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Digital Disruption and the Transformation of Italian Manufacturing

Piemonte Region and Northern Italy in the Global Competition

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Study prepared on the occasion of

International Conference

Industrial renaissance: digital disruption and the post 4.0 economy

Turin - October 27-28, 2017

in cooperation with

Compagnia di San Paolo

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Acknowledgement
We acknowledge the precious help of Riccardo Cappelli, Eric Estolatan and Francesco Righetti

Summary

Executive Summary

The main aim of this report is to provide detailed evidence on the long-term resilience of Italian manufacturing, focusing, in particular, on the regions in the North-West (primary locus of Italy's historical industrialization) and North-East (primary locus of industrialization in the 1980s and 1990s) of Italy. We study the case of Piemonte and also analyse the main trends in Lombardia, Emilia Romagna and Triveneto. Overall, this geographical macro area accounts for about 27 million people, equivalent to the population in BENELUX. The journey from Milano by train takes 45 minutes to reach Torino, 60 minutes to reach Bologna and 200 minutes to reach Venezia. Milano and Torino can be considered an urban agglomeration (e.g., the Metropolitan Statistical Area of greater Boston is about 110 km in diameter involves a mean work commute travel time of 45 minutes).

We introduce and discuss a set of indicators aimed at capturing industrial resilience in the most recent years. We examine the evolution of our main indicators from the mid-1990s, the period when Italian productivity began to lag behind that of Germany, the other main European exporter.

This report focuses, in particular, on how digital technologies (big data, computational power, algorithms and the related fast developments in artificial intelligence) are shaping the development of a new generation of cyber physical systems based on the convergence among robots, sensors and 3D printing. Digital technologies are reshaping the division of labour within and between firms, with a reallocation of capital and labour towards new activities. Moreover, digital technologies are increasing the importance of information-intensive monitoring and coordination activities while containing the relative importance of cost differences for lower skilled labour. Against this background of opportunities and challenges, regions and countries must facilitate the processes of re-shoring of those industrial activities with higher potential for generating value for the territories. The development of distinctive and smart capabilities related to the quality of institutions, scientific capabilities, technological skills and supporting infrastructures is crucial.

Italy and its most advanced Northern area are emerging from the longest economic recession since the Second World War, having been particularly badly hit by high levels of unemployment and significant loss of GDP per capita compared to the most advanced regions in Europe. However, the report identifies clear possibilities for economic resilience based on advanced manufacturing capacity. The data tell a story of crisis that started well before the most recent economic recession, related to the slow down since the mid-1990s of Italian growth and productivity rates. The crisis merely exacerbated and accelerated what was already in motion. Ultimately, the crisis probably triggered a very painful process of selection among those companies that were unable to keep abreast with foreign competitors, due to lower levels of investment in innovation and over-reliance on internal demand. A prolonged period of reduced internal demand spared only those companies able to innovate and to growth in their export shares. In Chapters 1 and 2 we discuss how greater fragmentation of the global organization of production across national borders, has been reshaping the competitive advantages of firms and nations. Firms have become organized in supply chains that can stretch across many countries and industries. However, following this wave of enthusiastic offshoring and outsourcing, some companies are beginning to reconsider this choice, as the initial cost advantages in alternative locations diminish and overstretched supply chains are starting to threaten the quality of and innovation in products and processes. We estimate that, given the current industry structure and to avoid endangering supply chains or production quality, only 13% of Italian jobs should still be offshore. This share is much lower than the comparable figures for other countries, for example, the US. At the same time, we estimate that, in the most recent years, Italy has caught up against its initial disadvantages with respect to other advanced economies, and has become more attractive for new manufacturing.

However, we highlight that today's manufacturing production differs from past manufacturing production. A process of intensive *servitization* is underway, involving an increasing share of (business) services being used as manufacturing inputs. Manufacturing goods are increasingly bundled with service. While it is clear that services are responsible for the largest share of GDP, a large portion of their value exists because they are crucial for the delivery of manufactured products and they are sold together with physical goods. In this context, Italian manufacturing has a relatively high services component. 'Made in Italy' relies increasingly on service activities to generate value for consumers.

Focusing on a set of regions in the North of Italy and, in particular, Piemonte, this report identifies a set of indicators that capture firms' economic and technological capabilities and regional educational background.

We argue that the combination of firm capabilities and public infrastructure is allowing the North of Italy to respond to the challenges of new digital manufacturing. In a comparison to a sample of European regions involved in advanced manufacturing production, such as the German regions of Baden-Wurttemberg and Bayern, we show that Italy's Northern regions (especially Piemonte, Emilia Romagna and Lombardia) have a competitive advantage in high-medium technology areas.

Taken together, the regions belonging to the greater region of North-West of Italy employ 1.6 million workers in manufacturing, a share of around 23% of total local employment. To trace technological capabilities, we investigate the number of patents owned by companies and public institutions in Robotics & Automation, and Computing Technologies, an area in which Europe has a position of competitive advantage, while Italy is ranked among the top countries in absolute and relative terms with growth in its relative specialization, second only to Germany's. At the regional level, Piemonte and Emilia Romagna perform well for number of patents per inhabitant and exhibit strong (growing for Emilia Romagna and decreasing for Piemonte) relative specialization, even higher than that in Bayern. In the area of Computing Technology, the situation is rather bleak; it is well-known that the US dominates this technological area, while Italy is ranked last among the eight countries examined, in both absolute and relative terms. At the regional level, the situation is slightly better, with all Northern Italian regions and, especially, Piemonte showing a growing share of patents in relative terms. With the exception of Île-de- France, all the regions considered have a negative specialization in Computing Technologies.

The literature shows that Italy's share of R&D expenditure in GDP is low (1.37% in 2014) due not only to the small size of its companies and its sectoral industrial focus but also to the low propensity of large high technology companies to invest in R&D. The situation improves when we consider Italy's Northern regions. All the Italian regions considered have achieved significant growth since 1995 then after the 2008 economic crisis. The growth rate has been particularly significant in Emilia Romagna and Triveneto. Piemonte with 2.2% of R&D to regional GDP outstrips countries such as Canada, The Netherlands, and the UK, and the share of business funding in Piemonte is about 80%, higher than all the countries considered and at the same level as Baden-Wurttemberg and Bayern. Even following the restructuring of research activities at FIAT after its acquisition of Chrysler and the transfer of some activities to North America, business R&D intensity in Piemonte has increased significantly.

Finally, we show that the Northern Italian regions considered, according to the PISA Test, perform in secondary education similarly to the highest ranked countries in Europe (e.g. Veneto is similar to Finland, the top ranked country in Europe). The percentage of the population with tertiary education is much lower, with a catching up in recent years, in the age bracket 30-34. Italy seems to suffer from lack of development of a dedicated technical higher education system. In other European countries, this system developed during the 1980s and 1990s and serves a significant share of students; however, in Italy, following several failed attempts, the Istituti Tecnici Superiori (ITS – Higher Technical Institutes) were finally launched in 2011.

In the Third Chapter of the report we map the characteristics and future prospects for the key product technology of robotics and 3D printing in Italy and most advanced manufacturing regions. In both areas, we survey the existing product differentiation, which, especially in the case of robotics, is broad and covers a large number of different applications. The CO-BOTs or collaborative robots segment appears to show the greatest potential. Italy is a key robotics market and in 2016 has increased its share by 1.7% for a value of EUR 676 million. There are also many producers and research institutions in Italy that are leveraging on these wide internal markets; these are surveyed in detail. Piemonte and Lombardia account for more than half the Italian market. In Lombardia, large incumbents are mainly driving this positive result, while in Piemonte there is a relative high density of innovative firms. Similarly, Italian additive manufacturing is a fast-growing sector, accounting in 2014 for EUR 130 million total revenues. Additive manufacturing in Piemonte represents a technological excellence, due mostly to Avio Aero (GE Aviation Group) and Cameri. Avio Aero includes an important chain of companies specialized in the realization of high technology components for the aerospace and energy sectors. In Torino alone, we surveyed about 20 innovative companies in these fields.

In the second part of Chapter 3 we briefly examine the evolution of the automotive industry and the pivotal role of Piemonte. The automotive sector is experiencing major innovations in the area of connected, intelligent and driverless cars. The industry exhibits two main trends: increasing concentration and power among large established companies, and a long value chain both upstream and downstream. In 2016, a record 94 million cars were produced (estimates predict 2 million sales in Italy by the end of 2017 with extremely high growth rate in the last 15 months, taking the Italian market back to almost the pre-crisis levels similar to France and the UK); however, global automotive manufacturing is concentrated in large own equipment manufacturers and involves high entry barriers. In Piemonte, there are

712 automotive components companies, which represents more than 36% of the total Italian car suppliers and accounts for more than 77,000 employees (55,500 in the automotive industry). In the distribution of Piemonte's turnover, generated by supplying **Fiat Chrysler Automobiles**, the impact of the group has grown further. Key regional drivers are innovation capabilities and export orientation; 74% of component companies in 2015 were involved in innovation activities (8% more than 2014), especially in the subcontracting and engineering and development segments. Piemonte’s export propensity has allowed the supply chain to ride the recent crisis and to reach nearly € 4.5bn (about 37% of exports Italian cars in 2015).

Overall, the report identifies a shortage of competences in Computing Technology and Artificial Intelligence, key competitive areas for Northern Italy and Piemonte in particular. Although the machinery and robotics industrial base is quite robust, the input gaps identified could create a bottle-neck in the evolution of this industry towards advanced digital manufacturing. The short-term risk is decline in competitiveness in a region where the automotive industry is pivotal. This geographical area can certainly move to the next phase of industrialization. In particular, if it builds on its competitiveness in mechatronics and additive manufacturing it could become a global leader. To realize this goal, it is necessary to further develop Computing Technology and Artificial Intelligence competences, and favour the interaction of these with the developing competences in robotics and automation. This process will require investment and coordination among the actors and should be underpinned by specific interventions. We focus on a bundle of policies aimed at promoting the development of lacking competencies and integrating these with local competitive advantage. Policy actions must take into account present situation of binding budget constraints, and the objective of delivering quickly since, in the fast-paced world of technological and industrial transformation, windows of opportunity are narrow.

We focus on two sets of polices. The first is aimed at developing human capital at different levels: the goal is to improve existing successful secondary, tertiary and post-graduate education. This type of formal education complements on-the-job training and the strengthening of apprentice contracts. At the same time, we suggest ways to attract foreign professionals, based on career opportunities, financial incentives and local quality of life. The second set of policies focuses on coordination and diffusion mechanisms in the area, also strengthening the relations with universities and research institutions, which are already focusing on computing and robotic technology. We suggest the set-up of a lean entity, whose role would be to coordinate the resilience efforts of the area. The report describes such policies and discusses examples of successful cases abroad along with an estimate of their costs.

1 Digital technologies and industrial transformations

1.1 Introduction

Over the past decades, 'digital technology' has shaped the so-called Third Industrial Revolution – the first in the XIX century being characterized by steam and water, and the second at the beginning of the XX century being based on electricity and the emergence of mass production. In his book, 'The Fourth Industrial Revolution', Klaus Schwab, Founder and Executive Chairman of the World Economic Forum suggests, will be a further step in human production based on a complete integration between the cyber and physical dimensions. The fourth revolution has the potential to transform not only the way we produce and distribute things but also the dynamics of customer engagement, value creation, management and regulation (Kagermann, et al., 2013; Schwab, 2017). An historical account of the origins, history and impact of cybernetics is beyond the scope and goals of this report (Ampère, 1843; Wiener, 1948; Simon, 1968). However, the idea of the *new cyber physical revolution or* 'Industry 4.0' has been introduced, inspired by the transformations made in German manufacturing (Kagermann, et al., 2013). Industry 4.0 has been described also as: Digital Manufacturing, Industrial Internet, Smart Industry and Smart Manufacturing (Hermann et al., 2016).

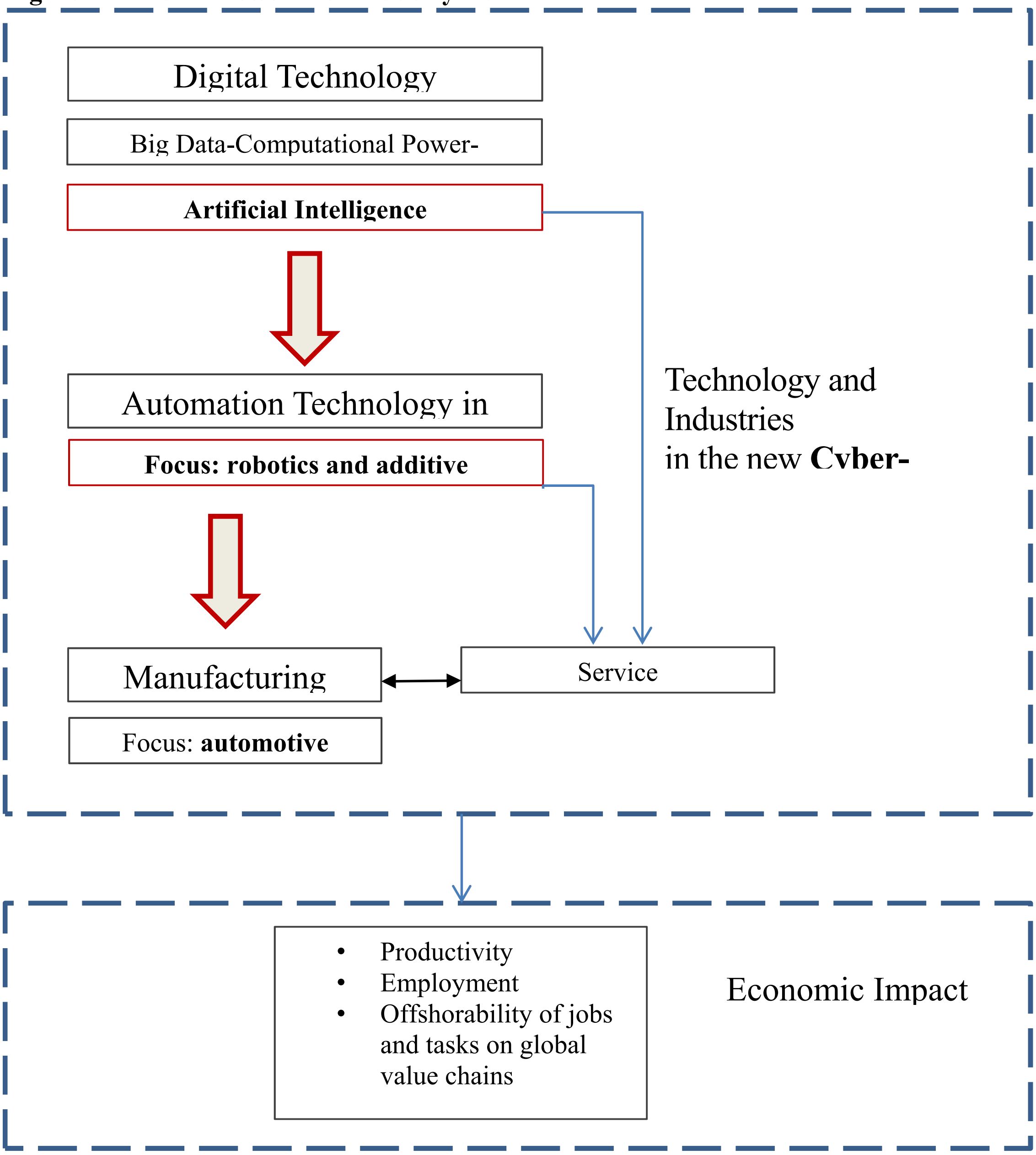
Since buzzwords emerge faster than the innovation waves they describe, the conceptualization of Industry 4.0 remains vague, although it can be thought of as the result of a convergence among the advances made in several related Information and Communication Technologies (ICT) and in Computer Science (CS) (Monostori, 2014), such as Artificial Intelligence (AI), cloud computing, the Internet of Things (IoT) and the accompanying robotics, sensor technologies, additive manufacturing and traditional manufacturing. This new revolution is being influenced by the economic globalization that has been taking place over the last 30 years and will shape future globalization.

Against this background, the present report proposes an analytical framework to investigate this epochal transformation in manufacturing, on two levels. First, at the industry level, we focus on the impact of the new generations of cyber-physical systems, on transportation and on the automotive industry, which is rooted historically in the Torino area, and the impact of mobility on previous industrial revolutions. Second, at the firm level, we shed light on the potential impact of the new cyber-physical transformation on employment and productivity, with a particular emphasis on the geographic division of labour, for both advanced and emerging economies[1]. We find some evidence of the re-shoring of manufacturing activities to their origin countries based on the fact that overstretched supply chains are endangering firms' competitive advantages.

[1] The research combines proprietary firm level databases with publicly available information from company press releases, news articles, peer-reviewed journals and trade and industry reports.

Although our analyses are partial and preliminary, they address the big questions at the core of international debates. Will robots replace human labour? Will robots distribute more wealth while freeing up human time for higher-skilled occupations, or will they generate more unemployment and concentrate wealth among a limited number of people? How is Italy positioned to manage this new technological and industrial environment? Will Italy's traditional manufacturing regions, Piemonte, Lombardia and Emilia Romagna, be able to reposition and take advantage of the emerging opportunities?

Figure 1.1 The framework for Industry 4.0



Source: authors' elaboration

A straightforward way to understand the mechanisms behind the recent acceleration in the automation of production processes is to consider them as the advent of a General-Purpose Technology (GPT).2 Our analysis relies on two key forces (see Figure 1.1). First, the effect of the digital technology on automation, driven by the capabilities of AI. Second, the effect of a new, more flexible family of robots on manufacturing. The combination of these effects is shaping a new paradigm of industrial production (the new Cyber-Physical Systems, CPS). It is in this context, also, that we can interpret the ongoing convergence between the manufacturing and service industries, often referred to as *servitization* since the services industries, increasingly, are providing content to enhance the quality of manufactured products.

However, as usual with GPTs, to see the ‘big picture’ requires investigation of the creation of new products or services that eventually might spark the emergence of new industries. For instance, in the cases of self-driving vehicles and drones, the digitization of signals from the external environment enables the self-driving capability of vehicles and the remote control of planes. Self-driving cars are a new product within an existing sector; drones represent the emergence of a new, steadily-growing sector.

New opportunities can be unleashed, also, by connecting products across otherwise independent sectors and exploiting digital capabilities. For instance, the case of *smart clothing* and *smart driving wheels*, which are aimed at the implementation of a system of real-time health control, while in the case of *smart mobility* and *car sharing*, it would not be futuristic to envisage a *car-on-demand* service, which would contribute to reducing congestion in modern cities.

