes, but more to a mismatch in the labour market, as shown by the deterioration in the ratio of job seekers to job offers: as a percentage, this dropped to 22.5% in 1997 (Dimou, 2004b). The structural disparity between supply and demand where qualifications are concerned is a result of the reduced size of the local labour market (Brueckner, Thisse and Zénou, 2002; Ibourk and Perelman, 2001) which could be, in its turn, a consequence of insularity. It adds layers of complexity to the behaviour of the economic agents.

Firstly, in order to attract and keep qualified labour, firms in Reunion offer higher salaries than their equivalents in mainland France (in the private sector, the average salary in Reunion is 6000 euros higher than on the mainland). On the other hand, qualified workers are prepared to travel further to find work which exactly matches their qualifications and salary expectations. This leads to more, longer commuting trips: between 1990 and 1999, there was an increase of 3000 in the number of daily home/workplace journeys involving a change of *commune*, which greatly increased road use, as shown in map 2.

Map 3: Average daily traffic on Reunion's roads



Secondly, job seekers with poor qualifications are less inclined to travel to find work, in this imbalanced labour market dominated by demand, which leads not only to great disparity in the unemployment level between *communes* (in 2002, this was 30% in St. Denis but 54% in St. Louis!), but also to a residential segregation of the population according to qualifications rather than income.

C. The trade-off between urban amenities and tropical ones

A third characteristic of insular spaces concerns the type of amenities and local public works.

Firstly, the urban amenities, very limited, are here replaced by environmental attractions: the proximity of beaches, the natural environment or even the geography of natural risks. This modifies the purpose of the town centres, which do not attract (and never have attracted) much residential accommodation, unlike most European towns. Further, this lack of concentration in the town centres implies large urban sprawl, featuring a horizontal series of

rather inhomogeneous residential zones where dispersed settlements of detached houses predominate over collective, vertical ones.

In the case of Reunion, the great majority of administrative services are concentrated in St. Denis (as well as the University, which attracts over ten thousand people daily), and yet the town has a notable lack of the type of urban amenities one usually finds in town centres, be they cultural (theatres, cinemas, etc.) or commercial (pedestrian shopping areas), which explains the low residential population density.

In addition to this phenomenon, there is the importance of the natural amenities, certain of which are peculiar to a tropical environment, and this encourages many households to make a different residential choice. Among these natural amenities, two play a decisive role:

- The beaches and lagoons are to be found on the west coast of Reunion, in particular in St. Paul and Etang-Salé, whereas the rest of the coast in Reunion (the north and east of the island) is unsuitable for beach or nautical activities.
- The island's relief cuts it into two different climatic regions: the eastern side (which receives the prevailing winds), is wet and humid, and suffers most from bad tropical weather (cyclones, depressions etc.), whereas the western (leeward) side enjoys dry, sunny weather, sheltered from storms.

The positioning of these 'tropical amenities' results in a residential concentration in the west of the island (75% of the population), with households of average to high income in the seaside *communes* (St Paul, St Leu, and Etang-Salé).

Table 4 : Proportion of the population with high income in the seaside *communes*

<i>Commune</i>	<i>Proportion of executives and intermediary professions in the resident population</i>	<i>Professional mobility of this category of the population (% working out of the commune)</i>
Saint Paul	38%	46%
Etang-Salé	40%	90%
La Réunion	30%	40%

Table put together by the author. Database : INSEE (1999)

These households belong to socio-professional classes which feature a high mobility coefficient, and they contribute to the large flow of commuting journeys along Reunion’s western traffic artery.

Table 5: Mobility coefficient according to socio-professional class (Reunion – 2002)

MOBILITY COEFFICIENT	
Farmers	9.19%
Craftsmen, shopkeepers, company heads	17.08%
Executives and highly qualified professions	40.80%
Intermediary professions	40.79%
Employees	26.85%
Labourers	35.08%

Database : INSEE (1999)

The trade-off made by households between urban amenities and tropical ones leads to an urban sprawl in Reunion which exacerbates the road congestion through the interaction of three factors:

Firstly, this kind of urban sprawl, dominated by detached houses, is not conducive to the development of public transport, particularly given that the rugged relief of the island has prevented the island from developing alternative forms of public transport, such as trains or trams. Private cars are used for 90% of journeys, compared to only 5% for public transport⁷, and this is despite Reunion having a lower rate of household car ownership than on the mainland⁸. Thus, Reunion has the same average number of mechanized journeys per day (2.70) as Marseilles (2.69), Toulouse (2.75) or Bordeaux (2.88).

