Market Structure and Technology:
Evidence from the Italian National Health Service

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Abstract

Sutton (1991, 1998) theorised that industries evolve into distinct market configurations in terms of concentration, depending upon product homogeneity and whether R&D or advertising are relevant relative to set-up costs. This paper tests the existence of such a relationship between technological profiles and market structure empirically, using the health care services provided by the Italian National Health Service as the specific economic framework. Our results support the empirical predictions made by Sutton. In particular, in markets where the technological intensity is low the lower bound to concentration converges monotonically to zero when the market size increases, for any level of product homogeneity. Conversely, in markets where the technological intensity is high the lower bound of concentration converges to some positive (non-zero) value when market size increases, while the lower bound increases (from zero) when the level of product homogeneity increases.

Keywords: health care, market structure, technology

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1. *Introduction*

In the past few decades health care markets generally have been affected by two distinct structural changes. On one hand, the rapid pace of technological development as well as the diffusion of new technologies has increased cost by improving the quality of care and introducing new and costlier products. On the other hand a clear trend has emerged nationally towards decentralization of public intervention in health care. During the 90s, reforms favoring regionalization have reshaped national health services in Canada, Italy, Spain and Sweden, determining the rise of regional health services differentiated on the basis of organization, institutions and services, and increasing the autonomy of agents operating in the health care markets on both the demand and the supply side. On the demand side, patients have gained the right to choose the facilities that best meet their needs or expectations, while on the supply side hospitals and other health structures, apart from fulfilling a series of essential services, have become more autonomous in concentrating their own resources on specific health care productions started by technological innovations.[1] As a whole, these changes have made health care markets more similar functionally to the traditional industrial sectors, where it is generally assumed that consumers are free to choose their supplier, suppliers are free to choose which product to offer and its quality, and technology plays a crucial role.

In Italy, insofar as hospital care is concerned, the adoption of the DRG-payment system and the patients` right to freely choose the accredited facilities that best meet their requirements have to some extent introduced a 'yardstick competition' scheme in the health care system (Cellini et al. 2000). Even if hospitals do not compete on prices (since their services are mostly free-of-charge), they try to attract patients by competing on the quality of the services provided (Mapelli 2000; Levaggi and Zanola 2004).[2]

A number of empirical studies have stressed the relevance of the relationship between geographic mobility of patients and the technological complexity of health services provided by

[1] In Italy, for instance, although a standard level of health care must be offered across different regions, the new system of regional funding has greatly increased interregional differences in the quality and quantity of the services provided by the National Health Service.

[2] It should be stressed that the DRG-based payment system is not applied to all Italian hospitals. The Italian National Health Service includes two categories of public hospitals: the Hospital Trusts, which have the status of quasi-independent public agencies and have financial and technical autonomy, and hospitals run directly by Local Health Units. The Local Health Unit represents the lowest level in the organization of the health care system and are organized as nonprofit firms. Local Health Units are run by a general director, responsible for ensuring sound financial management and provided by law with substantial autonomy in managing human, financial and technological resources. Hospital Trusts are financed through a DRG-based payment system whilst the hospitals included in Local Health Units use a cost reimbursement system. Even if the latter are not financed by a DRG-based payment system, (and, therefore, their financial solvency does not strictly depend on the number of services provided), they are however subject to competitive pressures. If the hospitals belonging to a Local Health Unit provide services of low quality, patients would move towards others and consequently the manager of the Local Health Unit would incur significant political costs.

different regional Health Services in Italy (Fabbri and Fiorentini 1996; Degli Esposti et al. 1996; Ugolini and Fabbri 1998; Spampinato 2001). Patients are more willing to travel, and therefore to bear the associated costs of transaction, if they need highly specialized.

The industrial organization literature has largely investigated the relationship between technology and market structure. In this regard a standard reference is offered by the theoretical and empirical contribution by John Sutton. A key feature of Sutton’s (1991, 1998) work on industrial organization is that industrial markets evolve into distinct configurations of varying concentration, depending upon product homogeneity and differentiable R&D or advertising costs. Sutton develops his analysis with reference to manufacturing sectors. A number of subsequent contributions perform empirical tests for several industries in the EU and the US, all of which support Sutton's predictions about market size and market structure (Robinson and Chiang 1996; Lyons and Matraves 1996; Matraves 1999; Giorgetti 2000, 2002, 2003; Marin and Siotis 2002; Gruber 2002; de Juan 2003; Buzzacchi and Valletti 2003). We argue that the same interpretation can be given to the health care system, and similarly test the predictions due to Sutton’s argument when applied to the National Health Service in Italy.

This paper is organized as follows. In Section 2 the theoretical framework proposed by Sutton is briefly illustrated. Section 3 discusses the criteria followed for the identification of the relevant markets for the analysis of hospital care services. Section 4 describes the data on the hospital care services provided by the Italian National Health Service that are at the basis of this empirical application and shows how the procedures presented in Section 3 have been applied to these data. Section 5 illustrates the statistical tests developed to test Sutton’s empirical predictions about the relation between market concentration and market size, and between market concentration and product homogeneity. Section 6 concludes.

2. *Technology and market structure: the Sutton’s approach*

Sutton (1991, 1998) investigates the relationship between an industry’s R&D intensity (measured by the ratio of R&D spending on sales) and its level of concentration (measured by the combined market share of some specified number of firms). Although this relationship has been debated at length, empirically and theoretically, no consensus has formed (reference?). From a purely theoretical basis the direction of causality was originally disputed.[3] During the 70’s however, the endogeneity of concentration and R&D intensity became accepted, such that

[3] The latter stance is mainly based on appeal to the *structure*/*conduct*/*performance* paradigm developed by Bain (1956). Within that paradigm, is it claimed that a one-way chain of causation runs in each industry from *structure* (the level of concentration) to *conduct* (the degree of collusion), and from conduct to *performance* (profitability). Structure, in this setting, is explained by the degree of scale economies in the industry and by observed levels of advertising and R&D outlays relative to industry sales.

both should be determined simultaneously within an equilibrium system. When tested empirically, no clear consensus emerged from cross-industry analyses concerning the sign and the form of the relationship, with all of positive, negative and no correlation found (references?)

According to the theoretical model, outlays can be considered as sunk costs incurred by the firm in order to enhance consumers' willingness-to-pay for the firm's product (Shaked and Sutton 1982, 1987; Sutton 1989, 1991, 1998). Thus R&D and advertising outlays can be chosen by firms, and their levels can be determined endogenously as part of the specification of industry equilibrium: thus they can be considered as *endogenous* sunk costs.

Here we are interested in two predictions put forward by Sutton (1991).

Prediction 1: In exogenous sunk-cost markets (where R&D is low) the lower bound to equilibrium concentration converges monotonically to zero as the ratio between the market size and the set up costs increases (see fig. 1).

Prediction 2: In endogenous sunk-cost markets (where R&D is intensive) concentration remains bounded away from zero as the ratio between the market size and the set-up costs increase (see fig. 2).

The intuition behind is the following. In exogenous sunk-cost markets, a continuing increase in market size gives entrants the opportunity to build a profitable scale of operations. Alternatively in endogenous sunk-cost markets a firm is willing to suffer short-term losses in order to gain long-term revenues. As market size increase, long-term revenues increase. Through this mechanism, increasing market size leads to a competitive escalation in short-term spending: eventually, when this spending becomes too high for new entrants entry is blocked. The degree to which concentration is bounded away from zero is an empirical matter.

In a later contribution, Sutton (1998) derives two distinct empirical predictions regarding the joint distribution of R&D intensity, concentration, and product homogeneity.

Prediction 3: In industries where R&D intensity is low, the lower bound to concentration converges to zero as the size of the market becomes large, independently of the degree of product homogeneity (see fig. 3).

Prediction 4: On the contrary, in industries where R&D intensity is high, the lower bound to concentration increases from zero with product homogeneity (see fig. 4).

Therefore, if R&D is ineffective in raising consumers' willingness-to-pay, it can be shown that R&D intensity is necessarily low. Following this, if we select a set of industry for which the R&D/sales ratio is high, we know that for this group R&D effectiveness is high. Whether this necessarily implies a high level of concentration depends on the strength of the linkages between sub-markets, which in turn depends on the scope economies and the degree of substitutability across products associated with different R&D trajectories. Where these are relevant (so homogeneity is high), concentration will be necessarily high since, if all firms have a low market share, an escalation of R&D spending will be profitable. A high-R&D-spending firm can capture sales from low-R&D-spending rivals on its own trajectory and on the others. On the contrary, when the scope economies and the degree of substitutability across products are limited (so homogeneity is low), concentration may be low in spite of the effectiveness of R&D spending. There are many product groups, associated with different R&D trajectories, and therefore escalation can yield only poor returns. If on the other hand R&D intensity is low, the absence of an escalation mechanism involving R&D makes the market able to support an indefinite number of firms, and therefore the theory predicts that the lower bound to concentration is zero independent of product homogeneity.

