MAKERS

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Paper on the technological upgrading in manufacturing in the light of the new manufacturing model

Task 1.1Review the recent trends in the manufacturing sector in Europe, US, Japan and Asia with secondary data

Task 1.2 Review the literature on the impact of new technology on manufacturing sector

Coordinate by UNIVE

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1. Review the recent trends in the manufacturing sector in Europe and worldwide

In 2015 China consolidated its leadership position as the main world manufacturing producer with 28,6% of global value added. United States come after, second with a 19% share, preceding all other world's advanced industries. Among European countries, Germany is leading with 6,1% of global value added, followed by Italy (2,3%) and United Kingdom and France (2,2%). Table 1 summarises some basic statistics about manufacturing sector and its weight.

Table 1: Manufacturing value added for top 10 countries.

Country	% of manufacturing global value added (current prices $)				% average annual growth of manufacturing value added (constant prices)			% manufacturing value added on national GDP			
	2000	**2007**	**2012**	**2015**	**2000-07**	**2007-12**	**2012-15**	**2000**	**2007**	**2012**	**2015**
China	6,8	12,9	22,8	28,6	11,7	10	7,1	31,9	32,6	30,2	29,3
USA	27,5	20,9	17,7	19	2,6	-0,9	2,4	15,1	12,8	12,3	11,8
Japan	17,7	9,9	9,8	6,5	2,8	-3,5	-1,1	21,2	20,3	18,6	18,3
Germany	7,2	8,2	6,5	6,1	2,6	-0,1	2,3	23	23,4	22,8	22,5
South Korea	2,6	3,2	3,1	3	7	4,4	1,4	29	28,2	31	28,2
India	1,4	2,4	2,8	3	8,5	5,8	3,5	19	19,5	17,9	17,3
Italia	3,5	4	2,5	2,3	1	-3,1	-0,2	19,5	17,7	15,4	15,8
UK	3,8	3,1	2,1	2,2	0	-1,5	0,5	15,7	10,5	10	9,9
France	3,4	3,4	2,4	2,2	1,8	-0,7	0,8	15,7	12,7	11,3	11,3
Mexico	2,2	2	1,8	1,7	0,8	1,1	1,7	20,5	17,4	17,9	17,8

Source: our elaboration on CSC, UNSD, Eurostat and IHS-Markit data.

The growth of China's manufacturing industries remains far above the world average, despite having continued to slow down over the last 5 years. The average annual growth rate fell to 7,1% in the 2012-2015 three-year period, against 10% in 2007-2012 and the 11,7% of 2000-2007. This has also affected the other BRICs, recording less brilliant performances. India is sustaining its pace of growth, but the rate is half than that of China. Russia and Brazil, instead, entered recession, losing respectively 1,6% and 3,8%.

Two tendencies can be observed in the manufacturing trends worldwide: an accentuated slowdown of the main players in the emerging world, and, on the other side, a rise in

advanced economies a long period of contraction, albeit not uniform in intensity. BRIC's annual average growth rate, expressed at constant prices and exchange rates, has gone from 8,6% between 2000 and 2007 to 7,4% in the five-year period 2007-2012 up to 5,2% of the 2012- 2015. During the same years western countries have gone from + 1,5% to -1,7% and then climbed to 1,1% (table 2).

These trends hide a remarkable heterogeneity between the two blocks. Among emerging countries, in fact, the abrupt rise of China (from an average annual growth of 10,0% between 2007 and 2012 to a 7,1% between 2012 and 2015) and India (from 5,8% to 3,5%) is accompanied by Russia's reversal (from +0,6 to -1,6%) and a further downturn of Brazil (-0,6% to -3,8%). Among the developed ones a significant growth was recorded by United States (+2,4% the average annual change), Germany (+2,3%) and Spain (+1,5%), while Italy struggled to reverse the route (-0,2%) and Japan remained firmly with a negative sign (-1,1%).

Table 2: Manufacturing value added.

	% of manufacturing global value added (current prices $)				*% average annual growth of manufacturing value added (constant prices)*		
	2000	2007	2012	2015	2000-2007	2007-2012	2012-2015
World					2,9	0,7	2,4
Advanced economies*	75,8	63,8	52,4	49,6	1,5	-1,7	1,1
Euro area	20,6	23,3	16,7	15,9	1	-2,5	1
BRIC	10,7	19,7	29,9	34,4	8,6	7,4	5,2

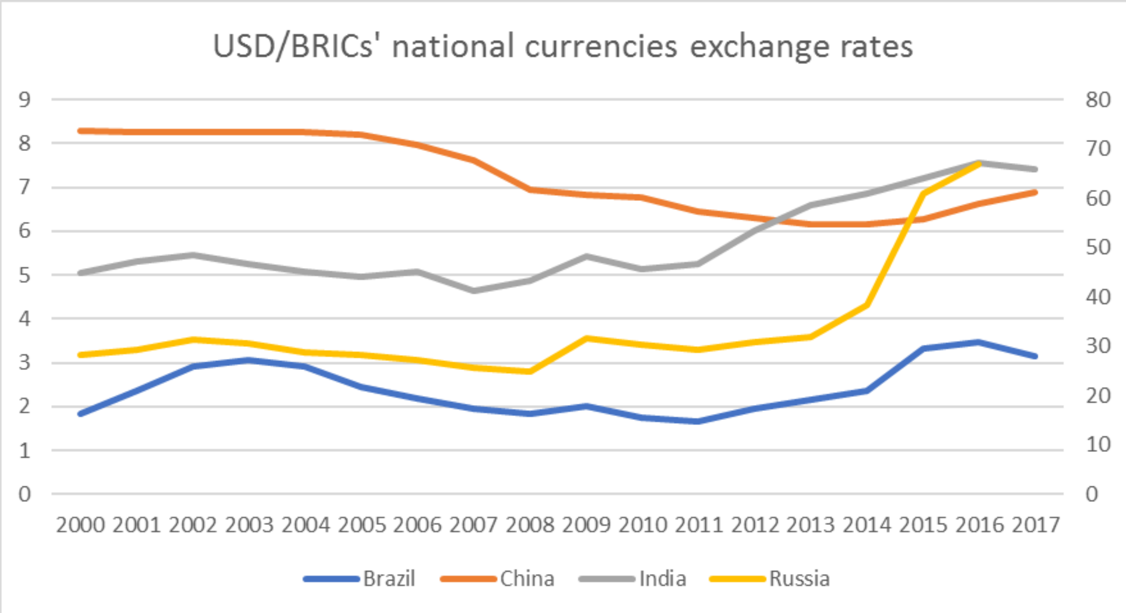
Source: our elaboration on CSC, UNSD, Eurostat and IHS-Markit data.

Note: *Advanced economies: UE-15, USA, Japan, South Korea, Canada, Switzerland, Euro area 12 member states.

The divergent trend in BRIC dynamics is also reflected in their respective global added value shares, expressed at current prices and exchange rates. China strengthens its top position in the rankings while India remains stably the sixth. Russia and Brazil, on the other hand, lose positions between 2012 and 2015, respectively, from ninth to twelfth and from the tenth to the fifteenth. The downward trend in these two countries has affected the collapse in commodity prices recorded since the second half of 2014, which has caused a sharp fall in national currencies: the rouble lost almost half of its value between 2012 and

2015 and the Brazilian currency about one-third, when compared to the US dollar (Figure 1).

Figure 1: US dollar/BRICs' national currencies average annual exchange rate.

