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Strategic sectors and essential jobs: a new taxonomy based on employment multipliers

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Strategic sectors and essential jobs: a new taxonomy based on employment multipliers*

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Abstract

In this paper we propose a novel sectoral taxonomy integrating three different attributes of sectors, namely i) the strategic dimension reflected into their belonging to different classes of the Pavitt taxonomy, ii) the capacity to create jobs both internally and externally with respect to their sector/country, iii) the essentiality in satisfying basic needs. To accomplish the task we rely on the World Input-Output Tables and on the Socio-Economic Accounts database (Timmer et al., 2015) to build vertically integrated sectoral employment multipliers and we focus on Italy as a case study, a country which has undergone a deep structural transformation in the last twenty years, loosing productive capacity and also employment potential. The period of investigation goes from 2000 until 2014. We validate the patterns against other selected OECD countries. We finally propose an agenda for industrial policies identifying three specific sectors of intervention for the State, namely the pharmaceutical, the automotive and the care sectors.

Keywords: input-output, industrial policy, productive structure, employment dynamics, care sectors

JEL classification codes: J21, L6, O14, O25

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1 Introduction

Identifying what is a strategic sector in order to foster growth and development of a given country, from an industrial policy perspective, is an object of primary interest. Strategic sectors are those commonly understood as drivers of change and transformations. In particular, evolutionary and structuralist approaches have usually identified so called high-knowledge and high-opportunities sectors as those embedding cumulative learning regimes, economies of scale and scope, disruptive technological and organizational innovations. Those sectors are commonly grouped under the so-called *Science-based* and *Specialised supplier sectors*, considering the Pavitt taxonomy (Pavitt, 1984), or alternatively as high R&D or more recently intensive digital sectors, according to OECD classifications (Calvino et al., 2018).

Although the importance of the embedded technological content, technology is only one aspect to assess the potential and the importance of a given sector. Together with the technological content another dimension is crucial to evaluate a given sector, namely its ability to create jobs. While the sheer number of jobs of a given sector is simply a proxy of size, the generation of employment outside the sector of belonging is an attribute usually not fully considered. Indeed, sectors are interconnected in their inputs requirements, involving both physical production and components, but also units of labour. Therefore, employment multipliers are a strong and useful statistical tool in order to rank sectors and evaluate their potentials. In addition, multipliers might be direct, i.e. involving the same sector (automotive vs automotive), indirect, i.e. involving another sector (automotive vs telecommunication), domestic, e.g., activating employment internally or, alternatively, foreign, e.g. activating employment outside the country borders. Those different classifications allow to detect whether the potential of employment generation is activated internally with respect to the sector/country or alternatively, externally.

A third attribute of sectors, more prevalent in services, is the so called essentiality of the needs that they are able to satisfy. While in the last two decades a strong emphasis has been put on so called KIBS (knowledge intensive business sectors), services to business firms seen as carriers of growth (Muller and Zenker, 2001; Corrocher and Cusmano, 2014), less importance has been devoted to so called essential jobs including healthcare, social services, education, sectors that in many countries are still largely under the realm of the State provision, the welfare state, but also as transportation, logistic and postal services. While KIBS have been almost unanimously considered to be strategic areas of investigation because their growth is related to businesses growth, none particular emphasis has been put on essential jobs until the advent of the pandemic, except by contributions in critical sociology mostly focusing on paid and unpaid care work and gendered division of labour (Orloff, 1996; Fraser, 2016, among others). In that phase, the attribute of essentiality of jobs has been explicitly and materially manifested, well beyond ethical considerations, by the exclusion of the latter from compulsory closures. Indeed, shutting done those activities would have meant first of all impeding to cure and deal with the disease.

Having considered all these aspects, it is urgent to enlarge the scope of understanding of sectors and of their importance in order to detect how to perform selective and vertical industrial policies

(Cimoli et al., 2009). In this paper we propose a novel sectoral taxonomy integrating three different attributes of sectors, namely i) the strategic dimension reflected into their belonging to different classes of the Pavitt taxonomy, ii) the capacity to create jobs both internally and externally with respect to their sector/country, iii) the essentiality in satisfying basic needs. To accomplish the task we rely on the World Input-Output Tables and on the Socio-Economic Accounts database (Timmer et al., 2015) to build vertically integrated sectoral employment multipliers and we focus on Italy as a case study, a country which has undergone a deep structural transformation in the last twenty years, loosing productive capacity and also employment potential. The period of investigation goes from 2000 until 2014. Before building our new sectoral taxonomy for Italy, including the attributes of being strategic, essential and of activating employment by means of sectoral interdependence, we validate the patterns against other selected OECD countries. We conclude by proposing an agenda for industrial policies based on the new sectoral taxonomy, identifying three specific sectors of intervention for the State, namely the pharmaceutical, the automotive and the care sectors.

The paper proceeds as follows: in Section 2 we present the theory and evidence of vertically integrated sectors; in Section 3 we introduce the notion of employment multiplier as a tool to operationalize the capacity of a sector to create employment according to input-output relations; in Section 4 we present our results in terms of both sectoral specialization and employment multipliers types and dynamics. Section 5 presents the sectoral taxonomy and a specific proposal for the implementation of industrial policies. Finally, Section 6 closes the paper.

2 Vertically integrated sectors: theory and evidence

The notion of *vertically integrated sectors* has been developed in the 1970s by Pasinetti (1973, 1977), as an enrichment of the so called analysis of industrial interdependecies and specifically building upon the analytical scheme proposed by Leontief (1951) with Input-Output tables (Scazzieri, 1990; Landesmann and Scazzieri, 1993, 1996; Di Berardino, 2017).

The idea behind the theory of vertically integrated sectors is the existence of sequential sectoral interdependencies, involving several stages of the production process, which for the sake of simplicity we can associate with the concept of supply chains, each of them activated for the production of a specific final commodity (one for each industry by assumption). In order to configure this dynamic interdependence, it is necessary to divide the entire economic system into sub-parts, called *subsystems*, each producing a final good and requiring, given the final demand, *direct* and *indirect* inputs from the other industries integrated with it. Taking into account the indirect inputs allows to include the entire chain of intermediate inputs a sector is providing to another one. The subsystem accounts for the flow of inputs produced by sector i and directly delivered to sector j at the final stage, and also for the flow of intermediate inputs produced by sector i but used by the other $N-i-j$ sectors to produce in turn intermediaries then provided to sector j. This interdependence is therefore essential for the sourcing or supply of the tangible and intangible inputs necessary in order to produce a given final output x. The idea is that firms, and therefore sectors, relate to each

others in order to be able to produce. Clearly, sectors have different degrees of interdependence and some of them are more autonomous or isolated than others. An archetype is the automotive and its associated industries. When a car company closes, all other suppliers of goods and services are deeply affected and challenged by the possibility to close down as well (Bivens, 2003).

The advantage of vertically integrated sectors consists in overcoming the traditional horizontal sector-based perspective of the production systems, and in that shifting the focus from sectors as separate entities to sectors representing economic branches integrated in supply chains (i.e. subsystems). Vertically integrated sectors can be calculated from Input-Output data, starting from the well known Leontief inverse matrix, and be used to reclassify an industry variable (as value added or employment) into an industry-by-subsystem matrix representation. The theoretical relevance of this approach and possible empirical applications have been recently addressed in Di Berardino (2017); Antonioli et al. (2020); Cresti et al. (2022); Riccio et al. (2022).

The first empirical application to the Italian case is due to Momigliano and Siniscalco (1982, 1984), more recently also taken up by Di Berardino (2017) and Di Berardino and Onesti (2021), among others. The latter two contributions have devoted significant efforts in investigating the increasing and evolving integration between manufacturing and services, with business services acting as key players in the process of manufacturing restructuring. The paper by Di Berardino and Onesti (2021) is of particular interest for our purpose inasmuch it explicitly takes into account the technological intensity of manufacturing subsystems, merging the evolutionary focus on the sectoral patterns of innovation with the framework of vertically integrated sectors. They show for instance that the major contraction in employment has mainly affected Suppliers Dominated manufacturing subsystems and that countries like Italy and Spain are mainly specialised in Suppliers Dominated and Specialised Suppliers subsystems, while in Germany and France the productive structure depends more on the production of Scale Intensive and Science Based subsystems respectively.

Concerning the empirical evidence on the Italian firms positioning in GVCs, without adopting I-O data, the works by Accetturo et al. (2011), Giunta et al. (2012), Agostino et al. (2016) and Accetturo and Giunta (2018) show that i) the positioning in GVCs explains part of the performance gap between Italian and German firms during the recession; ii) there exists considerable heterogeneity in Italian firms participating in GVCs; iii) the Italian involvement in GVCs is stronger when compared to Spain, France and Germany and the majority of Italian firms are suppliers (while in other countries this incidence is lower) that often operate in less profitable, intermediate stages of GVCs (Agostino et al., 2016). The low incidence of final producers displays another weakness of the Italian participation in GVCs, lacking key players that govern the chain through activities located at the beginning (e.g. R&D activity) or at the end (e.g. sales and after-sales services) of the production process, the high-value added activities according to the smile curve hypothesis (Meng et al., 2020; Baldwin and Ito, 2021; Stöllinger, 2021).

The GVCs literature has been increasingly relying on input-output data to extract measures of vertical integration and participation to supply chains, generally from an industry-by-subsystem matrix of value added embodied in intermediaries trade flows, (Koopman et al., 2014; Timmer et al.,

2014; Los et al., 2015; Kummritz, 2016; Constantinescu et al., 2019; Jona-Lasinio and Meliciani, 2019). Such measures, as the well known OECD/WTO Trade-in-Value-Added (TiVA) statistics, resemble mainly traditional indicators of offshoring activities, as the share of imported inputs in producing goods activated by final demand or specific foreign exports. On the basis of the I-O literature (Miller and Blair, 2009), summing elements by columns (row) backward (forward) linkages can be computed. The GVCs literature has often focused on the foreign component of backward linkages to calculate offshoring indicators since the seminal works by Feenstra and Hanson (1996, 1999). Such measures have been extensively used to relate changes in the performance of a sector not only to variation of its sectoral characteristics, but also on the changes taking place in the productive structure triggered by inter-sectoral linkages and final demand and thus on its position in terms of vertical integration or in terms of its participation in GVCs. Such indicators have been recently used also to assess sectoral employment dynamics (OECD, 2007; Gonzalez et al., 2015; Timmer et al., 2015; Marcolin et al., 2016; López González et al., 2019).[1]

3 Methodology and data: employment multipliers analysis

Among the various production inputs, one is of particular importance: labour. The amount of labour demanded by a firm in a given sector is not only limited to its direct employees/engaged workers, but it also includes the labour required to produce the intermediate goods demanded. Taking advantage of input-output analysis and of the Leontief inverse, it is possible to move from standard intermediate deliveries tables to the so-called employment multipliers matrix (Baker and Lee, 1993; Bivens, 2003, 2019), whose coefficients inform about the potential number of jobs generated internally and externally by each sector given a fixed amount of final demand (i.e. an additional unit), or given effective components of final demand in the period under consideration.

We take advantage of the approach put forward by Baker and Lee (1993) and Bivens (2003) to account for the amount of 'secondary' jobs supported by single industries in an economy. In this respect, the employment multipliers we construct aim specifically at measuring how variation in final demand in a given industry translates into wider employment changes throughout the economy. In this way we aim to investigate the international division of labour linked to global value chains, or as Suwandi (2019) puts it, the 'labor-value commodity chains'. Employment multipliers have also been studied by Valadkhani (2005) and Foster-McGregor et al. (2012), among others.