3. *The identification of relevant market: methodological issues*

In order to test the empirical predictions claimed by Sutton in the case of the hospital care services provided by the Italian National Health Service the relevant markets must first be identified. This issue is crucial when considering the anticompetitive strategies firms eventually undertake after mergers and acquisitions. Indeed, much of the literature about the identification of the relevant markets has been developed with the aim of detecting such strategies. In general, a relevant market can be characterized according to two different dimensions: the "product" dimension and the "geographic" dimension.

As underlined by Sutton (1991), the product relevant to identify a market can be characterized with either reference to the demand side by considering the substitutability of products in consumption, or to the supply side by focusing on the similarities in production techniques. The demand side criterion is used more frequently, although the latter is convenient when barriers to mobility between markets are relevant in the industry under consideration (Caveas and Porter 1978).

Two different approaches are usually seen when identifying the relevant geographic markets for a product. The first is based on the evolution of prices in different geographic areas; the second on the movement of physical quantities of the product across different areas. Since in Italy hospital care is essentially free-of-charge and, as a consequence, the market equilibrium is not reached through the price mechanism, we focus on the second approach.

Within this general perspective, a the method developed by Elzinga and Hogarty (1973, 1978) is most useful. This is a shipment-based technique involving measurements of product flows across areas, which is based on the application of two different tests:

1. the Little Out From Inside test (LOFI). The LOFI test concerns the supply side of the market and is based on the question, “What is the smallest geographic region required to account for nearly all shipments from a given producing area?”;
2. the Little In From Outside test (LIFO). The LIFO test refers to the demand side of the market and centers around the question, “Of total purchases within the region identified by the LOFI test do nearly all emanate from within that region itself?”.

The logic behind this approach is simple. If a certain area meets both of these tests, and this occurs when outflows to other areas and inflows into that area are relatively small, then that area is taken as a relevant market according to the Elzinga and Hogarty criterion. It is usually required that those outflows and inflows do not exceed a given threshold, which is often set to 10% or 25% of the total amount of production or consumption.

The Elzinga and Hogarty method was originally developed with reference to commodity markets, like beer (Elzinga-Hogarty 1973) or coal (Elzinga-Hogarty 1978; Warell 2005). It has been recently applied to the context of hospital care as well. During the 90s the US Department of Justice relied on the analysis of patients flows in order to assess a number of cases of hospital mergers (Capps et al. 2002, Capps et al. 2003). Moreover, Dalmau-Matarrodona and Puig-Junoy (1998) estimated geographic hospital markets in Catalunya as a first step to evaluating the potential effect of market structure on hospital technical efficiency.

4. *The identification of relevant markets: empirical application*

4.1. *The data*

The structure of the hospital markets in Italy is analyzed in this paper with data containing information about the services (discharges) provided by all the public hospitals operating in the Italian National Health Service during 1999. For any single discharge, the data-set reports the corresponding DRG according to the classification adopted by the Italian Ministry of Health, the tariffs corresponding to each DRG by which the Local Health Units were reimbursed, the hospital where the service was provided together with the Province where that hospital was located, and the Province where the patient resided. The data includes all the 492 DRGs covered by the classification by the Italian Ministry of Health as well as the 103 Provinces into which the Italian territory is partitioned.[4] Moreover, the Ministry of Health assembles the DRGs into 25 MDCs (representing specific diagnostic groups). Some observations are excluded due to

[4] No medical care services corresponding to DRG numbers 109, 438 and 474 are reported in the 1999 data-set, even if those DRGs are included in the official classification.

incomplete information (the tests are performed considering 480 DRGs).[5] The data is in the form of an origin-destination matrix, which allows direct investigation of each patients' mobility across Italian Provinces.

4.2. *Product and geographic dimension of the markets*

Testing the empirical predictions due to Sutton (1991, 1998) requires identification of the relevant markets, in terms of both the product and the geographic dimensions. For the product dimension we define the relevant markets in such a way that the criteria referring to the demand side and the supply side are, at least to some extent, both satisfied. If we consider the demand side criterion, we should only focus on the substitutability across hospital treatments, which is very low here because of the characteristics of the services in question. As a consequence, according to this criterion, each DRG should be regarded as a separate product., When considering the supply side however, the DRGs included in a specific MDC generally share many similarities in the production techniques. A hospital producing a DRG included in a specific MDC can easily provide another DRG not as yet provided in that MDC, while it is much more difficult technologically to provide a new DRG in an MDC that is not currently provided. Thus, considering these two perspectives jointly, it seems reasonable to regard the MDCs as the relevant main products that include the DRGs as sub-products.

The Elzinga and Hogarty criterion has then been applied distinctly for each MDC to the Provincial origin-destination matrix, in order to add the geographic dimension and to identify the relevant markets.[6] As a result, 1,425 distinct relevant markets have been identified. Fig. 5 and 6 report respectively the geographic sub-division of Italy into the relevant markets identified in the case of Burns and of Neonatal period diseases, taken as examples of products characterized by relatively few markets (42 in the case of Burns) and by a more fragmented market structure (83 in the case of Neonatal period diseases).

Some summary statistics of the structure of relevant markets classified according to product are provided in Tab. 1. The characterization of the relevant markets is much diversified across different products. First of all, the various products are sharply differentiated in terms of the number of services provided, of sub-products included and of hospitals producing those services. For example, the number of health services ranges from 1,097,901 (Cardio-vascular apparatus diseases) to 7,268 (Burns). Variability is marked also as far as the number of sub-products included in different product categories is concerned, which have a coefficient of

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[5] In order to perform statistical tests on the data, we have excluded from the data-set those observations that do not report complete information about the corresponding DRG, the hospital where the service is provided, the Province where the hospital is operative. A number of health services corresponding to DRG numbers 468, 469, 470, 476, 477, 480, 481, 482 and 483, which the official classification does not include in any MDC, have been removed as well.

[6] Annex 1 presents the empirical procedure employed in detail.

variation 0.68, whereas dispersion is much more limited when we look at the number of hospitals operating in each product, showing a coefficient of variation of only 0.14.

We consider the size of the relevant markets by the number of the residents in the corresponding geographic area as a measure of composition, which differs according to the products. The distribution of this index, summarized in terms of average and coefficient of variation, greatly vary across products. In general, markets that are large on average are, to some extent, associated with higher variability in that product compared to the others (compare for example Myelo-proliferative and Neonatal period diseases).

Another way to characterize the composition of the relevant markets is to look at the number and the territorial localization of the institutional entities (in this case the Provinces) composing those markets. Tab. 1 shows for each product the percentage of the relevant markets including more than one Province (*multiprov*), that provides a measure of fragmentation of markets in territorial terms.[7] Again a large dispersion is noticeable across products, ranging from a minimum of 18.1% (Neonatal period diseases) to a maximum of 52.1% (Factors affecting health and health services demand). Moreover, the composition of relevant markets by Provinces highlights possible territorial discontinuities in their geographic structure. The last column of tab. 1 (*discontinuity*) contains the number of non-contiguous Provinces in the same market for each product. For some specific products the structure of the relevant markets shows a relatively high number (up to 5) of non-contiguous Provinces. Upon closer investigation, those Provinces are usually located in Southern Italy as opposed to the central group of the (contiguous) Provinces constituting the market in Northern or Central Italy. This result is consistent, with previous research on patient mobility that shows relevant interregional patients flowing from South to Centre-North of the country.[8]

4.3. *Market concentration, product homogeneity and technology*

To analyze the market structure of the Italian National Health Service through Sutton's theoretical framework, some correspondences between the theoretical setting and the data need to be established. Thus (i) within each market hospitals operate as firms; (ii) revenue is measured by the number of services provided, multiplied by their corresponding tariff; (iii) the share of each hospital in each market is measured by the sales revenue gained by that hospital over the total revenue gained in that market.