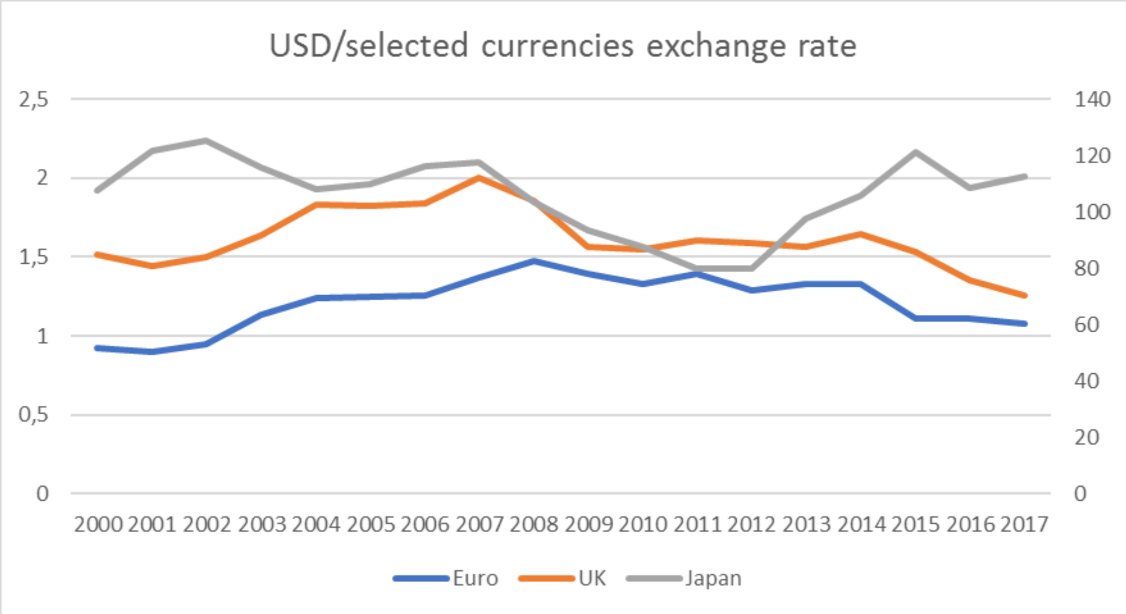


Source: our elaboration on Federal Reserve and Bank of Russia data. Russia and India are on secondary axis.

The exchange rate trend has penalised, albeit to a significantly lesser extent, the manufacturing share of all Euro area countries (-16,5% the dollar depreciation between 2012 and 2015) and Japan (-19,3% yen), while favoured the United Kingdom (+2,3% in those years the appreciation of the pound) (Figure 2).

The slowdown in BRICs is increasingly becoming a structural phenomenon and is reflected in the progressive loss of relative weight, which is under way already for several years in manufacturing sectors within those economies. In Russia and Brazil, the share of total national value added has fallen steadily since the second half of the 2000s, going below levels recorded in many advanced countries, despite the partial industrial development of those countries. The same thing has happened, to a lesser extent, even in India. Even China, although maintaining a share of total value added of more than 29%, has, however, declined by more than 3 percentage points between 2007 and 2015.

Figure 2: US dollar/selected currencies average annual exchange rate.



Source: our elaboration on Federal Reserve data. Japan is on secondary axis.

The main cause of this slowdown can be traced from the weakening of tremendous push for industrialization that was pushed by the international fragmentation of value chains. Production delocalisation processes that have been going on for more than twenty years from Japan, the United States and Europe have, in fact, been an extraordinary opportunity for the emerging world, especially for Southeast Asia, of export-driven manufacturing (and economic) growth. An opportunity, however, that is not repeatable over time and therefore destined to come to an end. In recent years, due to the economic crisis, there has been a growing aversion within the West towards further push for globalization and somewhat to slow down –if not reverse- the haemorrhaging of manufacturing activities.

The weakening of a western push to industrialise emerging countries has led the BRICs, with different strategies and results, to focus on alternative routes to fuel their manufacturing development. In particular, China has directed a growing share of its industrial output towards the domestic market, encouraging it to expand, by government policies, after decades of consumer compression in favour of private savings and thus capital. Thus, in the face of a rise in apparent commodity demand of 150,6% between 2006 and 2015, the export of goods has fallen from 34,7% to 12,8%[1]. Nevertheless, China

[1] Source: Centro Studi Confindustria (2016). Scenari Industriali.

is maintaining its position as one of main world's exporters (Figure 3), preceding USA and coming only after Euro Area.

For the rest of the BRICs, however, dependence on foreign demand has not dropped significantly over the last few years (unchanged or growing the propensity to export). A much smaller contribution of the domestic market than the Chinese one has surely contributed to this output. In India, the growth rate of domestic demand for manufactured goods was half of Chinese (+ 67,2% between 2006 and 2015), while it was almost zero in Brazil (+2,9%) and with negative sign in Russia (-5,8%).

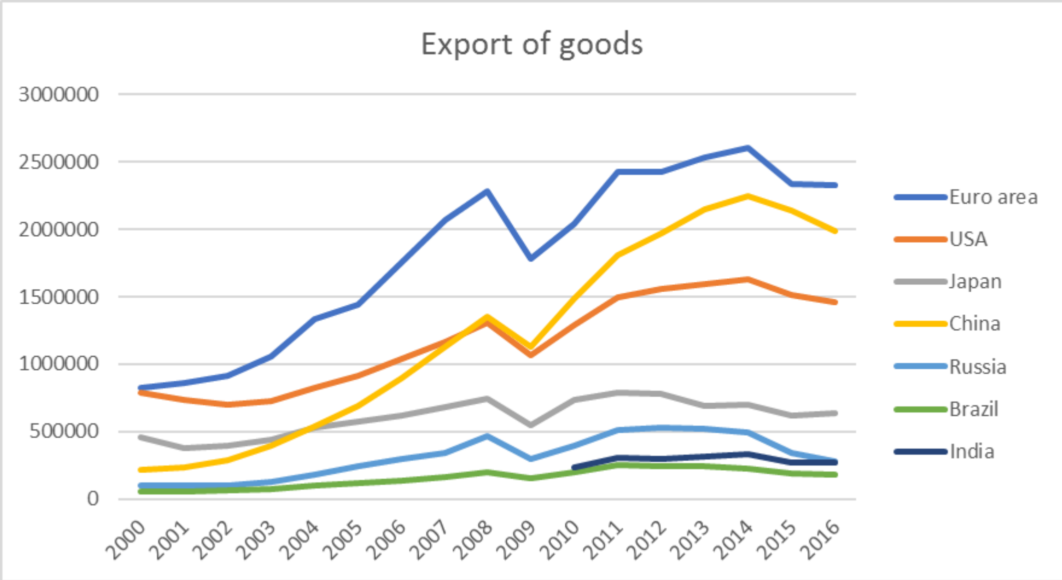
For these three countries, however, there has been a redefinition, similar to that of China, of the main export markets. Europe has lost importance, as opposed to emerging Asia which increased its weight since 2008. With the outbreak of the crisis, in Brazil and India, the export quota destined for North American countries stopped falling, reversing the route and marking an acceleration from 2014, driven by the solid growth of the main target market of the area, the United States[2].

As concerns European Union's international trade, China and USA are consolidating their positions as main partners (Figure 4), while the value of exported goods is slightly falling for Brazil, India and Japan.

Trade within BRIC countries shows an increasing export value between China and India (Figure 4), while trade between the Asian country and Brazil and Russia has a negative trend.

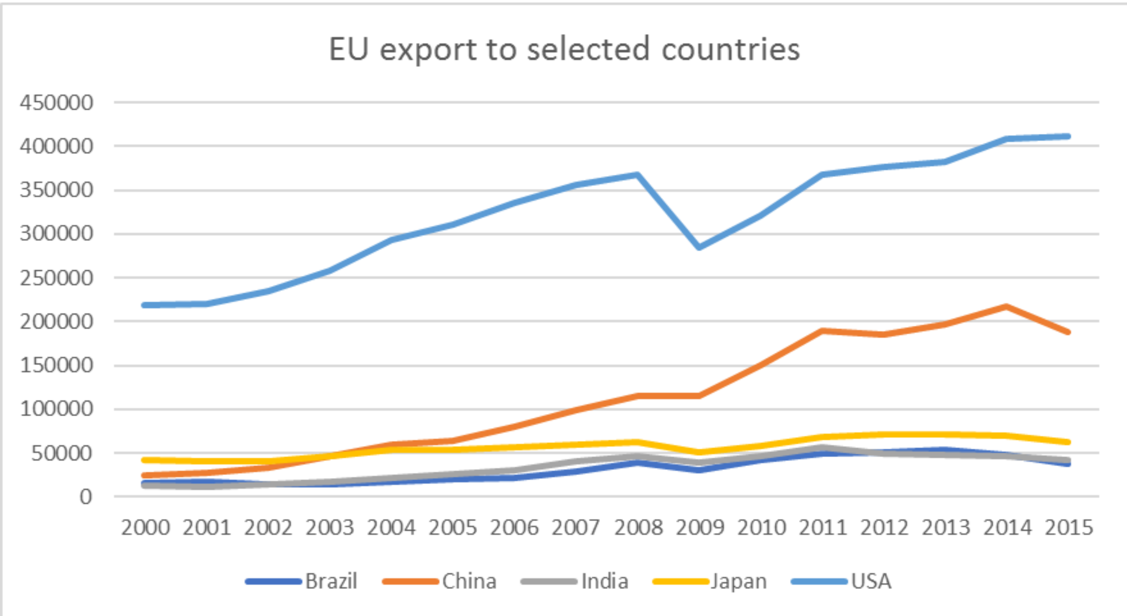
[2] Source: Centro Studi Confindustria (2016). Scenari Industriali.