In the following, in the first part of the analysis we keep the final demand fixed, namely we consider one unit increase per period, in order to rule out the role of demand. This is exactly the reason why they are called multipliers. Multipliers represent a crucial part of input-output analysis as they enable to extract a considerable amount of information from an I-O table, linking variation in final demand to the repercussions throughout the whole productive structure. In order to calculate employment multipliers, we rely on the Leontief inverse, a matrix that allows the quantification of the sequential effects on the branches of the economy induced by a one-unit initial

[1] See Bontadini et al. (2020) for a concise review.

increase in the production of a final good.[2] Analytically, the starting point is the generic available input-output matrix $\boldsymbol{Z}$ of intermediate deliveries, from which we compute the matrix $\boldsymbol{A}$ of direct inter-industry coefficients, post-multiplying $\boldsymbol{Z}$ by the inverse of the diagonal matrix of sectoral gross output $\hat{x}$:[3]

$$\boldsymbol{A} = \boldsymbol{Z}\hat{x}^{-1} \tag{1}$$

Matrix $\boldsymbol{A}$ is then used to compute the Leontief inverse matrix:

$$\boldsymbol{L} = (\boldsymbol{I} - \boldsymbol{A})^{-1} \tag{2}$$

With $\boldsymbol{I}$ being an identity matrix. Considering n industries with $i, j = 1, ..., n$, every $l_{i,j}$ element of the Leontief captures the *direct* and *indirect* requirements of increased output of industry i needed to produce one additional unit of final good in industry j. The importance of this tool is given by the possibility to calculate the *indirect* flows of intermediaries, thus providing a *vertical* representation of input-output relationships, as every cell includes the whole amount of contribution from each sector in the rows to every final production in the columns, the so called vertically integrated sectors, or subsystems. To sum up, every column of the Leontief inverse contains all the productive inputs from the various branches needed to produce a fixed amount of the related commodity for final consumption and investments purposes. In our analysis we compute the matrix of direct and indirect contributions of labour of each sector to produce the goods in the economy activated by one more unit of final good, which represents our employment multipliers matrix $\boldsymbol{E}$:

$$\boldsymbol{E} = \hat{l}\,\hat{x}^{-1}\,\boldsymbol{L} \tag{3}$$

Where $\hat{l}$ is the diagonal matrix of sectoral employment which, divided by $\hat{x}$, the diagonal matrix of sectoral output, results in a diagonal matrix of technical labour coefficients. $\boldsymbol{L}$ is the Leontief inverse.

We employ global tables (n industries for each of the m countries), hence every element $e_{ic,jk}$ stands for the amount of employees activated in sector i in country c by a one-unit increase in final production for subsystem j of country k. However, our analysis is restricted to Italy, thus we omit the k subscript. On the contrary we keep the subscript c as we want to keep track of the whole international supply chain, that is of the whole column and not just of the part related to Italy. Given n as the total number of industries (by rows) and subsystems (by columns) and m as the total number of countries, $\boldsymbol{E}$ can be represented as an nm x nm matrix:

[2] In Input-Output analysis, every sector (or economic branch) of the economy is assumed to produce an homogeneous good. Available I-O tables measure trade flows in monetary terms, usually in million of US$, as it is the case for World Input-Output Tables. As a result, in the Leontief Inverse framework, one-unit of final demand stands for one million US dollars.

[3] The hat over variables stands for the transformation from vector to diagonal matrix.

$$\boldsymbol{E}_{nm,nm} = \begin{bmatrix} e_{11,11} & \dots & e_{11,jk} & & \\ \vdots & \ddots & & & \\ e_{ic,11} & & e_{ic,jk} & & \\ & & & \ddots & \\ & & & & e_{nm,nm} \end{bmatrix}$$

The columns of this matrix are defined as production subsystems and can be imagined as the chains or induced activities activated by the production of final goods. The assumption that this approach entails is that the number of employees belonging to a standard sectoral classification can be thought as getting embodied in all the intermediate trade flows. When looking at the main diagonal of the matrix, one observes the demand for labour inputs (i.e. the employment multiplier) generated internally - or *directly* - within the sector. In addition, it is possible to identify the multipliers in other branches of the economy generated from the same subsystem j. These external, or *indirect* multipliers can be distinguished into *domestic*, if the sector i in which the employment is generated is still belonging to the same country of subsystem j (that is Italy in our case), or *foreign* if the opposite holds. We will therefore compute three measures of employment multipliers for each Italian subsystem j:[4]

- Direct Multiplier: Employees activated by the Italian subsystem j in the respective industry j:

$$Direct_j = e_{jj} \tag{4}$$

- Domestic Indirect Multiplier: Employees activated by the sum of Italian subsystem j's multipliers over Italian industries excluding the respective one, j. This multiplier can be interpreted as a measure of outsourcing of productive processes out of the sector but within the domestic economy. Here we omit the subscript c as it is only referred to Italy:

$$Domestic\,Indirect_j = \sum_{i=1}^{n} e_{i,j} \tag{5}$$

- Foreign Indirect Multiplier: Employees activated by the sum of Italian subsystem j's multipliers over foreign industries. This multiplier can be seen as a measure of offshoring of production processes abroad. Here the subscript c is necessary as we refer to all available countries except Italy:

$$Foreign\,Indirect_j = \sum_{i=1}^{n} \sum_{c=1}^{m} e_{ic,j} \tag{6}$$

[4]Note that the use of the notion of *direct* versus *indirect* is different from the one usually adopted in Input-Output analysis to describe the direct and indirect coefficients of the Leontief inverse. Also in the employment multipliers matrix every cell contains the direct and indirect labour coefficients. What we do here is to distinguish different parts of the supply chain, hence in our framework we compute an internal/direct component and an external/indirect one (which in turn is composed by domestic and foreign sub-parts).

In the next section we use these three measures to assess the heterogeneous capacity to generate employees within and outside the sector. We exploit the aggregation by Pavitt classes in manufacturing and services in Italy. Symmetric industry-by-industry Input-Output tables $\boldsymbol{Z}$ can be taken by the World Input-Output Database (WIOD) (Timmer et al., 2015), which includes also the Socio and Economic Accounts (SEA) dataset providing variables at a two-digit level of aggregation (NACE Rev. 2 classification) as employment, value added, gross fixed capital formation, labour compensation and so on. WIOD (2016 Release) is available for the period 2000-2014, for 43 countries (plus one Rest of the World) and 56 sectors. We use the number of persons engaged as employment variable to construct a global employment multipliers matrix, from which then we omit all subsystems (columns), not belonging to Italy. We end up with a 2408x56 matrix.[5]

4 Results

We now present our results in terms of both horizontal (industry) and vertical (subsystem) dimensions, accounting for sectoral heterogeneity and the dynamics of employment multipliers by Pavitt classes.

4.1 Sectoral heterogeneity and technological patterns: horizontal perspective

We start by presenting an overview of the recent evolution of the Italian productive structure in terms of labour productivity and employment evolution. In line with evolutionary studies documenting sectoral patterns of innovation and industry heterogeneity in terms of innovative capacity and learning regimes (Dosi, 1982; Pavitt, 1984; Breschi and Malerba, 1997), we aggregate sectors according to the Pavitt Taxonomy (Pavitt, 1984), a sectoral classification made of four classes characterized by heterogeneous i) technological attributes, ii) internal learning processes and iii) positioning along value chains. Such taxonomy, revised by Bogliacino and Pianta (2010, 2016) to include services beyond manufacturing, includes:

- Suppliers Dominated industries (e.g. Textile), in which innovation and learning depend from the acquisition of intermediate inputs and capital goods purchased from other sectors.
- Scale and Information Intensive industries (e.g. Automotive), in which innovation capabilities arise from the adoption of capital inputs embedding high technological contents but also from the ability to internally develop complex products and to manage complex organizations. Learning is cumulative and its effect is amplified by scale economies.
- Specialised Suppliers industries (e.g. Machinery and Equipment) providing capital equipments and components to a large spectrum of "downstream" sectors. Learning relies on

[5] 2408 rows stand for the 56 sectors in the 43 countries. SEA's variables for Rest of the World are not available, hence we omit from the Leontief before computing the employment multipliers matrix. 56 columns merely stand for the 56 Italian subsystems. We use Number of persons engaged instead of standard Number of employees (both available in SEA) mainly because the latter was a missing information for China. Employment is provided in thousands of units, so we divided each value by 1000 in order to get the exact number of jobs activated.

innovative efforts through formal expenditures on R&D and tacit knowledge accumulation in the design of artefacts and in their customization.

- Science Based industries (e.g. Pharmaceutical), whose technological progresses are strongly linked to those of basic and applied research and are locus of potential generation of new knowledge.

The four categories are presented by order of technological innovation content. The first two are considered as *downstream* classes while the last two are considered as *upstream* classes of the innovation process.[6] Indeed, specialization in highly innovative sectors, the upstream Pavitt classes, has been found to improve countries' development prospects (Dosi et al., 2021b). We now turn to present the evolution of these classes of industries.

Figure 1 shows the manufacturing shares of employees over the total of the economy distinguishing by the four categories. A clear tendency of deindustralization is detected in the Pavitt classes with lower technological content, especially for SD (green) and SII (blue) in the years of interest. Notice how these two categories represent the highest share of employees in absolute terms in manufacturing. In contrast, a steady trend is displayed by SS (violet) and SB (red). The first take-home message is that, as technological content and learning capabilities increase, the employment share absorbed in absolute levels is lower. However, in terms of dynamics, the employment share in sectors with higher technological content tends to be constant while it is significantly falling in sectors with lower technological content.

Figure 2, restricting on manufacturing, shows how the technological characterization adopted is reflected in the dynamics of labour productivity. In fact, labour productivity, here calculated as the ratio between the (nominal) value added generated and the number of employees for each individual industry, weighted by the industry's share in the relative Pavitt class, shows that the sectors with the highest technological innovation content, represented by the SB and SS classes, are those with the highest levels. However, given the tiny employment weight of these industries, the overall trend in labour productivity is much more driven by the SD and SII classes, with remarkably lower levels leading to the problem of stagnant productivity and neo-dualism in the Italian productive structure, as recently emphasised also by Costa et al. (2021). Two remarks are also needed: first, the 2008 crisis has represented a deep regime shift concerning the dynamics in labour productivity, impacting the whole four classes, which however show different reaction capacity in so far SB but also SD have been relatively less hit in terms of losses with respect to the two intermediate classes. Second, SII in which Italy historically presents a productive specialization, in the post-crisis period converges toward the bottom, reaching the lowest class SD, instead of approaching the immediately upper class, SS. Note that SII includes, among others, the automotive industry, which in terms of employment share is among the largest SII industries.

[6] In the following we will use the abbreviations SD (Supplier Dominated), SII (Scale and Information Intensive), SS (Specialised Suppliers), SB (Science Based) and NA (Not Assigned) for the group of services not belonging to any class.