In order to test the consistency of our data with the empirical predictions from Sutton's theory, three indices have been derived for each market:

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[7] Given the different size of the Provinces in which the Italian territory is partitioned, it is obvious that the number of Provinces provides only a *prima facie* measure of the territorial dimension of the markets.

[8] For instance, Donatini et al. (2001), claim that Northern regions attract more interregional patients than they lose to other regions, whereas the opposite occurs for Southern regions. This is because people in Northern Italy tend to receive care in their own or nearby regions, unlike their Southern counterparts.

1. The concentration index C_1, defined as the market shares corresponding to the firm providing the largest number of health services in the market;
2. The homogeneity index h, determined as the fraction of sales revenue corresponding to the largest sub-market (in terms of number of health services produced) in the market;
3. The size index $size$, determined as the revenue realized in the market, divided by the revenue of the median hospital.

Information about the technological characteristics of the relevant markets is also required. Given that information of this kind is not included in our data, we resort to more detailed data available for a particular Italian region (Emilia-Romagna). We assume that the technology adopted in the production of each category of health care is analogous across regions, unlike the composition of health care productions, which differs across regions. This data contains the number of health care services provided by every hospital distinctly by DRG and hospital ward and, on the other hand, total costs classified by main items (medical staff, paramedic staff, executive staff, non-durable goods purchases, etc.) incurred by hospital wards of each hospital. The basic cost items by hospital wards and services provided (measured in terms of hospitalization days) classified by hospital wards and DRG have then been aggregated across hospitals. Among the cost items the category of capital costs (depreciations plus capital goods hiring) have been selected. A capital intensity index has then been derived for each DRG as the product of the 'weight index', which measures, according to the Italian Ministry of Health, the overall amount of human and physical resources necessary to provide the services corresponding to that DRG, and the weighted average of the ratio of capital costs to total costs for each hospital ward, where the weights are given by the share of the total number of services each hospital ward provides in each DRG.[9] The capital intensity index is then considered to be a proxy for the technological intensity of each DRG.[10] Finally, the technological intensity index $tech$ for each relevant market has been derived as the weighted average of the capital intensity index for the DRGs included in that market, where the weights are given by the share of the total production of that market concerning for each sub-product (that is, each DRG).[11]

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[9] More precisely, for the *i*th DRG and the *j*th hospital ward, capital intensity index t_i is derived as:

$t_i = \sum_j \frac{k_j}{c_j} \frac{s_{ij}}{\sum_j s_{ij}} * w_i$ where *k, c, s* and *w* denote capital costs, total costs, the number of services (measured in terms of hospitalization days) and the weight index respectively.

[10] Higher research intensity might require more medical staffing (Blank and Vogelaar 2004). To consider this we have also tried to approximate the R&D intensity of the DRGs by defining a 'physician intensity index.' This is computed, analogously to the 'capital intensity index' with reference to the ratio between the costs for physicians and the total cost. The distribution of the values of the physician intensity index across different DRGs is similar to the capital intensity index one (the correlation between the two is 0.98). Therefore, resorting to the physician intensity index instead of the capital intensity index seems not to affect the results of our analysis significantly.

[11] We are aware that the index adopted here (the share of capital costs) is not an optimal proxy for the R&D intensity since it neglects relevant components of R&D, such as that provided by hospitals as units

The average values of $tech$, C_1, h and $size$ for the relevant markets classified by products are given in tab. 2. The values of $tech$ shows limited variation across products (coefficient of variation equal to 0.094) in comparison with the other indices reported, especially in the case of h and C_1 (0.535 and 0.506 respectively). Since, as discussed in Section 2, Sutton's theory provides different empirical predictions depending on whether the market considered is characterized by high or low technological intensity it is interesting to evaluate the relationship between the variation of the index $tech$ and that of some of the other characteristics of the relevant markets presented in tab. 1. In particular, the technological intensity of the market turns out to be significantly correlated with both market size and variation of market size within the corresponding product category, with multi-Province composition and with the probability of non-contiguous Provinces being in the same market.

5. *Empirical results*

The consistency of the empirical predictions by Sutton with the market structure of the Italian National Health Service is tested here on the basis of the relevant markets as identified and characterized in Section 4. Given that Sutton makes different predictions according to the technological intensity of the considered markets, we first partition the sample into two different markets, one with a relatively high level of technological intensity (high-*tech* markets) and a control group in which the technological intensity is relatively low (low-*tech* markets). A rather crude way to proceed is to order the markets by the $tech$ index, and to choose as cut-off the average (0.062).[12] To distinguish the two groups more sharply, we exclude from each group the 30% of the total number of markets whose $tech$ value is closest to the cut-off level. As a result, the high-*tech* and the low-*tech* group include 592 and 406 markets respectively.

The partitioning of the sample into the high-*tech* and low-*tech* groups makes it possible to stress some preliminary descriptive statistics. In particular, high-*tech* markets are characterized on average by lower values of h (0.284 and 0.442 respectively), higher levels of C_1 (0.508 and 0.447 respectively) and *size* (18.17 and 17.35 respectively).

5.1. *Market concentration and market size*

The relationship between C_1 and $size$ in each market is given in fig. 7 and 8. Our concern is comparing these diagrams with the predicted lower bounds from fig. 1 and fig. 2, which

and by university hospitals. However we stress that, as stated in Sutton (1991), the R&D intensity is considered only in order to partition the markets into two groups. Thus, possible measurement errors in this variable are not expected to affect the results of the analysis.

[12] Notice that our choice of the cut-off point is to some extent arbitrary and that other criteria could be adopted to define it.

reflect *Predictions 1* and *2* respectively. Following Sutton, we adopt Smith's (1985, 1994) use of a two-step procedure to estimate the lower bound for the scatters of observations shown in fig.7 and fig.8. The first step of the procedure requires making some *a priori* decision about the form of the schedule $f(z)$ that describes the lower bound. We can then obtain a consistent estimator of the actual schedule by minimising the sum of $y_i - f(z_i)$ subject to the constraint that all residuals shall be non-negative. The second step involves employing the method of pseudo-maximum likelihood to check that the pattern of the estimated residual fits a Weibull distribution.[13]

The three-parameter Weibull distribution is defined on the domain $t \geq \mu$ by:

$$\text{Prob}(T \leq t) = 1 - \exp\left\{ -\left[\frac{t-\mu}{\delta}\right]^{\beta} \right\}$$

where $\beta > 0$ and $\delta > 0$. The three parameters (β, δ, μ) denote shape, scale and location respectively. The location parameter μ represents the lower bound to the support of the distribution. If $\mu = 0$ the distribution simplifies to the so called two-parameter Weibull.

The procedure rests on the assumption that the distribution of residuals is identical at all values of the independent variable. This assumption would be unrealistic if applied directly to the values assumed by C_1, considering the upper limit of C_1 is equal to 1. For this reason we take the logit transformation of C_1:

$$C_1^* = \ln\left(\frac{C_1}{1-C_1}\right)$$

The first step of the estimate procedure implies making some assumptions about the form of the schedule describing the lower bound and estimating the parameter of the schedule. A reasonable family of candidate schedules would be:

$$C_1^* = a + \left(\frac{b}{\ln size}\right)$$

Fig. 7 and fig. 8 show the estimated schedules describing the lower bound in the high-*tech* markets (the dotted line) and in the low-*tech* markets (the thick line). As shown in Tab. 3, the estimated parameter a is equal to –3.773 and –6.161 for the high-and low-*tech* markets respectively. The estimated values for the parameter b result in a higher slope for the lower bound for low-*tech* markets (6.418) than for high-*tech* markets (3.744). Moreover, the parameters a and b are significant at a confidence level higher than 99% for both the two groups of markets. The standard errors of a and b are obtained with a Monte Carlo simulation of 10,000 repetitions, and support the generation of error terms from a Weibull distribution

[13] We have chosen to use a Weibull distribution as the distribution generating the level of concentration in the markets because it is a very flexible functional form. It can assume different shapes and different position in the plane according to the values given to its parameters. For this reason it has been widely used in fitting bounds to various empirical distributions (references).

characterized by the estimated parameters. The estimated schedules in the high-*tech* and low-*tech* markets give support to *Prediction 1* and *2* presented in Section 2.