Figure 3: Export of goods for selected countries. Millions of US dollars.



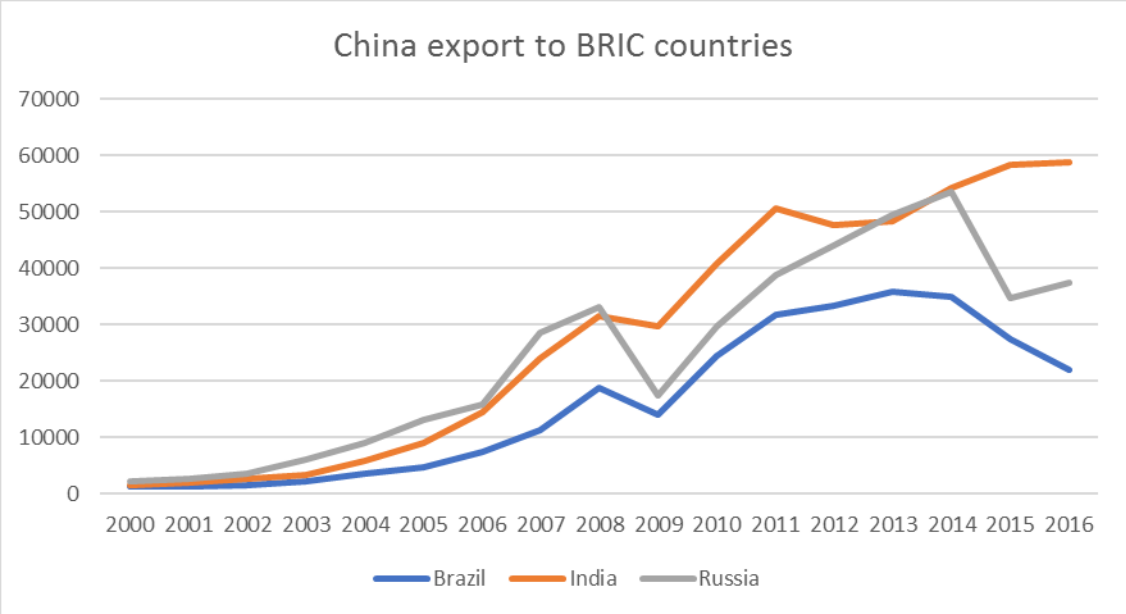
Source: our elaboration on OECD data.

Figure 4: Value of exported goods from EU to selected countries. Millions of US dollars.



Source: our elaboration on Comtrade data.

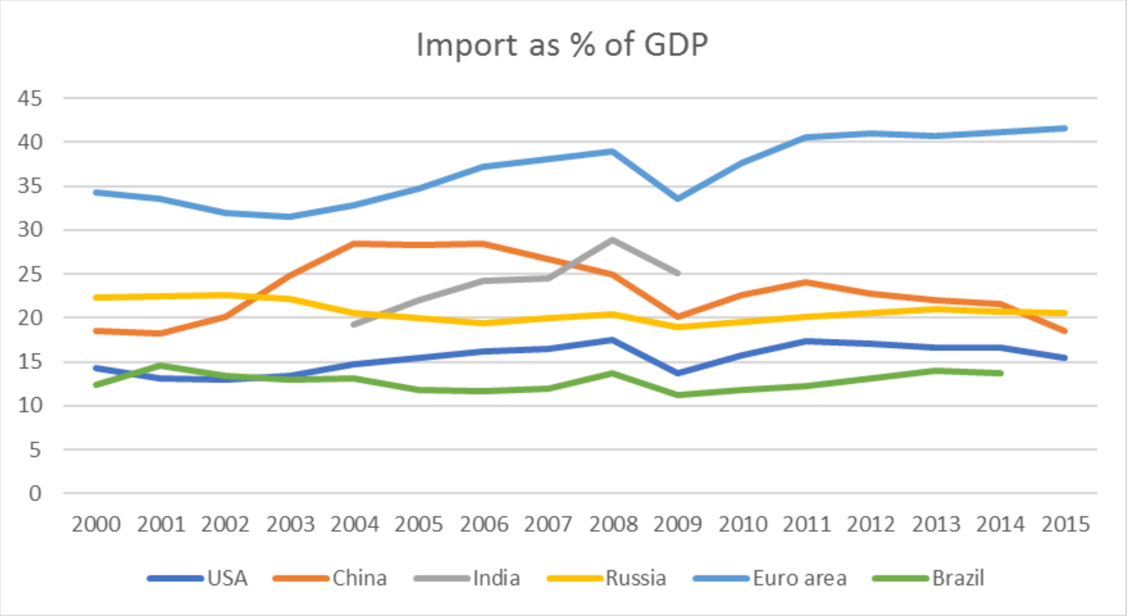
Figure 5: Value of exported goods from China to BRIC countries. Millions of US dollars.



Source: our elaboration on Comtrade data.

Changing the pace of the emerging world has had important repercussions not only on the export side, but also on the international BRICs'demand for industrial goods. The most important change, again, has affected the Asian superpower. Not only, as noted above, China has reduced its dependence on foreign demand, but has also loosened the supply side with foreign supply, increasingly satisfying domestic demand with domestic manufactured goods rather than import (in relation to domestic demand, imports have risen from the peak of 22,6% in 2004 to 8,3% in 2015). A similar tendency, but with much smaller proportions, has also been observed in Russia, but since the second half of 2014. Import of goods and services as percentage of GDP can be observed in Figure 6.

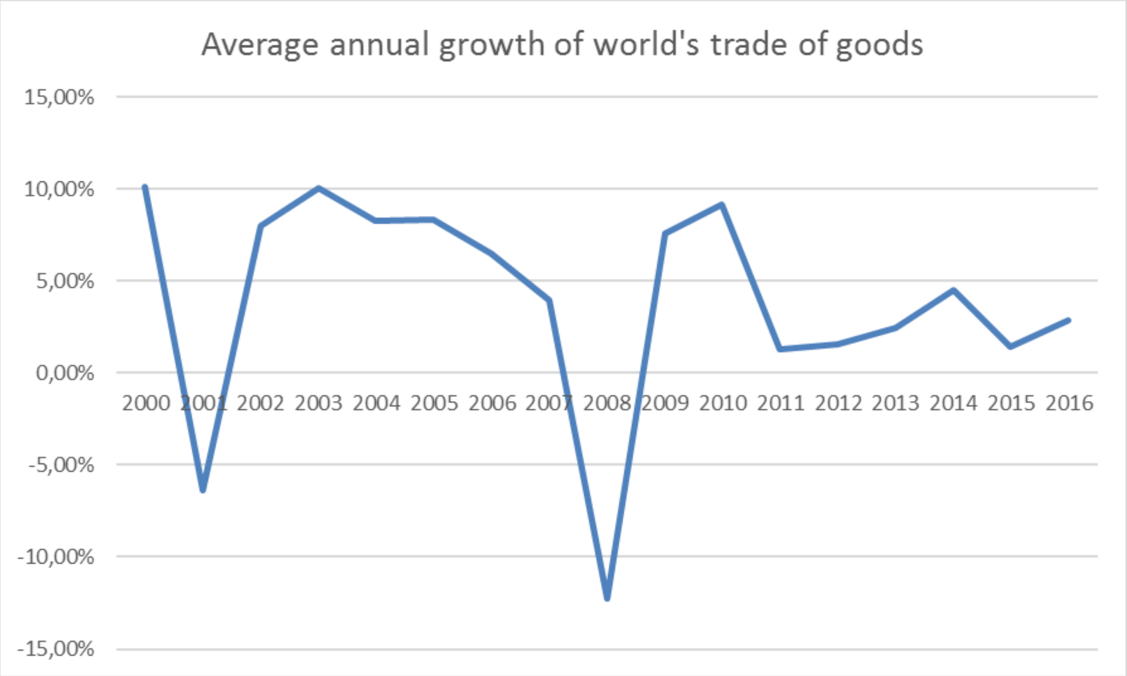
Figure 6: Import of goods and services as % of GDP.



Source: our elaboration on OECD data.

In 2016, world trade of goods has increased by 2,8%, continuing to rise after a slowdown in 2014-2015 period.