In the remainder of this chapter, we discuss the economic consequences of a digital disruption. Chapter 2 presents a discussion on the impact that rapid technological progress is having on firms’ internationalization strategies while Chapter 3 analyses the robotic industry as a fundamental technological and industrial cornerstone of the new CPS model and looks at its impact on automobile industry. In Chapter 4 we put forward a set of policy actions that could be implemented at the regional level to support the transition to digital manufacturing.

1.2 The resilience of manufacturing in the aftermath of the financial crises

It has become common in public economic debate to consider the present time as characterized by post-industrial economies, and there should have been a shift from a pattern of specialization based on manufacturing activities to one based on service activities. The statistics would indicate that this has happened to a degree since the share of activities classified as services has increased disproportionately, especially in developed countries. However, we argue that, first, a net separation between manufacturing and services tasks is overly simplistic, since, often, both activities are integrated into the production of final (manufactured) goods destined for consumers. Moreover, the financial crises that occurred in 2008 and 2011 (in Italy till 2015) refocused attention on the benefits of a stable

[2] GPTs are technologies characterized by the potential of pervasive use in a wide range of sectors and are the ultimate trigger of technical-driven long-run growth (Bresnahan and Trajtenberg, 1995).

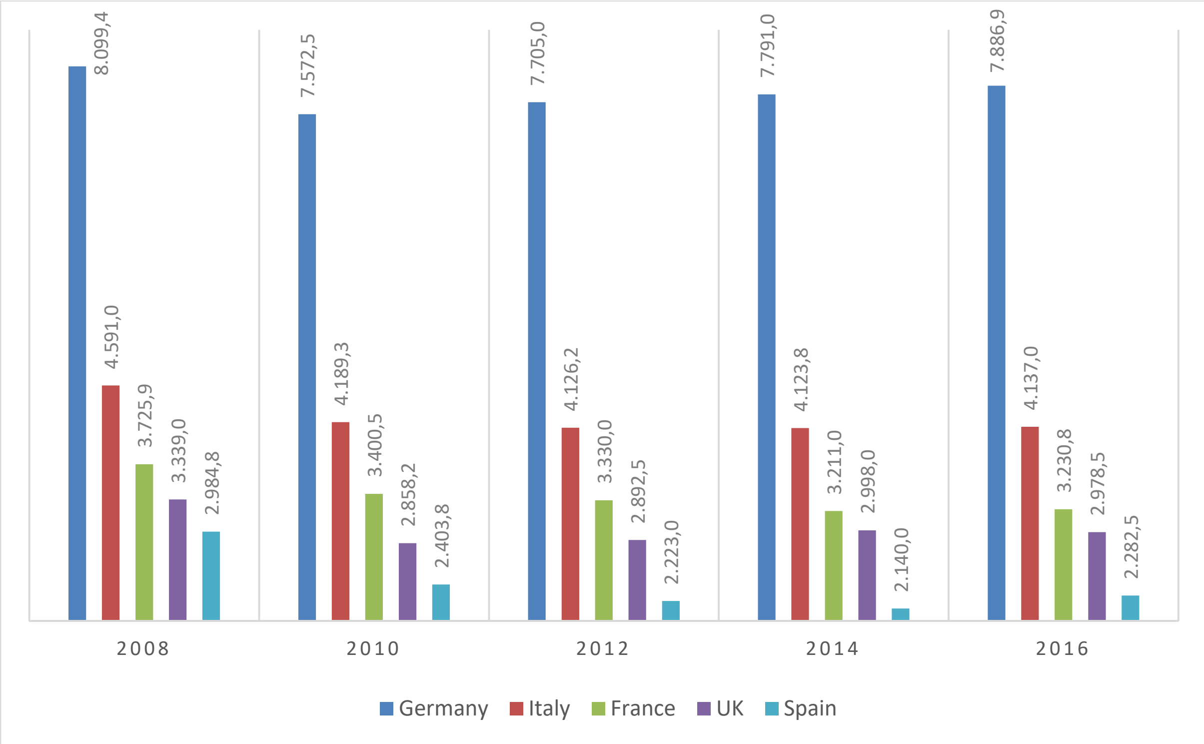
manufacturing base; many Italian companies started to increase their export revenues which compensated for losses in revenues and profits from reduced domestic demand. Many companies were able to react by innovating in products and processes to respond to the changing needs of both domestic and foreign consumers. This is evident in the revival of manufacturing in national statistics, although a consequence of a difficult selection process. In Italy, according to ISTAT (2016), the manufacturing industries have emerged from the most recent crisis with fewer firms and fewer employees.[3] However, there is evidence of a polarization with some healthy and more viable firms gaining market share at the expense of more fragile firms. As a consequence, Total Factor Productivity (TFP) increased overall in 2014 and 2015, with a rising trend for manufacturing and a declining trend for business services.

The post-industrial narrative tells us that advanced economies can no longer afford the costs of manufacturing, an activity that, progressively, has moved to China, India and other emerging economies. This narrative tells us also that we should focus on advanced services activities and the production of knowledge. Statistics on occupations tell a slightly more complex story. Even if we restrict our analysis to Germany, Italy, France and UK as main producing countries in Europe, we observe that they have not dismissed their productive capacity, in either absolute (Fig.1.2, panel a) or relative terms (Fig. 1.3 panel a). The share of Italian manufacturing remains at around 20%, second only after Germany. Although the manufacturing employment share shows an overall decreasing trend over the last decade, this is due mainly to a contemporary rise in services industries employment since, in absolute terms, the numbers of employees involved in manufacturing activities have been stable and slightly increasing in both Germany and in Italy since 2010.

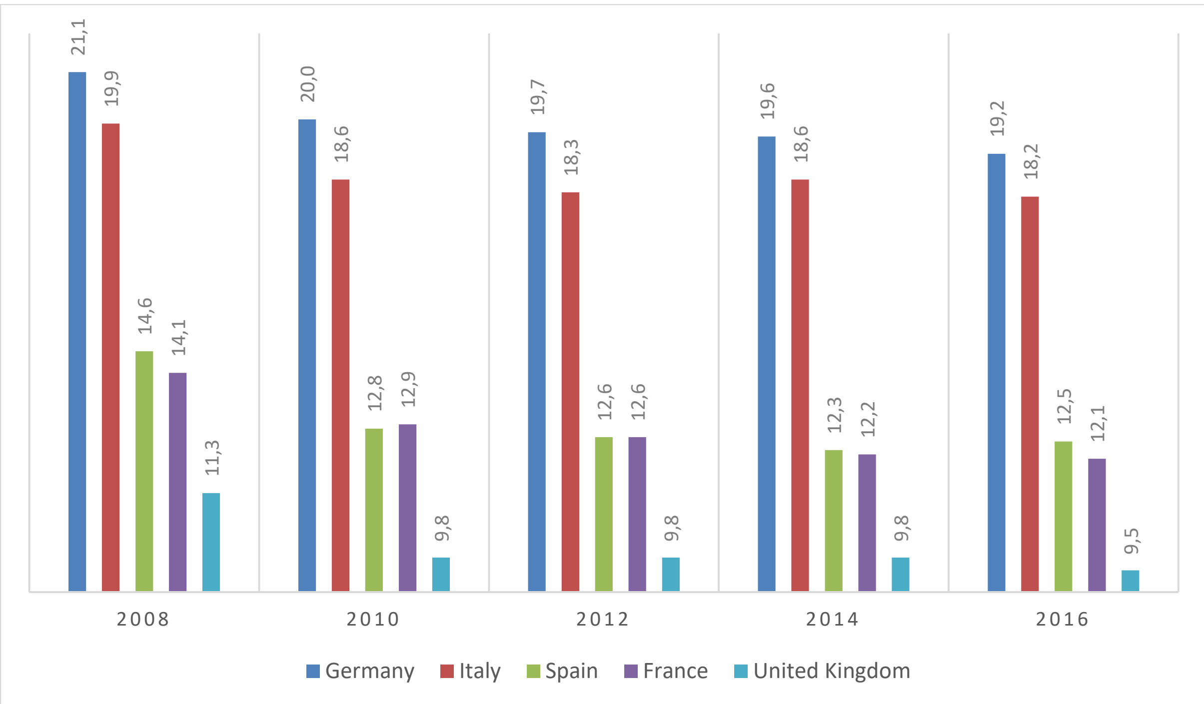
At the regional level, traditional industrial strongholds, such as Baden-Wurttemberg and Bayern in Germany, have kept their leadership and managed to recover to pre-crisis levels, while Italy has managed to maintain stable or slightly decreasing numbers for manufacturing occupations certainly in Lombardia and less so, in Piemonte and the North-East of Italy (panels b in Fig. 1.2 and Fig. 1.3). Although Piemonte is among the smallest of top European manufacturing regions in absolute terms, its historical focus on manufacturing activities makes it a champion in terms of percentage of manufacturing employment in total employment. Taken together, the regions belonging to the greater region of North-West of Italy employ 1.6 million workers in manufacturing, a share of around 23% of total local employment. Among Italian regions, the North-West also accounts for a large share of the services industries, which explains the apparent lower representation of manufacturing.

[3] Respectively, about 194,000 fewer firms and 800,000 fewer workers than before the onset of the last crisis (ISTAT, 2017).

Figure 1.2 Employment in manufacturing by main European countries, in absolute (a) and relative (b) terms.

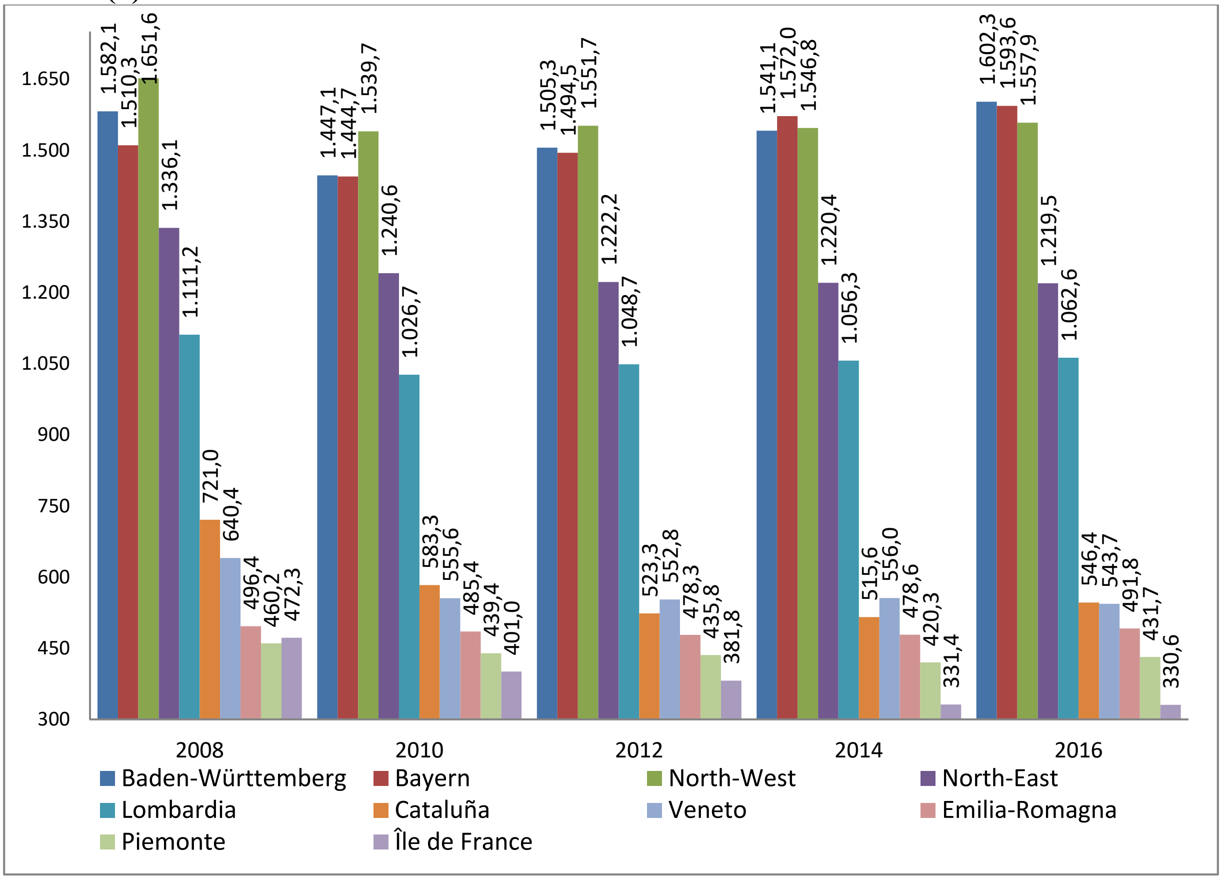


a) number of employees (in thousands)

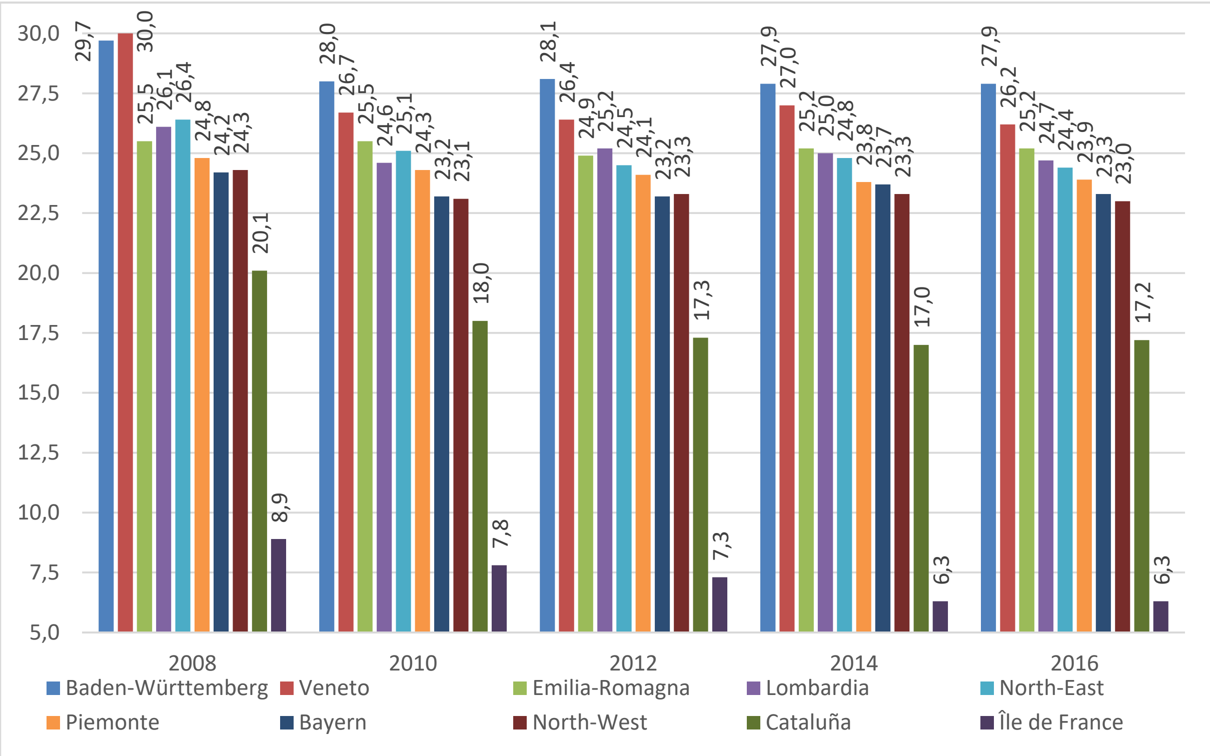


b) manufacturing employees as % of total in the country

Figure 1.3 Employment in manufacturing by main European regions, in absolute (a) and relative (b) terms.



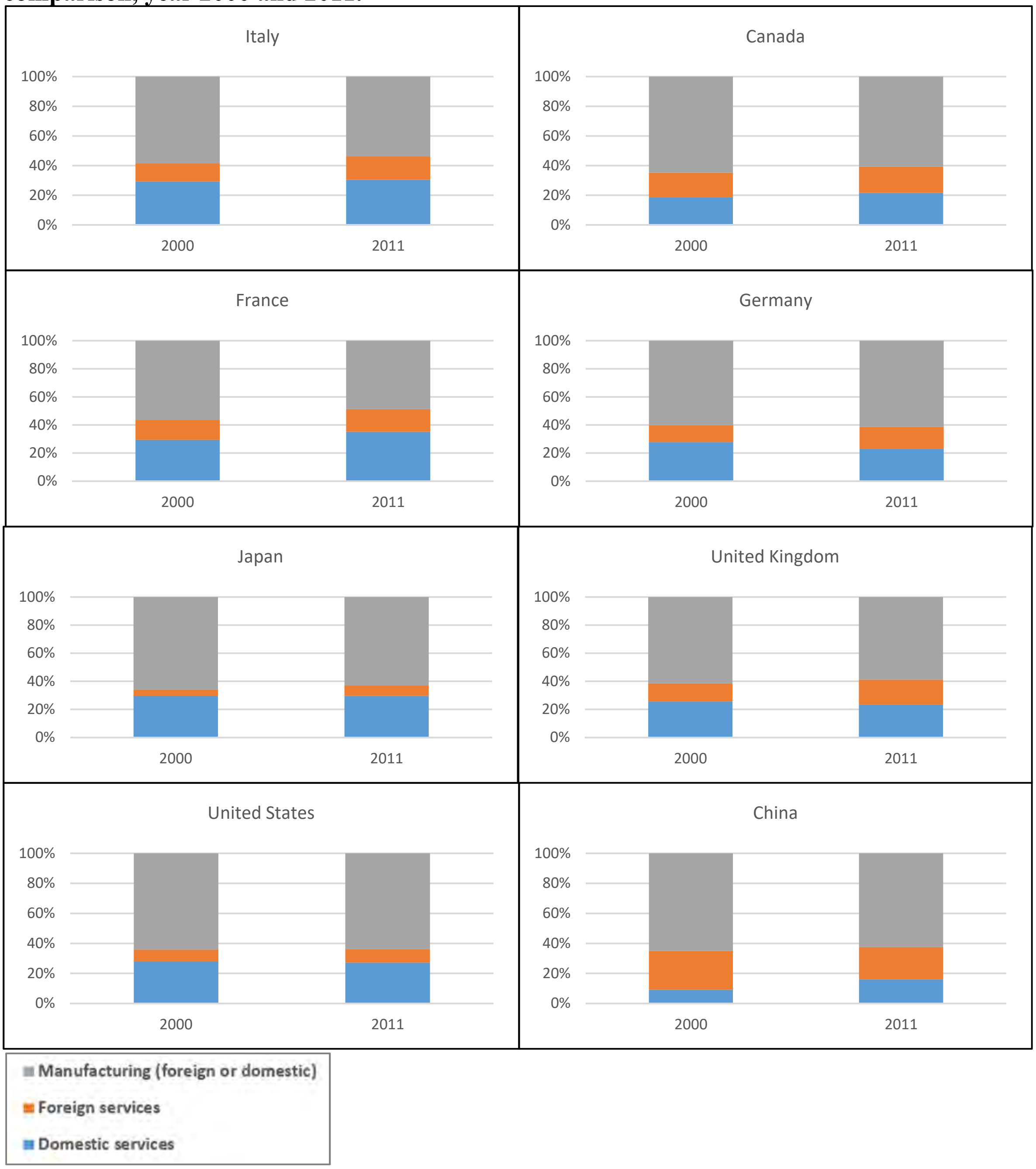
a) number of employees (in thousands)



b) manufacturing employees as % of total in the country

However, a net separation between manufacturing and services tasks is misleading because it misses the nature of modern production, which is fragmented across different tasks. A supply chain for the production of a final manufactured product includes both pre- and post-production services, which are ever more important to improve the quality of the product, innovation in production processes and the after-sales support of customers. Rather, the content of services activities embedded in the manufacturing of final products is becoming increasingly more important - and in some countries more than in others. Figure 1.4 reports the most recent statistics available for the G7 countries plus China, comparing years 2000 and 2011. Total manufacturing value in each country is decomposed into the value generated by manufacturing inputs, domestic services inputs and foreign services inputs. For example, for each euro of value added generated in the Italian manufacturing industries, about 46 cents come from tasks performed by services firms, which include research, design, engineering, marketing, advertising and other sales activities pre- and post-delivery of the manufacturing product to the final consumer.