As second step of this procedure, we check whether the associated set of residuals fits a Weibull distribution. Assuming that the set of residuals is distributed as a two-parameter Weibull, we show that residuals fit that distribution well for both high-*tech* and low-*tech* markets.[14,15] To test the hypothesis that the estimated schedules for both groups of markets converge to the same value as the market size goes to infinity, we examine the values assumed by C_1^* distinctively for high-*tech* and low-*tech* markets when $size$ goes to infinity. That value equals –3.773 (which corresponds to C_1 = 0.026) and –6.418 (C_1 = 0.002) for high-*tech* and low-*tech* markets respectively. These results are consistent again with *Predictions 1* and *2*.[16]

5.2 *Market concentration and market homogeneity*

The relationship between C_1 and h is shown in fig. 9 and 10 for the high-*tech* and low-*tech* markets respectively. We compare these diagrams with the predicted lower bounds shown in fig. 3 and fig. 4, which represent graphically *Predictions 3* and *4*. The data from the Italian National Health Service does not appear to contrast those theoretical predictions at face value. The high-*tech* group does not include observations where high values of h are coupled with low values of C_1, whereas some low-*tech* markets are characterized by both low product homogeneity and low concentration. This encourages a formal statistical procedure in order to test Sutton's predictions. Sutton's theory makes no general assumptions as to the functional form of the lower bound, however in the limiting case where all sub-markets are completely independent, the theoretical framework states that the bound for the high-*tech* group takes the form of a ray through the origin.[17]

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[14] The assumption that the residuals follow a two-parameter Weibull is made even by previous studies in the literature (Giogetti (2003), Marin and Siotis (2002)).

[15] We define $R_i = t_i - \mu$, given a reasonable value for μ, and rank R_i in ascending order. Then we define the cumulative distribution $F(R_i)$. If the R_i is defined as having a two-parameter Weibull distribution, a plot of $y_i = \ln(1/(1-F(R_i)))$ against $\ln R_i$ yields a straight line. Our analysis shows that the previous relationship is supported by the data (for simplicity, we omit the graphics) the set of residuals is well approximated by a Weibull.

[16] The estimated $\beta < 2$ is a known indicator of the appropriateness of Smith's procedure. The maximum likelihood is a more common method than Smith's procedure to estimate lower bounds, but when $\beta < 2$ its usual asymptotic results do not hold (Smith 1985, 1989). In our case the estimated value of the parameter β is less than 2 for both low-*tech* and high-*tech* markets (equal respectively to 1.349 and 1.795) and thus it is appropriate to use the Smith's approach.

[17] These predictions have been tested previously using a procedure due to Mann, Scheuer and Fertig (1973). This method is useful because it bypasses the estimation of the shape and scale parameters of the distribution and constructs directly a confidence interval for the lower bound. Thus it involves less computation than Smith's approach, however it requires dealing with samples of dimensions up to 100 observations, far smaller than ours. For this reason we continue with Smith's procedure.

For the same matters discussed in Section 5.1, before running the statistical test we apply to the C_1 index the transformation:

$$C_1^* = \ln\left(\frac{1}{1-C_1}\right)$$

As far as the form of the schedule describing the lower bound, a reasonable family of candidate schedules would be:

$$C_1^* = a * h$$

When Smith's procedure is applied, the estimated parameter a is equal to 0.177 and 0.069 respectively for high-*tech* and low-*tech* markets (as shown in Tab. 3). Therefore, the slope of the lower bound for the low-*tech* markets, even if not exactly equal to zero, is very close to zero and is much lower than the slope of the lower bound for the high-*tech* case. The estimate of parameter a is significant at a confidence level higher than 99% for both groups of markets. Thus the relationship between the estimated schedules in the high-*tech* and low-*tech* markets gives support to *Predictions 3* and *4*.

As for the relationship between C_1 and $size$, considering the relationship between C_1 and h we assume that the residuals are distributed as a two-parameter Weibull and, following the procedure described in Section 5.1, we show that they fit that distribution both in high-*tech* and in low-*tech* markets case.[18]

6. *Final remarks*

In this paper we have tested empirically the existence of the relationship between technological profiles and market structure claimed by Sutton's theory in a specific economic framework, that of health care services provided by the Italian National Health Service.

In order to test the empirical predictions by Sutton, we have identified the relevant markets for hospital care services in Italy in terms of both product and geographic dimensions. In particular, the Elzinga and Hogarty approach has been applied to data on patients' flows across Italian Provinces in order to derive the geographic dimension of each market. To our knowledge, this is the first time this approach has been utilized with reference to the Italian hospital treatments sector.

[18] Even in this case, the estimated value of the parameter β is less then 2 for both the categories of markets (respectively equal to 0.844 and 0.952), proving the suitability of the Smith's methodology.

Our results support the empirical predictions by Sutton, that in markets where technological intensity is low the lower bound to market concentration converges monotonically to zero when the market size increases, for any level of product homogeneity. Conversely, in markets where technological intensity is high the lower bound to concentration converges to a positive value different from zero when the market size increases, while the lower bound increases from zero with the level of product homogeneity.

These results provide some useful indications to the policy–makers about the functioning of the Italian National Health Service., In order to enhance the relevance of this evidence however, the institutional setting and the regulation constraints affecting the hospital treatment sector in Italy should be investigated more thoroughly. Moreover, the structure of hospital care markets identified here through the Elzinga and Hogarty approach could be further exploited in order to examine the potential effect on hospital technical efficiency.

References

Bain J.S. (1956), *Barriers to New Competition*, Cambridge, Harvard University Press.

Blackstone E.A., Fuhr J.P. (2000), "Economic Issues in Hospital Mergers and Health Systems", *Journal of Science and Health Policy*, vol. 1 (1), 82-109.

Blank J.L.T., Vogelaar I. (2004), "Specifying technical change: a research on the nature of technical change in Dutch hospital industry", *The Quarterly Review of Economics and Finance*, vol. 44, 448-463.

Buzzacchi L. and Valletti T.M. (2003), *Firm Size Distribution: Testing the "Independent Submarkets Model" in the Italian Motor Insurance Industry*, London School of Economics, mimeo.

Capps C., Dranove D., Greenstein S., Satterthwaite M., (2001), "The Silent Majority Fallacy of the Elzinga-Hogarty Criteria: a Critique and New Approach to Analyzing Hospital Mergers", *NBER Working Paper*, 8216, Cambridge, MA.

Capps C., Dranove D., Greenstein S., Satterthwaite M., (2002), "Antitrust Policy and Hospital Mergers: Recommendations for a New Approach", *Antitrust Bulletin*, vol. 17, 677-714.

Capps C., Dranove D., Greenstein S., Satterthwaite M., (2003), "Geographic Market Definition in Hospital Merger Cases", (Joint Statement) *Federal Trade Commission and Department of Justice Hearings on Health Care and Competition Law and Policy.*

Caves R.E., Porter M.E., (1978), "Market Structure, Oligopoly, and Stability of Market Shares," Journal of Industrial Economics, vol. 26(4), 289–313.

Cellini R., Pignataro G., Rizzo I., (2000), "Competition and Efficiency in Health Care: An Analysis of the Italian Case", *International Tax and Public Finance*, vol. 7, 503–519.

Dalmau-Matarrodona E., Puig-Junoy J., (1998), "Market Structure and Hospital Efficiency: Evaluating Potential Effects of Deregulation in a National Health Service", *Review of Industrial Organization*, vol. 13 (4), 447-66.

Degli Esposti G., M. Rimondi, G. Virgilio and C. Ugolini (1996), "Matrici di mobilità per DRGs: analisi descrittiva ed applicazioni per la programmazione e le politiche sanitarie regionali", *Mecosan*, vol. 19, 53-62 (in Italian).

Donatini A., Rico A., D'Ambrosio M.G., Lo Scalzo A., Orzella L., Cicchetti A., Profili S., (2001), "Health Care System in Transition, Italy", *European Observatory on Health Care Systems*, 3(4).

Elzinga K, Hogarty F., (1973) "The Problem of Geographic Market Delineation in Antimerger Suits", *Antitrust Bulletin*, vol. 18 (45), 45-81.

Elzinga K, Hogarty F. (1978), "The Problem of Geographic Market Delineation Revisited", *Antitrust Bulletin*, vol. 23 (1), 1-18.

Fabbri D. and G. Fiorentini (1996), "Mobilità e consumo sanitario: metodi per la valutazione di benessere", *Mecosan*, vol. 19, 37-52 (in Italian).

Giorgetti M.L. (2000), "La verifica empirica del modello di Sutton per i settori manufatturieri italiani", *L'industria*, vol. 21, 543-564 (in Italian).