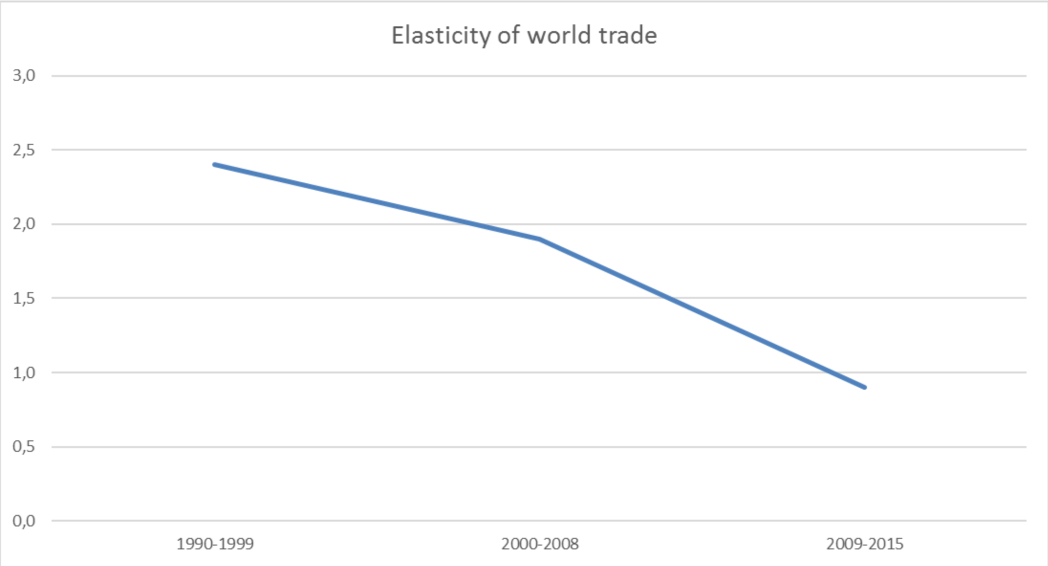
Figure 7: Average annual growth rate of world's trade of goods.



Source: our elaboration on CPB World Trade Monitor data.

The pace of international trade is consistent with that of world GDP, which in any case was less intense. In 2015 GDP growth rate was 3%. In the 1990s, world trade grew by an average of 7,0% per year, more than twice the GDP (+2,9%). In other words, the elasticity of trade, defined as the ratio between the percentage change of trade and GDP, was 2,4. In the early 2000s, before the crisis, the dynamics of trade slowed down to 6,4% per year, against a +3,4% of GDP, with an elasticity falling to 1,9. Over the past six years, trade grew by just 2,3% per year and 2,5% of GDP. As a result, elasticity has fallen below the unit (0,9) and is expected to remain on these levels even in 2017.

Figure 8: Elasticity of world trade.



Source: our elaboration on CSC, IMF and CPB World Trade Monitor data.

The causes of this slowdown are largely structural. Firstly, one drive of change is the transition of China and other emerging companies to a growth models based more on the service sector and the consumption of domestic production than on manufacturing and investment, albeit manufacturing remains an important component of foreign trade. Secondly, there is evidence of the persistent slowdown of investments, especially in advanced countries, because of weak and uncertain expectations about the future trend of demand and disruptive technological change. Thirdly, the greatest use of protectionist measures fueled by the return of nationalist movements has halted the rapid international fragmentation of production, i.e. of the expansion of global value chains, which in some cases seem to be in contract (especially in Asia). Fourthly and finally, the long tail of the

2008 crisis is still responsible for the weak growth of European countries, deeply integrated with foreign countries, also leading to weak foreign direct investment dynamics.

In addition, further negative factors have acted in the current year. In particular, low oil and other commodity prices have limited the demand for imports from emerging oil producing economies and contrasted global investment in the energy sector. Finally, the vote in favor of Brexit, which marked the start of a long, uncertain but certain exit path for the United Kingdom from the European Union, fueled political uncertainty, which continues to be high in the advanced countries. The scenario for the end of the current year and for the next is weakly positive. It could be favored by the gradual decline in political uncertainties, the improvement in the economic conditions of emerging commodity exporting economies (particularly Russia and Brazil) and with the strongest growth in the United States.

Recent currency movements have led to a general rebalancing of the price competitiveness of the major world countries. Except for the United States, whose products continue to be penalised by the strong dollar. Indeed, US price competitiveness, measured by the real effective exchange rate, increased by 1,0% in the last year (from the third quarter of 2015 to the third quarter in 2016), but much lower than the five years ago (-17,7% on the third quarter of 2011). The sharp devaluation of the pound, which began already with the Brexit referendum campaign and strengthened after the vote in favour of Brexit in June 2016, allowed significant gains in UK product competitiveness (+13,9% third quarter 2015), basically returning to the same level as five years ago (-0,2% in the third quarter of 2011)[3].

The euro exchange rate, after a slight depreciation against the dollar following the voting in favor of Brexit, stabilised close to the average of the previous months (1,12) and dropped in October 2016 at 1,09. In terms of monetary policy prospects, there is an expectation of rising rates by the Federal Reserve and continuing the ECB's ultra-expansive measures. The price competitiveness of the main European countries (Germany, France, Italy and Spain) declined by 1,1% in 2015, slightly above five years ago (+0,6% in the third quarter of 2011), remaining above the minimum recorded at the beginning of 2014 (+2,1%) when the euro was traded at $1,38. Similar trends can be observed also in 2016 and in first months of 2017.

[3] CSC and Banca d'Italia data.

In 2016, the yen appreciated significantly, partly offsetting a previous depreciation. Consequently, the competitiveness of Japanese goods has decreased by 15,1% during 2015, but remains broadly above the five-year levels (+13,5%).

Among the main emerging countries, there has been a tendency towards rebalancing the dynamics of competitiveness. Chinese goods rose 6,6% from the third quarter of 2015 to the third in 2016, favored by the deprecation of the yuan. However, it was less than 5,7% compared to the third quarter of 2011, due to a generally unfavorable production price dynamics.

Currencies of commodity-exporting countries, including Brazilian real, Russian ruble and South African rand, generally appreciated since the beginning of 2016, thanks to the stabilisation of commodity prices and the increased confidence of financial markets in emerging economies. The competitiveness of Brazilian products, in particular, fell by 20,5% in one year, but remained higher than 16,0% when compared to the previous period. India's competitiveness also fell slightly in the last four quarters (-1,8%), continuing along a downward trend already in place, and slightly above the third quarter 2011 levels (+1,7%).

The transformations that characterised the world trade in 2000s, with the extension of the global value chains and the advancement of China and other emerging economies, and the different price competitiveness trends between countries have profoundly changed the rankings of the major players in the trade in manufactured goods. In recent years, where international fragmentation of production and global trade has been interrupted, the pace of change has slowed down. Major currency movements, however, continue to change the ranking of major exporters and importers.

Table 3: Percentage share of total world trade of goods. Top 10 countries

	Exporters					Importers			
	2000	2007	2011	2015		2000	2007	2011	2015
China	4,5	10,3	12,4	16,4	USA	20,2	15,3	13,4	14,9
Germany	9,4	10,5	9,3	9,1	China	3,5	6,4	8,6	8,9
USA	12,3	8,2	7,4	7,8	Germany	7,3	7,4	7,2	6,6
Japan	8,6	5,8	5,2	4,3	France	5	4,7	4,3	4,2
France	5,3	4,4	3,6	3,9	UK	5,7	4,9	3,9	4,1
Korea	3,2	3,2	3,7	3,8	Japan	5,9	4,5	4,8	3,9
Netherlands	3,2	3,4	3,3	3,2	Hong Kong	3,6	2,9	3,1	3,8
UK	5	3,5	2,9	3,2	Korea	2,6	2,7	3,1	2,8
Italy	4,3	4,1	3,3	3,1	Canada	3,9	2,9	2,7	2,7
Belgium	3,3	3,5	3	2,8	Netherlands	2,9	2,9	2,9	2,7

Source: our elaboration on CSC and WITS data.

Nevertheless, the rise of Chinese manufacturing exports has continued. In 2015, it accounted for 16,4% of world trade (+4,0 percentage points in 2011), strengthening China's first position in the global ranking (achieved in 2009). China's share of world imports, however, has increased marginally in recent years (to 8,9% in 2015, +0,3 points), also due to the weakness in demand for intermediate goods and investment imported by local companies. Anyway, China is the second destination market in the world behind the United States.

US market shares increased between 2011 and 2015, especially on the import side, also due to the appreciation of the dollar. US imports accounted for 14,9% of global imports in 2015 (+1,5 percentage points on 2011), while exports for 7,8% (+0,4 points). This means that USA is on the first place on the import side and on the third one on the export side.