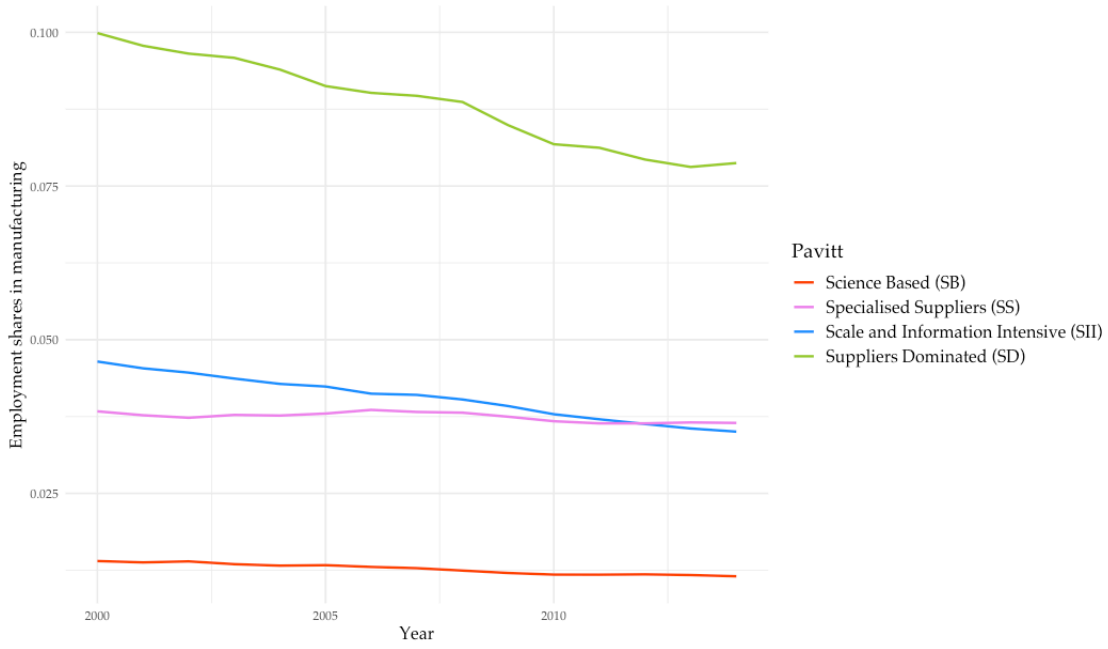

Figure 1: Employment share in manufacturing over the total of the economy, distinguished by Pavitt class: Science Based (red), Specialised Suppliers (violet), Scale and Information Intensive (blue), Suppliers Dominated (green)

If manufacturing has lost employment shares in the last twenty years, the dynamics of services appears characterized by an opposite trend as shown in Figure 3 in which the shares of employees in services represent almost the 70% of total employment. However, a problem of non-strategic specialization is detected also in services, as the workforce is largely absorbed by sectors with low content of innovation and learning capabilities, as it is the case for transport, logistics, wholesail and retail trade, accommodation etc. Remarkably, the group of industries absorbing the largest fraction of employment is composed by those services not assigned to any Pavitt class (Not Assigned) according to the revised Pavitt taxonomy proposed in Bogliacino and Pianta (2016). The NA category is composed by activities such as education, human health and social services, domestic care and home services. In the following, we will dig into the attribute of essentiality of those industries and in that overcoming the NA category.

Overall, the documented empirical patterns are in line with other studies pointing at the structural change process affecting the Italian economy (Confindustria, 2012; Accetturo et al., 2013; Arrighetti and Ninni, 2014; Lucchese et al., 2016; Di Berardino and Onesti, 2021). The main findings relate to the deindustrialization process at work, i.e. the relative slowdown of manufacturing in terms of hours worked and value added produced, with a simultaneous rise of services. In addition, a polarization in productivity and innovation dynamics is also detected, with increasing attributes of dualism among Italian firms and related industries (Bugamelli et al., 2018; Costa et al., 2021; Dosi et al., 2021a).

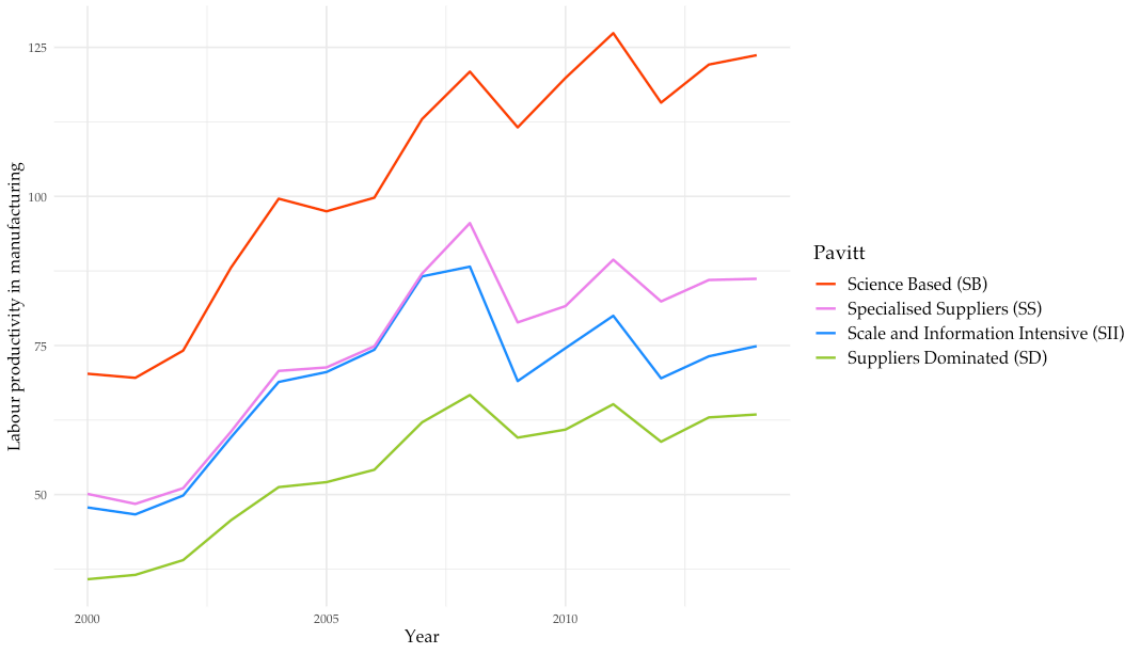

Figure 2: Labour productivity in manufacturing over the total of the economy, distinguished by Pavitt class: Science Based (red), Specialised Suppliers (violet), Scale and Information Intensive (blue), Suppliers Dominated (green).

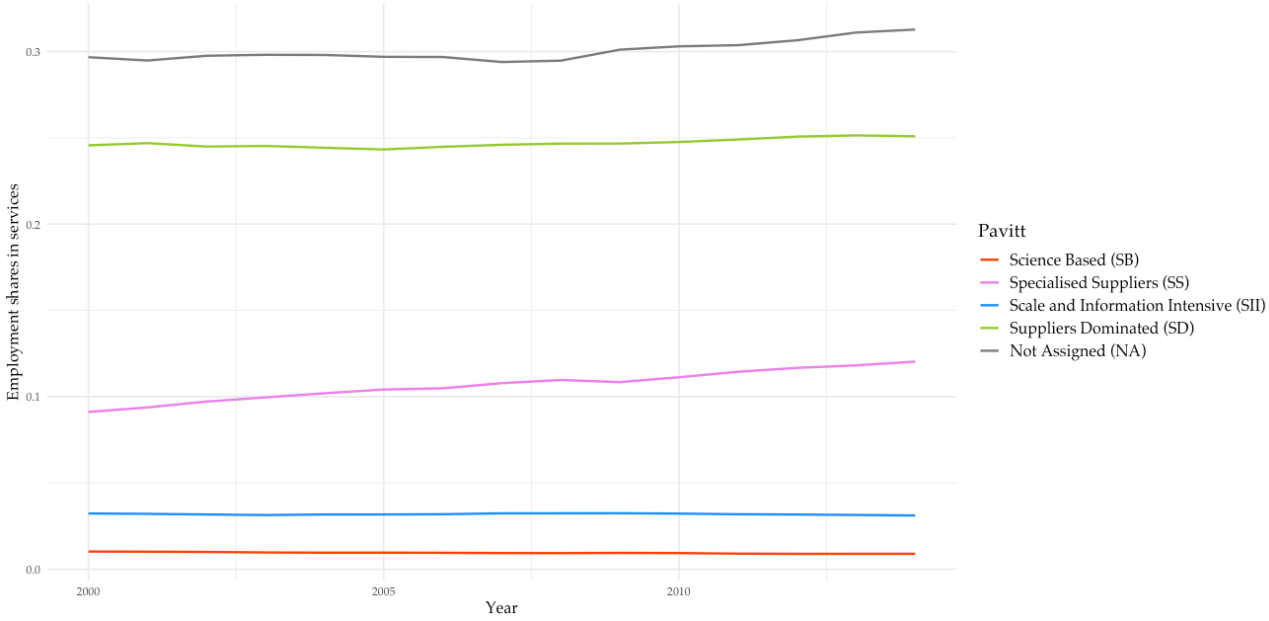

Figure 3: Employment share in services over the total of the economy, distinguished by Pavitt class: Science Based (red), Specialised Suppliers (violet), Scale and Information Intensive (blue), Suppliers Dominated (green), Not Assigned (grey).

4.2 Employment multipliers by Pavitt classes: vertical perspective

Figure 4 presents the time evolution of the three multipliers for the manufacturing aggregate classified in terms of the Pavitt's taxonomy for the period of interest (2000-2014). Each of the three multipliers is indicated in red (Direct), green (Domestic Indirect) and blue (Foreign Indirect). The first consideration relates to a progressive but common downward trend in multipliers over the period of observation. The underlying cause might be ascribed to technical progress, gradually expelling labour from productive activities by unit of output.[7] This evidence concerns all three types of multipliers and the four Pavitt classes.

Comparing the levels of the three multipliers, with the exception of the lowest technological class SD, where the direct multiplier (red) prevails over the other two, in the remaining three classes the domestic indirect multiplier (green) is always above the direct one. It should be recalled that the domestic indirect indicator can be considered as a measure of outsourcing of production activities outside the sector it belongs to (but remaining within the country). This signals that much of the productive activity depends on other sectors, whether in manufacturing or services. Therefore, the process of tertiarization and disintegration of firms can be seen in the constant reliance on labour input from other sectors of the economy.

With reference to the processes of offshoring and therefore the (potential) use of less domestic labour to produce Italian manufactured goods, the trend of the foreign indirect multiplier (blue) for SB and SII classes is really alarming. First, the clearest trend regards the foreign indicator (blue) in SII, always above the other two. This means that systematically the majority of jobs potentially activated by one million of US dollars in 2000-2014 by Italian subsystems concerns foreign industries. Secondly, we must notice that the SB class, which is considered the one that aggregates strategic high-tech sectors, is the one in which, since 2008, the foreign indirect multiplier has been increasing and then stabilising at a level much higher than the direct and domestic indirect ones. This relates to an accelerated process of relocation of manufacturing abroad and therefore less demand for domestic labour. Given that such dynamics explodes since 2008, the crisis marked a process of production restructuring towards abroad for Italian manufacturing as a whole. Lastly, for SD and SS, the foreign multiplier slightly below, after 2008 catches the other two indicators and this is especially true for SS.

Figure 5 focuses on services. Here the evolution is strongly different. First of all, we find a much more stable trend of the three multipliers over time, i.e. the issue of underlying technical progress is certainly less relevant in the case of service activities. With reference to the three multipliers, the direct one appears to distinctly prevail in all classes except for the SII class where the latter slightly overlaps with the domestic indirect one. The set of services not classified according to the Pavitt taxonomy - labelled as Not Assigned (NA) - largely represented by education, health and domestic care, appears to be the one wherein the discrepancy between the direct and indirect multipliers is

[7] We refer to technical progress as every employment multiplier stands essentially for an amount of labour, assumed to be entirely embodied in the intermediate goods, activated by a fixed amount of final demand, i.e. one unit (1 mn US $).

