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CAN ISLANDS PROFIT FROM ECONOMIES OF DENSITY? AN APPLICATION TO THE RETAIL SECTOR

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Can islands profit from economies of density? An application to the retail sector ⋆

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This paper examines the additional costs borne by retailers whose strategy relies upon the exploitation of density economies when they decide to expand their network in an island. Insularity implies indeed being a non-connected node in the network, thus preventing economies of density to be entirely exploited. On this regard, such a discontinuity would entail lower profits due to a reduced efficiency in the distribution network. Starting from real data regarding an Italian large retailer, we evaluate the extent to which insularity represents a threat for the exploitation of economies of density by the retail industry. In this respect, the Italian peculiar geograph- ical configuration makes it an interesting case study. The main finding is that while stores located in the mainland are interested by a progressive reduction of transport costs, Sardinia, which is a remote island, is not interested by such a pattern. Indeed, a contiguous distribution network helps lowering distances covered to make deliveries, thus reducing the burden represented by distribution costs. On this regard, geographical permanent features connected to insularity- such as low accessibility and small size prevent retailers to expand their network in an island, thus lowering competition and affecting consumers welfare.

Keywords: insularity, economies of density, retail sector.

JEL Classification: R12, L10, L81.

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1 Introduction

In a network model based on the economies of density, creating a contiguous store network and maintaining a high store density implies savings in distribution costs, even if these savings may come at the cost of compromising existing stores sales. A retailer exploiting economies of density may achieve cost savings not only by increasing the number of stores, but also creating a contiguous network of stores, since locating stores close to one another and to the distribution centres leads to substantial savings in distribution costs. In such a framework, placing new stores in an island implies a ”jump” (i.e. a discontinuity in the network), that would entail lower profits due to a reduced efficiency in the distribution network. In this case, being an island implies being a non-connected node, thus preventing economies of density to be entirely exploited.

The aim of the paper is to provide an estimation of the additional costs related to insularity in the retail sector, showing that insularity represents indeed a threat for the exploitation of economies of density. On this regard, the novelty of the paper is twofold. Firstly, we explicitly consider the role played by insularity in the retail industry, showing its detrimental effects on transport costs and retailers' profit maximization. Secondly, to the best of our knowledge, this is the first attempt to analyse economies of density in the retail sector for the Italian case. Relying upon the approach followed by Holmes (2011)[2] relating to Wal-Mart chain stores, we provide an analysis of economies of density in the Italian context using data from the retailer Esselunga.

Esselunga is the fourth largest retailer in Italy, in terms of total sales, covering more than 8 percent of total sales in the Italian retail sector, Nielsen Italia (2013). In the time span we take into account (33 years, from 1980 to 2012) Esselunga opened stores in six Italian regions (Lombardy, Piedmont, Ligury, Tuscany, Veneto and Emilia-Romagna), and has three distribution centres, located in Lombardy (Pioltello), Tuscany (Sesto Fiorentino) and Piedmont (Biandrate), which opened in 1980, 1984 and 2007, respectively. The reason why we took Esselunga into account is because of its similarities with the US retailer Wal-Mart. First of all, Esselunga does not stock the merchandise in warehouses, but uses distribution centres (DCs, henceforth), which are distributed in the area where it operates, and make daily deliveries. The choice of a logistic system based upon DCs can be explained with the strategic choice of operating locally, close to the stores, thus responding quickly to changes in demand. More importantly, placing DCs close to stores lead to substantial savings on transport costs. Secondly, looking at its opening sequence, we notice that Esselunga located its stores close together and close to

[2] It is interesting to notice that Holmes studies Wal-Mart roll out in all US states except Hawaii and Alaska, which are an island and a peripheral region, respectively.

a distribution centre. When we look at Esselunga expansion over time, we can detect some similarities with Wal-Mart pattern. Unlike Wal-Mart, Esselunga "jumped" to a far-off location in 1984, when it opened its first store in Toscana. After that, Esselunga placed new stores close to those already existing. Moreover, the opening of a new DC in Piemonte, in 2007, led to a substantial reduction in average distance of stores in Piemonte which were previously served by a DC located in Lombardia. The average distance indeed decreased from 88 to 48 kilometres.

The different geographical configuration of Italy, as well as political constraints preventing Esselunga to open new stores below Emilia-Romagna[3] make the Italian case different from the US one. However, the Wal-Mart case give us a theoretical background that can be easily applied to the Italian case to study the extent to which insularity represents a threat for the exploitation of economies of density. Furthermore, Italy represents an interesting case study for two reasons. First, its territory spreads from the North to the South, thus allowing to take the role of peripheral areas into account. Moreover, it includes two islands: Sicily and Sardinia. The former is densely populated and close to the mainland whereas the latter is characterized by low population density and remoteness. To estimate the cost attributable to insularity in the retail sector, we proceeded in three steps. First of all, we used real data from the Esselunga stores, to derive the demand model and costs, estimating sales for the entire period Esselunga opened new stores. Second, we applied the demand model estimated in the first step to a hypothetical network that closely follows the economies of density. Finally, we show that, in a network that follows economies of density, while distribution costs for regions on the mainland decrease markedly over time, distribution costs on an island do not[4].

The rest of the paper is organized as follows. In Section 2, a brief literature review is provided. In Section 3, the Esselunga real network is described, as well as the hypothetical network underlying assumptions. Section 4 describes the costs, Esselunga's maximization problem, and the methodology used to measure the economies of density. Section 5 presents the results for Esselunga real and hypothetical network. In particular, the costs attributable to the insularity are described in this section. In Section

[3] Bernardo Caprotti, founder of Esselunga, in his book "Falce e carrello", claimed that the retailer Coop (a large Italian retailer) hinder Esselunga expansion in order to reduce competition (Caprotti, 2007).

[4] Even if the Wal-Mart case represent a benchmark throughout the paper, providing us with a theorethical model to study economies of density, we cannot follow Holmes (2011) closely due to data limitation. Esselunga has indeed over 140 stores and 3 distribution centres, spread in five Italian regions, while Wal-Mart placed 3,176 stores and 78 distribution centres over 50 US states. While this may represent a limitation of the present study on the methodological side, it does not weaken our results. Indeed, our aim is to provide qualitative analysis of economies of density (i.e. trade off between cannibalization and reduction of transport costs) in relation to insularity costs, rather than to replicate Holmes (2011).

6, the conclusions and some final policy considerations are drawn. Furthermore, a detailed appendix is provided, describing technical details of the demand model and the data used in our analysis.

