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A multidimensional approach for the measurement of competitiveness and economic resilience: the design, production and exploitation of integrated micro level data[1]

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Abstract

The Istat new approach to the compilation of official business statistics, integrating into a single "statistical package" many information sources on firms' structure, strategies and performance, gives an answer to the demand for high-quality microdata to assess the vulnerability and resilience of the economic system. In this work we give some examples on how the new statistical package allows analysis of the heterogeneity within the economic system and helps measure at a very high level of disaggregation the performance of many segments of the production system, e.g. allowing to analyse the recent trends of firms' performance through the lenses of their structure and strategies.

Keywords: Frame-Sbs, heterogeneity, economic performance

1. Introduction

The assessment of the impact and the identification of the possible solutions in order to recover from the worst economic crisis since World War II have pushed researchers and policy-makers to intensify their efforts in understanding the determinants of competitiveness as well as the sources and the degree of resilience of economic systems in advanced countries.

The availability of reliable data clearly plays a crucial role in detecting the vulnerabilities (e.g. through effective "warning" indicators, see Röhn et al., 2015), in evaluating adjustment capability and structural change of an economic system (see Canova et al., 2014) and in assessing the effectiveness of policy measures (Garda and Zieman, 2014; Caldera et al., 2015). In particular, high-quality microdata are needed, that widen and deepen statistical information on the economic resilience, making it possible for example to take fully account of the heterogeneity within the production system. This goal may be attained by developing and enhancing the scope of Official Statistics in measuring business structure and performance.

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In this respect, a new approach for the compilation of official business statistics has been designed and implemented in recent years by Istat. This approach allows the production of high-quality official statistics according to the requirements of the EU regulations and, at the same time, statistical data to support the micro-meso and macro level of analysis of factors affecting the competitiveness of modern industrial systems. The latter task increasingly requires complex statistical information, able to combine aggregated measurements with quantitative evidence on the degree of heterogeneity within the system of enterprises. The greater the complexity and heterogeneity of the structure of a given economy, the greater the loss of information associated to an analysis based solely on aggregated figures. This particularly applies to the analysis of the Italian production system, which is characterized by highly specialized sectors and especially by an overwhelming role of small enterprises – the firms with less than 10 persons employed account for 95% of total units and for nearly 50% of total employment (compared to 29% on average in the EU).

The new Istat approach has two main components: on one hand, it heavily relies on a massive and intensive use of already available administrative data on Italian enterprises (e.g. fiscal, balance-sheets and social security data); on the other hand it complements this information with data collected through specialized statistical surveys. The aim is to develop a high-quality, consistent system of business statistics and economic indicators founded on the availability of good quality and timely business register, which represents a cornerstone for all information on the Italian productive system. This is particularly important when facing the need of detecting the factors of vulnerability and resilience of business systems, as is the case since the international crisis began.

As far as the first component is concerned, the result of the effort was the so-called Frame-SBS information system, including firm-level structural and economic information for each of the over 4.4 million Italian enterprises. In other terms, the mere sum of all firm's value added gives the official value added of the whole business system. More in general, the Frame-SBS dataset is aimed at playing a multifaceted role. Firstly, as just mentioned, it provides information on main profit-and-loss accounting data for each enterprise active in Italy in a given year, acting as the reference framework for the SBS annual statistics. Moreover, it is the cornerstone for further integration with other administrative and statistical microdata sources, referring to both structural and short-term trends. Finally, it is the reference framework for the convergence and consistency of many surveys on specific topics (e.g. the surveys on the industrial firms' turnover, the business climate or the perceived competitiveness factors of business units).

As expected, the new production system has determined substantial gains in terms of accuracy (as estimates of the main variables are free of sampling errors), consistency of business statistics over time and among business statistics domains (including National Accounts), and in perspective lower costs and respondent's burden.

The second component of the new approach to the production of business statistics encompasses a dedicated system of direct reporting surveys based on highly qualified samples focusing on well-targeted business populations. The aim of such surveys is to capture complementary (mostly qualitative) aspects of firms' activities (such as strategies, competitiveness strength points, possible participations in inter-enterprises relationships etc.). In doing so, they are particularly informative for multidimensional

analyses on the competitiveness of Italian firms and provide useful information for policy-making purposes.[4]

The availability of new and detailed quantitative and qualitative structural data on Italian businesses is a key factor for assessing the competitiveness and the performance of the economic system, and plays a central role to set up or fine tune policy measures oriented to boost productivity and employment growth. High quality information at high level of detail is essential in order to allow business analysts and policy makers to better analyse the characteristics and behaviour of sub-populations of firms, taking into account the fact that the Italian economic system is characterized by large heterogeneity in business performance.

In what follows, we use this "statistical package" to investigate some aspects of the performance (and vulnerability) of Italian firms from 2010 to 2014, namely in one of the most severe recessions of the Italian modern economic history. In particular, in Section 2 we describe the package (Section 2.1), showing how its first pillar – the Frame-SBS dataset – has been designed and implemented, and giving some examples about how it may take into account firm-level heterogeneity in order to investigate the vulnerable segments of the Italian productive system. Then (Section 2.2), the second pillar of the statistical package is illustrated, whose main component is at present the MultiPurpose Survey (MPS) carried out by Istat in the occasion of the 9th Italian Business Census (2012) on a very large set of firms' strategies. This survey allows to enhance the (structural) informative power of the first pillar taking into account the multidimensional nature of the firm's behaviour and performance. In Section 3 we show how the statistical package may be integrated with other short-term surveys, in order to analyse the persistence of the robustness and vulnerability factors over time, and to explain the most recent firms' performance – notably in such a difficult period as the 2011-2014 recession – on the basis of the structural and strategic "profiles" prevailing in the Italian business system. Section 4 concludes.

2. A "statistical package" for the analysis of competitiveness, resilience and vulnerability of Italian firms

The package is based on two pillars: the Frame-SBS dataset and the microdata of the MPS on firms' strategies. It needs to be reminded that, following a trend started in the last decade at Istat (see Giovannini, 2012), both datasets are made available also for research purposes through the Istat "Elementary data analyses laboratory − Adele". The next sections illustrate how the two pillars are designed.

2.1 Frame-SBS

The state-of-the-art of statistical tools and methods for the measurement of business phenomena makes it feasible the development of new indicators on the business structure and performance of specific sub-populations of businesses, consistent with the Business

[4] One recent example of such initiatives is the Think Tank on Competitiveness, Competition, Industry and Internal market, established by the Italian Presidency of the Council of Ministers Council and chaired by Enrico Giovannini (University of Tor Vergata, Rome), Gianluigi Tosato (LUISS, Rome) and Monica Frassoni (co-president of the European Green Party).

Register (BR) frame and Structural Business Statistics (SBS) figures, such as enterprises engaged in international activities, with limited costs and in a relatively short time span.

In Italy, SBS has been traditionally estimated using data collected through two direct annual surveys: the sample survey on Small and Medium Enterprises (SMEs; about 100,000 sampled enterprises with less than 99 persons employed representing a population of about 4.4 million of units), and the total survey on Large Enterprises (LEs; about 11,000 enterprises with 100 or more persons employed). Both surveys estimate totals of profit-and-loss accounts variables, employment, investments etc. in the industrial, construction, trade and non-financial services sectors. A large number of secondary variables are also included, mainly for National Accounts estimation purposes.

The development of new methodologies finalised to the statistical processing, and the quality improvement of administrative data sources has opened the floor to substantial information gains in the structural business domain. In particular, the applied and theoretical methodological research in this area increasingly focuses on the exploitation of micro-level data from available administrative data sources consistently with statistical standards and procedures. The increasing availability of business data from administrative sources also led to reconsidering and improving the use of direct reporting for the compilation of business statistics.

At Istat, the traditional SBS estimation strategy has been completely reversed from 2010 as reference year with the development of the Frame-SBS (Figure 1). In the new system, administrative and fiscal data are used as primary source of information (after due harmonization, they cover about 95% of the whole target population), while SMEs and LEs data essentially play a complementary role.[5]

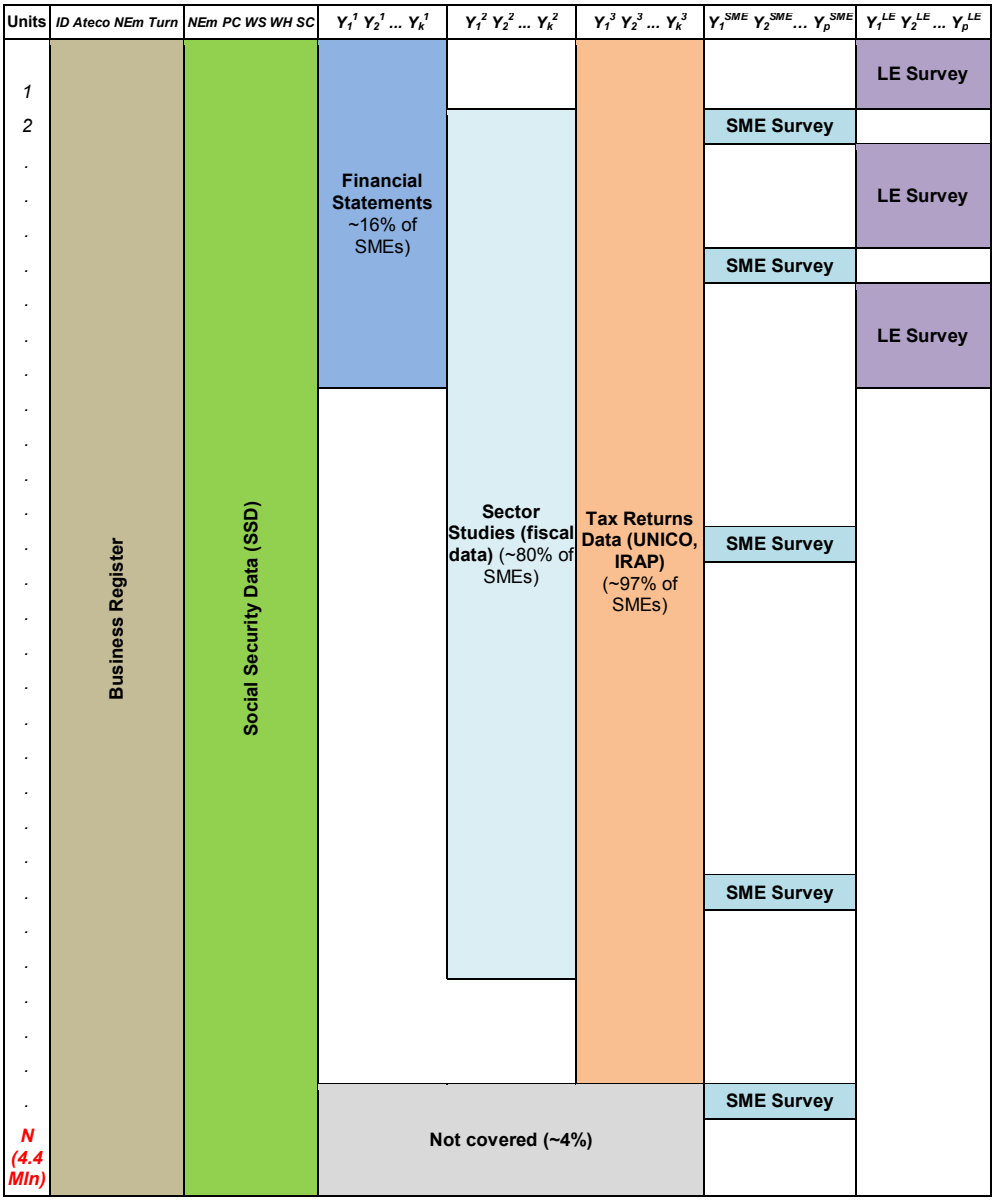
Fiscal data represent the most important administrative source: “Sector Studies” on smallest enterprises account the basic economic data for 67% of total enterprises (2.9 Mln); balance sheets on companies account for 16% (700,000); fiscal declarations data are used to estimate the main variables for 14% of businesses (600,000). Social security data on employment and wages are used for all the enterprises with employees (about 1.3 Mln). For the largest enterprises all the variables are collected by the LE survey.

As a consequence, a number of key economic variables (including turnover value added, labour cost, wage, export) are available at firm-level for the overall SBS population, namely the whole Italian business system (about 4,4 million of units in 2013; over 16 million of persons employed). The corresponding totals can be obtained at any level of detail (e.g. 4-digit Nace sectors) by merely summing-up firm-level data.[6]

[5] Each combined source actually covers different - yet partially overlapping - sub-populations of enterprises, and some sources provide information on (partially overlapping) variables:. Therefore for each source, this “common” information has been used for assessing the quality of input data, for harmonizing classifications and definitions with SBS concepts described by the SBS regulation, and for editing micro-data (identification of logical inconsistencies/measurement errors, removal of duplicated units, etc.).

[6] It has to be mentioned here that for some additional variables (such as many types of intermediate costs) statistical imputation is adopted to compensate for the sources under-coverage (see Luzi *et al.*, 2014 and 2015).

Figure 1 – Coverage and components of the Frame-SBS dataset



The "core" variables of the Frame-SBS represent the main aggregates requested by the SBS Regulation; the other SBS variables included in the statistical (components of the main economic variables etc.) are estimated at pre-defined levels of detail using a design based/model assisted approach (known as "projection estimator"), which exploits the randomization process of the SME sample selection under consistency constraints (as the

estimated totals of the components variables which contribute to a given main economic variable are to be coherent with respect to the estimated total of the aggregate itself, at domain level).[7]

The Frame-SBS is now the pillar of the new system of economic statistics in Italy, according to the innovation strategy launched in 2011 (Monducci, 2010), successively reinforced by a new modernization project started in 2014 (Alleva, 2014).

What is more, Frame-SBS is also the basis for a number of other uses. Allowing estimates for key economic account variables at a very detailed level, it facilitates the dissemination to end-users of larger, more detailed and better focused data. Furthermore, the Frame-SBS is currently used to estimate official SBS variables as well as aggregates of National Accounts at sector level.

Finally, the availability, on an annual basis, of main profit-and-loss accounts data on all companies active in Italy allows to carry out insightful analyses on both business structure and dynamics. As for the former, it is possible to assess the degree of heterogeneity within the business system, identifying the better- and worse- performing segments (e.g. sectors, clusters, etc.).

With regard to the dynamic analysis, the statistical register Frame-SBS allows to longitudinally evaluate the performance of single production units, pointing out for example the firm- and sector-level developments underlying the aggregate dynamics. This latter element is particularly important for an assessment of the resilience and vulnerability of the Italian business system, as the Frame-SBS dataset makes it possible to monitor on an annual basis the relative competitive position of all the Italian firms within their own sector or across the entire business system, in terms of profitability, productivity and other economic performance indicators. At the same time, it helps evaluate the economic features of entrant and exiting firms.[8]

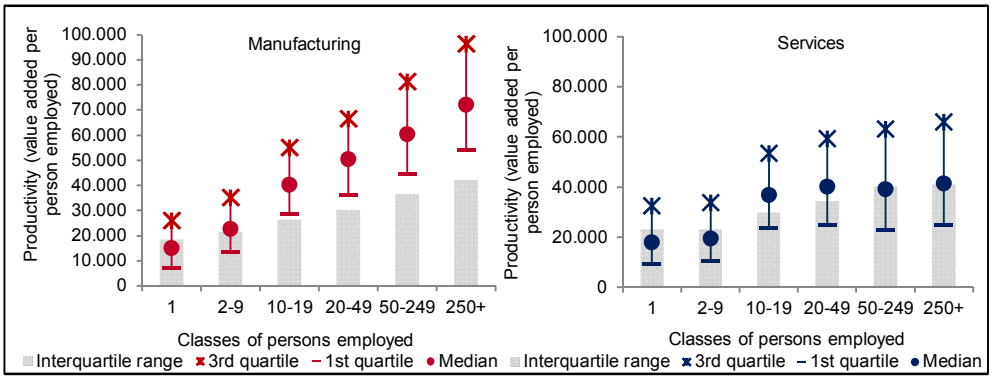
In order to better illustrate the informative potential of the Frame-SBS register, Figure 2 reports some statistics about the distribution of the labour productivity by firms' size classes in 2013, in manufacturing and services sectors.

Besides confirming the well-known positive correlation between firm's size and productivity, the data show the heterogeneity within all size classes, revealing for instance that with the exception of the micro enterprises segment, in any other size class the most productive firms (i.e. the ones belonging to the fourth quartile of the productive distribution) perform better than the median firm of the next higher size class. This is even more evident in the services sectors, where the third quartile of labour productivity in the 10-19 class is about 30% higher (and the third quartile of 20-49 class is over 40% higher) than the median value of the productivity of large firms (250+ persons employed).

[7] For further details on the methodology of construction and estimates of Frame-SBS see Luzi *et al.* (2014 and 2015).

[8] But see below for some important caveats regarding the difference between such "entry and exit" aspects and "true" business demography.

Figure 2 – Value added per person employed, by size classes – 2013 (euros)

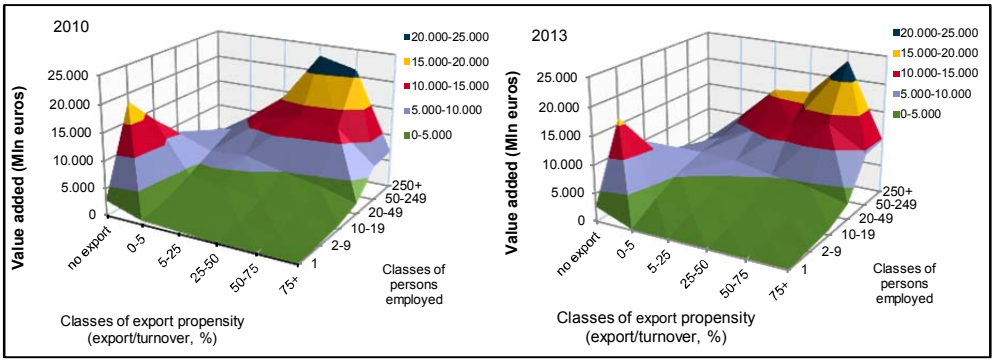


Source: Authors' calculations on Frame-SBS dataset.

Furthermore, the Frame-SBS is particularly powerful in the analysis of the structure and competitiveness of the Italian exporting firms. It is also the basis for the production of the official statistical information on the performance of Italian exporting firms, thanks to the integration with the *Trade by Enterprises Characteristics* (TEC) database (see e.g. Istat and ICE, 2015).

On such bases, Figure 3 reports the composition of value added in manufacturing sector by classes of firms' size and export propensity (measured by the export to turnover ratio). The relevant role of the exporting firms in shaping the overall performance of the Italian business system clearly emerges: in 2013 the value added of these firms (about 80.000 units) accounted for 82% of the total (it was 81% in 2012 and 77% in 2010), and the "Highly exporting" (i.e. firms with export over 50% of their turnover) accounted for 31.2%. What is more, between 2010 and 2013, also following a demand gap between foreign and domestic demand, the value added of exporting firms increased by 9 Billion euros, while the value added of non exporting firms decreased by nearly 10 Billion euros. The largest increase occurred in firms exporting over 75% of their turnover: +42% on average in all size classes with 10+ persons employed.

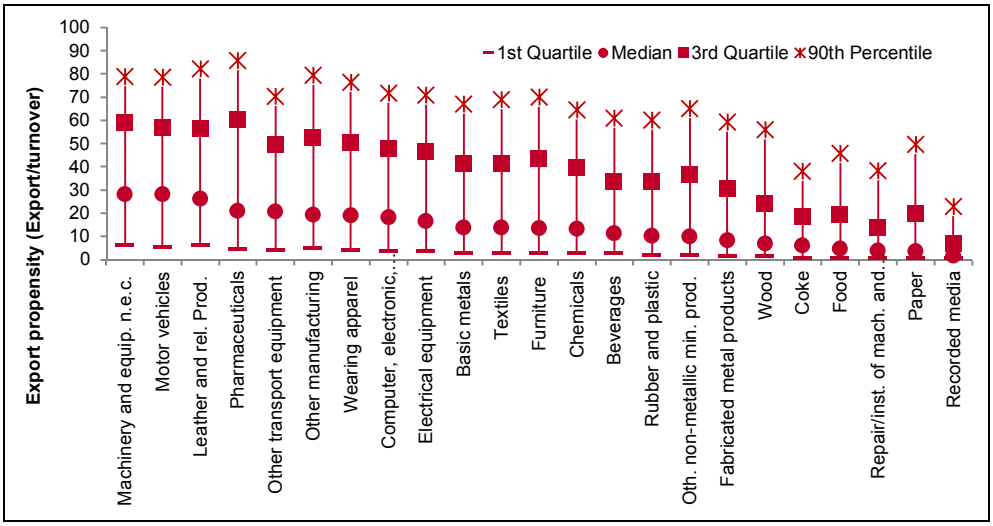
Figure 3 – Value added, by size classes and classes of export propensity; Manufacturing sector – 2010 and 2013



Source: Authors' calculations on Frame-SBS dataset.

The possibility of studying the export propensity of the Italian economy, both in cross-section and longitudinal analyses, is particularly relevant when considering periods when the foreign demand has been basically the only source of economic growth for Italian firms, like in 2010-2013.[9] In this respect, the Figure 4 reports the 2013 distribution of the export-to-turnover ratio within manufacturing sectors (only exporting firms are considered).

Figure 4 – Export propensity by Division of economic activity (2-Digit Nace). Manufacturing sector – 2013 (Only exporting firms considered; export to turnover ratio; percentages)



Source: Authors' calculations on Frame-SBS dataset.

On the one hand, it can be noted that among the most export-oriented activities there are some important industries of the Italian specialization model (Machinery, Motor vehicles, Leathers and Other transport equipment). On the other hand, it clearly emerges that even in these sectors − and all the more in less internationalized activities – the firms' export revenues generally account for just a fraction of their total turnover. In no industry, for example, the median export-to-turnover ratio reaches 30%, and in most cases it barely reach 20%. In other terms, notwithstanding Italy stands out among main European countries for its high number of exporting firms (nearly 200.000 units, in EU only Germany has a larger number; see Istat, 2014 and 2015a), these are basically "low-intensity exporters", and in 2013 even the overall performance of the Italian exporters was largely shaped by the domestic demand dynamics.

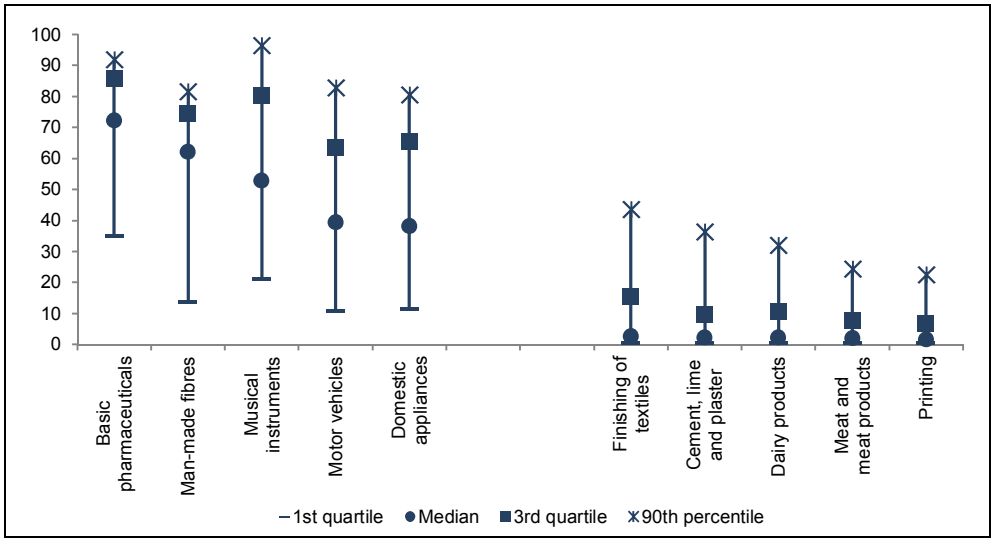
Moreover, due to the additive nature of the new dataset, these results can be verified also at a more disaggregate level (Figure 5): taking into consideration 3-digit Nace activities (but even 4-digit Nace might be considered), the median export-to-turnover ratio

[9] For further examples of the use of Frame-SBS in the analysis of the internationalization of Italian firms, see Istat (2015), and Costa *et al.* (2015b).

ranges from 53 to over 70% in sectors where the presence of foreign-owned enterprises is relatively frequent (Basic pharmaceuticals, Man-made fibres and Musical instruments), while in the remaining two sectors out of the top five export-oriented ones – Motor vehicles and Domestic appliances – it is around 40%, i.e. slightly more than the overall SBS average (34%). In this respect, therefore, the Frame-SBS provides a valuable basis for further investigations on the very sources of resilience and vulnerability of the Italian economy during the second phase of the Great Recession (2010-2013), when the business system had to deal with a growing foreign demand and a falling domestic demand.[10]

The new integrated dataset, allowing to assess export performance at a very disaggregate level, also makes it possible to calibrate policy measures aimed at improving the competitiveness of the Italian business system on foreign markets. In this respect, for example, the interquartile range of the export-to-turnover ratio may become a policy target for increasing the export propensity of the (numerous) already exporting firms.

Figure 5 – Export propensity by Groups of economic activity (3-Digit Nace): top and bottom values. Manufacturing sector – 2013 (Only exporting firms considered; export to turnover ratio; percentages)



Source: Authors' calculations on Frame-SBS dataset.

2.2 MultiPurpose Survey on Competitiveness of Italian firms - MPS

As regards the system of direct reporting surveys for the analysis of business competitiveness, the starting point has been the launch of a first, large scale survey (MultiPurpose Survey on Competitiveness of Italian firms - MPS) on the main factors of competitiveness of Italian firms, carried out in the occasion of the 9th Italian Business Census.

[10] See Section 3 for further details and examples on this.

As the purpose is to obtain a "map" of the firms' strategic choices and behaviour, in order to maximize the informative power of the survey the reference universe included only units with a "minimal organizational structure", i.e. with decision-making processes involving more business functions, ruling out, for example, almost all individual units.[11] In doing so, the survey (sample for the units with 3-19 persons employed, and a census for those with at least 20 persons employed; 250.000 enterprises surveyed in total) has collected qualitative data on a number of aspects of firms' behaviour, in particular entrepreneurship, governance, human capital management, inter-enterprise relationships, market orientation and competitiveness, innovation, internationalization, finance. Moreover, this type of surveys will be replicated in the future (even though on smaller samples of firms) on a periodic basis so as to monitor the evolution of structural competitiveness factors of the production system and the evolution in terms of modernization, competitiveness and growth potential.

The MPS 7-section questionnaire focused on the following thematic fields:[12]

a. *Entrepreneurship, control and governance*. The section addresses the "firms' identity", i.e. collects information on the firm's ownership structure, the management responsibilities, and decision-making processes. A subsection investigated the entrepreneurship in firms with less than 10 persons employed, in order to provide complementary information on a production segment which is still not covered by official business statistics. In particular, this subsection focuses on the main features of micro-entrepreneurship, such as the entrepreneur's age, nationality, gender, educational qualifications or previous working experience, as well as the effects of possible generational transitions of the business ownership.
b. *Human capital*. In the light of the importance of human capital as a strategic resource for a firm's competitiveness, gathered information refer mainly to the endowment of (and investment in) high-skilled human resources, staff training and caring for specific technical and specialized competences.
c. *Inter-enterprises relationships*. Since in such a fragmented and networked system as the Italian one business competitiveness depends not only on competitive strategies but also on firms' ability to activate productive relationships with other enterprises or institutions, this section investigates whether and to what extent Italian firms participate in business network.[13] Information are gathered on the type of relationship (subcontracting, network, joint ventures, consortia, informal relationships etc.), their goals, and the possible difficulties in activating them.
d. *Market*. Questions in this section position the company in its markets, gathering information – among others – on the extension of the market the firm operates in (local,

[11] The reference universe was identified in all the companies with no less than 3 persons employed (about 1.1 million units), that in 2011 employed almost 12.5 million persons employed (more than three fourths of the whole production system). Firms below a minimum complexity threshold were excluded. Due to the large observation field, a mixed investigation technique was adopted, with a census coverage for the over 75,000 companies with at least 20 persons employed and a sample survey on more than 180,000 entities with 3-19 persons employed.

[12] Other aspects, such as the provision and the use of ICT, since they are instrumental and pervasive in the business activities, were not investigated in a specific section of the questionnaire but were analyzed through single questions in different thematic sections.

[13] Here and in what follows the terms "Firms network" and "inter-enterprise relationships" are used as synonymous.

national, international), the location of firm's competitors, the firm's competitiveness strength points (price, quality, product diversification, production flexibility, location, etc.).

e. *Innovation*. This section addresses the complexity of innovation process, detecting the complementarity of different forms of innovation (product, process, organizational and marketing) and the main strategies adopted to support the innovative activity (e.g. R&D; acquisition of patents and licenses; marketing). The section also collects information about the ICT use in firms with less than 10 persons employed.
f. *Finance*. The questions of this section focus on the various firms' financing sources, both internal (e.g. self-financing) and external (such bank loans, risk capital etc.). Further information was also gathered about some aspects of the bank-firms relationships (such as the possible presence and role of a main bank).
g. *Internationalization*. This section aims at identifying the possible productive internationalization of firms, in terms of foreign direct investment, international productive agreements or both, collecting information also on motives and obstacles.

However, the main added value offered by the MPS survey is the possibility of adopting a cross-thematic perspective, for example to create a "map of strategies" of the Italian enterprises. In this respect, a two-step clustering procedure made it possible to group all the Italian firms in the following five strategic profiles.[14]

1. *Conservative firms*. It is the largest cluster (670 thousand entities, almost 64% of the total, almost 6 million persons employed). It includes firms with an average size of 8.9 persons employed, mostly operating in services and construction. These units are scarcely innovative (only 20% of them do innovate) and mainly focusing on sub-national markets (almost 67%). "Conservative" firms operate generally in Italian Southern and (to a lesser extent) Central regions. Finally, it is noteworthy that even though this group largely includes micro-enterprises, it also contains large firms, so that the profile of "conservative firm" characterizes a substantial portion of the overall Italian production system.
2. *Pocket-sized dynamic firms*. This cluster includes almost 205 thousand entities (nearly 20% of companies, with 2.6 million persons employed), with an average size of almost 13 persons employed and no strong connotation in terms of firm size. Such firms mainly compete on production diversification and product innovation (more than half of them are innovation oriented), but their strategies are mostly focused on sub-national markets (55.8%).
3. *Open firms*. This cluster includes 75 thousand entities with 1.7 million persons employed. The firms' size distribution is quite uniform (5% of the total of micro-enterprises, 12% of small firms, 15% of medium-sized firms, 17% of large ones), with an average size of 22.8 persons employed. Open firms mostly operate in industrial sectors (42.7%) and on international markets (almost 70%), innovate (59.1%) and activate inter-enterprises relationships (100%).

[14] In particular, the procedure proceeded as follows. Firstly, a multiple correspondence analysis was carried out in order to synthesize over 100 variables on firms' strategies included in the MPS1 survey. This led to identifying three "basic profiles" (factorial axes) associated with various dimensions the competitiveness of domestic firm. These profiles were mainly characterized by firms attitude towards innovation, internationalization, networking. Then, a mixed (i.e. with both hierarchical methods and non hierarchical algorithms) clustering procedure was carried out on these profiles, leading to the five groups illustrated in the text. For further detail see Istat (2013).

4. *Innovative firms*. This cluster includes 74 thousand companies with 1.5 million persons employed (average size of nearly 20 persons employed). Strategies of these units are mostly focused on the product and process innovations, but also on marketing innovation. Moreover, almost all firms in this group participate in productive inter-enterprise relationships and mostly compete on price and product quality, but their activity is mainly domestic-market oriented.
5. *Highly internationalized*. This cluster includes "only" 27 thousand units (2.6% of thee total)and 1.1 million employees, (average size of 40 employees). There are 1.9% of the whole micro enterprises, 5% of small ones, 11% of middle ones and 15% of large firms. These units mostly belong to enterprise groups and industrial sectors (while services are scarcely present), operate internationally ((over 90%), are strongly networked (100% of them participate in an inter-enterprise relationship) innovate (68.9%), and compete mainly on production flexibility and product diversification. Almost 50% of these firms are located in the Italian North-Western regions.

As a consequence, the MPS survey helps add some insights about the capability of resilience and competitiveness of the Italian production system, for example disentangling at firm-level the strategies leading to growth from the ones leading to "fatness". In particular, notwithstanding an extremely fragmented business structure, "truly" competitive behaviours and strategies seem within reach (and are actually undertaken) also for a segment of small-sized enterprises. At the same time, conservative and defensive attitudes are still widespread, also among medium and large companies.

3. Testing the pack in the scrum: an analysis of Italian firms' performance during the "double-dip" period (2010-2014) through the Frame-SBS and MPS dataset

The two-pillar statistical package represents the backbone of a number of possible analyses about the resilience and competitiveness of the Italian business system, allowing to properly consider not only the quantitative aspects – such as changes in employment, turnover, productivity etc. – but also the qualitative factors underlying the capability for Italian firms to survive or even thrive during a crisis. Some analyses of this kind have been already carried out and published by Istat (2014, 2015a and 2015b).

In this section we give some additional examples of such information potential for analyses of the resilience of the Italian production system. Firstly, we use the Istat data on business demography and Frame-SBS dataset to point out how the structural characteristics of the business system changed during the last recession (in terms of entry and exit from the business register, shifts along size distribution and so on). In this case the time span is limited by the availability of data on structural business statistics, namely the 2010-2013 period.

Then, the Frame-SBS and Business Census MPS datasets are integrated with the information from the Monthly Survey on the turnover dynamics of manufacturing firms, in order to depict the microeconomic developments underlying the performance of the business system in 2012-2014. This is particularly important in analysing the vulnerability and strength points of the system in a period characterized by two relevant factors: an increasing gap between domestic and non- domestic markets (which made the capability of

competing on international markets a survival matter for Italian firms) and the beginning of recovery (in last quarter 2014).

3.1 The Italian business system through the 2010-2013 recession: structural aspects

The information potential of Frame-SBS is remarkable also in the light of the business demography prevailing in Italy (see Istat, 2015c). Italian business system typically shows a noteworthy stability and persistence of active enterprises over time, with very low birth and death rates. This is accompanied by a gross annual rate of employment turnover (ratio of the total number of jobs involved in firms' births and deaths and the total number of persons employed in the firms) of about 5% (some 800 thousand employees).

This is important, as actually by its nature the Frame-SBS does not allows to analyse "real" business demography. The appearance of a firm in the business register for the first time – i.e. something usually defined as an "entrant" firm − does not necessarily indicate a genuine birth of a new business (see e.g. Criscuolo et al., 2014). It may also reflect an array of other possible events that may give rise to new legal entities, such as company spinoffs, the establishing of new firms within an enterprise group; mergers of more companies; the restructuring of existing firms, the renaming of companies .

Similar issues apply to the definition of "exiting" firm. For the same reasons, the presence of a firm in the business register in two or more years does not necessarily rule out the possibility that during that period some corporate events took place without any change in the firm's name or statistical code. Therefore, in analysing phenomena such as firm's employment dynamics it has to take into account that the possible change observed in the number of persons employed can be the result of an internal as well an external growth (e.g. through an acquisition of another company).

Considering all these caveats, the Frame-SBS dataset allows to assess the changes occurred in the Italian business system during the last recession. Including information on firms' structure and behaviour, the dataset makes it possible to evaluate whether (and how) the Italian productive system that is coming out from the crisis differ from the one that entered it, for example in terms of number and size of the units, employment, and (labour) productivity.

In this vein, considering only the enterprises with at least 1 person employed, some 3.3 million units resulted active both in 2010 and 2013 (about 75% of the 2010 total, accounting for 87% of total employment), with an overwhelming presence of micro-enterprises (95% of the Italian firms have less than 10 persons employed) that is one peculiarity of the Italian business system (see e.g. Istat, 2014).

In 2010-2013 about 21% of the firms increased the number of persons employed. The share is 19.8% for the micro-enterprises and much higher in the small and medium sized enterprises (about 40%). From a sector perspective, the share of firms with a net job creation is higher in manufacturing (30%) than in the service sector (19,7%). These changes have partially modified the structure of Italian firms by size. In particular, the transition matrix in Table 1 shows how in 2010-2013 Italian firms moved across the size classes (in terms of persons employed): the main diagonal indicates the persistence in the same employment class, while the cells below (above) that diagonal show the transitions towards higher (lower) size classes.

A noticeable persistence emerges, especially in the lower size classes that are traditionally more stable (also during the first phase crisis; see Istat, 2011). Of the nearly 3,3 million firms included in the business register both in 2010 and 2013, 2.9 millions (about 87.5%) remained in the same classes; over 190,000 (6% of the total) moved towards higher classes and a similar amount (about 216.000, 6.6% of the total) shifted downward. This net movement downwards involved over 2.3 million persons employed (16% of the total): nearly 680 thousands (almost 5% of the total) employed in the firms moving upwards, and over twice as much (1.5 millions, 11.1% of the total) involved in the shifts downward.

Table 1 – Transition matrix: shifts and persistence of firms in the classes of persons employed between 2010 and 2013 (firms with at least one person employed)

2010 size class	2013 size class						Total
	1	2-9	10-19	20-49	50-249	250+	
1	**1.630.708**	150.264	1.218	330	52	5	1.782.577
2-9	165.821	**1.105.768**	26.502	1.825	292	19	1.300.227
10-19	3.299	31.100	**79.087**	7.954	366	9	121.815
20-49	1.000	2.906	7.770	**33.081**	2.787	27	47.571
50-249	217	515	378	2.328	**14.838**	427	18.703
250+	15	25	7	38	369	**2.700**	3.154
Total	1.801.060	1.290.578	114.962	45.556	18.704	3.187	**3.274.047**

Source: Authors' calculation on Frame-SBS dataset.

Despite this, in the same period over 50% of firms increased their value added, and 15% showed a simultaneous increase in value added and employment. On the other side, 43% of firms have experienced a fall both in value added and employment. The share of these "declining" firms is quite stable across the different size classes, while the share of the "growing" enterprises is very low in micro-enterprises (13%) and higher in the other classes (28%-31%).

Such developments resulted in changes in labour productivity distribution.[15] The new transition matrix in Tables 2a-2b reports how in 2010-2013 firms either remained within the same quartile of labour productivity or moved into higher/lower quartiles, with respect to the whole economy (Table 2a) and firms' size classes (Table 2b). As for the former, the persistence is much lower with respect to the previous transition matrix: among the firms included in the business register both in 2010 and 2013, 51.6% of the units (about 1.7 million firms) remained in the same quartile of productivity.

[15] In order to take account of the technological differences between the sectors, each firm is classified on the basis of the quartiles of the 2-digit Nace industry it operates in. In this respect, for example, two firms both assigned to the second quartile but operating in two separate sectors may have very different levels of productivity, because each of them belongs to the second quartile of its own industry.

Table 2a − Number of enterprises by quartile of Labour productivity (value added per person employed). Years 2010-2013 (firms with at least one person employed)

Quartiles of Productivity (2010)	Quartiles of labour Productivity (2013)				Total
	Q1	Q2	Q3	Q4	
Q1	**342.797**	187.079	84.677	39.471	654.024
Q2	209.548	**346.020**	200.951	60.954	817.473
Q3	98.793	208.627	**400.308**	185.681	893.409
Q4	56.419	64.707	188.909	**599.106**	909.141
Total	**707.557**	**806.433**	**874.845**	**885.212**	**3.274.047**

Source: Authors' calculation on Frame-SBS dataset.

As far as firms' size classes are concerned, the persistence in the same quartile of productivity during (most of) the "double dip" period increases as we move towards the highest size classes, from 50% of micro firms to 75% of large-sized enterprises. More importantly, in every size class a "net movement" towards lower quartiles of labour productivity is observed: 1.8 percentage points among the micro enterprises (i.e. the downward shifts outnumbered the upward ones by over 57,000 units), 5.7 p.p. for the small-sized ones (about 9,700 units), 5.9 p.p. among the medium-sized firms (1,000 units), and only 0.9 p.p. among the large-sized enterprises (29 units).

Table 2b − Number of enterprises by quartile of Labour productivity (value added per person employed) and firms' size classes. Years 2010-2013 (firms with at least one person employed)

2010	2013					2013				
	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4	Total
Q1	**340.140**	185.728	83.800	38.374	648.042	**2.240**	1.202	763	940	5.145
Q2	206.788	**338.828**	195.217	58.870	799.703	2.422	**6.432**	5.167	1.858	15.879
Q3	94.813	202.646	**374.452**	170.729	842.640	3.588	5.514	**23.326**	13.613	46.041
Q4	50.043	61.617	174.179	**506.580**	792.419	5.567	2.772	13.377	**80.605**	102.321
Total	691.784	788.819	827.648	774.553	**3.082.804**	13.817	15.920	42.633	97.016	**169.386**

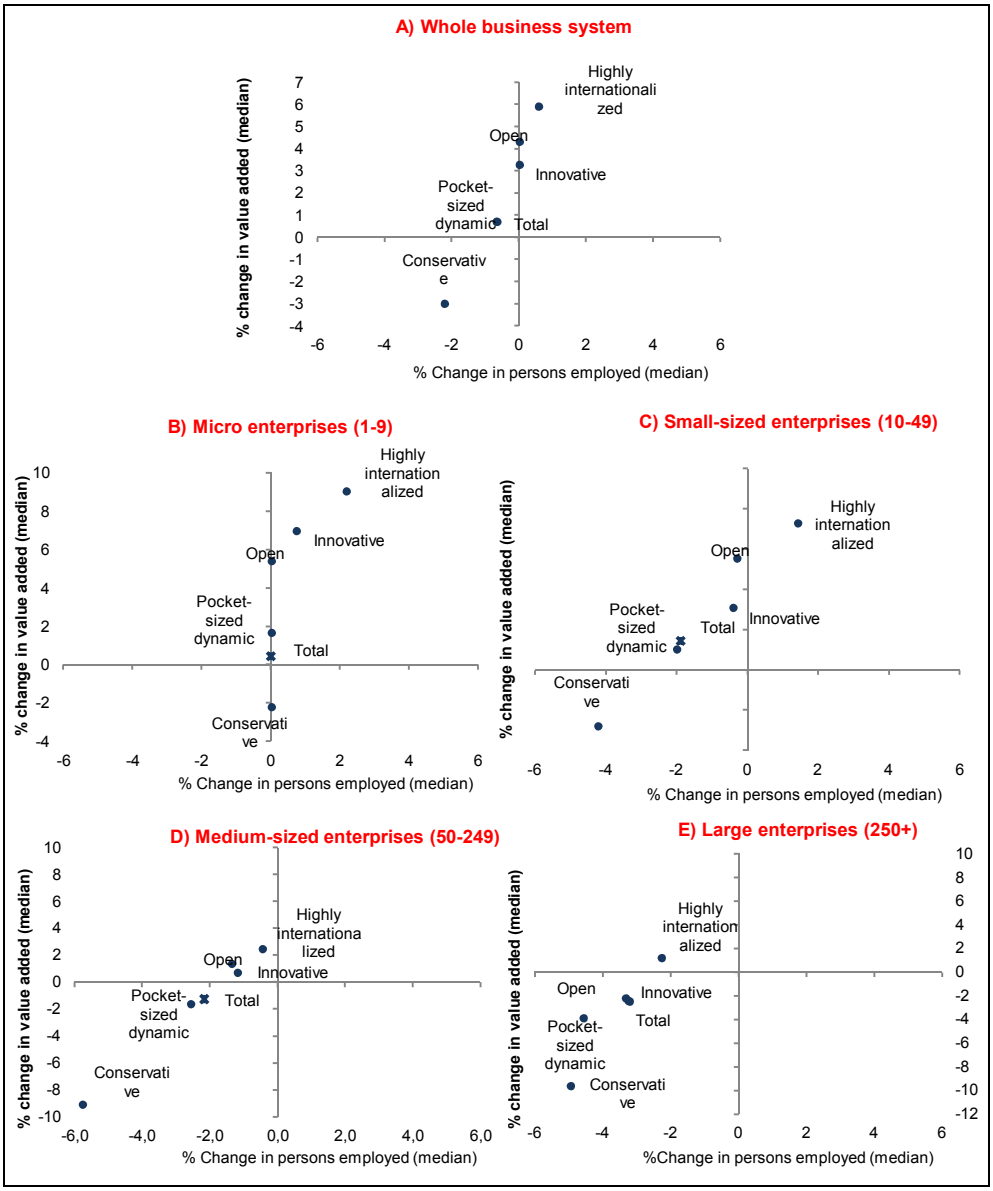
	Medium-sized enterprises (50-249 persons employed)					**Large-sized enterprises** (250+ persons employed)				
2010	2013					2013				
	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4	Total
Q1	**370**	126	90	135	721	**47**	23	24	22	116
Q2	296	**656**	463	206	1.621	42	**104**	104	20	270
Q3	343	406	**2.144**	1.162	4.055	49	61	**386**	177	673
Q4	753	285	1.195	**10.073**	12.306	56	33	158	**1.848**	2.095
Total	1.762	1.473	3.892	11.576	**18.703**	194	221	672	2.067	**3.154**

Source: Authors' calculation on Frame-SBS dataset.

The integration between the two pillars of the statistical package allows to further investigate these trends, analysing how the "strategic profiles" defined in Section 3

contributed to the firms' economic resistance during the crisis, in terms of firms' ability to generate value added and jobs. Some results are reported in Figures 6A-E, referring to the whole business system and four main firms' size classes. Again, only the units appearing in the Frame-SBS register both in 2010 and 2013 are considered.

Figure 6 – Median changes in value added and persons employed by strategic cluster, Years



Source: Authors' calculation on Frame-SBS and MPS1 datasets.

Three main facts come out. Firstly, on the overall, as well as in all the size classes, a general weakness in labour demand emerges, as opposed to better (in some cases good) performance in terms of value added growth. In this context, the evolution of business performance in the 2010-2013 recession appeared somehow more favourable among the smaller units.

Secondly, it is confirmed that in 2010-2013 the resilience of the Italian production system – in terms of ability to create value added and employment – depended on the firms' ability to operate on international markets. With reference to the whole business system, the total number of persons employed decreased by almost 1% (over 143 thousand people), while the overall value added rose by 0.8%. Within this context, the "highly internationalised" cluster (including many exporting firms that belongs to enterprise groups) was the only one in which during the period considered one firm out of two saw an increase both in value added and employment (respectively +6% and +0.6%). In turn, other strategic profiles oriented to export, innovation, and participation in inter-enterprise productive relationships – i.e. the "Innovative" and the "Open" ones – were much more effective in increasing value added (+3.3% and +4.3% respectively) than in creating jobs (the median percentage change is null for both of them), while the "Pocket-sized dynamic" firms, focusing on the product innovation and diversification but relying on the domestic market, experienced a very small median increase in value added (+0.7%) and a reduction in the number of persons employed (at least -0.7% for half of firms). Finally, the "Conservative" firms, less innovative, internationalised and networked, suffered on both fields (-3% in value added, -2.2% in employment).