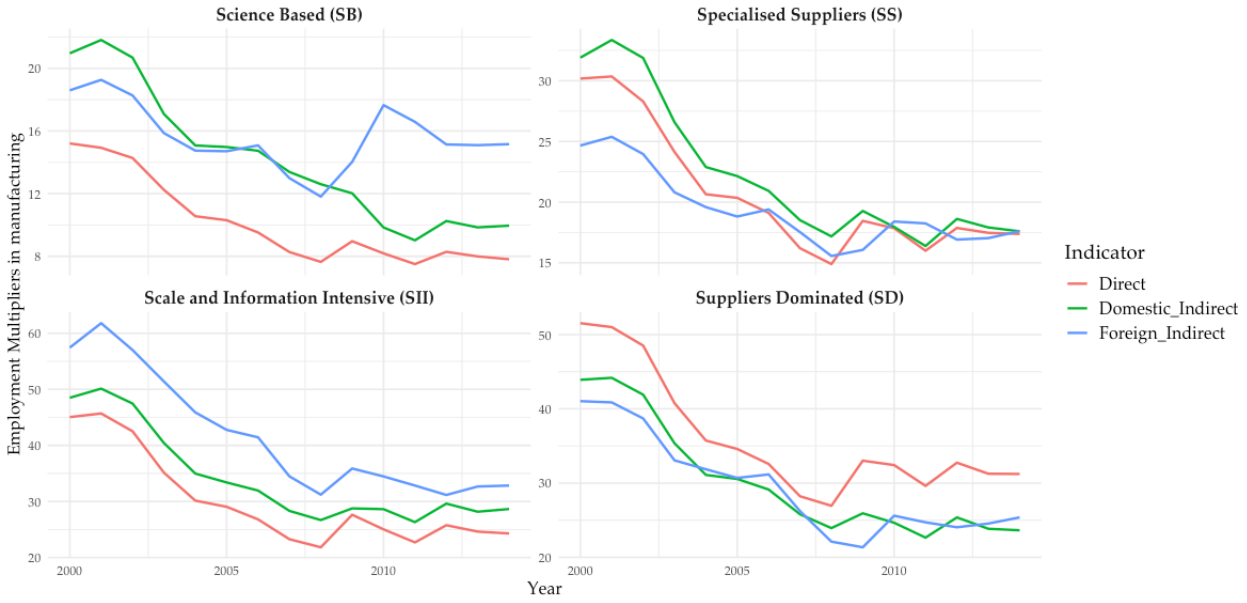

Figure 4: Trend in employment multipliers in manufacturing (direct, domestic indirect and foreign indirect) distinguished by Pavitt classes: Science Based; Specialised Suppliers; Scale and Information Intensive; Suppliers Dominated.

the greatest. Moreover, in such NA sectors, the amount of workforce potentially absorbed by one million dollars of final demand is extremely huge in comparison with industries belonging to other classes both in manufacturing and in services. Concerning foreign multipliers, it should be noted that in the case of services they are largely minor and in some cases almost non-existent. This clearly relates to the impossibility of trading certain types of services. It is therefore clear that the nature of interdependence that characterizes manufacturing versus services is deeply different.

From the evidence shown so far, in order to capture the properties of a productive sector as a whole with regard to its capacity to generate employment, it is not enough to simply look at the share of employment in the sector in itself, but it is necessary to consider its vertically integrated structure. And this holds especially for manufacturing. Indeed, if we consider the interdependencies of the entire subsystems, the multipliers generated in manufacturing are high and broadly comparable in absolute values to those generated by services, with the exception of the SD and NA classes.

4.3 Decomposition of indirect multipliers in manufacturing by Pavitt classes

The relevance of indirect multipliers for manufacturing industries can be further investigated. We have shown that the most advanced technological class, SB, has been increasingly offshoring productive activities abroad. This might be worrisome inasmuch the SB class gathers high-tech productions and workers' know-how which are likely to be lost by outsourcing parts of the production process. However, total employment multipliers do not allow to disentangle the destination of

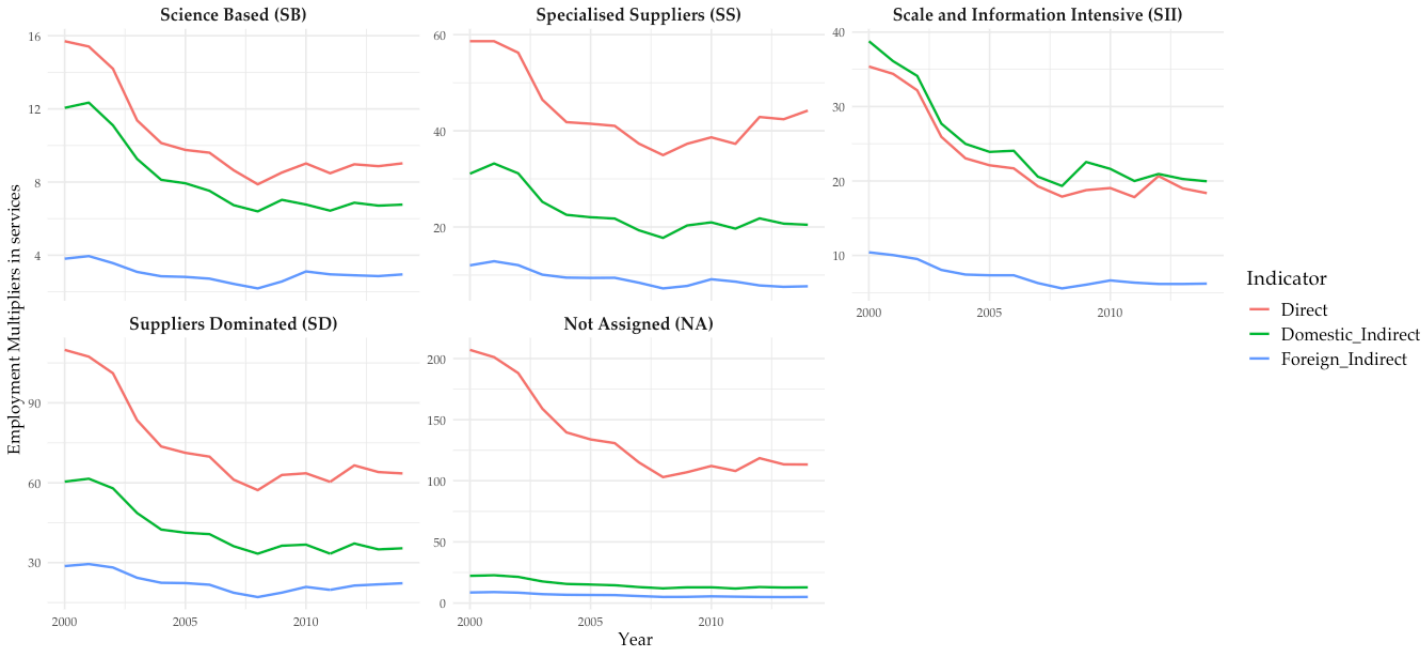

Figure 5: Trend in employment multipliers in services (direct, domestic indirect and foreign indirect) distinguished by Pavitt classes: Science Based; Specialised Suppliers; Scale and Information Intensive; Suppliers Dominated; Not Assigned.

such outsourcing and offshoring. In fact, they conceal various contributions destined to different industries and countries. Is the Italian SB class offshoring labour inputs to high-tech or low-tech productions? Is it externalizing manufacturing or services activities?

We can address these questions by assessing the composition of indirect multipliers, that is, we disentangle domestic (Figure 6) and foreign (Figure 7) multipliers distinguishing between manufacturing and services disaggregated by Pavitt classes. We end up with ten sub-indicators for each of the two measures: four multipliers by Pavitt classes in manufacturing, four multipliers by Pavitt classes in services, one multiplier for services not classified according to Pavitt taxonomy and a last one accounting for those sectors belonging neither to manufacturing nor services and related to utilities (mining, electricity an gas, water and waste collection, construction etc.). The sum of the ten components yields back the synthetic indirect indicator. In the following plots we show the percentage contribution of each sub-measure, focusing on three time periods, namely 2000, 2007 and 2014. We apply this decomposition to manufacturing only given the weak relevance of 'secondary jobs' activated by services.

First, by looking at Figures 6 and 7, we detect a prominent role of indirect multipliers toward Suppliers Dominated services (blue component) and this holds especially for the domestic components. In line with the literature on outsourcing and offshoring of services by manufacturing productions (Miroudot and Cadestin, 2017; Miroudot, 2019), our findings corroborate that manufacturing industries have been largely externalizing, especially within domestic borders, those

activities related to low-value added, 'heavy' services such as transport and logistics. On the contrary, comparing the two indicators (domestic vs foreign), we detect a remarkable role for the foreign indirect multiplier (Figure 7) toward the upstream Pavitt (SB in dark red and SS in light red) and the unclassified class (light grey share) which includes a broad heterogeneous category of activities (energy, mining, construction etc.). On the other hand, domestic indirect multipliers (Figure 6) display a significant sub-component toward Specialised Suppliers in services (turquoise bar), the so-called Knowledge Intensive Business Sectors (KIBS).

Looking by classes, the foreign indirect multiplier toward SB industries is higher especially in the Science Based class in itself in Figure 7, confirming that the increasing offshoring tendencies in SB class points to a loss of high-tech productive activities, and related workers' know-how, in favour of foreign industries. In this respect, the offshoring of Italian SB activities has been directed toward the SB class of industries worldwide. Finally, we do not detect significant changes in the composition of domestic and foreign indirect multipliers over time.

The decomposition of indirect employment multipliers in terms of activation of labour demand outside the manufacturing sector, both in services and abroad, confirms that i) the patterns of outsourcing are primarily directed toward low-value added service sectors as logistics and secondary towards KIBS, ii) the patterns of offshoring tend to destroy strategic industrial capacity and know-how, given that knowledge and competences of production processes to fabricate complex products, as in the case of SB and SS, are increasingly demanded from abroad.[8]

5 A sectoral taxonomy of employment generation capacity

Having considered the evolution and composition of employment multipliers in their different categories, we now move toward the construction of a comprehensive classification of sectors, advancing a proposal for a new sectoral taxonomy based on i) the types of employment multipliers more prevalent and ii) the attributes of the sectors. As will become clear, a methodological challenge that we face is providing a coherent way to categorize not only manufacturing but particularly services, being the latter deeply heterogeneous.

5.1 Sectoral ranking by employment multipliers

To build a sectoral taxonomy, we now move to a more disaggregated unit of analysis detecting which are the sectors mainly responsible for the creation of employment, both directly or indirectly, whether domestic or foreign. The taxonomy based on employment multipliers allows to characterize sectors beyond a purely technological dimension and to analyse their capacity to generate employment along the supply chain. The analysis however might be more nuanced, because claiming that a sector has a greater capacity to generate employment outside its own borders, i.e.

[8] Note that in services the notion of value added overlaps with paid wages, being intermediate inputs quite irrelevant. Therefore low-value added jobs correspond to low-paid jobs.

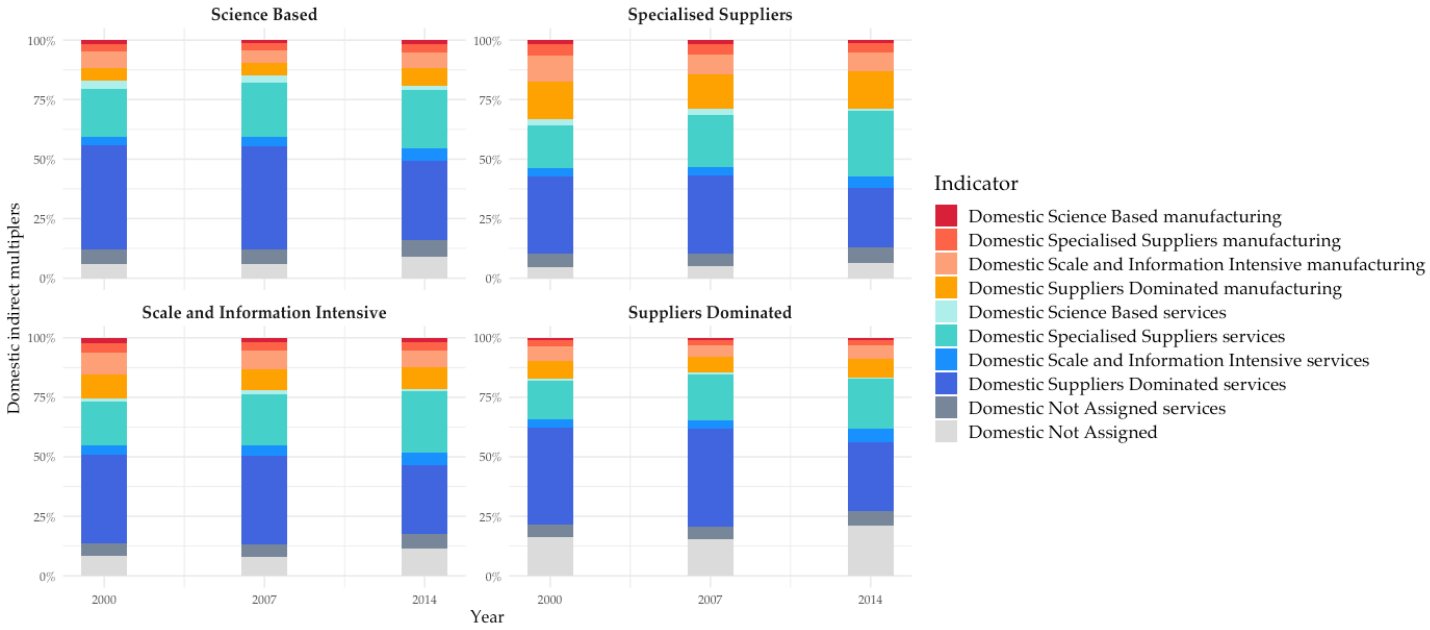

Figure 6: domestic indirect employment multipliers in manufacturing in 2000, 2007 and 2014 distinguished by Pavitt classes: Science Based; Specialised Suppliers; Scale and Information Intensive; Suppliers Dominated; Not Assigned.