2 Literature review

This paper stems from two key intuitions. On one hand, retailers such as Wal-Mart, exploiting economies of density, are able to maximise their profits, thus lowering prices and increasing consumers welfare. On the other hand, geography is crucial in determining the effectiveness of a strategy based upon economies of density. On this perspective, bad geography, in terms of remoteness and peripherality, increases transport costs, thus preventing economies of density to be properly exploited. Therefore, this paper draws upon two strands of literature. On one hand, it relates to the literature exploring the determinants of advantages and growth in the retail industry. On this regard, Holmes (2011) contribution regarding Wal-Mart location strategy represents a milestone. Wal-Mart opened new stores close to those already existent and to DCs, thus creating a contiguous retail network that radiates from the inside out. Holmes points out the existence of a trade-off between the benefits and costs of such a strategy. On one hand, a contiguous network allows stores to respond quickly to shocks in demand and to save on transport costs. On the other hand, keeping stores close together implies sales cannibalization. Being Wal-Mart logistic costs very secretive, Holmes uses a moment-inequality approach to infer the benefits of such a strategy, claiming that creating a contiguous network is a profit maximizing strategy. In other terms, following a strategy based on economies of density is the best possible choice: the cost reduction achieved by saving in transport costs more than compensates for the losses derived by cannibalization, thus allowing Wal-Mart to achieve the maximum possible profits.

Having a substantial competitive advantage with respect to its competitors and representing a giant in the US retail industry[5], Wal-Mart triggered a vast literature investigating its impact in the economic environment where it operates. Basker (2005), Basker and Noel (2009), Hausman and Leibtag (2007) show that when Wal-Mart opens new stores, average prices are lower. Moreover, Wal-Mart has been found increasing consumer surplus (Cleary and Lopez, 2008; Hausman and Leibtag, 2007) and containing inflation (Hausman and Leibtag, 2005). Finally, several papers show the impact of Wal-Mart on employment. Neumark et al. (2008) show that Wal-Mart affects county-level retail employment and earnings. Taking into account endogeneity of location and opening dates, they estimate that Wal-Mart store openings reduce employment in the retail sector by about 2.7 percent. Ellikson and Grieco (2013)

[5] According to McKinsey Global Institute, Wal-Mart alone is responsible for a large aggregate productivity gain realized over the past quarter century.

focusing on the grocery sector, use spatial data on grocery store sales, size and employment showing that Wal-Mart entry does not affect revenue or employment at grocery stores more than 2 miles away from the area where Wal-Mart is located.

Several papers analyzed as well entry decisions and localization choices in the retail industry by considering stores localization choices into account. Unlike Homes (2011), Jia (2008), Ellikson et al. (2013) and Nishida (2008), among others, consider retailers entry and localization decisions taking strategic interaction with competitors into account. Jia examines the strategic store placement of Wal-Mart and K-mart, allowing for non negative spillovers between stores belonging to the same chain. Nishida provides a model of spatial interaction, using data from a Japanese big retailer; however, she allows for a trade-off between the positive effects of density and the negative effects of cannibalization. Ellikson et al., departing from traditional profit-inequality approach of Pakes et al. (2006) and Bajari et al. (2007) allow for interaction among retailers in a high dimension network.

Even if Wal-Mart success has been imputed to several sources (the retail production function, economies of density, investment in information technology, management contiguity[6]) the exploitation of economies of density plays a key role. As pointed out by Holmes (2011) and Holmes and Lee (2012), economies of density cannot be disentangled from geography, since it is not only increasing the number of stores in a network that matters (i.e. economies of scale) but also their location. On this regards, as pointed out by Ellikson et al. (2013) the retail industry may take advantage of economies of density that may arise at global level (i.e. a more efficient logistic system) as well as at local level (sharing knowledge and pooling advertising resources).Therefore, this paper also relates to studies stressing the importance of geography in affecting firms performance. In particular, to our knowledge, this is the first paper which attempts to analyze the strategy of a retailer similar to Wal-Mart in Italy. Given the peculiarity of the Italian geographical configuration and the presence of peripherical and remote Southern regions as well as insular territories, this is an interesting case study.

Given the economic challenges faced by islands, investigating to what extent insularity represents a threat for retailers who base their strategy upon the exploitation of economies of density holds its own interest[7]. While the New Economic Geography[8] identifies trade costs as one of the key determinants of

[6] Neumark et al. (2008) point out that new employees are hired and trained at existing stores, and subsequently transferred to nearby stores once they open, thus allowing Wal-Mart to realize substantial savings.

[7] On this regard, no theoretical model explicitly tackles insularity, while empirical evidence about islands performance is fragmented and leads to conflicting results (Deidda, 2015).

[8] To the best of our knowledge there is no NEG model explicitly dealing with the economic implications of insularity, since standard economic models do not enable insularity to be disentangled from remoteness Deidda (2015).

the geographic shaping of economic activities, the geographical configuration has been identified as one of the main determinants of firm location and performance. On this regards, the recent contribution of Allen and Arkolakis (2014) emphasise the role of remoteness and thus trade (trade over space is costly), in determining disparities in economic development over time. They developed a model of economic geography which adds the geographic component where bilateral trade costs are derived as the accumulation of instantaneous trade costs over a surface- to the economic components (labor mobility, gravity, productivity and amenity spillovers). In particular, the authors emphasize the role of transportation networks by including topographical characteristics of a territory in the model, thus providing an empirically implementable framework to study the role of economic geography. Within a NEG framework, islands, like peripheral regions, do not occupy a central place within the trade network, being distant from the main population centres, thus hampering firms location. Moreover, remoteness in case of islands is exacerbated by physical discontinuity, which lead to economic exchange constrained to maritime and air transport, with consequences in terms of increased transport costs.