The further integration of the two pillars of the statistical package with other short-term statistic sources makes it possible to analyse more in depth how such aspects accompanied the performance of the Italian business system during the very last years.

3.2 Facing the demand gap: the Italian firms' performance in 2012-2014

As stated before, one of the main functions of the statistical package is to provide a "structure information cornerstone" for further integrations with other firm-level datasets, referring both to structural and short-term economic events. This feature allows to identify the developments underlying some important recent trends, also taking account, in a multidimensional way, the structural features and the strategic choices by which firms cope with those trends. The possibility of shedding light on the effects of the 2011-2014 "demand gap" is an example.

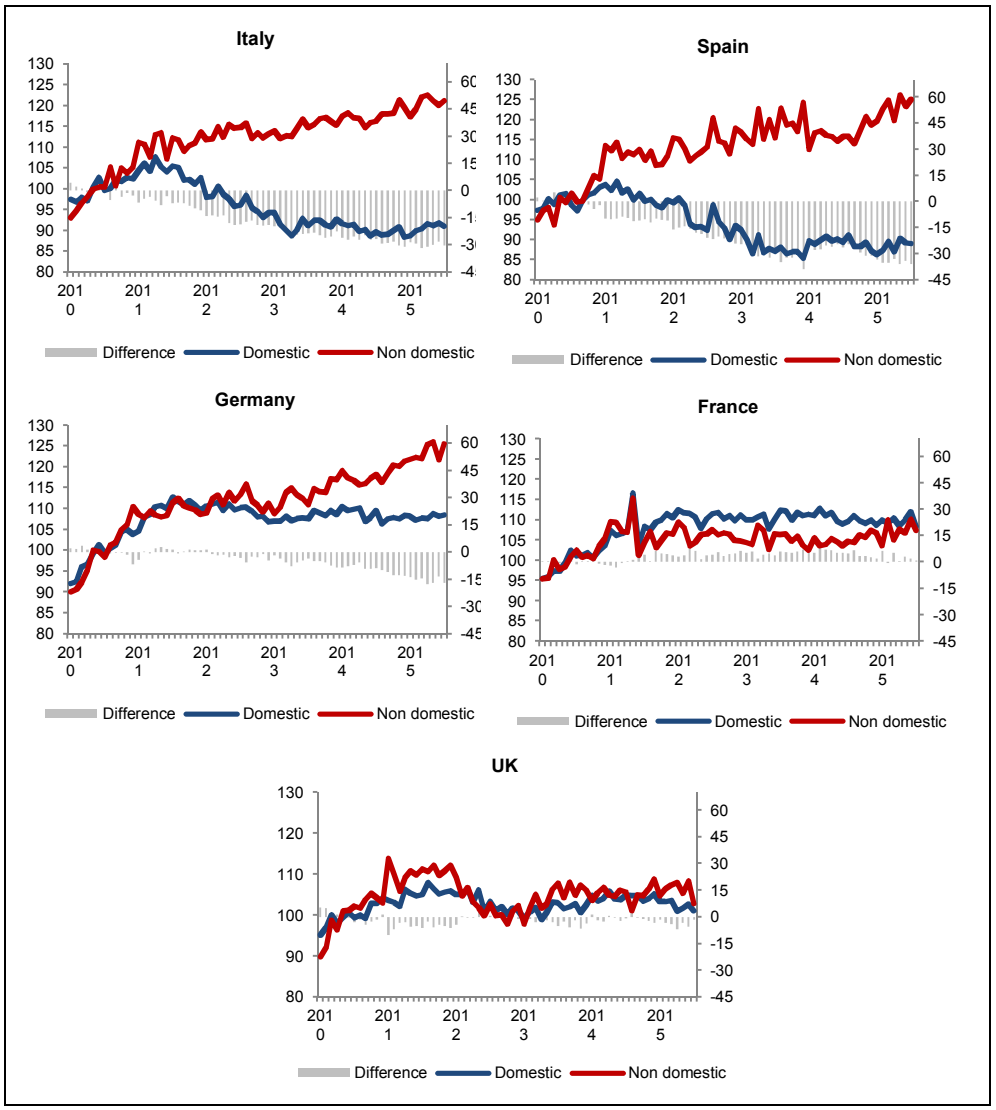
Since 2011 the Italian economy have been experiencing the opening up of a large and persistent gap between domestic and non-domestic demand (see Figure 7), with no comparable examples among main European countries except Spain.

This evolution forced Italian firms to deal with new economic scenarios, so stimulating new research and measurement of firms' multidimensional strategic profiles. Being able to monitor and analyse how the Italian firms face this type of developments is of great importance also for policy-making purposes, because scenarios may not be stable. The most recent data show in fact that during 2015 the demand gap slightly reduced, mainly due to a slowing down in the foreign demand (see Istat, 2015d).

The integration of the two above-mentioned pillars of the statistical package with one of the most important short-term source of information – the Istat monthly survey on the turnover of manufacturing firms – allows to investigate the micro-foundations of such developments, as it links the recent performance of industrial firms to the qualitative

information about their structure and behaviour, identifying the key factors that allowed many of them to survive.

Figure 7 – Domestic and non-domestic turnover in manufacturing sector (index 2010=100)



Source: Eurostat.

The monthly survey on firms' turnover focuses on units with no less than 20 persons employed. This is an important segment of the Italian economy: though relatively few in number (about 30,000 units, nearly 7% of the total manufacturing sector and 0.6% of the total business system), in 2013 these enterprises accounted for over 75% of the value added

in manufacturing (21.5% of total value added of the whole business system) and over 92% of the export.

When read through the lenses of the five strategic clusters defined in Section 3 ("Highly internationalized", "Open", "Conservative", "Innovative", "Pocket-sized dynamic"), this sub-population of the Italian industry appears quite heterogeneous in terms of structure and economic performance (Table 3).

Table 3 – Structure and performance of strategic profiles in the Italian manufacturing sector (2011) Enterprises with no less than 20 persons employed

Strategic profiles	Units (%)	Average size	Labour productivity (Value added/persons employed; thousands euros)	Share of Managerial firms	Network index (median)
Highly internationalized	19,3	124,7	65,9	20,8	43,9
Open	27	92,1	60,5	19,6	28,8
Innovative	10,2	91,3	60,7	15,7	11,5
Pocket-sized dynamic	18,1	90,8	57,5	19,4	10,6
Conservative	25,4	55,9	54,6	14,9	10,2
Total	100	88,9	59,4	18,2	21,9

Source: authors' calculation on Frame-SBS, MPS1.

First of all, in accordance with the theoretical and empirical literature, which has widely shown that to overcome the export entry barriers and successfully operate on international markets firms need to reach adequate levels of productivity,[16] the cluster of "highly internationalized" firms shows the highest values of firm's average size and productivity. Moreover, these units are strongly networked − so confirming that international activity is associated to more complex forms of business organization[17] − and are the ones among which the managerial governance is more frequent (nearly 21, as opposed to the 14.2% among the "Conservative" firms and the 5.3% in the overall manufacturing industry).

At the other extreme, 25% of firms in the sample here considered belong to the "Conservative" cluster. This segment basically includes the less dynamic firms of the sub-population of industrial firms with no less than 20 persons employed: the units in this cluster are in fact relatively smaller, less productive and most rarely managerially run than those of any other cluster. Finally, they are also less networked (network index is 10.2, compared to the average of 21.9 and 15.7 for the sample and entire business system respectively).

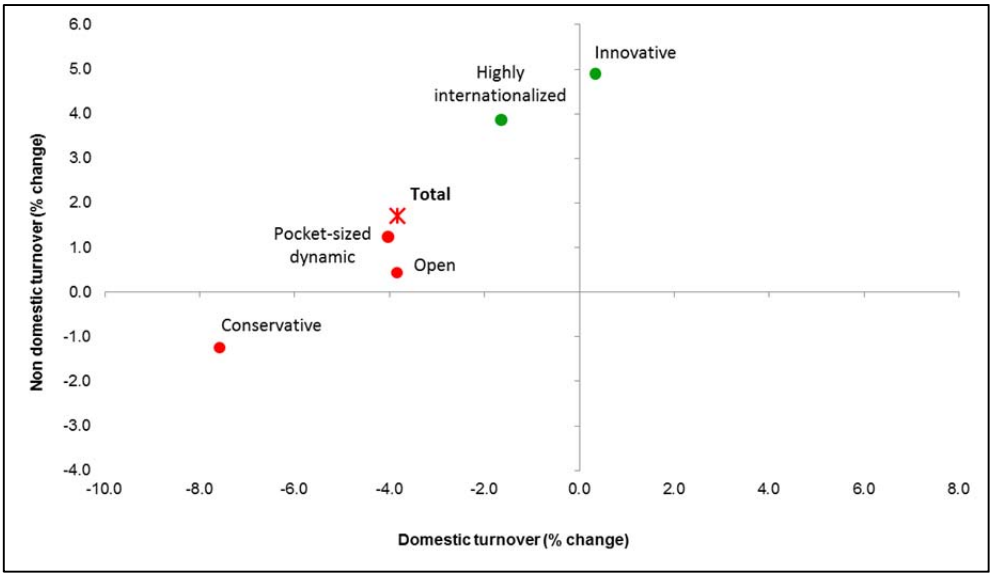
Such heterogeneity in competitiveness factors in 2011 seems to be able to explain substantial differences in firms' performance and competitiveness in the 2012-2014 period.

[16] See, among others, Melitz e Ottaviano (2008) for a theoretical framework; Wagner (2012) for a comprehensive review of empirical studies; Altomonte *et al.* (2012) for a cross-country comparison of firms' performance associated to different internationalization forms; Hollenstein (2005) for a study on the determinants of internationalization of (Swiss) SMEs; Costa *et al.* (2015) for an analysis of how the choices of different internationalization models affected the performance of Italian firms during the first phase of the crisis (2007-2010).

[17] The network index summarizes three dimensions of inter-enterprises relationships: the range of firms' relationship forms (e.g. subcontracting, joint ventures, other formal agreements, informal relationships etc.), the number of firm's counterparts involved in the relationships, the geographical extent of the relationships (especially if this involves counterparts abroad) Its values range from 0 to 100. For more details on the construction of the index, see Istat (2013c).

In this context, the clusters illustrated in section 3 draw a "strategy profile" for each different performances during the "double dip" period (Figure 8).

Figure 8 – Median percentage changes of domestic and non-domestic turnover in 2012-2014 by cluster (manufacturing firms with no less than 20 persons employed) (a)



Source: authors' calculation on Frame-SBS, MPS1, and Monthly Survey on turnover of manufacturing industry.
Green: clusters with positive changes in total turnover; **Red**: cluster with negative changes in total turnover.

First and foremost, in line with the prevailing literature, innovation and internationalization stand out as crucial factors in determining firms' capability to preserve their competitiveness on domestic and foreign markets. The "Innovative" cluster is the only one with positive turnover dynamics on both markets (median values: +0.3% for domestic turnover and +4.9% for export); in other terms, the choice of innovating products and processes (but also marketing strategies), as well as the participation in intense inter-enterprises relationships and strategies mainly relying on price competitiveness and product quality, allowed these firms to avoid the harsher consequences of the recent crisis and even keep prospering not only on international markets,[18] but also on a virtually stagnant domestic market.

In the same period also half of the "Highly internationalized" firms increased export (no less than +3.9%) and this performance offset the domestic turnover fall (median -1.6%), leading to a positive dynamics of total turnover (at least +2.3% for one firms out of two). In this case too, the firms' behaviour are mainly oriented to access new (international) markets adopting complex strategies of product positioning, based on product innovation, flexibility

[18] Actually, during the last recession these very strategies made it possible for many Italian manufacturing firms to successfully face the growing competitive pressure also on medium- and low-technology products (the "Made in Italy" goods), see Costa and Luchetti (2015).

in production and the establishment of many and intense relationships with other firms and institutions.

No other cluster showed such a good performance in terms of total turnover in the period considered: the "Open" and the "Pocket-sized dynamic" firms increased their sales abroad (median values: +0.4% and +1.2% respectively), but the fall in domestic turnover (-3.8% and -4.0% respectively) led to a total turnover decline by 1.5 and 1.8% respectively.

Finally, the "Conservative" firms had the poorest performance, with fall in domestic (median -7.6%), non-domestic (-1.2%) and consequently total turnover (-5.5%). These firms, in fact, show a very simple strategic profile, have a low propensity to innovate and focus their activity essentially on sub-national markets, that is on the field most severely hit by the recession.

The Italian manufacturing firms with at least 20 persons employed recently showed signs of recovery: in 2014, one out of two of them increased its total turnover by no less than 0.8% with respect to 2013. The revenues grew on the foreign markets (median 1.6%, compared with 0.2% in 2013) and were substantially unchanged on the domestic ones (less than +0.1%; it was -2.7% in 2013).[19]

This result, after three years of falling demand, is the main novelty, and largely explains the general upward shift in the distribution of performance of enterprises (in 2014, 53% of companies posted an increase in total turnover with respect to 2013, compared with 46% in 2012-2013).

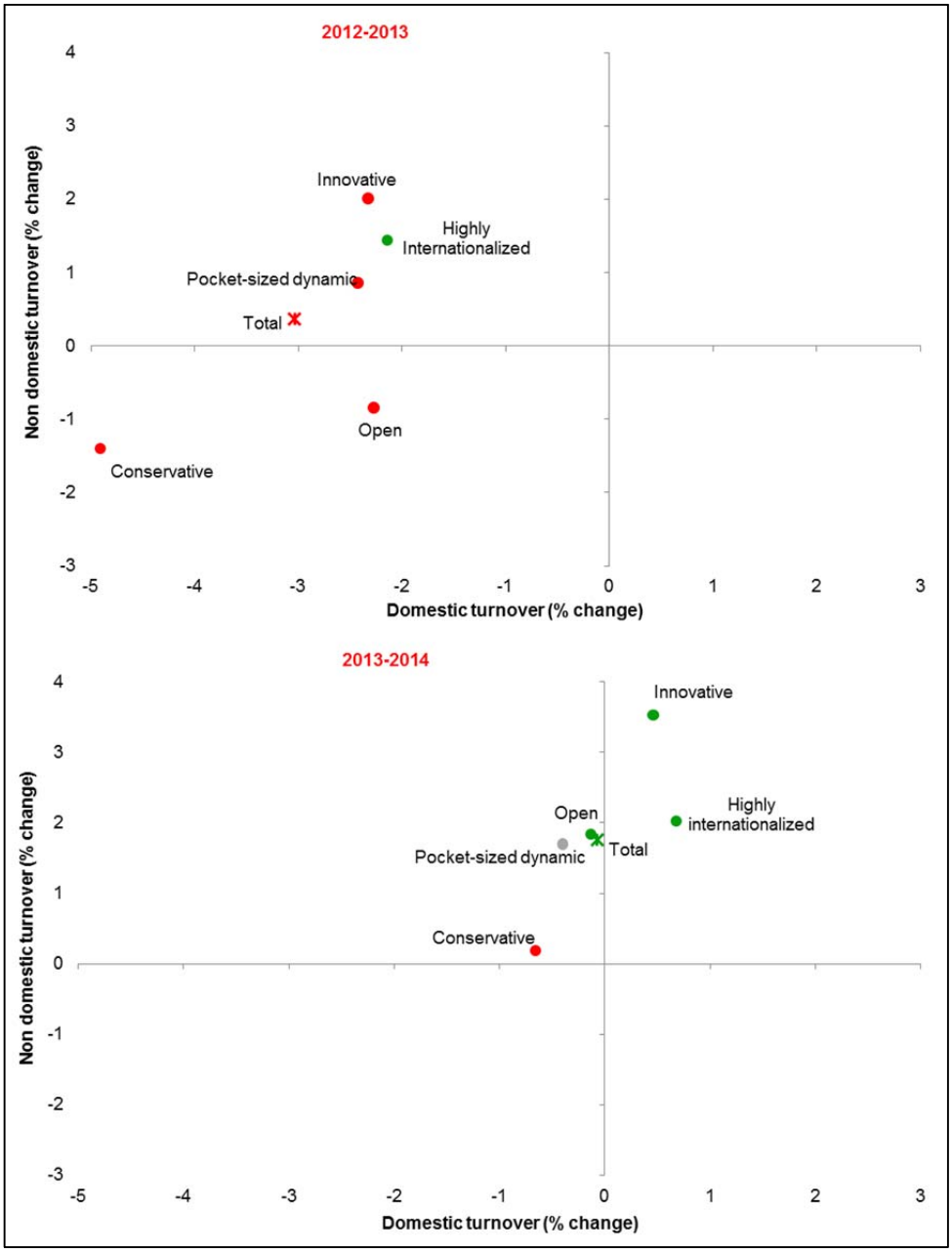
Figure 9 shows how these trends of turnover differ according to the firms' strategic profiles, even in presence of a general improvement between 2013 and 2014.

In 2012-2013, when any possibility to recover basically relied on the ability to compete on international markets, in no cluster the median dynamics of sales on domestic markets was positive; in three of them half of the firms increase saw their export, but only the "highly internationalized" firms benefited from a growth in the total turnover.

The 2013-2014 period saw a general upward and rightward shift of the distribution of firms' performance, with just the "Conservative" firms lagging behind, despite the increase in export.

[19] For further details on these dynamics, see Istat (2014, 2015).

Figure 9 – Median percentage changes of domestic and non-domestic turnover in 2012-2013 and 2013-2014, by cluster (manufacturing firms with no less than 20 persons employed) (a)



Source: authors' calculation on Frame-SBS, MPS1, and Monthly Survey on turnover of manufacturing industry.
Green: clusters with positive changes in total turnover; **Red**: cluster with negative changes in total turnover;
Grey: cluster with total turnover unchanged (i.e. the change was less than 0.1% in absolute value).

4. Conclusion

In this work we illustrated how the Istat new approach to the compilation of official business statistics provides an answer to the demand for reliable, high-quality microdata to assess the economic resilience and competitiveness of the economic system. The integration into a single "statistical package" of administrative and statistical sources on firms' structure and strategies significantly refines the basis for the production of official statistics, while providing an (accessible) firm-level dataset to support economic analyses consistent with official aggregated data.

This allows to measure economic resilience taking particularly into account a number of relevant elements. Firstly, it is possible to properly take in consideration the degree of heterogeneity within the economic system in terms of firms' structure, strategies and performance. In this respect, we were able to observe how some specific "strategic profiles" kept fostering the firms' performance even during such a severe recession as the 2010-2013 one, which determined non negligible changes in the structure of Italian business system (e.g. in terms of size and value added distribution).

This leads to important developments both from a positive (i.e. descriptive) and a normative (i.e. prescriptive) point of view. On the positive side, the new framework enhances the available economic information and (therefore) the ability to isolate at a very high level of disaggregation the "top" and "bottom" performing segments of the production system (especially in such a fragmented economic structure as the Italian one). On the normative side, the new statistical package enhances the possibility of more evidence-based policies for economic growth.

Finally, the new approach to business statistics establishes a cornerstone for further integrations with other short-term information, both from administrative and statistical sources. This helps analyse the "deep transformations" underlying the most recent developments and scenarios that the Italian business system has been facing, such as the firms' domestic and foreign performance during the recovery phase; the firm-level effects of labour market policies; the effects of changes in international trade scenarios on exporting firms' performance; the changes in import demand at firm-level.

Moreover, an implementation plan has been designed to further develop the "Statistical package". The main action points are: a) an enhanced use of administrative and statistical sources already available and already embodied in high-quality statistical processes, b) the design of new special surveys taking into account the needs of economic analysis for evidence-based policies.

As regards the first action, the aim is to support more in-depth micro-founded analyses of the Italian business system. To do so, Istat has launched a high-level task force including also researchers from Bank of Italy, universities and research centers. The task force is expected to develop in 2016 a set of further indicators aimed at assessing the competitiveness of Italian firms within their sectors and markets according to three relevant dimensions of enterprise's activity: employment and wages, participation in foreign trade, business location. For example, as regards the labour demand, the availability of individual data on all employees employed by Italian companies allows to evaluate the characteristics of labour input employed by businesses, in terms of socio-demographic characteristics, position and wage of each employee.

The second action will provide information from survey data on firms' governance, organization and strategies: a dedicated census survey on large and medium size businesses for a total of three thousand five hundred units has been carried out in 2015. This survey is devoted to shed light on the business organisation and competitiveness drivers of the so called complex business units. In particular, it adopts an innovative approach both in terms of identification of statistical units and information collected through the questionnaire. The questions focus on the managerial capability to project, develop and currently implement complex business strategies such ad internationalization and knowledge creation.

Furthermore, an update of MPS has been planned in order to evaluate the progress of Italian firms in the recent period, comparing the current situation with the 2012 one. In particular, the seven MPS topics will be updated by using ad hoc web-surveys on selected samples of firms, representative of the different clusters selected in 2012 (persistent firms) and of the business demography (new firms).

Finally, the innovative Istat approach to the business statistics is coherent with the need for high-quality and relevant official information to measure firms' competitiveness in a policy-oriented framework. This was also stated in the conclusions of the recent Lisbon Memorandum (2015 DGINS Conference) with reference to the main drivers for the development of the ESS.

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How do Firms *Perceive* their Competitiveness? Measurement and Determinants

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Abstract

In this paper, we propose a novel approach for analysing firm-level competitiveness, namely, that of a firm's subjective perception. By using a large, integrated database and an econometric strategy based on a generalized order logit model, our results indicate the presence of sectoral specificities and group heterogeneity in the way firms perceive their competitiveness. Industrial and services firms perceive differently those factors of competitiveness such as profitability, technological innovation, knowledge capital, complex ownership structure and internationalization patterns. In addition, firms' top performers tend to score more positively a number of competitive factors indicating technological input and output, knowledge capital and managerial abilities. We suggest that the use of a perceived competitiveness indicator could provide useful insights for more focused competitiveness policies.

Keywords: Perceived Competitiveness, Industrial Census, European Community Innovation Survey, Generalized Order Logit model

1. Introduction

Although the notion of competitiveness is widely used in the economic debate, there is little agreement among managers, policy makers and academics about how to define and measure it. Nevertheless, the competitiveness issue is increasingly recognized at the centre of the political debate, particularly within the European Union[2].

The European Commission has recently adopted a recommendation on the establishment of national competitiveness boards within the Euro Area. These boards should monitor performance and polices in the field of competitiveness to improve the knowledge basis for European Union economic policy coordination. An important aspect characterizing the role of the national competitiveness boards is that they should consider competitiveness in a broad sense. The traditional analysis of competitiveness focused mainly on price-cost factors, although they reflect only one part of the story. It has been argued that to capture the multifaceted nature of competitiveness and its long-run effects, it is important to enlarge the list of indicators used *"taking into account factors that can affect prices and quality content of goods and services relative to global competitors in the short term (including labour costs) as well as longer-term drivers such as productivity and innovation capacity, which are relevant not only for the relative performance of the economy but also for its growth potential and the capacity to attract investment, businesses and human capital"* (European Commission, 2015).

As a complement to this macroeconomic view, competitiveness may be analysed from the perspective of individual *success*, which, in turn, implies a firm's subjective perception of its business performance in relation to the achievement of its strategic objectives. This should

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2 The views and opinions expressed in this article are those of the author and do not necessarily reflect the official position of the National Institute of Statistics.

be considered a relevant aspect in the competitiveness analysis, as when firms make plans in terms of production, employment, and investments in physical and financial assets, it is crucial for them to understand their correct position with respect to their competitors.

In the short run, the use of measures based on individual perception to gauge the future performance of selected economic variables is not new. The ZEW economic sentiment index for the Euro area, the IFO Business Climate Index for the Germany economy and the Economic Sentiment Indicator (ESI) developed by the European Commission are some of the most followed leading indicators. Nevertheless, it has been shown that the use of data based on perceived competitiveness may provide a more comprehensive picture because they may consider other non-cost factors affecting firms' positioning and, ultimately, because the perception of competitiveness may differ among firms, even among firms engaged in the same field of business (European Commission, 2013).

In this study, we adopt a micro-founded approach to the analysis of firm's perceived competitiveness, which allows us to enlarge the set of potential drivers and to include factors that are not restricted to price/cost considerations.

To operationalize this approach, we first build a conceptual framework that, according to the relevant empirical debate, identifies the main dimensions of a firm's competitiveness and then assesses their relevance for a firm's self-perception.

To our knowledge, this approach represents a novelty within empirical investigations at the firm level and may offer a new perspective for both academic research and policy analysis on the competitiveness issue. It may stimulate a reconsideration of the results derived from empirical research to consider individual perception, which may provide useful insights for more focused competitiveness policies.

The main dataset used in this study comes from the multipurpose module of the 2011 Italian Census for Industry and Services, which has been linked to the Community Innovation Survey (CIS) for the period 2010-2012. The final sample consists of more than 10,000 firms in both industry and services for which accounting financial and economic information is available from balance sheets.

Our investigation also aims to capture possible differences in firms' self-perceived competitiveness between the industrial and services sectors. This approach may offer a different perspective to analyse sectoral differences in the light of the fact that during the most recent decades, the industrial structure of the most advanced economies has changed, with the shift from industrial to services activities.

According to recent estimates (Foster-McGregor et al., 2015)[3], the share of EU manufacturing value added in overall GDP declined from 20% to 16% in the period 1995-2011, whereas the share of services increased over the same time span. It is interesting to note that the same trend is still observed when a value chain perspective is adopted, i.e., by including in the productive process the upstream and downstream services, which might be conducted externally by services firms along the manufacturing value chain[4]. Following this approach, the EU contribution to world final demand of manufacturing products due to manufacturing activities declined from 25% in 1995 to 22% in 2011 (In Italy, the decline is even more pronounced, from 29% to 23%). Conversely, the share of services increased from 33% to 39% (from 34% to 40% in Italy).

This evidence indicates, on the one hand, the strong linkage between industry and services activity, and, on the other hand, the growing importance of services as inputs in the industrial production across European countries. Thus, it is reasonable to expect that industry and ser-

[3] This study has been conducted for the European Commission, DG Enterprise and Industry within the framework programme "Industrial Competitiveness and Market Performance".

[4] This exercise allows one to control for outsourced services activities, which may amplify the drop in the manufacturing share.

vices firms do not show significant differences in the way the determinants of competitiveness affect their subjective perception. Conversely, the presence of sectoral differences in firms' self-perception may indicate that the two sectors still differ because competitive advantages are perceived differently.

This paper is structured as follows. The next section presents an appraisal of the relevant empirical literature emphasizing the most important elements affecting a firm's ability to compete. Section 3 outlines the research focus by pinpointing the originality of the approach we intend to follow. The rich set of information coming from the integration of statistical and administrative data sources is also described. In Section 4, the econometric model is presented, while the regression results are discussed in Section 5. Section 6 provides a general discussion and concludes the paper.

2. The determinants of firm level competitiveness in the empirical debate

Competitiveness is a relatively new concept in economics, which reminds us of Porter's analysis of competitive advantages (Porter, 1985). It has been argued that the lack of solid theoretical foundations has generated scepticism among economists about the real possibility to measure it (Lall, 2001). However, the large body of empirical literature available so far have demonstrated the existence of a variety of driving forces of a firm's success and, through this route, the need for developing a comprehensive analytical framework that can consider the multidimensional nature of a firm's competitiveness. Indeed, in Porter's view of competitive advantages, firms combine favourable conditions (factor conditions, demand conditions, related and supporting industries and the context for firm strategy and rivalry) with internal capabilities to reach higher economic performance (Porter, 1990). Accordingly, in the empirical literature, there is a long history of efforts to test the validity of a variety of elements that may affect the ability of a firm to compete.

Among these, the debate on the robustness of the so-called SCP paradigm (Bain, 1956), which has dominated the industrial organization debate even during more recent years, has demonstrated that both firm-specific characteristics - i.e., size, efficiency measures or market share - and market structure - i.e., concentration - are both relevant in determining a firm's comparative advantages. The seminal studies by Demsetz (1973), Peltzman (1977) and, more controversially, Clarke et al. (1984) show that efficient firms grow and capture large shares of the market, thus claiming for the validity of the so-called firm efficiency view. However, the debate has continued even during more recent years, and the studies by Allen (1983), Delorme Jr et al. (2002), and Slade (2004), although using different methodological approaches, do find support for the SCP paradigm, thus claiming for the role of market structure in determining a firm's competitiveness.

Among the firm-efficiency conditions, innovation plays a crucial role. In the Schumpeterian view of competition (Schumpeter, 1934), firms engage in risky innovative efforts when they see prospects for gaining competitive advantages by creating products or services that are preferred by the market or by introducing new processes that increase production efficiency. From a strategic management perspective, the studies by Roberts (1999, 2001) and Hawawini et al. (2003) specifically recognize the role of managerial abilities - e.g., product innovation - in determining profitability and possibly its persistence. The view of permanent differences between innovative and non-innovative firms due to specific skills accumulated by the former may be found in the works by Geroski et al. (1993) and by Cefis and Ciccarelli (2005), which support the hypothesis of a positive relationship running from innovation to profitability. Their approach may be defined as the "process" view to innovation because it emphasizes the fact that persistent differences between innovative and non-innovative firms

do exist because of the bulk of superior competencies acquired over the years by innovative firms.

In addition, a firm may achieve competitive advantages on the basis of organizational improvements and learning processes that are developed over time. The accumulation of these strategic assets allows the firm to enhance its productivity by reducing unit cost over time (Arrow, 1962). Following this line of reasoning, the dynamic capabilities approach (Teece, 2010; Pisano et al., 1997) underlines the role played by knowledge assets such as human skills, marketing and organizational activities, external collaboration and intellectual properties.

Among firm internal conditions, financial leverage and the presence of possible financial constraints may crucially affect the cost of capital and, through this route, a firm's performance. However, the final impact on a firm's competitiveness remains not well-defined as, on the on hand, it is possible that more highly leveraged firms incur increasing debt costs, as suggested by the agency costs literature, implying a negative impact; on the other hand, one may underline the role of debt in reducing the free cash flow under managers' control (Jensen, 1986). Because seeking external financial resources exposes managers to increased monitoring, they are motivated to perform well. As a consequence, highly leveraged firms are expected to perform better.

Another important argument in understanding the determinants of firm competitiveness is the role of technological spillover. A number of different studies (Griliches, 1984, 1992; Mairesse and Sassenou, 1995; Los and Verspagen, 2000) has underlined the importance of R&D externalities in affecting firm economic performance in terms of productivity, but only a few have examined the impact on firm profitability. Previous studies suggest the presence of a clear negative effect of technological spillovers as measured by research inputs (Jaffe, 1986; Hanel and St-Pierre, 2002) and more controversial results when measured by research output (Geroski et al., 1993). In a different perspective, i.e., diffusion theory, Stoneman and Kwon (1996) found that a firm's profitability is negatively related to the number of adopters of new technologies. These results indicate that potential positive effect of knowledge dissemination may be contrasted by the negative effect of competition, which encourages other firms to imitate and then to erode their rivals' profitability.

Internationalization is another factor affecting competitiveness at the firm level. The importance of considering the behaviour of the firm in the international context was underlined by Porter (1990) among the first scholars. Within the stream of empirical literature that has tested the validity of international trade theories, extensive empirical evidence has been provided that firms engaging in international trade perform better than firms operating mainly in local markets. This holds for different dimensions typically affecting a firm economic performance: size, productivity, R&D intensity and capital intensity Wagner (2012). Nonetheless, evidence that international competition may have a significant impact on a firm's profitability is not conclusive (Girma et al., 2004; Temouri et al., 2013; Grazzi, 2012). It has been argued that operating in international markets brings about additional costs due to difficulties in complying with, e.g., new customer requirements or local regulations (Baussola and Bartoloni, 2015).

Most often, internationalization is associated with trade performance, which, however, cannot fully describe a firm's internationalization choices. In recent decades, an increasing number of firms have started to operate in foreign markets by using foreign direct investments (FDIs), e.g., by establishing a subsidiary in the foreign country or by acquiring shares of an overseas company or by a merger or a joint venture. It has been argued that because of the uncertainty that characterizes a firm's investment decisions, the process of internationalization follows a stepwise approach (Johanson and Vahlne, 1977): starting from an occasional export, firms gradually intensify their activities in foreign markets.

Indeed, more recent literature has emphasized the role of dynamics in a firm's internationalization choices (Eaton et al., 2008; Aeberhardt et al., 2014; Albornoz et al., 2012). These studies have shown that new exporters begin by exporting small amounts. Conditional on surviving, their exports grow and, for appropriate levels of profitability, they can start to invest abroad.

3. The research focus

3.1 General

Conventional wisdom in the economic literature has tried to link firms' competitiveness - variously measured - to factors affecting it. The review of the empirical literature has made it clear that there are not individual dimensions of competitiveness at the firm level but a variety of indicators, which should be analysed to fully describe the complex mechanisms at work.

In this contribution, we take a different approach, namely, we attempt to link a firm's perception of its competitiveness to a set of characteristics - both survey-based and from public registers - which may be considered proxies of the forces that are commonly indicated by the literature as mechanisms affecting a firm's competitive performance[5].

From a sample of more than 10,000 firms, in both the industry and services sectors, we measure the perceived competitiveness through firms' self-assessment of their position with respect to competitors (higher, in line, lower).

The main dataset is derived from the multipurpose module of the 2011 Italian Census for Industry and Services, which has been linked to the Community Innovation Survey (CIS) for the period 2010-2012. The multipurpose module is based on a census sample for firms with 20 employees or more, and a sample survey for firms with less than 20 employees. It provides information at end-2011 on a comprehensive set of factors affecting a firm's competitiveness, including ownership structure, human capital, commercial relationships, reference markets, innovation, finance and internationalization. Additional information on various aspects of the development of an innovation, including objectives and strategies and collaboration for innovation, is drawn from the CIS survey. Originally focused on the industrial sector, as of 1994, it has been extended to private services. The CIS wave for the years 2010-2012 is based on a sample of more than 18,000 firms with more than 9 employees. Firms with less than 250 employees are selected at random, while the survey is a census for firms with 250 employees or more.

For the firms included both in the multipurpose module and in the CIS sample, we have collected economic and financial information from the Bureau van Dijk (AIDA) database[6]. The final linking resulted in a sample of 10,943 firms. The frequency distribution of the sample is reported in Appendix 1, where the samples obtained at intermediate linkages are also provided for comparison. Linking the CIS data with accounting information from administrative sources allows for the use of additional proxies for a firm's economic and financial performance typically not considered in the census and in the innovation survey micro-data.

[5] This approach may be justified on the ground that, following the evidences within the European Union, *"In general, there appears to be a relatively strong link between perceived competitiveness and price/cost competitiveness"*(European Commission, 2013).

[6] The AIDA (Analisi Informatizzata delle Aziende) database is the Italian component of the European Amadeus database, distributed by Bureau van Dijk, and contains balance sheet information on approximately one million companies in Italy.

3.2 Self- reported competitiveness and determinants: data description

Approximately 76% of firms in the final sample reported a level of competitiveness in line with competitors, while percentages equal to 10.8% and 12.8% respectively reported levels that are lower and higher than competitors.[7] The average score is only slightly higher for services compared to industrial firms (Table 1), although these differences are statistically significant.

To capture the impact of different forces on a firm's competitiveness perception, we develop, in accordance with the reviewed literature, a comprehensive conceptual framework, which classifies individual indicators in groups of dimensions as follows:

Economic and technical efficiency This group includes a set of dimensions indicating a firm's performance in terms of economic and technical efficiency. According to previous empirical studies, a firm's economic performance may be measured both in terms of operating profitability as proxied by the return on sales ratio (*ros*) and in terms of productivity, given by the value added to employees ratio (*va*). In addition, market share (*share*), which is given by the ratio of a firm's sales to sectoral sales, is included as a proxy for a firm's market power. A measure of sales trend (*turn_ch*) is also included by computing the percentage change of a firm's turnover during the period 2010-2012.

A qualitative variable, which indicates whether the firm has introduced a technological innovation (a new product/service and-or a new process) during the years 2010-2012 (*inntech*), serves as a proxy for technical efficiency. Approximately 40% of our sample has introduced a technological innovation during the observed time-span, with the prevalence of the industrial sector(45%) compared to services (36%).

Physical and financial input. In this group, we include a set of quantitative variables capturing labour input and its characteristics: the number of employees (*empl*), the employment composition in terms of young workers (*young_w*) and female workers (*fem_w*), and labour compensation (*cosl*).

Physical capital deepening is also considered with the *kl* ratio (tangible fixed assets per employee). In addition, a qualitative variable (*rmac*) is introduced indicating whether the firm has bought advanced machinery and equipment during the years 2010-2012.

As concerns financial inputs, we use a measure of a firm's leverage (*lev*), which is given by the ratio of total debt to net capital, thus reflecting the extent to which a firm uses borrowing instead of internal resources to finance its activity. Other qualitative indicators are considered: (i) to capture situations in which the firm is highly dependent on external financing due to liquidity constrains (*ext_fin_liq*) or due to the need of funding productive investments (*ext_fin_inv*) and (ii) to identify firms whose bank debts are highly concentrated (more than 50%) at the main bank (*bank*). It is well known that Italian firms are highly dependent on bank lending. They share this characteristic with other important industrial systems, such as Germany and Japan. It has been argued that firms that borrow from a limited number of banks face lower financial constraints than firms with multi-banking relationships (Elsas, 2005; De Mitri et al., 2010). With more than three-fourths of the firms having multiple lending relationships, our sample depicts a situation of low bank concentration at the firm level.

[7] It is worth noting that in our final sample, the balance between firms in the higher and in the lower perception level is positive (+2 percentage points), whereas in the Industrial Census sample, the balance is negative and equal to -5 percentage points (even when the census sample is linked to the CIS sample of firms). As the final sample excludes small individual firms for which balance sheet information is not available, one can argue that the different composition in terms of perceived competitiveness of our final sample is related to the higher share of corporations that may be better positioned in facing competition than individual firms.

Knowledge capital. We include in this group of variables those firm-specific abilities or intangible assets that may affect its long-term competitiveness. We consider among these the ratio of high-skill workers to total employment (*h_skill_w*) and a dummy variable indicating whether high skill workers have been engaged during 2011 (*h_skill_2011*). Other dichotomous variables are included to capture a firm's attitude towards innovation and those activities that are typically connected to technological adoption, as follows:

(i) The introduction of marketing innovation (*innmkt*) is defined as *"the implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing"* (OECD, 2005); firms focusing on marketing innovation are likely to be able to understand changes in market demand and thus to successfully cope with customer requirements compared to competitors. Approximately 34% of the firms in our sample introduced a marketing innovation in the period 2010-2012. The propensity to introduce marketing innovation in the industrial sector is somewhat lower (32%) than in services as a whole (37%). In addition, we observe a higher propensity to innovate in the group of firms with a high level of perceived competitiveness (44%) compared to the other groups.

(ii) The engagement in in-house R&D activities (*rrdin*) and the acquisition of R&D activities performed by other enterprises or other research organizations (*rrdex*) are inputs of the innovative process and may be thought as proxies of the innovative effort at the firm level. Only 18% of our sample performs in-house R&D, and the percentage is even lover if we consider extramural R&D (8%). A firm's innovative effort as measured by internal and external R&D activities is much higher in the group of firms showing a higher level of perceived competitiveness (23% and 11%, respectively).

(iii) The engagement in internal or external training activities for the development and/or the introduction of technological innovation (*rtr*).

(iv) A dummy variable that signals whether the firm has cooperated on innovation with other firms or institutions (*co*) refers to the ability to share knowledge and competencies with other organizations during the process of development of product and/or process innovation.

(v) Finally, to keep the pace of technological innovation, firms that develop new knowledge should protect it and bring it to the market as soon as possible. Thus, intellectual property rights (IPR) are important tools for stimulating firms' innovation and enhancing competitiveness. We include in this group of firm-specific characteristics a dummy variable indicating whether in 2011 and in the two years before, the firm has adopted tools such as copyrights, trademarks, patents and registered designs for intellectual property protection (*int_prop*). Sample statistics indicates that, on average, 18% of our firms have exploited some form of IPR during the observed period. The number of IPR users is relatively higher in the industrial sector (22%) compared to services (14%) and, interestingly, in the group of firms with a higher level of perceived competitiveness.

Market conditions. According to the reviewed literature, the business environment in which firms operate is another crucial determinant of competitiveness. In this group of dimensions, we have included the *CR5* index as a proxy for market structure. Descriptive statistics show that higher levels of sales concentration characterize the industrial sectors (38%) compared to services (34%).

The proportion of sectoral innovators (*innset*, two-digit Nace classification level) serve as a proxy for new technological opportunities created by the increase in a sector's technological knowledge. We have, on average, 30% of firms that have introduced new products and/or new processes during the three-year time span, with significant differences between the industry and services sectors (33% and 26%, respectively).

Regional gaps in terms of both firms' economic performance and innovative efforts are generally recognized as stylized facts of the Italian industrial sector; thus, we have included

in this group four regional dummies (*nwest, neast, centre, south*) aimed at investigating the role of localization factors.

To provide more information about the nature of competition that firms need to face, an additional set of qualitative variables is also considered, as follows:

(i) A dummy variable indicating the presence of competitors that are localized abroad (*int_comp*). Of the firms in our sample, 28% compete internationally; however, international competition is more relevant for the industrial firms (the share of foreign competitors is equal to 34%) than for the services firms (21%).

(ii) A dummy variable (*ostob_est*) indicating the possible relevance of market factors (low demand, market dominated by established enterprises, intense price and/or quality competition), which may have hampered a firm's ability to fulfil its objectives. A large proportion of firms have indicated market factors as highly important (70%).

(iii) Finally, another dichotomous variable indicating, more specifically, whether a firm's innovative process may have been hindered by dominant competitors (*ostinn_mkt*). Indeed, only a limited proportion of firms within our sample (7%) have indicated market dominance as a possible threat to innovation, although the proportion increases significantly in the group of firms declaring a lower grade of competitiveness (16%).

Organizational patterns. A set of firm-specific dimensions, which are related to the firm internal conditions are used to describe its organizational behaviour. A firm's *age* is included. The effect of the variable *age* on a firm's competitiveness is ambiguous, as, on the one hand, it is likely that learning effects improve with time. According to this view, we should expect a positive relationship of this variable with a measure of a firm's competitiveness. On the other hand, technical and organizational learning require the development of skills and routines that are highly path-dependent (Nelson and Winter, 1982, 2002). In older firms, the cost of readjusting existing competencies to more recent practices may be higher than the marginal benefit generated from learning processes, thus suggesting a negative relationship as they may lose their ability to compete. The average age of our sample of firms is 23 years, with the firms in the services sector being slightly younger than those in industry.

The implementation of organizational changes such as new work organizations or new knowledge management systems may positively impact technological innovation. It has been argued that the complementarity use of technological capabilities and organizational competencies may improve a firm's economic performance. Thus, we have included a dummy variable (*innorg*) indicating whether the firm has introduced an organizational innovation (the implementation of a new organizational method in the firm's business practices, workplace organization or external relations, according to the definition proposed by the Oslo Manual (Oslo, 2005; p. 51). Of our firms, 41% have introduced in the observed period, an organizational innovation, without significant differences at the sectoral level, whereas interesting differences emerge according to the firms' perceived competitiveness: the propensity to introduce organizational innovation is equal to 52% in the "higher" group, compared to 34% in the "lower" group.

Other variables reflect changes in the firm's organizational structure. This information derives from the CIS questionnaire and concerns the corporate restructuring and outsourcing activities at the firm level, which may have occurred during the period 2010-2012. Thus, the dichotomous variable *change* assumes the unit value if one of these events have occurred during the observed time span. In addition, variable *newunits* indicates whether the firm has created new productive units in Italy or abroad. Summary statistics show that firms in the services industry are more dynamic compared to those in the industrial sector.

Finally, we also consider the role of internal barriers to the achievement of business objectives. In the CIS survey, firms are asked to assess the importance of different potential obstacles that are related to financial barriers, skill barriers and high costs of market entry.

From these answers, we construct a binary variable (*ostob_int*) that takes the value of 1 if the firm considers the degree of importance of these barriers as high or medium. The variable takes the value of 0 if the firm considers the barrier of low importance or not relevant at all. Another binary indicator is derived from the Industrial census (*ostinn_int*) and considers more specifically the degree of importance of internal factors hampering innovation, including the lack of information on technology and markets and on potential partners for innovation. The degree of importance of these obstacles is ranked higher for industry firms than for services and in the group of firms with a lower perception of their competitive level.

Internationalization. In this group, we include a set of variables that describe the spatial dimension of a firm's business activity. We have included a dummy variable indicating whether the firm went abroad to sell its product/services during 2011 (*intern*). The share of firms engaged in international trade is equal to 43%, with the high prevalence of firms operating in the industry compared to services sectors (47% vs. 39%). Additionally, the propensity to export is positively associated with a firm's perceived competitiveness: the share of exporting firms is significantly higher in the "higher" compared to the "lower" group of firms (+7 percentage points).

Productive internationalization is considered by including a dummy variable indicating whether the firm produced goods or services abroad (through FDIs or other international agreements) in 2011 (*intern_pd*) and two dummy variables that indicate whether the firm created new productive units in Europe (*newunits1*) or in non-European countries (*newunits2*) during the years 2010-2012. Productive internationalization is modest according to our data: only 8% of our sample produced abroad in 2011, and only 2% of our firms declared that they established new productive units in non-EU countries during the period 2010-2012. This evidence confirms established stylized facts on the internationalization of Italian firms. It is interesting to note that in the services sector, firms tend to have a higher propensity to move abroad in Europe than in the industry (11%, +6 percentage points).

Motives underlying a firm's choice to invest abroad are important determinants in the process of internationalization; thus, we have included two dichotomous variables that are intended to capture the relevance of factors that are related to the need of acquiring resources at a lower cost (*int_cos*) or exploiting the possibilities granted by new markets (*int_mkt*).

Finally, the ratio of foreign employees to total employment (*w_ue*) is another dimension of a firm's internationalization that we have considered. This ratio is modest in our sample of firms (3%), emphasizing the low propensity of Italian firms to attract foreign staff.

Ownership structure. The corporate structure is another relevant dimension that may affect a firm's perception of its competitiveness. The ownership structure is captured by variable *gp*, a dummy variable indicating whether the firm is part of a corporate group, while the relevance of family ownership is captured by a dummy variable (*prop_fam*) assuming the unit value when at least one of the three main shareholders is a family. Another indicator (*manag*) considers the role of the managerial responsibility within the firm, compared to the cases where the responsibility is under an individual entrepreneur or under a family. A firm's ownership nationality is captured by variable (*prop_ita*), which considers the nationality of the shareholders and assumes the unit value when at least one has Italian nationality. These statistics indicate that Italian firms are mainly family-owned and family-managed: 68% of the firms in our sample are family run, and in less than one-fourth of the cases, the firm's management is under the responsibility of a professional manager. Additionally, note that foreign ownership plays only a minor role (on average, only 10% of our sample belongs to an international group; see variable *gp_int*), thus confirming the poor attractiveness of the

Italian economic system (UNCTAD, 2013). However, our data highlight sectoral differences: in services, the role of both family and national ownership is less strong than in industry.

