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# Resilience and Digital Disruption

## Regional Competition in the Age of Industry 4.0

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## Regional Competition in the Age of Industry 4.0

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# Contents

# Chapter 1
# Introduction


The main aim of this book 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 the Piemonte region and also analyse the main trends in Lombardia, Emilia-Romagna, and Triveneto.[1] Overall, this geographical macro-area accounts for about 27 million people, equivalent to the population in Benelux. The journey by train from Milano (capital city of Lombardia) takes 45 minutes to reach Torino (capital city of Piemonte), 60 minutes to reach Bologna (capital city of Emilia-Romagna), and 200 minutes to reach Venezia (capital city of Veneto). Milano and Torino can be considered an urban agglomeration (e.g. the Metropolitan Statistical Area of greater Boston which 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 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 book 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

[1] Triveneto is commonly referred as the historical region in the North-East of Italy, including the following administrative regions: Veneto, Friuli-Venezia Giulia, and the provinces of Trento and Bolzano

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lower skilled labour. Against this background of opportunities and challenges, regions and countries must facilitate the processes of reshoring 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 book 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 slowdown 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 of foreign competitors, due to lower levels of investment in innovation and over-reliance on internal demand. A prolonged period of reduced internal demand has resulted in only those companies managing to survive that are able to innovate thanks to growth in their export shares.

In Chaps. 2 and 3, 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 USA. At the same time, we estimate that, in recent years, Italy has caught up with other advanced economies despite its initial disadvantages, 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, this research 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 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 and automation, and computing technologies, an area in which Europe has a 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 the 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 USA 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 Ile 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 and 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 Chap. 4, 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 have leveraged 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 responsible for these positive results, 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 Chap. 4, 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 equipment manufacturers and has 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 research identifies a shortage of competences in computing technology and artificial intelligence, key competitive areas for North Italy and Piemonte in particular. Although the machinery and robotics industrial base is quite robust, the input gaps identified could create a bottleneck in the evolution of this industry towards advanced digital manufacturing. The short-term risk is a 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 competence, and favour the interaction of these with the developing competence 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 the 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 postgraduate 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 volume describes such policies and discusses examples of successful cases abroad along with an estimate of their costs.

# Chapter 2
# Digital Technologies and Industrial Transformations


## 2.1 Introduction

Over the past few decades, 'digital technology' has shaped the so-called Third Industrial Revolution—the first in the nineteenth century being characterized by steam and water, and the second at the beginning of the twentieth 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 that it 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 contribution (Ampère, 1843; Wiener, 1948a, 1948b; 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 also been described as digital manufacturing, industrial Internet, smart industry, and smart manufacturing (Hermann et al., 2016; Nuccio & Guerzoni, 2019).

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 a result of a convergence among the advances made in several related information and communications 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.

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Against this background, the present contribution 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 reshoring of manufacturing activities to their origin countries based on the fact that overstretched supply chains are endangering firms' competitive advantages.

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?

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 Fig. 2.1). 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

[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.

[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 & Trajtenberg, 1995).