Giorgetti M.L., (2002), "Concentration and Scope Economies in the Pharmaceutical Sector", University of Brescia, Department of Economics, *Discussion Paper*, 205.

Giorgetti M.L. (2003), "Low Concentration and Scope Economies in the Pharmaceutical Sector Bound Estimation - Quantile Regression and Simplex Method: an Application to Italian Manufacturing Sectors", *Journal of Industrial Economics*, vol. 51, 113-120.

Gruber H. (2002), “Endogenous Sunk Costs in the Market for Mobile Telecommunications: the Role of License Fees", *Economics and Social Review*, vol. 33, 55-64.

de Juan R. (2003), "The Independent Submarkets Model: an Application to the Spanish Retail Banking Market", *International Journal of Industrial Organization*, vol. 21, 1461-1487.

Levaggi R., Zanola R., (2004), “Patient’s migration across regions: the case of Italy”, *Applied Economics*, vol. 36, 1751-1757.

Lyons B.R. and Matraves C. (1996), "Industrial Concentration", in S. Davies and B. Lyons, *Industrial Organization in the European Union: Structure, Strategy and the Competitive Mechanism*, Oxford University Press, 86-104.

Mann N., E. Scheuer and and K. Fertig (1973), "A New Goodness-of-Fit Test for the Two-Parameter Weibull or Extreme-Value Distribution with Unknown Parameters", *Communications in Statistics*, vol. 2, 383-400.

Mapelli V., “Tre riforme sanitarie e ventuno modelli regionali”, in Luigi Bernardi, *La finanza pubblica italiana, Rapporto 1999*, il Mulino, (in Italian).

Marin P.L. and G. Siotis (2002), *Innovation And Market Structure: An Empirical Evaluation Of The 'Bound Approach' In The Chemical Industry*, CEPR Discussion Paper, 3162, January.

Matraves C. (1999), "Market Structure, R&D and Advertising in the Pharmaceutical Industry", *Journal of Industrial Economics*, vol. 47, 169-194.

Robinson W.T. and J. Chiang (1996), "Are Sutton's Predictions Robust?: Empirical Insights into Advertising, R&D, and Concentration", *Journal of Industrial Economics*, vol. 44, 389-408.

Shaked, A. and J. Sutton (1982), "Relaxing Price Competition through Product Differentiation", *Review of Economic Studies*, vol. 49, 3-13.

Shaked, A. and J. Sutton (1987), "Product Differentiation and Industrial Structure", *Journal of Industrial Economics*, vol. 36, 131-146.

Spampinato G.C. (2001), "Mobilità sanitaria regionale e federalismo", *Politiche sanitarie*, vol. 2, 44-56, (in Italian).

Smith, R.L. (1985), “Maximum Likelihood estimation in a class of non-regular cases”, Biometrika, vol. 72, 67-92.

Smith, R.L. (1994), “Nonregular Regression”, Biometrika, vol. 81, 173-183.

Sutton, J. (1989), "Endogenous Sunk Costs and Industrial Structure"", in G. Bonanno and D. Brandolini (eds.), *Market Structure in the New Industrial Economics*, Oxford, Oxford University Press.

Sutton, J. (1991), *Sunk Costs and Market Structure*, Cambridge, MIT Press.

Sutton, J. (1998), *Technology and Market Structure*, Cambridge, MIT Press.

Ugolini, C. and D. Fabbri (1998), "Mobilità saniatria ed indici di entropia", *Mecosan*, vol.26, 9-24, (in Italian).

Warell L., (2005), “Defining Geographic Coal Markets using Price Data and Shipments Data”, *Energy Policy*, vol. 33(17), 2216-2230.

Werden J., (1981), “The Use and Misuse of Shipments Data in Defining Geographic Markets”, *Antitrust Bulletin*, vol. 26, 719-737.

Werden J., (1989), “The Limited Relevance of Patient Migration Data in Market Delineation of Hospital Merger Cases”, *Journal of Health Economics*, vol. 8, 363-376.

Tab. 1 Relevant markets description

Product number	Product	*number of services* #	*number of services* %	*number of DRGs* #	*number of DRGs* %	*number of hospitals* #	*number of hospitals* %	*size* *average*	*size* *coeff variation*	*multiprov*	*discontinuity*
1	Nervous system diseases	643,878	7.63	35	7.29	817	99.63	977,625	2.02	27.1%	0
2	Eye diseases	312,153	3.70	13	2.71	760	92.68	1,253,911	1.55	37.0%	2
3	Ear, nose, mouth and throat diseases	436,194	5.17	31	6.46	806	98.29	961,332	1.17	38.3%	1
4	Respiratory apparatus diseases	583,960	6.92	29	6.04	810	98.78	769,065	1.29	24.0%	0
5	Cardio-vascular apparatus diseases	1,097,901	13.01	44	9.17	813	99.15	812,393	1.39	25.4%	0
6	Digestive system apparatus	888,333	10.53	40	8.33	809	98.66	720,999	1.29	21.3%	0
7	Hepatobiliary and pancreatic diseases	331,566	3.93	18	3.75	797	97.20	1,011,928	1.69	29.8%	5
8	Muscle-skeletal system diseases and disesas of connective tissue	707,931	8.39	40	8.33	811	98.90	1,281,776	1.53	37.8%	1
9	Skin, subcutaneous tissue and breast diseases	583,268	6.91	38	7.92	809	98.66	961,332	1.32	30.0%	1
10	Endocrine, nutritional and metabolic diseases	172,431	2.04	17	3.54	808	98.54	1,441,997	1.67	42.5%	5
11	Kidney and urinary system diseases	385,963	4.57	32	6.67	798	97.32	1,068,146	1.61	31.5%	4
12	Male reproductive system diseases	146,877	1.74	19	3.96	778	94.88	994,481	1.28	29.3%	1
13	Female reproductive system diseases	277,077	3.28	17	3.54	779	95.00	1,088,300	1.35	41.5%	1
14	Gestation and birth	680,852	8.07	15	3.13	652	79.51	769,065	1.13	25.3%	0
15	Neonatal period diseases	412,222	4.89	7	1.46	648	79.02	694,939	1.11	18.1%	0
16	Diseases of the blood, of the haemopoietic organs and of the immune system	80,442	0.95	8	1.67	801	97.68	915,554	1.55	27.0%	5
17	Myelo-proliferative diseases	198,833	2.36	17	3.54	802	97.80	1,558,916	2.29	40.5%	5
18	Infectious diseases	70,018	0.83	9	1.88	792	96.59	1,130,978	1.10	33.3%	0
19	Mental diseases	179,980	2.13	9	1.88	803	97.93	873,938	1.38	24.2%	3
20	Alcool/drus abuse and induced organic mental diseases	32,289	0.38	5	1.04	756	92.20	860,894	1.52	23.9%	1
21	Traumatisms, poisonings and tossic effects of medicines	96,211	1.14	17	3.54	801	97.68	994,481	1.43	31.0%	2
22	Burns	7,268	0.09	6	1.25	616	75.12	1,373,331	1.66	28.6%	0
23	Factors affecting health and health services demand	83,820	0.99	7	1.46	798	97.32	1,696,468	1.04	52.9%	5
24	Serious multiple traumatisms	9,401	0.11	4	0.83	601	73.29	1,088,300	1.49	41.5%	1
25	HIV infections	18,035	0.21	3	0.63	360	43.90	1,478,798	0.98	52.6%	0
	Total	8,436,903	100.00	480	100.00	820	100.00	1,071,158	1.43	32.6%	1.72

Tab. 2 Technogical intensity, product homogeneity, concentration and size of the markets