4. Methodology

To model a firm's self-perception, we adopt an empirical specification that enables us to analyse the impact of different competitiveness dimensions by using a stepwise procedure. We first consider the impact of groups of homogeneous determinants for each type of dimensions (output, input, knowledge capital, market conditions, organizational patterns, internationalization, and ownership structure), and then, after determining the most meaningful characteristics that are relevant for self-perception, we will set up a comprehensive model, which may summarize the entire set of relevant dimensions.

Our econometric strategy is represented by a generalized order logit model (Fu, 1999; Williams, 2006), which can be formalized as follows:

$$P(comp\_perc_i > j) = g(X\beta_j) = \frac{exp(\alpha_j + X_i\beta_j)}{1 + exp(\alpha_j + X_i\beta_j)} \qquad (1)$$
$$j = 1, 2, ..., M-1 \quad i = 1, 2, ..., N$$

where M is the number of categories of the dependent variable, X represents the set of explanatory variables, and the subscript i identifies the firm in the sample N.

Our dependent variable *comp_perc* has three categories: 1, "lower"; 2, "in line"; 3, "higher". Thus, the probability that variable $comp\_perc$ will take each of the three values is equal to:

$$\begin{aligned} P(comp\_perc_i = 1) &= 1 - g(X_i\beta_1) \\ P(comp\_perc_i = 2) &= g(X_i\beta_1) - g(X_i\beta_2) \\ P(comp\_perc_i = 3) &= g(X_i\beta_2) \end{aligned} \qquad (2)$$

When $M > 2$, this model is equivalent to estimating a set of binary logistic regressions where the ordered categories of the dependent variable are combined. If $M = 3$, for j=1, the category 1, "lower", is contrasted with the categories 2, "in line", and 3, "higher". For j=2, the categories 1, "lower", and 2, "in line", are contrasted with the category 3, "higher", and for j=3, the category 3, "higher", is contrasted with the categories 1, "lower", and 2, "in line".

It is worth noting that in the generalized ordered logit model, the *proportional odds* assumption is relaxed as the coefficients β's may vary for each value of j. In other words, it is assumed that the relationship between each pair of outcome groups, say the "lower" versus the other two categories or the "higher" versus the first two categories, may be not the same. This methodology allows for a more precise estimation of the expected impacts, which may remain hidden when a "parallel-lines" model is assumed.

To provide a more precise measure of the effects of each of the explanatory variables with respect to the firm's competitiveness perception, we present estimates of the odds ratios, which we now discuss.

For a logit model with a set of variable X and an additional variable of interest z, the odds ratio (*or*) change when z changes by one unit is:

$$or = \frac{Pr(y_i = 1|X, z+1)/Pr(y_i = 0|X, z+1)}{Pr(y_i = 1|X, z)/Pr(y_i = 0|X, z)} = exp(\beta_z) \qquad (3)$$

where β_k is the coefficient of z.

For a continuous variable, the odds ratio is the change in the probability for a unit change in that variable. For a dummy variable, it is the difference in the probability between firms with the characteristic described by the dummy variable and the rest of the population.

Recall that the ordered logit model estimates the regression coefficients over the levels of the dependent variable; thus, we need to compare individuals who are in groups greater than j with those who are in groups less than or equal to j, where j is the level of the response variable. The interpretation would be that for a one-unit change in the predictor variable, the odds for cases in a group that is greater than j versus less than or equal to j are the proportional odds times larger.

5. Econometric estimates

5.1 Results by groups of dimensions

Following the methodology outlined in the previous section, we first consider the impact on a firm's self-perception of groups of homogeneous determinants for each type of dimensions.

Economic and technical efficiency We observe a positive and significant effect of a firm's profitability. The effect of variable ros on the likelihood of having a positive perception is lower in the group of higher performers (+2.3%) compared to the larger group of non-negative performers (+3.9%). This may be justified on the grounds that higher performers should compete in a more complex environment, and this circumstance may negatively affect the likelihood of reporting a positive score. In the industrial sector, the probability gap between the two groups of performers becomes more pronounced, thus indicating that industrial firms may face greater complexity compared to firms operating in the services sector.

To capture the notion of "relative" competitiveness and how this affects individual perceptions, we also estimate a model where a firm's profitability and productivity are industry-adjusted ($dros$ and dva). We derive these additional measures by subtracting the mean sectoral values from the individual firm's ros and va. The impacts we observe are mild, thus signalling a possible low self-perception of the firm's economic performance when this is evaluated in relative terms.

Another dimension with a positive impact on a firm's perception is its market $share$. Our estimates do not indicate any differentiation between categories of the dependent variables as the Wald test of parallel-lines assumption is statistically insignificant.[8] Thus, a one-percent increase in the market share determines an increase in the likelihood of a positive perception equal to +2.5% without significant differences at the sectoral level.

The introduction of a product/process innovation, as measured by the $inntech$ dummy, positively affects a firm's perception, particularly in the group of higher performers where the probability of a positive assessment is 55% higher than the rest of the sample (+65% in the services).

[8] Within the gologit2 procedure for Stata program the parallel-lines assumption is tested through an iterative process. First, a totally unconstrained model is fitted. Each variable is then submitted to a Wald test to verify whether its coefficients differ across equations, e.g., whether the variable meets the parallel-lines assumption. If the Wald test is statistically insignificant for one or more variables, the variable with the least significant value on the Wald test is constrained to have equal coefficients across groups. The model is then refitted with constraints, and the process is repeated until there are more variables that meet the parallel-lines assumption. A global Wald test is then performed on the final model with constraints versus the original unconstrained model; a statistically insignificant test value indicates that the final model does not violate the parallel-lines assumption.

Physical and financial input. Among this group of dimensions a firm's dependence on external financing plays a relevant role in affecting its competitiveness self-assessment. In particular, the leverage ratio negatively affect the probability of a positive score: a one percent increase in the debt to net capital ratio reduces the probability by 2.8% in the full sample of firms, although the coefficients estimated separately for the industry and the services activities are not significant at conventional significance levels. The effect we observe is non-significant when the $dlev$ variable, which is industry-adjusted, is included.

Our results also suggest that being highly dependent on external financing reduces the likelihood of a positive perception regardless of whether external resources are required for productive investments or in order to face liquidity constraints. It is interesting to note that firms which borrow from a limited number of banks tend to have a lower perception. This result may indicate that Italian firms prefer to diversify external financing resources among several banks. Estimations by sector reveal a more controversial picture as the $bank$ coefficient in not significant in the industry sector, whereas it is negative and significant in the services sector, where having established a close relationship with a limited number of bank reduces the probability of a positive perception by 22%.

The characteristics of physical inputs do not enter as important determinants of a firm's self-assessment: firm's size ($empl$) and labour compensation have a positive impact but the effect is very mild, while the workforce composition, both in terms of young and female workers, has a very mild effect.

Physical capital deepening (kl) does not play a key role, although it is worth noting that individual perceptions are positively influenced by the decision to invest in advanced machinery and equipment for innovation ($rmac$), with results that are differentiated by groups of firms according to their relative self-assessed performance. In particular, if we look at the entire sample (both industry and services firms), the probability of having a higher perception is increased by 16% in the group of "positive" performers, but it is much higher in the group of higher performers (+49%). These differences characterize specifically the industrial sector.

Knowledge capital. On average, skilled workers represent a limited component of the overall employment (5% in our sample of firms), and this may justify the very mild effect that variable *h_skill_w* has on a firm's competitiveness perception (mostly confined to the services sector). Despite this evidence, our estimates also suggest that a firm's decision to employ high-skilled workers during year 2011 (*hcapital_11*) positively and significantly affects a firm's perception. Estimates over the entire sample indicate a higher effect in the group of higher performers (+69%) compared to the group also including the firms "in line". In addition, we should expect a higher impact in the services sector compared to industry, although estimates by sector do not capture any significant difference between groups of performers.

Among the group of variables indicating a firm's innovation propensity, the engagement in marketing innovation exerts a positive and significant impact (+40%) only in the restricted group of higher performers, while in the broader group of non-negative performers, the impact is not significant, thus indicating the possible role of heterogeneity in the firm's perception. This evidence characterizes specifically the industrial sector, whereas in the services sector, we do not observe significant differences between the two groups of firms.

A firm's perception is also positively affected by the ability to put in place training activities for innovation, although the effect is significant within the services sector but not at the industry level. In line with this result, it is interesting to note that only within the restricted group of higher performers in the services sector, involvement in internal R&D activities positively and significantly affect a firm's competitiveness perception.

Finally, intellectual property protection, for which the variable *int_prop* serves as a proxy, exerts a positive and significant impact in both the industrial and services sectors, thus indi-

cating that intellectual property has increasingly been perceived as a source of competitive advantage for all businesses.

Organizational patterns and ownership structure In general, organizational changes significantly have an impact on a firm's perception: having established new productive units during the period 2010-2012 (*newunits*) together with the introduction of new organizational forms (*innorg*) show a significant impact on the probability of positive perception. Conversely, individual perception is negatively affected by obstacles to innovation and, more in general, to the successful achievement of business objectives. It is interesting to note that the estimated (negative) effect of variable *ostinn_int* is lower in the sub-group of higher performers, thus indicating that the impact of internal obstacles to innovation, although relevant, may be mitigated when the firm has a positive perception of its competitiveness level. A firm's *age* presents a negative impact, thus suggesting that older firms may face greater difficulties in competing.

Our estimates also show that firms' perception increases with more complex ownership structures. Taking part in a corporate group (*gp*) has a positive and significant impact in both the industrial sector and the services sector, while family ownership (*prop_fam*) exerts a negative impact, although not significant at conventional significance levels in the specifications by sector.

It is worth noting that the relationship between having managerial responsibility (*gest_manag*) and a firm's competitiveness self-assessment indicates a non-parallel slope, with the group of higher-performers showing a significant impact on the likelihood of a positive perception, while the effect does not appear significant when also including the firms "in line". This result holds for the services firms, while for the industrial firms, a constant coefficient (although not significant at the conventional levels) may indicate that the two groups of firms do not differ much.

Market conditions Our results show that sectoral characteristics such as industry concentration (*cr5*) or sectoral technological opportunities, for which the *innset* ratio serves as a proxy, do not significantly affect firms' perception.

Regional factors have a role in determining the positive self-perception of industrial firms: firms localized in the north-western, north-eastern and central regions show a better perception of their competitiveness compared to the firms localized in the South. Localization does not significantly affect the self-assessment of the services firms.

As concerns the international dimension of competition, for which the variable *int_comp* serves as a proxy, firms are more likely to have a negative perception when their competitors are localized abroad, although the estimated effect is not significant in the group of higher performers.

In addition, firms' perception is negatively affected by potential obstacles such as the presence of dominant competitors or market factors such as possible barriers to the achievement of business objectives. Our results show that the effect of the variable *ostinn_mkt* is relevant (-59% in the total sample of firms) and appears to be differentiated in the services sector, with a lower impact in the group of higher performers. Similarly, the coefficient estimate of the variable *ostob_est* shows effects that are differentiated in both the industry and services sectors: firms that perceive themselves as higher performers have a probability reduction, which is lower than in the group that also includes the firms “in line".

Internationalization Our estimates suggest that firms that are a part of an international group, for which the dummy *gp_int* serves as a proxy, tend to have a better perception of their

competitiveness. According to our model, the probability change is higher in the industrial sector (+45%) compared to the services sector (+25%).

Considering firms' internationalization choices, a firm's propensity to export (*intern*) significantly affects the probability of a positive self-assessment, but this effect is confined to the group of higher performers (+21%). Estimates by sector unveil a more differentiated pattern: in the services sector, the impact is positive and significant (+23%) without any relevant differentiation by groups of firms, while in the industrial sector, the impact is positive in the group of higher performers but it is negative - although not highly significant - in the broader group of firms that also includes the firms "in line". This result suggests a possible higher level of perceived complexity that may be felt by those industrial firms that decide to sell their products abroad.

Conversely, the propensity to produce services or goods abroad, for which the variable *intern_pd* serves as a proxy, does not produce a significant impact. This result is as expected, given the reduced number of firms engaged in productive internationalization, according to the industrial census results. Complementary information may be derived from the CIS survey: the decision to establish new units in other EU countries (variable *newunits1*) has a positive impact, while the impact of having established new plants in non-EU countries (variable *newunits2*) is not significant. This latter evidence is, however, as expected, given the modest proportion of firms reporting new plants in non-European countries during the observed time span. Finally, our estimates show that factors influencing productive internationalization may affect differently the probability of a positive self-assessment depending on the sector of activity: in the services sector, we observe a significant probability reduction (-51%) when delocalization is driven by the need to find resources at lower costs (variable *int_cos*). Conversely, in the industrial sector, the probability of providing a higher score increases more than double when the need to move abroad is justified on the grounds that firms want to exploit opportunities for new markets (variable *int_mkt*)

5.2 The full model: a parsimonious specification

In the previous section, we have modelled a firm's competitiveness self-perception and the factors affecting it by using a one-at-a-time approach instead of all simultaneously. This approach is relevant, as it allows one to pinpoint the best proxies for each of the factors we have suggested in Section 3.2.

In this section, we attempt to unify these preliminary results in order to propose a parsimonious specification that may fully describe the complex mechanisms at work. As a first step, a full specification is estimated to test for the joint significance of all the covariates in each group of dimensions. The results indicate that all the dimensions of competitiveness we have identified are relevant in shaping individual perception: the chi-square tests presented in Table 6 are significant for the complete sample of firms. Nevertheless, the tests performed by sector of activity unveil a quite controversial result for the industrial sector, as the variables included in the internationalization group are not jointly significant when combined with the full set of determinants, and the same is true for the group of variables indicating a firm's ownership structure, which is highly insignificant.

Although these tests only indicate that some of the variables used are jointly equal to zero in the industrial sector and thus do not imply that all of the estimated coefficients are equal to zero independently, we intend to explicitly investigate the role of sectoral differences in explaining possible heterogeneity in firms' self-perception.

In the specification shown in Table 7, we propose a parsimonious model, by including a restricted group of regressors, which may adequately synthesize our original set of factors. In the first two columns, we present the results for the complete sample of firms. In the first column, we also include a dummy variable indicating whether a firm operates in the

industrial sector, with the reference category being the services sector. The results indicate that industrial firms are expected to give a lower score to their competitive position compared to the services firms (-27%). On the basis of this evidence, a likely ratio test is used to test for structural change in the coefficients over the two sub-groups of industry and services firms. The test rejects the null hypothesis of equality between the two groups of coefficients, thus suggesting that firms operating in the industrial and services sectors do perceive differently competitiveness factors.

The *ros* index and the *inntech* dummy are proxies for the economic and technical efficiency. The positive effect of a firm's profitability on individual perceptions continues to be strong and differentiated among sectors and groups of firms. The effect of technological innovation is confirmed positive and significant although the parallel-line assumption is not violated, and thus, we do not observe differences between groups of performers when the effect is conditional on additional regressors. Nevertheless, the results for the services sector confirm the higher impact on the likelihood of a positive perception compared to the industrial sector.

From the group of physical and financial inputs, we have selected the leverage index (physical inputs do not play a key role in the restricted specification in Table 2, part B). The effect of variable *lev* continues to be negative although not highly significant in the full sample of firms and not significant at the conventional significance levels in the sub-samples at the sector level. The evidence that the *lev* coefficient is not highly significant when conditioning to the effect of other regressors is not surprising if one considers that the leverage index is derived from an administrative source of data (balance sheets), which is not designed for statistical purposes. Nevertheless, this result is consistent with the evidence in the restricted specification where we do find support that being highly dependent on external financing reduces the probability of a positive perception, without significant differences at the sectoral level.

Among the group of variables reflecting knowledge capital, we have selected three dummies indicating a firm's decision to employ high-skilled workers (*hcapital_11*), its propensity to introduce marketing innovation (*innmkt*) and the intellectual protection variable *int_prop*. All these variables positively and significantly affect a firm's self-assessment in the restricted specification of Table 3 and confirm their impact in the full model. In particular, the effect of variable *hcapital_11* continues to be higher compared to the industrial sector, although with homogeneous slop coefficients in the full model.

Among the factors affecting firms' internationalization, the two variables indicating a firm's export propensity and its decision to establish new units in other EU countries have been retained. The impacts on individual perceived competitiveness continue to be positive and significant over the entire sample of firms, although in the industrial sector, the estimated coefficient for variable *newunits1* appears not significant at the conventional significance levels. The effect of export propensity confirms a possible larger difficulty, which may be perceived by industrial firms compared to services firms.

The coefficient of the dummy *gest_manag*, which we have selected among the factors capturing the effect of complex ownership structures, is confirmed positive and significant. Note that in the industrial sector, the coefficient is now significant, although the effect continues to be milder compared to the services sector.

Finally, we have considered a firm's market condition by including the dummy variable indicating whether its competitors are located abroad (*int_comp*) and the firm's localization dummies. When conditional on the additional set of regressors, the negative impact of the *int_comp* dummy on individual perception is more precisely estimated in the group of higher performers: in fact, we observe in the full specification a negative and significant impact, which is, however, less pronounced than in the broader group of non-negative performers. This result indicates that firms that are better positioned than competitors perceive themselves

as less constrained by international competition compared to the group of firms that are in line with competitors.

The impact of the localization dummies in the industry sub-sample is now less significant, compared to the restricted specification in Table 5, particularly for the northeast and central areas. This result is not surprising, as other variables included in the full model (i.e., *inn_tech*, *int_prop* and *gest_manag*) are related to geographical characteristics and thus may pick-up regional differences.

6. Discussion and conclusions

In this paper, we have proposed a novel approach for analysing firm-level competitiveness, as it adopts a different point of view, namely, that of a firm' subjective perception. We have defined a conceptual framework that has enabled us to investigate how firms perceive their competitiveness level and how they feel the influence of competition factors.

By using a large, integrated database, we have identified groups of homogeneous determinants - both survey-based and derived from administrative archives, which are commonly indicated by the literature as mechanisms affecting a firm's competitiveness (economic and technical efficiency, physical and financial input, knowledge capital, market conditions, organizational patterns, internationalization, and ownership structure).

We have adopted a stepwise procedure that allows one to first analyse the impact of each group of determinants and then, after determining the most meaningful characteristics that are relevant for self-perception, to set up a comprehensive model, which may summarize the entire set of relevant dimensions. Our econometric strategy is represented by a generalized order logit model, which has been used to predict an ordinal dependent variable derived from a self-reported status (higher, in line, lower than competitors). By allowing regression coefficients to vary across different categories of the dependent variable, this methodology provides a more precise estimate of the expected impacts, which may remain hidden when a "parallel-lines" model is assumed.

Our results indicate the presence of sectoral specificities and group heterogeneity in the way firms perceive their competitiveness. We show that industrial and services firms perceive differently those factors of competitiveness such as profitability, technological innovation, knowledge capital, complex ownership structure and internationalization patterns. Indeed, differences also emerge if one looks at the sectoral sample means. It is worth noting that services firms are smaller, endowed with more female-intensive workers and less exposed to international competition. They are younger and with more younger, skilled workers than those operating in the industrial sector. These latter characteristics may in part explain a somewhat more advanced organizational structure (less family managed and more open to foreign ownership). Although we are aware of the fact that the services sector considered in this study includes a collection of tertiary activities, which are highly diversified, there is room to believe that this evidence could offer interesting suggestions for further research.

We have also found that firms' top performers, according to their perception, tend to score more positively, compared to the other firms with non-negative self-perception a number of competitive factors indicating technological input and output, knowledge capital and managerial abilities. They also tend to be less constrained by threats such as liquidity pressures, internal obstacles to innovation, market factors hampering business goals and international competition.

We further note that the heterogeneity we observe by groups of performers is not always confirmed when moving to the parsimonious specification. Thus, we conclude that although the sign of the variables included remains confirmed and significant, group-specific differences, which are captured in the set of regressions by homogeneous determinants, may be lost in the full model, which combines the various mechanisms at work.

In other cases, sectoral specificities and group heterogeneity are robust to the model specification. Our estimates show that for the top performers in the industrial sector, the impact of operating profitability on the likelihood of a positive perception is lower than in the group of non-negative performers, thus indicating that industrial firms may face greater complexity compared to firms operating in the services industry. However, we observe that in the services industry, having an ownership structure based on managerial responsibility positively and significantly affects the likelihood of a positive assessment only in the group of top performers.

The evidence outlined should certainly not be regarded as a rigorous test of the hypothesized relationships but rather as a proposed conceptual framework for competitiveness analysis. The methodology proposed in this work allows us to predict firms' confidence in their competitive position by linking self-reported data on perceived competitiveness to a wide range of possible determinants, both quantitative and qualitative, which are not confined to the typical price-cost aspects of competitiveness.

Our suggestion is that the use of a perceived competitiveness indicator, which may be developed by gathering the responses coming from structural business statistics, could provide useful insights for more focused competitiveness policies. When a micro-founded approach to self-reported competitiveness is adopted, as the one that is the basis of the present work, both academics and policy analysts may be better oriented for a comprehensive interpretation of possible mismatches observed between individual perception and what they actually observe in the real economy.

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Appendix 1 - Samples' comparison: distribution by sector, localization, size and perceived competitiveness

	Final sample (Business Census linked to CIS 2010-2012 and balance sheets)	2011 Business Census (multipurpose survey)	Business Census linked to CIS 2010-2012
by sector (Nace classification)		percentages	
Mining and quarrying	1.1	0.4	1.0
Food, beverages and tobacco	2.9	4.8	2.9
Textile industries	1.1	2.2	1.0
Dressmaking and garnments	1.0	2.7	1.0
Leather and footwear	1.1	2.2	1.1
Wood and wood products	0.8	1.7	0.9
Paper	0.9	1.1	0.8
Graphic art and recorded media	0.8	1.2	0.8
Coke products and petroleum refinery	0.5	0.1	0.4
Chemical industries	1.4	1.5	1.3
Pharmaceutical products	0.7	0.3	0.6
Rubber and plastic materials	1.3	2.7	1.2
Other non metallic mineral products	1.2	2.7	1.1
Metallurgy	1.2	1.3	1.1
Metal products	2.5	7.6	2.4
Computer products, elettronics and optics	1.0	1.3	0.9
Materials and electric machinery	1.2	2.1	1.1
Mechanical machinery and ncaa equipment	3.0	6.6	2.7
Motor vehicles, trailers and semi-trailers	1.1	0.9	1.0
Other transport materials	0.7	0.6	0.6
Furnitures	1.0	1.9	0.9
Other manufacturing industries	0.9	1.4	0.8
Repair and installation of machinery and equipment	1.0	1.9	0.9
Electricity, gas, steam and air conditioning supply	2.2	0.5	2.0
Water supply; sewerage, waste and remediation	4.4	1.8	4.1
Costruction	17.4	11.0	17.3
Wholesale and retail trade	27.2	22.2	27.3
Transportation and storage	8.7	7.6	8.1
Information and communication	4.4	3.2	3.9
Financial and insurance activities	0.5	1.2	4.5
Professional, scientific and technical activities	6.9	3.3	6.3
by size class (employees)			
less than 50	54.5	80.0	56.7
50-249	30.8	17.2	29.0
250 and more	14.7	2.8	14.3
by area			
north-west	31.5	35.6	30.8
north-east	30.6	28.0	31.2
centre	17.9	19.2	17.7
south	20.0	17.2	20.3
by perceived competitiveness			
lower	10.8	15.2	15.2
in line	76.5	74.7	74.7
higher	12.8	10.2	10.2
TOTAL	*10,943*	*98,481*	*12,622*

Appendix 2 - List of variables

Name	Type	Description	Source
comp_perc	1,2,3	Perceived competitiveness (1=lower; 2=in line; 3=higher)	Industrial Census 2011
Economic and technical efficiency			
ros	%	Return on sales. The ratio between gross operating profits and sales. An index of operating profitability	balance sheets
va	c	Labour productivity. Value added per employee ratio	balance sheets
share	%	Market share. The ratio of a firm's sales to sectoral sales	balance sheets
turn_ch	%	Sales change 2012-2010	Cis 2010-2012
inntech	0/1	The firm has introduced a technological innovation	Cis 2010-2013
Phisical and financial input			
empl	c	Number of employees	Asia register
young_w	%	Share of young workers (aged 15-29)	Industrial Census 2011
fem_w	%	Share of female workers	Industrial Census 2011
kl	c	Capital deepening. Tangible fixed assets per employee	balance sheets
cosl	c	Labour cost per employee	balance sheets
rmac	0/1	Acquisition of advanced machinery, equipment (including computer hardware) or software	Cis 2010-2012
lev	%	Leverage. The ratio of total debts to shareholders' funding	balance sheets
ext_fin_liq	0/1	High external borrowing due to liquidity constraints	Industrial Census 2011
ext_fin_inv	0/1	High external borrowing due to productive investments	Industrial Census 2011
bank	0/1	Bank debt concentrated at the main bank (more than 50%)	Industrial Census 2011
Knowledge capital			
h_skill_w	%	Share of high-skill workers	Industrial Census 2011
h_skill_2011	0/1	The firm has engaged high-skill workers during 2011	Industrial Census 2011
innmkt	0/1	The firm has introduced a marketing innovation	Cis 2010-2012
rrdin	0/1	The firm has performed in-house R&D	Cis 2010-2012
rrdex	0/1	The firm has acquired external R&D	Cis 2010-2012
rtr	0/1	The firm has been engaged in training activities for innovation	Cis 2010-2012
co	0/1	The firm has cooperated on innovation with other firms or institutions	Cis 2010-2012
int_prop	0/1	The firm has adopted tools for intellectual property protection	Industrial Census 2011

Appendix 2 continued **- List of variables**

Name	Type	Description	Source
Market conditions			
CR5	%	Concentration ratio. The market share of the five largest firms (sales)	balance sheets
innset	%	Sectoral innovators (technological innovation)	Cis 2010-2012
nwest	0/1	Regional areas	Asia register
neast	0/1		Asia register
centre	0/1		Asia register
south	0/1		Asia register
int_comp	0/1	Competitors localized abroad	Industrial Census 2011
ostob_est	0/1	Obstacles to business objectives: market factors highly important	Cis 2010-2012
ostinn_mkt	0/1	Obstacles to innovation: dominant competitors	Industrial Census 2011
Organizational patterns			
age	c	Firm's age (years)	Asia register
innorg	0/1	The firm has introduced an organizational innovation	Cis 2010-2012
change	0/1	Corporate restructuring/outsorcing	Cis 2010-2012
newunits	0/1	Created new productive units in Italy or abroad	Cis 2010-2012
ostob_int	0/1	Obstacles to business objectives: internal factors highly important	Cis 2010-2012
ostinn_int	0/1	Obstacles to innovation: internal factors	Industrial Census 2011
Internationalization			
gp_int	0/1	The firm takes part of an international group	Cis 2010-2012
intern	0/1	The firm has sold abroad its products/services	Industrial Census 2011
intern_pd	0/1	The firm has produced goods/services abroad	Industrial Census 2011
newunits1	0/1	Created new productive units in EU	Cis 2010-2012
newunits2	0/1	Created new productive units in non-EU countries	Cis 2010-2012
int_cos	0/1	Factors affecting productive internationalization: cost factors very important	Industrial Census 2011
int_mkt	0/1	Factors affecting productive internationalization: exploring new markets very important	Industrial Census 2011
w_ue	%	Share of foreign employees (EU)	Industrial Census 2011
Ownership structure			
prop_fam	0/1	Family ownership. At least one of the first three shareholders is a family	Industrial Census 2011
manag	0/1	Firm management under professional managers	Industrial Census 2011
gp	0/1	The firm takes part of a group	Cis 2010-2012
prop_ita	0/1	National Ownership. At least one of the first three shareholders is Italian	Industrial Census 2011

Appendix 3 - Descriptive statistics by perceived competitiveness

	all (N=10,943)		comp_perc = 1 (N=1,178)		comp_perc = 2 (N=8,369)		comp_perc = 3 (N=1,139)	
Variable	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
ros	3.31	7.52	0.77	8.79	3.46	7.31	4.52	7.13
va	71.44	133.96	53.37	57.07	71.27	122.40	87.63	218.02
turn_ch	127.64	8476.65	73.32	1199.56	32.51	512.62	742.46	23651.05
share	0.47	2.41	0.29	1.22	0.45	2.29	0.73	3.58
inntech	0.41	0.49	0.36	0.48	0.40	0.49	0.51	0.50
dros	2.71	282.86	-93.40	353.44	7.93	269.71	51.68	275.86
dva	23.04	163.29	-2.48	106.15	23.52	168.79	41.59	166.64
empl	201.05	1680.10	122.22	479.05	179.64	753.30	395.96	4300.85
kl	100.73	509.72	84.18	325.48	101.16	528.90	112.05	518.97
cosl	43.21	44.21	40.01	19.26	43.29	47.78	45.38	36.13
rmac	0.30	0.46	0.26	0.44	0.29	0.46	0.39	0.49
young_w	15.38	16.15	13.73	15.00	15.37	16.18	16.82	16.78
fem_w	14.42	12.67	13.87	12.54	14.29	12.67	15.68	12.72
lev	1.22	1.94	1.38	2.23	1.23	1.94	1.08	1.62
est_fin_liq	0.21	0.41	0.33	0.47	0.20	0.40	0.16	0.37
est_fin_inv	0.17	0.37	0.28	0.45	0.16	0.37	0.12	0.33
bank	0.23	0.42	0.28	0.45	0.23	0.42	0.21	0.41
dkl	409.87	4562.73	423.93	6008.80	390.20	3997.53	516.03	6086.64
dcosl	7.87	104.61	1.04	44.28	8.22	115.31	11.45	65.84
dlev	115.33	589.13	130.77	534.12	115.63	616.65	100.71	446.92
h_skill_w	5.33	12.08	4.30	11.34	5.17	11.74	7.21	14.32
h_skill_2011	0.31	0.46	0.23	0.42	0.29	0.46	0.43	0.50
innmkt	0.34	0.48	0.31	0.46	0.33	0.47	0.44	0.50
int_prop	0.18	0.39	0.15	0.36	0.17	0.38	0.26	0.44
rrdin	0.18	0.38	0.16	0.37	0.17	0.37	0.23	0.42
rrdex	0.08	0.28	0.07	0.25	0.08	0.27	0.11	0.32
co	0.09	0.29	0.09	0.28	0.09	0.28	0.12	0.33
rtr	0.18	0.38	0.16	0.36	0.17	0.38	0.24	0.43

Appendix 3 continued **- Descriptive statistics by perceived competitiveness**

Variable	all (N=10,943) Mean	Std. Dev.	q406 = 1 (N=1,178) Mean	Std. Dev.	q406 = 2 (N=8,369) Mean	Std. Dev.	> q406 = 3 (N=1,139) Mean	Std. Dev.
cr5	35.85	15.26	35.97	14.98	35.75	15.21	36.34	15.79
immset	29.66	17.09	30.41	17.87	29.21	16.92	31.73	17.22
int_comp	0.28	0.45	0.34	0.47	0.27	0.44	0.29	0.46
ostinn_mkt	0.07	0.26	0.16	0.36	0.07	0.25	0.04	0.19
ostob_est	0.70	0.46	0.82	0.39	0.70	0.46	0.61	0.49
nwest	0.31	0.46	0.29	0.45	0.32	0.46	0.33	0.47
neast	0.31	0.46	0.31	0.46	0.30	0.46	0.31	0.46
centre	0.18	0.38	0.17	0.38	0.18	0.39	0.17	0.38
south	0.20	0.40	0.23	0.42	0.20	0.40	0.19	0.39
change	0.17	0.38	0.16	0.37	0.17	0.37	0.20	0.40
newunits	0.09	0.29	0.07	0.25	0.09	0.29	0.13	0.34
ostinn_int	0.45	0.50	0.70	0.46	0.44	0.50	0.33	0.47
ostob_int	0.44	0.50	0.55	0.50	0.43	0.50	0.38	0.48
innorg	0.41	0.49	0.34	0.47	0.40	0.49	0.52	0.50
age	23.39	16.13	23.85	17.34	23.38	15.97	23.06	16.05
gp_int	0.10	0.30	0.08	0.27	0.10	0.30	0.14	0.34
newunits1	0.08	0.28	0.06	0.23	0.08	0.27	0.12	0.32
newunits2	0.02	0.14	0.01	0.11	0.02	0.13	0.03	0.16
intern	0.43	0.49	0.41	0.49	0.42	0.49	0.48	0.50
intern_pd	0.08	0.28	0.08	0.27	0.08	0.28	0.10	0.30
int_mkt	0.06	0.23	0.04	0.20	0.06	0.23	0.07	0.26
int_cos	0.05	0.21	0.05	0.22	0.05	0.21	0.05	0.21
w_ue	3.27	7.97	3.63	7.98	3.22	7.99	3.25	7.88
gp	0.57	0.49	0.50	0.50	0.56	0.50	0.65	0.48
prop_fam	0.68	0.47	0.73	0.45	0.69	0.46	0.61	0.49
prop_ita	0.93	0.25	0.94	0.24	0.93	0.25	0.91	0.28
gest_manag	0.22	0.41	0.20	0.40	0.21	0.41	0.29	0.45

Table 1 - Average values by sectors

Variable	Industry (N=5,730)	Services (N=5,213)	significance (t-test)	Variable	Industry (N=5,730)	Services (N=5,213)	significance (t-test)
comp_perc	1.99	2.05	***				
ros	3.89	2.67	***	cr5	37.71	33.81	***
va	77.14	65.19	***	innset	32.58	26.46	***
turn_ch	184.13	65.43		int_comp	0.34	0.21	***
share	0.58	0.35	***	ostinn_mkt	0.07	0.07	
inntech	0.45	0.36	***	ostob_est	0.71	0.68	***
dros	1.51	4.03		nwest	0.28	0.35	***
dva	19.33	27.12	**	neast	0.32	0.29	***
				centre	0.19	0.17	***
empl[a]	47.00	36.00	***	south	0.20	0.19	*
kl	119.63	80.01	***				
cosl	43.60	42.78		change	0.16	0.18	**
rmac	0.34	0.26	***	newunits	0.07	0.12	***
young_w	13.82	17.09	***	ostinn_int	0.48	0.43	***
fem_w	10.76	18.45	***	ostob_int	0.46	0.41	***
lev	1.33	1.11	***	innorg	0.41	0.40	
est_fin_liq	0.24	0.18	***	age	24.31	22.37	***
est_fin_inv	0.19	0.15	***				
bank	0.23	0.24	**	gp_int	0.09	0.12	***
dkl	155.97	688.33	***	newunits1	0.05	0.11	***
dcosl	5.33	10.65	***	newunits2	0.02	0.01	***
dlev	82.01	151.96	***	intern	0.47	0.39	***
				intern_pd	0.10	0.07	***
h_skill_w	4.18	6.60	***	int_mkt	0.07	0.04	***
h_skill_2011	0.32	0.29	***	int_cos	0.06	0.03	***
innmkt	0.32	0.37	***	w_ue	3.71	2.78	***
int_prop	0.22	0.14	***				
rrdin	0.24	0.10	***	gp	0.56	0.57	
rrdex	0.11	0.05	***	prop_fam	0.70	0.66	***
co	0.11	0.08	***	prop_ita	0.94	0.92	***
rtr	0.20	0.16	***	manag	0.20	0.24	***

Two-sample *t-test* with equal variances (confidence level=0.95).

(a) Medians are reported. The Wilcoxon rank-sum-test is performed.

Table 2 - Firm's perceived position against competitors - Economic and technical efficiency (Part A) and Phisical and financial inputs (Part B) (odds ratios)

Part A: Economic and technical efficiency

variables	*in line and higher vs. lower*	*higher vs. lower and in line*	*in line and higher vs. lower*	*higher vs. lower and in line*	*in line and higher vs. lower*	*higher vs. lower and in line*	*in line and higher vs. lower*	*higher vs. lower and in line*	*in line and higher vs. lower*	*higher vs. lower and in line*	*in line and higher vs. lower*	*higher vs. lower and in line*
	All sectors		Industry		Services		All sectors		Industry		Services	
ros	1.037***	1.023***	1.039***	1.016***	1.036***							
	[0.00409]	[0.00430]	[0.00539]	[0.00608]	[0.00465]							
va	1.004***	1.000**	1.003***	1.001***	1.005***	1,000						
	[0.000829]	[0.000193]	[0.00101]	[0.000252]	[0.00140]	[0.000326]						
turn_ch	1.000		0.999		1.000		1.000		0.999		1.000	
	0.00015		0.00082		0.00016		0.00015		0.00082		0.00016	
share	1.025***		1.028**		1.027**		1.026***		1.028**		1.029**	
	[0.00880]		[0.0130]		[0.0127]		[0.00888]		[0.0128]		[0.0129]	
inntech	1.180**	1.551***	1.209**	1.552***	1.225*	1.656***	1.189***	1.559***	1.203**	1.541***	1.252**	1.689***
	[0.0790]	[0.0921]	[0.105]	[0.136]	[0.131]	[0.136]	[0.0793]	[0.0927]	[0.105]	[0.135]	[0.133]	[0.138]
dros							1.001***		1.001***		1.001***	
							[0.00082]		[0.000181]		0,00098	
dva							1.003***	1.000**	1.003***	1.001**	1.003***	1.000
							[0.000580]	[0.000161]	[0.000857]	[0.000258]	[0.000794]	[0.000221]
Constant	5.782***	0.104***	5.035***	0.0862***	6.422***	0.119***	7.735***	0.114***	6.985***	0.0955***	8.714***	0.133***
	[0.332]	[0.00481]	[0.383]	[0.00617]	[0.566]	[0.00720]	[0.313]	[0.00478]	[0.394]	[0.00620]	[0.513]	[0.00732]
LL(0)	-7,366.45		-3,790.88		-3,556.39		-7,366.45		-3,790.88		-3,556.39	
LL(full)	-7,235.32		-3,718.18		-3,480.94		-7,229.74		-3,716.36		-3,484.10	
LR chi2(k)	268.28 (8)		145.40 (8)		150.90 (7)		273.43 (7)		149.03 (8)		144.57 (7)	
McFadden's R^2	0.0178		0.0192		0.0212		0.0186		0.0197		0.0203	
Observations	10,450		5,471		4,979		10,450		5,471		4,979	

Part B: Phisical and financial inputs

variables	*in line and higher vs. lower*	*higher vs. lower and in line*	*in line and higher vs. lower*	*higher vs. lower and in line*	*in line and higher vs. lower*	*higher vs. lower and in line*	*in line and higher vs. lower*	*higher vs. lower and in line*	*in line and higher vs. lower*	*higher vs. lower and in line*	*in line and higher vs. lower*	*higher vs. lower and in line*
	All sectors		Industry		Services		All sectors		Industry		Services	
empl	1.000***		1.000**		1.000***		1.000***		1.000**		1.000***	
	0.00025		0.00041		0.00034		0.00025		0.00041		0.00034	
kl	1.000		1.000		1.000							
	0.00042		0.00047		[0.000111]							
cosl	1.007***	1.001*	1.008***	1	1.007***	1.001*						
	[0.00196]	[0.000491]	[0.00303]	[0.000839]	[0.00263]	[0.000731]						
rmac	1.162**	1.491***	1,152	1.573***	1.409***		1.172**	1.491***	1.165*	1.577***	1.405***	
	[0.0833]	[0.0907]	[0.107]	[0.138]	[0.105]		[0.0839]	[0.0907]	[0.108]	[0.138]	[0.105]	
young_w	1.007***		1.008***		1.006***		1.007***		1.008***		1.006***	
	[0.00143]		[0.00231]		[0.00185]		[0.00143]		[0.00231]		[0.00184]	
fem_w	1,001	1.007***	1,003		1,000		1,001	1.007***	1,003		1,001	
	[0.00255]	[0.00230]	[0.00307]		[0.00248]		[0.00255]	[0.00230]	[0.00307]		[0.00247]	
lev	0.972**		0,976		0,974							
	[0.0116]		[0.0163]		[0.0166]							
est_fin_liq	0.628***	0,932	0.636***	1,025	0.645**	0,884	0.620***	0,92	0.640***	1,032	0.632**	0,866
	[0.0790]	[0.117]	[0.100]	[0.164]	[0.136]	[0.181]	[0.0775]	[0.115]	[0.100]	[0.165]	[0.133]	[0.177]
est_fin_inv	0.741**		0.773*		0.686*		0.742**		0.766*		0.697*	
	[0.0923]		[0.121]		[0.142]		[0.0922]		[0.119]		[0.144]	
bank	0.850***		0,911		0.782***		0.846***		0,912		0.776***	
	[0.0464]		[0.0702]		[0.0607]		[0.0461]		[0.0703]		[0.0603]	
dkl							1,000		1,000		1,000	
							[0.000058]		[0.000149]		[0.000062]	
dcosl							1.003***	1.000	1.003**	1.000	1.003***	1.000
							[0.000863]	[0.000204]	[0.00131]	[0.000357]	[0.00116]	[0.000258]
dlev							1.000		1.000		1.000	
							[0.000373]		[0.000113]		[0.000401]	
Constant	6.733***	0.109***	5.548***	0.0927***	7.684***	0.151***	8.764***	0.110***	7.645***	0.0936***	9.784***	0.155***
	[0.701]	[0.00695]	[0.835]	[0.00832]	[1.036]	[0.0125]	[0.535]	[0.00643]	[0.580]	[0.00745]	[0.791]	[0.0115]
LL(0)	-7,461.11		-3,832.99		-3,608.02		-7,451.45		-3,832.99		-3,598.37	
LL(full)	-7,326.53		-3,769.07		-3,451.27		-7,322.26		-3,770.53		-3.535.0908	
LR chi2(k)	269.16 (14)		127.84 (13)		133.49 (12)		258.37 (14)		124.91 (13)		126.56 (12)	
McFadden's R^2	0.0180		0.0167		0.0185		0.0173		0.0163		0.0176	
Observations	10,569		5,530		5,039		10,561		5,530		5,031	

Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1

Table 3 - Firm's perceived position against competitors - Knowledge capital (Odds ratios)

Firm's perceived position against competitors - Knowledge capital (odds ratios)

variables	*in line and higher vs. lower*	*higher vs. lower and in line*	*in line and higher vs. lower*	*higher vs. lower and in line*	*in line and higher vs. lower*	*higher vs. lower and in line*
	All sectors		Industry		Services	
h_skill_w	1.006***		1,003		1.004*	
	[0.00190]		[0.00331]		[0.00237]	
h_skill_11	1.388***	1.693***	1.496***		1.682***	
	[0.103]	[0.105]	[0.109]		[0.126]	
innmkt	1,082	1.403***	1,018	1.388***	1.214***	
	[0.0741]	[0.0859]	[0.0957]	[0.127]	[0.0849]	
int_prop	1.267***		1.245**		1.384***	
	[0.0791]		[0.107]		[0.128]	
rrdin	0.971		1.093		0.597***	1.303**
	[0.0689]		[0.0998]		[0.0947]	[0.166]
rrdex	1.064		1.073		1.160	
	[0.0983]		[0.125]		[0.177]	
co	0.879		0.926		0.805	
	[0.0780]		[0.109]		[0.108]	
rtr	1.156**		1.079		1.287***	
	[0.0745]		[0.0943]		[0.123]	
Constant	6.835***	0.0962***	6.044***	0.0849***	7.542***	0.115***
	[0.280]	[0.00431]	[0.313]	[0.00522]	[0.426]	[0.00655]
LL(0)	-7,744.39		-3,989.42		-3,732.98	
LL(full)	-7,634.52		-3,940.27		-3,661.41	
LR chi2(k)	219.74 (10)		98.29 (9)		143.13 (9)	
McFadden's R^2	0.0142		0.0123		0.019	
Observations	10,943		5,730		5,213	

Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1

Table 4 - Firm's perceived position against competitors - Organizational patterns (Part A) and Ownership structure (Part B) (Odds ratios)

Part A: Organizational patterns

variables	*in line and higher vs. lower*	*higher vs. lower and in line*	*in line and higher vs. lower*	*higher vs. lower and in line*	*in line and higher vs. lower*	*higher vs. lower and in line*
	All sectors		Industry		Services	
change	0.992		1.009		0.970	
	[0.0601]		[0.0878]		[0.0826]	
newunits	1.389***		1.353**		1.332***	
	[0.107]		[0.170]		[0.132]	
ostinn_int	0.324***	0.562***	0.322***	0.618***	0.329***	0.529***
	[0.0219]	[0.0345]	[0.0296]	[0.0547]	[0.0332]	[0.0453]
ostob_int	0.774***		0.755***		0.809***	
	[0.0360]		[0.0491]		[0.0540]	
innorg	1.400***		1.463***		1.712***	
	[0.0929]		[0.0956]		[0.116]	
age	0.996***		0.997*		0.996*	
	[0.00140]		[0.00195]		[0.00204]	
Constant	16.76***	0.169***	15.42***	0.152***	16.58***	0.195***
	[1.208]	[0.0101]	[1.519]	[0.0126]	[1.667]	[0.0153]
LL(0)	-7,744.39		-3,989.42		-3,732.98	
LL(full)	-7,463.18		-3,851.21		-3,598.72	
LR chi2(k)	562.42 (8)		276.42 (7)		268.51 (7)	
McFadden's R^2	0.0363		0.0346		0.0360	
Observations	10,943		5,730		5,213	

Part B: Ownership structure

variables	*in line and higher vs. lower*	*higher vs. lower and in line*	*in line and higher vs. lower*	*higher vs. lower and in line*	*in line and higher vs. lower*	*higher vs. lower and in line*
	All sectors		Industry		Services	
gp	1.295***		1.222***		1.394***	
	[0.0675]		[0.0883]		[0.105]	
prop_fam	0.888**		0.886		0.904	
	[0.0531]		[0.0759]		[0.0756]	
prop_ita	1.038		0.944		1.162	
	[0.0976]		[0.137]		[0.145]	
gest_manag	0.971	1.334***	1.115		0.880	1.453***
	[0.0804]	[0.0947]	[0.0997]		[0.105]	[0.138]
Constant	7.613***	0.122***	7.530***	0.123***	7.618***	0.118***
	[0.820]	[0.0132]	[1.209]	[0.0198]	[1.126]	[0.0175]
LL(0)	-7,744.39		-3,989.42		-3,732.98	
LL(full)	-7,701.20		-3,975.83		-3,701.79	
LR chi2(k)	68.07 (5)		27.16 (4)		62.38 (5)	
McFadden's R^2	0.0044		0.0034		0.0084	
Observations	10,943		5,730		5,213	

Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1

Table 5 - Firm's perceived position against competitors - Market conditions (Part A) and Internationalization (Part B) (Odds ratios)

Part A: Market conditions

variables	*in line and higher vs. lower*	*higher vs. lower and in line*	*in line and higher vs. lower*	*higher vs. lower and in line*	*in line and higher vs. lower*	*higher vs. lower and in line*
	All sectors		Industry		Services	
cr5	1.000		0.999		1.003	
	[0.00149]		[0.00235]		[0.00201]	
innset	1.002	1.008***	1.008***		0.997	1.011***
	[0.00201]	[0.00183]	[0.00192]		[0.00378]	[0.00304]
int_comp	0.706***	0.961	0.616***	1.003	0.786**	1.072
	[0.0526]	[0.0679]	[0.0590]	[0.0992]	[0.0892]	[0.103]
ostinn_mkt	0.407***		0.473***		0.288***	0.552***
	[0.0345]		[0.0546]		[0.0382]	[0.104]
ostob_est	0.503***	0.661***	0.516***	0.678***	0.491***	0.667***
	[0.0398]	[0.0395]	[0.0549]	[0.0605]	[0.0589]	[0.0541]
nwest	1.232***		1.293***		1.084	
	[0.0804]		[0.119]		[0.101]	
neast	1.140**		1.266***		1.005	
	[0.0745]		[0.113]		[0.0969]	
centre	1.108		1.207*		1.000	
	[0.0816]		[0.121]		[0.109]	
Constant	14.19***	0.138***	10.71***	0.112***	18.90***	0.150***
	[1.551]	[0.0130]	[1.623]	[0.0157]	[3.147]	[0.0194]
LL(0)	-7,744.39		-3,989.42		-3,732.98	
LL(full)	-7,593.26		-3,915.19		-3,644.49	
LR chi2(k)	302.26 (11)		148.45 (10)		176.98 (12)	
McFadden's R^2	0.0195		0.0186		0.0237	
Observations	10,943		5,730		5,213	

Part B: Internationalization

variables	*in line and higher vs. lower*	*higher vs. lower and in line*	*in line and higher vs. lower*	*higher vs. lower and in line*	*in line and higher vs. lower*	*higher vs. lower and in line*
	All sectors		Industry		Services	
gp_int	1.379***		1.451***		1.253**	
	[0.102]		[0.161]		[0.124]	
newunits1	1.491***		1.371**		1.445***	
	[0.121]		[0.193]		[0.145]	
newunits2	1.252		1.204		1.367	
	[0.210]		[0.266]		[0.366]	
intern	1.029	1.209***	0.852*	1.326***	1.235***	
	[0.0663]	[0.0724]	[0.0730]	[0.119]	[0.0845]	
intern_pd	1.041		0.900		1.322	
	[0.180]		[0.212]		[0.337]	
int_mkt	1.270		2.135***		0.935	
	[0.211]		[0.563]		[0.246]	
int_cos	0.704**		0.889		0.486***	
	[0.108]		[0.184]		[0.122]	
w_ue	0.997		0.996		1.001	
	[0.00281]		[0.00363]		[0.00445]	
Constant	7.788***	0.125***	7.530***	0.102***	8.296***	0.146***
	[0.328]	[0.00522]	[0.445]	[0.00656]	[0.458]	[0.00765]
LL(0)	-7,744.39		-3,989.42		-3,732.98	
LL(full)	-7,705.80		-3,963.28		-3,712.09	
LR chi2(k)	77.17 (9)		52.28 (10)		41.77 (8)	
McFadden's R^2	0.0050		0.0066		0.0056	
Observations	10,943		5,730		5,213	

Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1.