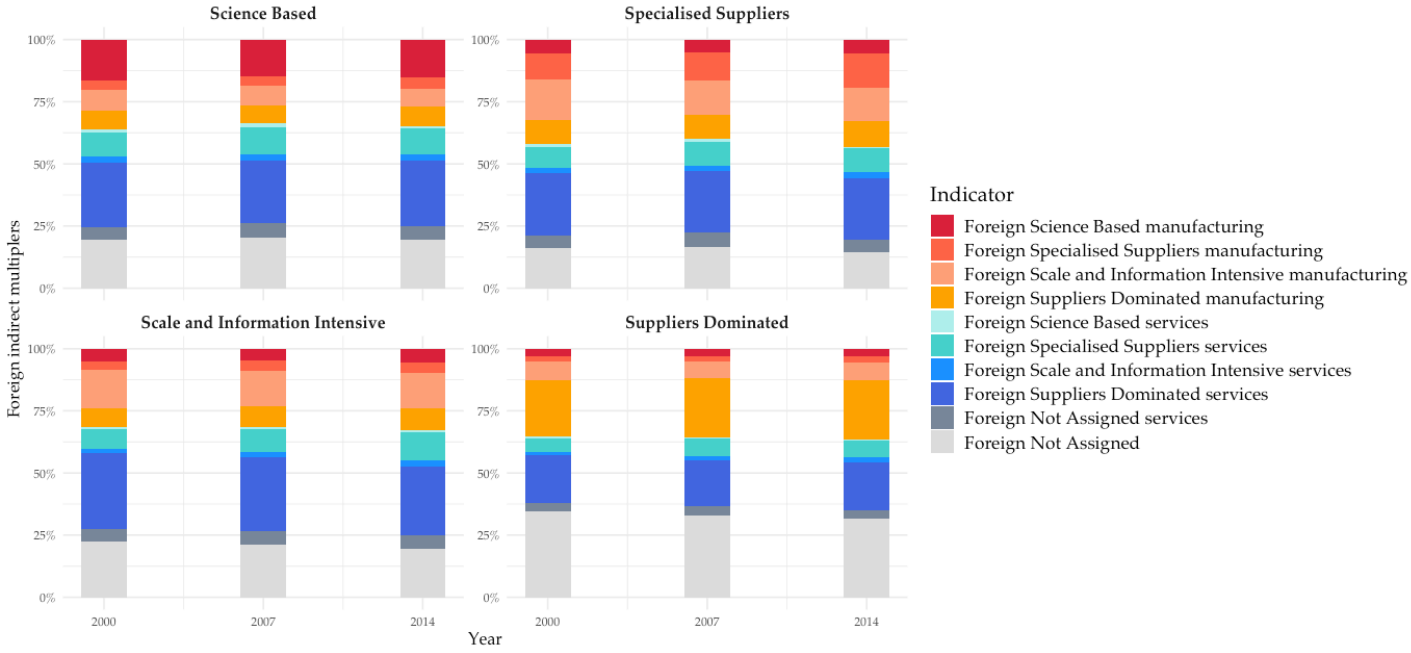

Figure 7: foreign indirect employment multipliers in manufacturing in 2000, 2007 and 2014 distinguished by Pavitt classes: Science Based; Specialised Suppliers; Scale and Information Intensive; Suppliers Dominated; Not Assigned.

it has greater indirect multipliers than direct ones, is equivalent to observing that the sector has a greater degree of outsourcing of production processes, within which labour is embodied.

Ruling out the temporal dimension and focusing on the cross-sectional one in 2014 (the most recent available year), we present in Figure 8 the ranking of all Italian industries in the three types of multipliers, highlighting also the Pavitt class to which they belong to.

Starting with the *direct* indicator (first column), we observe that the sector with the highest multiplier is the one related to activities of households as employers, which largely reflect home care activities.[9] This means that an increase in one unit of final output in this sector (equivalent to a monetary value of production of one million of US dollars) induces an increase in approximately sixty jobs in the sector itself. This number is an outlier across all the remaining multipliers assessed (but not across countries as we shall see). The other industries multiply directly less than twenty employees. Together with the aforementioned home care service, in the top of the ranking we register other essential activities related to education, social assistance, health care. In addition, the role of postal service, forestry and logging, crop hunting and animal production, retail trade, accommodation and food services is detected. Among the top fifteen industries in the direct multiplier ranking, but after the 'care' ones, the only high-tech activities (Specialised Suppliers class in this case) are the ones related to legal, consultancy, administrative and other professional, scientific and technical jobs.

Given this evidence, the sectors with the highest *direct* potential absorption of domestic employment are the so-called low-value added jobs. According to the revised Pavitt taxonomy, these sectors largely belong to the Not Assigned or to the Suppliers Dominated class which represent the groups of industries with the lowest technological content. On the other hand, some of these low-value added activities are related to domestic care and education and this aspect will be further elaborated in the proposed taxonomy in the next section.

To sum up, with reference to the sectors able to create more employment internally (direct multiplier), the key role of activities not belonging to any Pavitt class and displaying the lowest technological learning content is detected. Nonetheless, we call them *essential* jobs, as they are largely related to *care* services, thus enabling to denote their relevance in contrast with a pure *strategic* technological attribute.

Going to indirect multipliers, the values, both for domestic and foreign ones, reach a maximum around seven employees per one million dollar of final demand. Looking at the *domestic* indirect multiplier (second column), i.e. those industries that activate employment along the supply chain in Italy - but at the same time with a higher degree of outsourcing - top ranking industries are so-called heavy services, i.e. air, water and land transport, together with commercial services and publishing. In addition, medium and low-tech manufacturing industries emerge, such as food products,

[9]The label for this sector is 'Activities of households as employers; undifferentiated goods- and services- producing activities of households for own use'. This class includes, for instance, the activities of households as employers of domestic personnel such as maids, cooks, waiters, valets, butlers, laundresses, gardeners, gatekeepers, stable-lads, chauffeurs, caretakers, governesses, babysitters, tutors, secretaries etc. The service performed by this activity is consumed by the employing household. Other activities concern basic services as teaching or educating, or hunting and gathering, agriculture, provision of clothing and other items produced by households for their need.

automotive, transport equipment and furniture. The top industries in this ranking belong mainly to Suppliers Dominated, Specialised Suppliers and Scale and Information Intensive, showing more heterogeneity but less asymmetry in the level of multipliers than in the case of direct multipliers. In fact, the top activities multiplying employees domestically are equally referred to manufacturing and services industries. The role of heavy services such as air, water and ground transport stands out, together with low to medium technology manufacturing as food and tobacco, automotive, transport equipment. Moreover, the majority of industries display a domestic multiplier around four.

The third ranking shows the ordering of industries by *foreign* indirect multipliers. The novelty here is the role of offshoring in high-tech manufacturing such as chemicals, computer, electronic and optical, electrical equipment, belonging to Science Based and Specialised Suppliers classes. It must also be underlined the dominant role of manufacturing in general, with also Suppliers Dominated industries - as Textile and Food, beverages and tobacco - and Scale and Information Intensive industries - as Coke and refined petroleum products, basic metals and automotive - entering in the top part of the ranking. The multipliers for the top fifteen industries range from four to seven units, in line with those from the domestic indirect indicator, even though there is not a value around which the multipliers are centred. The presence of high-tech industries in this ranking offers another perspective to account for the alarming offshoring trend in the Science Based class in countries like Italy, already pointed out in Figure 4.

In order to validate our findings, we confront Italy against other three OECD mature economies (Germany, the US and France). Indeed, quite similar considerations apply to Figures 13, 14 and 15 in the Appendix in which we plot the same rankings for the other three economies. Few main differences emerge with respect to the Italian case, which are also quite telling of different productive and specialization strategies taken by countries and the varieties of capitalism at work. Germany, France and the US show less Specialised Suppliers industries among the top in the ranking for the domestic indirect multiplier. Regarding top positions for the domestic indirect indicator, differently from Italy, we detect Insurance and pension funding which rank second in Germany and third in France; Crop, hunting and animal production third for Germany; Water collection, treatment and supply fourth for France; Wood and cork third for the US. Concerning the foreign indirect multiplier we highlight the predominance of Specialised Suppliers and Scale and Information Intensive, while Science Based industries display lower positions in the ranking. Main differences emerge from: fishing and aquaculture third in Germany; Wood and cork again third for the US; Coke and refined petroleum products at mid ranking for the US, while in the others is among the top ten. Regarding the direct multiplier, only the US show different features, with values ranging from zero to fifteen, Activities of household ranking sixth, while it is usually first, and repair and installation in fifth position, while for Italy it was a middle-ranking industry.

Overall, despite country attributes, the detected similarities in the sectoral ranking lead us to advance a new taxonomy of sectors.

Figure 8: Multipliers in 2014, in industries by Pavitt classes: Science Based (red), Specialised Suppliers (violet), Scale and Information Intensive (blue), Suppliers Dominated (green), Not Classified (grey).

5.2 A taxonomy for selected representative industries

On the basis of their technological content, essentiality and potential capacity to generate employment within or outside their own industry, either domestically or abroad, it is possible to propose a novel sectoral taxonomy, which we summarise in Table 1.[10]

We start with the usual distinction between services and manufacturing industries, the latter more oriented towards jobs activation along the supply chains and basically dominating the foreign multiplier ranking.[11] This evidence is related to an important and, at a first-sight obvious, result: there is a strong dichotomy between high employment-generating *essential* jobs and low employment-generating *strategic sectors*.

We then identify six groups of industries, two in manufacturing and four in services, each of them defined along two main attributes, namely the types of employment multipliers (column) and the technological (strategic) vs essentiality dimensions by row mostly characterizing the industry. The main distinction in terms of the nature of activity, as said, stems from manufacturing versus services, the latter more heterogeneous than the former.

Within manufacturing, we distinguish according to the technological and strategic content, upstream Pavitt industries, with high foreign indirect multipliers (e.g, Chemicals, Computer, electronic and optical equipment) versus downstream Pavitt industries displaying prominent domestic and foreign indirect multipliers (e.g., textile, automotive, basic metals).

Switching to services, we classify a first group of activities with a huge direct multiplier and a low technological content, but at the same time exerting a prominent role in satisfying essential needs for society. Besides postal services we identify what we call the care activities. Then heavy services (e.g. logistics and transport) together with media and commercial services follow. These two categories share the feature of ranking quite high in domestic indirect multipliers.

Lastly, we identify another group of high-tech services that contributes to employment generation only with respect to the direct multiplier, but to a less extent than essential services and with an actual strategic role in terms of technological advancements not well identified. Indeed, this broad category could refer to the so-called Knowledge Intensive Business Services (KIBS) sectors, consisting of companies providing ICT services, marketing, legal and accounting consultancy, often considered the new productive heart of a decadent manufacturing industry under servitization. Insurance, financial companies, real estate consultancy, do not rank high in direct multipliers and do not emerge at all for Italy, while Germany and France display a different pattern of the industry. The telecommunications industry, research and development, ICT services show up only after the top ten position in each employment multiplier ranking. The only exception of a specialised supplier service is advertising and market research which ranks second for domestic multiplier and eighth for direct one. Overall, the service industries which generate more employment have little to do with the much vaunted financial and consultancy sectors, but are instead those that actually

[10] We took into account the most important and representative sectors, being also the ones for which the comparison with other countries hold.