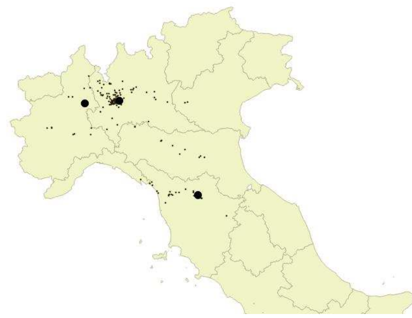
3 Esselunga Network

3.1 Real Network

As for the real network, we considered the diffusion of Esselunga during the period starting in 1980 and ending in 2012, thus running the network model for a period equal to 33 years. Using administrative data, we were indeed able to recover Esselunga stores and DCs opening sequence[9]. Esselunga opened its first stores in 1980 in Lombardia, placing 28 stores and one distribution center at Pioltello (province of Milan). In 1984, it spread in Tuscany, where it placed 12 stores and one distribution center at Sesto Fiorentino (FI). On average, it opened 3,6 store each year. Its third distribution center was opened in 2007, at Biandrate (province of Novara) in Piemonte. In total, Esselunga opened 141 stores and 3 distribution centers in the time span 1980-2012, placing stores in Lombardia, Toscana, Piemonte, Veneto, Emilia-Romagna and Liguria. Figures 1-**??** show Esselunga real diffusion. In particular, Figure 1 shows the stores and distribution centers present in Italy today. Figure 2(a) shows the stores and distribution centers present in 1980, and hence it shows the first stores and the first distribution center opened in Lombardia. Figure 2(b) shows the stores and distribution centers present in 1986. In this period new stores and a new distribution center were opened in Tuscany. Figures **??** and **??** go ahead

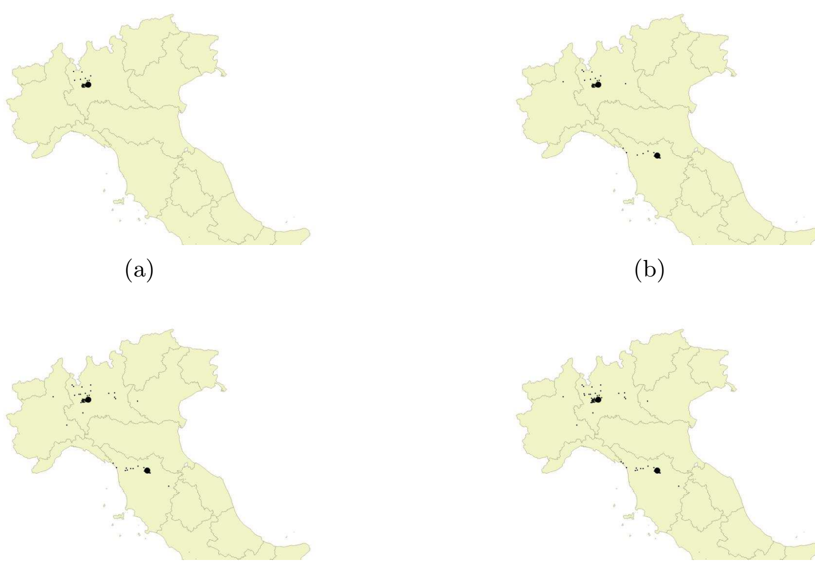
9 We use administrative data (”Visure storiche”)from the Chamber of Commerce of Milan. (Registro Imprese, 2014).

showing the Esselunga real diffusion from 1987 to 2012 in Lombardy, Tuscany, Piedmont, Ligury, Emilia-Romagna and Veneto.



(a)

Fig. 1: Real Esselunga store network.



(a) (b)

(c) (d)

Fig. 2: (a) Stores opened in 1980, (b) between 1983 and 1986, (c) between 1987 and 1991, and (d) between 1992 and 1995.

Figure 1 shows a network where the stores are packed closely together and are close to a distribution center. However, unlikely Wal-Mart, in 1984 Esselunga jumped to a far-off location, Toscana, where it

(a) (b) (c) (d)

Fig. 3: (a) Stores opened between 1996 and 2000, (b) between 2001 and 2004, (c) between 2005 and 2009, and (d) between 2010 and 2012.

placed 13 stores and one distribution center. Furthermore, the number of Wal-Mart's stores and the number of States where Wal-Mart's stores are located are higher than those of Esselunga[10].

Albeit similarities with Wal-Mart, Esselunga is not characterized by quantitative evidence supporting strong economies of density[11] (see section 5.1). In order to apply the Wal-mart model to the Italian case, estimating the costs attributable to insularity, we created an Esselunga hypothetical network which is heavily characterized by economies of density. This network, as well as the model proposed to analyze it, are described in detail in the next sections.

[10] Wal-Mart placed its stores over all US 50 states. Particularly, it opened 3,176 stores and 78 distribution centers over 35 years (from 1970 to 2005) Holmes (2011).Esselunga placed stores in only 6 Italian regions over a span of 33 years. Specifically, it placed 87 stores in Lombardia between 1980 and 2012; 29 stores in Toscana between 1984 and 2009; 12 stores in Piemonte between 1985 and 2012; 10 stores in Emilia between 2005 and 2007, 1 store in Liguria in 2006; and 2 stores in Veneto, one in 1988 and another in 2001.

[11] However, this does not prevent us to apply the Wal-Mart model to the Esselunga case. We chose the Italian retailer Esselunga for its logistic system. Indeed Esselunga, as Wal-Mart, does not stock the merchandise in warehouses, but uses DCs. In addition, as table 5 in the appendix shows, Esselunga's potential customers behave in a similar way to Wal-Mart ones. On this regard, we are allowed to use the demand parameters of the real network to a hypothetical one which follows economies of density. Therefore, we can assume that demand parameters can be used in an out of sample prediction of an hypothetical network. In such a network, the reduction of transport costs, as the network density increases, will mainly depend upon store and DC location.

3.2 Hypothetical Network

For symmetry with the real network, we studied the hypothetical diffusion of Esselunga over a span of further 33 years, from January 1st, 2013 to January 1st, 2045 assuming the opening of 127 stores and 3 distribution centers (see Appendix 7.2 for more details).

The hypothetical diffusion of Esselunga is shown in Figure 4. The *Real Esselunga Network* is represented by the big and small squares that model the distribution centers and the stores, respectively. Instead, the *Hypothetical Esselunga Network* is represented by the big and small circles that model the distribution centers and the stores, respectively.

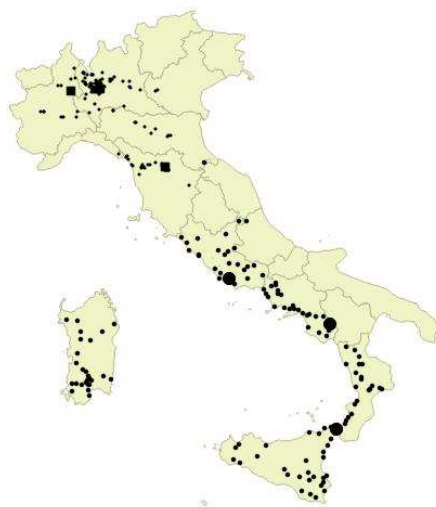


Fig. 4: *Real Esselunga Network* (big and small squares) and *Hypothetical Esselunga Network* (big and small circles).

We assume that Esselunga opens hypothetical stores in Calabria, Campania, Lazio, Sardinia and Sicily. Hypothetical DCs are instead opened in Calabria, Lazio and Sicily. Furthermore, we assume that, once a store or a distribution center is opened, it will never be closed.