Figure 1.4: Service content in manufacturing value added of G7 countries and China, a comparison, year 2000 and 2011.



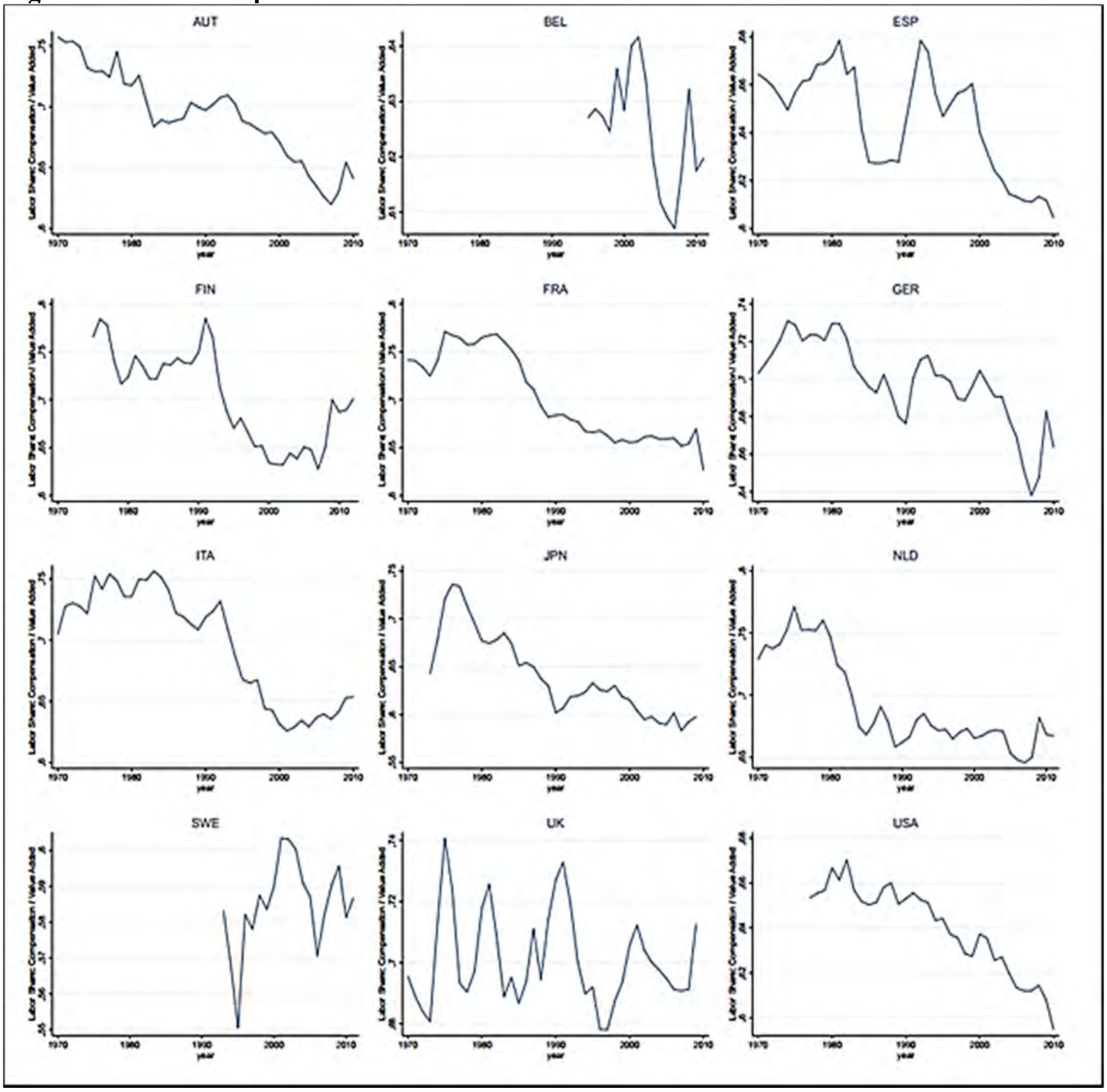
Source: authors' elaboration on OECD TiVA database.

In this context, among the reported countries, Italy is ranked second after France (52%) for the highest services content in 2011. The USA is the country with the lowest services content in manufacturing although it achieves a non-negligible share of 36%. If we look at the contribution of foreign services inputs, that is, at the input of foreign suppliers of business services to Italian manufacturing, we observe that their share is about 15% of the total value. The values are similar for leading European partners and Canada. Japan appears less open to inputs of foreign services while the USA and China are two peculiar cases that require some further qualification. China is notorious for entering global production and trade from a base of manufacturing activities where Chinese firms could have achieved cost advantages given the low level of salaries after China's accession to the World Trade Organization (WTO) in 2001. At that time, it had almost no base of production services, which explains why, in 2000, we observe less than 10% of value sourced from domestic services inputs, while R&D activities, engineering, marketing, etc., essentially were sourced from trade partners that had started to integrate China in their global value chains. China has upgraded its manufacturing production progressively while, simultaneously, starting to develop its national provision of business services. On the other side of the world, the USA has been progressively losing its manufacturing base and specializing in the provision of business services (including finance). US business services are also exported to emerging countries, such as China, where part of the US original manufacturing moved after companies started outsourcing and offshoring. In 2000, also, debate emerged over the costs and benefits of delocalization. Blinder and Krueger (2007) discuss how easy it was to offshore US manufacturing activities, either physically or electronically. They conclude that about 25% of all US manufacturing or service activities, potentially will be offshorable within a decade or two. In the following analyses, we try to provide an estimate, albeit imperfect, of the offshorability of Italian jobs. Currently, given Italy's productive structure, a share of some 13% of Italian jobs could be offshored.

1.3 More robots, fewer jobs?

What is happening in Italy in the aftermath of the great recession seems to be a long run tendency that is not limited to the most recent few years. As discussed above, the overall increase in the productivity of Italian firms in 2014-2015 has been matched with a process of polarization, where some already healthy firms gained market share at the expense of more fragile firms, resulting in fewer firms and fewer jobs involved in manufacturing activities. However, the financial crisis of 2008 and 2011 and the following sovereign debt crisis might have just accelerated a process that began in many countries in the 1970s. Figure 1.5 reports the decrease in the share of labour in gross value added in Italy, from values around 75% to a 65% in 2010. In this respect, the most studied country, the USA, broke the 60% threshold in 2010. Author et al. (2017) explain this as due to the so-called superstar firms in the high-tech industries adopting a 'winner takes most' strategy. In a nutshell, ongoing technological progress coupled with decreasing barriers to international trade allowed bigger firms to become bigger, fostering competitive pressures that hit especially smaller firms.

Figure 1.5 Labor compensation on value added in 1970-2010.



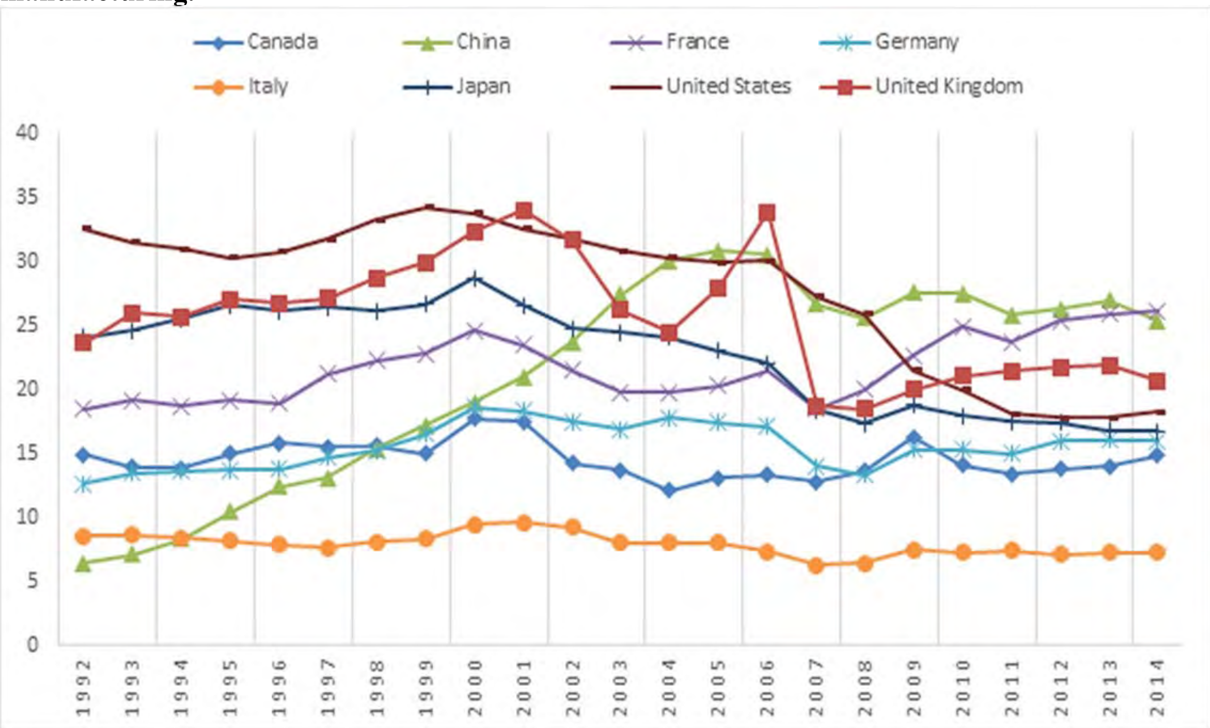
Source: Author et al. (2017) based on KLEMS data.

Ultimately, what allows bigger firms to become *superstars* and concentrate market shares is their dynamism related to new technologies. Author et al. also correlate the rise in market concentration to growth in patenting intensity. That is, the companies that produce more knowledge are also the ones that are more likely become *superstars*. However, the decrease in the share of labour corresponds to an increase in remuneration of capital as a factor of production: bigger firms can rely more on economies of scale and can afford to buy better and technologically advanced machines that can substitute the work previously performed by human beings.

The change seems to be structural in all sectors, regardless of the nature of the output. Whether an industry produces high-tech or low-tech goods, some *superstar* companies emerge that rely heavily on technology intensity and relatively more investment in capital than in labour.

This process occurs in countries following different specialization patterns. For example, traditional Italian manufacturing - with a stable share 7%-8% of total manufacturing exports - is less high-tech than in other G7 countries (see Figure 1.6). Nonetheless, ISTAT data show that a relevant fraction of companies in the traditional Made in Italy sectors are growing more than other smaller and fragile competitors in the same industry. The overall effect is a rise in the country's productivity and a loss of manufacturing jobs. This very rough picture suggests that Italy has still a relevant industrial base which can play a role in the rapidly changing manufacturing landscape.

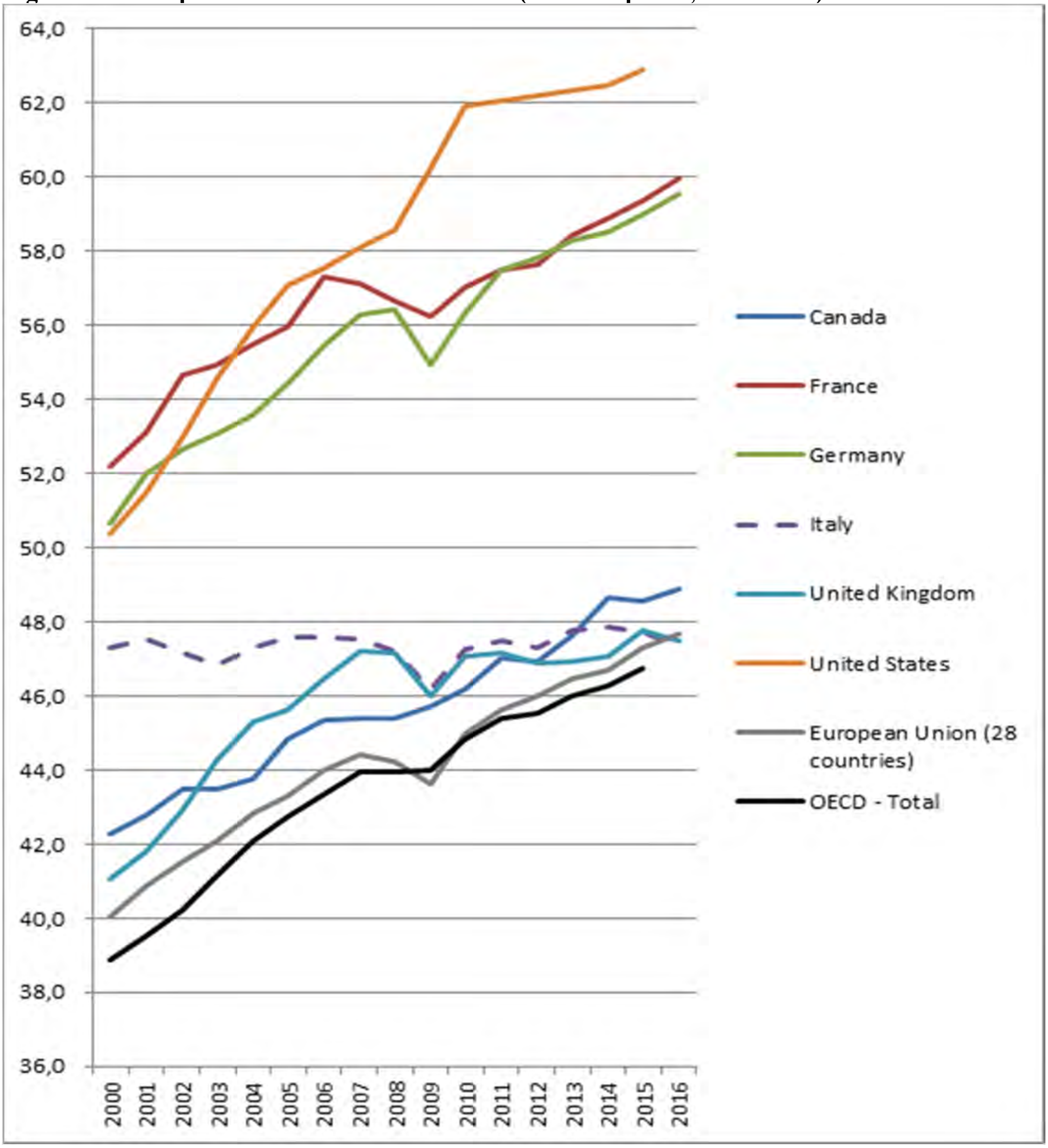
Figure 1.6 High-tech exports for G7 + China in the period 1992-2014, as % of total manufacturing.



Source: Eurostat/Comext.

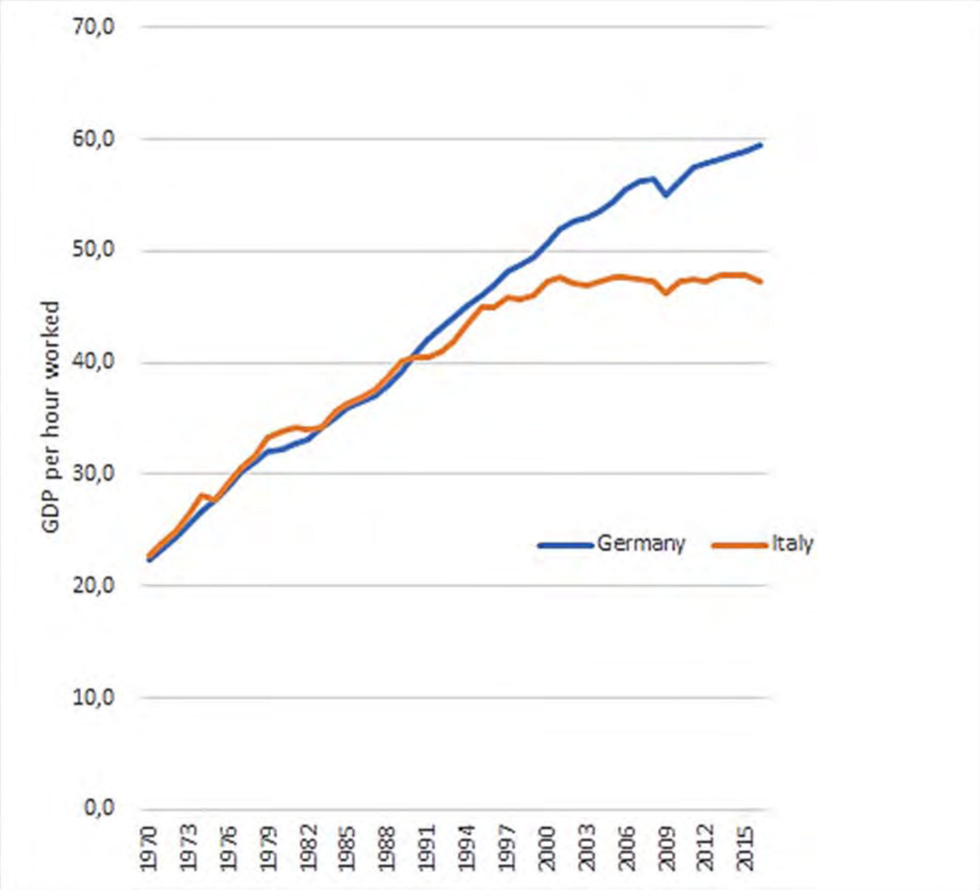
Underlying all of this is the inescapable productivity conundrum related to Italy (Calligaris et al., 2016) (see Figures 1.7 and 1.8). Figure 1.7 shows that, over the past 20 years, Italy did not have any productivity growth. If we zoom in on the European context, comparison with Germany is self-explanatory (Fig.1.8). Until the end of the 1980s, both Germany and Italy showed steadily increasing GDP per hour worked; however, from the 1990s, Italian productivity lost momentum and has stagnated.