Table 6 - Test for the joint significance of covariates by group of dimensions

Groups of dimensions	All sectors		Industry		Services	
	chi2	p. value	chi2	p. value	chi2	p. value
Economic and technical efficiency	81.74	0.0000	45.31	0.0000	49.4	0.0000
Phisical and financial inputs	60.32	0.0000	30.35	0.0014	33.66	0.0002
Knowledge capital	93.25	0.0000	44.57	0.0000	60.15	0.0000
Organizational patterns	210.09	0.0000	111.41	0.0000	90.95	0.0000
Ownership structure	16.77	0.0050	0.86	0.9302	23.59	0.0003
Market conditions	197.32	0.0000	100.34	0.0000	114.36	0.0000
Internationalization	21.93	0.0051	12.95	0.1135	27.57	0.0021

Table 7 - Firm's perceived position against competitors - Restricted model

	in line and higher vs. lower	*higher vs. lower and in line*	*in line and higher vs. lower*	*higher vs. lower and in line*	*in line and higher vs. lower*	*higher vs. lower and in line*	*in line and higher vs. lower*	*higher vs. lower and in line*
variables	All sectors		All sectors		Industry		Services	
ros	1.043***	1.027***	1.042***	1.025***	1.044***	1.018***	1.038***	
	[0.00389]	[0.00432]	[0.00388]	[0.00429]	[0.00515]	[0.00608]	[0.00452]	
inntech	1.192***		1.151***		1.149*		1.250***	
	[0.0649]		[0.0623]		[0.0882]		[0.0972]	
lev	0,984		0.980*		0.981		0.986	
	[0.0120]		[0.0119]		[0.0166]		[0.0174]	
h_skill_11	1.578***		1.572***		1.517***		1.639***	
	[0.0846]		[0.0843]		[0.113]		[0.127]	
int_prop	1.346***		1.306***		1.338***		1.405***	
	[0.0864]		[0.0837]		[0.118]		[0.135]	
innmkt	1,038	1.315***	1,077	1.361***	1.206**		1.187**	
	[0.0762]	[0.0849]	[0.0786]	[0.0876]	[0.0929]		[0.0892]	
newunits1	1.253***		1.324***		1.248		1.266**	
	[0.105]		[0.111]		[0.178]		[0.133]	
intern	1.213***		1.214***		1.193*		1.244***	
	[0.0708]		[0.0709]		[0.107]		[0.0962]	
gest_manag	1.246***		1.268***		1.193**		0.979	1.509***
	[0.0720]		[0.0732]		[0.0984]		[0.118]	[0.140]
int_comp	0.534***	0.750***	0.511***	0.711***	0.504***	0.737***	0.576***	0.777**
	[0.0425]	[0.0569]	[0.0404]	[0.0538]	[0.0543]	[0.0799]	[0.0715]	[0.0841]
nwest	1.049		1.082		1.206*		0.888	
	[0.0725]		[0.0745]		[0.117]		[0.0882]	
neast	1.03		1.034		1.156		0.894	
	[0.0705]		[0.0707]		[0.108]		[0.0903]	
centre	1.054		1.055		1.175		0.911	
	[0.0811]		[0.0811]		[0.123]		[0.104]	
dind	0.733***							
	[0.0356]							
Constant	7.297***	0.0927***	6.220***	0.0806***	5.112***	0.0692***	7.604***	0.0955***
	[0.527]	[0.00691]	[0.419]	[0.00578]	[0.466]	[0.00699]	[0.742]	[0.00935]
LL(0)	-7,744				-3,989		-3,733	
LL(full)	-7,038		-7,059		-3,641		-3,386	
LR chi2(k)	484.29 (17)		443.12 (16)		216.67 (15)		253.04 (16)	
McFadden's R2	0.0333		0.0304		0.0289		0.036	
ll ratio test for structural stability						63.77 (26)		
Observations	10,342	10,342	10,342	10,342	5,413	5,413	4,929	4,929

Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. The log likelihoods ratio test for structural stability is a chi2 test for equality between two sets of coefficients. The 95% critical value is equal to 48.29

Metodi per il trattamento delle diverse componenti della mancata risposta totale applicati all'indagine Istat sulla Disabilità[1]

Claudia De Vitiis[2], *Alessio Guandalini*[3], *Francesca Inglese*[4], *Marco D. Terribili*[5]

Sommario

Gli effetti negativi della mancata risposta totale sulle stime di un'indagine campionaria devono essere opportunamente trattati. I metodi, generalmente adottati per tale scopo, si basano sull'uso di informazioni ausiliarie note sui rispondenti e i non rispondenti e non tengono conto delle cause che determinano la mancata risposta. In questo lavoro, metodi che considerano tale aspetto sono stati sperimentati per il trattamento della mancata risposta dell'indagine Istat sulla Disabilità. I metodi usati sono il metodo di aggiustamento sequenziale dei pesi campionari e il metodo basato su un modello di selezione multipla del campione; il primo è stato adottato per correggere i pesi campionari dei rispondenti, il secondo per verificare le ipotesi sottostanti il primo metodo e per analizzare l'impatto degli effetti distorsivi di diverse cause di mancata risposta su alcune stime dell'indagine.

Parole chiave: Mancata risposta totale, metodo sequenziale, modello di selezione.

Abstract

The negative effects of non-response on the estimates of a sample survey must be properly treated. The methods, generally used for this purpose, are based on the use of auxiliary information known both for respondent and not respondent units, without taking into account the causes of the non-response. In this paper, methods, which consider this aspect, have been tested for the treatment of non-response in the Istat survey on Disabilities. The methods applied are the sequential weight adjustment method and the method based on a sample selection model with multiple selection equations; the first was adopted to correct the sample weights of the respondent units to the survey, the second to verify the assumptions which underlie of the first method and to analyze the impact of the bias effects produced by different causes of non-response on some survey estimates.

Keywords: total non-response, sequential weight adjustment, sample selection model.

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1. Introduzione

La presenza della mancata risposta totale (MRT) nelle indagini statistiche comporta una riduzione dell'attendibilità delle stime finali, determinata sia dall'aumento della varianza campionaria sia dall'introduzione di effetti distorsivi. Quest'ultimi sono tanto più gravi quanto più i rispondenti differiscono sistematicamente dai non rispondenti, rispetto a certe caratteristiche di interesse. Per eliminare, o almeno attenuare, tali effetti è necessario che, nella fase di stima di un'indagine campionaria, la MRT sia opportunamente trattata.

La mancata risposta totale può essere determinata da molteplici cause: l'irreperibilità, o mancato contatto, dovuta al fatto che l'unità statistica non ha ricevuto il modello di rilevazione o non è stata contattata dall'intervistatore; il rifiuto, quando l'unità statistica ha espressamente manifestato la volontà di non collaborare all'indagine; l'inabilità a rispondere dell'unità statistica.

Tradizionalmente, nelle indagini Istat, la MRT è trattata senza tener conto delle cause che possono generarla. Negli anni più recenti, l'attenzione dei ricercatori in ambito statistico è stata sempre più rivolta allo sviluppo di metodologie che considerano tale circostanza. L'esigenza di trattare il problema secondo un'ottica alternativa a quella tradizionale nasce da alcune importanti considerazioni: la prima è che le cause determinanti la mancata risposta hanno origine da condizioni diverse, infatti, se il rifiuto a partecipare all'indagine esplicitamente espresso da un individuo è riconducibile ad un "atteggiamento mentale", lo stesso non si può dire per il mancato contatto o per altre cause oggettive; la seconda è che se distinte cause di mancata risposta totale hanno differenti relazioni con le variabili d'indagine allora gli effetti distorsivi sulle stime possono, a loro volta, essere diversi (Groves e Couper, 1998).

In questo lavoro si propone uno studio empirico di metodi di correzione per mancata risposta totale che prendono in considerazione le diverse forme attraverso cui il fenomeno si presenta. Tali metodi partono dal presupposto che la risposta può essere vista come il risultato di distinti processi, ognuno generato da una specifica causa.

L'indagine Istat sull'"Integrazione sociale delle persone con disabilità" (indagine sulla Disabilità) del 2010 ha rappresentato il giusto contesto entro cui effettuare tale sperimentazione grazie sia alla disponibilità di informazioni ausiliarie sia alla particolare configurazione della MRT all'indagine.

La prima circostanza deriva dal fatto che l'indagine è condotta su un sotto-campione dell'indagine multiscopo "Condizioni di salute e ricorso ai servizi sanitari" anni 2004-2005 (indagine sulla Salute). Inoltre, l'indagine - realizzata con tecnica di rilevazione CATI - è affetta da un elevato tasso di mancata risposta totale, imputabile soprattutto all'irreperibilità degli individui disabili piuttosto che al rifiuto di collaborare all'indagine espresso dagli individui contattati. L'elevata quota di irreperibili è determinata dalla combinazione di più fattori: in primis, all'indagine sulla Salute non sempre erano state fornite, da parte dell'intervistato, le coordinate telefoniche, oppure quelle fornite erano errate; in secondo luogo, al momento della rilevazione, alcuni individui disabili non sono risultati raggiungibili al numero telefonico rilasciato perché cambiato o dismesso. Quest'ultima situazione è, da una parte, strettamente legata all'indagine sulla Disabilità e più precisamente al lag temporale che intercorre tra la stessa e l'indagine di riferimento sulla Salute, dall'altra, è connessa ad un aspetto critico che riguarda più in generale le indagini realizzate con tecniche CATI. Infatti, la maggior parte delle indagini basate su interviste

telefoniche, soffre da alcuni anni di un calo partecipativo legato all'aumento della sotto-copertura della rete di telefonia fissa - determinata dallo sviluppo di mezzi di comunicazione alternativi al classico telefono fisso di famiglia - soprattutto per determinate fasce di popolazione, compromettendo così la rappresentatività del campione rispetto all'intera popolazione.

I metodi presi in considerazione nella sperimentazione per il trattamento della MRT dell'indagine sulla Disabilità sfruttano informazioni ausiliarie note per i rispondenti e i non rispondenti e utilizzano, secondo un'impostazione alternativa che tiene conto delle cause che l'hanno generata, metodi generalmente adottati anche nell'approccio tradizionale al trattamento del problema.

Tali metodi sono il *metodo di aggiustamento sequenziale dei pesi campionari* (sequential weight adjustment method) e il metodo basato sul *modello di selezione multipla del campione* (sample selection model with multiple selection equations). Il primo è un metodo di aggiustamento dei pesi campionari sviluppato in più passi che utilizza tecniche di riponderazione (Rizzo *et al*., 1996; Kalton e Flores-Cervantes, 2003) basate sul "response propensity method" (Rosenbaum e Rubin, 1983; Bethlehem *et al*., 2011) o su "algoritmi di classificazione ad albero di tipo CART" (Breiman *et al*., 1984; Rizzo *et al*., 1996). Il secondo metodo costituisce uno strumento utile alla modellizzazione di differenti meccanismi di autoselezione del campione. Il modello di selezione del campione (Heckman, 1976, 1979), espresso nella forma estesa a più equazioni di selezione, assume una particolare configurazione che permette di correggere la stima di una variabile di interesse dagli effetti distorsivi generati da più cause di MRT (Groves e Couper, 1998; Bethlehem *et al*., 2011).

Entrambi i metodi considerano la natura sequenziale del processo di risposta e la distorsione come funzione di distinti processi, ma assumono ipotesi diverse circa la relazione esistente tra le fasi del processo di risposta; il metodo di aggiustamento sequenziale dei pesi campionari assume che i processi di risposta siano indipendenti, condizionatamente ad un insieme di variabili ausiliarie, mentre il metodo basato sul modello di selezione multipla del campione assume che siano correlati.

Lo studio empirico dei metodi utilizzati per la correzione della mancata risposta è stato condotto ponendoli sempre a confronto con gli stessi metodi sviluppati secondo l'impostazione tradizionale del trattamento del problema. Questo ha permesso di valutare, nel complesso, le performance delle nuove procedure rispetto a quelle standard.

Nella sperimentazione, inoltre, i due metodi sono stati utilizzati con finalità diverse; il metodo di aggiustamento sequenziale per correggere i pesi campionari dei rispondenti all'indagine sulla Disabilità; il metodo basato sul modello di selezione multipla del campione per verificare le ipotesi che sono alla base del primo metodo (indipendenza dei processi di risposta) e per analizzare l'impatto degli effetti distorsivi provocati da diverse cause di mancata risposta sulle stime di specifiche variabili dell'indagine.

L'articolo è strutturato nel modo seguente: la sezione 2 illustra le caratteristiche dell'indagine sulla Disabilità e la particolare configurazione che la MRT in essa assume; nella sezione 3 si illustrano caratteristiche e differenze dei metodi proposti, si formalizza il metodo basato sul modello di selezione multipla del campione e si descrivono i metodi di stima dei parametri del modello; le sezioni 4 e 5 riportano i risultati della sperimentazione e alcune considerazioni conclusive.

2. L'indagine "Integrazione sociale delle persone con disabilità"

2.1 Caratteristiche generali

L'indagine sull'"Integrazione sociale delle persone con disabilità" rientra nel progetto "Sistema di Informazione Statistica sulla Disabilità" nato da una convenzione tra l'Istituto nazionale di statistica e il Ministero del Lavoro e delle Politiche Sociali.

Il progetto è volto alla realizzazione di un sistema di indicatori che permette, attingendo alle diverse fonti di dati istituzionali attualmente disponibili, di monitorare il fenomeno della disabilità in Italia e di fornire un supporto alla programmazione delle politiche sociali. L'obiettivo più importante dell'indagine è di sopperire alle lacune che le altre fonti presentano sull'argomento attraverso l'acquisizione di informazioni riguardanti l'integrazione sociale delle persone con disabilità nel loro contesto di vita e le cause che ne ostacolano la piena partecipazione.

La definizione di disabile adottata nell'indagine è conforme con la nuova Classificazione internazionale del Funzionamento, della Disabilità e della Salute (Icf) approvata dall'Oms (Organizzazione Mondiale della Sanità) nel 2001. Sulla base di tale classificazione è definito disabile "chi ha una riduzione o perdita di capacità funzionale nel condurre un'attività in maniera o nei limiti considerati normali per un essere umano".

L'indagine sulla Disabilità presenta alcune importanti peculiarità: è condotta su un sotto-campione dell'indagine multiscopo "Condizioni di salute e ricorso ai servizi sanitari"[6] costituito da individui identificati, in occasione dell'indagine suddetta, come disabili; si tratta di un tipo di indagine di ritorno in quanto sono intervistate persone già contattate nell'indagine di riferimento[7]; è realizzata a distanza di 5-6 anni da quella di riferimento con la tecnica di rilevazione CATI. L'intervista è somministrata a un familiare o altro soggetto che si prende cura della persona con disabilità (proxy) in tutti i casi nei quali il disabile non è in grado di rispondere all'intervista e per i bambini disabili di età inferiore ai 14 anni.

L'indagine sulla Disabilità[8] è stata condotta per la prima volta nel 2004, l'ultima edizione risale invece al 2010.

Relativamente all'anno 2010, in conformità allo scopo individuato nel progetto suddetto, l'indagine ha acquisito numerose informazioni atte alla descrizione delle condizioni di salute e dei livelli di inclusione sociale degli intervistati nei diversi ambiti di vita (scuola, lavoro, rete di relazioni sociali, tempo libero, ecc.) e alla valutazione dell'interazione tra condizioni di salute e fattori ambientali, che possono agire come barriere (limitazioni alla mobilità, difficoltà di accesso a percorsi formativi o lavorativi, mancanza di adeguati sostegni per i bisogni assistenziali, ecc.).

La popolazione di interesse dell'indagine è stata, nell'anno 2010, diversamente definita rispetto alla prima edizione: essa è costituita dagli individui, di età compresa tra 6 e 80 anni, che all'indagine "Condizioni di Salute e ricorso ai servizi sanitari", condotta nel biennio 2004-2005, avevano riferito la propria condizione di disabilità o di avere difficoltà nelle

[6] Il disegno di campionamento è a più stadi comuni-famiglie, con stratificazione dei comuni

[7] Dall'indagine sono escluse le persone la cui disabilità è insorta successivamente al periodo di rilevazione dell'indagine salute

[8] I risultati sono presentati nelle "Statistiche in breve" del 2005

funzioni di mobilità o una riduzione di autonomia[9], ancora in quella condizione al momento dell'intervista. Sulla base della gravità delle limitazioni riferite dagli intervistati la popolazione di interesse dell'indagine risulta suddivisa in due sotto-insiemi, le persone con limitazioni funzionali gravi e le persone con limitazioni funzionali lievi.

Il campione complessivo è risultato pari a 3.502 individui con limitazioni funzionali gravi e a 7.482 individui con limitazioni funzionali lievi.

La numerosità del campione originario si è ridotta nel corso della rilevazione, perché alcuni individui identificati come disabili all'indagine sulla Salute, non sono più risultati tali: si tratta di individui usciti dalla condizione di disabilità, o deceduti oppure istituzionalizzati, ossia trasferiti in centri di ricovero in maniera stabile.

Gli individui non eleggibili hanno rappresentato il 21,6% del campione originario dei disabili con limitazioni funzionali gravi e il 15,9 del campione originario dei disabili con limitazioni funzionali lievi, comportando così una riduzione del campione complessivo che è passato da 3.502 a 2.744 unità nel primo campione, e da 7.482 a 6.293 unità nel secondo.

2.2 La mancata risposta totale

L'indagine è stata caratterizzata da un tasso di mancata risposta totale alquanto elevato, determinato in larga misura dall'irreperibilità degli individui disabili piuttosto che dal rifiuto di collaborare all'indagine espresso dagli individui contattati.

Di seguito sono riportati, con riferimento al campione dei disabili con limitazioni funzionali gravi, i risultati dell'analisi condotta sulla variabile dell'indagine "esito" utilizzata per quantificare le componenti di mancata risposta connesse a due distinte fasi del processo di risposta, la fase di contatto e la fase di partecipazione degli individui contattati.

Dalla tavola 1 risulta evidente un tasso di mancato contatto (47%) più elevato del tasso di rifiuto (23,4%) delle unità contattate. La mancata risposta ha coinvolto 1.630 unità su 2.744, di questi 1.290 non hanno potuto rispondere al follow-up dell'indagine perché è stato impossibile ricontattarli, mentre 340 si sono rifiutati di rispondere.

[9] Il collettivo contattato per l'indagine rivolta alle persone con disabilità è stato individuato tra coloro che, in occasione dell'indagine "Condizioni di salute e ricorso ai servizi sanitari" realizzata nel 2005- 2006, avevano dichiarato di:

- avere, anche con l'aiuto di ausili e apparecchi sanitari, il massimo grado di difficoltà o molta difficoltà in almeno una delle funzioni della mobilità e della locomozione (difficoltà che nelle situazioni più gravi si configura come confinamento), delle funzioni della comunicazione (vedere, sentire, parlare), delle funzioni della vita quotidiana (vale a dire delle attività di cura della persona) – rilevato per la popolazione di 6 anni e più.
- essere invalidi, secondo quanto dichiarato dagli stessi intervistati collocandosi tra i tipi di invalidità indicati (cecità, sordomutismo, sordità, invalidità da insufficienza mentale, invalidità motoria), indipendentemente dal riconoscimento legale dell'invalidità;
- avere una riduzione di autonomia, vale a dire essere colpito da una malattia cronica o da un'invalidità permanente che riduce l'autonomia personale fino ad avere bisogno di un aiuto saltuario o continuativo per le esigenze della vita quotidiana in casa o fuori casa (Istat, 2005).

Tavola 1 - Tipologia di risposta nelle due fasi del processo di risposta (contatto e partecipazione)

Fase	Esito	Numero di casi	Tasso
Prima (contatto)	Unità non contattate	1290	47,0%
	Unità contattate	1454	53,0%
	Campione effettivo	*2744*	*100,0%*
Seconda (partecipazione)	Unità partecipanti	1114	76,6%
	Unità che rifiutano	340	23,4%
	Unità contattate	*1454*	*100,0%*

Fonte: Indagine sulla Disabilità

3. Metodi per il trattamento delle componenti di mancata risposta totale

3.1 Premessa

Nel trattamento della mancata risposta totale (MRT) secondo un approccio che tiene conto delle cause che la determinano, i metodi a cui si è fatto riferimento nella sperimentazione sono il *metodo di aggiustamento sequenziale dei pesi campionari* (sequential weight adjustment method) e il metodo basato sul *modello di selezione multipla del campione* (sample selection model with multiple selection equations). Il primo metodo è stato sviluppato sia in un'ottica parametrica (Bethlehem *et al*., 2011) che non parametrica (De Vitiis *et al.*, 2012).

I metodi assumono che il processo di risposta si sviluppa in modo sequenziale attraverso un susseguirsi di fasi disposte in una struttura gerarchica e che la distorsione è funzione di contraddistinti processi generati da diverse cause di MRT.

A parte questi tratti comuni, i metodi presentano importanti differenze: assumono ipotesi diverse circa la relazione esistente tra le fasi del processo di risposta; correggono in modo differente le stime dei parametri di popolazione dagli effetti distorsivi.

Relativamente a quest'ultimo aspetto, il primo metodo porta alla costruzione di tanti fattori correttivi quante sono le fasi del processo di risposta attraverso l'uso di modelli annidati, il secondo porta alla correzione della stima di una generica variabile d'indagine attraverso l'uso di un modello che mette in relazione la variabile stessa con le fasi del processo di risposta.

Nel contesto studiato, in cui il processo di risposta è composto dalla fase di contatto delle unità campionarie e dalla fase di partecipazione all'indagine da parte delle unità contattate, il *sequential weight adjustment method* si configura come un metodo in cui la correzione dei pesi campionari è realizzata in due passi e il *sample selection model* come un modello con due equazioni di selezione.

Il metodo di aggiustamento sequenziale dei pesi campionari utilizza modelli annidati per stimare le propensioni individuali dei singoli processi e assume che le fasi del processo di risposta sono indipendenti condizionatamente ad un insieme di variabili ausiliarie (ipotesi MAR - missing at random).

Nell'approccio parametrico, il response propensity method (Rosenbaum e Rubin, 1983) è adattato alle due fasi del processo di risposta (contatto, partecipazione) attraverso l'uso di modelli annidati di tipo logit. Il modello logit, definito nella prima fase, stima le

propensioni individuali al contatto per tutte le unità del campione selezionato (modello di contatto), mentre il modello logit, definito nella seconda fase, stima le propensioni individuali alla partecipazione per le unità campionarie contattate (modello di partecipazione). Le probabilità individuali predette per le singole fasi possono essere utilizzate per la costruzione dei fattori di aggiustamento sia in modo diretto che indiretto: nel primo caso i fattori correttivi sono calcolati come inverso delle probabilità predette (response propensity weighting) con il modello di contatto (prima fase) e con il modello di partecipazione (seconda fase); nel secondo caso le probabilità predette sono utilizzate per la definizione di strati o celle di aggiustamento (response propensity stratification). Nelle celle, i fattori correttivi sono calcolati come inverso del tasso di contatto nella prima fase e del tasso di partecipazione nella seconda fase (Bethlehem et al., 2011; Groves e Couper, 1998; Iannacchione, 2003).

Nell'approccio non parametrico, l'aggiustamento sequenziale dei pesi campionari è realizzato tramite modelli basati su algoritmi di classificazione ad albero di tipo CART (Breiman *et al*., 1984; Rizzo *et al*., 1996). I modelli di classificazione sono definiti per ogni fase del processo di risposta, analogamente all'approccio parametrico. I fattori correttivi sono calcolati come inverso dei tassi di contatto e di partecipazione stimati nei nodi terminali (celle di aggiustamento) degli alberi ottimali ottenuti rispettivamente tramite il modello di classificazione del contatto e il modello di classificazione della partecipazione degli individui contattati (De Vitiis *et al.*, 2012).

L'impostazione sequenziale di aggiustamento dei pesi campionari determina, dunque, la costruzione di due fattori correttivi: il primo corregge il peso degli individui contattati per tener conto degli individui non contattati; il secondo corregge il peso dei rispondenti per tener conto dei non rispondenti tra i contattati. In questo modo i fattori correttivi catturano ognuno l'effetto distorsivo proprio associato alla singola fase del processo di risposta.

Il metodo basato sul modello di selezione del campione (Heckman, 1976, 1979) con equazioni multiple, utilizza un modello di riferimento (*equazione di regressione* o *di outcome*) per modellare i processi di selezione del campione (*equazioni di selezione*) determinati dalle fasi del processo di risposta e la media condizionata degli errori nei campioni selezionati. Il sistema di equazioni del modello è definito sul campione completo, mentre l'osservazione delle variabili dell'indagine è determinata dall'esito positivo dei processi di risposta. Il modello stima il valore atteso di una generica variabile di indagine, condizionato ad un set di variabili ausiliarie e al risultato dei processi di risposta; la sostituzione di tale valore a quello osservato della stessa variabile porta ad una stima del parametro di popolazione corrispondente corretta dagli effetti di selezione del campione (Groves e Couper, 1998; Bethlehem *et al*., 2011).

Gli effetti distorsivi determinati dal mancato contatto e dal rifiuto (modello con due equazioni di selezione) sono controllati dalle propensioni alla selezione associate alla due fasi del processo di risposta se sussiste indipendenza tra il termine di errore e le covariate del modello di regressione. I due effetti sono catturati, tramite il modello di regressione, dalla stima di specifici parametri, che sono i coefficienti delle variabili di selezione generate dalle propensioni nei singoli processi (Groves e Couper, 1998; Bethlehem *et al*., 2011).

A differenza del metodo di aggiustamento sequenziale dei pesi campionari, quest'ultimo, assume l'esistenza di correlazione sia tra i processi di risposta, sia tra questi e la variabile di indagine. Altre differenze tra i due metodi sono riconducibili all'assunzione

delle ipotesi sulle distribuzioni dei termini di errore dei modelli.

Nell'approccio sequenziale basato su modelli logit annidati, la funzione di distribuzione logistica non include l'esistenza di correlazione tra i termini di errore dei modelli, determinando così il fatto che le equazioni specificate, per ogni fase del processo di risposta, sono tra loro indipendenti e quindi stimabili separatamente. Nel modello di selezione doppia del campione i termini di errore seguono una distribuzione congiunta proprio per tener conto della correlazione tra le equazioni di selezione e tra queste e l'equazione di outcome. Per tale ragione le equazioni del sistema sono stimate simultaneamente.

La stima dei parametri dei modelli è effettuata, sia nei modelli logit annidati che nel modello di selezione, con il metodo della massima verosimiglianza (MLE). Per il modello di selezione del campione è possibile utilizzare il metodo di stima in due step proposto da Heckman (1979) che evita alcune complicazioni del metodo di stima basato sulla massima verosimiglianza completa. Tale metodo parte dalla considerazione che il valore atteso condizionato del termine di errore dell'equazione di outcome può essere visto come una variabile omessa, la cui omissione determina proprio la distorsione (Heckman, 1976, 1979).

Nel sample selection model, in particolare, la dipendenza dei metodi di stima parametrici dall'assunzione di normalità degli errori ne costituisce certamente un limite. Per superare le assunzioni sottostanti i modelli, una soluzione percorribile è quella di utilizzare metodi di stima non parametrici o semi-parametrici. Tali metodi di stima non sono stati considerati in questo lavoro, pertanto il modello è nel seguito presentato e sviluppato solo in un'ottica parametrica.

Per una descrizione più approfondita e per la formalizzazione del metodo di aggiustamento sequenziale dei pesi campionari si rinvia all'articolo di De Vitiis *et al.* (2012) oltre a quelli riportati in bibliografia.

3.2 Il metodo basato sul sample selection model

3.2.1 Formalizzazione del modello

Il *sample selection model*, introdotto da Heckman in ambito econometrico, costituisce un valido strumento per modellizzare i meccanismi di autoselezione dei rispondenti quando la mancata risposta è generata da più cause (Bethlehem *et al*., 2011).

Nel caso in cui l'osservazione di una generica variabile di indagine (variabile di outcome) dipende da diverse componenti di mancata risposta totale, il modello di selezione del campione deve tenere conto sia della natura sequenziale del processo di risposta che dei singoli processi. Nel modello devono essere definite tante equazioni di selezione quanti sono i processi di risposta coinvolti.

Se la mancata risposta totale è generata dal mancato contatto delle unità campionarie e dal rifiuto delle unità contattate allora si definiscono due equazioni di selezione su tutte le unità del campione *s*; la prima è definita per la variabile latente "propensione al contatto" (prima fase del processo di risposta) e la seconda è definita per la variabile latente "propensione alla partecipazione" (seconda fase del processo di risposta). L'equazione di outcome del modello è anch'essa definita su tutte le unità del campione *s*, ma è valorizzata soltanto quando i risultati dei processi di risposta sono congiuntamente positivi.

Nel sistema di equazioni del modello, le probabilità individuali dei due processi di selezione sono condizionate ad un insieme di variabili ausiliarie che sono inserite anche

nell'equazione di outcome. Questo perché la distorsione può essere determinata dal fatto che le propensioni alla selezione dei vari processi dipendono da variabili ausiliarie che influenzano anche la variabile d'indagine stessa.

Il modello di selezione che tiene conto della doppia selezione del campione generata dalle due fasi del processo di risposta è, dunque, specificato in termini di variabili latenti. Esso assume pertanto la seguente forma:

$$\begin{aligned} \delta_i^* &= \mathbf{X}_i^C \beta^C + \varepsilon_i^C , \\ \varphi_i^* &= \mathbf{X}_i^P \beta^P + \varepsilon_i^P , \\ y_i^* &= \mathbf{X}_i^Y \beta^Y + \varepsilon_i^Y , \end{aligned} \quad (3.1)$$

per i=1,…..,n. Le equazioni definite per le variabili latenti δ_i^* (propensione al contatto) e φ_i^* (propensione alla partecipazione) costituiscono le equazioni di selezione del modello. Se $\delta_i^* > 0$ la variabile indicatrice C_i per la i-ma unità del campione s assume valore 1, nel caso contrario assume valore 0. Se $\varphi_i^* > 0$ la variabile indicatrice P_i per la i-ma unità del campione s assume valore 1, nel caso contrario assume valore 0. La variabile indicatrice P_i è osservata soltanto quando $C_i = 1$, altrimenti è censurata. L'equazione definita per la variabile y_i^* è detta equazione di regressione (o equazione di outcome) del modello, si tratta di una variabile latente osservata soltanto quando $C_i = 1$ e $P_i = 1$. Pertanto la variabile target dell'indagine per la i-ma unità, y_i, è definita come segue

$$y_i = \begin{cases} y_i^* & se\ \ C_i = 1;\ P_i = 1 \\ . \quad se\ \ C_i = 1;\ P_i = 0\ \ oppure\ \ C_i = 0 \end{cases} \quad (3.2)$$

Le variabili esplicative del modello sono rappresentate dai vettori $\mathbf{X}_i^C$, $\mathbf{X}_i^P$ e $\mathbf{X}_i^Y$, mentre β^C, β^P e β^Y sono i coefficienti ignoti del modello. I termini di errore del modello $\left(\varepsilon_i^C, \varepsilon_i^P, \varepsilon_i^Y\right)$ sono assunti seguire una distribuzione normale multivariata $N \sim \left(\mathbf{0}, \boldsymbol{\Sigma}\right)$,

$$\begin{pmatrix} \boldsymbol{\varepsilon}_i^C \\ \boldsymbol{\varepsilon}_i^P \\ \boldsymbol{\varepsilon}_i^Y \end{pmatrix} \approx N\left(\mathbf{0}, \begin{bmatrix} 1 & \varsigma_{CP}\sigma_Y & \varsigma_{CY}\sigma_Y \\ \varsigma_{PC}\sigma_Y & 1 & \varsigma_{PY}\sigma_Y \\ \varsigma_{YC}\sigma_Y & \varsigma_{YP}\sigma_Y & \sigma_Y^2 \end{bmatrix}\right). \quad (3.3)$$

Nella matrice di varianze e covarianze, $\boldsymbol{\Sigma}$, $\varsigma_{YC}\sigma_Y$ è la covarianza tra la variabile di indagine y e il contatto, $\varsigma_{YP}\sigma_Y$ è la covarianza tra la variabile di indagine y e la partecipazione. Le correlazioni tra la variabile di indagine y e le variabili indicatrici del contatto e della partecipazione all'indagine è rispettivamente indicata con ς_{YC} e ς_{YP}, mentre la correlazione tra i tipi di risposta è indicata con $\varsigma_{PC} = \varsigma_{CP}$, essendo la matrice $\boldsymbol{\Sigma}$ simmetrica. Per tale proprietà della matrice anche $\varsigma_{YC} = \varsigma_{CY}$ e $\varsigma_{YP} = \varsigma_{PY}$.

La distorsione dovuta alla doppia selezione del campione, prima delle unità contattate e

non contattate e poi delle unità rispondenti e non rispondenti, è determinata dalla correlazione tra i termini di errore del modello, ovvero se $E\left[\varepsilon_i^Y \middle| \varepsilon_i^C\right] \neq 0$ e $E\left[\varepsilon_i^Y \middle| \varepsilon_i^P\right] \neq 0$ (Bethlehem *et al.*, 2011).

L'obiettivo del sample selection model - con due equazioni di selezione - è di stimare, tramite il modello di regressione, il valore atteso di y_i condizionato ad un set di variabili ausiliarie $\mathbf{X}_i^Y$ e al risultato dei due processi di risposta. Lo stimatore di Horvitz-Thompson per la media della popolazione di una generica variabile di indagine y, che assume la forma

$$\hat{\bar{Y}}_{HT} = \frac{1}{N}\sum_{i\in s}\frac{E\left[y_i \middle| C_i = 1; P_i = 1, \mathbf{X}_i^C, \mathbf{X}_i^P, \mathbf{X}_i^Y\right]}{\pi_i}, \quad (3.4)$$

risulta modificato in quanto il valore osservato y_i della variabile y per la *i*-ma unità del campione *s* è sostituito con la stima del valore atteso condizionato, ottenuta mediante diverse procedure di stima del modello di selezione (3.1).

La specificazione del modello per la stima dell'equazione di outcome dipende dalla natura della variabile target. Se la variabile di outcome è di tipo continuo il modello di riferimento è il modello di regressione lineare, se invece è di tipo dicotomico o categorico allora il modello di riferimento è il modello probit. Il sistema di equazioni è, in quest'ultimi casi, definito come probit multivariato con selezione del campione se la variabile di outcome è dicotomica, e come probit multinomiale con selezione del campione se la variabile di outcome è categorica.

3.2.2 Metodi di stima

Per la stima di un modello con due equazioni di selezione definite per i processi di contatto e partecipazione, è possibile utilizzare il modello proposto da Poirier (1980). In tale modello, detto "Bivariate probit model with partial observability", le variabili binarie definite per le due equazioni di selezione non sono osservate individualmente, ma ciò che è osservato è il loro prodotto. In tale ottica, il verificarsi dell'evento contatto $C_i = 1$ e dell'evento partecipazione $P_i = 1$ può essere espresso con il prodotto $C_i \times P_i = 1$. Le unità del campione *s* assumono dunque due soli valori, 1 quando $C_i = 1$ e $P_i = 1$ e 0 in tutti gli altri casi.

Il valore atteso y_i della variabile y associato alla *i*-ma unità del campione *s*, può essere espresso come

$$E\left[y_i \middle| C_i \times P_i = 1, \mathbf{X}_i^C, \mathbf{X}_i^P, \mathbf{X}_i^Y\right] = \mathbf{X}_i^Y \beta^Y + \sigma_Y E\left[\varepsilon^Y \middle| C_i \times P_i = 1, \mathbf{X}_i^C, \mathbf{X}_i^P, \mathbf{X}_i^Y\right], \quad (3.5)$$

dove

$$E\left[\varepsilon^Y \middle| C_i \times P_i = 1, \mathbf{X}_i^C, \mathbf{X}_i^P, \mathbf{X}_i^Y\right] = \varsigma_{YC}\sigma_Y\left(\frac{\phi\left(\mathbf{X}_i^C\beta^C\right)\Phi\left(\mathbf{X}_i^P\left(\beta^P - \varsigma_{PC}\beta^C\right)\right)\Big/\sqrt{1-\varsigma_{PC}^2}}{\Phi_2\left(\mathbf{X}_i^C\beta^C, \mathbf{X}_i^P\beta^P, \varsigma_{PC}\right)}\right) + \quad (3.6)$$

$$+\varsigma_{YP}\sigma_Y\left(\frac{\phi\left(\mathbf{X}_i^P\beta^P\right)\Phi\left(\mathbf{X}_i^C\left(\beta^C-\varsigma_{PC}\beta^P\right)\right)\Big/\sqrt{1-\varsigma_{PC}^2}}{\Phi_2\left(\mathbf{X}_i^C\beta^C,\mathbf{X}_i^P\beta^P,\varsigma_{PC}\right)}\right),$$

in cui $\phi(\cdot)$ e $\Phi(\cdot)$ rappresentano rispettivamente la funzione di densità e la cumulata della distribuzione di una normale, mentre Φ_2 è la cumulata della distribuzione della normale bivariata.

Il modello (3.5) può essere implementato stimando le due equazioni di selezione con un modello probit bivariato, oppure, ipotizzando una correlazione nulla tra i termini di errore delle due equazioni di selezione, con due modelli probit separati. In quest'ultimo caso la (3.6) può essere espressa nella forma ridotta

$$E\left[\varepsilon^Y\middle|C_i\times P_i=1,\mathbf{X}_i^C,\mathbf{X}_i^P,\mathbf{X}_i^Y\right]=\varsigma_{YC}\sigma_Y\left(\frac{\phi\left(\mathbf{X}_i^C\beta^C\right)}{\Phi\left(\mathbf{X}_i^C\beta^C\right)}\right)+\varsigma_{YP}\sigma_Y\left(\frac{\phi\left(\mathbf{X}_i^P\beta^P\right)}{\Phi\left(\mathbf{X}_i^P\beta^P\right)}\right)= \quad (3.7)$$
$$=\beta^{\lambda^C}\lambda_i^C+\beta^{\lambda^P}\lambda_i^P\ ,$$

dove $\beta^{\lambda^C}=\varsigma_{YC}\sigma_Y$ e $\beta^{\lambda^P}=\varsigma_{YP}\sigma_Y$ sono i coefficienti rispettivamente dei nuovi predittori $\lambda_i^C=\frac{\phi\left(\mathbf{X}_i^C\beta^C\right)}{\Phi\left(\mathbf{X}_i^C\beta^C\right)}$ e $\lambda_i^P=\frac{\phi\left(\mathbf{X}_i^P\beta^P\right)}{\Phi\left(\mathbf{X}_i^P\beta^P\right)}$ del modello di regressione.

Seguendo la prima procedura, si ottengono le stime $\hat{\beta}^C$ e $\hat{\beta}^P$ dei coefficienti necessari per determinare i due termini dell'equazione del valore atteso condizionato di ε_i^Y (3.6); seguendo la seconda procedura e utilizzando i parametri stimati tramite i due modelli probit per le equazioni di selezione, è possibile, invece, ottenere la stima dei termini della (3.7), $\hat{\lambda}_i^C$ e $\hat{\lambda}_i^P$, detti inverse Mills ratios (Hechman, 1979; Bethlehem *et al*., 2011).

Tali termini sono funzioni decrescenti monotone, $\hat{\lambda}_i^C$ della probabilità della *i*-ma unità del campione *s* di essere contattata e $\hat{\lambda}_i^P$ della probabilità della *i*-ma unità del campione *s* di partecipare all'indagine. Essi esprimono il fatto che le unità del campione con una elevata propensione al contatto o alla partecipazione all'indagine hanno una bassa probabilità di introdurre effetti distorsivi.

Le due procedure conducono alla stima di due covariate, i due termini dell'equazione del valore atteso condizionato di ε_i^Y nella prima e gli inverse Mills ratios nella seconda, attraverso i quali viene ridefinita l'equazione di regressione. L'introduzione nel modello di tali covariate - le variabili di selezione generate dalle propensioni nei singoli processi - consente di correggere la stima del valore atteso y_i dalla distorsione indotta dai due effetti di selezione.

4. La correzione della mancata risposta totale nell'indagine sulla Disabilità

4.1 La sperimentazione

L'indagine sulla Disabilità è affetta, come detto, da un elevato tasso di non risposta imputabile soprattutto all'elevato tasso di mancato contatto degli individui risultati disabili all'indagine sulla Salute.

Il trattamento della MRT dell'indagine in fase di stima è stato preceduto da un'analisi condotta su tre collettivi di interesse costituiti da individui non contattati, individui contattati non rispondenti e individui rispondenti.

La particolare configurazione della mancata risposta totale all'indagine e le differenze dei collettivi per alcune caratteristiche, come l'età, la ripartizione geografica di appartenenza, ecc., messe in evidenza dall'analisi riportata in De Vitiis *et al.* (2012) sono stati elementi determinanti la scelta di utilizzare un nuovo approccio per il trattamento della MRT dell'indagine. A questi si aggiunge il fatto che, grazie alle numerose informazioni rilevate all'indagine sulla Salute relativa al biennio 2004/2005, è stato possibile utilizzare, nei modelli, che sono alla base delle procedure di correzione della MRT, numerose variabili ausiliarie di tipo socio-demografico (sesso, età, stato civile, titolo di studio), oltre a quelle relative alle patologie e alle condizioni percepite dall'individuo circa le sue difficoltà nella vita quotidiana.

La sperimentazione, svolta in due fasi successive, è stata sviluppata sempre secondo due impostazioni, quella tradizionale, o standard[10], che considera come non rispondenti sia gli individui risultati irreperibili sia quelli che hanno espresso un rifiuto esplicito di collaborazione all'indagine e quella alternativa, in cui le due componenti di mancata risposta sono tenute distinte.

Nella prima fase sono state implementate diverse tecniche di riponderazione basate sia sull'uso di modelli logit che di modelli di classificazione CART. Le probabilità individuali predette tramite i modelli logit (modello di risposta nell'approccio tradizionale e modelli di contatto e di partecipazione nell'approccio alternativo) sono state utilizzate per il calcolo dei fattori correttivi applicando sia il response propensity weighting che il response propensity stratification (cfr. par. 3.1). In quest'ultimo caso, gli strati, o celle di aggiustamento, sono stati definiti tramite la tecnica degli uguali quantili delle probabilità individuali predette. Negli strati così definiti, i fattori correttivi sono stati calcolati come inverso dei tassi stimati (di risposta, contatto e partecipazione). Gli stessi tassi (De Vitiis *et al.*, 2012) sono stati calcolati nei nodi terminali (strati) degli alberi ottimali di classificazione stimati tramite i modelli CART (modello di classificazione della risposta nell'approccio tradizionale e modelli di classificazione del contatto e della partecipazione nell'approccio alternativo).

I risultati delle procedure sviluppate secondo le due impostazioni sono stati valutati attraverso un'analisi comparativa avente l'obiettivo di individuare il set di pesi finali con

[10] Relativamente ai metodi di correzione dei pesi campionari sono stati applicati modelli di stima della propensione alla risposta (modello di risposta) al fine di determinare un unico fattore correttivo. Relativamente al metodo basato sul modello di selezione del campione, nel modello è stata utilizzata un'unica equazione di selezione per la propensione alla risposta.

migliori performance. A tal fine sono stati considerati due indicatori: l'indice di concordanza e la statistica $1+CV^2$ di Kish (1992). Il primo indice, dato dalla differenza relativa tra le probabilità individuali osservate e quelle predette (De Vitiis *et al.*, 2012), è un indicatore indiretto della correzione della distorsione indotta dalla mancata risposta in quanto misura la bontà di adattamento del metodo di stima delle probabilità adottato (si fa riferimento alle probabilità individuali predette con i modelli logit e alle probabilità stimate nelle celle di ponderazione determinate sia con l'approccio parametrico che con l'approccio non parametrico). La statistica $1+CV^2$ di Kish (1992) è, invece, una misura dell'impatto della maggiore variabilità dei pesi campionari corretti per mancata risposta sulla varianza delle stime.