As for the real network, on average each distribution center supplies about 40 stores. We assumed that a new distribution center is opened every seven years, after the opening of about 30 stores, and that each year four stores are opened. In order to allow for contiguity with the real network, the first distribution center opens in Lazio, the second in Campania, and the third in Sicily. It is worth noticing that choosing a contiguous network of DCs plays a key role in order to allow for the exploitation of economies of density.

In this hypothetical network the problem that Esselunga has to face is to decide which hypothetical stores need to be opened each year to maximize its profits, given the number, the locations and the opening dates of the real stores and of the real and hypothetical distribution centers as well as the number and the locations of the hypothetical stores. Specifically, the opening dates of the hypothetical stores - and thus the stores' opening sequence - are the solutions of the Esselunga's problem.

4 The proposed Model

Before defining the Esselunga's problem to solve, and hence the optimal opening sequence for the hypothetical stores, we need to define the cost components of Esselunga. Even if our analysis - aiming at estimating the additional costs attributable to insularity- focuses on distribution costs, we need also to define the other components of cost which enter in the Esselunga's problem affecting the Esselunga's profit.

4.1 Fixed and Variable Costs

Assuming that Esselunga made a single delivery run from the distribution center to each store each day, the distribution costs are defined as follows:

$$C_j^d(t) = \tau d_j(t). \tag{1}$$

where

- τ is the cost per kilometre per year of servicing the store j.
- $d_j(t)$ is the distance in kilometre from store j to the closest distribution center opened at time t.

Distribution costs are fixed costs, and hence they do not vary with the sales volume.

Let's consider now the variable costs. Labour costs, C_j^{lab}, vary with the sales volume and are defined as follows:

$$C_j^{lab}(t) = \nu^{Labor} * R_j(t) \tag{2}$$

where

- ν^{Labor} is labour cost coefficient of proportionality.
- $R_j(t)$ are the revenue of store j, at time t.

Intuitively, the larger the sales volume at a store j, the larger are the number of workers and thus labour cost.

Finally, the amortization costs, C_j^{am}, are defined by the following equation:

$$C_j^{am}(t) = \nu^{Am} R_j(t). \tag{3}$$

where

- ν^{Am} is amortization cost coefficient of proportionality.

The larger the sales volume at a store j, the greater are the parking lot and the required space, and consequently the greater the amortization costs.

Appendix 7.2 explains how the parameters τ, ν^{Labor} and ν^{Am} were computed.

4.2 Esselunga's Problem

Esselunga solves a maximization problem, as follows:

$$\sum_{t=T_{I,R}}^{t=T_H} \sum_{j \in B_t^{Ess}} [\mu R_j(t) - (C_j^{lab}(t) + C_j^{am}(t) + C_j^d(t))] +$$
$$\max_a \sum_{t=T_{I,H}}^{t=T_H} \sum_{j \in B_t^{Ess}} [\mu R_j(t) - (C_j^{lab}(t) + C_j^{am}(t) + C_j^d(t))] \tag{4}$$

where:

- a is the opening sequence, including the set of stores opened in each period t.
- $T_{I,R}$ is the initial time. It is the time in which Esselunga starts its real expansion. It is set to 1980.
- $T_{I,H}$ and T_H indicate the beginning and the end of the Esselunga hypothetical diffusion. The hypothetical diffusion goes from $T_{I,H} = 2013$ to $T_H = 2045$.
- B_t^{Ess} are the Esselunga stores present in the market at time t.
- $\mu R_j(t)$ is the *gross margin* of store j before accounting for distribution, amortizations, labour costs and taxes at time t.
-

$$R_j(t) = \sum_{l|l \in r_j, dist_{jl}<30, t_{O,j}<t_{O,j' \in l}} \lambda_l(t) * p_{j,l}(t) * n_l(t) \quad (5)$$

is the revenue of the store j at time t to which the consumers of the locations l can contribute. All consumers of the generic location l, that is distant from the store j less than 30 km[12] and that is located in the region, r_j, of the store j, can be potential consumers of store j when the store j' located in their municipality l is closed[13];

- λ_l represents the average spending per consumer;
- $p_{j,l}$ is the probability that a consumer located in municipality l buys from the Esselunga store j. It is calculated using the demand model (see Appendix 7.1);
- n_l is the number of potential consumers at location l;
- $\mu R_j(t) - [C_j^{lab}(t) + C_j^{am}(t)]$ indicates the operating profits.

4.3 A Measure of the Economies of Density

Economies of density lead to a reduction in the distribution costs. However, the benefits of cost savings come at the cost of a reduction of the operating profits of the existing stores, due to a cannibalization effect. If economies of density exist, the reduction in the distribution costs more than compensates the reduction of the operating profits.

To verify if this compensation exists, we divided the stores of the hypothetical network in three groups, g_1, g_2 and g_3, where each group of stores, g_h, is defined by Esselunga age at opening, age_o. Specifically, age_o, is defined as the number of years that Esselunga has been in a region since the first opening in that region (as in Holmes, 2011). According to this definition, in the first group there are the first stores in their respective regions, opened when Esselunga had been in their regions for a period not longer than 2 years. In the second group, there are the stores opened when Esselunga had been in their regions for a period between 3 and 5 years. Finally the third group contains the stores in their respective regions, opened when Esselunga had been in their regions for a period higher than 5 years.

We first computed the number of stores, N, for each group g_h. Then, for each group of stores, g_h, we split up the stores in the group on the basis of the region, r, where the stores are placed obtaining the sets called $g_{h,r}$ in the following. For each set $g_{h,r}$, we computed the average value, across the store new openings, of incremental sales, S_I, operating profit, P_O, incremental distribution center distance,

[12] $dist_{jl}$ is the distance in kilometre between store location j and location l.

[13] This is because, a consumer at location l usually buyes at a store located near her house rather than at more distant similar store. Note that, $t_{O,j} < t_{O,j' \in l}$ indicates that the opening date $t_{O,j}$ of store j is earlier with respect to that of the store j', $t_{O,j'}$.

D, stand-alone sales, S_I^{S-A}, and stand-alone operating profit, P_O^{S-A}. Finally, given the average values of these quantities for each region, we computed the regional average for each group g_h.