Figure 1.7 GDP per hour worked in US Dollars (constant prices, 2010 PPPs)



Source: OECD

Figure 1.8. GDP per hour worked in US Dollars (constant prices, 2010 PPPs)- Germany vs. Italy



Source: Elaboration on Eurostat

Table 1.1 What economic studies tell us of the impact of automation on employment

Paper	Time period	Country	Method	% Jobs at risk	Results
Frey-Osborne (2013)	Next 10-20 years	US	occupation-based approach – 9 skill categories	47%	47% of all jobs in the US are in the high risk category, *"meaning that associated occupations are potentially automatable over some unspecified number of years, maybe a decade or two"* (p. 38).
McKinsey Global Institute (2017)			2,000 job activities, 18 human capabilities	49% of work activities, less than 5% of occupations	
Brzeski and Burk (2015)		Germany	Based on Frey-Osborne (2013)	59%	
Dengler and Matthes (2015)		Germany		15% with high substitution potentials	*"fears of a massive loss of jobs through ongoing digitalisation are currently unfounded"*

Paper	Time period	Country	Method	% Jobs at risk	Results
Pajarinen and Rouvinen (2014)		Finland		35%	
Acemoglu and Restrepo (2017)	1990-2007	US	effect of robots on employment in a commuting zone relative to other commuting zones that have become less exposed to robots.	1 robot/1000 - 0,37% employment to pop ratio	Two opposite forces should be considered: displacement effect and productivity effect
Arntz, et al., OECD (2016)		US	task-based approach	9%	*"the estimated share of "jobs at risk" must not be equated with actual or expected employment losses from technological advances"*
		Germany		12%	
		France		8%	
		UK		10%	
		Canada		9%	
		Japan		7%	
		Italy		10%	
		Korea		6%	
Ambrosetti (2017)	Next 15 years	Italy	Based on Frey-Osborne (2013)	14,9%	
		Germany		14,4%	
		France		13,9%	
Bakhasi et al., Nesta (2017)	Next 15 years (2030)	US and UK	120 O*NET Occupation-related features	20% in occupation that are likely to shrink	…but 10% in occupations that are likely to grow: *"far from being doomed by technology and other trends, we find that many occupations have bright or open-ended employment prospects. More importantly […] the skills mix of the workforce can be upgraded to target such new opportunities"*

In recent years, much effort has been devoted to estimating the impact of automation on employment. A non-exhaustive collection of studies, from consultancy reports to academic papers, is reported in Table 1.1 with some coordinates on findings and methodologies. Interestingly, the estimates vary significantly according to geographic coverage, methods and perspectives. In some cases, the failure of predictions can be attributed to approaches that do not consider industrial activities as composed of diverse tasks with implicitly different propensity for standardization and, hence, automation (among others, see Arntz et al., 2016). The percentage of jobs at risk for Italy has been estimated in the bracket 10% to 15 %.

Since scholars disagree so fundamentally about the consequences for employment, it might be useful to reverse the question and ask whether and how technological change might have a positive impact on employment.

In fact, technological change can generate mechanisms that are able to more than compensate for job losses in the longer term (see also Calvino and Virgillito, 2016). For example, it is possible that there is a 'sectoral shift' from machine-using industries to machine-producing industries and a reallocation of workers to the latter. Also, the introduction of new products may stimulate consumption and, possibly, employment in different industries.

The net effect on labour markets will be dependent on: i) how much the labour force complements or substitutes for automation in production in the market for production factors; ii) how much new products are complements/substitutes for older products in the final goods market. In the first case, labour markets will expand if workers are able to move up the ladder to higher-skill occupations that are needed to enable automation. In the second case, labour markets will expand if newer products do not just cannibalize older products, merely reducing the market shares of low-tech companies, but respond to new demand from modern consumers.

1.4 Digital disruption and the 'great convergence' with emerging economies

When trade barriers started to fall in the early stages of economic globalization, some countries were more able than others to take off on and catch the advantages of shortening geographical distances.[4] Faster circulation of goods allowed the *unbundling* of production from consumption on a global scale. The primary drivers of globalization were a decrease in import tariffs as well as a drop in transportation costs. In fact, firms that originated in the countries that, nowadays, we consider as among the most industrialized nations, started to serve the needs of consumers on a global scale. At the dawn of globalization, Western Europe, the US, Canada and Japan were at the forefront to benefit from the technological advantages derived from the Industrial Revolution. They started a process of agglomeration of economic forces, expanding their economic activity and reinforcing their competitive advantages on a global scale.

In these countries, firms engaged in the same industries could choose to cluster next to shared transport infrastructures and R&D laboratories. Also, firms in adjacent industries were attracted by the possibility to establish buyer-supplier linkages, hence, shaping local supply chains. They were able to benefit from direct or indirect technological spillovers arising out of geographical proximity. Eventually, a geographic concentration of manufacturing production paved the way for a divergence with those other countries that were unable to keep pace with technological progress.

The adoption of modern digital technologies is having a different impact on the distribution of world income and rebalancing the differences between industrialized nations and emerging economies. Companies are using digital technologies to bridge geographic distances and combine factors of production located in different countries. In this perspective, digital technologies allow for the faster circulation of knowledge within and across companies, and are reshaping the organization of production across countries. More than

[4] For a timeline of the economic globalization and detail on the two *unbundling* waves, see Baldwin (2006, 2016).

ever, it is possible now that the tangible and intangible assets of a company originated in an industrialized country can combine with labour provided by residents in other countries. As a result, production has become fragmented in relation to tasks, and supply chains have become global, because companies are able to profit from the competitive advantages of alternative locations, in different countries, to which they can decide to offshore or outsource segments of production that previously were performed at home and/or inside the company.

Initially, offshoring and outsourcing strategies were directed towards exploiting local cost advantages whether in China, Eastern Europe or other emerging countries. However, limits emerged to the possibility of basing firms' choices of productive locations exclusively on labour cost arbitrage. On the one hand, economic growth in emerging countries allows for actual and prospective rises in local salaries, which, in turn, makes it less convenient for further offshoring operations. On the other hand, excessive stretching of company supply chains can endanger the ability to innovate in products and processes.

Alongside labour cost advantages, uncertainty in supply networks, exchange rate volatility, complex coordination of inventories and ever-changing consumer preferences are difficulties that may enter the location decision. Indeed, there is some evidence (see Section 2.4 for a discussion of Italy and two interesting cases) that companies have started reshoring some productive activities back to their home country as either the benefits of offshoring have ended, (e.g. labour costs have increased) or an overstretched supply chain is endangering their competitive advantages.

The development of the new CPS may offer the possibility for a broader rethinking by European companies of their offshoring strategy as labour cost advantages become less relevant and the skills requirements for new production systems become stricter.

1.5 Digital technology and automation in manufacturing

Digital technologies have been developing continuously since the end of WWII, but it is only since the diffusion of computers in the 1980s, followed by the networking of computers (Internet) in the 1090s that the potential of the digital industries for many aspects of humans' daily lives has been unleashed.

But what is their effect on productivity? Apparently, the diffusion of new technologies can lead to a temporary decrease in productivity. In the US, despite rapid progress in computers, productivity was slower in the 1970s and 1980 because, following the introduction of a major innovation, the development of other smaller complementary innovations is needed for it to spread throughout the economic system. The development of such complementary innovations can take time. Then, a technological dynamism induced by a GPT leads not only to the introduction of complementary innovations but also to the origin of new products, services and, eventually, sectors (Helpman and Trajtenberg, 1994; Bresnahan and Trajtenberg, 1995)

Among others, Dedrick et al. (2003) provides robust evidence that the productivity paradox vanishes when complementary innovations are taken into account. Antonelli et al. (2010) show the relevant impact on multifactor productivity of patents in ICT when they are based on multi-technological classes, that is, the ICT require complementary innovative efforts in various different realms, to fully release their potential.

Only in the recent years the following key complementary innovations enabled the full potential of ICT to be unleash:

1. Digitization and Big Data
2. Algorithms
3. Computational power.

Digitization, defined as the capability to create data as inputs to ICT from multiple sources, including image, video, text and speech, which are the main innovations complementing ICT as a GPT, and are combined with algorithmic refinements and improved computational power. Digitization is at the basis of the process responsible for **Big Data.** It is widely acknowledged (e.g. see Table 1.2) that the term 'big data' identifies datasets that are not simply very large in term of bytes, but highlight the variety of multimedia sources that generate these data (images, text, video, etc.), and the rapid and continuous flow of incoming data (Gartner, 2012).

Table 1.2 How big are Big Data

29 million observations	1937 the first US government Big Data Project tracking social security
1 Zettabyte	2016 global Internet data traffic, 5 times more than 2011
90%	of world data have been generated since 2014
102 billion dollars	is the size of Big Data Market

Source: Authors' elaboration

The availability of big data challenges traditional techniques of analysis and allow the application of existing **algorithms** and the creation of new ones which leverage on the large scale of the observations in the dataset. The science of data is aimed at extracting patterns from complex information. In the age of big data, algorithms are required to solve different classes of problems, including pattern recognition, classification, clustering, dimensionality reduction, similarity matching, etc.

Table 1.3 Example of big data algorithms for business

Business Activity	*Machine Learning*	*Value*
Predict churn / default	Supervised	Increase business insights
Profile customer and market segmentation	Unsupervised	Increase business insights
Image classification	Supervised	Improve process
Recommendation engines	Unsupervised/ Supervised	Improve service

The collection, storage and analysis of large amounts of data via the deployment of advanced algorithms require **computational power,** which has only recently become available. The computational power of a system does not depend only on the speed of the processor but also and increasingly on the architecture or network in which the processor is embedded. While up to the 1990s the increased computational power was driven by the geometric scaling of its components and, thus, by the investment in hardware in the semiconductor industry, more recently, the rise in network or distributed computing has extended computational capabilities far beyond the boundaries set by the hardware structure. In network computing, computers work together like the nodes in a network, or over the internet (so-called cloud computing). The applications that profit most from network computing are those related to parallel computing, which consists of a series of computer protocols to distribute a problem over various computational cores and reassemble the results. The de facto standard in parallel computing is 'Mapreduce', developed by Google for its own business purposes, but subsequently released and updated for free. The diffusion of 'Mapreduce' and the cheap availability of cloud computers has made it possible for any data science to access the required computational power to exploit the potential of big data.

Within the theoretical framework of GPT, it is possible to understand why only recently and not before:

- data analytics have become a tool for sound evidence-based decision making;
- firms can increase the complexity of the supply chain thanks to detailed quality control;
- sensor technologies have diffused rapidly in factories;

- robots are able to interact with humans and enhance their skills, instead of substituting for labour in relatively simple tasks.

When algorithms and artificial intelligence interact together with physical machines within a system of reciprocal control, feedbacks and loops, this is described as a CPS, which is the key feature of the firm in Industry 4.0 In Industry 4.0, manufacturing is envisaged as featuring machine systems that have self-prediction capabilities and self-awareness, thereby allowing intelligent production capabilities on the shop floor ('smart factories'). Autonomous systems in Industry 4.0 understand their tasks based on explicitly represented knowledge about the machine, the task and the environment without detailed programming and human control, and enabling greater flexibility in the production process (Rosen, et al., 2015) and capabilities for customizable, small-lot production (Brettel, et al., 2014).

In smart factories, human workers and machines interact, with the former becoming the purveyors (the 'creative problem solvers') of the production process, providing flexibility for on-site decision and monitoring processes (Gorecky, 2014). For instance, in Wang, et al.'s (2015) system architecture, human workers are in the *supervision and control terminal* layer. As such, smart factories can best be understood as the integration of industrial networks, cloud computing, supervisory control terminals and smart shop-floor resources (e.g. robots). (Wang, et al., 2016).

In contrast, traditional production lines are only able to perform single functions; the shop-floor is not part of a closed loop and machines that perform pre-determined tasks are deployed along the conveyor belt (Wang, et al., 2015). These traditional production schemes emphasize achievement of cost efficiencies and gather data during operations, used mainly for understanding current factory conditions and detecting system failures (Lee, et al., 2014).

Robotics have advanced significantly since the first mechanical systems were conceived. Various technological breakthroughs in engineering, computer science, information technology and related sciences have extended what is technically feasible, which is allowing various stakeholders to expand the potential of robots.

However, an exact conception of robots is nebulous – Joe Engelberger, regarded as 'the father of the industrial robot', once said, 'I can't define a robot, but I know one when I see one' (Carlisle, 2000). An all-encompassing definition of a robot remains problematic since its various forms, intelligence and purposes vary significantly (HBR Wilson, 2015). Different informants provide different definitions, varying from a mechanical system positioned behind a work fence (i.e. an autonomous vehicle is not a robot), to a contraption that displays autonomy and the ability to respond physically, to an entire system of machines working together on the shop floor (Pearson, 2015).

The above described advancements seem only to exacerbate the problem: artificially-intelligent agents (AIAs) (e.g. software robots) are a point of contention for roboticists and industry stakeholders since some maintain that robots require a physical embodiment (Wilson, 2015; Pearson, 2015; Perlongo, 2016). Thus, the term 'robot' tends to be overused with non-specialist industry observers being quick to attach it to any new technological development (Perlongo, 2016). As a result, potential users approach robot-centred adoption conservatively – productivity gains are unproven and older systems seem more reliable (Leitão 2009; Brettel, et al., 2014).

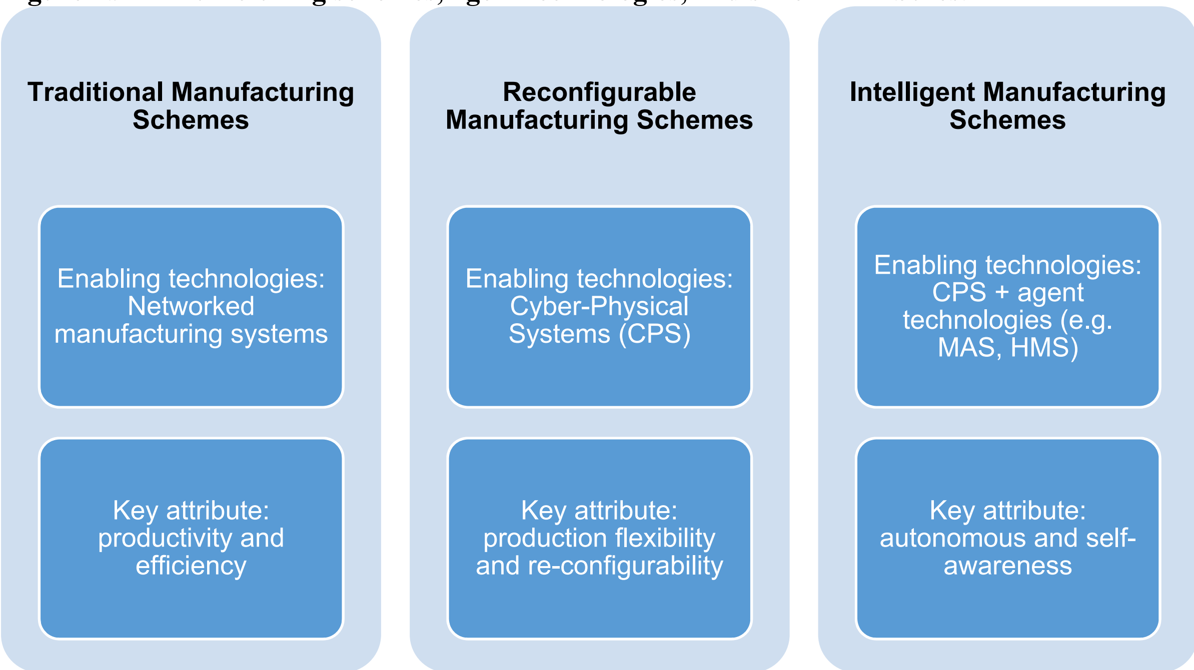
Key to the realization of Industry 4.0 is the continued advancements in CPS, which are likely to become the foundations of smart factories. CPS are automated systems that connect the operations of the physical reality to computing and communication infrastructures (Jazdi, 2014). They constitute partial breaks with traditional automation pyramids because they are designed to be collaborating computational entities with intensive connections to the surrounding physical world and its on-going processes (Monostori, 2014). In addition, generally they are characterized as software-intensive systems, in which the software is a critical part of the integration (Wang, Törngren & Onori, 2015).

Increased intelligence and autonomy in CPS are related positively to the realization of smart factories. On today's smart shop floors, CPS are realized in part through Reconfigurable Manufacturing Systems (RMS), such that machine components can be added, removed or re-arranged. RMS feature modularization by enabling manufacturing companies to adapt to changing production requirements in a cost-efficient way (Brettel, 2014).

The behaviour of CPS physical components derives from advances in Distributed AI (DAI) (Leitão, 2009). Two of the most prominent systems being tested in industrial applications are Multi-Agent System (MAS) and a related variant called the Holonic Manufacturing System (HMS). MAS are comprised of intelligent agents that negotiate with one another to implement dynamic reconfigurations to achieve flexibility (Wang, et al., 2016) and are characterized by decentralization and parallel execution of activities (Leitão, 2009). In practice, MAS agents often are combinations of software (through the provision of interaction capabilities among distributed multiple agents and/or agent autonomy) and hardware agents (robot variants) in production systems (Pěchouček & Mařík, 2008; Wang, et al., 2016).