Nella seconda fase, per alcune variabili di interesse dell'indagine sulla Disabilità, sono stati implementati i modelli di selezione del campione, seguendo sempre l'impostazione tradizionale e alternativa; nel primo caso è stato utilizzato un modello con una sola equazione di selezione del campione definita per la propensione alla risposta, mentre nel secondo caso sono stati utilizzati modelli con due equazioni di selezione definite per la propensione al contatto e la propensione alla partecipazione (cfr. par. 3.2).

Il modello con due equazioni di selezione del campione è stato impiegato per verificare le ipotesi che sono alla base del metodo di aggiustamento sequenziale dei pesi campionari (ipotesi MAR, indipendenza dei processi di risposta). A tal fine sono state analizzate le correlazioni esistenti tra i processi di risposta e tra questi e le variabili di interesse dell'indagine.

L'analisi delle correlazioni tra le variabili di interesse e il singolo processo di risposta (modello di selezione con una equazione di selezione) o due distinti processi di risposta (modello con due equazioni di selezione) ha permesso di studiare l'impatto degli effetti distorsivi provocati da diverse cause di mancata risposta sulle stime.

Infine, per le stesse variabili, sono stati posti a confronto i valori ottenuti per le rispettive stime trattando la mancata risposta totale con tecniche di riponderazione, applicate sia in modo tradizionale che sequenziale (De Vitiis *et al*, 2012), e con il sample selection model espresso nella forma standard, ovvero con una equazione di selezione, e nella forma estesa a più equazioni di selezione.

4.2 Aggiustamento dei pesi campionari: metodo standard vs. metodo sequenziale

4.2.1 Modelli parametrici e non parametrici

I modelli logit e CART utilizzati nella sperimentazione per la costruzione dei fattori correttivi dei pesi campionari delle unità rispondenti all'indagine sono stati definiti secondo le due impostazioni. Nell'approccio tradizionale il modello di stima delle probabilità individuali è definito per la variabile risposta R_i (1.114 individui disabili rispondenti all'indagine e 1.630 individui disabili non rispondenti), mentre, nell'approccio sequenziale, i modelli di stima delle probabilità individuali di contatto (prima fase) e di partecipazione (seconda fase) sono definiti rispettivamente per le variabili contatto, C_i (1.454 individui disabili contattati e 1.290 individui disabili non contattati), e partecipazione all'indagine, P_i (1.114 individui disabili rispondenti, 340 individui disabili non rispondenti tra i contattati).

Le variabili ausiliarie utilizzate sono: presenza del telefono, età, stato civile (coniugato e non coniugato), livello di disabilità (da 1 a 3), difficoltà motorie (1=si, 0=no), numero di invalidità (da 0 a 5), numero di disabilità (da 0 a 5), difficoltà nelle funzioni giornaliere (1=si, 0=no).

Nei modelli sono state adottate diverse classificazioni della variabile età: nel modello di risposta (approccio tradizionale) sono state individuate quattro classi di età (≤12, 13-21, 22-75, >75) sia nel caso del logit che del CART; nei modelli logit di contatto e di partecipazione (approccio sequenziale) sono state individuate rispettivamente due classi di età (≤12, >12) e cinque classi di età (≤21; 22-55; 56-59; 60-77; >77), mentre, per il solo modello di classificazione (CART) della partecipazione sono state individuate tre classi di età (≤21, 22-59, >59).

Le classi di età sono state determinate tramite l'algoritmo di classificazione CART condizionando la distribuzione di ogni singola variabile target (risposta, contatto e partecipazione) ad un unico predittore costituito dalla variabile continua età.

Nella tabella che segue sono descritti i modelli adottati per la stima delle probabilità individuali in ogni approccio; in particolare, per ogni modello sono riportate le covariate risultate significative, l'AIC (*Akaike Information Criterion*) che è un indicatore di bontà di adattamento del modello logit ai dati e la funzione di costo-complessità del modello CART che costituisce un criterio di scelta ottimale dell'albero di classificazione ((Breiman *et al*., 1984; Rizzo *et al*., 1996; De Vitiis *et al*., 2012). Tali indicatori assumono valori più bassi nel modello di contatto (approccio sequenziale) rispetto al modello di risposta (approccio tradizionale).

Tavola 2 – Modelli logit e CART per la variabile risposta, contatto e partecipazione

Modello	Approccio tradizionale		Approccio sequenziale			
	Risposta		Contatto		Partecipazione	
	Covariate	Indice	Covariate	Indice	Covariate	Indice
Logit AIC	Presenza del telefono 4 classi di età Stato civile Livello di disabilità Difficoltà motorie Numero di invalidità	3.388	Presenza del telefono 2 classi di età Stato civile Difficoltà motorie Numero di invalidità Numero di disabilità	3.347	5 classi di età	1.564
CART $K_a(T)$	Presenza del telefono 4 classi di età Difficoltà nelle funzioni giornaliere	0.406	Presenza del telefono	0.325	3 classi di età	0.249

4.2.2 Principali risultati

Le tabelle che seguono mostrano alcuni importanti risultati della sperimentazione. La tavola 3 riporta i valori dell'indice di concordanza calcolato sia con riferimento ai due approcci che ai diversi metodi di stima delle probabilità individuali adottati; l'indice assume valori più elevati quando è calcolato sulle differenze tra le probabilità individuali osservate e le probabilità stimate nelle celle di ponderazione (costruite secondo la tecnica riportata in tabella) ottenute a partire dalle probabilità individuali predette dai modelli di contatto e di partecipazione utilizzati nell'approccio sequenziale.

Tavola 3 – Indici di concordanza per i modelli considerati

			Indice di concordanza		
		Tecnica	Approccio tradizionale	Approccio sequenziale	
Modello	Metodo		Risposta	Contatto	Partecipazione
Logit	Response propensity stratification	Quartili	0,569	0,574	0,645
		Quintili	0,569	0,581	
		Decili	0,573	0,584	
	Response propensity weighting	Probabilità individuali	0,565	0,569	0,647
Cart		Nodi terminali	0,574	0,583	0,648

Nelle tavole 4 e 5 sono riportate alcune informazioni di sintesi delle distribuzioni dei pesi finali, e la statistica $1+CV^2$, ottenute sempre secondo i due approcci di correzione della mancata risposta totale.

Dalla tabella 5, in cui si riportano i risultati della prima e della seconda fase di correzione nell'approccio sequenziale, si evince che la variabilità dei pesi campionari corretti nella prima fase del processo di risposta per il mancato contatto rimane sempre più contenuta rispetto a quanto accade quando si adotta un solo fattore correttivo nell'approccio tradizionale (Tav. 4).

Tavola 4 – Sintesi delle distribuzioni dei pesi finali – Approccio tradizionale

			Approccio tradizionale			
Modello	Metodo	Tecnica	Media	Max	Min	$1+CV^2$
Logit	Response propensity stratification	Quartili	1046,72	7692,57	98,83	1,680
		Quintili	1037,98	8861,92	99,02	1,673
		Decili	1037,62	9781,18	89,22	1,731
	Response propensity weighting	Probabilità individuali	1022,55	7235,38	94,09	1,615
Cart		Nodi terminali	1035,76	6796,77	94,09	**1.567**

Infine, aggiungendo un ulteriore fattore correttivo (seconda fase del processo di risposta), che tiene conto della mancata partecipazione all'indagine delle unità contattate, si nota una generale diminuzione della variabilità dei pesi finali.

E' da precisare che per la seconda fase di correzione basata sul modello logit di partecipazione, la definizione delle celle di aggiustamento (response propensity stratification) è stata effettuata considerando i soli quintili della distribuzione delle probabilità individuali predette.

Il confronto dei risultati, ottenuti con i due approcci e con una modellizzazione della risposta (o delle sue componenti) basata sia su metodi parametrici che non parametrici, mette in luce come l'approccio sequenziale conduca sempre a risultati migliori (in termini di variabilità dei pesi finali corretti), in particolare quando la tecnica di correzione è basata sugli alberi di classificazione poiché si registra una minor variabilità dei pesi corretti per le due componenti di mancata risposta.

Tavola 5 – Sintesi delle distribuzioni dei pesi finali - Approccio sequenziale

Modello	Metodo	Tecnica	Media	Max	Min	$1+CV^2$
		Prima fase				
Logit	Response propensity stratification	Quartili	800,38	5056,95	63,28	1,583
		Quintili	799,40	5597,08	61,52	1,623
		Decili	799,68	5968,48	57,55	1,664
	Response propensity weighting	Probabilità individuale	793,09	6009,83	58,63	1,603
Cart		Nodi terminali	798,18	5585,59	68,51	1,554
		Seconda fase				
Logit	Response propensity stratification	Quintili	1028,87	7081,31	104,13	1,555
	Response propensity weighting	Probabilità individuale	1027,73	7350,38	101,51	1,555
Cart		Nodi terminali	1026,71	7003,45	102,98	**1,531**

4.3 Modello di selezione del campione: modello standard vs. modello con selezione multipla

4.3.1 Modelli di selezione per specifiche variabili di interesse

Nella sperimentazione sono state individuate due variabili di tipo dicotomico su cui si è deciso di testare il metodo per ottenere stime di totali della popolazione corrette per la distorsione indotta da una o due componenti di mancata risposta totale.

Le variabili considerate riguardano, la prima, la condizione di analfabetismo degli individui disabili intervistati (Y_1=1 individui disabili analfabeti, Y_1=0 individui disabili non analfabeti) e la seconda la condizione occupazionale degli stessi (Y_2=1 individui disabili in cerca di occupazione, Y_2=0 individui disabili non in cerca di occupazione).

Nell'approccio tradizionale l'equazione di selezione, espressa nel modello per la variabile "propensione alla risposta", è descritta con riferimento alla variabile risposta R_i (1.114 unità individui disabili rispondenti e 1.630 individui disabili non rispondenti).

Nell'approccio alternativo, in cui si considerano due distinti processi di selezione, le equazioni di selezione espresse nel modello sono definite, la prima, per la variabile "propensione al contatto" e, la seconda, per la variabile "propensione alla partecipazione". Tali equazioni sono descritte con riferimento alle due variabili osservate, contatto C_i (1.454 individui disabili contattati e 1.290 individui disabili non contattati) e partecipazione all'indagine P_i (1.114 individui disabili rispondenti e 1.630 individui disabili non rispondenti). In questo caso le variabili indicatrici del contatto e della partecipazione sono definite sempre per tutte le unità del campione (2.744).

Le variabili ausiliarie utilizzate nei modelli, sia di selezione che di regressione, sono: la ripartizione geografica (Nord-Ovest, Nord-Est, Centro, Sud, Isole); difficoltà motoria (1=si, 0=no); numero di invalidità (da 0 a 5); gravità dell'invalidità (in una scala da 1 a 3); presenza del telefono (1=si, 0=no); classe d'età (fino a 12 anni, da 12 a 21 anni, da 21 a 75 anni, oltre i 75 anni).

I modelli, sia per le equazioni di selezione che per l'equazione di outcome, sono stati costruiti attraverso un'attenta scelta di queste variabili. Le variabili per ciascun modello di selezione, sono riportate nella tavola 6, in ordine di significatività.

I modelli implementati sono risultati sempre significativi, infatti il test del rapporto della massima verosimiglianza fornisce risultati positivi sulla significatività di ciascun modello. Anche i coefficienti di regressione risultano essere significativamente diversi da 0 per le variabili e per le modalità delle variabili considerate.

Tavola 6 – Modelli di selezione del campione con una equazione di selezione (risposta) e con due equazioni di selezione (contatto e partecipazione)

		Variabili di stima	
	Variabile indicatrice	Condizione di analfabetismo	Condizione occupazionale
		Covariate	
Approccio tradizionale con una equazione di selezione (unica componente di non risposta)			
Equazione di outcome		Classi d'età Numero di invalidità Ripartizione geografica Gravità dell'invalidità Difficoltà motoria	Gravità dell'invalidità Ripartizione geografica Numero di invalidità Classi d'età Difficoltà motoria
Equazione di selezione	Risposta	Presenza del telefono Classi d'età Numero di invalidità Difficoltà motoria Gravità dell'invalidità	Presenza del telefono Classi d'età Numero di invalidità Difficoltà motoria Gravità dell'invalidità
Approccio alternativo con due equazioni di selezione (due componente di non risposta)			
Equazione di outcome		Classi d'età Numero di invalidità Ripartizione geografica Gravità dell'invalidità Difficoltà motoria	Gravità dell'invalidità Ripartizione geografica Numero di invalidità Classi d'età Difficoltà motoria
1-Equazione di selezione	Contatto	Presenza del telefono Classi d'età Difficoltà motoria	Presenza del telefono Classi d'età Difficoltà motoria
2-Equazione di selezione	Partecipazione	Numero di invalidità Classi d'età Gravità dell'invalidità Ripartizione geografica	Numero di invalidità Classi d'età Gravità dell'invalidità Ripartizione geografica

5. Confronto tra metodi

Nelle tabelle 7 e 8 sono riportati i totali stimati con i diversi approcci per le modalità delle due variabili sopra descritte. Nell'approccio tradizionale i totali sono ottenuti con pesi campionari corretti con la procedura basata sul modello CART; nell'approccio sequenziale i totali sono ottenuti con pesi campionari corretti in entrambe le fasi del processo di risposta con la procedura basata sul modello CART.

Nel caso del sample selection model, i valori attesi delle variabili considerate sono determinati utilizzando diversi modelli di stima: il modello probit senza effetti indotti dalla selezione del campione, i cui parametri sono stati stimati con il metodo della massima verosimiglianza (MLE); il modello con una equazione di selezione (risposta) i cui parametri sono stati stimati con il metodo MLE e il metodo in two-step di Heckman; il modello con due

equazioni di selezione (contatto e partecipazione), dove, per la stima dei parametri delle equazioni di selezione sono state utilizzate due procedure di stima, nella prima (procedura 1) detti parametri sono stati stimati con un probit bivariato e nella seconda (procedura 2) con due probit separati (cfr. par. 3.2). Essendo le variabili dipendenti studiate di tipo dicotomico, per la stima dei parametri dell'equazione di outcome sono stati utilizzati modelli di tipo probit.

Tavola 7 – Confronto della stima del numero di individui disabili analfabeti e del numero di individui disabili non analfabeti (Valori assoluti e percentuali) nei diversi approcci

	Metodo di stima	Individui disabili analfabeti	Individui disabili non analfabeti	Totale
Approccio basato sulla correzione dei pesi campionari				
Tradizionale (una fase)	CART	97.088 (8,1%)	1.104.100 (91,9%)	1.201.188 (100.0%)
Sequenziale (due fasi)	CART	96.034 (8,0%)	1.105.154 (92,0%)	1.201.188 (100.0%)
Approccio basato sul modello probit senza selezione				
	MLE	97.836 (7,9%)	1.102.881 (92,1%)	1.200.717 (100.0%)
Approccio basato sul sample selection model				
1 eq. selezione	MLE	93.709 (7,4%)	1.107.479 (92,6%)	1.200.716 (100.0%)
	Heckman two-step	89.348 (7,6%)	1.111.369 (92,4%)	1.200.717 (100.0%)
2 eq. selezione	Procedura 1	91.003 (7,6%)	1.109.714 (92,4%)	1.200.717 (100.0%)
	Procedura 2	91.049 (7,6%)	1.109.627 (92,4%)	1.200.717 (100.0%)

Tavola 8 – Confronto della stima del numero di individui disabili in cerca di occupazione e del numero di individui disabili non in cerca di occupazione (Valori assoluti e percentuali) nei diversi approcci

	Metodo di stima	Individui disabili in cerca di occupazione	Individui disabili non in cerca di occupazione i	Totale
Approccio basato sulla correzione dei pesi campionari				
Tradizionale (una fase)	CART	326.178 (27,1%)	875.010 (72,9%)	1.201.188 (100.0%)
Sequenziale (due fasi)	CART	322.670 (26,9%)	878.518 (73,1%)	1.201.188 (100.0%)
Approccio basato sul modello probit senza selezione				
	MLE	323.078 (27,9%)	877.639 (72.1%)	1.200.717 (100.0%)
Approccio basato sul sample selection model				
1 eq. selezione	MLE	327.850 (27,3%)	873.339 (72,7%)	1.201.189 (100.0%)
	Heckman two-step	329.825 (27,5%)	870.892 (72,5%)	1.200.717 (100.0%)
2 eq. selezione	Procedura 1	330.640 (27,5%)	870.077 (72,5%)	1.200.717 (100.0%)
	Procedura 2	329.776 (27,5%)	870.941 (72,5%)	1.200.717 (100.0%)

Per le due variabili considerate nella sperimentazione si verificano situazioni opposte. Rispetto al modello probit senza effetti di selezione, i metodi che ne tengono conto portano a valori più bassi nel caso della stima del numero di disabili analfabeti, e a valori più alti nel caso della stima del numero di individui disabili in cerca di occupazione.

Il motivo di questo si può apprezzare maggiormente quando si utilizza il sample selection model: nel caso in cui si considera una sola equazione di selezione la correlazione tra la variabile di interesse e la mancata risposta ς_{YR}, che dà il segno alla correzione della distorsione, nel primo caso è negativa, ς_{Y_1R} = - 0.0250, mentre nel secondo caso è positiva, ς_{Y_2R} = 0.0137.

Il discorso è analogo quando si considerano due equazioni di selezione. In questo caso entrambe le componenti di mancata risposta hanno una correlazione negativa con la variabile "condizione di analfabetismo", infatti ς_{Y_1C} = -0.0253 e ς_{Y_1P} = -0,0005, e positiva con la variabile "condizione occupazionale", ς_{Y_2C} = 0,0151 ς_{Y_2P} = 0.0008. Il segno assunto dalle correlazioni tra la variabile di interesse e i processi di selezione determina il segno della correzione nella (3.6) e (3.7).

Analizzando le stime ottenute con i due modelli di selezione è possibile affermare che l'effetto di selezione, dovuto ai processi di selezione del contatto e della partecipazione, ha un impatto sulle stime della percentuale di individui disabili analfabeti e degli individui disabili in cerca di occupazione rispettivamente vicino allo 0,5% ed allo 0,3%.

L'ordine di grandezza della correzione di tali effetti distorsivi è influenzato dal livello di correlazione tra la mancata risposta o le sue componenti con la variabile di interesse. Nell'esempio queste, seppur basse, hanno un effetto non trascurabile.

Inoltre, poiché i valori delle correlazioni ς_{YR} e ς_{YC}, per entrambe le variabili indagate nei due modelli di selezione sono molto simili, è possibile dedurre che gli effetti distorsivi della mancata risposta totale siano in gran parte determinati dalla componente mancato contatto e, solo per una parte residuale, dalla componente rifiuto. Quindi possiamo affermare che l'effetto di selezione è principalmente dovuto al mancato contatto e non al rifiuto a partecipare all'indagine.

La correlazione positiva tra la le due componenti di mancata risposta denota una buona propensione alla partecipazione all'indagine degli individui disabili, una volta contattati. Tuttavia, essendo questa esigua, la correzione che ne deriva ha un impatto marginale sulle stime. Questo risultato, determinato molto probabilmente dall'elevato tasso di mancato contatto, giustifica l'ipotesi di indipendenza tra le due componenti di mancata risposta fatta nel lavoro di De Vitiis *et al*. (2012).

6. Conclusioni

La sperimentazione di metodi alternativi al trattamento della MRT è stata resa possibile dalla disponibilità di un ampio numero di variabili ausiliarie note per le unità rispondenti e le unità non rispondenti. La carenza di informazione ausiliaria può costituire, in generale, un limite applicativo dei metodi presentati nel lavoro che, tuttavia, in futuro, potrà essere superato grazie alla crescente disponibilità di sistemi integrati di informazioni di fonte amministrativa che costituiscono un punto centrale della modernizzazione avviata dall'Istituto.

L'applicazione dell'approccio sequenziale di aggiustamento dei pesi campionari ha dato buoni risultati, soprattutto quando i fattori correttivi sono stati determinati a partire da una modellizzazione non parametrica dei processi di risposta.

La sperimentazione del metodo di correzione della mancata risposta totale basato sul *sample selection model* ha consentito di analizzare gli effetti distorsivi determinati dai legami tra le diverse componenti della mancata risposta e tra queste e le specifiche variabili di interesse.

Il *sample selection model*, soprattutto nella sua formulazione estesa a più equazioni di selezione, è un approccio molto interessante perché applicabile a diversi contesti di studio, come la stima per indagini basate su tecniche miste di rilevazione. Molte indagini Istat, infatti, stanno introducendo tale metodologia che, se da un lato è utilizzata proprio per contenere la mancata risposta totale, dall'altro può introdurre specifici effetti distorsivi sulle stime che devono essere analizzati e trattati in fase di stima. Sebbene il metodo presenti livelli di complessità elevati, esso consente di studiare gli effetti combinati della tecnica di rilevazione e delle mancata risposta totale, o delle sue componenti.

L'applicazione del *sample selection model* al contesto presentato nel lavoro costituisce una fase iniziale di studio che ci ha consentito di intuire le potenzialità del metodo. Ulteriori approfondimenti in un'ottica simulativa, tuttavia, sono necessari per poter studiare le proprietà degli stimatori utilizzati. Inoltre, sarà opportuno valutare anche il ricorso a metodi di stima non parametrici e semi-parametrici che possono portare a notevoli vantaggi nel caso in cui non sono verificate le ipotesi alla base dei modelli.

Infine, è nei nostri obiettivi l'applicazione del modello di selezione multipla del campione a situazioni più complesse in cui più fattori possono concorrere a introdurre effetti distorsivi sulle stime delle indagini statistiche (mixed-mode, MRT o sue componenti).

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Incomplete Stratified Sampling design for the University graduates' vocational integration survey

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Sommario

Le indagini campionarie finalizzate alla produzione di stime per una molteplicità di domini, in alcuni casi, utilizzano un disegno stratificato semplice (SSRS) in cui gli strati sono ottenuti a partire dall'incrocio delle variabili che definiscono i domini di stima (stratificazione a più vie). Quando le variabili di stratificazione sono non annidate e presentano molte modalità, il disegno può risultare inefficiente a causa dei molti strati e della popolazione ridotta. Il lavoro introduce il disegno a Stratificazione Incompleta (ISS) in grado di superare tali inefficienze sfruttando appieno le informazioni ausiliarie disponibili, sia dalla lista di campionamento sia da altre fonti quali indagini precedenti per allocare il campione. Tale caratteristica è meno spiccata nei disegni SSRS. Il disegno ISS è stato utilizzato per selezionare il campione dell'indagine Istat sui laureati del 2015. Questo richiede una dimensione campionaria minore rispetto al disegno SSRS per rispettare le soglie di precisione fissate delle stime, poiché il disegno ISS non ha vincoli di numerosità negli strati.

Parole chiave: Stratificazione a più vie, stratificazione incompleta, allocazione campionaria

Abstract

For sampling surveys aiming at producing estimates for different domains of interest, in some cases, a sampling design adopted is the Stratified Simple Random Sampling (SSRS) design in which strata are defined by crossing of the variables that define the domains of estimate (multi-way stratification). When there are many strata, the SSRS design could be inefficient due to many small strata. The paper introduces the Incomplete Stratified Sampling(ISS) enables to overcome such inefficiencies exploiting the auxiliary information available both from the sampling frame and from other sources such as previous surveys. Such opportunity is less marked in the SSRS designs. The ISS has been used to draw the sample of the Istat 2015 survey on University graduates' vocational integration. The design requires a smaller sample size than the SSRS design to satisfy the fixed precision thresholds of the estimates, since with the ISS design the allocation process has no constraints on stratum sample sizes.

Keywords: Multi-way stratification, incomplete stratification, sample allocation

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1. Introduction

Literature on finite population sampling has devoted much attention on planning the sampling design and the outlining of the inclusion probabilities. The paper takes into account the class of stratified designs and in particular the Stratified Simple Random Sampling (SSRS) designs. In SSRS designs the definition of the inclusion probabilities coincides with the sample allocation by stratum, being the number of stratum sampled units given by summing up the inclusion probabilities over the stratum population. These designs are broadly applied in the official statistics: firstly for the easy implementation, secondly because they can be used to plan the sample size of sub-populations or domains of interest at design stage allowing to control the sampling errors in this phase. For the latter purpose, the domains of interest are classified by type of domain. For instance, in the socio-demographic surveys the partition types could be the gender, the province or region of residence, the age by class. Such partitions could be nested (for instance province in the region) or not nested (for instance gender and age by class). A practical SSRS design considers the finer not nested partitions and combines the category of each partition for obtaining the strata. In this way, the sample size of each domain is planned because are planned the stratum sample sizes. These designs are sometimes denoted as multi-way stratified design (Winkler, 2009) and, in particular, if the stratification is built up by two partitions we have a 2-way stratification design. Usually and mainly the instrumental role (plan the domain sample sizes) of the multi-way strata outweighs the efficiency issues of a sampling design.

The allocation of a SSRS design can be implemented according to an optimization problem. The optimal allocation for a univariate population is well-known (Cochran, 1977). In case of a multivariate scenario, where more than one characteristic is to be measured on each sampled unit, the optimal allocation for individual characteristics do not have much practical use, unless the characteristics under study are highly correlated. This is because an allocation that is optimal for one characteristic will generally be far from optimal for others. Therefore, the criteria established for the problem's multidimensionality leads to a definition of an allocation that loses precision, compared to the individual optimal allocation. For these reasons, the methods are sometimes referred as compromise allocation methods (Khan et al., 2010). Although we do not talk about optimal allocation we still define reasonable sample allocation criteria. They depend on several elements defining the sampling strategy: the inferential approach, the parameters of interest, the domains of interest, the estimator and, finally, the a priori information on the phenomena of interest. To tackle the problem several compromise allocation criteria have been proposed. A classical compromise allocation is given by the convex function of proportional allocation to population sample size and equal stratum sample size allocation (Costa et. al. 2004) or the power allocation (Bankier, 1988). Chromy (1987), Bethel (1989) and Choudhry et al. (2012) give a mathematical formalization to the compromise allocation, according to an optimization problem. All these criteria are suitable for the SSRS design. Along with the SSRS design, in this paper we propose another sampling design that we denote as incomplete stratification sampling (ISS) design (Falorsi and Righi , 2015). The ISS design is based on a stratification, where the units belongs to the same stratum have the same inclusion probabilities, but, differently from the SSRS design, the number of sampled units is a random variable while the interest domain sample sizes are still planned at design stage.

The ISS can be considered a special case of balanced sample in the randomization approach (Deville and Tillé, 2004), where the balancing totals are the resulting domain allocations. This feature could have a strong impact on the overall sample dimension. On the other hand the sample allocation for the SSRS design requires at least two sampled units in each stratum (if two in the population) to obtain unbiased variance estimates and the inclusion probabilities in each stratum must be rounded off such that summing up at stratum level we obtain an integer number (so that we can select an integer number of sampled units). These two issues are not strictly related to the optimization problem defining the compromise allocation and they represent a sort of exogenous constraints that produces inefficiency on the allocation. These problems can be overcome by the ISS design.

In section 2 we give a brief formalization of the optimization problems for the SSRS and ISS sampling design in the multivariate scenario. We show that the two formalizations are quite similar. Section 3 focuses on the definition of some input parameters involved in the optimization problem. They can significantly modify the optimal sample allocation solution. We compare the allocations achieved by a SSRS and ISS designs in section 4 where an experiment on *University graduates' vocational integration* survey data is performed. Some conclusions are presented in section 5.

2. Allocation problem

Let U be the reference population of N elements and let U_d (d=1, …,D) be an estimation domain, i.e. a generic sub-population of U with N_d elements, for which separate estimates must be calculated. Furthermore we denote by U_h the h^{th} (h=1, …, H) sub-population where the inclusion probability π_k of unit k (k=1, …, N_h) must be equal to π_h. In the SSRS design U_h is a stratum and each U_h does not cut across the U_d's. The allocation problem searches for the vector $\boldsymbol{\pi}' = (\pi_1,...,\pi_h,...\pi_H)$ satisfying a given criterion.

We formalize the criterion according to an optimization problem. Both for the SSRS and ISS designs it is mainly based on the following system

$$\begin{cases} Min\left(\sum_{k\in U} \pi_h\, c_h\right) \\ V(\hat{t}_{(dr)}) \le \overline{V}_{(dr)} \quad (d = 1,...,D; r = 1,...,R) \\ 0 < \pi_h \le 1 \qquad\qquad (h = 1,...,H) \end{cases} \quad (2.1)$$

where: c_h is the uniform cost for collecting information from unit $k \in U_h$;

$V(\hat{t}_{(dr)})$ is a measure of precision (variance) of the estimate $\hat{t}_{(dr)}$ of total

$t_{(dr)} = \sum_{k \in U_d} y_{kr}$ on the domain U_d for the variable y_r, in which the expression of $V(\hat{t}_{(dr)})$ depends on the sampling design implemented; $\overline{V}_{(dr)}$ is a fixed precision threshold for $\hat{t}_{(dr)}$ estimate; the y_r (r= 1, …, R) are the driving variables for the allocation. In this formalization their totals represent the (main) parameters of interest.

In case of the SSRS design further, well known, constraints are necessary:

$$\begin{cases} \boldsymbol{\pi}_h = 1 \text{ when } N_h = 1 \\ N_h \boldsymbol{\pi}_h \geq 2 \text{ when } N_h \geq 2 \\ N_h \boldsymbol{\pi}_h \text{ must be equal to an integer} \end{cases} \qquad (2.2)$$

The optimization problem (2.1)-(2-2) defines the vector $\boldsymbol{\pi}$ such that: the variance of the estimates is less than the fixed thresholds; the sample size in each stratum is an integer, being larger or equal to 2 if the stratum population is larger or equal to 2.

We point out that the (2.2) are SSRS design specific constraints. If we use another sampling design the (2.2) could change. The ISS is still a sampling design based on a stratification. In practice, the main difference with the SSRS design is on the random selection scheme. The ISS design provides a fixed sample sizes on the U_d' and not on the U_h, whit $\pi_k = \pi_h$ for $k \in U_h$. It means the constraints (2.2) do not hold anymore. They are replaced by the following constraints

$$\sum_{U_h \in U_d} N_h \boldsymbol{\pi}_h \text{ must be equal to an integer.} \qquad (2.3)$$

The (2.3) leads to round off the optimal solution of (2.1) to integer values at U_d level. We highlight that the influence of the (2.3) on the optimal solution is much less pressing than the effect of the (2.2) constraints. So the optimal solution is better preserved.

The implementation of the ISS design is performed by using the Cube algorithm (Deville and Tillé, 2004). Cube algorithm draws balanced samples under the randomization approach and ISS is specific case of balanced sampling. In the system (2.1) the variances in the variance constraints must be related to valid expression for the balanced sampling designs. Falorsi and Righi (2015) shows the variance expression in case of ISS design suitable for the optimization problem (2.1).

The optimization problem (2.1) with the constraints (2.2) or (2.3) plans the U_d sample sizes so that is minimized the expected cost ensuring that the precision measures on the estimates of the driving variables are bounded and that the inclusion probabilities lie between 0 and 1.

For a concrete use of the optimization problem other parameters, included in the $V(\hat{t}_{(dr)})$ expression, have to be fixed. In particular: the definition of $V(\hat{t}_{(dr)})$, in the SSRS design, requires the knowledge of the variance S^2_{hr} for the variable y_r in the stratum U_h; in the ISS design the population mean $\overline{Y}_{hr}$ for each variable y_r in the stratum U_h has to be known as well. Of course such parameters are unknown as they are the targets of the

survey. Then, we have to replace these values with some estimates and to treat the estimates as true values. A common strategy is to use the previous survey data, where the variable y_r have been collected and to perform an estimation procedure.

The estimation of S_{hr}^2 and $\overline{Y}_{hr}$ is crucial on the final allocation and at the same time often underrate when planning the sampling design.

Chromy (1987), Bethel (1989), Falorsi *et al.* (1998) and Choudhry *et al.* (2012) propose different algorithm converging to the same solution for solving the problem (2.1) when $V(\hat{t}_{(dr)})$ is the variance of the SSRS design. Falorsi and Righi (2015) consider the variance expression of the ISS design in the optimization problem and propose a new algorithm. Since the ISS is a special case of the balanced sampling design, where the balancing variables are ${}_{\mathrm{d}}\delta_{\mathrm{k}}\pi_{\mathrm{k}}$ (being ${}_{\mathrm{d}}\delta_{\mathrm{k}}$ the variable indicator of domain *d*), the expression for the variance proper for the balanced sampling (Deville and Tillé, 2005) is taken into account in the allocation procedure.

3. Estimation of the parameters for the allocation

The section focuses on the estimates of the $\overline{Y}_{hr}$ and S_{hr}^2 for the allocation. We assume that the U_h are small domains and direct estimates based on previous survey data are not reliable. For this reason, the practical approach is to use a model based approach borrowing strength from larger sub-population data. The aim is to exploit as much as possible the knowledge on the y_r variables before conducting the survey, because in this way a sample size as small as possible will be enough for obtaining satisfying estimates of such characteristics. We consider $\overline{Y}_{hr}$ as a model prediction of each value y_{kr} for $k \in U_h$, being the auxiliary variables of the model known also in the list frame available for the sampling selection; S_{hr}^2 are the model variance. Therefore, the first step for setting up the optimization problem is to produce the *best* prediction of $\widetilde{\overline{Y}}_{hr}$ and $\widetilde{S}_{hr}^2$. What *best* means is strictly related to the goodness of fit of the estimated model with the previous survey data. According to this approach we can go beyond the multi-way stratification. In fact, the best prediction model for the y_{kr} could be defined out of the multi-way strata so that the mean and variance model can be different within the multi-way strata. In this sense we are searching the optimal stratification (Khan *et al.*, 2008) with the only constraints that the strata do not cut across the domains of estimate for guaranteeing that the domain sample sizes are planned at the design stage. Furthermore, we could have an individual prediction value when using a prediction model with at least one continuous auxiliary variable.

We point out that the granularity of the stratification affects the final allocation, especially when a SSRS is adopted, since the weight of the constraints (2.2) increases in the optimization problem when the number of small strata increases.

In the following, an application on real survey data tests the sample allocation issue with the SSRS and ISS under different prediction models leading to the multi-way

stratification or a more detailed stratification. We restrict the analysis to fixed effect models but in general random effect models typically used for the small area estimation problem could be investigated (Rao, 2003).

The output of the optimization procedure gives a sample allocation with the expected percentage CV for the estimates on the domains. These values will be lower or equal to the CV thresholds. In practice, when the sampling survey has been conducted and the estimates computed, the real CV estimates (in absence of non-response) will generally differ from the expected ones for two main reasons: the super-population models generating the variable of interest differ from the models used for defining the input parameters; the input parameters are estimated, rather than being true. When we search for a best model, we try to choose a model as closest as possible to the true super-population model. In this way, we can reduce the possible difference among the expected and the observed CV of the estimates.

4. Application

The experiment has been carried out on the basis of data from the last edition of the university graduates' vocational integration survey conducted by the Italian National Statistical Institute.

The survey aims at investigating the graduates' employment conditions, the working stability, the job placement and the economic activity area. The data have been collected in 2011 on the population of about 173,800 graduates', who hold a Bachelor's Degree during the calendar year 2007. The next planned edition of the survey will be conducted during year 2015 and it will regard the population graduates', who got a university degree, both Bachelor and Master, during the calendar year 2011.

The interest domains of the survey are defined on the basis of gender, degree programs and university, variously crossed and aggregated. The 2011 survey used a SSRS design where the 2,981 not empty strata were obtained by crossing the variables degree program, gender and university.

The application has been carried out on 2011 survey data in order to plan the sample design of 2015 survey edition. Two types of domains are considered: degree programs crossed with gender (DOM1) and university crossed with educational area (DOM2), for an overall number of 542 domains. The survey produces actually estimates for other more aggregate domain partitions, which can be obtained as aggregation of DOM1 and/or DOM2.

The experiment has been developed in two main phases: the first one devoted to the selection models for predicting the $\overline{Y}_{hr}$ and S^2_{hr}, based on 2011 survey and frame data. In the second phase the SSRS and ISS allocations have been compared in terms of overall sample sizes.

The first phase used 2011 complete information, deriving from both survey and frame, to estimate model parameters, to be used for planning the next edition of sample design for which only auxiliary information in the frame is available.

4.1 Model selection

We consider three binary variables y_r (r=1,2,3) describing the condition of the graduates three years later than the graduation: working (yes/no), looking for a job (yes/no), studying (yes/no). To predict the binary responses, logistic regression models have been fitted using auxiliary variables chosen from the list of variables available in the previous survey and in the current sampling frame: UNIVERSITY of the degree achievement (80 modalities), educational AREA of the course (9 modalities), branch of knowledge of the course or GROUP (16 modalities), degree program or COURSE (44 modalities) AGE CLASS at the graduation moment (3 modalities), NUTS 2 residence REGION (21 modalities), GENDER (2 modalities) and FINAL GRADES CLASS (3 modalities). The original continuous variables, age and final grades, have been recoded as categorical variables to allow the implementation of both SSRS and ISS designs.

Several logistic regression models have been studied relatively to the three dependent variables (table 4.1). They represent the set of benchmarking models or models we found statistically significant. The Akaike Information Criterion (AIC) has been used to evaluate their goodness of fit. The investigated models have different and increasing levels of complexity. Models from 1 to 3 are the simplest ones and they are considered as a benchmark for the more complex ones. Model 4 was the one used for planning the 2011 sample design, the previous survey occasion.

Model 5 uses all the auxiliary variables defining the planned domains (gender, university, educational area) but aggregating them, in order to deal with computational issues.

Models 6 and 7 have been chosen according to the goodness of fit; they differ for the variable GROUP (model 6) and the COURSE (model 7).

These models have been studied with the aim to describe accurately the dependent variables and the obtained predictions vary within the two-way strata. In these two models, the units with the same covariate pattern (or profile) have the same prediction. In the allocation procedure each profile is a stratum.

Table 4.1 – Proposed models' AIC, relatively to the dependent variable working, looking for a job, studying.

Model	AIC-Working	AIC-Looking for a job	AIC-Studying
1: Total average (only intercept)	37,700	26,570	42,976
2: Gender	37,624	26,451	42,892
3: Group	34,251	25,256	33,885
4: Gender+ Group+ Group * Gender	34,020	25,088	33,782
5: Gender+Area + Gender*Area + University	32,737	23,865	32,941
6:University+Group+Age class+Region+Gender+Final grades class	30,390	22,252	29,531
7:University+Course+Age class+Region+Gender+Final grades class	30,004	22,231	28,577

We have to take care with this issue since each stratum defines an inclusion probability and each of them is an unknown in the system (2.1). Then, the system could not be solved due to computational limit when the model define too many profiles.

Figure 4.1 – Proposed models' ROC curves, relatively to the dependent variable working, looking for a job, studying

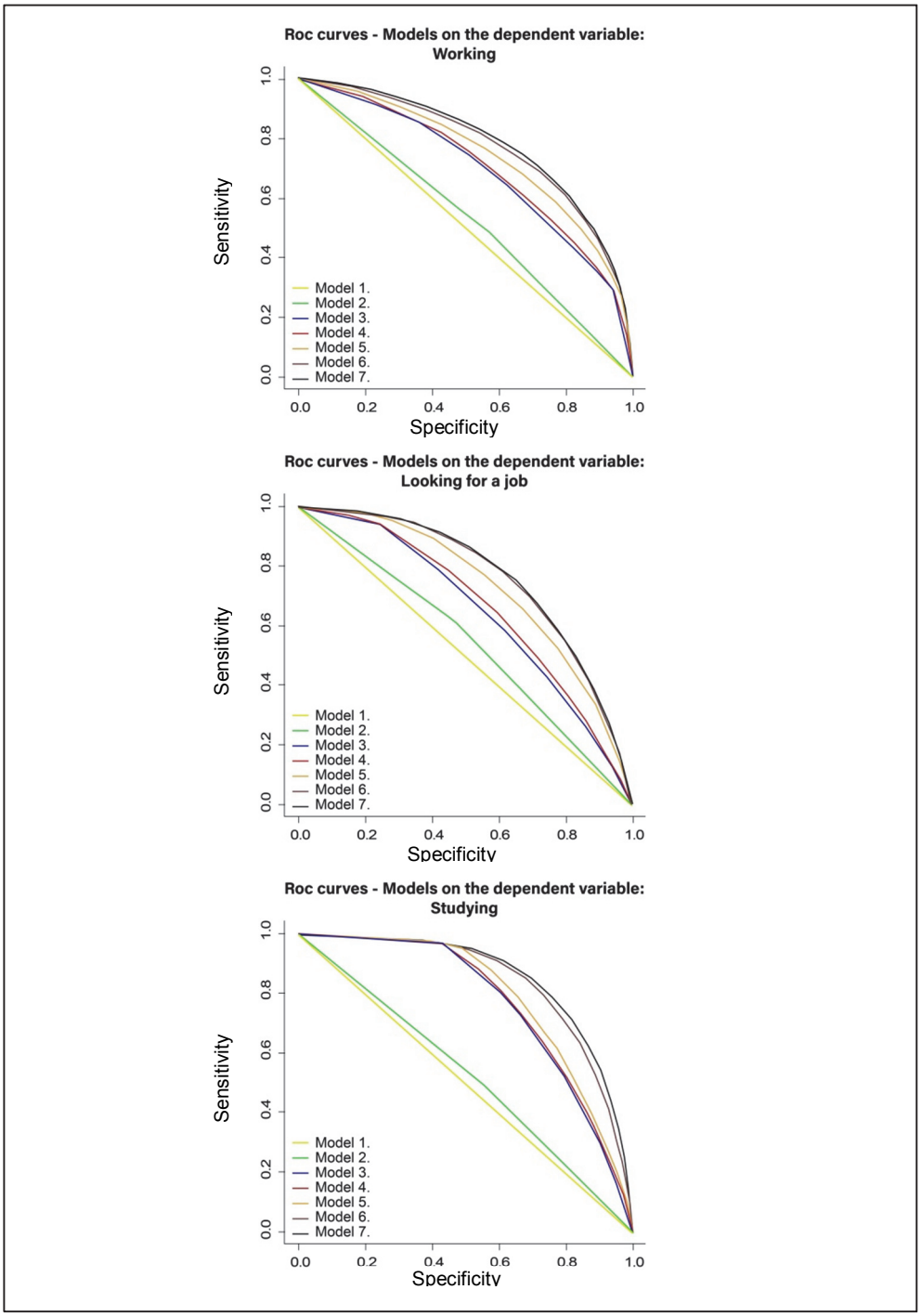

Table 4.1 shows that the increasing complexity produces decreasing AIC, denoting a better fit. The relative differences among the model goodness of fit are depicted by the ROC curves (figure 4.1).

In the graphs sensitivity (true positive rate) is plotted in function of specificity (false positive rate), varying the cut-off point; so each point on every ROC curve represents a sensitivity/specificity pair. The area under the ROC curve (called AUC, in acronym form) is a measure of how well a model can distinguish between two modalities of a dependent variable (working/not working, looking/not looking for a job, studying/not studying). The more complex the model is, the more bent the curve is, maximizing its AUC.

The graphs confirms that the model 7 should be the best model, and so it can be considered the closest one to the true and unknown superpopulation model generating the three variables of interest.

Nevertheless, we stress the model 7 has got some drawbacks (see section 4.3) related to the number of classes of the variable COURSE. This number along with the sample size for fitting the model could be a reason to explain why COURSE is significant. We argued, that other model selection methods could be considered in the future, as the cross-validation or revision error techniques.

4.2 Sample allocation

Once we got the predicted values of the needed quantities discussed in section 3 through the models described in section 4.1, we compared the sample allocation of the optimization problem (2.1) using the constraints (2.2) or (2.3) respectively for the SSRS and ISS design. Both the sample allocations were performed fixing the same precision thresholds according to the percentage Coefficient of Variation (CV) of the sampling estimates for the totals of the three variables of interest. For DOM1 domain type the following three CV had been considered: 13%, 25% and 20% respectively for “working”, ”looking for a job”, “studying”; for DOM2 domain type the following three CV had been considered: 13%, 25% and 15%.

4.3 Results

Table 4.2 shows the overall sample sizes for both the sampling designs, SSRS and ISS, having set the cost for collecting information constant. Furthermore, the table displays the number of strata considered in the designs. For models 1 to 5, where the profiles are aggregations of the two-way strata, we have 2,981 strata. Models 6 and 7 define respectively 8,743 and 31,486 profiles so, therefore, strata.

Tavola 4.2 - Number of strata for the proposed models and sample sizes for SSRS and ISS designs

Model	*Strata considered in the allocation procedure*	SSRS	ISS
1: Total average (only intercept)	**2,981**	**26,419**	**24,845**
2: Gender	2,981	26,673	25,232
3: Group	2,981	31,539	30,061
4: Gender+ Group+ Group * Gender	2,981	31,345	29,879
5: (Gender*Area)+University	2,981	36,624	35,027
6: University+ Group+Age class+Region+Gender+Final grades	8,743	63,246	34,620
7: University+Course+Age class+Region+Gender+Final grades	31,486	63,168	34,622

The comparison between SSRS and ISS allocation shows that the latter design requires a smaller sample size to satisfy the precision thresholds. What happens in the SSRS design is that the constraints (2.2) enlarge the sample size with the result that the expected CVs can result unnecessarily below the threshold stated than the expected CVs obtained for the ISS design.

The further interesting evidence is related to the model choice. Table 4.2 displays that the simplest model 1 gives the smallest sample size both for the SSRS and ISS design. The result does not imply that we have to choose model 1, but that the allocation for model 1 will give observed CV estimates probably very far from the expected ones.

Finally, we focus on the model 6 and 7. The sample size of the ISS sampling design are equivalent and the complexity expressed by the model 7 does not bring a real gain in terms of sample size. The model 6 has been used to plan the sample allocation of 2015 survey.

5. Conclusions

The sampling surveys in official statistics are usually characterized by a large number of domains for which several parameters have to be estimated. When the domain membership binary variable values are known for each population unit at the design stage it could be useful to select a sample in which the sample size for each domain is planned. In this way, in some extent the design enables to control the sampling errors of the domain estimates. The paper introduces the Incomplete Stratified Sampling (ISS) design to deal with the domain sample size allocation and compares the ISS efficiency in terms of overall sample size to the efficiency of the multi-way Stratified Simple Random Sampling (SSRS) design commonly used to fix the number of domain sampled units at design stage. The comparison is carried out using optimal allocation methods that, in the case of multivariate and multi domain context, actually define a compromise allocation criterion. The methods have been evaluated modifying the mean and variance input parameters. The modifications depend on the working models used for predict these parameters since in practice they are unknown. The estimated or predicted parameters are used as if they were observed and, as a consequence, if the estimated values are too far from the true values the allocation can lead to misleading conclusion on the expected precision of the estimates. When this risk is recognized, we are aware of the importance to work with the “best” model to exploit as much as possible the information on the phenomena of interest when planning the design.