Secondly, despite the distance involved and the reduced scale of their economy, the occupants of these spaces naturally try to catch up with European ‘standards’ of income per person, access to public services, and improving standards of living and consumption (Dommen and Leballe, 1988). However, the indivisibility of local publicly-owned facilities, which are necessary to satisfy the basic needs of residents, can quickly lead to an inevitable and costly ‘infrastructural waste’ (Dimou, 2004). This waste occurs to a greater or lesser extent

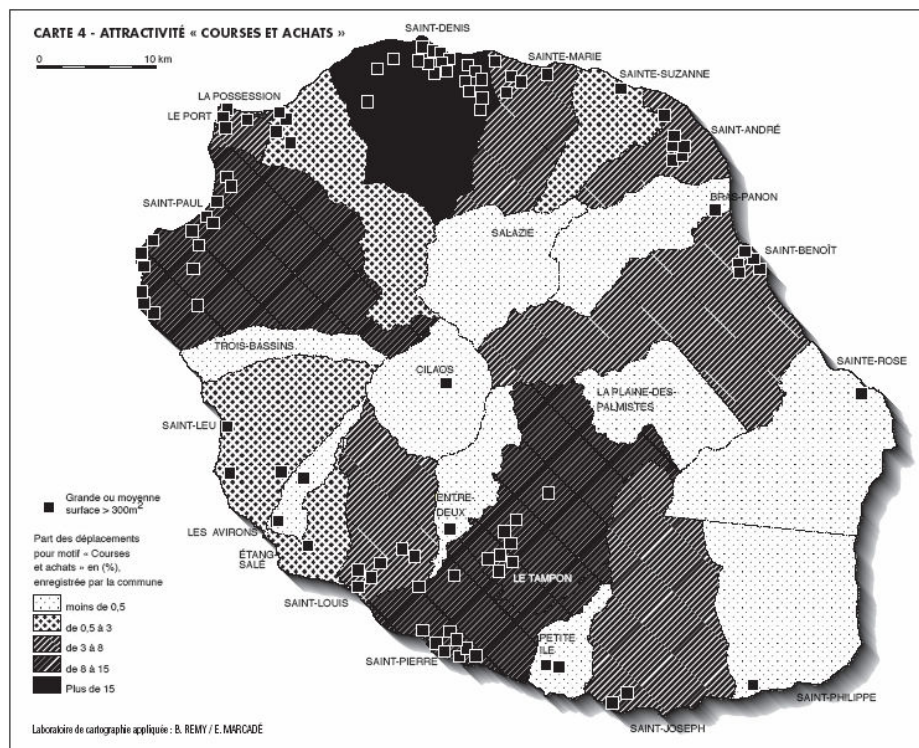
⁷ This imbalance is much less pronounced in mainland French regions, where the figures are 60% and 20% respectively.

⁸ 63% of households in Reunion have one car and 14% more than one, compared to 80% and 30% respectively in mainland France.

according to the choice of spatial distribution of facilities, a choice influenced more by policy decisions to harmonise the public services and treat users fairly, than by calculations of economic efficiency and profitability.

Thirdly, the locations of the shopping centres are influenced by the amount and direction of commuting journeys. Today, as can be seen from map 3, 65% of the large and medium-sized shopping centres are concentrated on the three main arteries used by workers: the north-west and north-east routes which connect St. Denis and Le Port to the residential *communes* of St. Paul, La Possession, St. Marie and St. Suzanne, and the southern artery between St. Pierre and Le Tampon. This new distribution of shopping centres reinforces, therefore, the traffic congestion around Reunion's three urban centres.

Map 4: Localities of medium and large supermarkets in 2002



The structural effects linked to insularity and ultra-peripherality improve our understanding of the characteristics of Reunion Island's urban hierarchy, as well as the differences in attraction exerted by the various towns, expressed by the volume and distance travelled in commuting journeys. Nevertheless, this explanation should not lead us to an hypothesis of uniform behaviour in choice of locality and household journeys, but rather should allow us to better understand the diversity of choices in a very specific regional context.

Conclusion

This analysis is a prerequisite for policy decisions concerning projects undertaken by local government over transport provision and infrastructure, aimed at reducing congestion and improving, in years to come, the accessibility of the island's zones. There is an urgent need for these projects, since demographic projections suggest that by 2025, Reunion's population will have reached one million, which will involve a doubling of the number of cars. However, the high or even prohibitive cost of these projects (the provisional budget of the planned work already stands at 1200 thousand million euros), and the doubts expressed over their effectiveness, have fuelled a lively debate, the result of which will affect the island's development for decades to come.

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RESUME

A travers l'examen du cas de l'île de La Réunion, ce papier propose de transposer les analyses contemporaines sur les hiérarchies urbaines et les lois rang-taille, jusque-là essentiellement réservées à l'étude des centres urbains européens et nord-américains, aux espaces ultra-périphériques et insulaires. L'hypothèse de base est que l'insularité a des effets-structure sur le comportement de localisation et de déplacement des ménages et par là-même sur la formation d'une hiérarchie urbaine régionale.

ABSTRACT

Through the study of Reunion Island, this paper aims to apply contemporary analysis on urban hierarchies and rank-size laws for cities to the case of peripheral and insular regions. This analysis had, until recently, only been applied to Central European and US regions. The main hypothesis is that the condition of insularity has structural effects on locational behaviour as well as on the mobility of households. It thus determines the regional urban hierarchy.