The incremental sales, S_I, and the operating profit, P_O, of all stores at each group g_h in their opening year, t_O, are computed according to the following equations:

$$S_I = \frac{1}{N_r} \sum_{r=1}^{r=N_r} \left\{ \frac{1}{N_{g_{h,r}}} \sum_{j \in g_{h,r}} R_j(t_O) \right\} \tag{6}$$

$$P_O = \frac{1}{N_r} \sum_{r=1}^{r=N_r} \left\{ \frac{1}{N_{g_{h,r}}} \sum_{j \in g_{h,r}} [R_j(t_O) - (\nu^{Labor} * R_j(t_O) + \nu^{Am} R_j(t_O))] \right\} \tag{7}$$

where $N_{g_{h,r}}$ is the total number of Esselunga stores in the group g_h and in the region r, N_r is the number of regions in the group g_h and R_j are the revenue computed following eq. 5. Namely, the incremental sales (operating profit) is what the store j adds to total Esselunga sales (profit) in its opening year.

Incremental distribution center distance, D, is defined by:

$$D = \frac{1}{N_r} \sum_{r=1}^{r=N_r} \left\{ \frac{1}{N_{g_{h,r}}} \sum_{j \in g_{h,r}} \min_i D_j(t_O) \right\} \tag{8}$$

where $\min_i D_j(t_O)$ defines the distance of the store j from the nearest distribution center opened at t_O.

Stand-alone sales, S_I^{S-A}, and stand-alone operating profit, P_O^{S-A}, of new store openings are defined as follows:

$$S_I^{SA} = \frac{1}{N_r} \sum_{r=1}^{r=N_r} \left\{ \frac{1}{N_{g_{h,r}}} \sum_{j \in g_{h,r}} R_j^{SA}(t_O) \right\} \tag{9}$$

$$P_O^{SA} = \frac{1}{N_r} \sum_{r=1}^{r=N_r} \left\{ \frac{1}{N_{g_{h,r}}} \sum_{j \in g_{h,r}} [R_j^{SA}(t_O) - (\nu^{Labor} * R_j^{SA}(t_O) + \nu^{Am} R_j^{SA}(t_O))] \right\} \tag{10}$$

where the revenue R_j^{SA} is calculated using eq. 5 assuming that the consumers distant from the store j less than 30 km can be potential consumers of store j also when the store located in their municipality is opened. Namely, they are defined as the sales (profits) that would be gained in a particular year for preexisting stores in a region if no new stores were opened in that year and in that region.

5 Esselunga and Economies of density

The model proposed was implemented in Smalltalk language and ran over a simulation period equal to 66 years, (given a simulation step equal to one year). The model defines a sequence of hypothetical store openings a, which solves the Esselunga's problem taking as given the opening dates of the real stores and DCs as well as those of the hypothetical DCs.

Given the enormous number of possible combinations of hypothetical store opening sequences, the model sets the sequence of regions where, year by year, Esselunga opens its hypothetical new stores. Hence, given a region to which a precise number of stores is associated, the new store openings are selected in random way.

Note that, according to what happens in reality, the stores placed in Tuscany and in Liguria refer to the DC in Tuscany, whereas all the remaining stores (real and hypothetical) refer to the nearest DC.

5.1 Real Network

First of all, we ran the model in order to demonstrate that the real network does not strongly benefit from the economies of density. Table 1 shows the number of Stores, N, and the average value of incremental sales, S_I, operating profit, P_O, incremental distribution center distance, D, stand-alone sales, S_I^{S-A}, and stand-alone operating profit, P_O^{S-A} of new store openings.

We compute these values averaging by three groups of stores, that - because of the different time configuration of the stores in the two networks - are defined in a different way with respect to the groups of the Esselunga hypothetical network.

The first group contains the first stores in their respective regions, opened when Esselunga had been in their regions for a period not longer than 10 years. In the second group, there are the stores opened when Esselunga has been in their regions for a period between 11 and 20 years. Finally in the third group, there are the stores in their respective regions, opened when Esselunga has been in their regions for more than 20 years.

In Table 1 no strong evidence of economies of density emerges. Indeed, in the cases of distribution chain characterized by economies of density the stores opened later should deliver lower operating profit, but they should be closer to a distribution center, and hence, should support lower distribution costs. Consequently, both the operating profit, P_O, and the incremental distribution center distance, D, should decrease while the network, and the density, is increasing. In Table 1 the incremental distribution center distance, D, decreases as we move down along the fifth column. Instead, the operating profit,

Table 1: Number of Stores, N, incremental sales, S_I, operating profit, P_O, incremental distribution center distance, D, stand-alone sales, S_I^{S-A}, and stand-alone operating profit, P_O^{S-A}, of new store openings for Esselunga real network. (Note S_I, P_O, S_I^{S-A}, and P_O^{S-A} are expressed in millions of euros, and D in kilometre.)

	N	S_I	P_O	D	S_I^{S-A}	P_O^{S-A}
All	141	6	1.04	87.67	8.3	1.45
$1 \leq Age_o \leq 10$	65	3.64	0.63	86.6	6.42	1.12
$11 \leq Age_o \leq 20$	30	11.1	1.93	75.8	11.2	1.94
$Age_o > 20$	46	8.76	1.52	50.4	9.3	1.62

P_O, increases as we move from the first group to the second group. So even if the distribution costs decrease, the magnitude of this decreasing is not enough to claim that the Esselunga real network is characterized by economies of density.

Finally it should be noted that, at least for the first 10 years, there is a big difference between stand-alone and incremental sales, implying a substantial degree of market overlap with existing stores. Indeed, for the first group, average stand-alone sales is about €6.42 million, compared to an incremental value of €3.64 million and for the second group it is about €11.2 million, compared to €11.1 million[14].

5.2 Hypothetical Network

Using the model described in Section 4, we were able to pick a sequence of hypothetical profit-maximizing store opening a (see Eq. 4). The sequence of store opening a chosen by the simulator, the *Hypothetical Scenario*, individuates a network which is strongly characterized by the economies of density.

This sequence defines a *Hypothetical Esselunga Network* that spreads from North to South and creates a contiguous network, opening new stores first in Lazio, then in Campania, Calabry, Sicily, and at last, in Sardinia (see Table 8). Starting from the real network, figures 5 - 6 show the hypothetical Esselunga diffusion from 2013 to 2045.

In the hypothetical network, the stores are closely packed together and Esselunga does not jump to a far-off region when it places new stores. It places its stores in a contiguous way, from Lazio to Sardegna, obtaining in this way higher profits thanks to lower distribution costs.

[14] Note that, we can access to only aggregate level data about Esselunga. In 2012 the total sales amount to 6,781 milions and labour costs to 779 milions. So, on average, in 2012 a Esselunga real store had an amount of sales equal to 48 milions and incurred labour costs equal to 5.5 milions. All the discrepancies between observed data and estimated data can be attributed to measurement error.