In 2015, Germany has confirmed its second position as the country of origin of world trade in goods (9,1% of the total) and the third as a target market (6,6%). German market shares have decreased since 2007: over the last four years they have fallen to a modest extent, even because of the devaluation of the euro. In particular, the impetuous dynamics of imports have led to a 0,6% point decrease in its world share.

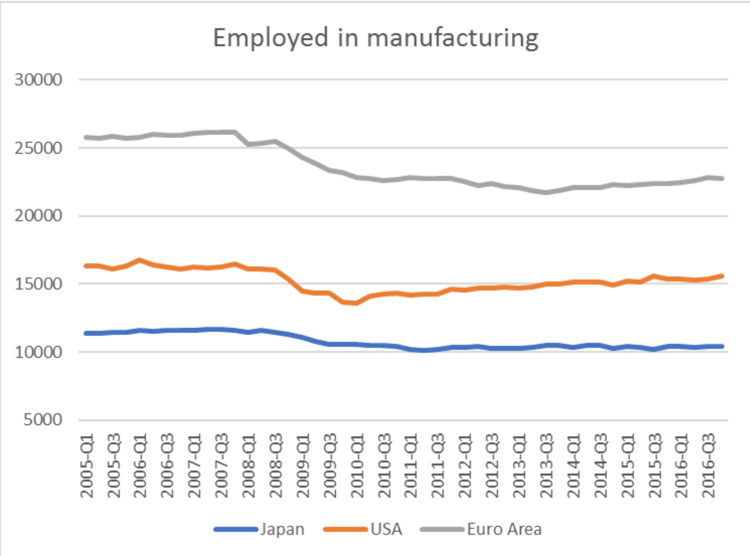
The shares of the other main European countries also fell slightly, owing to the weak euro and low domestic demand, which affected imports and exports (via intra-area demand). Except for France, which recorded an increase in the share of exports and a marginal reduction in imports (-0,1), gaining thus a position both in the global ranking of exports

(fifth place) and in import (fourth place), due to the simultaneous decline recorded by Japan. Italy dropped from eighth to ninth out of the exporting countries, overtaken by Britain (whose performance in next years could be penalised by the pound) and has risen to the eleventh among the importing countries.

Finally, the negative performance of Japan in 2015 was partly due to the sharp devaluation of the yen (which recovered partially in 2016), and also because the stimulus effect on its exports was much lower than expected.

The slowing down and the difficulties of manufacturing, especially in developed countries, can be observed also in employment in this sector.

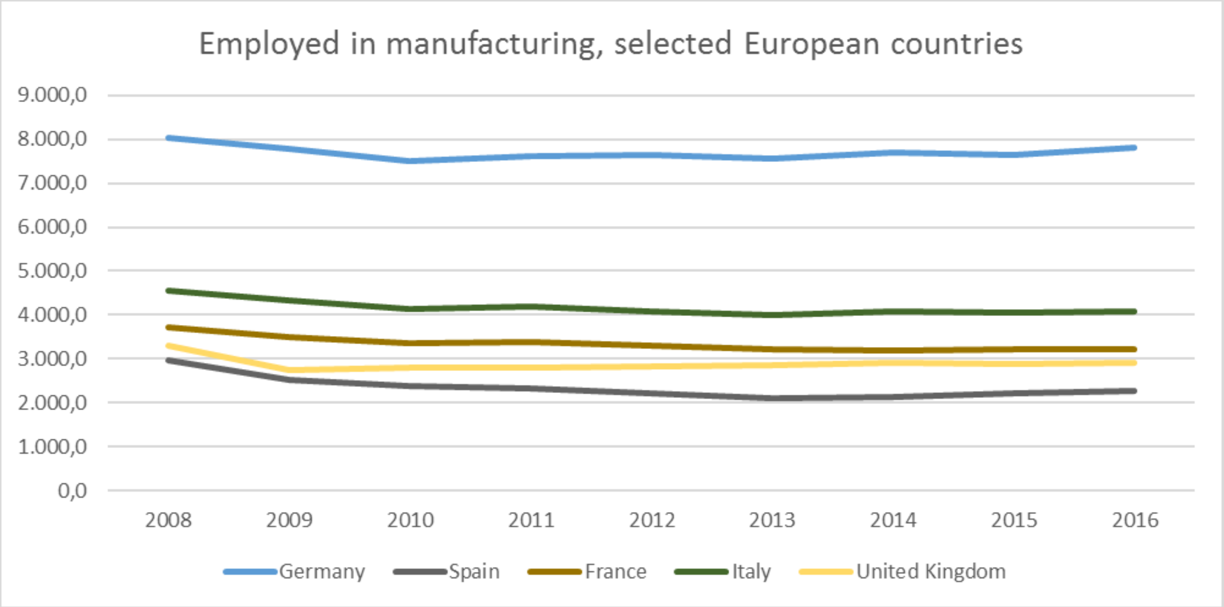
Figure 9: Employed in manufacturing. Thousands of people.



Source: our elaboration on OECD data.

There has been a slightly growth for the USA and Euro area labour market since 2009, but in both countries the number of people employed in manufacturing activities is well below pre-crisis level. For Japan, the employment rate for manufacturing is essentially stable over last seven years.

Figure 10: Employed in manufacturing for selected European countries. Thousands of people.



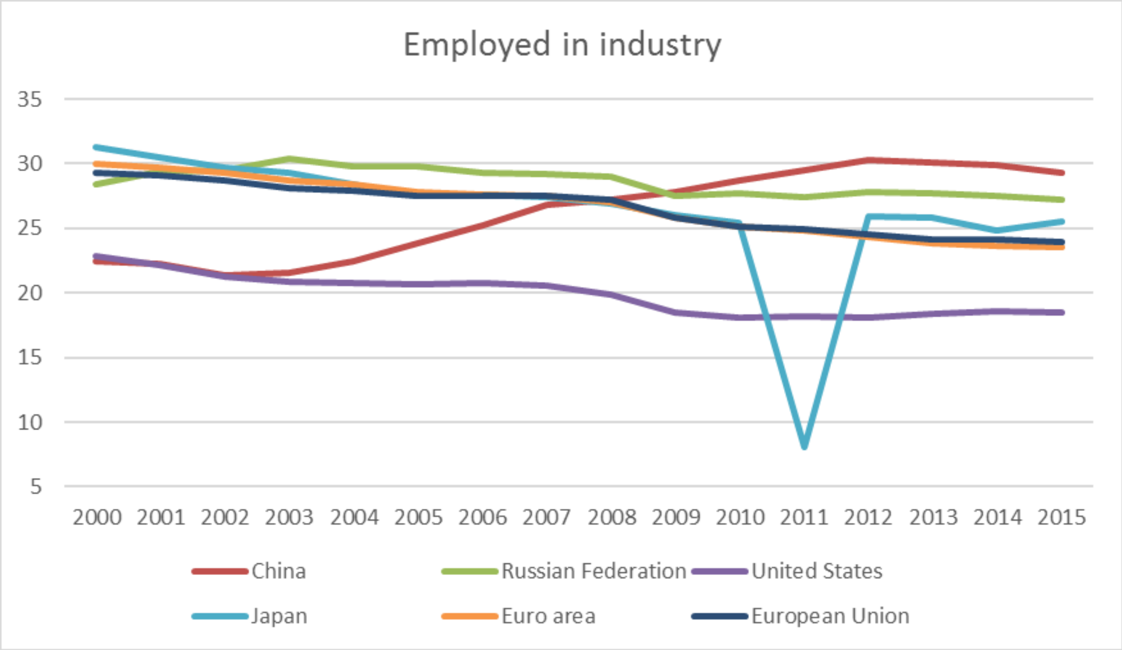
Source: our elaboration on Eurostat data.

Taking a closer look for main European countries, it can easily be observed that only Germany and Spain have recorded a slightly increase in employment in manufacturing. All countries, however, are not able to regain jobs lost during the 2008 crisis.

The industry sector consists of mining and quarrying, manufacturing, construction, and public utilities (electricity, gas, and water), in accordance with divisions 2-5 (ISIC 2) or categories C-F (ISIC 3) or categories B-F (ISIC 4).

The growth of people involved in industry is below 30% for observed counties. Since 2003, China recorder the highest growth, but even its share contracted in recent years.

Figure 11: Share of employed in industry as percentage of total employment.



Source: our elaboration on World Bank data.