The paper is then focused on the search of the suitable working model and on the behavior of the sample allocation joined with the SSRS and ISS design. This search can lead to leave the multi-way stratification and to define a more deep stratification. The main results of the experiments reveal that the ISS design always outperforms the SSRS especially when the number of strata increases. That means the ISS is a more flexible tool and it can be used to choice the best working model to predict the input parameters. On the other hand, when the SSRS design has to be implemented we must pay attention on the number of strata generated by the working model to avoid the sample size inflates too much because of exogenous design constraints.

The next 2015 edition of the university graduates' vocational integration survey has been realized using the ISS design and this choice allow to define a more efficient design than in the past.

Finally, the allocation process based on the ISS design can be implemented taking into account the unit non response, that generally afflicts the large sample survey. Suppose that the phenomenon of non response is substantially different among response subgroups, where the response propensities are roughly constant for the units belonging to a given subgroup. We can identify at design stage the subgroups and obtain reliable estimates of the response propensity through previous surveys. We can add this extra dimension on the basic multi-way stratification and perform the sample allocation with the aim to plan the size of the sample really observed (unit non response excluded). The approach could be unfeasible using the standard SSRS since the new dimension has a multiplicative effect on the number of strata and the related constraints. Instead, for the ISS design, the new dimension has an additive effect on the number of constraints to be satisfied.

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The heterogeneity of undeclared work in Italy: some results from the statistical integration of survey and administrative sources[1]

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Abstract

The heterogeneity of undeclared employment is analysed by exploiting microdata derived from the statistical integration of the labour force survey with administrative records tracing regular jobs, whereby irregularity is flagged by comparing independent sources. Following previous approaches, logistic regression is used to model the probability of being undeclared as a function of individual characteristics and local context indicators. A segmentation of irregular employment gives the possibility to appreciate the coexistence of different specialization patterns deriving from the combination of supply and demand effects. They seem to support the adoption of an approach to active policies where local conditions should receive greater attention.

Keywords: Labour market, Undeclared work, Non-observed economy, Logistic regression, Multiple correspondence analysis, Cluster analysis.

Sommario

L'eterogeneità dell'occupazione non regolare viene qui analizzata attraverso l'uso del campione della rilevazione sulle forze lavoro i cui microdati sono stati integrati con le informazioni contenute negli archivi amministrativi che tracciano l'occupazione regolare. Attraverso una regressione logistica è stata modellata la probabilità di avere un'occupazione irregolare in funzione delle caratteristiche socio-demografiche dell'individuo, di fattori locali di contesto relativi al mercato del lavoro e alla struttura produttiva, e delle caratteristiche della posizione lavorativa. Una segmentazione dell'occupazione non regolare evidenzia alcuni modelli di specializzazione attraverso la combinazione fra caratteristiche dell'offerta e struttura della domanda. Dai risultati sembra emergere un quadro favorevole all'adozione di politiche attive su base territoriale.

Parole chiave: Mercato del lavoro, Occupazione non regolare, Economia sommersa, Modello logistico, Analisi delle corrispondenze multiple, Analisi dei gruppi.

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Introduction

Research on undeclared work[4] has progressively moved from the mere estimation of the incidence of this phenomenon, at most broken down by a few main variables, towards more explicit insights into its multi-facet nature, contributing to enrich analysis and – potentially – to address and support suitable and dedicated policies[5]. For this purpose, the statistical integration of survey and administrative data might prove a promising tool for the provision of helpful insights on hidden work segmentation through the use of microdata and within a methodological approach that addresses the issue of producing accurate level estimates.

The use of microdata is fundamental for this purpose. In the recent past ISTAT achieved important results in estimating irregular labour input by means of an aggregated (or *macro*) approach, methodologically founded on the cross comparison of detailed domain aggregations of employment data from independent sources[6]. This approach guaranteed as a matter of fact accurate level estimates of irregular labour input in Italy, with an appreciable breakdown at least for the national accounts purposes it was meant to satisfy: nevertheless, macro approaches are not suited for the provision of detailed analyses of hidden labour market. More recently, the analysis of household survey microdata has gained ground, based on the indirect detection of irregularity at individual level throughout the selection of groups of response items within the survey questionnaire. Cappariello *et al.* (2009), in particular, derive very interesting results by flagging individuals in employment

[4] According to European Commission (2007), "*Undeclared work is defined as any paid activities that are lawful as regards their nature but not declared to public authorities, taking into account differences in the regulatory system of Member States. This definition links undeclared work with tax and/or social security fraud and covers diverse activities ranging from informal household services to clandestine work by illegal residents, but excludes criminal activities*" (p.2). This is coherent with OECD (2002), where it is defined as "*Employment concealed by the enterprises choosing not to respect employment regulations or immigration laws by hiring labour* off the books" (p.38). This kind of employment involves the paid production and sale of goods and services that are unregistered and/or hidden from the state in order to avoid taxes, social security payments, and security standards. For all the other respects the production is perfectly legal. Within this definition, and despite the absence of an unambiguous alternative agreed upon at international level, it shall be dealt here with jobs which are not traced in administrative records. In this sense the term undeclared seems to fit well the objectives of the paper. "Irregular work" will be the only term used as a synonym of undeclared work hereafter, despite of its broader meaning and even if in the literature undeclared work is "a*lso referred to as the informal, hidden, cash, twilight, dual, subterranean, parallel, underground, second, unofficial, or shadow economy, as well as moonlighting"*, see for example Renooy *et al*., (2004), Williams (2007), ILO (2010) and ILO (2013).

[5] See for example Williams *et al.* (2004), Renooy *et al.* (2004). With reference to the Italian case, see for example Lucifora (2003) or Gobbi *et al.* (2007) and Cappariello *et al.* (2009) and their literature review on these issues. See also the Italian version of the latter work: Cappariello-Zizza. 2009. *Istruzione ed economia sommersa*. In: Banca d'Italia, Mezzogiorno e politiche regionali. Seminari e convegni n. 2, novembre, p. 191-214. An important stimulus to policy oriented research on undeclared work has been conveyed by the initiatives of the EU Commission. For a recent overview see for instance European Commission (2007, 2014) or else the Commission Staff Working Document "*Impact Assessment Accompanying the document Draft Proposal for a Decision of the European Parliament and of the Council on establishing a European Platform to enhance cooperation in the prevention and deterrence of undeclared work*" (Brussels, 9.4.2014 SWD(2014) 137 final).

[6] For an overview of "macro approaches" see the one provided in GHK *et al.* (2009). On the so called "Italian approach" see Calzaroni (2000) whose methodology was founded on the comparison between Census data and Labour force survey data: on the same subject see also Baldassarini (2001). Boeri *et al.* (2002) support the idea that a large share of irregular employment is hidden among those who are classified unemployed or inactive. See Zizza (2002) for a survey of this literature. See also Cappariello *et al.* (2009) or, on a more specific perspective, Baccini *et al.* (2003), Isfol (2007a, 2011).

as irregulars if they do not declare social security coverage[7]; Boeri *et al.* (2002) worked on a survey sample limited to Sicily where irregularity was directly asked in the questionnaire. These approaches, if on the one hand they do not meet the target of providing unbiased level estimates (mainly because they cannot correct the response biases, for example by exploiting data source integration), on the other hand they set the scene for a deeper study of individual characteristics and for segmentation analysis[8].

The paper develops along this path of research by exploiting microdata derived from the statistical integration of the Italian labour force survey (LFS) sample with administrative records tracing formally regular jobs (hereafter summarised with ADMIN), where irregularity is flagged at individual level by comparing the employment status reported by independent sources. It is the first time that a micro integrated database is used to provide estimates of undeclared work for official statistics purposes. The integrated LFS sample (labelled with LFS-ADMIN[9]) has the advantage of allowing the use of a huge amount of microdata where the detection of irregularity is derived within a statistical integration process that corrects employment level bias[10]. Investigation of heterogeneous nature of undeclared work, due both to individual strategies of firms and of workers and their interplay, as well as to the social contest in which they operate[11], has been furthermore made possible by the use of microdata. Those parts of the existing literature on undeclared work that treat the issue of its heterogeneous nature are firstly illustrated and discussed (par.1); an overview of LFS-ADMIN then follows with a description of undeclared work estimates (par. 2); some results obtained from modelling the probability of being in undeclared employment are then discussed (par. 3); then a segmentation of undeclared employment based on individual and job characteristics, as well as on the ADMIN traces of each individual, is provided (par. 4). Some conclusions are finally drawn.

1. Heterogeneity of undeclared work

Several domains of heterogeneity referred to undeclared work have been investigated in the existing literature and since a relatively long time. Portes *et al.* (1989) for instance recognize that if on the one hand informal economy has a universal character, since it is

[7] They worked on the microdata of the biennial Survey on Household Income and Wealth, run by the Bank of Italy with a sample of nearly 8.000 households. In spite of the limited sample size and a narrow definition of irregularity, they provide several interesting insights, inter alia on its ties with education and gender.

[8] Eurobarometer (2007, 2013) conducted Europe-wide direct surveys on undeclared work commissioned by EU institutions. Nevertheless in European Commission (2014) it is also stated that such methods tend to under-report the extent of irregular work, particularly in specific domains. On this point see also, for example, Andrews *et al.* (2011).

[9] The methodology adopted to build LFS-ADMIN has been developed by an ISTAT working group and it is described in AA.VV. (2015); for a concise description see par. 2. A first experience at ISTAT on survey and ADMIN sources integration is documented in Cascioli (2006).

[10] The integrated sample LFS-ADMIN has been developed by ISTAT starting with reference years 2010 and 2011, with the purpose of supporting national accounts benchmark estimates of regular and irregular labour input (namely number of persons in employment, jobs and hours actually worked). See ISTAT. *I nuovi conti nazionali in SEC 2010*. Nota informativa, 6 October 2014 (pages 21-25) or also ISTAT. *Il ricalcolo del Pil per l'anno 2011*. Nota informativa, 9 September 2014 (pages 9-11). LFS-ADMIN estimates are now replied annually to update benchmark estimates: at the moment the delay is about t+17 months and it depends on the timing of ADMIN data. Some analyses on undeclared work derived from LFS-ADMIN are reported in ISTAT (2015, ch.4.1.2) and in De Gregorio *et al.* (2014).

[11] Under a theoretical approach these elements are developed in Pfau-Effinger (2009).

found in countries and regions characterized by very different economic systems and development achievements, on the other hand it is also quite a heterogeneous phenomenon, with large differences both between and within countries.

Heterogeneity can be examined under several perspectives and with varying degrees of complexity in the analytical framework. Simple descriptive statistics already clearly evidence the large variability in the incidence of irregular jobs across areas and economic activities. Labour demand and supply factors are clearly connected with the explanation of such heterogeneity: they involve the connections and vertical integration of irregular jobs with the formal side of the economy ("*comprising regulated economic units and protected workers"*)[12]; the characteristics of labour employed on the informal side, for instance concerning education and skill; the characteristics of individuals and of their environment, deriving from gender, citizenship, age, household structures and incomes, etc.; the general and local government attitudes towards the irregular sector, as summarised, for instance, by their effects on the functioning of local labour market and active labour market policies, on income distribution, on business structure, on the attitudes towards tax compliance and, more generally, on the quality of the social capital; by the legal and normative infrastructure that rules welfare and the functioning of the economy.

Further sources of heterogeneity derive from the intrinsic nature of undeclared work: the borders between regular and irregular labour input are not clearly distinguishable. As a matter of fact, undeclared labour input actually derives not only from straight irregular jobs (whether primary or secondary) but also from formally regular ones, due to unreported working time with partial evasion of social security and tax duties. The importance of this so called *grey* labour input might also be envisaged as the result of a partial adaptation to policies tailored to contrast purely hidden jobs[13]. It is interesting to notice that two main implications derive from this latter point. First, accurate estimates of grey and irregular labour input as a whole necessarily require actual working time information and estimates. Secondly, it becomes increasingly inadequate to represent irregularity as a headcount binary variable, while continuous or k-way categorical variables would better satisfy this purpose.

Put into a historical perspective, according to some authors the heterogeneity of irregular work has accompanied in the last decades the loss of homogeneity registered in the formal side of the economy, particularly in the industrial and services workforce and working conditions. The literature on dualism and industrial districts[14] partly stresses these issues while analysing the substitution of solid vertical production processes with more fluid networks of horizontal activities. As a result, informal economy is intended as having reinforced such progress towards heterogeneity in working situations[15].

The presence of informality in working conditions across different segment of working population is associated (if it is observed as a whole) with a wide range of employment opportunities and channels of access. Nevertheless these are usually segmented according

[12] Chen (2007).

[13] On the relevance of grey labour input in Italy see the final report of the so called "Giovannini Commission" (MEF, 2011), and Isfol (2007b). See the huge work (mainly through empirical analysis) provided by Williams (e.g. Williams (2010)). See also, more recently, De Gregorio-Giordano (2014) who deal with false part-time contracts in Italy. Boeri *et al.* (2002) focused instead on the fading borders between irregularity and unemployment.

[14] See for instance the milestone provided by Berger *et al.* (1980).

[15] This view is proposed in Capecchi (1989).

to the status of the worker: for instance citizenship, gender, age or else. It is widely recognized that women and ethnic minorities are more likely concentrated in low-paid, unskilled segments of irregular labour market. As a result, specific groups tend to be confined in specific markets.

Furthermore, heterogeneity is also seen as the result of individual choices based on the perceived advantages and disadvantages of not being protected by welfare coverages. In some cases the income differences between formal and informal employment may be not large, and in some segments workers could earn more money in informal than in formal employment[16]. Households conditions might also influence this balance, since access to social security might be assured by at least one member of the household.

Other dimensions of heterogeneity are deemed to be dependent on the degree of penetration of workers organizations (such as trade unions) and on elements tied to technological and sector-specific aspects. In some activities (for instance garment, construction or hotels and restaurants) informal labour practices is recognized to be used with the purpose of compressing labour costs. In the garment industry this attitude might reflect a deliberate (and possibly in some case successful) effort to increase competitiveness in the face of international competition; in other industries where international competition is irrelevant, as in the construction industry, undeclared work solutions come at the expense of organized labour. In hotels and restaurants organized labour has never been very strong: hence, immigrant labour and associated informal labour practices were not needed originally to lower firms' labour costs.

Firm size - as measured for instance in terms of number of employees - is also relevant in disentangling heterogeneity, since informality is observable in large and small firms, in capital-intensive and labour intensive industries. Heterogeneity in undeclared work goes with heterogeneity of their employers: it is increasingly apparent that "*by no means all businesses working on an* off-the-books *basis are wholly underground enterprises*"[17]. Most of those firms have been identified as firms officially belonging to the formal side of the economy but conducting a part of their trades on an *off-the-books* way[18]: their size ranges from micro businesses to small and medium sized enterprises.

Furthermore, the undeclared work related to self-employment confirms the above picture and multiplies the range of undeclared activities. In the literature, irregular self-employment has been envisaged as a sort of spontaneous answer to overregulated markets[19]. This neo-liberal approach has nevertheless been put into discussion more recently as the attention has been addressed towards the actual condition of those who are classified in self-employment. The works dedicated to the analysis of "dependent self-employment" has recognized that formal self-employment often hides economic dependence and this applies more frequently to undeclared businesses[20].

[16] Williams *et al.* (2004).

[17] Williams (2004a) p. 6.

[18] Williams (2004b), Williams (2006).

[19] There is a huge amount of literature on the issue of dependent self-employment, that is reviving in this last years due to the widespread need to provide official statistics with suitable definitions of employment in order to properly follow the increase in self-employment. See OECD (2000), Steinmetz *et al.* (1989), Linder *et al.* (1990), Muehlberger *et al.* (2007), Kautonen *et al.* (2010).

[20] See ILO (2002). Williams (2004b) distinguishes the "*micro-entrepreneurs starting-up fledging business ventures and using such work as a start-up strategy and on the other hand the more established self-employed who are serial users of underground work*".

According to some authors, "*The emerging view is that the informal economy consists of various heterogeneous markets with different groups of individuals and firms engaged in a variety of informal activities, for diverse reasons and at varying pay/incomes*"[21], and there is a wide scope for avoiding stereotypes and "*evaluating critically the representation of underground economy in advanced economies as comprised of marginalized populations working* off the books *as employees for wholly or partially underground businesses under exploitative conditions*"[22]. The idea behind this approach is that the adoption of a "thin" reading of irregular work only concerns a very particular segment of irregular labour market, while disregarding the multiplicity of forms and motivations assumed by irregular employment. Many studies in the last twenty years confirmed this approach by providing evidence that undeclared work is not necessarily concentrated in the weakest areas of the labour market or in the most deprived regions. Their finding is that a large part of irregular work derives from formally employed people, usually living in affluent regions. Without denying the weakest part of irregular employment and the presence of unscrupulous employers, it has been realized that irregular work does not necessarily imply low-paid jobs in an exploitative context. This depends mainly on the sector of activity, on the technology endowments and on the degree of organization of employers.

The conclusion that is usually drawn is that undeclared work derives from a combination of a plurality of factors[23]: as a result individual causal factors alone do not provide useful explanations unless their interaction with local and environmental factors is appropriately taken into account. The causes and determinants of undeclared work are seen in particular as dependent on market relations (labour markets, goods and services markets and information markets), institutional relations (of citizens with public authorities and tax authorities), individual characteristics and other environmental factors[24]. The causes within the above-mentioned categories all lead to various manifestations of undeclared work. This approach is helpful in policy design, in order to specifically tackle this mix of factors and circumstances: in other words policy should be tailor-made while there seems to be no scope for any standard recipe[25].

2. The LFS-ADMIN integrated sample and the identification of irregular workers

2.1. The integrated sample

Since the 1990s ISTAT has been producing estimates of undeclared work for national accounts purposes based on the integration of statistical sources. What became known in

[21] Andrews *et al.* (2011, p.8).

[22] This position is clearly stated in Williams *et al.* (2004, p. 2).

[23] Pfau-Effinger (2009).

[24] Arezzo (2013) reads undeclared work through the lenses of the theories of social capital.

[25] See Mateman *et al.* (2001), Renooy *et al.* (2004) and, for a detailed overview of this approach, Williams *et al.* (2004). It is worth noticing that these findings stem from the special attention that, as early as 1998, the European Commission decided to dedicate to the causes and consequences of undeclared work in the EU and to the possible policies to counter the phenomenon. For this purpose, the Commission issued the Communication on Undeclared Work and financed several research activities.

the literature as the "Italian approach"[26] was based on the statistical integration at domain level of estimates derived from business and administrative sources (covering regular jobs) and from household surveys and census data (covering regular and undeclared employment), within an analytical framework coherent with the objective of insuring exhaustiveness within the production boundary defined by the system of national accounts (SNA2003). The conceptual framework, widely accepted at international level, was based on the idea that undeclared work is the key to reconcile at domain level the estimates provided by independent sources.

More recently, the progress in the use of administrative sources, and in particular the availability of nearly exhaustive individual information on regular jobs[27], paved the way for further innovations in this area, with a passage from macro to microdata integration. The new approach is founded on the statistical integration of the LFS microdata with those of the administrative sources that trace regular employment[28]. The general principle is to model for each individual in the integrated sample an estimate of her employment status and to flag it as undeclared where no validated administrative signals are available.

Italian LFS is a continuous survey with a yearly sample of more than 600 thousand interviews representative of individuals in the resident population[29]: it provides monthly and quarterly figures for the main aggregates and yearly figures at NUTS3 level[30]. The sampling design is rather complex, with two stages (municipalities are PSUs, households are FSUs), stratification of PSUs and rotation of FSUs[31]; within each NUTS3 domain, PSUs are selected with PPS sampling[32]. The sample is uniformly spread across all the weeks of the reference year: all territorial domains are represented in each month and in each of the four waves of the panel.

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[26] "*The ISTAT Analytical Framework relates the Non Observed Economy to the statistical problems to be addressed by national accountants so as to identify the origins of the lack of exhaustiveness and their impact on the statistical system*", OECD (2002, pag.42). More details are provided by Calzaroni (2000).

[27] The development of a linked employed-employee database by ISTAT has been of the utmost importance to spur the adoption of micro level statistical integration of survey and administrative sources.

[28] It has been developed and introduced to support the estimates of undeclared work at individual level in occasion of 2011 national accounts benchmark. Full details of the new approach are reported in AA.VV. (2015).

[29] Italian LFS survey is run within the legal framework set by the corresponding EU statistical regulations. The principal legal act is the Council Regulation (EC) No 577/98 (see the most recent quality report in Eurostat 2015). It should be reminded that although officially resident, permanent members of collective facilities (hospices, religious institutions, barracks, jails, etc.) are excluded from LFS. Non-residents comprise foreign citizens irregularly present in Italy, who are consequently not included in this analysis: notice that the rate of irregularity in this segments is very high. National accounts estimates on the contrary are exhaustive and cover the labour input of non-residents.

[30] NUTS3 level of the territorial units classification (last version is 2014) corresponds to the more than one hundred "province" in which Italy is actually split. This level is an estimation domain in LFS sampling design. Lower levels of territorial disaggregation, such as Lau1 (corresponding to NUTS4) and Lau2 (NUTS5), have not been considered here.

[31] Here PSUs and FSUs are the usual acronyms for primary and final sampling units. Households follow a 2-2-2 rotation scheme: they participate to the survey for two consecutive quarters, then they temporally exit from the sample for the following two quarters, and then come back in the sample for two quarters. This produces a 50% overlap of the sample between a quarter and the previous one and a 50% overlap between a quarter and the same quarter of the previous year. For details see Discenza *et al.* (2014) and Di Consiglio *et al.* (2014).

[32] PSUs are stratified according to the demographic size. Large municipalities are always included in the sample; the others are selected within each stratum with probability proportional to the size of the resident population.

The individual tax code is the key adopted for record linkage with ADMIN microdata[33]. The LFS sample weights are here used for modelling statistical integration, for running descriptive analyses on the integrated sample (further in this section), and in the analyses of unit level data (sections 3 and 4). The choice of a survey-weighted estimator in the logistic model considered in section 3 derives mainly from the complexity of the LFS sample design which make it most likely not ignorable. It is well known that maximum likelihood estimators become biased and inconsistent when the sampling design is informative[34]; nevertheless, the use of weighted estimators can result in substantial loss of efficiency which is expected to be larger the smaller is the sample size and the larger the variation of the sampling weights[35]. Actually, the LFS sample is quite large and the variability of sampling weights appears relatively restrained (cv=75%): it is largely determined by PSUs inclusion probabilities, while there is no evidence that the response variable – i.e. the nature of employment (regular vs. undeclared) - has noticeable influence on such probabilities. Despite the complexity of the LFS sample, several factors explain the strong equivalence which has been found between the results obtained from weighted and unweighted estimators: this evidence seems due to the structure and size of the LFS sample that contribute to smooth the effects due to the likely informative nature of the design.

LFS-ADMIN integration consisted in the estimate of the actual employment status for each record in the sample based on a statistical model aimed at reconciling the information independently gathered by LFS and ADMIN. Potential sources of incoherence may in fact derive from time-related and definitions-related issues. As concerns the former, it is well known that the employment status recorded by LFS for each individual is in fact referred to a particular week in the year (the "reference week"). On their part ADMIN data are a set made of several distinct sources[36] characterised by varying degrees of precision in detailing the characteristics – and namely the time profile – of actual labour input. Differences concern in particular their accuracy in detailing the dates of the employment status and in focussing the events taking place in LFS reference week: to simplify, ADMIN sources are usually very accurate for employees but less precise for self-employment.

As for definitions, the employment status recorded in LFS and ADMIN necessarily differs. LFS adheres to ILO standards: in principle it covers any kind of labour input, regular or irregular. On the contrary, ADMIN status is mostly referred to administrative

[33] This deterministic procedure of record linkage has been regarded as highly reliable and – given the time constraints – a lower priority has been given to the evaluation of linkage errors: of course, such aspects needs further attention to take properly into account the fact that for less than 5% of the individuals in LFS sample the tax code could not be validated through ISTAT Population register. In these cases the tax codes have been imputed based on the structural characteristics of the individual (*inter alia*, gender, age, territory, citizenship, LFS employment status). This choice has been driven by the need to consider the LFS as a whole, in order to adopt the original sample weights and to compare directly original LFS estimates with those of the integrated sample. The individuals with imputed tax code were not considered in the estimation of the parameters of the integration model described below. See AA.VV. (2015) for more details.

[34] See Pfeffermann (1993) and Skinner in Chambers *et al*. (2003, ch.6).

[35] Pfeffermann (1993), Chambers *et al*. (2003, ch. 6). See also Kish (1990).

[36] ADMIN data derive mainly from social security sources on employees of private enterprises in industry and services (INPS-EMENS), in recreation (ENPALS), agricolture (INPS-DMAG), of domestic personnel (INPS-Lavoratori domestici), of public administrations (INPDAP) and on self-employed such as collaborators (INPS-Gestione separata and INPS-Collaboratori professionali), owners in the business sectors (Sistema informativo ASIA-Indipendenti), and in agricolture (INPS-Autonomi agricoli). All these sources have been used as input to build the employment register (DB Occupazione) supporting ISTAT system of business registers (ASIA).

rules that do not necessarily match ILO standards: for instance, it only refers to labour input with formal traces and thus excludes by definition entirely undeclared jobs; furthermore it may include false positives.

Tackling reconciliation thus implies the adoption of methods to detect, measure and correct the biases affecting both sources: notably, the possible under-coverage of employment and particularly of secondary jobs by LFS[37], ADMIN over-coverage of regular jobs and ADMIN lack of coverage of irregular work [38]. By adopting source-dependent error models, the actual strength of the employment signals conveyed by each ADMIN source is evaluated through the comparison with LFS employment status[39]. This process is aimed at filtering ADMIN sources in order to render them homogeneous providers of signals concerning the actual employment status of the individual in the reference week. Given the validated ADMIN employment status, the probability of LFS employment under-coverage is predicted at individual level. Irregular jobs have finally been defined as employment spells unmatched in the reference week with validated ADMIN signals. The integrated dataset lists the jobs performed by the individuals in the LFS sample who are actually employed, with further details concerning the order of the job (whether primary, secondary, etc.), the regularity status, the economic activity (4-digit NACE), the number of weekly actually worked hours, the type of employment, the tasks and duties undertaken in the job[40], the business register data on the employer and the rest of LFS information collected through the survey questionnaire[41]. Integrated job data are thus combined with the personal characteristics of the worker and with the whole profile of his yearly ADMIN records[42]. Since the focus here is on employment, only the individuals in employment according to the integrated estimates[43] have been selected from LFS-ADMIN, by considering only their

[37] Boeri *et al.* (2002), for instance, affirm that a meaningful share of unemployed and inactive LFS respondents are actually employed in the informal sector. See AA.VV. (2015) for a deeper insight of this issue.

[38] ADMIN over-coverage is source dependent: the accuracy of the dating of actual labour input is the core issue. As a matter of fact, a lack of precision mainly affects the sources on self-employment. On the contrary, those on employees are usually very precise and report duration and dates of labour contracts. The probabilistic approach adopted for LFS-ADMIN integration is fully described in AA.VV. (2015) and it is inspired by the recent ESS literature on data integration. See also De Gregorio, Filipponi *et al.* (2014). Previous research by the ESSnet on data integration drove this approach: see also García Martínez (2011), Hochfellner (2011), Kuijvenhoven *et al.* (2011), Linder *et al.* (2012), Zhang (2012). Pavlopuolos *et al.* (2012) tackle the issue of the lack of a benchmark between survey and administrative data in the measurement in temporary employment. All these models face data integration as conditional probability estimates. Fuzzy variables techniques could also be explored to measure irregularity.

[39] It is assumed that P_k^R is the probability for the individual *k* in the LFS sample to have a "true" regular employment status (y_k^R=1) conditional to the values assumed by the auxiliary variables in ADMIN (A_k) and in LFS (S_k) and given the ADMIN employment status (a_k=1):

$$P_k^R = \Pr(y_k^R = 1 | a_k = 1, A_k, S_k)$$

Based on an estimate of P_k^R and on the LFS error model, individual predictions of irregular employment status undeclared to LFS are derived. See AAVV(2015) and De Gregorio, Filipponi *et al.* (2014).

[40] They are coded through ISCO nomenclature.

[41] In the case of irregular jobs, the information is derived mostly from the answers to the LFS questionnaire and eventually from their recent regular working history recorded in ADMIN. Statistical imputation (generally hot-deck donor imputation) is used for the LFS individuals rescued from employment under-coverage. See AA.VV. (2015) for further details.

[42] In perspective, ADMIN data can be organized longitudinally and individual regular histories can be used more efficiently to outline and detect irregularity.

[43] They include thus all the individuals in LFS sample who are in employment according to LFS plus the remaining individuals rescued throughout ADMIN signals and LFS under-coverage estimates.

primary job (be it regular or irregular)[44]: considering years 2010 and 2011 together, the total sub-sample consists of about 480.000 individuals, 48.000 of which with an irregular primary job[45].

2.2. Some descriptive evidence

Within the definition given in advance, in this framework undeclared work here refers only to "fully undeclared work" of resident population: both "partially undeclared work" (also called "under-declared work" as, for instance, a full-time employee officially registered as a part-time one) and fully undeclared work of non-resident population are not considered here.

The descriptive statistics reported in Table 1 derive from the use of the LFS-ADMIN integrated sample with the original LFS sampling weights. Given the assumptions concerning the deterministic nature of record linkage, ADMIN data and the results of the integration process can be regarded *de facto* as mere extensions of the LFS questionnaire.

LFS-ADMIN estimates for the whole period 2010-2011 confirm some expected characteristics of irregular employment already highlighted by other independent estimates[46]. The incidence of undeclared employment is estimated nearly 10% of total employment in the target population (Table 1). Higher rates can be found among women, foreign citizens (especially from EU countries), self-employed, young people, low education segments, South, and in agriculture, constructions, hotels and restaurants, households services. Other aspects stand out clearly: elderly people seem affected by higher rates, like low skilled professionals; the households structure and the role of the individual within the household both play a non-secondary role; the presence of other irregular workers in the household is also associated with larger irregularity rates.

[44] According to the ESA regulation, the primary job determines the characteristic of each employed, namely whether he is an employee or a self-employed, the sector in which he works and also the regular or irregular nature of the worker. This independently from the characteristics of any eventual secondary job.

[45] These individuals originate about 55 thousand secondary jobs, 8.000 of which correspond to irregular jobs. All these figures are very stable between 2010 and 2011.

[46] See for example ISTAT national accounts estimates (*La misura dell'occupazione non regolare nelle stime di contabilità nazionale*, http://www.istat.it/it/archivio/39522, or ISTAT. *L'economia sommersa e il lavoro non regolare*. Audizione del Presidente dell'Istituto nazionale di statistica presso le Commissioni riunite V Commissione "Programmazione economica, bilancio" del Senato e V Commissione "Bilancio" della Camera, 21 July 2005). See also Cappariello *et al.* (2009).

Table 1. Indicators of undeclared work by segment. Two-year 2010-2011 (%)

Segment	Rate (a)	Share on total(b)
TOTAL	9.8	100.0
GENDER: Men	9.0	53.9
GENDER: Women	11.0	46.1
MARITAL STATUS: Unmarried	13.0	41.5
MARITAL STATUS: Divorced or widow	11.5	9.1
CITIZENSHIP: EU	21.7	6.4
CITIZENSHIP: Extra EU	18.0	10.9
AGE: 15-24 yrs.	21.3	12.0
AGE: 55-64 yrs.	23.2	3.8
AGE: 65 yrs. or more	36.7	1.0
ISCED: Primary education or less (ISCED 0&1)	19.7	11.6
ISCED: Lower secondary education (ISCED 2)	11.1	34.9
HOUSEHOLD: Single	13.7	16.5
HOUSEHOLD: Child, with both parents	14.6	19.4
HOUSEHOLD: Child, with single parent	13.0	5.5
HOUSEHOLD: Presence of irregular job holders	17.9	13.4
NACE: Agricolture	21.6	8.9
NACE: Construction	12.8	10.8
NACE: Hotel and restaurants	16.1	8.4
NACE: Recreation	25.8	3.3
NACE: Other households services	21.5	6.4
NACE: Households as employers	29.8	8.4
NUTS1: South & Islands	15.7	45.5
NUTS2: Campania	19.5	14.5
NUTS2: Calabria	19.8	5.3
NUTS2: Sicilia	15.1	9.9
TYPE OF EMPLOYMENT: Self-employed	12.8	35.3
ISCO: Skilled agricultural workers (ISCO 6)	15.8	3.7
ISCO: Elementary occupations (ISCO 9)	19.7	19.6

Source: LFS-ADMIN, Two-year 2010-2011

(a) Undeclared employment as percentage of total employment in the segment.

(b) Undeclared employment in the segment as percentage of total undeclared employment.

From statistical integration do emerge further characteristics of undeclared workers: for instance, it is important to notice that they are frequently traced in ADMIN during the reference year though not in the reference week. In other words, such traces are not compatible with any coverage in the reference week of LFS interview but anyway characterize the working activity of the individual in other parts of the year. This seems to imply some switching from regularity, suggesting again that the treatment of undeclared

work should be followed through continuous or at least multi-modal variables[47]: this point is also supported by the circumstance that an important share of undeclared workers reports to the LFS to be working in large local units[48]. These aspects open the way for specific analyses dedicated to undeclared outsourcing of services by larger enterprises. Furthermore, irregular jobs are also associated with lower actually worked hours (about 14% less than regular ones): nevertheless such difference is tiny in segments marked by a higher incidence of irregular jobs. This appears another promising subject for further research. Although the well-known stereotypes of irregularity are evidently confirmed, the integrated sample confirms also that heterogeneity lays behind them[49]. Irregularity is spread across many segments of the labour market, although with different intensities, and this basic fact deserves a special focus in order to target the analysis and support policy.

3. Modelling the probability of being an undeclared worker

The probability for a person in employment to work undeclared can be analysed from different perspectives. In this section, the individual characteristics (such as age, gender, household, citizenship, etc.) have been primarily used as independent variables: other variables have been progressively introduced to summarize local context effects.

A battery of NUTS3 (i.e. province) level labour market indicators is used to monitor the effects induced by actual local market and active policy conditions on individual profiles: the activity and unemployment rates, the contact rate with public or private job centers[50], the coexistence rates of the so called *grey area* with official labour force and of potential employment[51] and with total employment[52]. For Italian LFS the NUTS3 coefficients of variation for the unemployment rate ranged from 3.7 to 30.8 in 2011[53], with a median of 10.2% and 5th and 95th percentiles respectively equal to 5.1 and 18.8%[54].

A proxy of the local attitudes towards tax compliance was adopted, based on the

[47] Such evidence might encourage the adoption of a fuzzy variable approach to target irregularity. This approach has been for instance already adopted for the analysis of poverty (see Betti *et al.* 2009). For a general overview of fuzzy variables see, *inter alia*, Colubi *et al.* (2007).

[48] The afore mentioned "Commissione Giovannini" strongly emphasised the need to provide sound estimates of the so called *grey area* of undeclared work.

[49] This point is also stressed in the contribution of Cappariello *et al.* (2009).

[50] This rate is computed as the share of unemployed and *grey area* inactive population (willing to work but who don't search actively or who are not immediately available for starting a new job) that contact job centers in the weeks before the LFS interview. The idea behind this choice is that a higher use of official channels is an indicator of active policy concern and marks an antibody against informal jobs.

[51] As defined by the sum of unemployed and *grey area*.

[52] These indicators have been derived for total population aged 15-64 years and for younger population (15-34 years), separately by gender. The contact rate has been derived only for population 15-64 by gender. In order to avoid the drawbacks of the strong correlation among these indicators, their first three principal components, estimated by gender, were also used. The principal components were extracted, separately by gender, from a dataset of 110 NUTS3 indicators without weighting. The first one (85% of total inertia) expresses the general quality of the local labour markets: high activity rates and relatively strong active policies as opposed to unemployment and grey area. The second one (8%) gathers the effects of official placement facilities in moving potential labour force from inactivity to unemployment. The third factor (3%) describes the intensity of official placement non accompanied by evident effects.

[53] Eurostat (2015), ch.9.

[54] These latter data are derived from ISTAT Information System on Quality (SIQual, http://www.istat.it/en/tools/data-quality) and are referred to 2006 data.

partition of the NUTS3 levels into eight clusters provided in the DBGEO database developed by the Italian tax authority[55]. The effects of the employment structure of local regular business have been summarized with sector and firm size indicators by gender, all derived from the integrated sample. Finally, a last set of input variables concerning the actual job of the individual - Nace and type of employment (employee or self-employed) – has been used to introduce the demand side of the irregular labour market.

By using the nature of employment - whether regular or undeclared - as the response variable, a logistic model (1) has been run to estimate the probability of undeclared work in function of the above mentioned sets of variables. Several specifications have been tried, changing the sets of variables, the interactions and the model groups[56]. What follows is the general simple effect version:

$$logit(IRR_{i(gk)}) = \alpha + P'_{i(gk)}\beta + X'_{(gk)}\gamma + W'_{i(gk)}\lambda \qquad (1)$$

where *i*, *g* and *k* stand for the individual *i*, resident in the *k*-th NUTS3 and whose gender is *g*; *IRR* is the binary response variable; *P* summarizes social and demographic characteristics of each individual; *X* are the local indicators on labour market, tax compliance and business structure; finally *W* labels the variables describing the actual primary job of each individual.

Employment is generally characterized by gender differences, for example, in participation, skills, earnings, types of work and working conditions[57]. Gender is here considered as an element of heterogeneity of undeclared work as well[58]: so, as an alternative to including gender into the model as a dummy variable including its interactions with other predictors, it has been preferred the adoption of two distinct models, one for females and one for males, in order to investigate different aspects of the gender dimension of undeclared work.

Three simple effects models were run separately on the two genders, and some results are reported hereafter: model A uses only *P* variables, model B introduces the *X* set and model C adds *W* variables. All three models appear to fit the data well, with increasing scores from model A to model C: for instance, for both model groups the concordance ratio ranges from about 67-68% to 73-74%[59]. Both groups show that foreign citizens have a higher probability of being in irregular employment: within this segment, EU citizens have a far larger risk of being

[55] The clustering is based on variables concerning tax behavior, criminality, consumption patterns, business structure, technological development, transport infrastructure, characteristics of taxpayers (see for more details "*Indagine conoscitiva sugli organismi della fiscalità e sul rapporto tra contribuenti e fisco*", Audizione del direttore dell'Agenzia delle entrate, Senato della Repubblica, VI Commissione finanze e Tesoro, Rome, 2 aprile 2014.). A first cluster, labelled *All right*, joins a high life standard with appreciable tax compliance; *the Equilibrist*, groups small NUTS3 with medium living standard and tax compliance; *the Industrial* gathers industrial territories relatively compliant; *Metropolis* are the urban areas with medium-high tax evasion; *Nothing to declare* are small NUTS3 with tax non-compliance and low wealth; *Not angels* are areas with critical compliance and medium-low living standard; *Risky habits* are weak local economies, with criminality and medium compliance; *Total risk* characterized by very low compliance and very low living standards.

[56] The main results obtained throughout alternative specifications do not differ substantially. Models with weighted and unweighted observations have also been tested, without appreciable differences. All the data reported in this work derive from the use of weighted observations.

[57] World bank (2012).

[58] Renooy *et al*.(2004), Capecchi (1989).

[59] See the tables A.1-A.3 in the Appendix for details on model fit and estimates.

irregular with an odds ratio in model A larger than 1.4 points as compared to the rest of foreigners. This difference somehow reduces as context and job effects are introduced: in model C the ratio drastically decreases - although only for males[60] - remarking the importance of the demand side factors. Age appears characterized by some symmetry: the probability of being irregular grows as the distance from central age classes increases, especially for elder males. It's worth noticing that for young people age and household effects add up, given the higher odds associated to individuals living with parents. Some differences between genders do emerge if the effect of household structure is accounted for. Men living alone have a relatively higher probability of undeclared work, with an odds ratio that doubles that of adults living with a partner and a son (the benchmark less "at risk of irregularity"). The corresponding odds ratio for women is far lower and this might be due to the conditions laying behind the choice of living alone[61]. Another class with a higher irregularity risk is the class of single parents living with sons; here the odds nearly double the benchmark. Household income is also important in determining the risk of irregularity: the presence of another income earner operates quite differently according to whether this additional income is regular (slightly lower risk) or irregular (much higher risk). A low education attainment is confirmed to be a crucially risky condition, even harder for women. It is interesting to notice that, in the case of men, the possession of a university degree puts the individual more at risk as compared to an intermediate level of education (such as the completion of secondary schools)[62].

Labour market conditions seem to operate differently by gender. The risk of irregularity for men increases more rapidly as labour market weakens. But as for women, active labour market policies when associated to high unemployment rates may partially translate into a higher participation in the irregular side of the market. This does not seem to be the case for men, for whom higher contact rates with job centers reduce the risk of irregularity. Tax compliance attitudes cope well with explaining undeclared work for both genders, in particular when territories are included in the *Total risk* cluster. The effect associated with the structure of regular business deserves some attention. For males, the higher the relative weight (in terms of regular employees) of "risky" sectors such as agriculture and construction, the lower the probability of being employed in undeclared jobs: this might be connected with the emersion of previously undeclared activities, as a likely reaction to policies aimed at fighting this phenomenon[63]. On the contrary, the relative weight of regular employees in households services and in microenterprises seems related to higher irregularity risks.

The introduction into the analysis of details on the characteristics of the irregular jobs brings into light other gender differences. While in general self-employed are more at-risk-of-irregularity, such effect is much stronger for men. Let alone jobs in agriculture, whose odds are more than twice those of industry, higher risks are run by women in household services and by men in construction and trade. Finally, while industry is the less risky sector for men, this is not so for women.

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[60] See the table A.4 for significance tests on the differences in estimates of logistic model coefficients by gender.

[61] It should be noticed that the household here described derives from administrative population registers, and might not coincide with the actual "economic household".

[62] This aspect, however, needs further analysis in order to explain why the same is not found for women: a possible answer can be drawn from the fact that the introduction of context factors reduces this unexpected difference, and this could be interpreted as a sign of the weakness of local markets and policies to meet this segment of labour supply.

[63] This effect does not seem anyway to be at work for women.

Considering as benchmark one of the most virtuous profiles (profile 1: a middle-aged highly educated male in a household with a regularly employed wife and at least two sons. See Table 2), model A predicts for him a 4.2% probability of being undeclared. Should his ISCED level be the lowest one, his probability would increase by 1.3 p.p. and by further 1.7 p.p. if his wife would not work. In the same situation a woman is predicted to start 2.2 p.p. higher in profile 1, and her probability would jump up more rapidly if she had a low education and no income from her husband. The same individuals, living single and with a low ISCED, would both show about 12% probability of being irregular. If they were EU citizens, the predicted probability would more than double.

Profile 2 describes a young individual living with both parents in a household with at least one regular income: his predicted probability goes near to 20% and near 30% if she was a girl. Both probabilities are over respectively 30% and 40% if the household income was irregular. A higher ISCED would reduce both probabilities and the gender distance. But if profile 2 was an EU citizen the predictions would double. A foreigner living single with a low ISCED and an age between 25 and 34 years (profile 3) has between 25% and 33% probability of being irregularly employed.

A middle-aged parent living alone with at least two "not-income-earner" sons (profile 4) has almost 10% probability of being irregular, 13% if woman, 28% if woman and EU citizen and more than 20% if Extra EU. A slightly higher ISCED level would cut the prediction. Profile 5 describes what happens to the son if his parent is not an income earner: if male, his prediction would be 26%, 37% if his parent was an irregular himself and respectively 32% and 45% if female.

The adoption of model B and C introduce variability in these profiles. The prediction for male in profile 1 ranges from 2% to 11% if context factors are introduced and its maximum peaks 19% with model C predictions; for women the right tail of the distribution is prolonged. In general, the distribution of prediction is strongly skewed for the more virtuous profiles. The predicted probability of profile 2 for women ranges from 16% to 52% if context factors are accounted for, and may pass 70% if the type of job is considered: the same profile for men has a maximum ten point lower. Local factors generate heterogeneity also within segments apparently protected against the risk of irregularity.

An appropriate evaluation of these results needs a consideration of the error associated to the integration model[64]. Furthermore, it must be kept firmly into consideration the fact that the observed population does not include those foreign citizens whose presence in Italian territory is not regular. Those people are by definition also irregular workers, but their structural characteristics are rather peculiar in terms of age, citizenship, gender, skill, education even if compared with those of the foreigners who are instead regularly present in Italy. For this reason, our results can hardly be generalized to this segment of the present population.

[64] De Gregorio, Filipponi *et al.* (2014) moved some steps forward in this direction following the developments of the ESSnet on Data integration. See also García Martínez (2011), Hochfellner (2011), Kuijvenhoven *et al.* (2011), Linder *et al.* (2012), Pavlopuolos *et al.* (2012), Zhang (2012). Replication techniques and bootstrapping have been used by De Gregorio, Filipponi *et al.* (2014) in order to validate these estimates of irregular labour input for national accounts purposes: they provided encouraging results (see also as a references Wolter 2007, Kuijvenhoven *et al.* 2011).