(a) (b)

Fig. 5: Stores opened from 1980 to 2019 (a) and from 1980 to 2026 (b), in *Hypothetical Scenario*.

(a) (b)

Fig. 6: Stores opened from 1980 to 2034 (a) and from 1980 to 2045 (b) in *Hypothetical Scenario*.

In Table 2, number of Stores, N, incremental sales, S_I, operating profit, P_O, incremental distribution center distance, D, stand-alone sales, S_I^{S-A}, and stand-alone operating profit, P_O^{S-A} of new store openings for this scenario are shown.

Table 2: Incremental sales, S_I, operating profit, P_O, incremental distribution center distance, D, stand-alone sales, S_I^{S-A}, and stand-alone operating profit, P_O^{S-A}, of new store openings for *Hypothetical Scenario*. (Note S_I, P_O, S_I^{S-A}, and P_O^{S-A} are expressed in thousands of euros, and D in kilometre.)

	N	S_I	P_O	D	S_I^{S-A}	P_O^{S-A}
All	127	492.78	85.74	290.48	525.61	91.45
$1 \leq Age_o \leq 2$	40	641.62	111.64	366.65	711.82	123.86
$3 \leq Age_o \leq 5$	60	469.69	81.72	266.59	483.52	84.13
$Age_o > 5$	27	277.28	48.25	239.64	285.93	49.75

We can note that, as we move down the table to stores opening later in a region (hence as the density increases), both the operating profit, P_O, and the incremental distribution center distance, D, decrease. So, the stores opened later deliver lower operating profit, but they are closer to a distribution center, and hence, support lower distribution costs. Given that the second effect compensates the first, Esselunga hypothetical network is characterized by economies of density. Indeed, as we move from the first group to the second group we have a reduction of the operating profit equal to €29.92 thousands and a reduction of the distribution costs equal to €280.66 thousands; as we move from the second group to the third group we have a reduction of the operating profit equal to €33.47 thousands and a reduction of the distribution costs equal to €75.57 thousands.

It's worth noticing that there is a small difference between stand-alone and incremental sales, implying a small degree of market overlap with existing stores. Average stand-alone sales is €0.49 million compared to an incremental value of €0.46 million, and a small degree of market overlap with existing stores emerges in each group[15].

5.3 Insularity Costs

Previous analysis leads to some useful implications as for the evaluation of additional costs of insularity. In presence of strong economies of density, the distribution network plays a key role, since maintaining the stores packed closely together and close to a distribution centre is crucial to save on transport costs. Intuitively, placing new stores in an island entails a higher cost burden- in terms of transportation costs- than placing these stores in a peninsular region.

In order to evaluate the convenience to open new stores in an island, and in particular in Sardinia, we evaluate distribution costs in four different years: $t = 2013$, $t = 2020$, $t = 2027$ and in $t = 2035$[16].

Table 3 shows the average distances between the stores and the nearest DC in each region[17]. Looking at Table 3 we can notice that the opening of new DCs decreases average distance for all regions but Sardinia. Consequently, in case of a production strongly characterized by economies of density, distribution costs are permanently higher for an island. On this regards, insularity implies

[15] This small degree of market overlap can be explained by the chosen store configuration and by the small number of stores. The assumption that only one store is located in each municipality strongly affects the degree of market overlap. By contrast, the real network shows a higher degree of market overlap (e.g. in Milano there are 26 stores).

[16] 2013 is the year we assume the hypothetical diffusion of Esselunga starts, while 2020, 2027 and 2035 are the opening years for DCs of Sala Consilina, Latina and Messina respectively. These are the years when the distance between store j and DC can vary.

[17] Sardinia can be reached to/from all its ports, so we can assume that all DCs are eligible to supply stores in Sardinia.

a discontinuity with respect to stores in the mainland, thus breaking the distribution network. In particular, we can notice that the reduction in the distance from DCs is huge in relatively central regions located in the mainland (ex. Lazio) as well as in peripheral regions (ex. Calabria). In Lazio, the average distance passes from 251.04 to 69.08, while in Calabria it reduces from 678.06 (2013) to 92.98 (2035).

We can notice as well important differences when looking at Sicily and Sardinia. They are both islands, albeit Sardinia is much more remote (i.e. located far off the mainland) and less connected with the mainland with respect to Sardinia. On this regards, while stores located in Sicily may benefit from distribution centres located in neighbouring regions by land transport, Sardinia is located far-off other regions and needs air or sea transport.

In addition, when considering only land transport, that is the usual mode of transport of Esselunga, a DC in an island only serves the stores which are located in that island, while DCs located in the mainland - albeit in a peripheral region- also serve stores in the other regions. This implies also a bigger market share for the stores in the mainland than that for the stores in a island. Consequently, for a retailer is always more convenient placing new stores and distribution centers to decrease the distribution costs in the mainland. Only when the market in the mainland is saturated the retailer will have convenience placing new stores and distribution centers in an island.

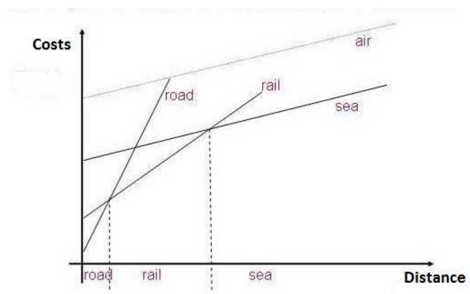
Table 3: Average of the distances, $\overline{d}(DCs)$, of the stores in a region from the nearest distribution centers, in km.

	$\overline{d}$ (DCs)			
Stores' Region	2013	2020	2027	2035
Calabria	678.065	392.385	162.612	92.9804
Campania	430.254	160.982	77.6825	77.6825
Lazio	251.04	69.7822	69.7822	69.7822
Sardinia	481.467	374.28	366.677	362.874
Sicilia	758.739	465.44	338.879	128.431

Not having access to confidential data on Esselunga logistics costs, in order to evaluate the distribution costs, we used the measure of cost per kilometre, τ, provided by Holmes (2011). As a result, τ does not allow a strictly accurate calculation of the distribution cost.

Table 4 shows the average of the distribution costs, $\overline{C}^d$, across all regions, showing that they decrease for all regions but Sardinia, as we move from the second column to the fifth column (and hence while

(a)



(b)

Fig. 7: Price Index (a) and Transport Costs(b). Source: Ufficio Studi Confcommercio (2014) (a); Mazzarino (1998)(b)

new DCs open over time)[18]. The average of these costs in 2035 across all regions, but Sardinia, is equal to €0.27 milions. Instead in the same year, in Sardinia, they are equal to €1.02 milions showing that, distribution costs in an island are substantial higher than those in the peninsular regions.