A HMS is a holarchy that integrates the entire range of manufacturing activities from order booking, to design, production and marketing, to achieve agile manufacturing (Babiceanu & Chen, 2006; Shen, et al., 2006; Leitão, 2009). HMS builds on the concept of agents' reactivity and is able to perform system reconfiguration in order to achieve pre-programmed situations (Pěchouček & Mařík, 2008). The HMS agents or holons, can include both hardware and software components and are autonomous entities. Considered a whole, HMS include sub-holons, comprising inherited original characteristics while, at the same time, being part of a broader holon to which it passes on some of these characteristics (Babiceanu & Chen, 2006). The potential of these DAI agent technologies (and other comparable agent technology variants) combined with developments in machine learning, have a significant influence on the realization of intelligent manufacturing, in which systems can be expected, within certain limits, to solve unprecedented, unforeseen problems based on even incomplete and imprecise information (Monostori, 2014).

Figure 1.9 Manufacturing schemes, agent technologies, and salient attributes.



Source: author elaboration of Lee, et al. (2014)

1.6 Mapping techno-economic performance in Digital Manufacturing of Italy and Piemonte

Industry 4.0 is an emerging approach to the adoption of next-generation robotics in industrial applications. Significant productivity gains are expected from the full realization of Industry 4.0 (Deutsche Bank Research, 2014; Bauer, et al., in Hermann et al., 2016; Boston Consulting Group, 2015) (see Table 1.4).

Table 1.4 Industry 4.0 productivity gains in Germany by 2025.

Source	Year	Estimate (in billions EUR)		Productivity gains (%)	
		Lower-bound	Upper-bound	Lower-bound	Upper-bound
Deutsche Bank Research	2014	267	267	30.0	30.0
Bauer, et al.	2015	78	78	NA	NA
Boston Consulting Group	2015	90	150	15.0	25.0

Source: Deutsche Bank Research (2014); Boston Consulting Group (2015); Bauer, et al. in Hermann et al. (2016).

Digital manufacturing has huge potential, but is still evolving and has no secure standards. Practitioners and academics compete to identify its key drivers. A review of the main contributions highlights three salient features (see Table 1.5): 1) horizontal integration through value networks to facilitate inter-corporation collaboration; 2) vertical integration of hierarchical subsystems inside the factory to create flexible and reconfigurable manufacturing systems; and 3) end-to-end engineering integration across the entire value chain to support product customization (Kagermann, et al., 2013; Brettel, et al., 2014; Wang, Wan, et al., 2015; Wang, Wan, et al., 2016)

Hermann et al. (2016), which is the most recent survey of the literature on digital manufacturing, provides the most concise description to date: Industry 4.0 can be regarded as a collective term for technologies and concepts in the organization of the value chain. Within the modular structured Industry 4.0 smart factories, CPS monitor physical processes, create virtual copies of the physical world and make decentralized decisions. CPS communicate and cooperate with each other and humans in real time, over the IoT, while the Internet of Services (IoS), offers both internal and cross-organizational services that can be utilized by all the participants in the value chain.

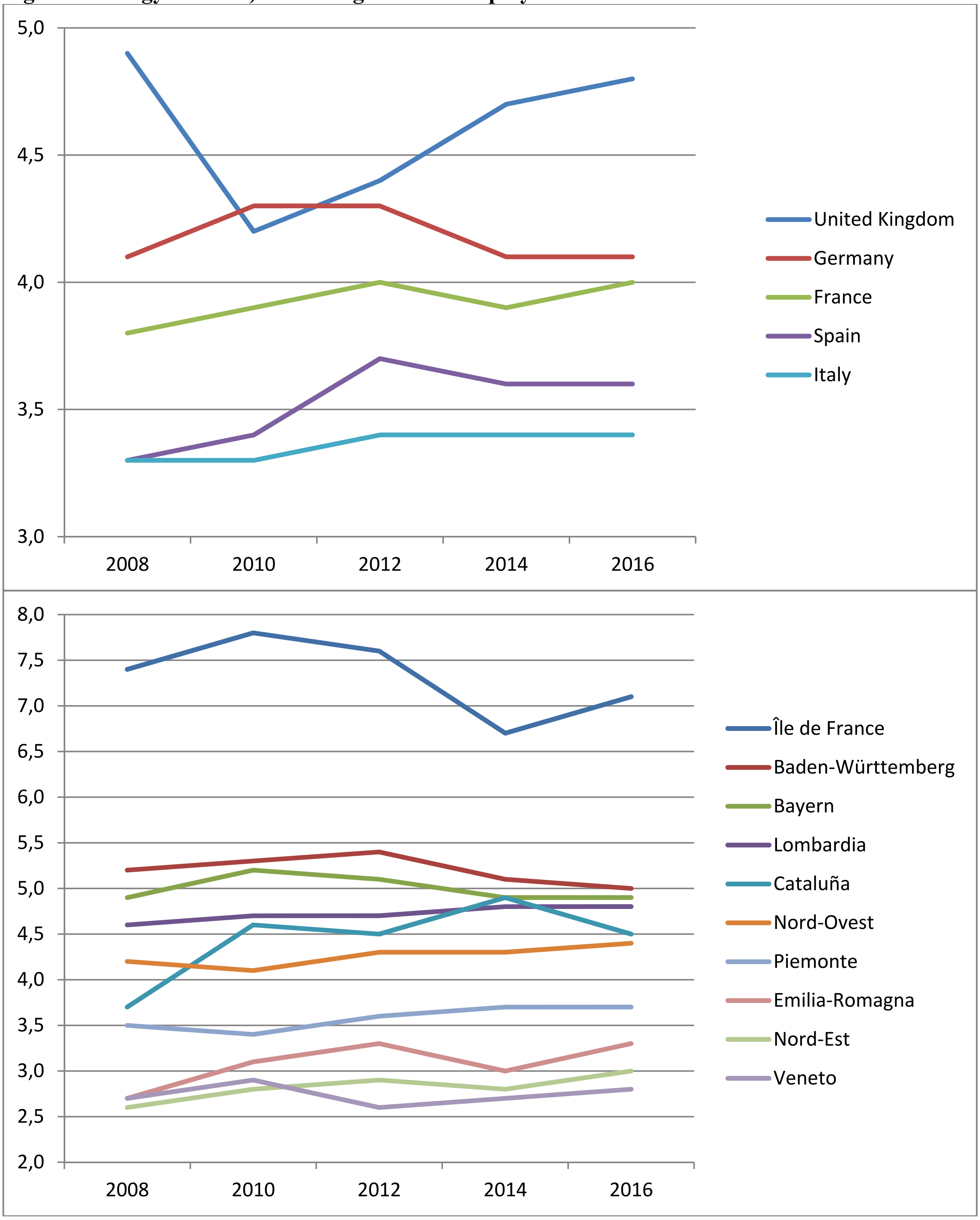
Table 1.5 Scanning of Industry 4.0 technologies and proposed system design and architectures.

Three Features of Industry 4.0	Relevant technologies	System design and architecture
Horizontal integration through value networks; Vertical integration and networked manufacturing systems; End-to-end digital integration of engineering across value chains	Nine technologies in (BCG, 2015): 1) Autonomous robots, 2) simulation, 3) horizontal and vertical integration, 4) Industrial IoT, 5) cybersecurity, 6) the cloud, 7) additive manufacturing, 8) augmented reality, 9) big data	6 requirements of NGMs (Shen, et al., 2006): 1) Integration of heterogeneous software and hardware systems; 2) open system architecture; 3) efficient and effective communication among departments; 4) embodiment of human factors; 5) adaptability to external changes; 6) fault tolerance
Kagermann, et al. (2013); Brettel, et al. (2014); Wang, et al. (2015); Wang, et al. (2016)		6 design principles (Hermann, et al., 2016): 1) Interoperability; 2) Virtualization; 3) Decentralization; 4) Real time capabilities; 5) Service Orientation; 6) Modularity

Three Features of Industry 4.0	Relevant technologies	System design and architecture
Horizontal integration through value networks; Vertical integration and networked manufacturing systems; End-to-end digital integration of engineering across value chains Kagermann, et al. (2013); Brettel, et al. (2014); Wang, et al. (2015); Wang, et al. (2016)		6C system configuration (Lee, et al., 2014): 1) Connection (sensor and networks); 2) Cloud (data on demand); 3) Cyber (model & memory); 4) Content (meaning and correlation); 5) Community (sharing & collaboration); 6) customization (personalization and value)
		5C functional architecture (Lee, et al., 2015): 1) smart connection level; 2) data-to-information; 3) cyber level; 4) cognition level; and 5) configuration level
		Four layers (Wang, et al., 2016): 1) Physical resource layer (with 3C capabilities with autonomy and social capabilities); 2) industrial network layer; 3) cloud layer; 4) supervision and control terminal layer

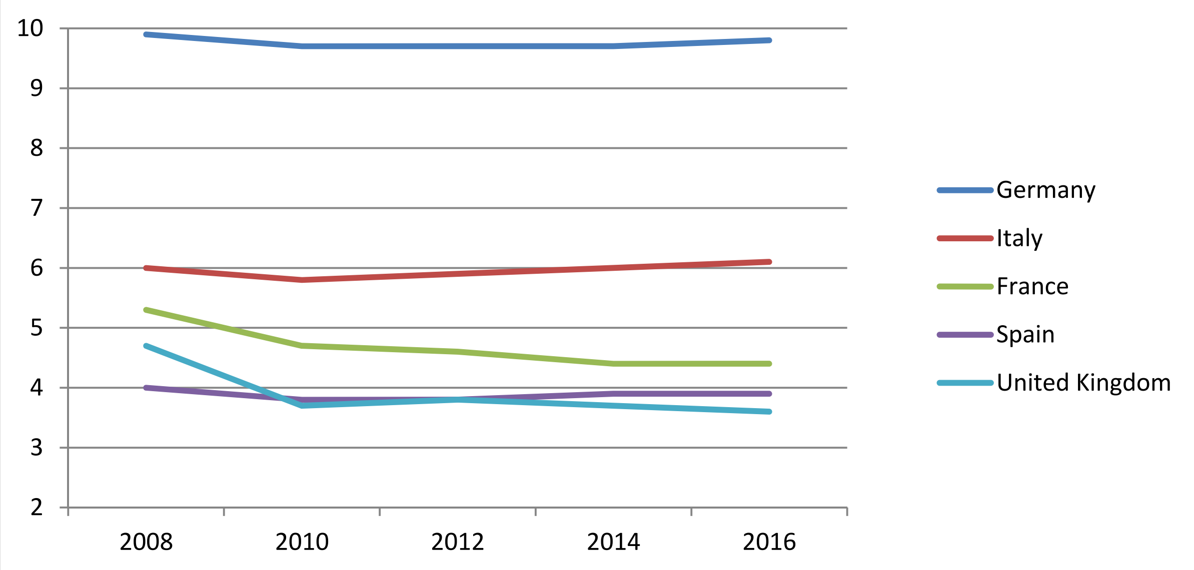
In this section, we map the potential techno-economic performance of Italy and the regions in North of Italy with particular attention to Piemonte in digital manufacturing using a combination of employment, patenting statistics and other R&D and educational statistics. When we look at employment in high technology sectors (Fig.1.10) Italy as a whole, and Piemonte to a slightly less so are generally weak. With the remarkable exception of Lombardia, this applies also to knowledge-intensive high-technology services. On the other hand, if we consider employment in high and medium high-technology manufacturing (Fig.1.11), Piemonte's average is over 10% of total employment. It is ranked after Baden-Wurttemberg and Bayern, and just before Emilia Romagna and Lombardia and it shows a positive increase since 2007, in line with one of the two top German regions.

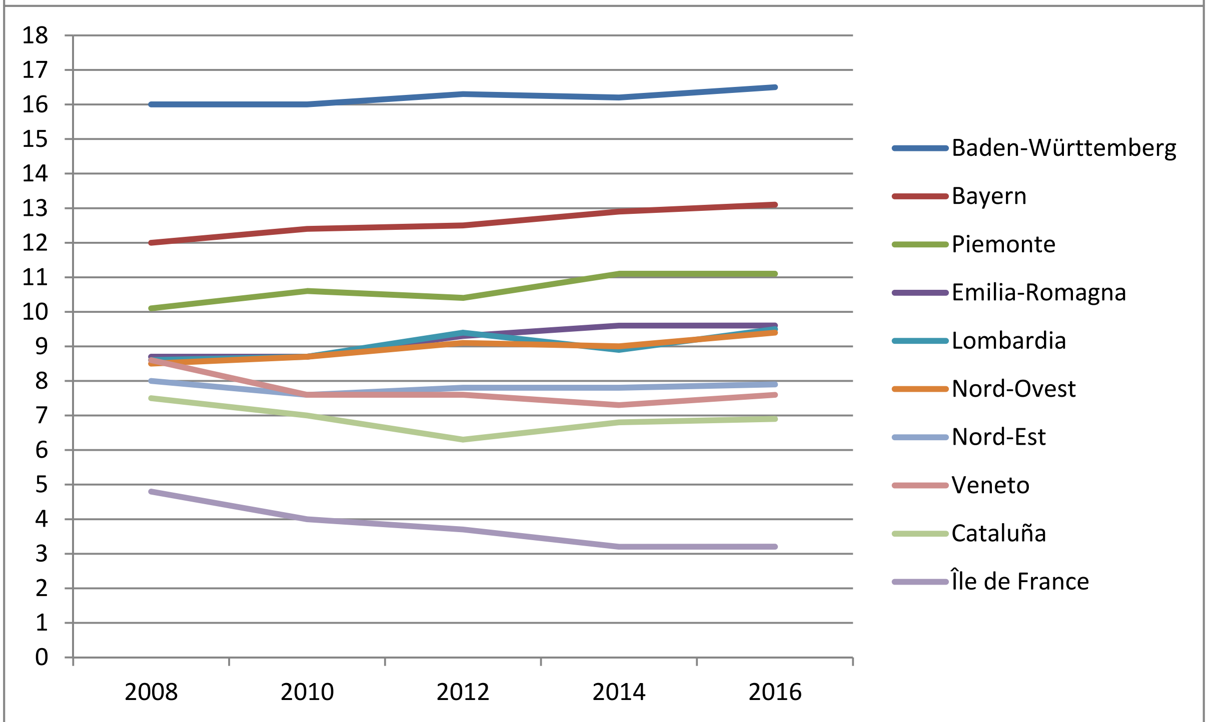
Figure 1.10 High-technology sectors (high-technology manufacturing and knowledge-intensive high-technology services) Percentage of total employment



Source: Elaboration on Eurostat

Figure 1.11 High and medium high-technology manufacturing. Percentage of total employment





Source: Elaboration on Eurostat

A common approach to mapping abilities in a specific technological area is to use patent statistics. To approximate digital manufacturing (industry/technology does not exist in IPC (International Patent Classification technological classes) we consider robotics/automation technologies patents to compute IPC Technology (IPCT) classes. To compute the number of regional and national patents for these two technology areas we rely on the information contained in the ICRIOS-PATSTAT database (see Coffano and Tarasconi, 2014). Patents are assigned to a region/country using inventors' addresses. Computing technologies patents are included in the IPC 3-digit code G06; to assign patents to robotics/automation technologies, we use the list of IPC codes provided by Aschhoff et al. (2010).[5]

Figure 1.12 shows the absolute number of regional and national patents for robotics/automation technologies, computing technologies, and a combination of both technologies. This last category is identified by the co-occurrence of IPC code G06 (i.e. computing technologies) and any of the IPC codes associated to robotics/automation technologies (Aschhoff et al., 2010). We consider yearly patents developed in two different periods, i.e. early 1990s and early 2010s.[6]

At the national level, country ranking of patent production in robotics and automation highlights not only Germany's leadership but also that this country is forging ahead. We observe a similar pattern in the patents of computing technology where the US is the leader. In this second technology, Germany and Japan are ranked equal second. This suggests that in absolute value we are observing a process of concentration of knowledge production in different areas.

Figure 1.13 replicates Figure 1.12 but using the number of patents per capita (millions of inhabitants) in order to increase comparability among countries and regions. At the country level, it is clear that the European countries considered show better performance than the US, and that German leadership is even stronger. At the regional level, Italian regions show non-negligible production in robotic/automation technology and, over time, show some signs of improvements in computing technologies, in which, historically, they have been weak.

Figure 1.14 depicts the normalized Revealed Technological Advantage (RTA) index, which compares a region's performance in a specific technological area with its average technological performance. An RTA index larger than 1 indicates specialization. At the country level, Germany and Italy traditionally have been highly specialized in machinery and, thus, their specialization in robotics and automation technologies is not surprising. The US is more specialized in computing technologies. Both Germany and Italy show a tendency towards increased specialization in computing technology. Note the case of Korea, which has shifted from being non-specialized in computing technologies into a pattern of specialization of computing technologies.

At the regional level, specialization patterns are more pronounced; at the country level, various regional specializations become levelled out. While with the exception of Lombardia, Italian regions retain specialization in automation and robotics, none of the Italian regions shows a pattern of specialization in computing technologies.

Note that, in general, the pattern for computing technology is both less pronounced and less stable than is the case for automation and robotics. This suggests that competitive

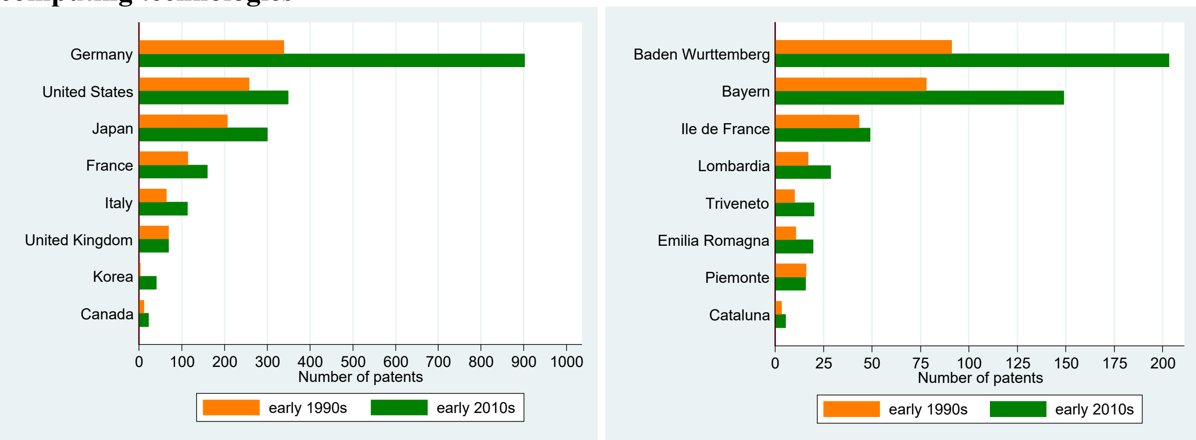
[5] Based on an analysis of the characteristics of technologies as described by the IPC system, the authors provide a conversion table mapping a set of key enabling technologies to the IPC codes. Robotics/automation technologies are identified by IPC codes: B03C, B06B 1/6, B06B 3/00, B07C, B23H, B23K, B23P, B23Q, B25J, G01D, G01F, G01H, G01L, G01M, G01P, G01Q, G05B, G05D, G05F, G05G, G06M, G07C, G08C; except for co-occurrence with sub-classes directly related to the manufacture of automobiles or electronics. Additional information, i.e. the list of IPC codes related to the manufacture of automobiles or electronics, are from Van Looy and Vereyen (2015).