2. Manufacturing renaissance in US

Manufacturing was the anchor of the American Dream. Entrepreneurial dynamism allowed social upgrading and the possibility for the seller of a beverage at the corner stall to become a global tycoon. There is no doubt that its reputation has rusted over time not least due to globalisation and in part the strategic decisions of those very home born tycoons, not operating globally as multinational firms.

Jobs in the manufacturing sector fell from 41% of total employment in 1979 to 13.2 in 2000 and then to 8.9 in 2009. This freefall was due to US companies shutting down production in the US to relocate it in Asia. Factory towns became ghost towns: where entire one or two generations were working in the local factory with no alternative jobs emerging after its closure if not lower paid waiting or delivery jobs in the service industry. Offshoring more the productivity gains can explain job losses (Helper et al 2012), in fact productivity growth did not rise as much during the period 1990-2000 to explain employment contraction.

The financial crisis brought to the fore an unacceptable imbalance in the economy that was undermining the main drive of economic growth in the US economy, demand. And that is when the penny dropped. Since there has been a lively debate on *why* and *which* manufacturing matters in the US- as well as in Europe.

Manufacturing is important on a number of levels.

It provides a wide spectrum of jobs that are better paid and have better standard than services.

Manufacturing services are the drivers' of a country's innovation. In the US, although accounting for 11% of GDP, manufacturing contribute to 68% of R&D spending – 2008 (Helper et al 2012). Innovation also follows manufacturing: as entire sectors were offshored to China, patenting is such sectors have worryingly dropped in the US with a loss of knowledge leadership and therefore strategic competitiveness (Helper et al 2012 refer to the case of rare-earth technology as an example).

Manufacturing anchors high value service sectors. Pisano and Shih (2009) argue that the decline of manufacturing will trigger a chain reaction dragging behind high value added chunks of the economy, services in particular.

Manufacturing produces tradable goods that can be exported, contributing to the trade balance. The US has had a trade deficit since the 1970s and its manufacturing trade deficit has risen in the 1990s and early 2000s, mostly in transport, ICT/electronics and apparel (Pisano and Shih, 2009). Trade deficit is reduced by either increasing exports and that is where the pro-manufacturing advocates would say manufacturing is key for the long term prosperity of the US and/or by reducing imports. The latter does not only refer to import of final goods but also of intermediate. A way to reduce imports is to rebuild more US-based supply chains to re deduce international outsourcing. This has triggered a lively debate on “back-shoring” as a strategy that allows companies to swap foreign suppliers with domestic suppliers. The Trump’s slogan of “America first” partly refers to the opportunity for firms to bring some production back to the US: the slogan has an economic foundation but it was very much sold on a more emotional level.

The question *which manufacturing?* is harder to address. Indeed studies have found that it is not a sector rather another since each sector might include both low and high value added segment.

The high value added segments are those where high skill-high wages can be afforded (Helper et al 2012). Competition in global markets has already swept way low end production which tended to be very labour intensive. Indeed, Cooke et al (2016) find import competition from developing and emerging economies in the US domestic market caused job losses especially ‘among manufacturing workers with less than a high school degree’. The narrow convertibility of such a low level of skills also explains their lingering in long term unemployment as mentioned before.

Important to this is also to pin point to the degree of erosion of the knowledge core of industries, and this can be done by ascertaining what competences and skills has survived in those places where industrial specialisation was located. Reynolds et al (2015) apply a local system approach to explore the advanced manufacturing sector in Massachusetts.

Another aspect is that advanced manufacturing industries are becoming increasingly less ‘job intensive’ (Muro, 2016) thanks to the penetration of automation and digitalisation on the shopfloor. The resurgence of high value industries such automotive, aerospace, computers or pharma, might be welcome for their innovation retention, export potentials, but an upward job trend in unlikely to match an upward output trend.

In parallel to scholarly and think tank debates, the US Obama presidency was particularly keen to pro-actively support manufacturing sectors and set up the Subcommittee on Advanced Manufacturing (SAM) as part of the National Science and Technology Council in 2012. Federal policy aims at some specific advanced industries linked to emerging technologies such as advanced materials, engineering biology, pharma, bio-manufacturing, bio-manufacturing for regenerative medicine, advanced bio-product manufacturing (White House, 2016). This visible support in favour of manufacturing was catalysed by the Advanced Manufacturing National Programme (www.manufacturing.org) which is meant to channel interests, policies and instruments as well as deliver greater competitiveness for advanced manufacturing industries in the US.

3. Technological change and 4th industrial revolution

There is some consensus that economic progress can be associated to four industrial revolutions, each pushed by a wave of technological changes (Marsh, Rifkin). Innovations related to steam power, cotton, steel, and railways coupled with mechanisation and the introduction of Taylorism contributed to the first industrial revolution. Standardised demand was satisfied by mass production thanks to scale and scope economies. Marshall's industrial districts and cottage industries were dwarfed or replaced by mechanisation, convoy belts and factories. The 'second' industrial revolution was triggered by the introduction of electricity, heavy and mechanical engineering and synthetic chemistry. In this wave, new sectors emerged (automotive and consumable goods) and we saw the consolidation of the large scale production model. The 'third' industrial revolution was triggered by innovations in electronics and computers, petrochemicals and aerospace. Large scale productions became also multi-plant, multi-product and multi-located marking the emergence of complex organisational forms such as multi-national firms. At this time demand became volatile and we saw the breakup of mass markets and the resurgence of firm clusters as focal points for growth thanks to their flexibility and innovation. At the same time the impact of technology on transport and communications accelerated a process of globalisation that led some Fordist plant mutating into complex multi-national firms operating production activities across close as well as distant supply networks.

A host of new technologies are driving the current and fourth industrial revolution. The ripening of a range of new innovations that started in the mid-1980s is driving a wave of change in our techno-economic paradigm with its impact on our production methods. These include biotech, nanotech, neuro-technologies, green and renewables, ICT & mobile tech, 3D, AI, Robotics, sensoring and space technology and drones. Changes in the organisation of production are still speculative, but some foreseen implications are the emergence of smart factories to reorganise internalised production on the one hand; and of small makers to capture niche demand on the other.

The strategy to upgrade EU manufacturing to new, digitalised and connected, production systems can be seen from different points of view. What is expected to be the new industrial paradigm, Industry 4.0 (I4.0), has many facets. I4.0 requires proper digital technologies (Baur and Wee, 2015), but it is not simply limited to them. It embraces both

products and processes (Schmidt *et al.*, 2015) and involves a reorganisation of supply chains (Platform I4.0, 2015). Other frequent features are those of smart products, processes, factories and services. The term "smart" underlines to ability of digital technologies to allow communication and interactions of objects, thus widening the design of production processes and products and service developments.

I4.0 is expected to rise flexibility, reduce lead times, allow mass customisation, enable new services based on big data and create attractive work structures (Heng, 2014). Productivity gains might be huge, widening opportunities in every industry. At the same time, growing job automation and polarisation (Cowen, 2013; Brynjolfsson and McAfee, 2014) are emerging as main challenges. The discussion whether digital revolution will be disruptive for almost every industry (McQuivey, 2013) or not (Gordon, 2016) is still open.

To quantify the impact of digital technologies at this point is extremely hard, simply due to a lack of widely accepted definition of digital economy and tools for measuring it. The value of ICT related activities could be the closest approximation, which accounts for about 6% of total value added in OECD area (OECD, 2014). However, impact of digital technologies goes far beyond ICT and new tools are required for a proper measurement.

Furthermore, it is difficult to evaluate the value generated by related technologies (Grover and Kohli, 2012; Yoo et al., 2012). This is true for several reasons. I4.0 technologies are not so new as might appear. What we call digitalisation today started with the introduction of computers in business processes and evolved during the years. The same is for each of the technologies of I4.0. Their relevance grew during the years, as they improved and became more integrated in business processes. It is hard, now, to distinguish the "digital" part, and measure it, from the "non-digital". Another problem is the lack of widely accepted definition of what makes a business "digital" or part of I4.0 paradigm. The implementation and use of digital technologies are surely related to IT infrastructures, which are essential for further development, but it might be limiting to consider this digital upgrading only as a part of an evolved ICT system. Moreover, lack of studies and researches in this field makes it hard to compare business performances and set a benchmark to understand the real dimension of the phenomenon.

Most of academic works tend to link I4.0 to cyber-physical systems: highly automated and hyper connected production processes. That is certainly true for medium-large and structured manufacturing firms, but it does not suit well for smaller firms. Companies

producing high-quality customised products could hardly recognise themselves in this kind of definition. Thus, it is important to distinguish the effects that the upgrading of manufacturing can have on different business and, consequently, on different regional and national systems. It is necessary to consider firm’s size, activity, industry and core competences in order to analyse the impacts of digital transformation. Considering I4.0 as a single paradigm a priori might not be an optimal approach.