[11] The manufacturing vs. services perspective can be better appreciated in graph 12 in the Appendix.

provide some form of care work and in fact meet a direct need.

The taxonomy shows that the notion of labour value in a given sector goes beyond a mere technological attribute and concerns, for example, the capacity of the sector to generate new employment. Our starting point was to highlight a productive crisis in strategic sectors as SB and SS classes, chiefly prone to offshoring. We then showed how sectors defined as essential are not only essential in terms of what they provide but also in terms of their capacity to create employment. The intangible sectors of insurance, finance and real estate are the main absentees in Italy at least. The taxonomy therefore tends to reconcile the contrasting patterns of being essential vs being strategic for each given sector.

5.3 Three proposals for industrial policy

In light of the taxonomy, we now move to the policy sphere providing an implementation of the tool to identify the industries wherein to operate. We propose therefore an agenda for a direct intervention in three specific industries in order to identify specific priorities with respect to a broader framework of an industrial policy strategy for Italy already highlighted in the literature (see Lucchese et al., 2016; Cresti et al., 2020). Our three proposals are guided by both criteria of strategic relevance for the industrial capacity of the country and maintenance of productive activities in specific sectors, and criteria of essentiality of some productive activities and the ensuing need to attribute recognition to often defined unproductive jobs.

Methodologically, we move a step forward with respect to potential employment multipliers towards effective multipliers, inasmuch we want to propose policy actions on the basis of the actual trends, driven by effective rather than potential demand, that have taken place in the period of interest. As a result, we post-multiply the employment multipliers matrix for the diagonalized matrix of final demand $\hat{d}$, provided again by the WIOD and including both consumption and investment components from all countries in the dataset.[12] We end up with matrix $\boldsymbol{E_{eff}}$, whose generic element $e_{ic,jk}$ stands for the amount of the employees effectively activated in sector i in country c by the effective component of final demand for subsystem j of country k.

$$\boldsymbol{E_{eff}} = \hat{l}\,\hat{x}^{-1}\,\boldsymbol{L}\,\hat{d} \tag{7}$$

Backward and forward linkages are then calculated summing by columns and rows respectively. Therefore, we adopt the 'effective Leontief', that is the standard Leontief inverse matrix post-multiplied by final demand:

$$\boldsymbol{L_{eff}} = \boldsymbol{L}\,\hat{d} \tag{8}$$

The generic element $l_{ic,jk}$ of this matrix stands this time for the amount of production (in US$ mn) activated in sector i in country c by the effective component of final demand for subsystem j

[12] Final demand has been computed considering the consumption side (by household, government and organizations) and the investment one (capital formation and changes in inventories).

	Relevant Employment Multiplier(s)
Upstream Pavitt Manufacturing	*Foreign indirect* (e.g. Chemicals; Computer, electronic and optical; Electrical equipment; Machinery and equipment)
Downstream Pavitt Manufacturing	*Domestic and Foreign indirect* (e.g. Textile; Food, beverages and tobacco; Automotive; Coke, refined petroleum products; Basic metals)
Essential Services	*Direct* (e.g. Activities of households as employers; Education; Postal and courier activities; Human health and social work activities)
Professional Services	(e.g. Administrative and support service activities; Professional, scientific and technical activities; Architectural and engineering) activities; Legal, accounting and consultancy)
Heavy Services	*Domestic indirect* (e.g. Air transport; Water transport; Sewerage and waste)
Commercial and Media Services	(e.g. Advertising and market research; Video and music Publishing activities)

Table 1: Sectoral Taxonomy of employment generation capacity for selective industries

of country k.

Pharmaceutical

The Italian pharmaceutical industry ranks among the first positions in Europe in terms of sectoral production, but increasingly more as a third party producer, in which Italian companies, although registering high volumes of turnover and exports, are responsible for one or more stages of the production process but not of the final production and commercialization of the goods. This pattern is becoming a common feature among the most advanced sectors of the Italian manufacturing and it heralds the consolidation of a new model of productive specialization in which the country tends to be subordinated to foreign production networks guided by big corporations. From pharmaceuticals to components and machinery, Italy produces on behalf of third parties for manufacturers in other countries, like Germany (Gaddi and Garbellini, 2016; Celi et al., 2017; Gaddi et al., 2021). In this respect, acting as subcontractor does not allow to play an actual role in the definition of the research and development strategies of the firm that tends to become subordinate to the production and market choices of the foreign clients.

Vertically integrated sectors can be useful not only to capture the backward side of the productive integration (the inputs required), but also the forward one (production triggered by foreign demand). Regarding the backward dimension, we have illustrated that the Italian pharmaceutical industry (included in the Science Based class) from 2000 onward has progressively increased the offshoring of its production activities, transferring respectively demand for inputs, and among these employment, abroad. At the same time, the position as subcontractor of the industry, that is producing for other chains, has been consolidating, as shown in Figure 9, in terms of employment (red line) and production inputs (light blue line) activated by the effective components of foreign final demand. In summary, the Italian pharmaceutical industry produces a lot, but largely intermediate components for final products from other countries, i.e. it depends on the strategies of foreign companies, as in the case of German and US pharmaceutical companies, for instance.

The need for a State able to produce pharmaceutical goods has never been more urgent than during the Covid-19 pandemics (Dosi, 2021; Florio, 2022), in order to contrast the supply crisis of vaccines and other essential goods for collective health. In this context, we argue that there is a huge need for investments in a public pharmaceutical industry capable of doing research and innovation in areas that are unprofitable for the private sector but necessary for public health. In addition, the role of the State could manifest through public procurement measures aimed at stimulating productions of specific essential final products as antibiotics or vaccines, and in that orienting the research direction. What is also required is a comprehensive strategy for the Italian productive system, ranging from employment to the production of essential final goods. Indeed, the production of pharmaceuticals cannot be separated from the underlying supply chain of equipment, machine tools, laboratory instruments and reactors needed for experimentation and production. For its nature of sector vertically integrated with the entire production system and its ability to stimulate innovation and create jobs, a new industrial policy cannot ignore a targeted and radical strategy

for the pharmaceutical industry which links good employment generation, innovation and health care.

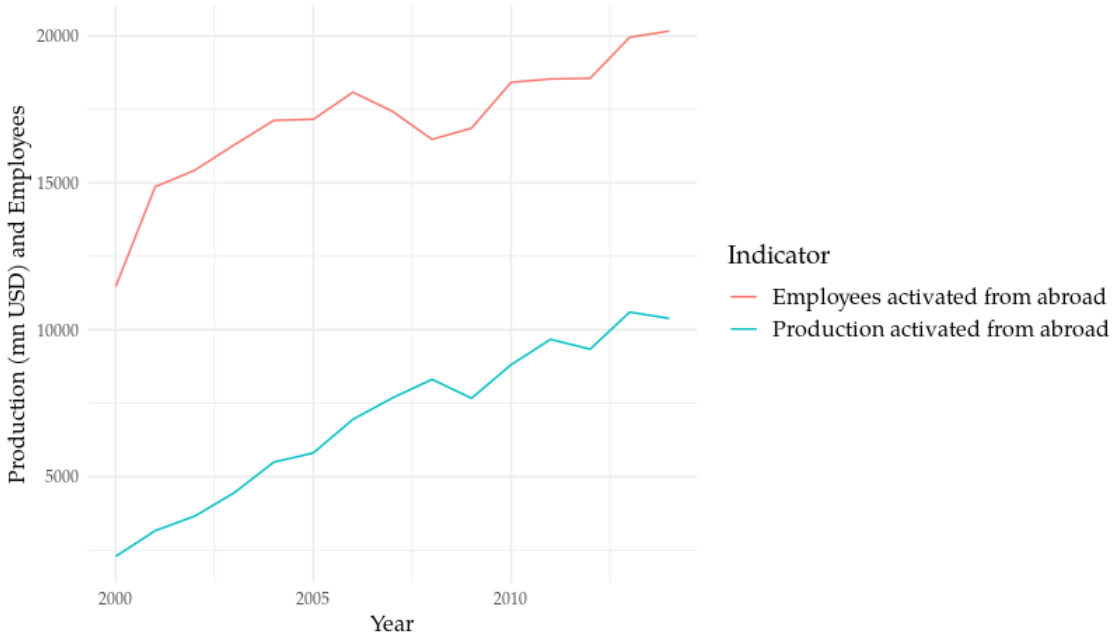

Figure 9: Trend in production (mn$) and employment (employees) in Italian pharmaceutical industry activated from effective components of demand for foreign final goods

Automotive

First, the transfer of FIAT to FCA in 2014 and now the new acquisition by PSA with the formation of the neo-group Stellantis tell of an inexcusable absence of the State's role in influencing research and development trajectories, employment plans, car design and not least ownership structure. Italy, when compared to the other two main European car-producing countries (France and Germany) systematically fails to participate with ownership shares, in addition to a long-lasting lack of even a simple plan for car production. It is urgent, also in light of the new corporate restructuring that has taken place in the ex-FCA group, an industrial policy in the automotive sector that configures the role of the State as a guarantor of the public interest, especially in protecting and guaranteeing employment, and capable of providing direction and guidance on what to do and with which technologies, starting with sustainable and integrated mobility.

Figure 10 shows a dramatic fall in sectoral employment in the Italian automotive in recent decades (blue line). However, this trend is also associated with the highly integrated nature of the automotive sector, which is evident in its ability to generate employment chiefly outside the sector, in the supply chain proxied by domestic indirect multiplier (green line), rather than internally by looking at direct multiplier (red line). Thinking of this industry as an isolated entity does not allow to understand its potential, typical of the manufacturing sector, to activate production and

employment in other branches of the economy. In formulating an industrial policy proposal for the Italian automotive sector, it is necessary to adopt a sectoral interdependent perspective in which technological and employment development are two interrelated directions to be pursued.

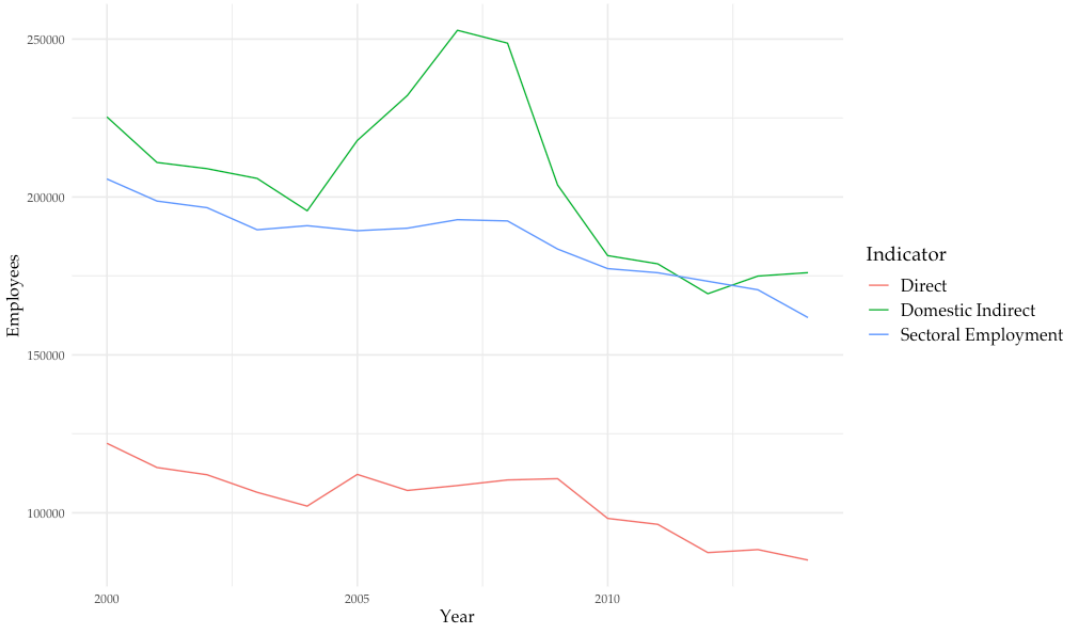

Figure 10: Trend in sectoral, direct and domestic indirect employment in Italian Automotive industry activated from effective components of final demand

Care

One of the most significant results obtained via our analysis is the ability of the care sectors in generating a huge amount of workforce internally. Such role also reflects a massive need of the Italian population for the services produced by this branch of the economy. In addition, projections by the Bureau of Labor Statistics predict for the US over the next ten years that six over the top ten growing occupations will be in the health and care sectors and it is not difficult to imagine similar projections for Italy.[13] As such, in the proposed taxonomy we have defined them as essential jobs, in line with a growing literature stressing the need to invest in high-quality care services, especially after the pandemic crisis (see De Henau and Himmelweit, 2021).