[6] For both periods, we consider the first year for which data are available. Moreover, we calculate a three-year moving average to smooth annual fluctuations.

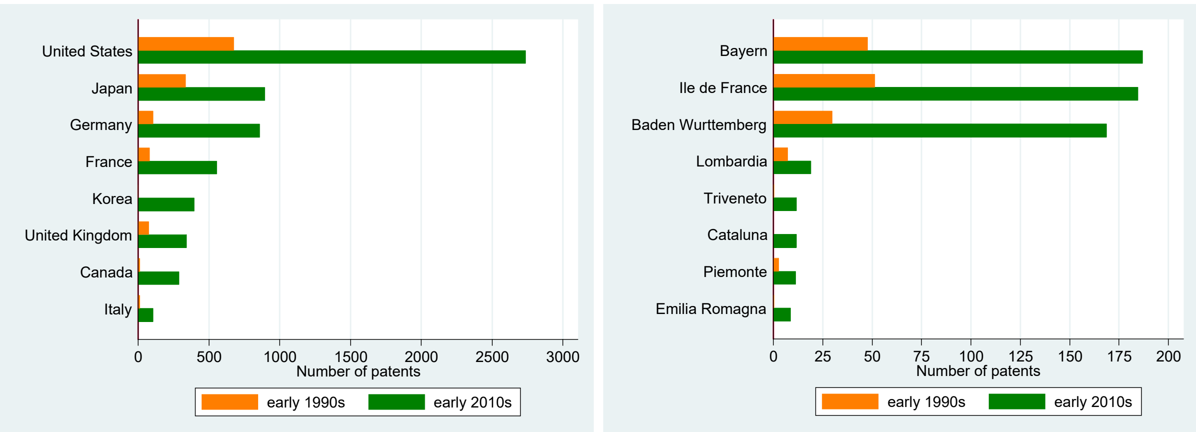
advantages in computing technologies are less cumulative and more contestable compared to robotics.

This evidence provides some contrasting results related to the Italian competitive system and, specifically, that in Piemonte and Emilia Romagna, one the one hand, specialization in robotic/automation persists and is increasing although not comparable with Bayern in absolute terms. In contrast, the Italian regions exhibit extreme weakness in the production of computing technology, which creates bottlenecks to the integration of these technologies into robotics and automation. However, the evidence suggests that the main advantage for future competition is could become the specialization in automation and technology and also that it might be possible to close the gap in computing technologies.

Figure 1.12 Number of regional and national patents for robotics/automation technologies, and computing technologies

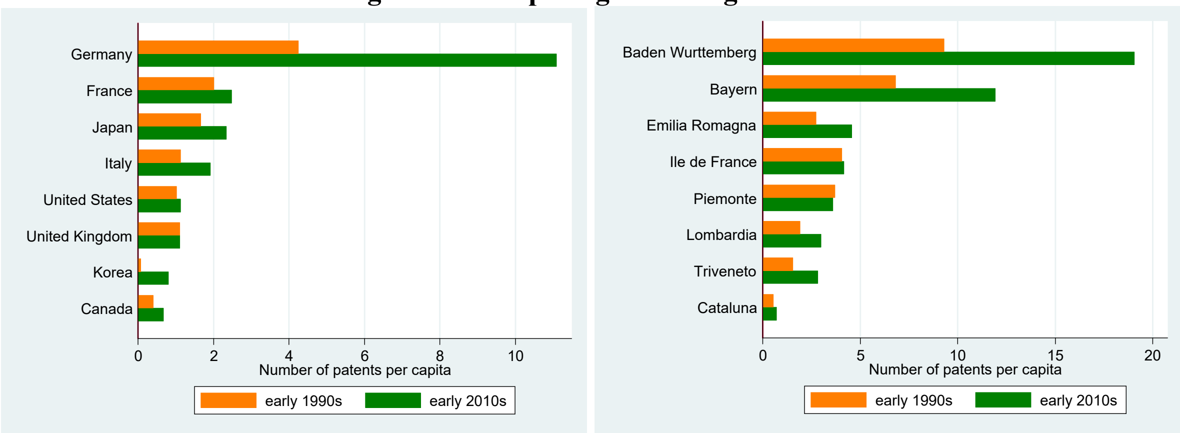


a) Robotics/automation technologies

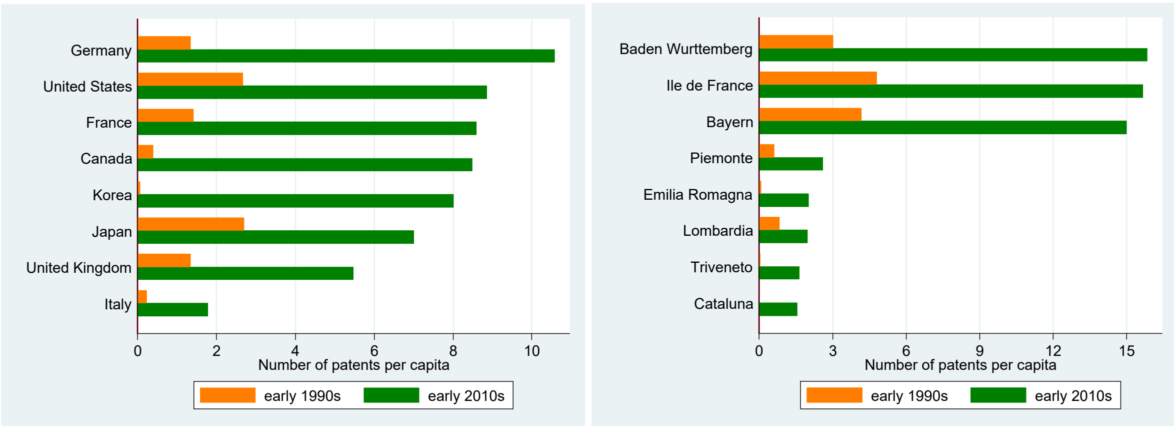


b) Computing technologies

Figure 1.13 Number of regional and national patents per million inhabitants for robotics/automation technologies and computing technologies

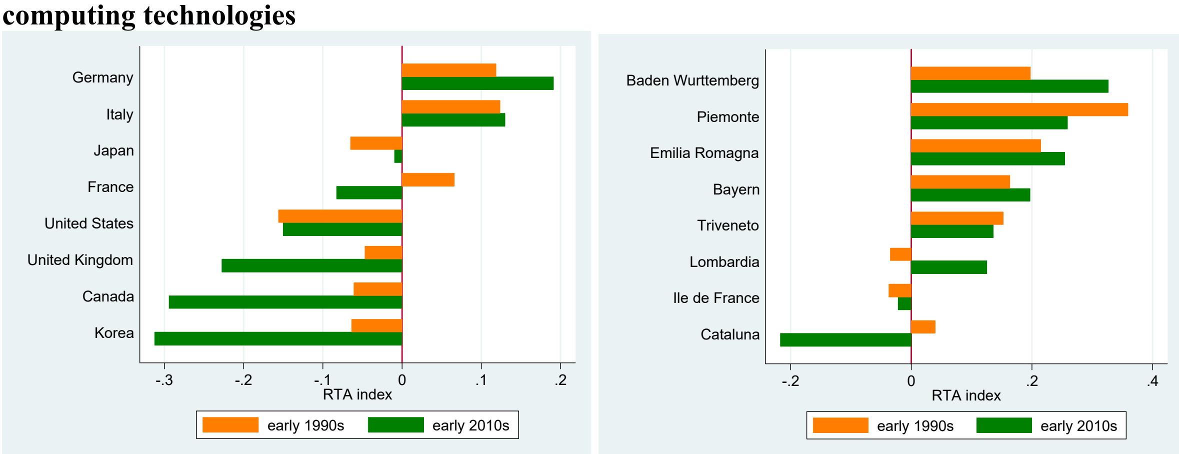


a) Robotics/automation technologies

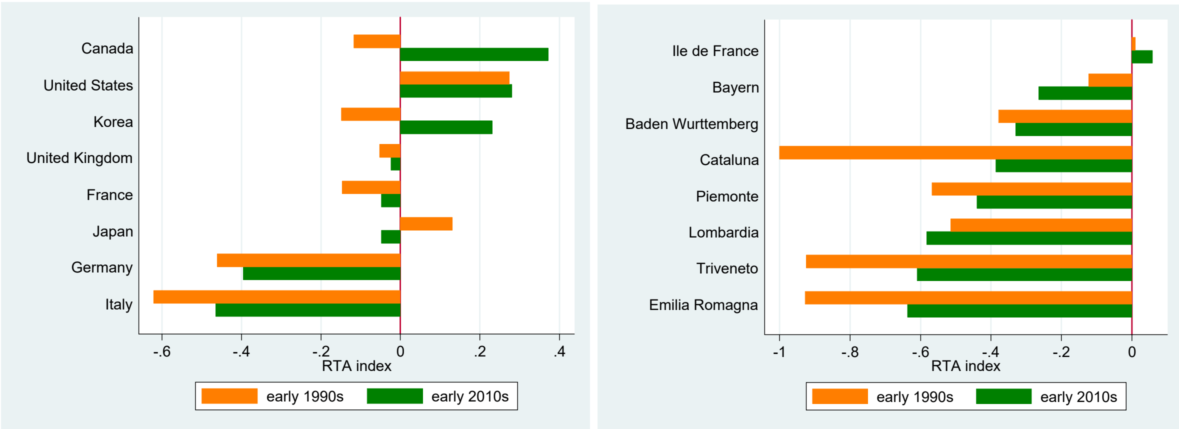


b) Computing technologies

Figure 1.14 Regional and national RTA index values for robotics/automation technologies and computing technologies



a) Robotics/automation technologies



b) Computing technologies

Finally, we briefly analyse R&D and human capital. It has frequently been noted that the modest Italian expenditure on R&D is not only the smallest among the G7 countries as a percentage of GDP (Table 1.6) but also it has a small business share funding. In 2013/14 Italian companies contributed slightly more than half of R&D expenditure, compared to 78% in Japan, 71% in the US and 67% in Germany. Unsurprisingly, Baden-Württemberg and Bayern are ranked at the top among European regions. Piemonte performs well measured as a percentage of GDP (2.2%) and, especially, as business expenditure (80%), outdoing any other Italian region.

The second area where Italy traditionally lags compared to the G7 countries, is average education. Table 1.7 confirms that even the most industrialized Italian regions have a much lower percentage of the population with tertiary education compared to European competitors. Although Italy has made attempts to narrow this gap, especially among the youngest cohorts, if the working population is considered, Lombardia is lagging than 10 points behind Baden-Wüttemberg and Piemonte is lagging by almost 15%. However, these huge differences are associated also to the fact that, in Italy, technical tertiary education, such as two-year postsecondary diplomas, has only recently started to develop with the creation in 2011 of the Istituti Tecnici Superiori (ITS – Higher Technical Institutes). In Germany, a significant share of higher education students are educated in the *Fachhochschulen* (there are also similar institutes in France); these institutions have played an important role in supplying a qualified workforce. The education perspective improves significantly if we consider student performance according to PISA indicators (Table 1.8). The mathematics and scientific capabilities of students in the regions Northern Italy are commensurate with European and G7 countries, with Lombardia and Triveneto on a par with the top performing country Finland, and Piemonte and Emilia Romagna ranked closely behind.

Table 1.6 Gross R&D expenditures (GERD) as % in GDP and Business enterprise R&D expenditures (BERD) as % in GERD

Country/Region	GERD as % in GDP			BERD as % in GERD
	1995	2007	2013/2014	2013/2014
Belgium	1,64	1,84	2,46	71,22
Canada	1,66	1,91	1,74	53,70
France	2,23	2,02	2,23	64,97
Germany	2,13	2,45	2,88	67,65
Italy	0,94	1,13	1,37	55,38
Japan	2,61	3,34	3,40	77,76
Korea	2,20	3,00	4,29	78,22
Netherlands	1,85	1,69	1,95	56,03
United Kingdom	1,68	1,63	1,68	65,15
United States	2,40	2,63	2,76	71,08
Baden-Württemberg	3,4	4,15	4.80*	80.58*
Bavaria	2,71	2,81	3.16*	76.26*
Catalonia	0,86	1,43	1.50*	56.60*
Ile de France	3,36	2,85	2.96*	68.41*
Piemonte	1,64	1,76	2,22	79,95
Emilia-Romagna	0,78	1,42	1,72	66,70
Lombardia	1,07	1,16	1,31	70,16
Triveneto	0,59	0,92	1,20	60,34

Source: OECD data for non-Italian regions; ISTAT data for Italian regions; * refers to 2013

Table 1.7 Percentage of population with a tertiary education

Region	2005	2016	growth rate	2005	2016	growth rate
Age	25-64			30-34		
Baden-Württemberg	26	31,7	22%	29,1	38	31%
Bayern	24,3	30,1	24%	27,8	38,3	38%
Cataluña	30	38,6	29%	41,2	43,1	5%
Île-de-France	38,7	47,3	22%	51,2	57,2	12%
Piemonte	11,2	17	52%	16,6	24,5	48%
Lombardia	12,6	19,3	53%	18,7	30,8	65%
Provincia Bolzano/Bozen	10,3	16,5	60%	13,8	23,9	73%
Provincia Trento	12,1	18,7	55%	16,3	35	115%
Veneto	11,2	16,2	45%	16,1	29,6	84%
Friuli-Venezia Giulia	12	17,4	45%	19,3	22,2	15%
Emilia-Romagna	13,4	20,7	54%	19,9	29,6	49%

Source: EUROSTAT

Table 1.8 Mean PISA2012 scores

Country/region	Reading Mean	Reading SE	Math Mean	Math SE	Science Mean	Science SE
Belgium	509	(2.3)	515	(2.1)	505	(2.2)
Canada	523	(1.9)	518	(1.8)	525	(1.9)
Finland	524	(2.4)	519	(1.9)	545	(2.2)
France	505	(2.8)	495	(2.5)	499	(2.6)
Italy	490	(2.0)	485	(2.0)	494	(1.9)
Germany	508	(2.8)	514	(2.9)	524	(3.0)
Japan	538	(3.7)	536	(3.6)	547	(3.6)
Korea	536	(3.9)	554	(4.6)	538	(3.7)
Netherlands	511	(3.5)	523	(3.5)	522	(3.5)
Spain	488	(1.9)	484	(1.9)	496	(1.8)
United Kingdom	499	(3.5)	494	(3.3)	514	(3.4)
United States	498	(3.7)	481	(3.6)	497	(3.8)
OECD average	**496**	**(0.5)**	**494**	**(0.5)**	**501**	**(0.5)**
Bolzano	497	(2,4)	506	(2,1)	519	(2,2)
Emilia Romagna	498	(6,5)	500	(6,4)	512	(6,2)
Friuli Venezia Giulia	518	(4,1)	523	(4,4)	531	(4,7)
Lombardia	521	(5,9)	517	(7,6)	529	(6,8)
Piemonte	506	(4,8)	499	(5,8)	509	(4,4)
Trento	521	(5,2)	524	(4,1)	533	(3,9)
Veneto	521	(6,0)	523	(7,6)	531	(6,1)
Catalonia	501	(4,7)	493	(5,2)	492	(4,2)

Source: OECD

2 Participation in global supply chains and the offshorability of Italian jobs

Rapid technological progress fosters transformations in the organization of production, both within and across countries. In recent decades, the main consequence of such progress has been the fragmentation of production by tasks. Companies may decide to profit from the competitive advantages of alternative locations and to offshore segments of their production which, previously, were performed at home and/or within the firm.

Whether a company signs a contract with a foreign supplier or establishes a subsidiary abroad, there can be an impact on employment and welfare in the country of origin. Most often, an offshoring strategy allows the company to specialize in its core activities, remain competitive in the market and gain market share, which results in more jobs overall. However, as discussed in Chapter 1, some categories of workers might be disadvantaged by their tasks becoming standard routines which require very little knowledge stock. In this case, robots can substitute for humans, while workers may be in fierce competition with workers in other countries if an offshoring strategy is feasible.

Here, we adopt a company perspective. First, we provide some insights into the generation of value by Italian companies in supply chains, using a sample of some 336,814 manufacturing and services firms in Italy, and information on financial accounts. We then investigate whether there is a limit to the degree of *offshorability* of the Italian economy, given its industrial structure. That is, we examine whether there is a threshold of *offshorable* jobs, beyond which competitiveness and innovation are endangered. Finally, we offer some insights into the internationalization strategies of Italian firms, including increased participation in international supply chains and their impact on economic growth. All our findings point to a robust and resilient persistent Italian productive system. However, we argue, that major differences in the performance of some companies and industries are highlighting the need for policies to offset the possibly unequal benefits from fast technological progress and economic interdependence with the rest of the world.

2.1 ‘Who’s smiling now?’

In an ideal production sequence, involving one or more firms along the supply chain, we can envisage starting a business line from design, to research and development of a blueprint. These are pre-production services whose implicit knowledge and skills content is quite high on average. It is after these phases that manufacturing for the production of intermediate inputs, such as parts, components and semi-finished products, begins, leading eventually to the delivery of a final good, which, in turn, requires additional so-called post-production services (marketing, advertising, logistics, other business services). The later stages, which are designed to bring together demand and supply, require a relatively high knowledge content while the production of intermediate inputs and their assembly involve more standardized tasks that, nowadays especially, rely on routines and automation.

Figure 2.1 refers to a celebrated framework from the business studies literature (Mudambi, 2008), which has been discussed at length in international fora (among others, OECD, 2013), and which represents the previous sequence of business functions as a *smiley*, based on the pattern of a hypothetical plot of the economic value of the individual tasks along the supply chain.