To capture value from digital innovation firms do not only have to invest in technologies. They need a successful IT and business strategy, proper competitive context, digital organisation and IT capabilities (Fichman, 2012). As has been noticed, well-designed IT-architecture is essential for developing new products and processes (Fink, 2007). This is even more pertinent in case of digital innovation. Planning and deep understanding are at the base of a successful implementation of digital technologies. Each activity has a specific technology frontier. What is crucial is to invest in right technologies, the ones that are necessary and can lead to a concrete benefit for the business. Therefore, besides analyzing technological upgrading, it is important to consider other factors that can enable and promote the diffusion of technologies and their positive effects for the economy.

4. Industry 4.0 in the EU debate

The EU debate on Industry 4.0 has developed around the digitalisation agenda. Indeed drawing the German definition of Industrie 4.0, the EU is adopting a conceptualisation that revolves around 3 main disruptive changes in the organisation of production: 1) smart factories as new cyber-physical spaces 2) computer integrated manufacturing processes thanks to digitally integrated supply chains and cloud data management and 3) new business models with servitisation. Quite self-explanatory is the very fact that the title of a EU Parliament briefing on Industry 4.0 (EU Parliament, 2015) refers to 'digitalisation for productivity and growth'. Indeed, in (ibid), I4.0 is defined as "*a group of rapid transformations in the design, manufacture, operation and service of manufacturing systems and products"* (p2). Or again *"I4.0 describes the organisation of production processes based on technology and devices autonomously communicating with each other along the value chain"* (EU Parliament, 2016).

In this conceptualisation, the technological change that the fourth industrial revolution is argued to have unleashed remains limited to the production sphere triggering a change in the tecno-economic paradigm. The impact is on the organisation of production inside the factory with the escalation of automation with the related introduction of IoT and AI; and the coordination of the supply chain via seamless transactions via cloud-based data sharing. The derived benefits are flexibility, efficiency, quality of products, and productivity. This somewhat significantly narrows the disruptive potential of this wave of new technologies. On the one hand, technologies should help tackling of fundamental societal issues we are facing; and on the other hand, some of the production changes will require societal cooperation at different changes along the production-consumption continuum. For instance, a change in the business model that leads to products becoming servitised (see Deliverable 1.2 of MAKERS) require consumers altering their preference from owning to renting/hiring –say- a car, a washing mashing.

In EU Parliament (2016) it is recognised that Industry 4.0 is expected to drive three levels of change: technological change through the adoption of digital technology; social change due to the requirement of new competences and skills; and change in the business paradigm for SMEs. The underlying objective is to significantly increase productivity of a *smart factory* that would unfold over 5-10 years. Such definition and implementation was designed by Germany policy makers to address German industry's long term

competitiveness, and as such it played to its strengths in mechanical engineering sectors (*Ibid*). The dual strategy adopted by Industrie 4.0 has been indeed both to increase the efficiency of already relatively highly automated factories and to create a competitive advantage for German machine producers by innovating product that embedded digital technologies to be sold on global markets (see also Heng 2014).

The German conceptualisation of Industry 4.0 reveals its main limitations. Firstly, **it cannot be rolled out across all EU countries and become an EU policy agenda**. Secondly, it refers only a very small number of technologies that are part the so called 'fourth industrial revolution', a number of advancements in new material, green technology, biotech for instance are not ignored. Thirdly, it dismissed the importance soft technology such as design. Fourthly, it ignored the green concerns that need to change production, products, consumption and recycle (the new emerging cradle to cradle circular model). Finally, **it does not address any of the societal challenges we are facing**, including urbanisation, aging, sustainability as examples.

This EU debate on the future of manufacturing has been and must remain broader. There has been a recognition that a new *advanced manufacturing* model -a smart manufacturing model- needs to be designed and implemented, evidence of this are reports such as A European Industrial Renaissance (EU Commission, 2014), Advanced Manufacturing-Advanced Europe (EU Commission 2014). Upgrading EU manufacturing is a cross cutting agenda that requires contributions from DG Growth, DG Connect, DG Employment and Dg Environment. These are working within their ambit, implementation interventions that draw on the EU 10 priorities.

From the industry perspective, the need for a wide-ranging understanding of a modern EU industry (Business Europe, 2017) is spelt out with an emphasis on issues such as circular economy, energy, sustainable mobility and urban environment.

In MAKERS we are working towards conceptualising and providing evidence of a broader and truly game changing formulation of **Economy 4.0** where firms, consumers, users, institutions, communities, people, workers, entrepreneurs engage with each other in the world of production and consumption.

5. Industry 4.0 in Italy

Industry 4.0 has become very debated topic in Italy only in the last two years. For a long time the discussion concerned a superficial imitation of the German model, often focusing on few single technologies. The most popular of those are surely 3D printing and Internet of Things. Recently, the attention is shifting towards a more general and reasonable vision, accompanied also by a national industrial plan that is centred on technological neutrality. In our point of view I4.0 is a conceptual framework that outlines a more mature digital technological adoption process of firms. This process is marked by a high level of network connectivity and data processing.

Currently there are no significant studies that can give an exhaustive picture of the situation about Industry 4.0 in Italy. Various work focused on either single technologies or specific sectors. Significant research in this regard is that of Fondazione Nord-Est, which analysed the diffusion of some digital technologies in the fields of made in Italy[4]. From the work emerges that the technologies of digital manufacturing are penetrating also in smaller firms of the traditional made in Italy. In different sectors, companies use innovative tools (combining different technologies) that are consistent with the challenges of their industry in order to promote productivity and consolidate new competitive advantages. Among the companies in the "home system", 22,3% use robotics and/or laser cutting systems, 32,3% in goldsmith uses 3D printing and/or laser cutting systems, and 15,1% in fashion adopts laser cutting. Data on the diffusion of IoT-enabled technologies (sensors and distributed connectivity) shows how the offered potential has not yet been explored by companies in Made in Italy: the share of those that have started experimenting in this field is less than 7%. Regarding the use of the Web (website, social media and e-commerce), companies have started a digitalisation path that, when compared with what is happening in other European countries, seems to be likely improvable. Compared to the national average, traditional made in Italy sectors show greater liveliness, especially in the fashion industry. Smaller companies are experiencing novel approaches to the digital market, too.

A second work based on national-level data is that of Federmeccanica, which involved a sample of metal producers, mechatronics, and related companies[5]. According to the survey, 64% of companies claim to adopt at least one of the 11 enabling technologies

4 http://madeinitaly.newcraftclub.it/
5 http://www.federmeccanica.it/industria40

considered. The evidence reaffirms greater awareness, and therefore adoption, of technologies by larger companies. It should be noted that collaborative robotics, big data, nanotechnologies, and intelligent materials are, in that order, mostly adopted by larger companies. By contrast, computer security and mechatronics are adopted by both large and small businesses. 3D printing and cloud computing are adopted by companies with relatively small turnover but with a medium/large number of employees. Nanotechnologies, 3D printing and robotics (collaborative and non-collaborative) tend to be more widely adopted by more export-oriented businesses, while IoT, computer security and big data tend to be adopted by most home-based companies. Businesses that adopt nanotechnologies, collaborative robots, and intelligent materials are at the top of technological intensity: they are those that on average adopt a greater number of technologies.

From these and other researches emerge that for some technologies the adoption processes seem to be already in place. On other fronts, the adoption of IoT is for instance still limited. Opinions of entrepreneurs and managers seem to confirm the idea that while the more traditional technologies such as additive printing, 3D scan and advanced cutting systems are basically an evolution of technologies already in use, which reduces greatly the costs involved for their adoption, the IoT world and virtual reality, for example, remain far from the sensitivity of many businesses. This situation seems to be surely related to issues of a technological nature, but above all it is related to the change of paradigm and thus of a business model that many of these solutions involve (for example, the most extreme forms of servitisation). In such a delicate passage, Italian firms rely too little the knowledge and expertise they could access from universities and research centres.

It is clear that the discussion on the Fourth Industrial Revolution is strongly linked to the technological aspect. This has contributed to create a climate of mistrust and concern in large part of businesses, especially small and medium sized ones which cannot fully understand the potential of technologies. These doubts also arise from the way Industry 4.0 was presented to companies. As the accent has always been put on factors such as robotics, sensors etc., businesses have struggled and are still struggling to recognise themselves in a business model that looks completely different from the one they have followed for years. Therefore, the need to move the discussion from a mere technological aspect to a more systemic vision appears quite clear. It is necessary to take into account the diversity and the multiple traditions that individual businesses have.