Table 2. Predicted probability of being in undeclared employment, by gender, profile and model (%)

Profile	Age	Role and household structure	ISCED	Other incomes	Male					Female				
					A	B		C		A	B		C	
						min	max	min	max		min	max	min	max
										ITALIAN				
1	35-54	Spouse (2 Parents & ≥2 sons)	5	REG	4.2	2.0	11.3	1.6	19.1	6.4	2.8	14.9	1.8	29.5
1.1	35-54	Spouse (2 Parents & ≥2 sons)	2	REG	5.5	2.6	14.3	1.9	22.9	10.0	4.5	22.2	2.8	40.5
1.2	35-54	Spouse (2 Parents & ≥2 sons)	2	none	7.2	2.7	14.7	2.0	23.6	12.9	4.8	23.6	3.7	41.0
1.3	35-54	Single	2	none	12.1	5.9	27.9	4.4	40.7	12.7	5.6	26.7	3.8	47.2
2	15-24	Son (2 Parents & ≥2 sons)	2	REG	19.2	9.6	39.8	7.5	50.6	29.8	15.7	51.8	11.8	70.0
2.1	15-24	Son (2 Parents & ≥2 sons)	2	IRREG	35.3	15.3	52.0	11.6	63.5	48.6	32.2	62.7	26.4	73.9
2.2	15-24	Son (2 Parents & ≥2 sons)	5	REG	15.3	7.5	33.6	6.1	45.4	20.8	9.7	39.6	7.6	66.5
2.3	25-34	Son (2 Parents & ≥2 sons)	2	REG	13.4	6.3	29.4	4.9	38.9	19.4	10.2	36.7	7.2	59.7
4	35-54	Parent (1 Parent & ≥2 sons)	2	none	9.6	4.2	21.3	3.6	28.0	13.0	5.3	25.7	4.1	45.2
4.1	35-54	Parent (1 Parent & ≥2 sons)	3-Apr	none	5.4	2.8	12.4	2.5	16.8	8.0	3.8	17.8	2.5	25.7
5	15-24	Son (1 Parent & ≥2 sons)	2	none	25.7	11.9	44.1	9.2	54.6	32.4	17.8	49.6	13.9	65.9
5.1	15-24	Son (1 Parent & ≥2 sons)	2	IRREG	37.3	17.3	52.8	14.2	58.0	44.6	27.7	58.1	21.9	63.1

Profile	Age	Role and household structure	ISCED	Other incomes	Male					Female				
					A	B		C		A	B		C	
						min	max	min	max		min	max	min	max
										EU				
1	35-54	Spouse (2 Parents & ≥2 sons)	5	REG	10.5	6.0	25.3	4.4	33.1	15.1	7.3	31.4	5.8	37.3
1.3	35-54	Single	2	none	26.8	16.2	52.9	11.9	60.2	27.3	16.8	48.8	11.3	63.3
2	15-24	Son (2 Parents & ≥2 sons)	2	REG	38.7	25.5	49.6	18.8	52.1	52.3	39.6	70.8	34.8	76.3
3	25-34	Single	2	none	31.4	19.7	58.7	15.1	65.5	33.2	21.1	55.9	15.2	70.5
4	35-54	Parent (1 Parent & ≥2 sons)	2	none						27.9	18.1	40.4	12.7	41.8
										EXTRA EU				
1	35-54	Spouse (2 Parents & ≥2 sons)	5	REG	7.3	4.8	21.7	3.7	27.8	11.2	5.9	25.9	3.9	27.2
1.3	35-54	Single	2	none	19.7	13.2	48.6	10.4	61.2	20.9	11.5	42.8	9.0	60.5
2	15-24	Son (2 Parents & ≥2 sons)	2	REG	29.7	20.6	59.1	17.1	65.1	43.6	27.6	67.2	22.4	67.2
3	25-34	Single	2	none	23.5	15.2	52.8	11.9	65.5	26.0	17.0	50.1	12.5	68.6
4	35-54	Parent (1 Parent & ≥2 sons)	2	none						21.4	12.8	34.9	9.8	41.5

Source: LFS-ADMIN, years 2010-2011

4. A segmentation of undeclared employment

The individuals in LFS-ADMIN with an irregular primary job have been analysed by means of a sequential use of correspondence analysis (MCA) and Ward hierarchical clustering[65]: the focus now is more strictly on the irregular job and on the sector specific features related to the use of undeclared labour input. The variables used in the analysis are those included in the sets *P* and *W* mentioned above: further variables from individual ADMIN traces have been added to *W*, scaled according to the intensity of ADMIN signals[66].

With nearly 50 variables and 150 modalities the first ten eigenvalues accounted for about 40% of total inertia[67]. Better results were obtained by replying separate sector analyses, although the structure of the data base, as revealed by the first components, appears relatively stable if MCA is separately run by economic activity. The results from the overall sample are reported hereafter. In general, the first component (6.5% of total inertia) opposes two poles that could be summarized as "*unskilled blue collars*" vs. "*skilled self-employed*"[68]. The second component (5.8%) offers a further distinction somehow specular as compared to the first one: "*skilled white collars*" vs. "*low education self-employees*"[69]. The third component (4.6%) opposes the activities of "*foreign women*" vs. "*aged & skilled craft workers*".

Ward clustering on the first ten MCA components delivers a tentative classification of irregular employment: the description of a nine cluster partition is reported in Table 3. Such partition explains more than 64% of total inertia. Construction and household services show a specialisation in cluster 3 (the largest), characterised by low skill part-time employee jobs: it sounds reasonable to find in this cluster a relatively strong presence of residents in EU countries. Construction is also represented in cluster 8, where more skilled craft professions are included and where also industry and trade have a meaningful presence: in this segment young people and foreign workers from central and northern regions are relatively more frequent. Industry itself is strongly present in cluster 9 where employees have intermediate skill levels and are more frequently partially traced in the annual ADMIN: northern regions and EU residents have some ties with this group.

Agriculture has two main specialisations. Employees of this sector feed the cluster of older, low education and low skill workforce (cluster 6): South and foreign residents describe well the segment. A very low education score although accompanied by high skill professional levels, draws cluster 4 where agriculture self-employment has a stronghold:

[65] Fuzzy clustering could eventually be explored in order to take account of the above mentioned fuzziness of the concept of irregularity.

[66] The net monthly income declared to LFS, the hours actually and normally worked, the number of secondary jobs have been used as illustrative variables.

[67] Given the large number of variables and modalities, and as a consequence given the high number of eigenvalues of MCA, the share of explained inertia is relatively appreciable. Low explained inertia does not mean that the analysis is not valid, but it does mean that extra care should be eventually taken in interpreting the plot. A reevaluation technique might be applicable anyway.

[68] On one side, foreigners, young men, employees, low education, elementary profession, full-time; on the other, self-employed, professionals and entrepreneurs, central age classes, higher education, part-timers, also women, with extremely weak ADMIN traces.

[69] On one side, young women, with medium-high education, clerical workers, northern and central regions, with ADMIN traces; on the other, self-employed skilled workers, with low education, aged, men, Italians

they are relatively old and mostly Italians and from the South. Self-employment in trade activities is also well represented in this cluster and in cluster 1 (alike business services), where education level is higher and where central and northern regions and male employment have a relatively higher presence.

Cluster 5 shows a meaningful presence of persons employed in the business and household services: this cluster appears somehow between employee jobs and self-employment. Individuals are quite young, with a high education and they are engaged in medium-high skilled professions. They are mostly Italians from central and northern areas, and women are relatively more present. This cluster has much in common with cluster 2, where household services (mainly recreation and health services) have an appreciable specialisation: in this case, high education is combined with high skill employee jobs and older individuals.

The connection between the individual characteristics of irregularity with the individual traces present in ADMIN sources (that belong to the regular side of the market) suggests a deeper scrutiny. On the one side, the flows from regularity to irregularity (and vice versa) can be deemed as strongly dependent on the nature of individual labour market "stories" (quality, experience, age). On the other side the patterns of irregularity look somehow ADMIN-dependent in the sense that they seem to have been moulded by sector specific habits and needs and by local influences.

Table 3. Clusters of individuals in undeclared employment, by NACE, gender, age and citizenship *(% distrib. and specialization rates by segment)*

Cluster	Short description	Distr.	Specialization rates											
				NACE										
			Total	Agriculture	Industry	Construction	Trade Horeca	Business services	Household services	Women	Young 15-34	EU	Extra EU	South
1	Self employees, Very weak ADMIN, Italians	7.8	100	29.4	98.0	109.8	164.5	150.2	46.9	77.3	58.8	16.9	26.5	84.2
2	High education, Large units, White collars, High skill, Weak ADMIN	9.6	100	12.8	35.8	15.5	25.8	128.0	213.5	115.4	66.8	31.4	16.7	91.0
3	Employees, No ADMIN traces, Part-time, Low skill, Low education	28.8	100	65.1	85.8	117.8	98.6	81.0	121.7	105.2	103.3	141.7	100.4	106.0
4	Self-employed, ADMIN traces, Aged, Italians, Low education, High skill	9.6	100	268.0	49.5	98.4	157.7	98.1	36.1	87.8	61.4	14.6	46.5	127.9
5	Young, unmarried, high edu., medium-high skill, Italians, weak ADMIN	5.4	100	9.7	71.1	30.4	67.7	188.0	133.3	117.6	169.5	21.6	24.3	69.2
6	Employees, Elementary occ., Low edu., South, Parents, Weak ADMIN	6.6	100	757.4	60.1	39.1	57.0	30.8	14.9	80.2	86.9	135.0	135.2	167.3
7	Female, Foreigners, weak ADMIN, Single, part-time	3.7	100	9.2	8.2	11.8	18.3	15.7	294.8	181.4	70.6	353.8	484.3	56.3
8	Weak ADMIN, Blue collars, Craft, Male, Med.-young, Low edu.	11.0	100	21.1	146.5	209.2	136.2	99.3	43.9	73.0	148.4	138.7	138.2	92.1
9	Blue collars, traces in ADMIN, Some skill	17.6	100	46.2	199.6	108.1	102.2	100.6	69.0	99.1	105.5	94.0	120.1	92.1
	Total	100	100	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: LFS-ADMIN, Two-year 2010-2011

Concluding remarks

The availability of household survey microdata is essential for disentangling the complexity of undeclared employment. The main challenge is represented by the micro-level indirect detection of irregular job holders and by the correction of the under-coverage associated with the latent nature of the phenomenon. The statistical integration of large survey sample microdata with administrative records is a promising approach since the individual flagging of irregularity can be combined with the treatment of employment status biases.

This work tests the possibilities offered by the integrated LFS-ADMIN sample developed by ISTAT to support national accounts benchmark estimates. The descriptive analyses seem to confirm the results derived from previous research adding more details on irregular employment, especially with reference to the heterogeneous characteristics of individuals and of their environment. A measurement of the effect of those characteristics on the probability of being in undeclared employment highlights the relevance of factors that appear connected with weaker individual positions in the labour market. These factors seem strongly dependent on local conditions, so that the same individual profile may be characterised by quite different probabilities of being undeclared according to whether the local labour markets are or are not endowed with appreciable inclusion capabilities: huge inactivity rates, large *grey areas* and scarcity of efficient policy actions are all presumably associated with a higher probability of being irregular. It seems that the local economic environment actually plays an important role: low tax compliance and a higher weight of very small firms offer larger room for undeclared work. This aspect and the causal links need further investigation based on tailored methodological approaches.

The segmentation of undeclared employment shows how heterogeneous is the combination of labour supply conditions with actual labour demand. This evidence gives the possibility to appreciate the coexistence of different models of irregularity obtained by combining sector and socio-economic conditions that reveal quite reasonable specialisation patterns. Such results would suggest the need to adopt coordinated approaches to contrast irregularity, based on active policies and where local conditions should receive greater attention. Although these suggestions need further assessment, they seem to confirm the results of previous researches on this subject, especially those conducted more recently and spurred by the European Commission. In particular, Italian results clearly identify the heterogeneous nature of undeclared work and help to reject any stereotyped view as a fully marginalised segment of the labour market. Nevertheless, they confirm also that such heterogeneity derives mainly from the interaction of labour demand with local labour market performances, while the weakness of the conditions of irregular labour supply (education, age, gender, skills, household conditions) accompany the large part of the individuals on this side of the market. For this reason, these results also evidence that there is a large scope for policies, in order to recover locally the human and social capital lost in undeclared activities.

Though encouraging, the approach based on statistical integration of independent sources also deserves some further deepening under several profiles: they mainly concern definitions and methodological issues. The boundaries of irregularity need in particular to be accurately scrutinised. In the developments shown here, undeclared employment corresponds to work that is not traced in any administrative register: that may include also activities that simply are not subject to any administrative obligation (as for example it may happen for very small scale self-employment in agriculture). Furthermore, implicit in LFS-

ADMIN there is the hypothesis that the LFS records only legal businesses, although possibly undeclared: this assumption needs to be verified, with the help of the advancement that are taking place in the measurement of illegal economy. The most important definitional issue has anyway to do with the need to fully consider the grey economy within the context of irregularity analysis. This aspect seems extremely relevant under the economic point of view: its measurement involves progresses in the estimates of actual working time both from households and business statistics sides[70].

The methodological aspects are those who appear more promising, both for the statistical integration process and for the analysis of irregularity. The approach actually based on logistic regression might exploit further advancements in this area and in particular moving from traditional statistical analysis to causal analysis of multivariate data in particular for the evaluation of the efficacy of labour market active policies. For the same purpose, propensity score matching approaches might be worth to be tested. The use of more sophisticated approaches based on logistic regression could also be tested in order to face more properly the events associated with measurement error in covariates.

Future research involves in the near future a refinement in the shaping of the LFS-ADMIN sample through the enlargement of the set of ADMIN sources to those concerning income and tax registers: this perspective appears extremely appealing in order to provide income and labour input estimates in a same methodological environment. In the medium term, developments should be aimed at a more efficient use of ADMIN data to improve the breakdown of estimates, for instance through approaches based on small area estimations. A quite challenging research activity, starting from LFS-ADMIN integration, could be oriented to the analysis of the interactions between regular and irregular side of the labour market at local level. Finally, an entirely new approach would consider the idea of turning upside-down the logic behind LFS-ADMIN: passing from the integrated LFS-ADMIN sample to the exploitation of LFS-ADMIN inference in order to make a deeper use of the information in the whole set of ADMIN data, which cover the universe of the formally regular jobs the present population is engaged in.

[70] Baldi *et al*. (2013).

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Appendix

Table A.1. Model fit statistics of the logistic regression, by model and model group

Model Fit Statistics	MALE				FEMALE			
	No Intercept	Model A	Model B	Model C	No Intercept	Model A	Model B	Model C
AIC	164,651	154,984	149,197	147,402	137,044	129,536	125,611	122,890
SC	164,662	155,245	149,626	147,893	137,044	129,789	126,026	123,366
-2 Log L	164,649	154,934	149,115	147,308	137,044	129,486	125,529	122,796
Chi-square test (a)								
Likelihood Ratio		9,716	15,534	17,342		7,557	11,514	14,246
Score		11,082	17,161	19,003		8,841	12,985	15,675
Wald		9,789	14,590	15,935		7,722	11,026	13,090
Other model fit statistics								
Percent Concordant		67.0	72.2	73.4		65.9	70.5	72.8
Percent Discordant		31	26.9	25.9		32.2	28.7	26.5
Percent Tied		2	0.8	0.8		1.9	0.8	0.7
Pairs		5.85E+09	5.85E+09	5.85E+09		3.68E+09	3.68E+09	3.68E+09
Somers' D		0.36	0.453	0.475		0.337	0.417	0.462
Gamma		0.367	0.457	0.478		0.343	0.42	0.466
Tau-a		0.063	0.079	0.083		0.071	0.088	0.098
C		0.68	0.726	0.737		0.668	0.709	0.731

(a) All test statistics have a probability less than 0.0001. The degrees of freedom are 24 for model A, 41 for model B and 47 for model C.

Table A.2. Test statistics for logistic regression variables, by model and model group

		MALE			FEMALE		
Effect	DF	Model A	Model B	Model C	Model A	Model B	Model C
CITIZENSHIP	**2**	**<.0001**	**<.0001**	**<.0001**	**<.0001**	**<.0001**	**<.0001**
AGE CLASS	5	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
HOUSEHOLD STRUCTURE AND ROLE	1	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
EDUCATION	4	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
OTHER HOUSEHOLD REGULAR INCOMES	1	<.0001	0.060	0.016	<.0001	0.000	<.0001
OTHER HOUSEHOLD IRREGULAR INCOMES	1	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
LABOUR MARKET (by Gender) Fact.1 (a)	1		<.0001	<.0001		<.0001	<.0001
LABOUR MARKET (by Gender) Fact.2 (b)	1		0.501	0.514		0.043	0.025
LABOUR MARKET (by Gender) Fact.3 (c)	1		0.000	0.000		0.999	0.690
DBGEO PARTITION	7		<.0001	<.0001		<.0001	<.0001
REGULAR EMPLOYMENT STRUCTURE (by Gender) Agricolture	1		0.613	<.0001		<.0001	<.0001
REGULAR EMPLOYMENT STRUCTURE (by Gender) Construction	1		0.005	0.000		0.218	0.133
REGULAR EMPLOYMENT STRUCTURE (by Gender) Trade	1		0.551	0.844		<.0001	<.0001
REGULAR EMPLOYMENT STRUCTURE (by Gender) Business services	1		0.061	0.204		<.0001	<.0001
REGULAR EMPLOYMENT STRUCTURE (by Gender) Household services	1		<.0001	<.0001		<.0001	<.0001
SHARE OF EMPLOYMENT IN MICROENTERPRISES	1		0.000	0.001		0.525	0.891
TYPE OF JOB (Employee/Self-employed)	1			0.000			<.0001
IRREGULAR JOB NACE CODE	5			<.0001			<.0001

(a) Unemployment, inactivity and grey area vs. virtuous labour market.

(b) Unempoloyment and placement vs. grey area.

(c) Placement.

Table A.3. Parameter estimates, by model and model group

		MALE						FEMALE					
		Model A		Model B		Model C		Model A		Model B		Model C	
Variables	Modalities	Est.	St.Err. Pr.	Est.	St.Err. Pr.	Est.	St.Err. Pr.	Est.	St.Err. Pr.	Est.	St.Err. Pr.	Est.	St.Err. Pr.
Intercept		-0.961	(0.0228) ***	-1.458	(0.1206) ***	-1.182	(0.1217) ***	-0.605	(0.027) ***	-2.006	(0.1659) ***	-1.743	(0.1686) ***
CITIZENSHIP (ref=Extra EU)	Italian	-0.519	(0.0149) ***	-0.675	(0.0155) ***	-0.644	(0.0158) ***	-0.517	(0.0146) ***	-0.596	(0.0151) ***	-0.607	(0.0155) ***
	EU	0.459	(0.0236) ***	0.458	(0.0242) ***	0.398	(0.0245) ***	0.433	(0.0213) ***	0.414	(0.0218) ***	0.413	(0.022) ***
AGE (ref=75+)	15-24	-0.068	(0.0267) *	-0.119	(0.0271) ***	-0.057	(0.0278) *	0.098	(0.0333) **	0.103	(0.0338) **	0.327	(0.0345) ***
	25-34	-0.492	(0.0188) ***	-0.583	(0.0192) ***	-0.517	(0.0196) ***	-0.467	(0.0252) ***	-0.513	(0.0255) ***	-0.346	(0.026) ***
	35-54	-0.716	(0.016) ***	-0.748	(0.0162) ***	-0.703	(0.0165) ***	-0.748	(0.0232) ***	-0.797	(0.0235) ***	-0.699	(0.024) ***
	55-64	-0.363	(0.0195) ***	-0.451	(0.0199) ***	-0.475	(0.0201) ***	-0.450	(0.0262) ***	-0.541	(0.0266) ***	-0.535	(0.0271) ***
	65-74	0.534	(0.0282) ***	0.621	(0.0286) ***	0.563	(0.0293) ***	0.417	(0.0436) ***	0.468	(0.0441) ***	0.232	(0.0448) ***
HOUSEHOLD (ref=Other)	Single	0.221	(0.0235) ***	0.333	(0.0241) ***	0.317	(0.0243) ***	-0.088	(0.0269) **	0.024	(0.0274) n.s.	0.007	(0.0277) n.s.
	Spouse(2Parents&1son)	-0.434	(0.0216) ***	-0.444	(0.0219) ***	-0.431	(0.022) ***	-0.214	(0.0205) ***	-0.194	(0.0207) ***	-0.198	(0.0209) ***
	Spouse(2Parents&≥2sons)	-0.356	(0.0196) ***	-0.481	(0.02) ***	-0.482	(0.0201) ***	-0.066	(0.0189) **	-0.141	(0.0192) ***	-0.186	(0.0194) ***
	Parent(1Parent&1son)	-0.197	(0.0822) *	-0.066	(0.0833) n.s.	-0.085	(0.0837) n.s.	-0.191	(0.0369) ***	-0.050	(0.0375) n.s.	-0.026	(0.0378) n.s.
	Parent(1Parent&≥2sons)	-0.039	(0.0884) n.s.	-0.026	(0.0903) n.s.	-0.021	(0.0905) n.s.	-0.059	(0.0364) n.s.	-0.030	(0.0367) n.s.	-0.025	(0.0371) n.s.
	Spouse(2no sons)	-0.323	(0.0233) ***	-0.280	(0.0237) ***	-0.265	(0.0238) ***	-0.146	(0.0218) ***	-0.091	(0.022) ***	-0.111	(0.0223) ***
	Spouse(2with other comp.)	-0.266	(0.0569) ***	-0.246	(0.0575) ***	-0.264	(0.058) ***	0.039	(0.0598) n.s.	0.071	(0.0608) n.s.	0.025	(0.0615) n.s.
	Son(2Parents&1son)	0.164	(0.0301) ***	0.121	(0.0305) ***	0.131	(0.0306) ***	0.179	(0.0328) ***	0.129	(0.0332) ***	0.146	(0.0336) ***
	Son(2Parents&≥2sons)	0.410	(0.027) ***	0.270	(0.0275) ***	0.285	(0.0276) ***	0.424	(0.0285) ***	0.283	(0.029) ***	0.305	(0.0293) ***
	Son(1Parent&1son)	0.171	(0.0379) ***	0.248	(0.0385) ***	0.256	(0.0387) ***	0.042	(0.0451) n.s.	0.029	(0.0455) n.s.	0.050	(0.0459) n.s.
	Son(1Parent&≥2sons)	0.496	(0.0395) ***	0.414	(0.0402) ***	0.424	(0.0404) ***	0.262	(0.0472) ***	0.179	(0.0477) **	0.218	(0.0481) ***
EDUCATION (REF=ISCED=6)	ISCED 0-1	0.575	(0.0179) ***	0.465	(0.0183) ***	0.402	(0.019) ***	0.743	(0.0215) ***	0.625	(0.0219) ***	0.573	(0.0227) ***
	ISCED 2	0.115	(0.0124) ***	0.099	(0.0126) ***	0.109	(0.0129) ***	0.144	(0.0137) ***	0.146	(0.0139) ***	0.158	(0.0142) ***
	ISCED 3-4	-0.498	(0.0241) ***	-0.308	(0.0246) ***	-0.287	(0.0248) ***	-0.395	(0.0238) ***	-0.212	(0.0244) ***	-0.193	(0.0246) ***
	ISCED 5	-0.158	(0.0131) ***	-0.171	(0.0133) ***	-0.118	(0.0135) ***	-0.338	(0.0134) ***	-0.347	(0.0136) ***	-0.289	(0.0138) ***
OTHER HH INCOMES (ref=None)	Regular	-0.147	(0.00838) ***	-0.016	(0.00866) n.s.	-0.021	(0.00871) *	-0.143	(0.0109) ***	-0.039	(0.011) **	-0.049	(0.0112) ***
	Irregular	0.269	(0.0111) ***	0.230	(0.0113) ***	0.217	(0.0114) ***	0.258	(0.0128) ***	0.214	(0.013) ***	0.197	(0.0132) ***

Table A.3 *(continued)*. **Parameter estimates, by model and model group**

		MALE									FEMALE								
		Model A			Model B			Model C			Model A			Model B			Model C		
Variables	Modalities	Est.	St.Err.	Pr.	Est.	St.Err.	Pr.	Est.	St.Err.	Pr.	Est.	St.Err.	Pr.	Est.	St.Err.	Pr.	Est.	St.Err.	Pr.
LABOUR MKT (by gender)	Factor1(a)				0.093	(0.00729)	***	0.093	(0.00733)	***				0.076	(0.00771)	***	0.073	(0.00778)	***
	Factor2(b)				-0.006	(0.0092)	n.s.	-0.006	(0.00923)	n.s.				0.025	(0.0122)	*	0.028	(0.0123)	*
	Factor3(c)				-0.055	(0.0147)	**	-0.058	(0.0148)	**				0.000	(0.0179)	n.s.	0.007	(0.018)	n.s.
DBGEO CLUSTER (ref=All right)	Equilibrist				0.007	(0.024)	n.s.	-0.001	(0.0241)	n.s.				-0.025	(0.0265)	n.s.	-0.046	(0.0267)	n.s.
	Industrial				-0.183	(0.0277)	***	-0.185	(0.0278)	***				-0.149	(0.0286)	***	-0.142	(0.0289)	***
	Metropolis				0.031	(0.0399)	n.s.	0.031	(0.0401)	n.s.				0.048	(0.0456)	n.s.	0.067	(0.0461)	n.s.
	Nothing to declare				0.055	(0.0309)	n.s.	0.054	(0.0311)	n.s.				0.105	(0.0306)	**	0.071	(0.0309)	*
	Not angels				0.031	(0.0301)	n.s.	0.035	(0.0303)	n.s.				0.097	(0.0344)	**	0.113	(0.0347)	**
	Risky habits				-0.053	(0.0324)	n.s.	-0.054	(0.0325)	n.s.				-0.100	(0.0375)	**	-0.119	(0.0378)	**
	Total risk				0.274	(0.0335)	***	0.281	(0.0337)	***				0.243	(0.0378)	***	0.269	(0.0381)	***
REGULAR EMPL.STRUCT. (by gender) (ref=Industry)	Agricolture				-0.001	(0.0026)	n.s.	-0.011	(0.00263)	***				0.033	(0.00359)	***	0.023	(0.00366)	***
	Construction				-0.011	(0.00394)	**	-0.014	(0.00396)	**				-0.017	(0.0135)	n.s.	-0.021	(0.0137)	n.s.
	Trade&Horeca				0.002	(0.00342)	n.s.	0.001	(0.00345)	n.s.				0.018	(0.00309)	***	0.018	(0.00313)	***
	Businessservices				0.005	(0.00266)	n.s.	0.003	(0.00268)	n.s.				0.019	(0.00317)	***	0.018	(0.00321)	***
	Householdservices				0.016	(0.00208)	***	0.012	(0.0021)	***				0.013	(0.00203)	***	0.011	(0.00206)	***
EMPLOYMENT IN MICROENTERPRISES					0.007	(0.00198)	**	0.006	(0.00199)	**				0.001	(0.00182)	n.s.	0.000	(0.00184)	n.s.
TYPE OF JOB (ref=Employees)	Self-employed							-0.030	(0.00788)	**							-0.356	(0.00884)	***
IRREGULAR JOB NACE (ref=HH services)	Agricolture							0.487	(0.0196)	***							0.515	(0.0263)	***
	Industry							-0.396	(0.0162)	***							-0.137	(0.0243)	***
	Construction							0.130	(0.0156)	***							-0.088	(0.0547)	n.s.
	Trade&Horeca							-0.216	(0.0147)	***							-0.213	(0.0187)	***
	Business services							-0.304	(0.0158)	***							-0.344	(0.0213)	***

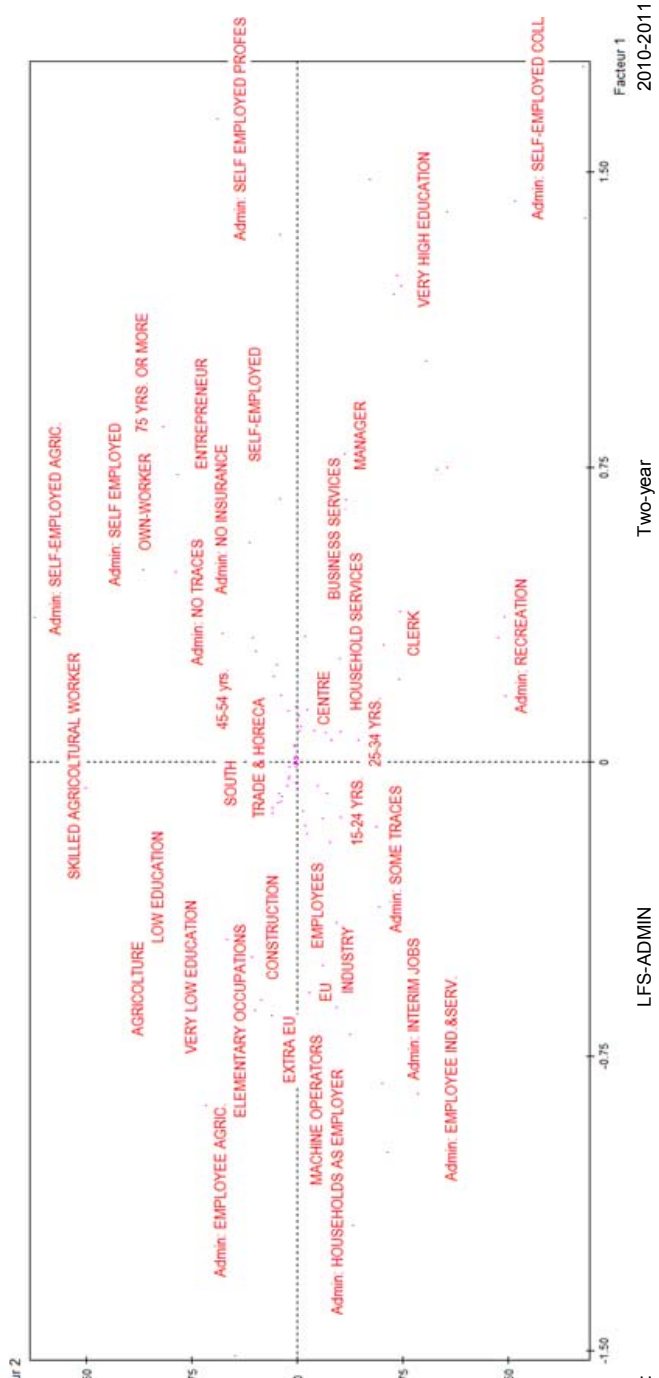
Note: *** if Pr. < 0.0001; ** if 0.0001<Pr<0.01; ** if 0.01<Pr<0.05; * if 0.05<Pr<0.1; n.s. otherwise.

Table A.4. T-test on the gender differences in coefficients estimates by model (Men-Women)

	MODEL					
Variables and modalities	A		B		C	
Intercept	-10.1	**	2.7	**	2.7	**
CITIZENSHIP=Italian	-0.1	n.s.	-3.7	**	-1.7	n.s.
AGE=15-24	-3.9	**	-5.1	**	-8.7	**
AGE=25-34	-0.8	n.s.	-2.2	*	-5.3	**
AGE=55-64	2.6	**	2.7	**	1.8	n.s.
AGE=65-74	2.3	*	2.9	**	6.2	**
HOUSEHOLD=Single	8.7	**	8.5	**	8.4	**
HOUSEHOLD=Spouse(2Parents&1son)	-7.4	**	-8.3	**	-7.7	**
HOUSEHOLD=Spouse(2Parents&≥2sons)	-10.6	**	-12.3	**	-10.6	**
HOUSEHOLD=Spouse(2no sons)	-5.5	**	-5.8	**	-4.7	**
HOUSEHOLD=Spouse(2with other components)	-3.7	**	-3.8	**	-3.4	**
HOUSEHOLD=Son(1Parent&1son)	2.2	n.s.	3.7	**	3.4	**
HOUSEHOLD=Son(1Parent&≥2sons)	3.8	**	3.8	**	3.3	**
EDUCATION=ISCED 0-1	-6.0	**	-5.6	**	-5.8	**
EDUCATION=ISCED 2	-1.5	n.s.	-2.5	*	-2.6	*
EDUCATION=ISCED 3-4	-3.1	**	-2.7	**	-2.7	**
EDUCATION=ISCED 5	9.6	**	9.3	**	8.8	**
OTHER HOUSEHOLD INCOMES=Regular	-0.3	n.s.	1.6	n.s.	2.0	*
LABOURMARKET(bygender)=Factor2(b)			-2.0	*	-2.2	*
LABOURMARKET(bygender)=Factor3(c)			-2.4	*	-2.8	**
REGULAR EMPL.STRUCT.(bygender)=Agricolture			-7.7	**	-7.5	**
REGULAR EMPL.STRUCT.(bygender)=Trade&Horeca			-3.4	**	-3.6	**
REGULAR EMPL.STRUCT.(bygender)=Businessservices			-3.3	**	-3.5	**
EMPLOYMENT IN MICROENTERPRISES			2.2	*	2.4	*
TYPE OF JOB=Self-employed					27.5	**
IRREGULAR JOB NACE=Industry					-8.9	**
IRREGULAR JOB NACE=Construction					3.8	**

Note: ** if Pr<0.01; * if 0.01<Pr<0.05; n.s. otherwise.

Chart A.1. Modalities on the first two factor's space



Source: LFS-ADMIN Two-year 2010-2011

The ISTAT–MATIS corporate tax model [1]

Antonella Caiumi [2], *Lorenzo Di Biagio* [3]

Abstract

In this paper we present a new corporate microsimulation model (ISTAT–MATIS) which combines a multi-period framework with the use of large complementary data set. The new ISTAT-MATIS is an algebraic framework that reproduces tax liabilities of Italian corporations and fiscal groups in accordance to fiscal rules. The multi-period framework allows for dynamic simulation and to consistently trace firm-level inter-temporal developments of fundamental tax base variables, like for example interests deduction add-backs (carry forwards), losses carry forwards and tax allowances carry forwards. The ISTAT–MATIS model is founded on corporate tax return data plus additional information drawn from other administrative sources on Italian corporations and ISTAT statistical archives. The database covers the whole population of limited-liability firms thus allowing for conclusions on the revenue impact of tax changes. The model framework incorporates all the complexities of the Italian tax regime, including the tax treatment of losses, the partial interest deductibility rule, the group taxation and the newly implemented 'Aiuto alla Crescita Economica' (ACE, Aid to Economic Growth). The model accomplishes the dual purposes of dynamic forecasting and policy analysis. We illustrate the potential use in the distributional analysis of recent tax changes for Italian corporations.

Keywords: Tax treatment of losses; Allowance for corporate equity; Corporate taxation; Microsimulation

1. Introduction

Microsimulation is a modeling technique typically used to simulate the behavior of the basic unit of analysis and provides a description of the whole population

[1] The views expressed in this paper are those of the authors and do not necessarily represent the institutions with which they are affiliated. Any errors or mistakes remain the authors' sole responsibility. This paper, in its previous versions, has been presented and discussed at: Chamber of Deputies – Camera dei Deputati (Roma, February 28, 2013); International Institute of Public Finance – IIPF, Annual Congress (Taormina, August 21-25, 2013); International Institute of Public Finance – IIPF, Annual Congress (Lugano, August 20-23, 2014); International Microsimulation Association – IMA, European Meeting, (Maastricht, October 23-24, 2014); Ministry of Economic Development – MiSE, Finance for Growth 2.0: estimates of the impact of business incentives (Roma, February 5, 2016); Italian Society of Economists – SIE, Annual Congress (Univ. Bocconi, Milano, October 20-22, 2016); XII National Conference of Statistics (Roma, June 22-24, 2016).

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taking into account differences across individuals. The main advantage of microsimulation models in relation to economic policy analysis is that policy implications can be analyzed at the disaggregated level. Tax systems may impose a non-uniform effective tax rate on different businesses, depending on their size, ownership structure (standalone versus belonging to a group of firms, domestic versus foreign-owned), business activity and location. Corporate tax microsimulation models compute the net tax liabilities for individual firms and are used to forecast the revenue impact as well as the distributional consequences of tax reforms, and assess ex-ante whether policy initiatives had the intended or unintended effects.

The starting point for tax microsimulation models is a (large) microdata set which provides comprehensive information on the determinants of individual tax liabilities. In principle, corporate tax models require the use of two complementary company-level data sources — confidential corporate tax return data and accounting data — because usually corporate taxable income differs from economic income. Corporate tax returns allows to precisely determine the tax position of corporations in each fiscal year as well as to recover information on the use of non-debt tax shields, like capital allowances, losses carry forward and preferential tax treatments. Knowledge of loss offsetting and firms' ability to shift taxable profits over time are especially important for revenue forecasting. However, to completely identify heterogeneity in business activities other information are required. In particular, company accounts provides information of interest on the economic determinants of corporate profits.

Microsimulation models for firms are relatively rare compared to models for households (Ahmed 2006, Buslei et al. 2014). Firm models are more complex than household models both because firm behavior involves inter-temporal aspects and tax rules are usually more complex. In addition, access to firm data, especially tax, is more restricted compared to household data. Firm's models are usually static, thus disregarding behavior and time. A notable exception is the study of Finke et al. (2013) that provides an analysis of the German 2008 corporate tax reform based on a model that allows for behavioral responses of firms to tax changes.

To our knowledge this is the first study that documents a multi-period corporate microsimulation model founded on corporate tax returns. The approach developed in this paper is inspired by previous microsimulation models for Italy. A comprehensive corporate tax microsimulation model for Italy is MATIS (Modello per l'Analisi della Tassazione e degli Incentivi alle Società) developed under the aegis of the University of Bologna (Bontempi et al., 2001). The MATIS model is multi-period and based on accounting data for large manufacturing firms (Centrale dei Bilanci archive). Caiumi (2001) improves the design of the statistical archive of MATIS by selecting a representative sample with a stratified method from the universe of firms listed on the ISTAT firms register (Archivio statistico delle imprese attive, ASIA). Further, Caiumi (2006, 2007) develops a one period model based on cross-sectional confidential tax returns data reproducing the Italian corporate tax (Imposta sul reddito delle società – IRES) and the local business tax (Imposta Regionale sulle Attività Produttive) after major corporate tax reforms from 2004 untill 2008, and Caiumi (2005) develops a framework to analyse the structure of fiscal groups and revenue losses stemming from the newly introduced consolidation regime. Balzano et al. (2011) develop a one

period micro-based model that exploits numerous data sources, including published financial statements and survey data on Italian firms.

In this paper we present a new corporate microsimulation model (ISTAT–MATIS) which combines a multi-period framework with the use of large complementary data set. The new ISTAT–MATIS is an algebraic framework that reproduces tax liabilities of Italian corporations and fiscal groups in accordance to fiscal rules. The model framework incorporates all the complexities of the Italian tax regime, including the tax treatment of losses, the partial interest deductibility rule and the group taxation. The model accomplishes the dual purposes of dynamic forecasting and policy analysis.

The multi-period framework allows for dynamic simulation and to consistently trace firm-level inter-temporal developments of fundamental tax base variables, like for example interests deduction add-backs (carry forwards), losses carry forwards and tax allowances carry forwards. Tax changes often provides advantages partially offset by restriction in other provisions and the sign of the net effect on tax liabilities may vary over time. In particular, this model approach is particularly suited to evaluate tax reforms that are gradually introduced into force, like the Allowance for Corporate Equity (ACE) which was introduced in Italy in an incremental fashion in 2011.

The ISTAT–MATIS model is founded on corporate tax return data plus additional information drawn from other administrative sources on Italian corporations and ISTAT statistical archives. The available archives cover the population of corporations over a fairly long period of time (1998-2011). The integrated database used in this paper covers the years 2005-2011. The sources involved in the integration process are the company accounts database, the ISTAT archive on national business groups, the statistical register of Italian active enterprises (acronym ASIA), information on spin-offs and mergers, and business structural surveys, in particular the survey on foreign trade (COE), the survey on Italian enterprises controlled by foreign firms (Fats-inward) and the survey on resident firms with foreign subsidiaries (Fats-outward).

Being based on the entire population of corporations, our results allows for conclusions on the distribution of the tax burden among taxpayers as well as on the revenue impact of tax changes. Moreover, the richness of the database allows analyzing distributional effects across key variables, like economic sectors, technological intensity, size expressed both in terms of turnover and number of employees, location, export-oriented, and last but not least, property structure. At the current stage, the model does not account for behavioral responses by taxpayers to tax changes. Therefore its analytical capacity is limited to first round effects. We plan to develop the model further and incorporate the main effects that corporate taxes exert on the main corporations' decisions, in particular investment, financing and factor demand behavior, product supply and profit-shifting activities.

The objective of this paper is to describe in details the structure of the model and illustrate the potential use in the distributional analysis of tax changes and in the identification of the effects of tax provisions adopted in the aftermath of the economic and financial crisis up to 2014. On one side, several important features of the corporate tax system have been changed, such as the treatment of tax losses. On the other side,

pro-growth provision have been introduced, like the expanded deduction of the labor component of the IRAP and the newly implemented 'Aiuto alla Crescita Economica' (Aid to Economic Growth). For an in-depth analysis of these tax reforms see Caiumi and Di Biagio (2015). In this paper we present the distributional impact of all tax changes on corporations over the course of the simulation years 2011-2014.

The paper is organized as follows. The next section overviews the current CIT system in Italy. Section 3 presents the ISTAT–MATIS model framework and its use for the computation of effective average tax rates. Interpretation of results are discussed in Section 4. Section 5 concludes.

2. The main features of the Italian Corporate income Tax

This section overviews the structure of the tax system in force as an introduction to a more detailed analysis in the next sections.

2.1 The tax treatment of losses

The tax treatment of losses changed in 2011. According to rules previously in force, losses arising in a given tax period could be carried forward and deducted from corporate taxable income in subsequent periods up to a maximum of five years. Tax losses arising in the first three tax periods following the company establishment date could be deducted from taxable income in subsequent periods with no time limits, as long as losses concern a new business activity (e.g., the losses are not incurred in the course of a merger or business contribution). As from 2011, tax losses are no longer subject to a 5-year expiration period even for not-expired losses incurred in previous years. However, 20% of a year's taxable income cannot be offset against tax losses carried forward and will be subject to corporation tax. Losses incurred by a company during the first three taxable periods may be carried forward and entirely used to offset corporate taxable income, but, as before the reform, only if they arise from a new business activity. The reform of the tax treatment of losses leave unchanged the ban to losses carryback.

2.2 Consolidated taxation mechanism

After the major reform of 2004 the economic reality of corporate groups is formally recognized with the introduction of a formal group taxation system to the aim of further aligning the Italian tax system to the most efficient tax systems in force within the EU. In broad terms, the group relief recognizes to a business the same overall tax treatment of losses whether it operates as a single entity or as a group. Two different group taxation systems are in force; a national tax consolidation system and a world tax consolidation system. Consolidation for tax purposes is available to domestic groups, with each subsidiary in a group free to choose whether or not to consolidate. Consolidation is available to a parent and its resident companies that are

under its direct or indirect control. The control requirement is met when the participation company holds more than 50% of the share capital of another company and is entitled to more than 50% of the profits of that company. Domestic consolidation may also be adopted if a non resident company is the controlling company but only if the company is resident in a country that has concluded a tax treaty with Italy and carries on business activities in Italy through a permanent establishment holding the participation in the controlled Italian companies. Domestic consolidation is not available to companies benefiting from a reduction of the corporate tax. It requires a minimum three-years commitment. Once an option for consolidation is made, it may not be revoked for three years unless the subsidiary ceases to be controlled by the parent company. The new domestic consolidation employs a 'pooling' approach. Exercising the consolidate taxation option therefore involves calculating a single taxable income for all companies included in the tax consolidation, by compensating income and losses within the consolidation scope (with adjustment for intra-group transactions). Taxable incomes are fully offset regardless of the controlling share. Tax losses realized previously to exercise the consolidation taxation option cannot be attributed to the parent company.
The group taxation system provides additional opportunities and tax advantages such as the offsetting of tax credits and tax liabilities among group members, like for example the amount of the notional deduction in excess of the net taxable income as described in more detail below.
World tax consolidation effectively extends the group taxation treatment to foreign companies; incomes and losses realized by foreign subsidiaries are imputed to the Italian controlling company in proportion to the controlling share and calculated according to Italian tax rules.

2.3 The Participation Exemption

A central feature of the major tax reform of 2004 was the adoption of a participation exemption as a system to avoid the double taxation of revenues from participations in other corporations/partnerships in the form of dividends and capital gains. The PEX regime implies that 95% of capital gains realized by companies resident for tax purposes on the disposal of equity investments in corporations/partnerships resident in Italy or abroad are IRES-exempt. Equity investments eligible for such treatment are those classified as non-current financial assets, engaged in commercial activities, held continuously for at least twelve months and resident for tax purposes in a country or territory other than a tax haven (white list countries). Capital losses, write-downs and expenses related to the disposal of equity investments qualifying for the participation exemption are not deductible. Dividends received from corporations resident for tax purposes in Italy or a State or territory other than a tax haven are excluded from taxable income for IRES purposes in the amount (currently) of 95%.

2.4 Interest deductibility regulation

Corporations can fully deduct interest expenses and similar charges (not capitalized in the cost of assets) in an amount equal to interest income and similar revenues. The excess may be deducted up to a ceiling of 30% of Gross Operating Profit (GOP).[4] Interest expense that cannot be deducted (due to limit exceeding) can be carried forward to subsequent tax periods and added to the amount of interest expense and similar charges for such periods. To allow a gradual implementation of the new rule, the ceiling is augmented of an amount equal to 10,000 euros in the first year (2008) and 5,000 euros in the second year (2009). As from 2010, the GOP portion not used in a given tax period as it exceeds interest expense may be carried forward to increase GOP in subsequent years.
Specific rules apply in the case of companies participating in the consolidated taxation mechanism. The excess of GOP not completely used for interest deduction by the company that generated it, can be used to compensate interest expense not deducted by other entities belonging to the consolidation scope. This compensation is not allowed to interest expense carry forwards generated prior to the access to the consolidation. In addition, further restrictions apply to a consolidated company that holds both interest expense not deducted and loss carry forwards generated prior to exercising the consolidated taxation option. The aforesaid excess of interest expenses can be deducted from the consolidated taxable base up to the amount of the taxable income that the same company had conveyed to the consolidation. This is to avoid circumvent the rule that preclude loss carry forward generated prior to the access to the consolidation to be transferred to the consolidated taxable base.

2.5 The newly implemented 'ACE'

Starting from tax period 2011, taxable income is split into two components, ordinary and above-normal return. Ordinary income is exempt under ACE. The provision is aimed at spurring companies' own capitalizations by counterbalancing the tax advantage of debt.
The ordinary return is computed by applying a notional interest rate to new equity generated after 2010. [5] Specifically, the ACE base is computed from the algebraic sum of positive components (capital increases and allocations of profits to reserves) and negative components (the contemporaneous increase in equity investment qualifying for participation in related entities) due to anti-avoidance rules. The latter amount does not include any profits from that year. The notional interest is computed using a percentage set annually by the Minister of Finance. The percentage is set considering the Italian public debt securities' average return and a risk factor. The return is set at 3% for the first three fiscal years (2011–2013). It has been recently increased at 4%, 4.5% and 4.75% for the three subsequent years. Afterwards it will be based

[4] GOP is equal to the difference between item A (Production Value) and item B (Production Costs) in the income statement, increased by depreciation and amortization of property, plant and equipment, and intangible assets and lease payments.

[5] See Zangari (2014) for a comparison with the Belgian ACE system.

on Government bonds rate. The amount of the notional deduction in excess of the net taxable income can be carried forward to relieve future taxable income with no time limitation. The ACE relief is applied also to firms belonging to a fiscal group. The ACE deduction is computed at the firm level up to entirely offset its taxable income. The amount of the notional deduction in excess of the net taxable income can be carried forward to relieve future taxable income or attributed to the parent company. As for tax losses, the overhang of the ACE deduction, arising before the access to a fiscal group, cannot be transferred to the fiscal unit.