Product number	Product	*tech*	*h*	C_1	*size*
1	Nervous system diseases	0.0474	0.4666	0.4597	17.9059
2	Eye diseases	0.0519	0.6654	0.4247	15.5411
3	Ear, nose, mouth and throat diseases	0.0549	0.3639	0.4800	17.3861
4	Respiratory apparatus diseases	0.0576	0.2716	0.5387	18.6868
5	Cardio-vascular apparatus diseases	0.0599	0.5115	0.4259	17.1099
6	Digestive system apparatus	0.0602	0.3383	0.4072	17.9716
7	Hepatobiliary and pancreatic diseases	0.0605	0.3323	0.3878	17.8155
8	Muscle-skeletal system diseases and disesas of connective tissue	0.0605	0.6164	0.6059	17.2347
9	Skin, subcutaneous tissue and breast diseases	0.0606	0.2067	0.4516	18.9330
10	Endocrine, nutritional and metabolic diseases	0.0618	0.2193	0.4279	16.8962
11	Kidney and urinary system diseases	0.0623	0.2051	0.4338	18.4210
12	Male reproductive system diseases	0.0625	0.1522	0.4132	18.8856
13	Female reproductive system diseases	0.0625	0.3954	0.3881	18.1526
14	Gestation and birth	0.0628	0.3733	0.3828	17.9747
15	Neonatal period diseases	0.0634	0.1810	0.4550	18.9333
16	Diseases of the blood, of the haemopoietic organs and of the immune system	0.0636	0.1262	0.4419	18.4780
17	Myelo-proliferative diseases	0.0639	0.2623	0.5014	19.0146
18	Infectious diseases	0.0641	0.1551	0.4782	19.7165
19	Mental diseases	0.0642	0.2530	0.4122	19.3412
20	Alcool/drus abuse and induced organic mental diseases	0.0648	0.4865	0.3724	18.0296
21	Traumatisms, poisonings and tossic effects of medicines	0.0656	0.6366	0.6326	14.6717
22	Burns	0.0664	0.4236	0.5137	16.0294
23	Factors affecting health and health services demand	0.0690	0.1840	0.4927	18.9380
24	Serious multiple traumatisms	0.0713	0.2021	0.4751	17.8962
25	HIV infections	0.0744	0.5396	0.5706	20.2641
	average value	0.0617	0.3345	0.4584	17.9151

Tab. 3: Estimated parameters (standard errors in parentesis)

	size		***homogeneity***
parameter	*a*	*b*	*a*
Hig-*tech*	-3.773 *(0.200)*	3.744 *(0.251)*	0.178 *(0.007)*
Low-*tech*	-6.161 *(0.558)*	6.418 *(0.688)*	0.069 *(0.015)*

Fig. 1 Lower bound for concentration in low R&D intensity industries

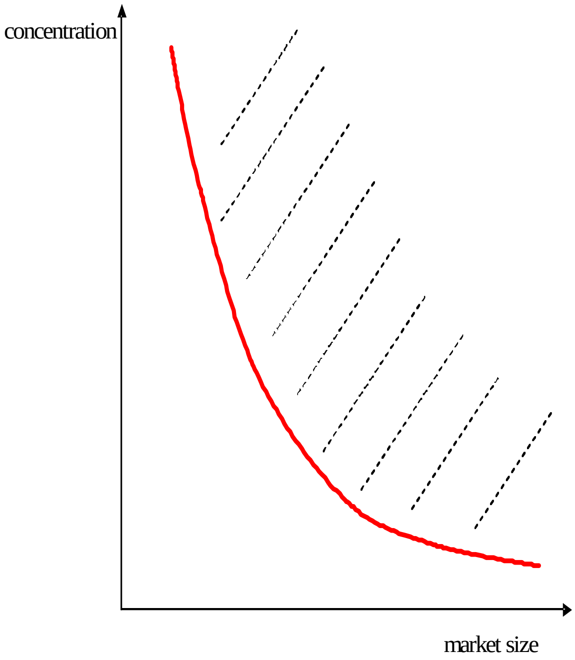


Fig. 2 Lower bound for concentration in high R&D intensity industries

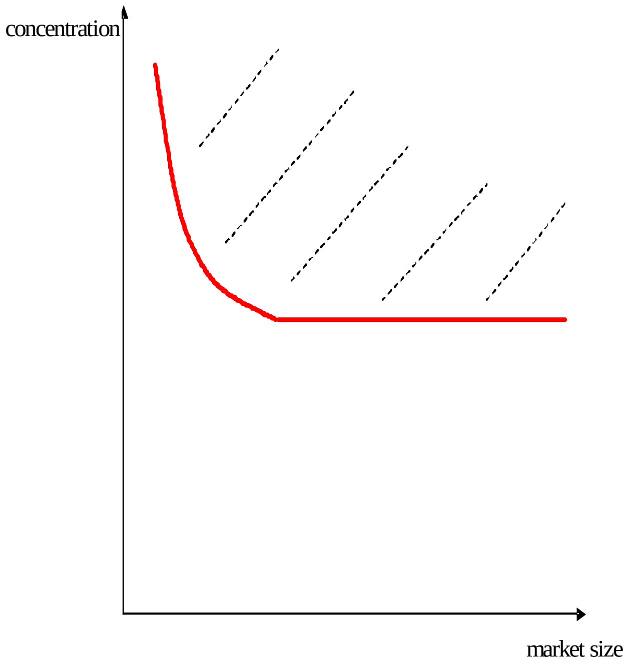


Fig. 3 Lower bound for concentration in low R&D intensity industries

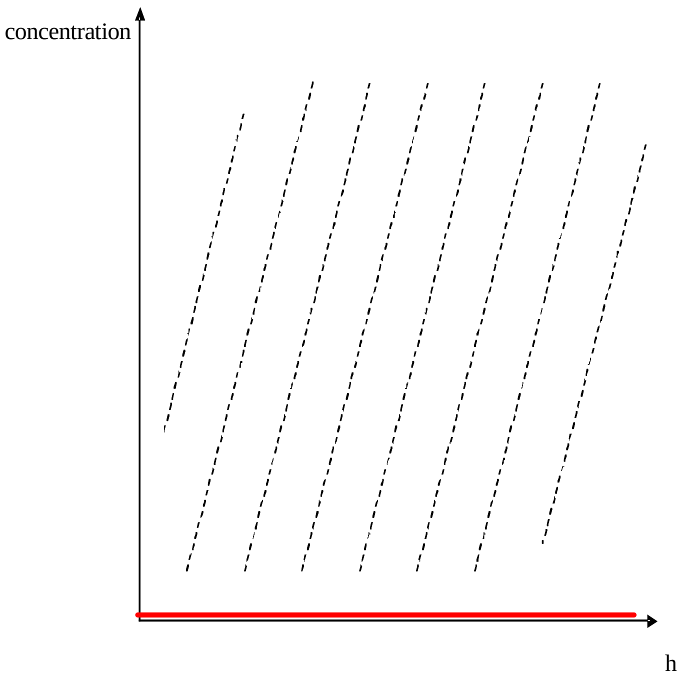


Fig. 4 Lower bound for concentration in high R&D intensity industries

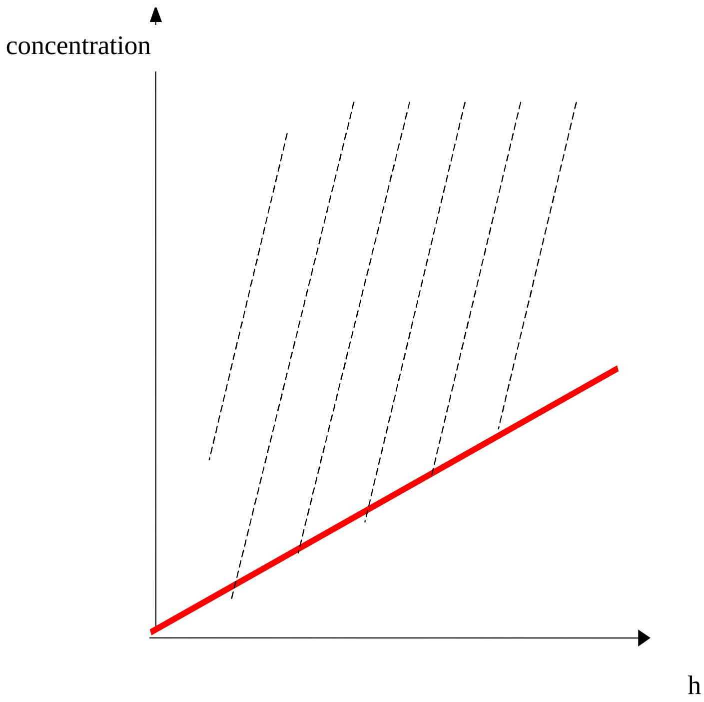


Fig. 5 : The relevant markets for MDC 22 (Burns)