Figure 11 shows the trends in three of the sectors with the highest employment generation capacity according to the effective multipliers calculated in 2014. Three over four of the top sectors are represented by care jobs, which among home care, education, health and social care absorb about 4.5 million people. Dramatic is the fall in the education sector since the austerity years (2007-2008).

A naive assessment might negatively judge the centrality in terms of labour absorption of the care sectors in the Italian production system, identifying them as a sign of a weak specialization

[13] https://www.bls.gov/news.release/pdf/ecopro.pdf

strategy. If manufacturing represents the locus of innovation and the cradle of positive spillovers for the productive structure, equally relevant is the centrality and importance of care jobs as demonstrated by the actual employment trend. These jobs are essential in meeting needs and as such an industrial policy cannot ignore them, but should instead acknowledge the centrality of the sectors primarily via wage increases.

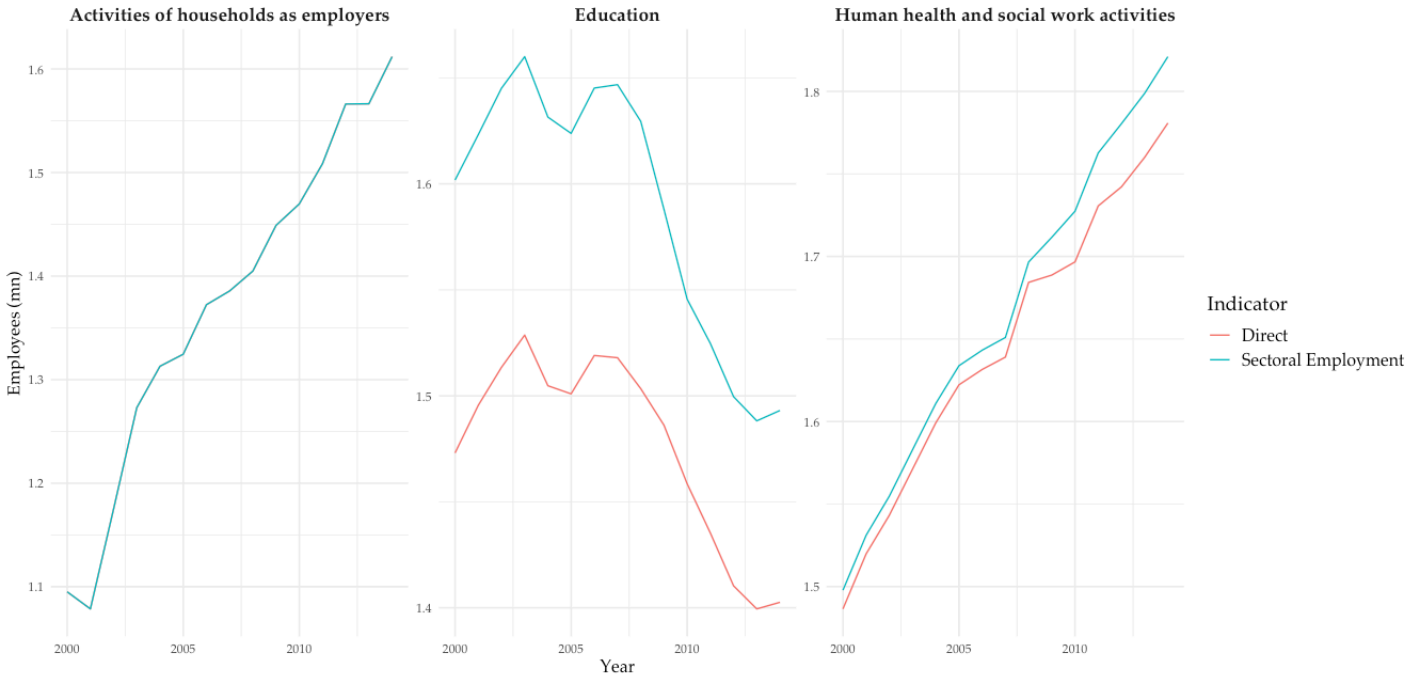

Figure 11: Trend in sectoral and direct employment (in millions) in Italian top 3 Care industries activated from effective components of final demand

6 Conclusions

This paper put forward a novel way for assessing productive structures in terms of the ability to generate employment within and outside single industries. We accomplish the task by applying the methodology of employment multipliers analysis to the case of the Italian productive system and its interdependence with the global production network. The sectoral analysis highlighted the well known weak specialization of Italy in low-tech sectors and in services in terms of workforce absorption. The evidence we provided suggests that the greatest workforce absorption belongs to the less technological advanced services sectors as education and social and care activities. In addition, such sectors are almost isolated in terms of linkages, namely they activate jobs largely within the sector (what we called direct multiplier). In contrast, especially for upstream classes of the Pavitt taxonomy, manufacturing industries are in line with services concerning the ability to generate employment along the supply chain. In particular, we detected an increasing offshoring tendency for the manufacturing Science Based class after the 2008 crisis. We were also able to assess the

content of outsourcing and offshoring, decomposing the synthetic indicators of domestic and foreign indirect employment multipliers. In line with the literature, we found that a large part of externalization is toward Suppliers Dominated industries in services (transport and logistics) and this holds especially for domestic outsourcing, together with a central role played by Specialised Suppliers in services. In contrast, foreign activation of employment is more directed toward upstream classes, meaning that Italy is largely dependent from high-tech inputs from other countries.

After mapping and ranking sectors in terms of their employment generation, we provide a sectoral taxonomy based on their ability to generate jobs. The main novelty of our classification lies in the dichotomy between strategic sectors in technological terms versus essential activities due to significant potential in workforce absorption together with massive satisfaction of societal needs regarding care, health and education. Eventually, we proposed three areas of interventions for industrial policy in Italy building upon the effective multiplier approach.

The analysis we put forward might help policymakers in more comprehensively addressing industrial policy interventions. So far industrial policy actions have been usually focused on technological and productivity motives for boosting manufacturing and strategic sectors. We believe that the lenses of employment multipliers can suggest a novel way for determining which branches of a productive system should be targeted in order to generate employment spillovers in the rest of the economy. Moreover, this approach clearly highlights the possible trade-offs industrial policy faces in terms, for instance, of addressing high-tech productions with innovation spillovers or low-tech sectors with huge workforce absorption. Lastly, our results suggest that industrial policy must target the whole supply chain of an industry, both domestically and abroad, including elaborating a strategy in terms of participation in GVCs. The latter entails the understanding of how positioning firms and sectors along the 'smile curve'.

To sum up, our contribution relies on a novel approach to assess productive structure development and participation in GVCs, by looking at the capacity of sectors to generate jobs combined with technological characteristics belonging to each of them and the capacity to satisfy basic needs. Future lines of research might first encompass other countries or economic areas, and second better dealing with specific bilateral interdependences among selected countries to determine relationships of dependence versus dominance in terms of workforce requirements along GVCs.

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Appendices

A Further evidence

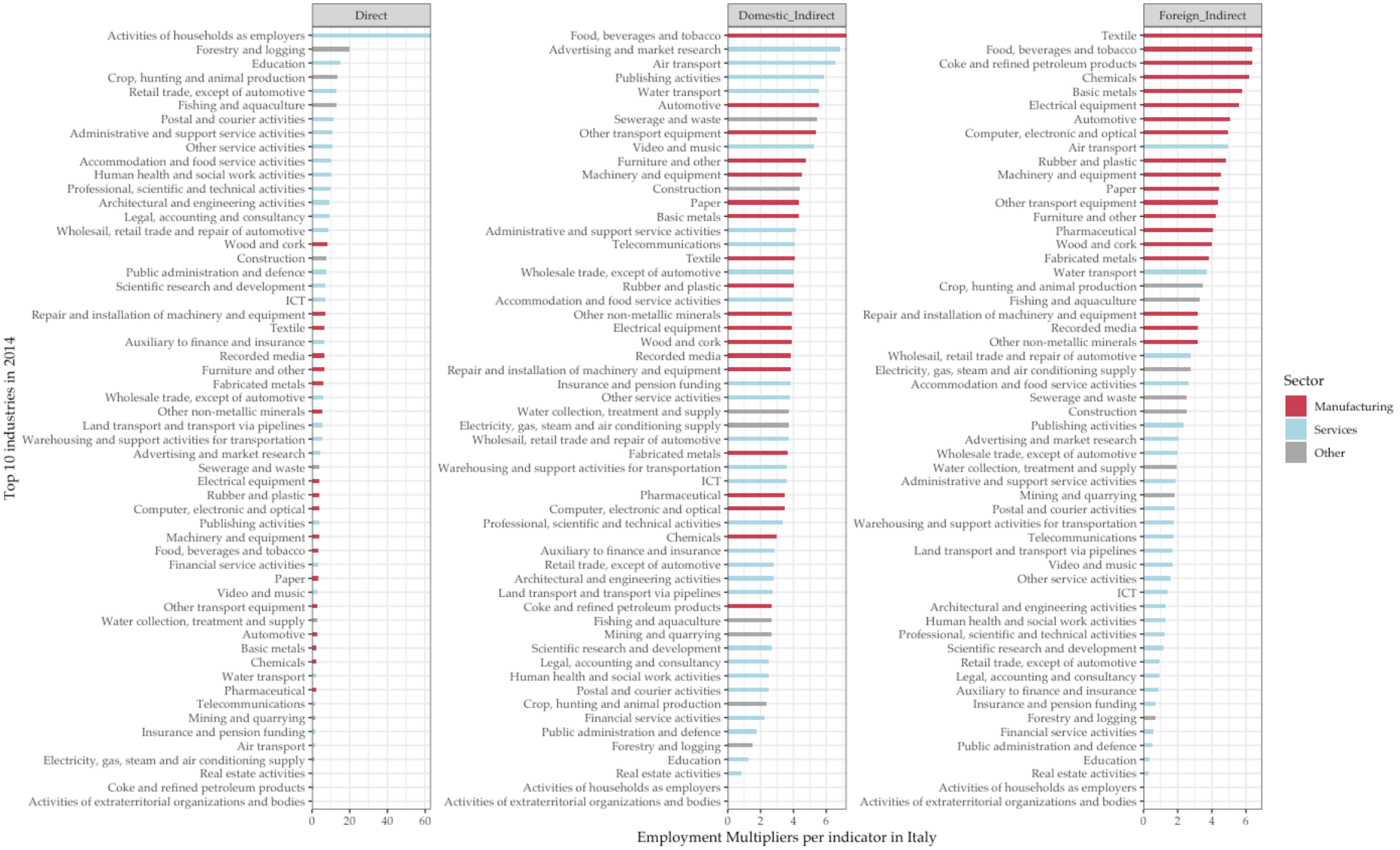

Figure 12: Multipliers in Italy in 2014, in industries by Sector: Manufacturing (red), Services (light blue) and Other (grey).