Figure 2.1 The concept of a 'smile curve', source: Mudambi (2008)

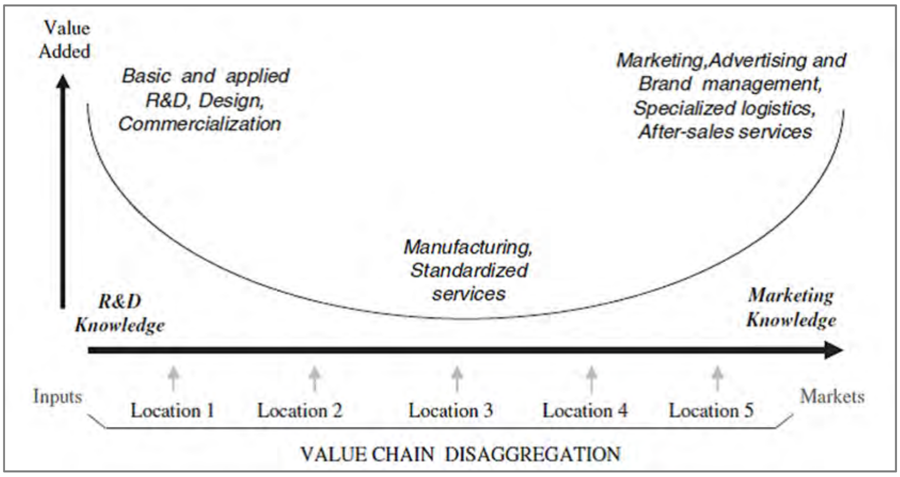
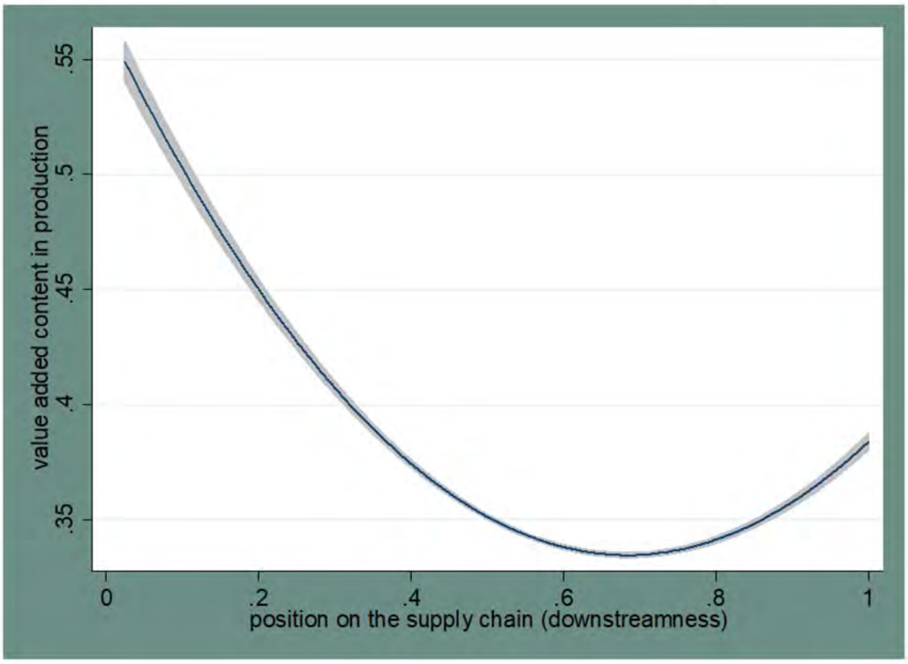


Figure 2.2 The smile curve of Italian firms, source: Rungi and Del Prete (2017)



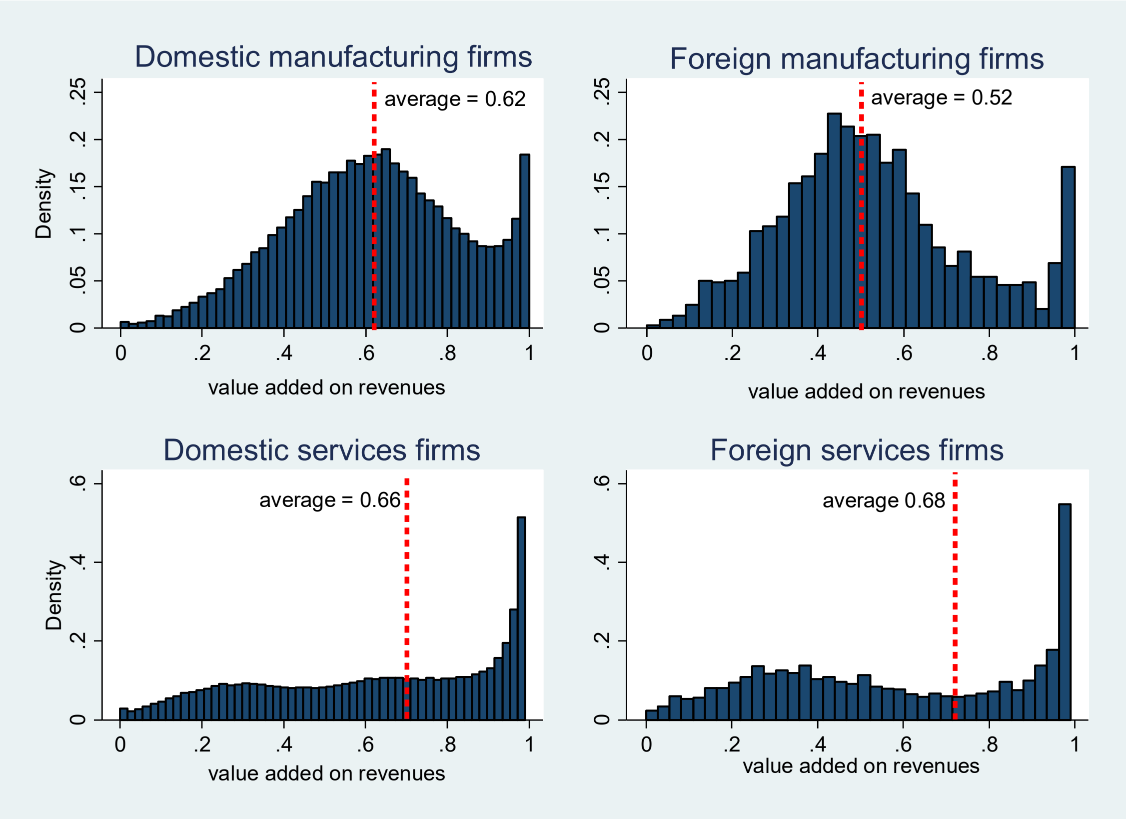
However, the division of labour in real-world organization of production is often much more sophisticated than Figure 2.1 would suggest. For this reason, Figure 2.2 investigates the generation of value by Italian firms, adopting a finer metrics for the positioning of companies along the supply chain, while exploiting a simple econometric investigation that takes account of the heterogeneous characteristics of Italian firms.[7]

Here, we use *downstreamness* to measure how far an industry (and the firms in it) are far from final demand. Based on the input-output linkages among 420 industries (Antràs and Chor, 2013), it is possible to define, in greater detail, the position of a company in one industry relative to a company in another industry. Firms in upstream industries can be considered suppliers of the firms in downstream industries. *Downstreamness* ranges in the interval 0 to 1, where 0 is the beginning of a business line and 1 is the delivery to the final consumers.

We derive firm-level generation of value among a sample of 336,814 manufacturing and service companies active in the year 2015. The value added content of each firm is the economic value it generates, that is, net of purchases of intermediate inputs, over sales. Therefore, it can be considered as representing what each company distributes to production factors, as employee wages, dividends and interest on capital, and taxes for public services. In aggregate, we can say that all the value generated by companies in a country will sum to the gross value added of that country. The higher the value generated by firms, the higher the growth of that country. At the level of the company, it is the value it generates for its immediate stakeholders, both the owners of the capital and the workers. From a supply chain perspective, it is the portion of value generated by a single task before reaching the final consumer.

[7] For details of the econometric investigation, see Rungi and Del Prete (2017) for all EU firms. Briefly, the value-added content of production is regressed on downstreamness by a quadratic term, after controlling for firm-level heterogeneity in size, capital intensity, productivity and price-cost margins. The narrow band on the graph in Figure 2.2 represents a statistical confidence interval significant at 95%.

Figure 2.3 Firm-level value added content in manufacturing vs services, domestic vs foreign



Source: authors' elaboration

We can conclude that Italian 'supply chains' show great reliance in the first stages of production to generate value, but that the country as a whole lacks competitive advantage in the later stages of production when supply meets demand.[8] In other words, in Italy, there is a possible lack of competitiveness of the production processes, which stems from that part of the supply chain where companies meet consumers. To gain a deeper insight into this, Figure 2.3 reports the separate distribution of manufacturing and services firms, divided, in turn, among a set of domestic companies and a set of multinational enterprise subsidiaries active in Italy.

We observe a heterogeneous distribution of both manufacturing and services firms. Also, some producers generate more than 80% of economic value, while others generate less than 20%. The averages reported in the panels in Figure 2.3 may not be representative of the underlying reality. Nonetheless, services firms, structurally, are different from manufacturing firms. They usually require fewer intermediate inputs, goods and services to perform their activities. On average, they are smaller in size than manufacturing firms because they do not benefit from economies of scale or scope. In the Italian case, more than half services firms are able to generate above 90%, while the performance of the remaining half differs widely.

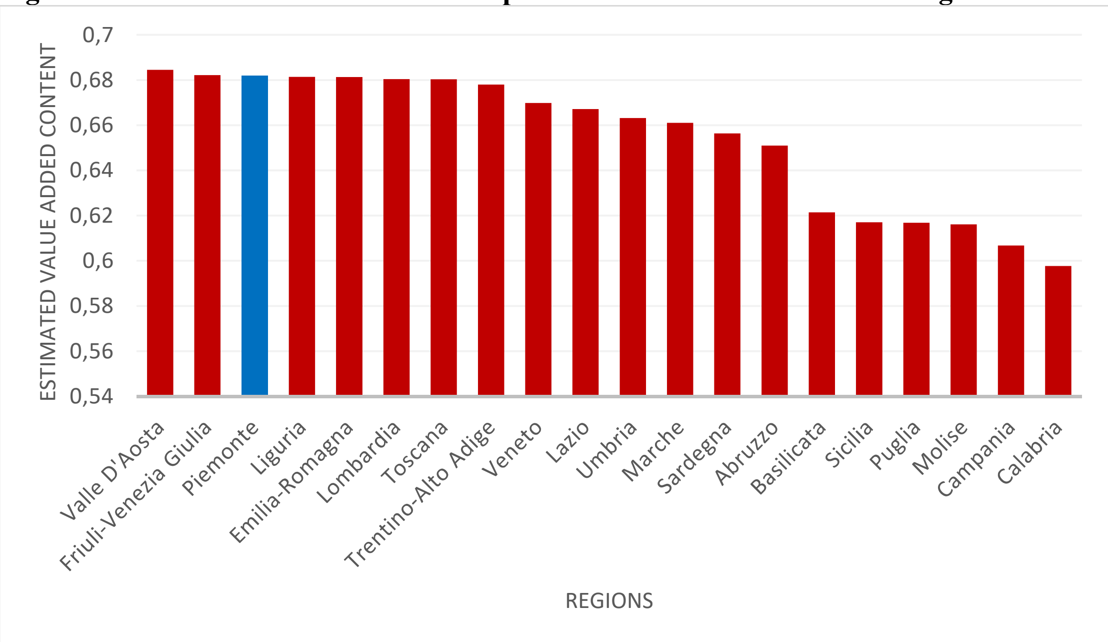
In general, foreign and domestic services show no significant differences in their distribution, whereas domestic manufacturing firms produce at a higher value than foreign companies, especially if we look at the VI decile in the distribution. The econometric results

[8] In fact, a similar exercise for EU firms (Rungi and Del Prete, 2017) shows that companies involved in later production stages generate on average about 20% more value than Italian firms represented here.

reported in Appendix Table II.2, suggest a phenomenon of value added retention, according to which the country retains the higher value manufacturing production stages because they are crucial for maintaining present and building future competitive advantage. This does not apply to the services sector.

Geographic location, even more than the foreign *vis à vis* domestic dimension of companies, confirms the presence of a strong divide between the North and the South of Italy. This can be seen clearly in Figure 2.4, which plots the representative company in each region, after controlling for possibly unequal size, industry affiliation, productivity and capital intensity (see Appendix Table II.1). Representative firms located in the South of Italy are lagging badly, whereas all the Northern regions, including Piemonte, are in a rather narrow range around 68% of value to revenue.[9]

Figure 2.4 Value added content in the representative firm of each Italian region



Source: authors' elaboration

2.2 *Offshorability* of Italian jobs

One of the most common reasons for offshoring intermediate stages is the cost advantage that companies can derive from paying less to achieve the same output. After technological progress and trade barriers progressively reduced the frictions among countries, a big pool of cheaper labour in developing countries has become available to companies from the developed countries. However, reduced labour costs are not the only reason that firms are keen to offshore. There are shipping costs to consider and intermediate goods can spend weeks in transit at customs. However, everything considered, companies still are able to find producers in other countries able to provide high quality parts or components. The firm might decide to sign a contract with the relevant supplier and either close down an existing

[9] Representative value added content is estimated as region fixed effects from the regression model reported in Appendix Table II.2, which controls for heterogeneity of firms and industry composition.

domestic plant or terminate a contract with a domestic supplier. Alternatively, a firm might acquire the supplier company or establish a new plant in the relevant foreign country. All of this applies also to services when a foreign provider or a foreign subsidiary can perform the same activity more cheaply or at higher quality.

The surge in offshoring is at the heart of the wave of economic globalization and is also the most critical aspect of globalization, due to its impact on domestic labour markets. Most economics scholars would acknowledge that there may be short-run effects on employment either because some workers will be excluded from the labour market, or, if a skills upgrading is possible, because they are reallocated to more efficient activities (Gorg, 2011). Unfortunately, the evidence supporting the neutral effect of globalization on unemployment in the long run is mixed. The discontents would argue that job creation abroad only compensates for job destruction at home, with no overall gains. Also, it is not easy to upgrade the skills of unemployed workers, and the efficiency gains from offshoring need to be sufficiently large to boost the overall number of jobs (Ottaviano, 2015). More generally, there is a lack of conclusive evidence because it is difficult to disentangle the effects of technological progress from the effects of globalization. In fact, economic globalization has occurred simultaneously with technological progress and, therefore, it could be argued that the first is, in part, a consequence of the second. Ultimately, a proper understanding of the impact of globalization on unemployment should separate the impact of automation on production since machines are also substitutes for human labour.

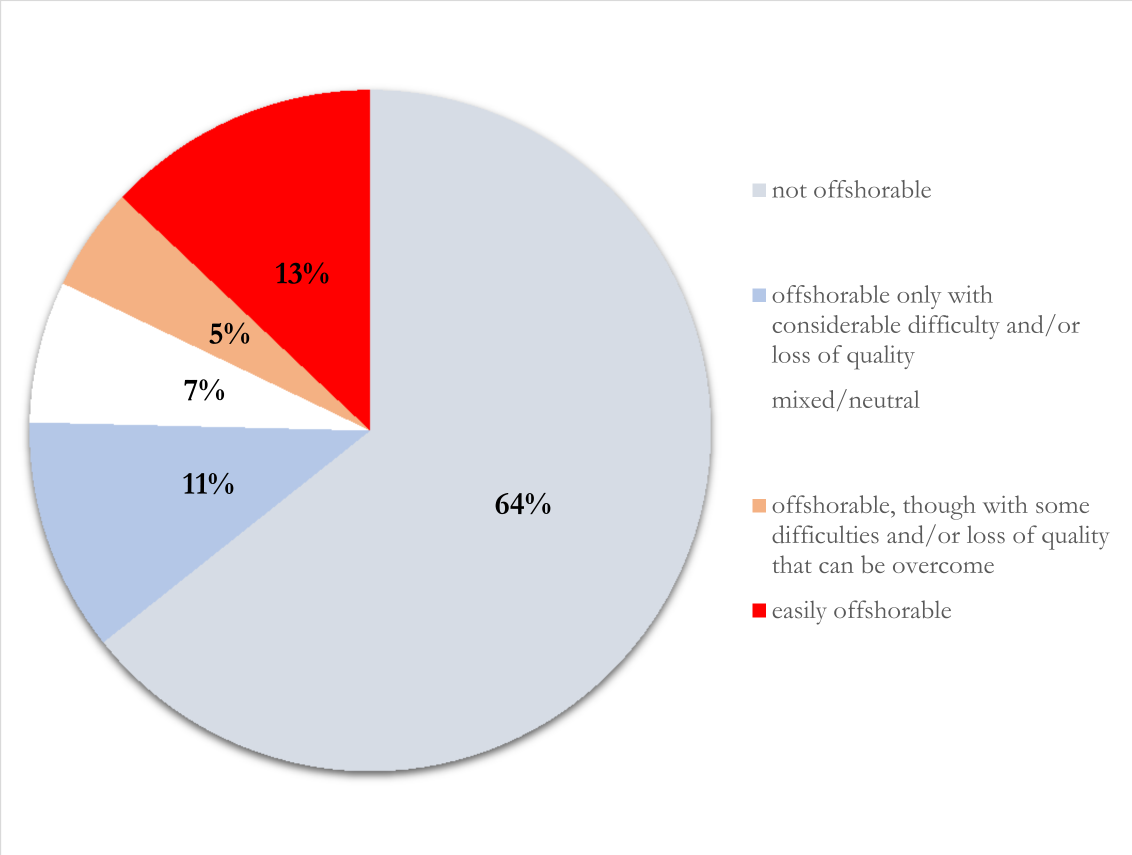
Debate and research on the impact of offshoring on employment are far from being concluded. More recently, another perspective has been added. Another reason for concern is the possibility that competitiveness and innovation are being threatened by the separation of strategic tasks which are located at a distance from one another. This is a company perspective that can affect the overall growth potential of a country or region.

For example, take the case of R&D activities which it is preferable to retain in the developed country, near to where researchers are being educated. In contrast, manufacturing activities tend to be relocated to where they can be produced more cheaply. However, most innovation activities are not one-shot tasks. They usually require continuous interaction among the workers involved in different stages of production in order to identify where improvements can be made to products or production processes. By their very nature, all production stage that require face-to-face interaction among workers are more difficult to offshore.