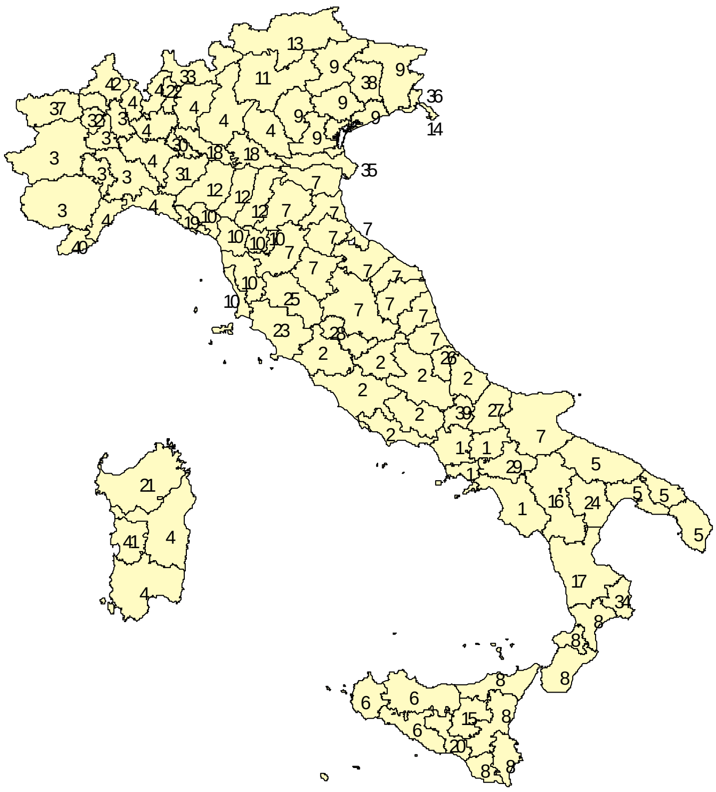


Fig.6: The relevant markets for MDC 15 (Neonatal Period Diseases)

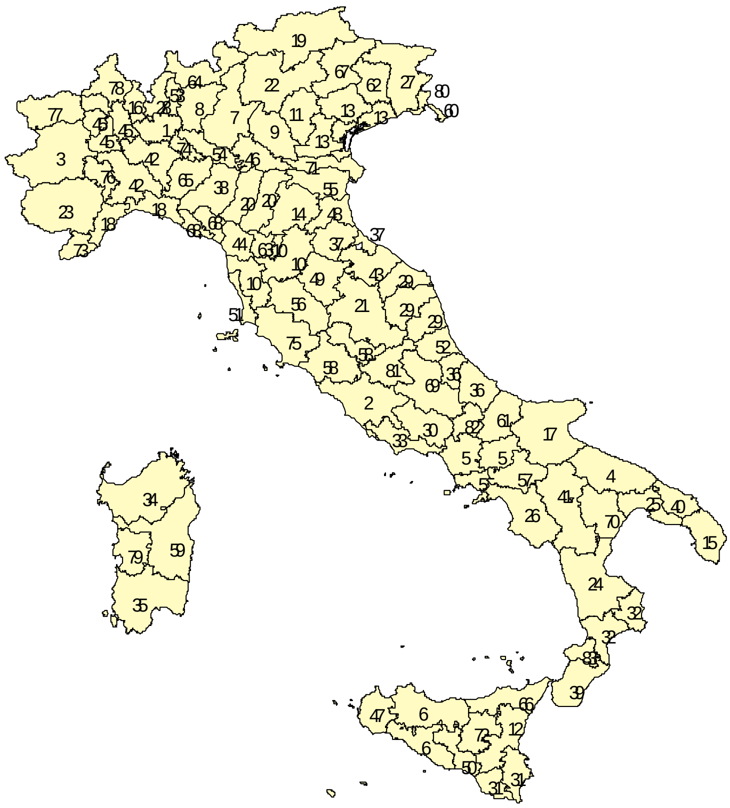


Fig.7 Market concentration and size in high-tech markets

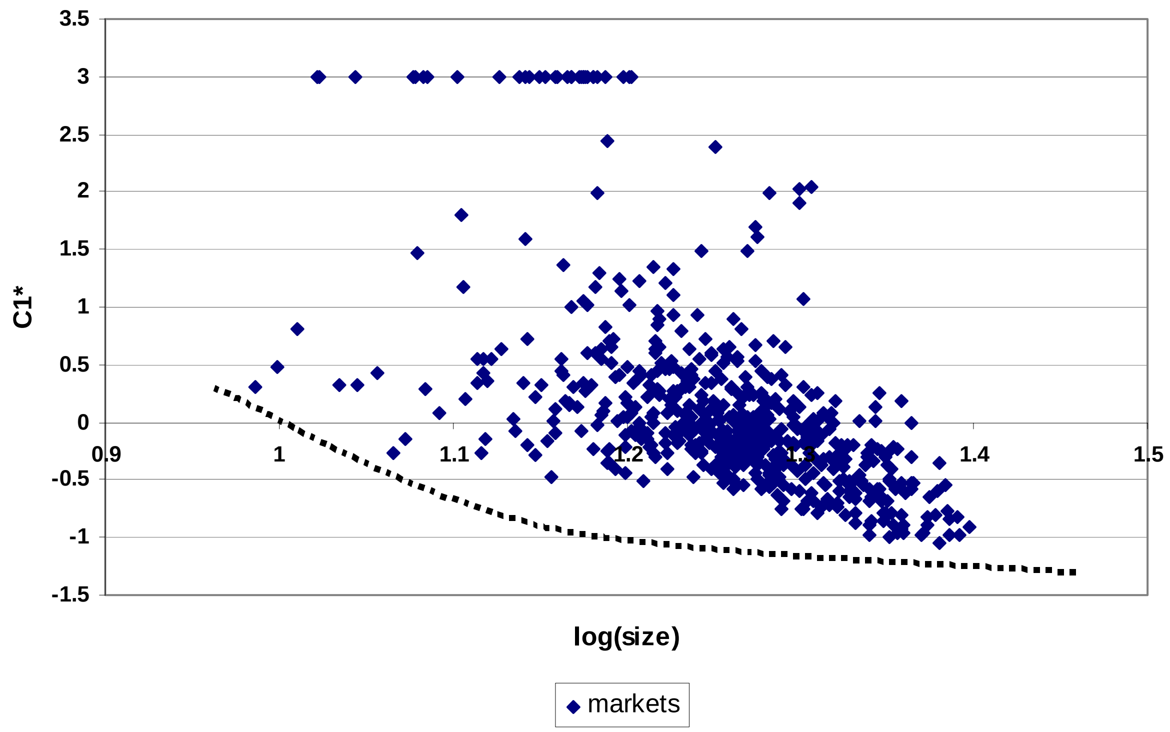
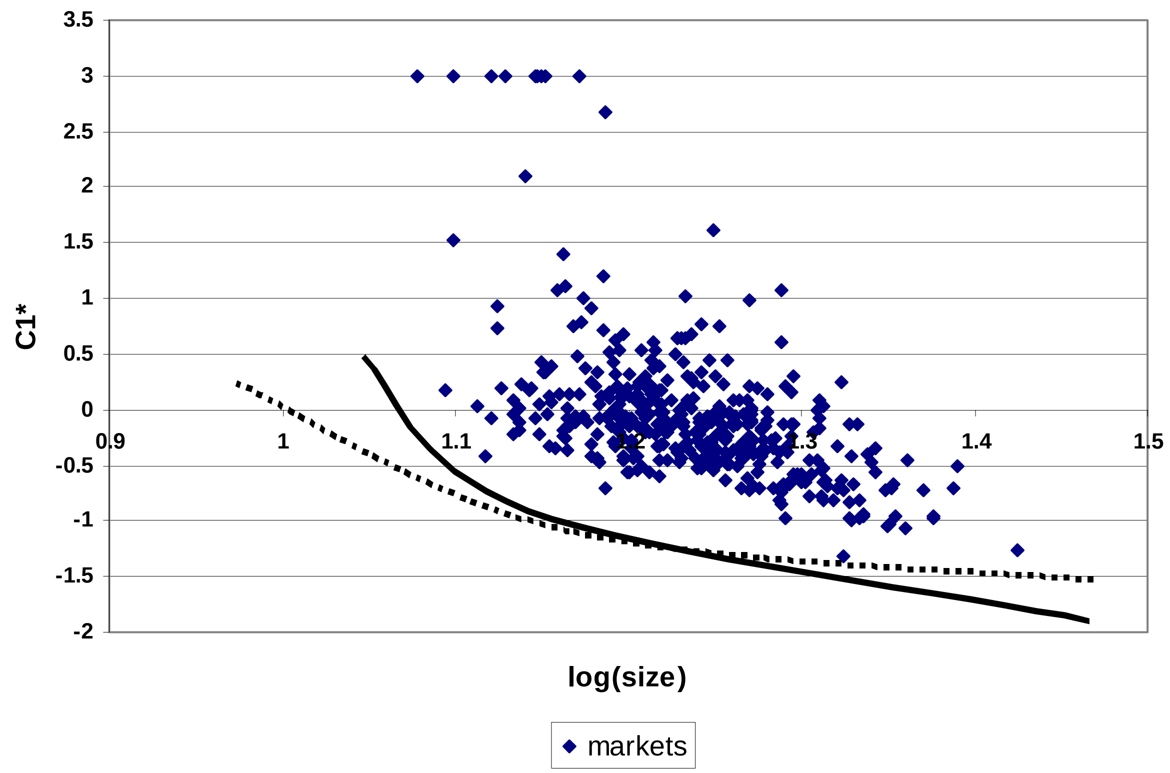