2.6 The local business tax

The IRAP tax base is calculated by a direct subtraction method as the difference between gross receipts (sales revenues) and the cost of intermediate goods and services (purchases from other firms plus depreciation). Neither labor costs nor interest payments are deducible from the tax base.[6] However, the fiscal burden of the IRAP on the labor component of the tax base has been progressively reduced, mostly through the introduction of tax deductions in favor of permanent employees. Regional governments can levy an additional one (currently 0.92) percentage point or either reduce it to the same extent. The tax rate can also be differentiated according to the economic sector and the categories of firms.[7] Like the CBIT system, the IRAP seeks to eliminate the favorable fiscal discrimination of debt financed investment by disallowing a deduction for interest payments, but it is not neutral to investment given that outlays for capital goods are not immediately deductible (but only in accordance with normal income tax depreciation schedules).[8]

As of 2008 10% of the IRAP can be deducted from the IRES taxable base (and from income of firms subject to IRPEF) for firms that sustain financial and labor costs. After 2012, the total amount of the IRAP stemming from the labor component (net of applicable deductions) is deducible against the IRES. The lump sum deduction of the interest expenses component of the IRAP still applies. The overall deduction (lump sum and analytical) admitted to be offset against the IRES taxable base cannot exceed the amount of the IRAP tax debt. The share of unused deduction due to firm's tax-exhaustion can be carry-forward as a tax loss in future years.[9]

[6] The IRAP is essentially a net income type of value added tax on an origin basis (cfr. Ceriani and Giannini, 2009). Its peculiarity consists in the fact that it is levied not on income when taxpayers receive it, but before its distribution, on the value of production generated in each tax period by subjects engaged in business activities. The misunderstanding of this characteristic is at the root of the perception by taxpayers as a particularly oppressive tax.

[7] Under certain conditions, since 2013, regional governments can even set the rate to zero.

[8] Moreover, it probably favors capital over labor because tax depreciation allowances exceed economic depreciation (Bordignon et al., 2001).

[9] In practice, the tax code allows to offset first the IRAP deductions and then, on the residual taxable base after tax loss deductions, the ACE deduction.

3. The corporate tax microsimulation model and data

3.1 Data description

Our database combines corporate tax return data and additional information drawn from other administrative sources on Italian corporations and ISTAT statistical archives, providing extensive information for various taxpayer groups with different characteristics relevant to policy analysis. The sources involved in the integration process are the company accounts database, the ISTAT archive on national business groups, the statistical register of Italian active enterprises (acronym ASIA), information on spin-offs and mergers, and business structural surveys, in particular the survey on foreign trade (COE), the survey on Italian enterprises controlled by foreign firms (Fats-inward) and the survey on resident firms with foreign subsidiaries (Fats-outward).

The richness of the database allows firstly to identify a broad range of category of firms in accordance with technological intensity, financing structure, profitability, size, age, location, export orientation, and ownership structure. Secondly, by combining information from both corporate tax returns and company accounts, the database allows to reproduces in detail the key features of the corporate tax base in Italy, in particular the treatment of corporate losses, the consolidated taxation mechanism, the interest deductibility regulation, the local business tax and the allowance for corporate equity, for relevant tax payer categories - single entities and fiscal groups. Thirdly, since all data sources contain firm level observations for consecutive time periods (panel data), the database allows to implement a multi-period framework. Currently, the available archives cover the population of corporations over a fairly long period of time (1998-2015). The integrated database used in this paper covers the years 2005-2011.

The number of tax returns filed by corporations has constantly increased in recent years (see Table 1). Most of them are standalone corporations. The number of fiscal groups has also grown. In 2008, 4,936 group tax returns were filed (about 84 percent of which were from corporate groups with five or fewer corporations) - almost two thousand more than in 2004 when the national tax consolidation was introduced - whereas the number of tax returns for corporations not participating in the group taxation system was 1,020,833. In 2011 5,624 group tax returns were filed (about 83 percent of which were from groups with five or fewer), while 1,074,013 corporate tax returns came from corporations not participating in the consolidation.

Being based on the entire population of corporations, simulation results allows for conclusions on the distribution of the tax burden among taxpayers as well as on the revenue impact of tax changes.

Figure 1 - The ISTAT-MATIS microsimulation model and data

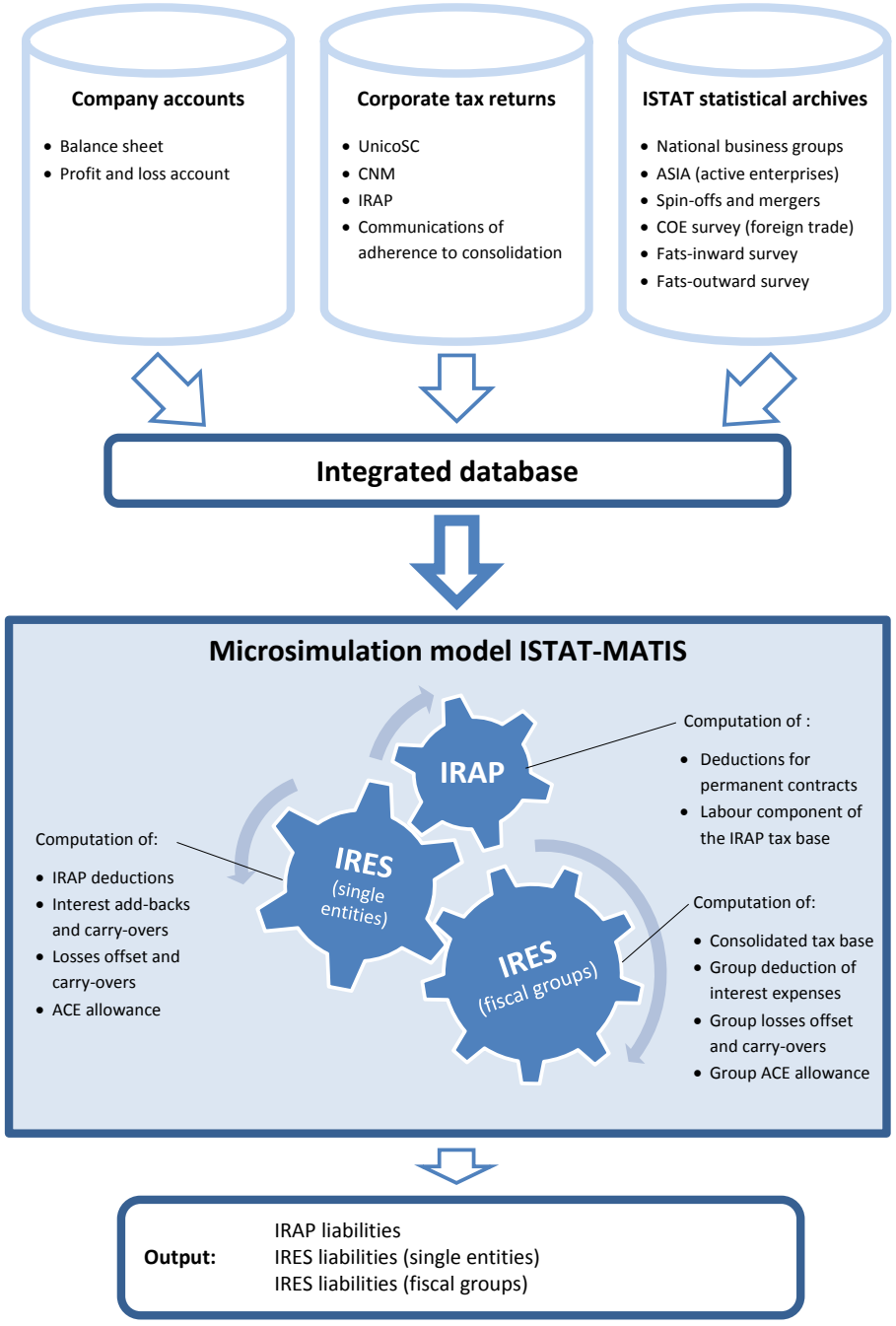


Table 1 - IRES Taxpayers

Tax year	Single entities	Companies in tax groups	Fiscal groups	Total
2008	1,021,276	20,033	4,936	1,041,309
2009	1,047,019	21,270	5,249	1,068,289
2010	1,067,386	21,789	5,314	1,089,175
2011	1,062,713	22,499	5,498	1,085,212

Number of companies that have filed a corporate tax return by year and type of tax return

Table 2 - Distribution of fiscal groups by number of companies

Tax year	Number of companies				
	2	3	4	5	≥ 6
	%	%	%	%	%
2008	42.9	20.2	12.8	7.3	16.8
2009	42.7	20.4	12.7	7.1	17.1
2010	41.5	20.9	12.8	7.5	17.3
2011	41.8	20.4	12.9	7.9	17.0

Source: tax return data

3.2 The ISTAT–MATIS model framework

The main determinant of income liable to corporate tax is corporate profits before taxes. However several adjustments reflecting allowances and requirements under the tax law are needed to establish the linkage between corporate profits before taxes and taxable income. The Italian corporate income tax (IRES) envisages that the taxable income has to be determined by adding to income before taxes stemming from company accounts, (profits or losses, P(L)), upward fiscal adjustments, Adj+, and by subtracting downward fiscal adjustments, Adj-, losses carried forward from previous tax periods, LCF, and other deductions from the tax base, like the ACE allowance:

$$\text{CIT base} = \text{P(L)} \pm \text{Adj} - \text{LCF} - \text{ACE} \tag{1}$$

The tax code reckons on a large number of fiscal adjustments. Some of them have temporal nature, by deriving from the possibility to partition specific income components over several tax years (for example, the taxation of capital gains); other adjustments respond to the need of avoiding double income taxation (i.e., dividends received); finally, other adjustments entail more substantial changes in the taxable income, i.e., the add-backs of non deductible interest expenses, or the allowance of

tax bonuses. The losses carry forward allows a company to deduct from the taxable income the negative tax base accrued in the previous years. Related entities are free to choose, satisfied some requirements, whether or not to file a consolidated tax declaration. Exercising the consolidate taxation option, therefore, involves calculating a single taxable base for all companies included in the tax consolidation, by compensating income and losses within the consolidation scope. Taxable incomes are fully offset regardless of the controlling share. Also losses carry forward of the fiscal group from previous tax period are subtracted, as well as the ACE allowance that pertains to the fiscal group. Tax losses and ACE leftovers realized previously to exercise the consolidation taxation option cannot be attributed to the parent company. For each fiscal group, the taxable income is determined as follows:

$$\text{CIT base}_{\text{FG}} = \sum \text{CIT base} - \text{LCF}_{\text{FG}} - \text{ACE}_{\text{FG}} \tag{2}$$

The microsimulation tax model ISTAT–MATIS is an algebraic framework that reproduces tax liabilities of Italian corporations and fiscal groups in accordance to fiscal rules. The microsimulation tax model ISTAT-MATIS is founded on fiscal declarations both at the company level and the fiscal group. As known, the majority of the adjustments required by law cannot be inferred on the basis of accounts data. An important advantaged of return data with respect to balance sheets and P&L accounts is the possibility to take into account all unpredictable tax adjustments in the computation of the taxable base in order to precisely determine the tax position of the corporation. All fiscal variables are based on information drawn from the tax archives. The sources involved in the computation of the corporate taxable base at the firm level include data from the "UnicoSC" form and the "IRAP" form filed by each corporation, and tax declarations filed by the controlling companies ("CNM" form). Other available archives at the firm level are used as complementary data as described below.

Tax adjustments that are not explicitly modeled in our simulation procedures are drawn from corporations' tax declarations data (table RF of the UnicoSC form). Next, we offset losses brought forward from earlier tax years against taxable base. We explicitly model the tax treatment of losses according to tax rules. For the first year of our panel and for all records that enter the panel in subsequent years, loss carry forwards from earlier periods are taken from corporations' tax declarations (table RS of the UnicoSC form). For newborn firms, the procedure sets loss carry forward equal to the tax loss incurred in the first year it occurs. In addition, we model the tax treatment of national tax consolidation. Information on consolidation group structure is drawn from the communications of adherence to the group taxation merged with all tax declarations filed by the controlling companies ("CNM" form). Specifically, we model the "pooling system" currently in force by computing the taxable income of each group member at the individual level; individual profits or losses are then transferred to the parent company and aggregated at the group level to determine the consolidated taxable base of the group. Pre-consolidation losses are offset against the taxable income of the subsidiary before consolidation. Losses carry forwards at the group level are initialized as described above for the computation of the company's

taxable base. After computing the taxable base at company and group level, ISTAT-MATIS computes tax liabilities for all taxpayers by applying the statutory tax rate.

Corporations are also liable for the local business tax, levied on an adjusted profit measure which exclude financial flows and extraordinary items of income, at a rate which varies across regions. The model draws information on the components of the IRAP taxable base from "IRAP" form and update deductions allowed on permanent workers according to more recent tax provisions. An implicit tax rate is applied in order to account for regional variations in tax rates. This is computed as the ratio between the IRAP tax charge and the taxable base. An indicator of the tax incidence of IRAP on the cost of labor for permanent workers is computed on the basis of information on the cost of labor drawn from the P&L statement, the number of dependent employees from the ASIA register and the amount of allowed deductions and the associated number of permanent workers from table IS of the "IRAP" form.

3.3 Simulations using ISTAT-MATIS

We follow the conventional approach in microsimulation modeling to consistently assess the effects that tax policy has on firms cash flow as opposed to other drivers, such as broader economic changes as well as changes in firms' economic and financial structure and in demographic composition (firm age, firm size, location etc.). This methodology consists in simulating a set of counterfactuals on the basis of the same information dataset in order to evaluate what the impact would be on firms cash flow if alternative provisions were to be applied.

The current version of the ISTAT–MATIS model reproduces the CIT system in force in year 2008 and subsequent tax changes until year 2014, as illustrated below, on the basis of historical firm data. Given that data on firms are available with time lags, it is not possible to simulate the most recent tax reforms starting from the year of entry into force. Simulation results are obtained by slipping backwards the simulation year as if the reforms were introduced in year -3, such that the legislation in force in year is simulated on the basis of information for the year -3. In this paper, the tax year 2008 is used to simulate tax rules in force in 2011 and so forth.

The drawbacks of this approach are obvious in the presence of significant changes both in the tax structure and in the economic conditions underlying the simulation period in comparison to the year of reference for the tax rules. However, this doesn't seem of a major concern here. After the major tax reform in 2008, the broad structure of the Italian corporation tax system has remained relatively unchanged. Also, the economic downturns, that have so heavily affected the profitability of firms since the financial crisis in 2008, still persists. Thus, the chosen time span 2008-2011 seems suitable to be deployed for distributional analysis of recent tax reforms.

An important feature of our microsimulation procedure is that it does not require the underlying data panel to be balanced, therefore our simulation results are not affected by selection bias.

A first simulation implements in detail the tax structure in 2008 and all tax changes until the end of 2010. This outcome is used as term of comparison for all further simulations so as to compute changes in firms cash flow stemming from the tax

change (*benchmark simulation*). Our benchmark simulation incorporates the 2008 tax reform that saw a significant drop of the main statutory corporation tax rate from 33% to 27.5% and of the IRAP tax rate from 4.25% to 3.9% and the broadening of the tax base through the abolishment of accelerated and anticipated capital depreciation allowances and the introduction of a stronger restriction to interest deductibility in replacement of a thin-cap rule as described above (Section 2).

The simulation procedure reproduces the main dynamical components of the tax base for single firms and fiscal groups. Among tax adjustments, we model the computation of the interest add-backs as well as the deductions of IRAP from IRES (both the lump sum deduction and the analytical deduction). All remaining tax adjustments are algebraically added.

As for the interest deductibility rule, we follow straightly the regulation in place both before 2010 and after the reform occurred in 2010. Information required to compute net interest expense and the limit to interest deductibility are drawn from tax declaration (table RF "UnicoSC" form) combined with accounting data. Net interest expense exceeding the GOP rule are added to the taxable base. The amount of net interest expense carried forward from previous years that can be deducted in the current year is subtracted from the tax base. Non-deductible interest expense are carried forward to subsequent years. As from 2011, the unused GOP limit is carried forward to subsequent years without limitation. In the case of presence of both losses carried forward from previous years and unused GOP, as stated by law, we compute first the share of deductible interests carry forward from previous years and then the deduction of losses carry forward from previous years. Moreover, we model the additional tax advantages provided by the domestic group relief that allows the offsetting of non deductible interest expenses of a company with the unused ceiling arising from another company of the same fiscal group.

In what follows of this section we describe the implementation of recent tax reforms: the new tax treatment of losses introduced in 2011, the expanded deduction of the labor component (net of deductions) of the IRAP against the IRES in year 2012 and the newly implemented ACE regime introduced in year 2011.

The simulation denoted *"Reform of tax losses"* reproduces the new treatment of losses. As from 2011, tax losses are no longer subject to a 5-year expiration period even for not-expired losses incurred in previous years. However, only 80% of a year's taxable income can be offset against tax losses carried forward, thus the residual 20% will be subject to corporation tax. Losses incurred by a company during the first three taxable periods may be carried forward and entirely used to offset corporate taxable income, but, as before the reform, only if they arise from a new business activity. The reform of the tax treatment of losses leave unchanged the ban to losses carryback. We suppose that it is convenient for the firm to use first the losses that can only be used to partially offset the taxable income and then the losses that can be used to fully offset the residual 20% of the taxable income.

The simulation named *"expanded IRAP deduction"* takes into account the complete system of IRAP deduction from IRES and allows to quantify the differential effect of the new deductibility rule with reference to the pre-existent lump-sum IRAP deduction described above. The expanded IRAP deduction is computed as the

amount of the labor cost, as results from the profit and loss account, net of applicable deductions drawn from the "IRAP" form (table IC and IS). We follow the tax rule by applying first the expanded IRAP deduction and then the lump-sum deduction and limiting their total amount to the whole IRAP tax due. The unused deductions are added to losses carried forward and used to offset taxable base in subsequent years.

The simulation of the new *"incremental ACE"* regime accounts for the deduction of a notional return to equity - from 2011 to 2014 (2008-2011 simulation years) - obtained by the product of the net positive variation of equity as for the end of 2010 and the notional ACE rate set at 3% in the first three years 2011-2013 and recently increased to 4% for 2014, respectively. Anti-avoidance rules are also applied. The net variation of equity is computed by adding net increments observed for contributions in cash and retained profits feeding available reserve provisions (table RF "UnicoSC" form) and subtracting the increments of control participations as well as the increments of loans granted within a group (accounts data). In contrast, it is not possible to account for cash contributions within a group on the basis of the available data. This gives rise to a potential source of overestimation for the simulated ACE allowance. Anti-avoidance rules against the "refreshing" of the old capital are approximated by excluding from the benefit firms that are involved in transformation events (mainly cessation for transformation in a new firm). In addition, we exclude firms that are subject to insolvency proceedings (i.e. failure, liquidation and extraordinary administration) based on the Statistical Register (ASIA). Then the upper limit of the qualified ACE base is set equal to the net worth of the company existing at the end of the tax year with the exclusion of the reserves for own shares (accounts data). For newborn firms the computed deduction reckons on the entire amount of equity (net of participations and loans within a group). The ACE relief is entirely offset against the company's taxable income. The amount exceeding the taxable base is brought forward and added to the ACE allowance of the next periods or attributed to the fiscal group. Unrelieved ACE deductions against the group taxable income are carried forward, proportionally, by the same companies that generated them. As for tax losses, the surplus of ACE allowance accrued prior to exercising the option for the consolidation are strictly used to offset the company taxable income of the next periods.

The simulation exercises encompass all corporations that filed the tax return module at least once over the years 2008-2011. Simulation results illustrated in Section 4 are based on a subsample of about 860,330 corporations selected by excluding firms belonging to agriculture, financial sector, health, education, as well as firms showing non-positive turnover that are not active (with the only exception of newborn firms). This subsample accounts for approximately the 75% of the total corporate tax revenue.

Given the complexity of our microsimulation framework and because of the use of a large database that combines together a variety of data, it is necessary to test the ability of the model to provide reliable analysis of policy changes. See Appendix A for some insights.

3.4 Computing effective tax rates

The consequences of recent tax reforms on the tax burden borne by firms can be evaluated by computing effective tax rates indicators which exploit variations in statutory tax rates and tax base. In the context of interest here, the computed indicators are ex-post ones, in that they reflect the current taxation of corporate profits resulting from past investment and financial decisions, then they are so called backward-looking. While forward-looking measures are usually recognized non-exhaustive indicators of the relevant elements of the tax base that can affect effective taxation (Nicodème 2001, Caiumi et al. 2015), micro backward-looking indicators have the advantage that all the elements of taxation can be taken into account.[10] Besides, the use of a detailed microsimulation model enables to isolate tax provisions so as to look at their separate effects and overcome a well-known shortcoming of conventional backward-looking indicators.

The literature on public finance distinguishes two effective tax rate indicators, the average effective tax rate and the marginal effective tax rate. The average effective tax rate measures the ratio of business tax revenue to corporate profits for different groups of firms and allows to assess equity and efficiency aspects of tax policy reforms, whereas the marginal effective tax rate is defined as the present value of current and expected future taxes paid on an additional unit of income earned today (Graham 1996, Shevlin 1990). As known, average effective tax rates are relevant as regards firms' location decisions. In contrast, marginal effective tax rates play an important role in determining the scale of the investment. The complexity involved in the computation of marginal tax rates goes beyond the purpose of this paper[11], henceforth we restrict ourselves to the computation of average effective tax rate.

There are numerous ways of constructing measures of effective tax rates. While the numerator of a basic average tax rate includes tax accrued, the denominator can be defined as some measure of economic corporate profits, like profits before tax or net operating surplus. On one hand, one can argue that financial flows can be quite volatile then the net operating surplus is a more reliable measure than the alternative. On the other hand, a ratio of corporate income tax to the gross operating surplus is an indicator of the tax burden on investment, but not a measure for the taxation of profits since it disregard the financing structure of the enterprise.

The option retained here is to compute the effective average tax rates as the corporate tax liability assessed in a year over before-tax profits earned in the same year.[12] To account for the dynamical components of the taxable base we consider the whole time span of the simulation period (2011-2014) as follows

[10] The main distinction between backward-looking and forward-looking approaches is based on the type of information used. Backward-looking measures are based on observed data on corporate profits or company accounts, while forward-looking measures are computed from the simulation of tax debt on the return of an hypothetical investment project taking into account fiscal parameters.

[11] See Arachi and Bucci (2013) for a recent analysis on Italy.

[12] Tax credits are not considered in the numerator.

$$\text{ETR}_i = \frac{\sum_{t=2011}^{2014} \quad _{i,t}(1+\quad)^{T-t}}{\sum_{t=2011}^{2014} \quad _{i,t}(1+\quad)^{T-t}} \tag{3}$$

where indexes the taxation rules, $_{i,t}$ is the tax debt at year obtained by applying the statutory tax rate to the taxable base, and $_{i,t}$ are the profits before taxation at year . We compute future value of taxes accrued and pre-tax profits by applying a real interest rate set at 2.5%, the average real interest rate on bank lending to firms in the same period.

This measure is clearly undefined for zero profits. In addition, if the firm is in a loss position then a positive tax charge would generate a negative ETR implying a completely different interpretation. For these reasons the analysis below considers only observations with positive profits. In addition, we consider only companies that are present in our panel for all the quadriennium. Consistently, we set the numerator and the denominator at zero in periods when the firm is in a loss position. The ratio - given by total taxes accrued over a period of time on total pre-tax profits over the same period of time - returns a more reliable assessment of the tax burden borne by firms than a weighted average of yearly effective tax rates.

By construction, the average tax rate is comprised between 0 and 1, being not-defined for negative values of the denominator (firm in a loss position). In the case it is greater than 1 it is set equal to 1 to avoid excess sensitivity of the first moments of the distribution to outliers (e.g., tax due may exceed earnings because of upward fiscal adjustments). Earnings before taxes is computed from tax return data. For fiscal units earning before taxes is computed by pooling profits and losses within the consolidation scope.

A measure of the total tax charge on profits, including the CIT and the local tax is obtained by adding to the IRES tax debt and the IRAP burden on the profits component of the tax base. This is computed by subtracting interest expense (from the income statement) and the labor cost (from the income statement) to the net production value (from the IRAP tax return), and then applying the effective IRAP tax rate borne by the firm as it results from the IRAP tax return (see section 2.6 above).

4. The distribution of the effective tax burden on firms: a descriptive analysis

This section illustrates the main features of the computed average effective tax rates at the firm level. By including only observations for single companies and fiscal groups where the ETR is well defined, i.e., all companies and fiscal groups with positive profits and with no missing observations over the entire simulation period (2011-2014), the selected sample is reduced to 570,161 out of 860,330 units. Notice that the number of corporations with positive profits is always larger than the number of corporations with positive tax charge, because of losses brought forward or the usage of other tax deductions. Table 3 (first row) shows that this group of firms correspond to 13 percent of the selected corporations for the benchmark simulation. After the introduction of the new treatment of losses it decreases at 5.6 percent. Further by applying the extended IRAP deduction it raises at 6.6 percent. Finally, with the

new ACE allowance the number of firms that have zero tax charge increases at 8.6 percent.

Table 3 - Companies with zero tax charges and computed effective tax rates for companies with tax charges (mean, median, cv). Percentage points

	Benchmark	Losses	expanded IRAP deduction	ACE
zero tax charge	13.0	5.6	6.6	8.6
mean	31.5	32.5	30.9	29.2
median	29.1	29.3	28.1	27.1
CV	75.7	71.9	74.8	78.4

Companies with zero tax charges are tax exhausted due to the use of losses carried forward from previous years. Simulation results for the years 2011-2014. The simulation *Benchmark* implements the 2008 tax reform and all subsequent changes until 2010; *Losses*, in addition to the *Benchmark*, incorporates the new treatment of losses introduced in 2011; further *expanded IRAP deduction* includes the IRAP deductions from IRES; with respect to this latter *ACE* includes the ACE introduced in 2011.

The mean of the ETRs is 31.5% for the benchmark simulation, to be compared, respectively, with 32.5% for the new treatment of losses, with 30.9% when also considering the extended IRAP deduction and with 29.2% when further accounting for the new ACE allowance. In all cases the mean is significantly above the median, indicating a right-hand side asymmetric distribution.

The dispersion in ETRs is quite high as the coefficient of variation is well above 70% in all cases. Average tax rates vary across firms due to differences in tax losses carried forward, differences in depreciation allowances as well as in tax planning strategies or the ability to shift profits over time. Differences in ETRs do not necessarily mean that the tax code is more favourable towards a specific group of firms than others, but it can for instance be due to the fact that those companies are more able to exploit the possibilities offered by the tax code to optimize the tax burden that companies have to bear. However, an important issue in the debate on the economic effects of the taxation on corporate profits is whether large corporations are paying their share of the tax burden. From a theoretical point of view, corporate income taxation that creates a favorable tax treatment for a specific categories of firms reduces its efficiency.[13]

Based on our results the tax burden on Italian companies seems not strongly related to size. Table 4 also splits companies according to two different variants of firm size: the turnover and the number of employees. The first one separates out companies that are considered small as their turnover is lower than 5 millions euros. The second criterion is based on a threshold of 20 employees. The distance in the effective tax rates between small firms and medium-large companies is fairly limited

[13] An extensive and growing literature deals with this topic. See for instance Zimmerman (1983), Santoro (2004), Nicodème (2007).

according to both criteria both for the benchmark simulation and the new treatment of losses. After the introduction of the expanded IRAP deduction the difference in the ETR increases. The tax burden is lower on firms with a turnover higher than 5 million euros of about 1.5 percentage points at the mean level, but it is negligible at the median level. However, the distance in the tax burden between small firms and the other firms is higher according to the second criterion. Tax liabilities for firms with less than 20 employees are of about 5 percentage points higher on average than for other firms. In contrast, small companies have mostly benefited from the ACE. By selecting only beneficiaries firms (about 36% of the total number of firms considered here) we observe that the reduction of the tax burden is significantly higher for smaller firms than larger ones under both size definition (Table 5). This finding is in sharp contrast with results for the Belgian ACE (Conseil supérieur des Finances, 2014) and may be possibly due to the incremental mechanism introduced in Italy. We will explore this issue more in depth in further analysis.

Table 4 - Effective tax rates by small and other companies (percentage points)

		Benchmark	Losses	expanded IRAP deduction	ACE
by turnover:					
mean	small firms	31.5	32.5	31.3	29.6
	other firms	31.7	32.4	29.7	28.0
median	small firms	29.0	29.1	28.2	27.3
	other firms	29.5	29.6	27.8	26.7
by employees:					
mean	small firms	32.1	33.2	32.5	30.7
	other firms	30.4	31.3	27.8	26.3
median	small firms	29.0	29.2	28.7	27.6
	other firms	29.2	29.4	27.0	25.9

See note for Table 3

The following pictures detail the relationship between effective tax rates and the size of the firm by deciles of turnover and employees. Each graph depicts the trend in ETR at the mean and median level measured by the axis on the left, as well as the dispersion measured on the right hand side axis. We compare simulation results for the 2008 corporate tax reform (our benchmark simulation) with those for the current tax system after the most recent tax reforms. As we can see, the relationship between the ETRs and the turnover is quite stable for the most recent tax regime, while it shows a moderate upward trend in the former tax system (Figure 2). In contrast, in the current tax regime the relationship between the ETRs and the number of employees is quite stable up to the 8th decile, afterwards the profile changes becoming inversely

Table 5 - Effective tax rates by small and other companies (percentage points) - only ACE beneficiaries

		pre-ACE	post-ACE	difference
mean	total	31.6	27.9	3.7
median	total	28.8	27.1	1.7
by turnover:				
mean	small	32.6	28.3	4.3
	other	29.6	27.1	2.5
median	small	29.3	27.3	2.0
	other	28.0	26.7	1.3
by employees: mean				
	small	33.5	29.0	4.5
	other	28.9	26.4	2.5
median	small	29.7	27.6	2.1
	other	27.7	26.4	1.4

pre-ACE corresponds to the *expanded IRAP deduction* simulation; post-ACE is the *ACE simulation*. See also note for Table 3

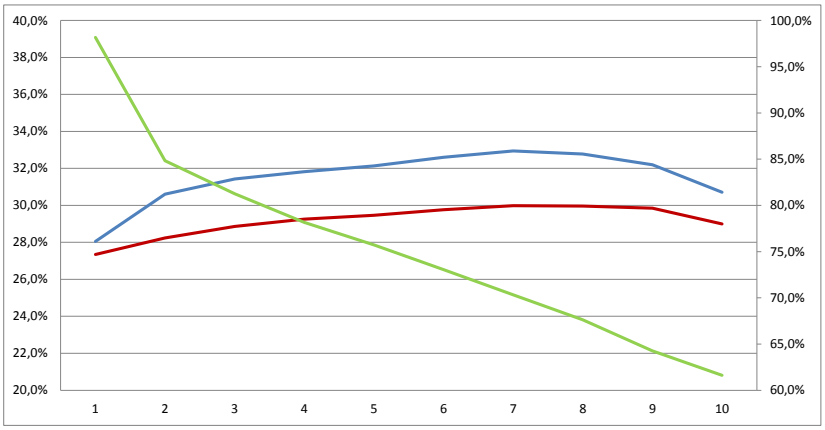
related to size, while it was quite stable overall in the previous tax regime (Figure 3). Notice that the difference between mean and median is quite regular under both tax regime when firm size is captured by turnover. This is not the case when we consider the number of employees: the difference between mean and median values is higher for firms in the bottom side of the distribution, indicating the presence of very high ETR values for smaller firms than for other firms. It is also worth underlying that the dispersion is overall quite high and inversely related with firm size, according to both criteria.

5. Concluding remarks

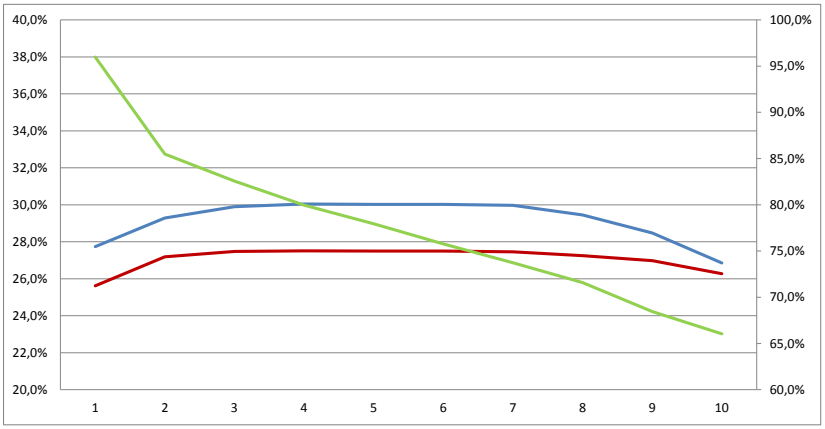
The measurement of effective taxation of companies is a difficult task. To address the complexities posed together from corporate taxation and the heterogeneity of firms, we need a considerable amount of information throughout the enterprise as well as advanced tools. This paper illustrates the new ISTAT-MATIS microsimulation currently used by ISTAT in the economic analysis of corporate tax reforms in Italy.

We use a unique database that combines information from corporate tax returns data, company accounts and statistical archives as a basis for the computation of the tax base. The merging of tax and accounting information provides comparative advantage in terms of precision for the tax base compared to other databases that only rely on accounting data. In addition, statistical archives allows us to link the variabil-

Figure 2 - Effective tax rates by deciles of turnover



(a) Benchmark

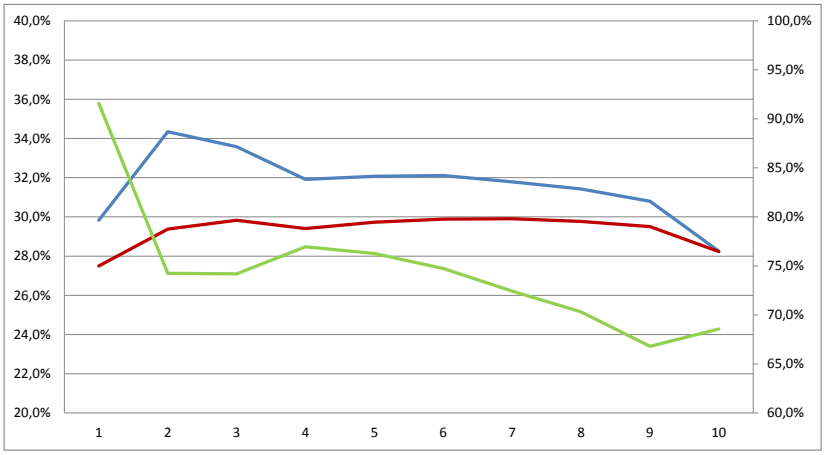


(b) ACE

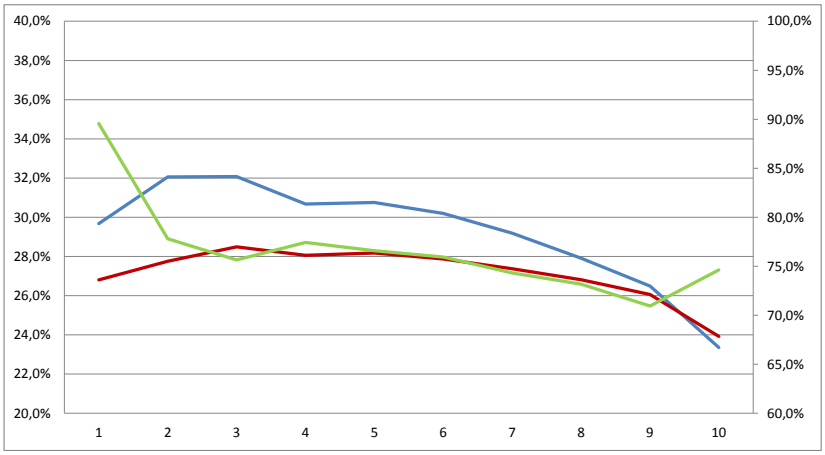
Benchmark simulation incorporates the 2008 tax reform and all subsequent changes until 2010. *ACE* simulation includes in addition the 2011 reform of tax losses, all IRAP deductions from IRES, and the ACE introduced in 2011

ity in effective tax rates with some relevant firm's characteristics usually disregarded in this type of analysis, such as the degree of internationalization of the firm.

Figure 3 - Effective tax rates by deciles of employees



(a) Benchmark



(b) ACE

See note for Figure 2

The model framework is multi-period in order to account for inter-temporal components of the taxable base, such as losses carried forward, group consolidation or tax allowances carried forward. In particular, the structure of the model allows us to

account for all relevant interdependencies among tax provisions over time, as well as to trace the cumulative effects of the incremental ACE regime recently introduced in Italy.

In this paper, we describe the main features of the Italian Corporate Income Tax, the simulation methodology used and the computation of corporate effective tax rates. We also show some evidence based on our simulation results on the relationship between ETRs and firm size. From the empirical investigation, it appears no clear relation between the ETR and the turnover of the firm according to both the 2008 tax regime and the current one. The relationship between the ETR and the number of employees seems positive only in the upper deciles after the introduction of the Irap deduction from the IRES tax base. Differently from the Belgian ACE, the Italian ACE regime reduces the tax burden to a higher extent on small firms than larger ones. Caiumi and Di Biagio (2015) provides deeper insights of the impact of the recent tax reforms.

Policy makers are concerned about whether they can maintain their current levels of corporate income tax revenues and how they can create an attractive investment climate for domestic and foreign investors. This study contributes to the literature on firm level models and shows how the model framework developed here can be particularly suited to evaluate the gains from the implementation of alternative tax systems. Further efforts should be devoted to enrich the analytical potential of ISTAT-MATIS by incorporating firms' responses to tax changes.

A The validation of the model

In this appendix we assess the performance of the current model to consistently approximate the IRES tax base and to provide fine-grained policy information. In Table A.1 simulation results are compared with official data provided by the Department of Finance for the same tax years, 2008-2011. At the aggregate level the IRES tax due is over estimated by only 3% in all four years considered. Tables A.2-A.4 compare estimates of the main components of the taxable base with information drawn from tax declarations at the firm level for the last year of simulation (2011). As we can see, for losses carry-forward, losses used and the taxable base there are no systematic deviations of the ISTAT–MATIS microsimulation results: each variable is exactly predicted for more than 65% of companies in our database and the estimated deviation between simulated and actual data is lower than 2% on average (Tables A.2-A.4). The quality of our estimates drops for the ACE deduction. The distance with real data is on average equal to 11.2%. However, this does not seem to significantly affect the estimated distributional impact of the new ACE regime in terms of tax savings, beneficiaries and implicit tax rates as shown in Table A.5.

Table A.1 - Comparison of ISTAT–MATIS simulation results with official tax return data. IRES tax due (thousand of euros)

Tax year	Single entities		Fiscal groups	
	simulation	Agenzia delle Entrate	simulation	Agenzia delle Entrate
2008	23,954,612	23,589,293	14,766,116	14,124,477
2009	21,421,570	20,821,636	14,319,947	13,897,647
2010	22,808,730	22,143,140	12,782,185	12,292,081
2011	23,114,893	22,648,003	12,531,896	12,178,419

Source: ISTAT–MATIS microsimulation model and official tax return data from “Agenzia delle Entrate”

Table A.2 - Comparison of ISTAT-MATIS simulation results for the taxable base with tax return data: Losses carried forward, 2014

	companies	frequencies (%) over estimation	exact estimation	under estimation	simulated values (average)	UnicoSC (average)	difference %
Total	860,330	14.8	76.1	9.1	103,459	104,893	-1.4
Sectors							
Manufacturing	134,109	15.1	73.9	11.0	229,820	236,063	-2.6
Public utilities	14,592	22.2	70.5	7.3	232,638	237,059	-1.9
Construction	157,251	13.0	76.4	10.7	49,278	54,534	-9.6
Trade	186,210	14.0	77.9	8.1	75,542	77,726	-2.8
Other services	368,168	15.6	76.1	8.3	89,573	87,123	2.8
Turnover							
< 1	38,908	31.8	55.0	13.2	156,986	144,681	8.5
1-500,000	511,420	15.6	74.9	9.4	52,983	54,750	-3.2
500,000 - 2 mln	187,143	11.9	80.2	7.9	66,368	66,968	-0.9
2 - 10 mln	93,140	10.8	81.1	8.1	154,285	153,908	0.2
10 - 50 mln	23,644	9.3	81.8	8.8	507,702	508,501	-0.2
$>$50 mln	6,075	6.5	86.5	7.0	2,800,010	2,917,239	-4.0
Localization							
North-West	253,432	14.4	76.2	9.4	147,870	147,937	0.0
North-East	178,603	14.3	75.9	9.8	94,831	99,550	-4.7
Center	215,603	14.6	76.4	9.0	87,277	88,807	-1.7
South	212,692	15.8	75.9	8.3	74,190	74,396	-0.3
Ownership structure							
Standalone	696,640	14.9	76.5	8.5	47,800	46,581	2.6
Belonging to a group	137,285	15.1	72.8	12.1	244,647	248,759	-1.7
Consolidated taxation	18,172	6.7	87.3	6.0	637,898	701,374	-9.1
Foreign controlled	6,479	16.6	70.0	13.4	1,425,454	1,464,731	-2.7
Multinational	1,754	12.5	73.7	13.8	738,903	801,454	-7.8

Source: ISTAT–MATIS microsimulation model and official tax return data from “Agenzia delle Entrate”

Table A.3 - Comparison of ISTAT–MATIS simulation results for the taxable base with tax return data: Losses deduction, 2011

	frequencies (%)			simulated	UnicoSC	difference
	over estimation	exact estimation	under estimation	values (average)	(average)	%
Total	6.0	90.7	3.3	6,248	6,203	0.7
Sectors						
Manufacturing	7.1	88.2	4.7	13,946	14,195	-1.8
Public utilities	9.7	86.6	3.7	23,004	23,013	0.0
Construction	6.0	90.5	3.5	3,686	3,418	7.8
Trade	5.0	92.3	2.6	4,179	4,180	0.0
Other services	5.9	91.0	3.1	4,921	4,839	1.7
Turnover						
1	3.6	95.3	1.1	2,094	1,969	6.3
1-500,000	6.0	91.3	2.7	2,229	2,081	7.1
500,000 - 2 mln	6.3	89.3	4.4	4,920	4,732	4.0
2 - 10 mln	6.4	88.5	5.1	11,868	11,673	1.7
10 - 50 mln	6.2	88.5	5.4	41,902	42,599	-1.6
50 mln	4.6	90.8	4.5	187,178	200,148	-6.5
Localization						
North-West	6.0	90.4	3.6	9,048	9,076	-0.3
North-East	6.0	90.3	3.7	6,691	6,671	0.3
Center	5.9	90.9	3.2	5,299	5,219	1.5
South	6.0	91.1	2.9	3,503	3,385	3.5
Ownership structure						
Standalone	5.8	91.2	3.1	3,284	3,131	4.9
Belonging to a group	7.1	88.3	4.7	12,428	12,483	-0.4
Consolidated taxation	3.8	93.3	2.9	39,013	42,899	-9.1
Foreign controlled	7.4	85.8	6.8	79,955	80,085	-0.2
Multinational	9.1	84.2	6.7	88,069	81,773	7.7

ISTAT–MATIS microsimulation model and official tax return data from “Agenzia delle Entrate”

Table A.4 - Comparison of ISTAT–MATIS simulation results for the taxable base with tax return data: aggregate, 2011

	frequencies (%)			simulated	UnicoSC	difference
	over estimation	exact estimation	under estimation	values (average)	(average)	%
Total	11.5	67.4	21.0	135,725	134,832	0.7
Sectors						
Manufacturing	16.4	58.1	25.5	294,425	293,124	0.4
Public utilities	12.5	59.6	27.9	1,013,578	1,006,772	0.7
Construction	13.6	65.3	21.0	54,680	52,664	3.8
Trade	11.3	68.0	20.6	102,975	102,597	0.4
Other services	8.9	71.7	19.4	94,303	94,012	0.3
Turnover						
1	5.3	90.7	4.0	12,275	11,017	11.4
1-500,000	6.9	77.9	15.2	15,438	15,310	0.8
500,000 - 2 mln	15.3	53.9	30.8	56,343	55,670	1.2
2 - 10 mln	24.1	39.6	36.4	185,103	183,345	1.0
10 - 50 mln	33.5	30.4	36.1	845,358	841,154	0.5
50 mln	42.0	26.0	32.0	9,979,026	9,935,446	0.4
Localization						
North-West	13.3	64.8	21.9	206,922	206,323	0.3
North-East	13.4	67.3	19.3	141,165	139,969	0.9
Center	10.7	68.1	21.3	132,680	131,054	1.2
South	8.8	70.0	21.3	49,407	49,161	0.5
Ownership structure						
Standalone	10.3	69.3	20.4	46,572	46,146	0.9
Belonging to a group	15.4	61.0	23.7	182,716	180,484	1.2
Consolidated taxation	24.1	51.9	24.0	2,499,399	2,492,682	0.3
Foreign controlled	20.9	53.9	25.2	1,686,271	1,679,438	0.4
Multinational	34.6	35.7	29.6	1,650,815	1,651,520	0.0

ISTAT–MATIS microsimulation model and official tax return data from “Agenzia delle Entrate”

Table A.5 - Comparison of ISTAT–MATIS simulation results for tax savings, beneficiaries and implicit tax rate arising from the new ACE regime with tax return data, 2011

	ACE allowance (%)		beneficiaries (%)		27,5%-implicit tax rate	
	simulation	UnicoSC	simulation	UnicoSC	simulation	UnicoSC
Total					-0.25	-0.23
Sectors						
Manufacturing	32.8	39.4	21.5	24.4	-0.24	-0.26
Public utilities	8.9	6.8	2.2	2.4	-0.18	-0.12
Construction	8.9	6.6	16.1	14.1	-0.30	-0.21
Trade	15.6	15.6	23.0	22.4	-0.24	-0.22
Other services	33.7	31.6	37.2	36.6	-0.28	-0.24
Turnover						
< 1	0.3	0.2	0.4	0.3	-0.18	-0.11
1-500,000	10.4	9.5	34.5	29.8	-0.38	-0.32
500,000 - 2 mln	11.0	7.8	29.7	27.7	-0.30	-0.20
2 - 10 mln	17.9	14.6	25.0	27.7	-0.30	-0.23
10 - 50 mln	19.3	18.7	8.3	11.3	-0.28	-0.25
> 50 mln	41.1	49.2	2.1	3.2	-0.20	-0.21
Localization						
North-West	48.1	51.0	36.3	39.8	-0.27	-0.26
North-East	23.3	23.9	25.3	29.7	-0.27	-0.25
Center	18.8	18.2	21.7	19.4	-0.19	-0.17
South	9.9	6.9	16.7	11.2	-0.28	-0.17
Ownership structure						
Standalone	31.4	24.1	72.9	68.0	-0.28	-0.20
Belonging to a group	26.5	25.6	21.3	24.0	-0.31	-0.27
Consolidated taxation	33.9	40.7	3.7	5.2	-0.22	-0.24
Foreign controlled	5.7	6.9	1.5	2.0	-0.15	-0.17
Multinational	2.6	2.7	0.6	0.8	-0.26	-0.24

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