It is possible that decreasing the barriers to trade and investment combined with the adoption of ICT may have caused over-optimism and excessive fragmentation of those strategic tasks that ensure firm competitiveness. It is difficult to identify *ex-ante* which tasks should be offshored without risking the firm's competitive advantage. One possibility is to ask workers how much their tasks are standardized and how much face-to-face interaction with colleagues is required. This is what Blinder (2009) did for the US case, exploting surveys of US workers to describe the potential for offshoring for each occupation. In the US case, given its industrial structure, they estimated that around 25% of jobs could be offshored in the immediate future.

Figure 2.5 estimates the offshorable jobs in the case of Italy, drawing on Blinder's (2009) study.[10]

Figure 2.5 Offshorable jobs in Italy



Source: authors' elaboration

Based on a representative sample of 336,814 Italian firms in manufacturing and service industries (Table II.1 in Appendix), we estimate that it would be possible to offshore about 13% of jobs without losing much quality of products and services and without major difficulties to the organization of the remaining domestic activities.

On the other hand, a core of 64% jobs in the Italian productive system, at the end of 2015, could not be offshored without considerable losses in quality and difficulties related to completing the remaining tasks. The intermediate situations are less relevant. An additional 5% of jobs could be offshored, although at the cost of some reasonable difficulty. About 11% of jobs could be offshored, but with considerable difficulty. Overall, we can conclude that at least twothirds of occupations in Italy are robust to an offshoring strategy and should not be

[10] See also Blinder and Krueger (2013). In the absence of *ad-hoc* surveys in Italy such as the one exploited in Blinder (2009), we source from their data the responses provided by US workers about face-to-face interaction with colleagues and standardization of their tasks. The original data include information for about 800 different tasks, nested in 420 6-digit NAICS industries. We matched this information to Italian firm-level data, about 336,814 companies, also NAICS 6-digit classes. Therefore, the estimates in Figure 2.5 are based on the median *offshorability* of the tasks in each 6-digit industry. Median values are chosen given the peculiar power law distributions of tasks within industries.

considered for relocation of activities abroad. The number of jobs that are offshorable is considerably less than has been estimated for the US.

2.3 Re-shoring

After the recent enthusiasm over the offshoring of activities from advanced economies to emerging countries, some companies are beginning to reconsider their strategies. Kinkel and Maloca (2009) analysed 1,663 responses from German companies and found that offshoring had lost momentum since between 16% and 25% of offshoring decisions had been reversed within four years of the initial decision. In a survey of US firms, Tate et al. (2014) identified a moderate (varying in magnitude with the industry) trend towards reshoring back home.

More recently, the European Reshoring Monitor[11] began to collect global information on reshoring companies, including the reasons why firms considered that the decision to offshore had been mistaken. Although not exhaustive and lacking statistical relevance, Tables 2.1 and 2.2 provide a snapshot of a non-negligible phenomenon. The European Reshoring Monitor suggests that the main reasons for reshoring include: i) increased costs of logistics (24%); ii) impossibility to meet "Made in" regulation (22%); iii) lower quality of production abroad (22%); and iv) a general increase in labour costs (18%). Among the cases reported by the European Reshoring Monitor for the year 2016, 121 out of the 376 in Europe have Italian headquarters. Table 2.2 presents the allocation of headquarters by macro-region and shows that the North of Italy particularly involved in the reshoring wave. The Appendix presents two peculiar cases of explicit reshoring based on maintaining manufactured product quality (FIVE company) and proximity to R&D (Turolla company). Their evidence is illustrative of the problems companies encounter when in offshoring.

[11] The European Reshoring Monitor (http//reshoring.eurofound.europa.eu) is a EU funded initiative undertaken as part of a multi-annual research project on the future of manufacturing in Europe. The project collects information on individual reshoring cases from several sources such as media, specialized press and the scientific literature.

Table 2.1 Some cases of reshoring

Headquarters	Offshoring location: China	Asia (excl. China and Japan)	East Europe	West Europe	North America	Central and South America	Africa and Middle East	Oceania	n. a.	Total
Europe	127	39	64	116	9	5	11		5	376
North America	214	46	2	24	23	14	1	2	3	329
Asia (excl. China and Japan)	4	1	1	5	-	-	-	-	-	11
Japan	3	1	1	1	-	-	-	-	-	6
China	-	-	-	2	-	-	-	-	-	2
Africa and Middle East	-	-	2	1	-	-	-	-	-	3
Oceania	1	-	-	-	-	-	-	-	-	1
Total	349	87	70	149	32	19	12	2	8	728
% of Total	47,9%	12,0%	9,6%	20,5%	4,4,%	2,6%	1,6%	0,3&	1,1%	100,0%

Source: Uni-CLUB MoRe reshoring

Table 2.2 Reshoring in Italy

Geographic Area	Region	Reshoring cases
North East Italy	Veneto	36
	Friuli Venezia Giulia	6
	Trentino Aldo Adige	3
	Totale	45
North West Italy	Emilia Romagna	32
	Lombardia	28
	Piemonte	7
	Liguria	4
	Totale	50
Central Italy	Marche	9
	Toscana	9
	Umbria	2
	Lazio	1
	Abruzzo	1
	Totale	22
South Italy	Campania	2
	Puglia	2
	Totale	4
Total		121

Source: Uni-CLUB MoRe reshoring

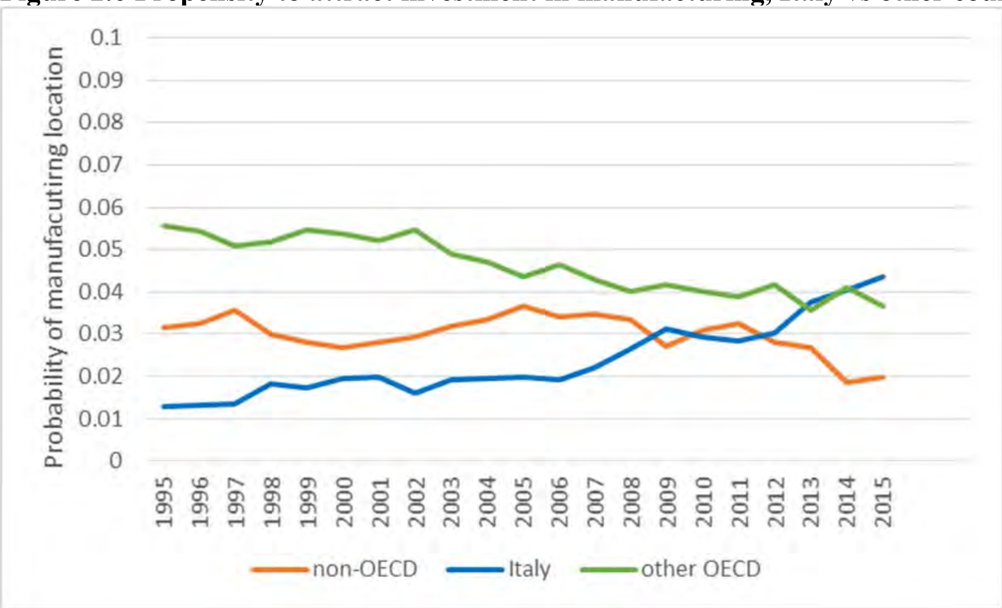
It is difficult to collect exhaustive information on the extent of reshoring by companies because most are reluctant to disclose management strategies. However, Figure 2.6 reports a more general trend in investment in manufacturing in Italy.

We first consider all those Italian companies that invested in manufacturing plants in Italy from 1995 to 2015. For those same companies and during the same period, we track the decision to locate their manufacturing plants elsewhere in the same period. We can broadly classify investment operations by these companies as: i) located in Italy; ii) located in another advanced economy (OECD countries); iii) located in an emerging economy (non-OECD country).

This allows us to track how Italy is considered an alternative location for manufacturing plants, by domestic and international investors. Figure 2.6 presents estimates of the propensity[12] of an investor to locate a manufacturing plant in Italy and the respective averages for an advanced and an emerging economy.

We found that, at the beginning of the period, Italy did not attract new manufacturing production, compared to other advanced economies that were attracting relatively more plants, on average. For every 100 new manufacturing plants in the world, around 1 was located in Italy and almost 6 in another advanced economy. Since 2011, emerging countries have lost some of their attractiveness for manufacturing, whereas Italy is much more attractive, with a 5% probability that a new plant in the world will be located in Italy rather than elsewhere.

Figure 2.6 Propensity to attract investment in manufacturing, Italy vs other countries



[12] To estimate location choice, we employ a conditional logit model, which takes account of each country in the world as a possible alternative for establishing a manufacturing plant. We extracted from Rungi et al. (2017) a sample of 21,013 new manufacturing companies that were incorporated in the period 1995-2015. After controlling for some traditional national economic characteristics (GDP per capita, population, working population, etc.), we derived predicted probabilities. For details on the procedure, see among others Schmidheiny and Brulhart (2011).

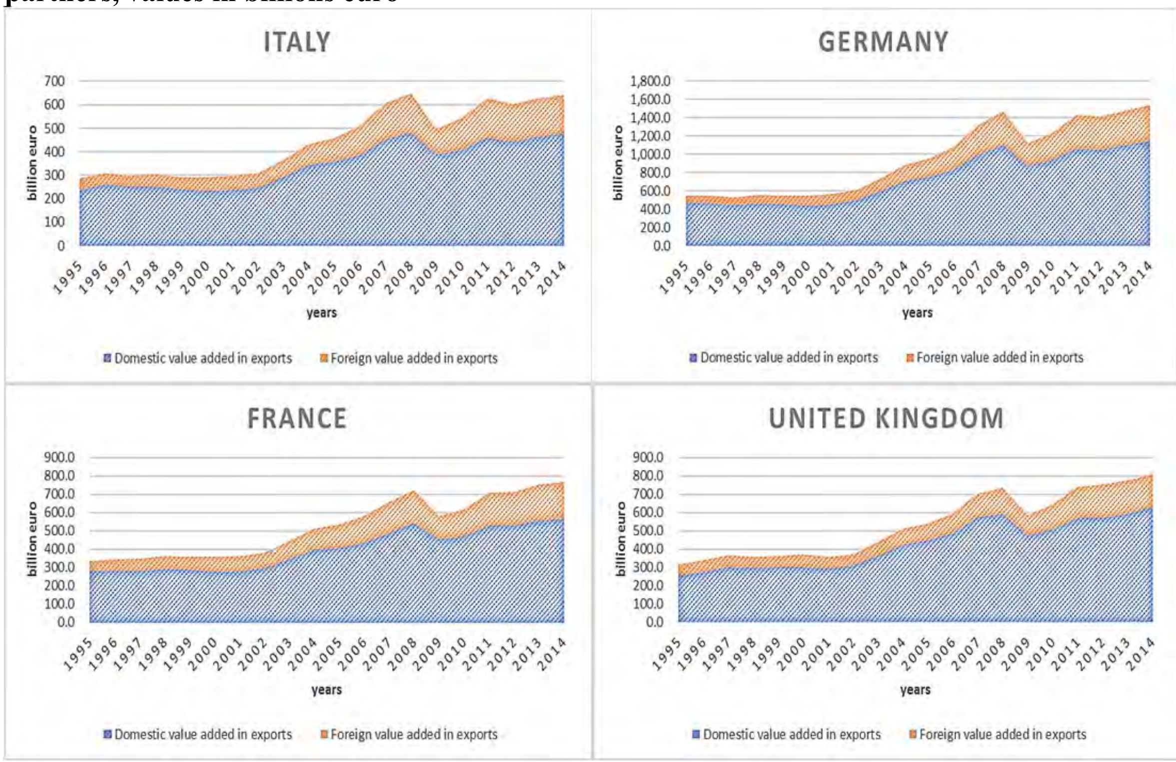
2.4 Participation in supply chains and contribution to growth

Understanding the contribution of international trade to economic growth has always been problematic because, usually, both export and import flows are gross measures, that is, they include the value of imported intermediate inputs used in the production stages performed at home.

Take the example of a car assembled in and exported from Italy, whose components are all imported from another country. Its entire export monetary value is attributed to Italy in official statistics, although the value of the parts and components should be deducted from the gross exports of cars because they were generated (and already recorded) in the country from which they were sourced. In this simple case, only the difference between the value of the exported output and the value of imported inputs should be recorded in Italy as contributing to the generation of income and, hence, growth.[13]

Figure 2.7 presents TiVA OECD data to separate the contribution to growth of Italian exports from the economic value of imported intermediate inputs.

Figure 2.7 Domestic and foreign value added of Italian exports vis à vis main European partners, values in billions euro



Source: authors' elaboration on OECD TiVA database

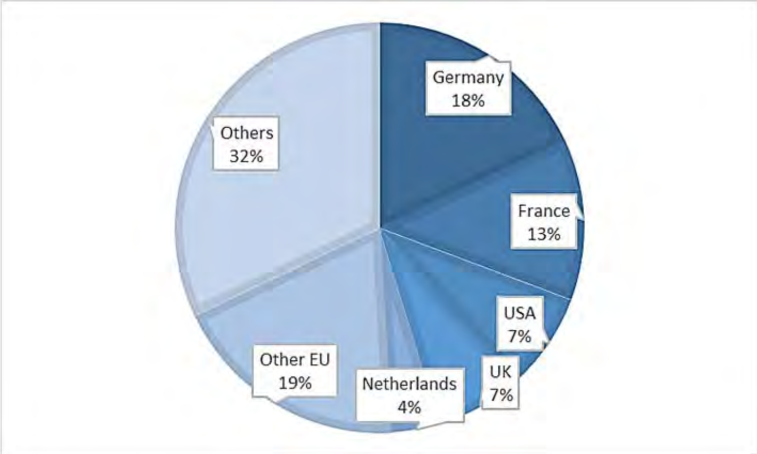
[13] The illustrative case is just a simplification of much more complex networks of production, when intermediate stages of production cross national borders several times, spanning different countries and industries, before reaching the final consumer. In this case, the attribution of value to countries is more sophisticated and requires some algebra. Among others, we refer to Timmer et al. (2015), who used the automotive example to explain the basics of an accounting for trade flows according to the origin of the value added.

Starting from the mid 1990s, total exports have increased considerably in Italy and in the rest of the world, as documented by several sources (among others, see WTO, 2013). However, a good and increasing proportion of trade flows come from economic participation in international supply chains. The *foreign value added in exports* that we report in Figure 2.7 represents the economic value coming from abroad since the imported goods and services end up in the exported product. This component is generally increasing in all of the bigger EU countries represented here, although it is slightly larger in the case of Italy. Briefly, Italian exporters benefit considerably from integration in supply chains and their exports also have increased, thanks to the sourcing of better and/or cheaper intermediate inputs from abroad.

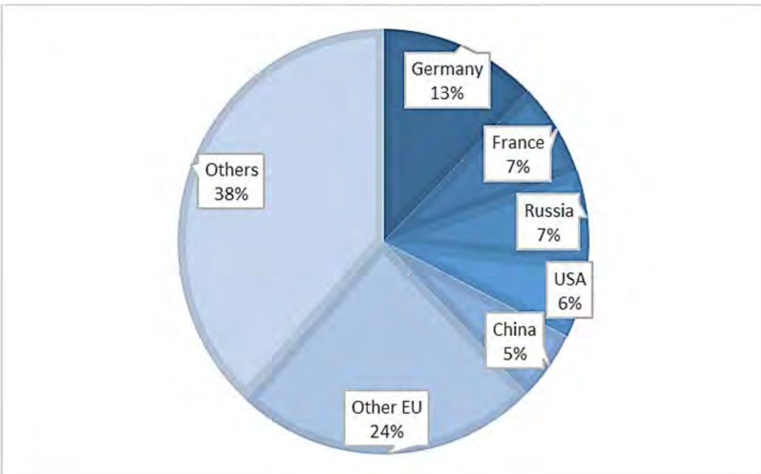
Starting from around 83% in the mid 1990s, the relative share of domestic value added in exports has decreased to a value around 75%. More foreign value added implies greater participation in international supply chains. However, both domestic and foreign value added have increased in absolute terms, showing that a complementarity can exist between domestic and foreign inputs in national production. It is possible that better quality inputs from abroad could also stimulate more production at home and an overall gain from participation in supply chains. Overall, Italy and its main European partners continue to generate the majority of economic value in exports, domestically, that is, about three-quarters of total export value, indicating that domestic tasks prevail over offshored tasks in Europe.

Figure 2.8 reports the main countries of origin of the economic value, and the offshored tasks, which, ultimately, are embedded in Italian exports, respectively in 1995 and 2011 (last available year). We briefly identify the countries of origin of the foreign value added content represented in Figure 2.7. Over 20 years ago, the then European Union members represented a majority of the value (61%), with the top contributions coming from Germany, France, the UK and the Netherlands in Europe, and the US. In 2011, Italian exporters have diversified the origin of their intermediate inputs and extra-EU countries now represent 54% of foreign value added content in total exports. Germany is still the main provider of Italy'seconomic value, but its share has decreased to 13%. The presence of Russia (7%) among the top partners is justified by its natural resources and energy contributions, while, nowadays, China represents an important source of intermediate inputs, either goods or services, comparable to the US.

Figure 2.8 Top partner countries for Italy when sourcing value sourcing of intermediate inputs



c) year 1995



d) year 2011

2.5 Conclusions

In this chapter, we traced the generation of economic value by Italian firms using their financial accounts. We plotted each firm's position in the ideal supply chain and identified those segments where the most value is generated, at the top and bottom of the chain, depicted by a *smile curve*. We discussed how excessive fragmentation of production can endanger the transmission of value along supply chains and estimated that, given the present industrial structure, a further 13% of Italian jobs could be offshored without jeopardizing the quality of products or services and without raising difficulties related to performing the production tasks that remain at home.

Following a first optimistic wave of offshoring in the 2000s, we documented how some companies are reconsidering the reshoring of some activities to their home country, to avoid overstretching supply chains and to retain sources of competitive advantage in geographical proximity. Firm-level data on the investment decisions made by domestic and foreign investors since 1995, in Italy and elsewhere, allowed us to estimate that Italy has become an attractive location for manufacturing production.

Finally, we examined the last two decades of Italy's participation in international supply chains and its main EU partners, using data on the domestic and foreign economic value embedded in the exports of Italian producers. We found that the lion's share of value is generated at home and seems to complement the foreign value of imported intermediates. However, the integration with extra-EU partners has increased considerably because of their already high representation in the value imported through inputs that are embedded in Italian exports.

Overall, we can conclude that the Italian productive system has been robust to integration in international supply chains, thanks to a strategy of diversification of input sourcing from abroad, which allowed an increase in the quality and quantity of exports. However, in our view, there is little room for further offshoring by companies, because, generally, Italian jobs have an inherently high knowledge and skills content, both aspects that are difficult to coordinate from remote locations.