Fig.8 Market concentration and size in low-tech markets



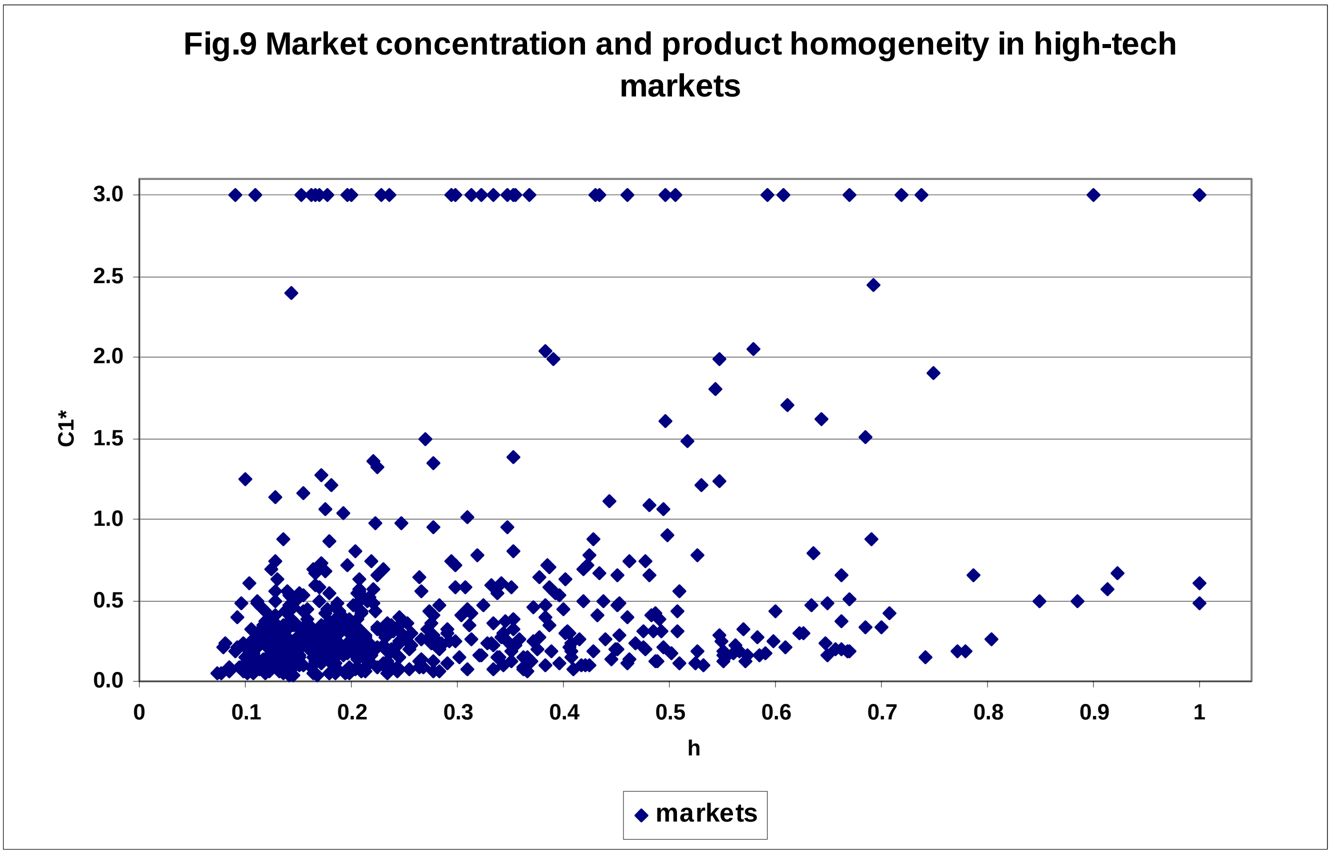


Fig.9 Market concentration and product homogeneity in high-tech markets
3.0
2.5
2.0
1.5
1.0
0.5
0.0
C1*
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
h
markets

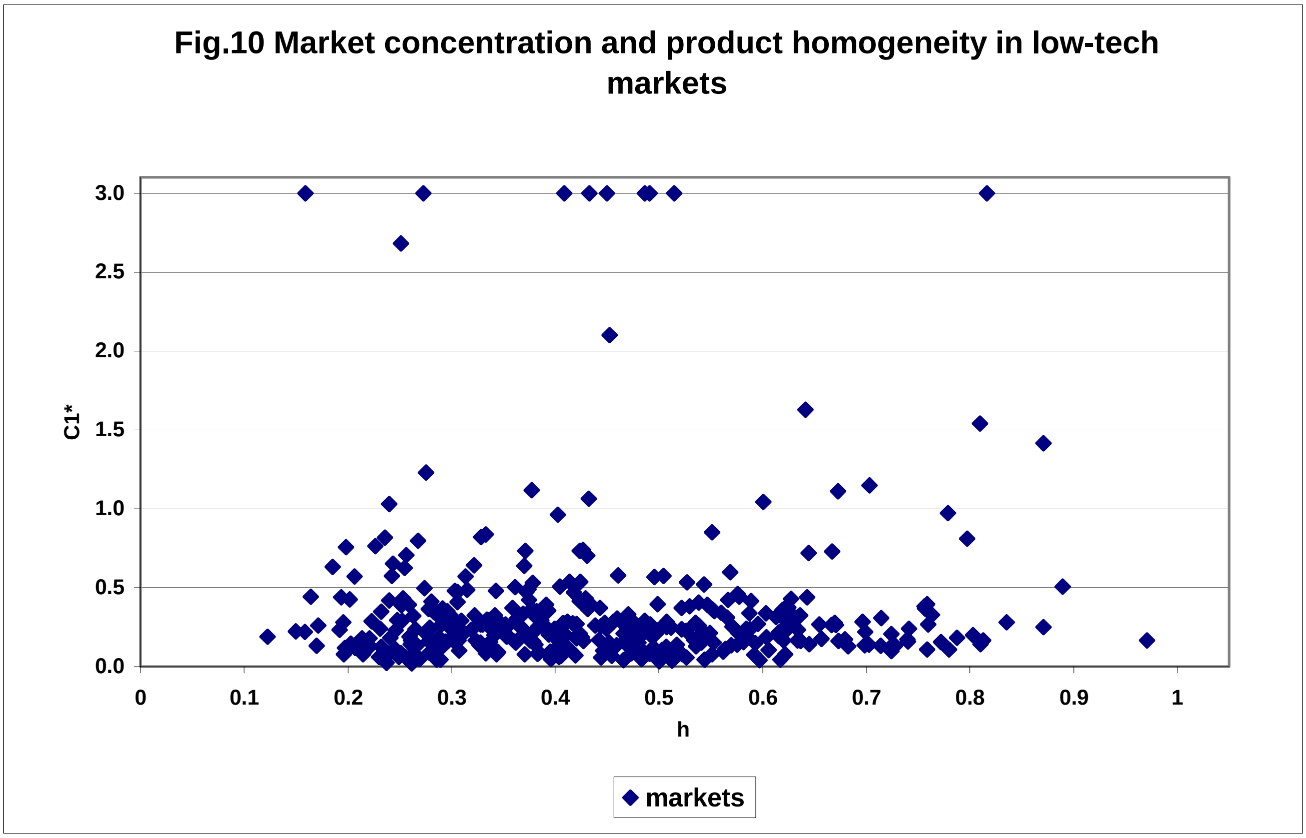


Fig.10 Market concentration and product homogeneity in low-tech markets
3.0
2.5
2.0
1.5
1.0
0.5
0.0
C1*
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
h
markets