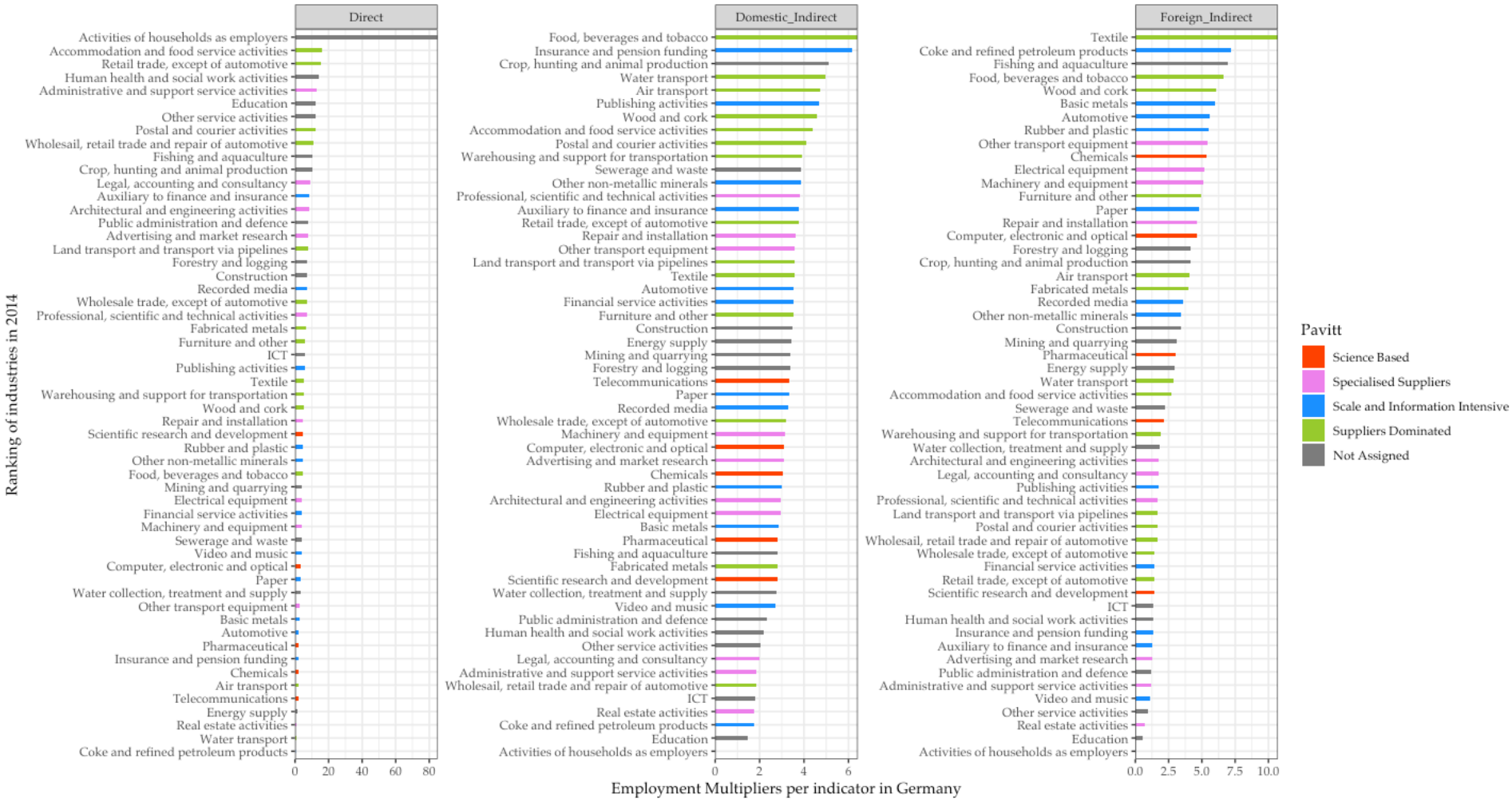

Figure 13: Multipliers in Germany in 2014, in industries by Pavitt classes: Science Based (red), Specialised Suppliers (violet), Scale and Information Intensive (blue), Suppliers Dominated (green), Not Classified (grey).

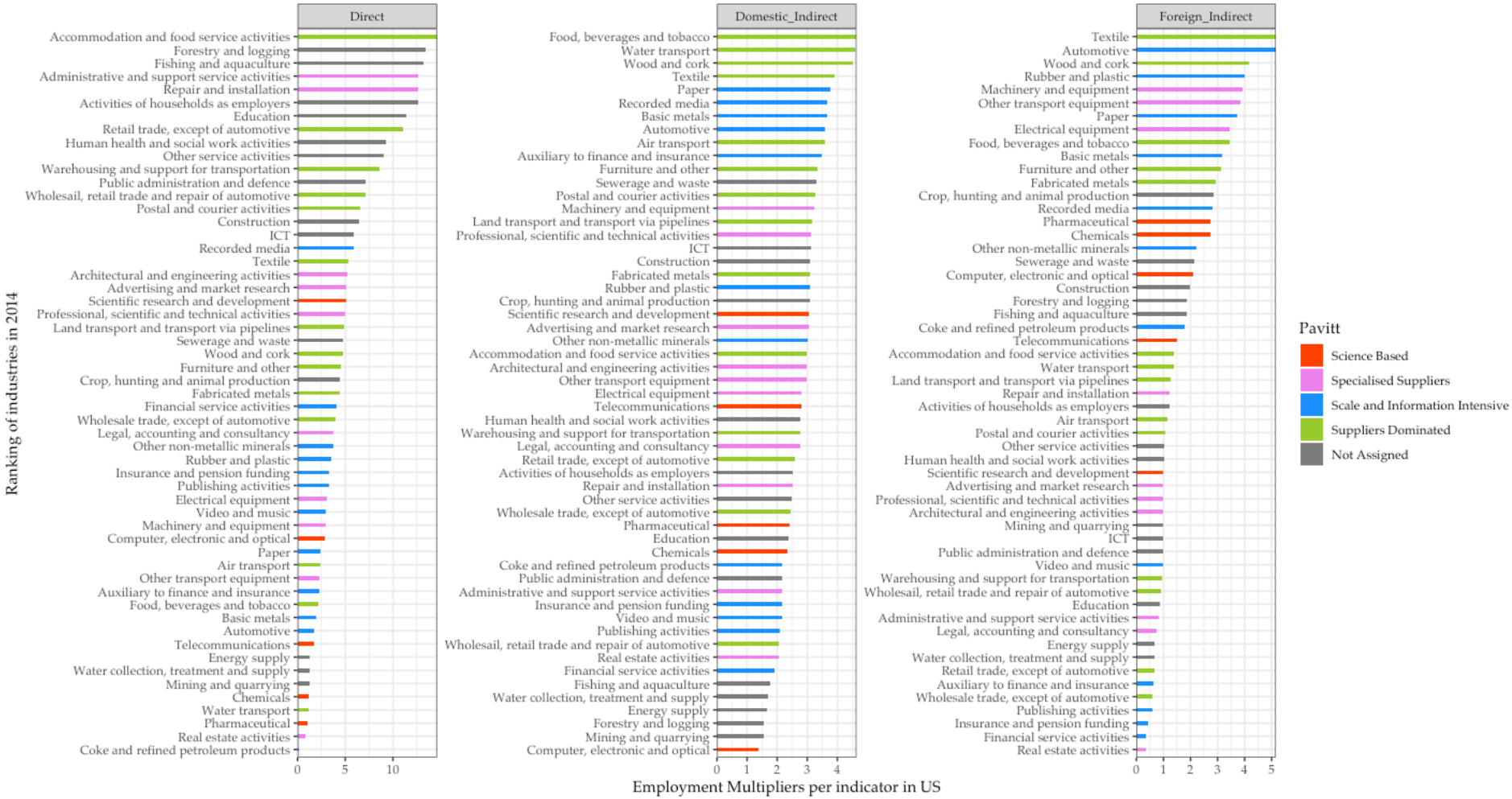

Figure 14: Multipliers in USA in 2014, in industries by Pavitt classes: Science Based (red), Specialised Suppliers (violet), Scale and Information Intensive (blue), Suppliers Dominated (green), Not Classified (grey).

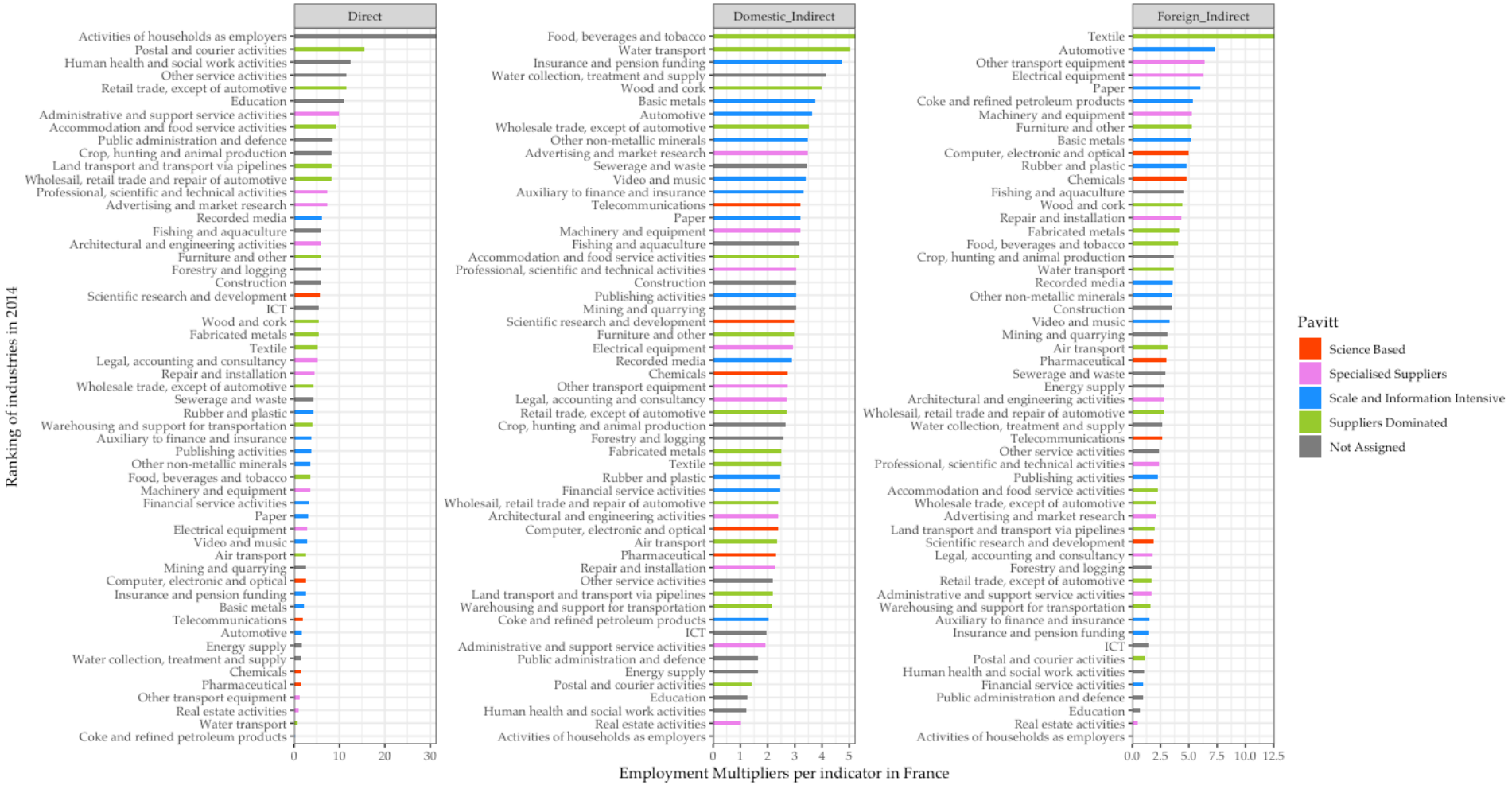

Figure 15: Multipliers in France in 2014, in industries by Pavitt classes: Science Based (red), Specialised Suppliers (violet), Scale and Information Intensive (blue), Suppliers Dominated (green), Not Classified (grey).