Table 4: Average of the distribution costs, $\overline{C}^d$, in each region over time, expressed in milions of euros.

	$\overline{C}^d$			
Stores' Region	2013	2020	2027	2035
Calabria	1.9	1.1	0.46	0.3
Campania	1.2	0.45	0.22	0.22
Lazio	0.7	0.2	0.2	0.2
Sardinia	1.35	1.05	1.03	1.02
Sicilia	2.13	1.3	0.95	0.36

[18] $\overline{C}^d$ are computed as the average of the distance, $\overline{d}(DCs)$, multiplied by the parameter τ, which is equal to 2.805 thousand of euros per kilometre per year.

In addition, transport cost estimated for Sardinia might be downward biased given the costs of sea or air transport are always higher than those of land transport. Figure 7 (a) shows how different modes of transport are charachterized by different trends and how the price index for sea transport is always higher than for land transport. Figure 7 (b) shows how the choice about the most suitable mode of transport depends on distance and on the quantities being transported. For example, for distances of 500 to 700km, the most convenient mode of transport is by land Mazzarino (1998). The model deals with distances between stores and the distribution centres within this range. Consequently, the value of τ proposed by Holmes represents, to some extent, a lower bound of cost per kilometres and our evaluation of transport cost might be downward biased. The proposed approach thus represents a good starting point that can be easily modified once the Italian value for τ is known.

6 Conclusions

The US retailer Wal-Mart is considered one of the top retailers in the US for its supply chain management practices, which give it a key competitive advantage that has enabled Wal-Mart to achieve leadership in the retail industry, increase operational efficiency and focus on customer needs. Wal-Mart benefits from a logistic system based on economies of density. Creating a continuous store network and a pattern of distribution centres, that can easily supply stores, allows a retailer to reduce delivery distances, lower transportation costs and respond quickly to shortages in demand.

Using the Wal-Mart logistic system as a reference, we analysed the extent to which economies of density are affected by insularity and its implied land discontinuity. Exploiting the similarities between Wal-Mart and the Italian retailer Esselunga we were able to provide a qualitative and quantitative explanation of the additional costs that being an island implies for a big retailer. First, we calibrated the demand and the problem faced by Esselunga using real data from the retailer. Second, we used the model developed in the first step to develop a hypothetical diffusion scenario. Our analysis shows that a hypothetical retail network of stores and distribution centres created as a profit-maximizing opening sequence follows the economies of density. A distribution network where stores are close together and new stores are located near distribution centres reduces distances for deliveries and transport costs, therefore resulting in higher profits. In such a scenario, insularity - implying land discontinuity - prevents a retailer from exploiting fully the economies of density. Indeed, while stores on the mainland would show a progressive reduction of distribution costs, Sardinia is not involved in such a pattern.

This analysis suggests some interesting policy implications, showing that being insular implies additional costs (besides those associated to remoteness) for businesses that exploit economies of density. Being a non-connected node prevents a distribution chain such as the retailer Esselunga from fully exploiting the benefits of economies of density, significantly affecting profitability and, in turn, the consumers welfare. However, island discontinuity with respect to the mainland cannot be eliminated, but only offset with adequate policy interventions. On this regard, a policy maker who wants to mitigate islands' disadvantage should put into practice interventions that would allow islands to compensate for being a non-connected node, thus allowing retailers to expand their distribution network in a island, and consumers to benefit from lower prices that would arise if a retailer similar to Wal-Mart comes to an island. With this in mind, policymakers should promote interventions to minimise the disadvantage faced by islands in this respect. In particular, they should thus focus on an improvement of the transportation and distribution network, with qualitative (i.e. increasing efficiency of routes) and quantitative (i.e. subsidization of transport costs) interventions that would help islands to offset distance and discontinuity with respect to the mainland, thus reducing overall transport costs.

7 Appendix

7.1 Demand Estimation

Following standard literature, we used a discrete choice approach to estimate demand, assuming that a consumer has two choices: buying from Esselunga, or buying from competitors located in the same municipality.

Particularly, we assumed that a consumer living in municipality l can choose between buying at Esselunga store j or buying from another store (the "outside option")[19].

The utility of buying from Esselunga store j, located in municipality l, following Holmes (2011), can be formalized as follows:

$$U_{jl} = -h(density_l)(dist_{lj}) + (StoreChar_j)\gamma + \epsilon_j \tag{11}$$

and, as in Holmes (2011)

[19] We assumed no heterogeneity among Esselunga competitors.

$$h(density_l) = \xi_0 + \xi_1 ln(density_l) \tag{12}$$

where:

- $density_l$ equal to the population density of the municipality l;
- $dist_{lj}$ is the distance between location l and store j[20].
- $StoreChar_j$ are store-level characteristics (number of employees, size, presence of parking facilities, age).

The utility of consumers buying from the "outside option" can be defined as:

$$U_{0l} = -b(density_l) + (Gdp)\alpha + \epsilon_0 \tag{13}$$

and

–

$$b(density_0) = \alpha_0 + \alpha_1 ln(density_0) + \alpha_2 ln(density_0) \tag{14}$$

where:

- Gdp is GDP per capita.

Given Esselunga market share with respect to its competitors, we are able to estimate, following Berry log-linearization procedure Berry (1994), the probability, $p_{j,l}(t)$, that a consumer located in municipality l buys, at time t from an Esselunga store j. The empirical counterpart of the demand model described above is the following equation:

$$\begin{aligned} ln(s_{jl}) - ln(s_{0l}) = \beta_1 ln(density_l) + \beta_2 ln(dist_{lj}) + \beta_3 dist_{lj} * ln(density_l) + \\ \beta_4 age_j + \beta_5 mq_j + \beta_6 d_{park,j} + \beta_7 d_{empl,j} + \beta_8 gdp_l + \alpha + \epsilon_j \end{aligned} \tag{15}$$

where:

- $dist_{lj}$ is the distance between location l and store j;
- $density_l$ is population density of municipality l;
- s_{jl} is the market share of store j with respect to competitors located in the same municipality;
- s_{Ol} is the share of these competitors;

[20] We assumed that all consumers live in the city centre; therefore, $dist_{lj}$ is calculated as the distance between store j and the city centre.

- age_j is the age of the store;
- mq_j is size of the store;
- $d_{park,j}$ is a dummy variable indicating the presence of the parking;
- $d_{employ,j}$ is a dummy variable indicating whether the number of store employees is higher than 50;
- gdp_l is the GDP per capita;
- α is a constant term;
- ϵ_j is the error term.

Table 5 shows demand estimation results for 2012[21]. As in Holmes (2011), we assumed demand parameters to be constant over the entire time span. In this way, using demographic and store-level variables for the previous years, we were able to derive the probability for the entire period of stores opening in the real and hypothetical scenarios. More competitors in a densely populated area decrease the probability of buying from an Esselunga store, while distant stores are less attractive. Furthermore, being a big store (in terms of square meters and number of employees) increases the attractiveness of Esselunga, as well as the presence of parking facilities.

Table 5: Parameter Estimates For Demand Model.

Definition	Value	Definition	Value
$ln(density_l)$	-2.6335 ***(0.04821)	$ln(dist_{lj})$	-2.4323 * (1.2498)
$dist_{lj} ln(density_l)$	0.041 (0.0572)	age_j	0.0056 (0.0035)
mq_j	0.0009 ***(0.0003)	$park_j$	0.8197 * (0.4175)
$d - empl_j$	0.7031 *(0.3627)	pil_l	0.1599 (0.1444)
α	8.3802 *(4.3419)		
n. obs	141	R^2	0.551

In Table 6 the probability $p_{i,l}$ a consumer at location l, shops at an Esselunga real store j as a function of the population density at the location l, $density_l$ and of the distance between location l and store j, $dist_{lj}$ is shown. Note that the other variables in the definition of the probability are set to their mean values.

Results show that the outside good is better in more dense areas.

7.2 Model Calibration

The data used in the analysis come from four different sources.

[21] Standard errors in parentheses. $***$, $**$ and $*$ indicate significance at 1, 5 and 10 per cent level, respectively.

Table 6: Probability $p_{i,l}$ a consumer shops at an Esselunga real store.

Distance (Km)	Population Density (Hundreds of People)							
	10	40	60	80	100	300	700	1000
1	0.99999	0.9998	0.999	0.999	0.998	0.979	0.842	0.678
2	0.99998	0.9995	0.998	0.997	0.995	0.918	0.564	0.342
4	0.99993	0.998	0.994	0.989	0.98	0.769	0.291	0.145
6	0.9998	0.996	0.989	0.979	0.965	0.664	0.207	0.1
8	0.9997	0.994	0.985	0.971	0.952	0.611	0.182	0.089

– Nielsen database, which contains detailed information about Esselunga stores: market shares, size of the store, number of employees (classes), type of store, address. Further, the Nielsen database provides us with data about market shares of Esselunga competitors, which allow us to calculate market shares of the "outside option", at municipality level.
– Balance sheet data, which provides data about Esselunga costs (capital depreciation, labour costs.)
– Administrative data ("visure storiche") which provides the opening date of each store.
– Istat datawarehouse, which provides demographic variables (population density, average spending per consumer etc.) for the real and hypothetic store scenario.

Table 7 shows the values of cost parameters in the model. The values of the parameters, ν^{Labour} and ν^{Am} are extracted from Esselunga annual reports and balance sheets. Given the labour and amortization costs and the value of the sales in 2012, these parameters were computed as proportionality coefficients. The parameter τ is expressed in thousands of euros per kilometre per year. This is a crucial parameter in our analysis, since it allowed us to compute Esselunga distribution cost. Given Esselunga logistic costs data are not publicly available, we use the american value of τ, as defined in Holmes (2011).

Table 7: Other costs of the model.

Parameter	Value
τ	2.80493
ν^{Labour}	0.115
ν^{Am}	0.041

As regards the hypothetical diffusion of Esselunga, it was studied over a span of 33 years, from January 1st, 2013 to January 1st, 2045. We assumed that Esselunga overall opens 127 stores in Calabria, Campania, Lazio, Sardinia and Sicily and 3 new distribution centers in Calabria, Lazio and Sicily.

We selected 130 municipalities and assumed that each one contains a store or a distribution centre. Table 8 shows the number of stores opened in each region, and Table 9 shows the location and the opening dates of each distribution center.

Table 8: Configuration of the hypothetical Stores: Location and number.

Store Location (Region)	Number Of Stores
Calabria	21
Campania	27
Lazio	21
Sardegna	29
Sicilia	29

Table 9: Configuration of the hypothetical Distribution Centers: Location and Opening Date.

DC's Region and Location	Opening Date
Campania– Sala Consilina (SA)	2027
Lazio– Latina (LT)	2020
Sicily– Messina (ME)	2035

We located the stores and DCs near to the highways following the real configuration and did not performed specific market analysis, because such an analysis is beyond the scope of this paper. In Table 10 we show some data about municipalities chosen for locating the hypothetical stores. In particular, we report the most significant data for the demand model. Specifically, we show the average and the standard deviation of the population density l, $density_l$, and the distance between locations l and stores j, $dist_{lj}$, across the municipalities in each region. In addition, we show the value of GDP per capita for each region, pil.

Table 10: Some statistics about hypothetical municipalities chosen.

	Average(Deviation Standard)		Value
Region	$density_l$	$dist_{lj}$	gdp
Calabria	270.894 (249.592)	4.02211 (1.77993)	16.5307
Campania	696.919 (834.178)	3.49904 (1.1551)	16.1776
Lazio	405.665 (385.588)	6.00578 (2.79266)	28.5758
Sardinia	111.098 (97.4106)	4.76593 (1.49561)	19.4486
Sicily	375.525 (355.177)	4.93654 (2.55698)	16.6282

Note that distribution costs play a key role in the profit-maximizing algorithm, and hence in the choice of the optimal timing of openings. As an example, opening first in Lazio and then in Campania is a profit-maximizing choice, even if Campania has a higher population density than Lazio. Indeed, opening in Campania would break network contiguity, leading to higher distributon costs and thus lower profits than those one could obtain opening in Campania.

In order to apply the demand model to the hypotethical network, we extracted from the Istat datawarehouse the population density, $density_l$, the population at the location l, n_l, the gross national product, gdp_l, and the expense per consumer, λ_l. Furthermore, we made some assumptions - based on Esselunga balance sheet data - as for store-level charachteristics, such as square meters, mq_j, dummy variables $d_{empl,j}$ and $d_{park,j}$ and the distance, $d_{l,j}$, between the store and the consumer's location. Particularly, given that store size as well as the number of employees depend on its potential market, we estimated an average potential market of 106.07 per capita per square meter and an average number of employees of 0.048 per capita per square meter. This allows us to define the size of the hypothetical stores and the number of their employees given the location of the store.

Finally, as regards the variable $d_{l,j}$, we assumed that each possible store location (municipality), has a circular shape. So, once the square kilometre of each location is known, and assuming that the stores are located in suburbs, we computed the variable $d_{l,j}$ as the radius of this circle.

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