A national law, known as "*Piano Industria 4.0*", was issued to promote and facilitate this delicate passage. *Piano Industria 4.0* is intended as an opportunity for all companies that want to seize the opportunities associated with the fourth industrial revolution. The Plan provides concrete measures based on the following guidelines:

- Operate in a logic of technological neutrality
- Act with horizontal and not with vertical or sectoral actions
- Act on enabling factors
- Orient existing tools to encourage technological leap and productivity
- Coordinate key stakeholders without entrusting public sector a leading role

National politics starts from the definition of technologies that compose the Industry 4.0 paradigm, too. Those explicitly mentioned in the legislation are:

- Advanced manufacturing solutions: interconnected and rapidly programmable collaborative robots
- Additive manufacturing: 3D printers connected to digital development software
- Augmented reality: increased reality in support of production processes
- Simulation: simulation of interconnected machines to optimise processes
- Horizontal/Vertical Integration: Information integration across the value chain from supplier to consumer
- Industrial Internet: multidirectional communication between production processes and products
- Cloud: handle large amounts of data on open systems
- Cybersecurity: security in network operations and open systems
- Big Data and Analytics: analysing a large database to optimise products and production processes

The stated objectives are to promote: greater flexibility through the production of small lots at high-scale costs; greater speed from prototype to serial production through innovative technologies; increased productivity through lower set-up times, reduced errors and machine shutdowns; better quality and less waste through sensors that monitor real-time production; greater product competitiveness due to the greater functionality of the Internet of Things.

To achieve these objectives, two sets of complementary actions, defined key guidelines and accompanying guidelines are planned. The formers are divided into innovative investments, skills, governance and awareness. The accompanying guidelines, instead, relate to enabling infrastructures and public support tools.

Innovative investments are aimed to boost private investment in I4.0 technologies and assets, increasing private spending on research, development and innovation, and boosting finance to support I4.0, venture capital and start-ups. Compared to existing policies, this plan should increase private investment in the three above-mentioned elements of respectively €10 billion, €11 billion and €2,6 billion. Competence-regarding measures, on the other hand, should lead to 200.000 university students and 3.000 specialised managers on I4.0 topics, + 100% of students enrolled in Technical Institutes about I4.0 themes and about 1.400 PhDs focusing on I4.0, as well as the creation of national competence centres. In terms of governance and awareness, finally, policies will be put in place to raise awareness about the importance of I4.0 and create a public-private governance.

The accompanying guidelines, in turn, have the following objectives:

- Ensure adequate network infrastructures
- Collaborate to the definition of IoT interoperability standards
- Ensure private investments
- Support major innovative investments
- Strengthen and innovate the presence on international markets
- Support wage-productivity exchange through decentralised business bargaining

To achieve these goals, interventions aim to ensure that 100% of Italian companies will be covered at 30Mbps by 2020, 50% of Italian companies will be covered at 100Mbps by 2020. There will also be 6 consortia in the field of IoT standard. There will be made available +€0,9bn for reform and refinancing for 2017 of the "Fondo Centrale di Garanzia", +€1bn for development of contracts focused on I4.0 investments and +€0,1bn for investments on digital sales channels “(*Piano Made in Italy*”).

Among the measures most enthusiastically accepted by companies are the ones related to financial aspects. In addition to the possibility of using a 250% amortisation for certain investments, there are: tax deductions up to 30% for investments up to €1 million in start-

ups and innovative SMEs; absorption by "sponsor" companies of start-up losses for the first 4 years; tax relief through capital gains on medium/long-term investments; funding for the creation of new companies with a I4.0 focus with a combination of facilitating tools and institutional actors; investment funds devoted to the industrialisation of ideas and patents with high technological content; VC funds dedicated to start-up I4.0 in co-matching.

It can be noticed that the policy, albeit starting from the adoption of technologies, develops around enabling factors such as human capital, governance, and financial instruments. Another interesting measure is the creation of digital innovation hubs and competence centres. The first ones are entities that should be a bridge between business, research and finance. Trade associations have been identified as key players for this role. The competence centres, on the other hand, will be only few and selected on national basis. There is a strong involvement of universities and large private players, as well as the contribution of key stakeholders (research institutions and start-ups). Those centres will be polarised on specific and complementary technological areas and provided with a proper business model and managerial skills.

The aims of these two subjects are complementary and in some cases overlapping. However, a quite precise mission for both of them can be found. Digital Innovation Hubs will have the task to raise awareness of businesses in existing I4.0 opportunities, support private individuals in innovative investment planning activities, addressing Competence Centres, support businesses in accessing public and private funding tools, carry out mentoring service to businesses and interact with European DIH. Competence Centres, on the other hand, will be involved in training and awareness issues about I4.0, demonstrations on new technologies and access to best practice about I4.0, technology consulting for SMEs, launch and acceleration of innovative projects and technological development, support for experimentation and production of new I4.0 technologies and coordination with European competence centres.

The initial plan expected a private commitment of over €56 billion for the period 2017-2020, in view of a public commitment of around €24 billion. The actual amount, however, at this time is hardly measurable, due to ongoing changes to the plan and the late launch of several planned measures.

For the success of *Piano Industria 4.0*, however, it seems to be central the role played by competence centres, structures that have the purpose to promote and support applied

research, technology transfer and advanced technology training, as already mentioned. It is important to emphasise that these centres will not only support companies from a technological point of view, but also by developing services aimed to stimulate businesses to redesign their business models and support them in action so that they can seize the opportunities that digital technologies offer. Competence centres should be one of the elements of the ecosystem that needs to be created to foster the adoption of digital technologies by acting on enabling factors and going beyond the mere technological aspect. This should allow the development of multiple technological trajectories that can enhance territorial specialisations, shaping digital instruments based on real situations and avoid imposing a unique Industry 4.0 model for everyone. At the moment, these centres are still in an embryonic state, due also to continued slippage of implementing acts that should make available public funds. The world of digital innovation hubs appears more active, founding in several trade associations more reactive support. This is a sign of a necessity of businesses to have an interlocutor able to accompany them in processes of digital transformation. In this sense, the role assigned to competence centres is even more important. Despite the difficulties these centres are experiencing in the take-off phase, it is admirable the attempt of specialisation that some of them are following. The case of the 9 Universities of Veneto, Trentino and Friuli Venezia Giulia can be mentioned, whose pole will specialise in the so-called "SMACT" technologies (acronym for "Social, Mobile, Analytics, Cloud and Internet of Things") and that one of Politecnico di Torino, which will focus on automotive sector and on the development of its technologies, with particular emphasis on additive manufacturing. The logic of the network seems to be a good driver for the work of these actors. The specialisation that each pole should achieve would lead to an expansion of the capabilities of the entire economic fabric, avoiding unnecessary overlapping and creating competences and excellence that can compete on an international scale.

Summarising, Industry 4.0 is the main discussion topic about the industrial transformation of the Italian production system, as demonstrated also by the significant public commitment made in this direction. It is certainly a good thing to move the horizon of observation from a mere technological aspect to a broader vision that involves aspects such as human capital, governance, internationalisation, finance, public-private partnerships, and so on. It is also necessary to define an Italian model of Industry 4.0,

which takes into account the specificities of the national companies and give value to territorial specialisations.

6. The case of Veneto region (Italy)

To analyse the diffusion of digital technologies in Veneto (Italy) a survey was submitted to manufacturing, construction and tertiary companies. Total number of respondents is respectively 633, 51 and 207. The sample is representative for both size of companies and activities. Knowledge and diffusion of following technologies were investigated: automation and robotics, industrial internet of things, smart products, additive manufacturing, mixed reality, big data and virtualisation of IT systems. Case studies and structured interviews followed the collection of data. The survey dedicated an in-depth-analysis to additive manufacturing.

Diffusion of digital technologies in Veneto region varies across industries. Share of digital users (i.e. firms that use at least one digital technology) for manufacturing and construction is respectively 37% and 33%, while it is 64% for tertiary. The knowledge about technologies is similarly distributed: it is highest in tertiary and lowest in construction. The analysis shows the existence of different technological frontiers among sectors. Intensity of use and types of technologies are significantly different depending on firm's activity. There is also an important gap between levels of knowledge and use of technologies. It is highest of additive manufacturing: 60% of firms declare to know the technology but less than 10% uses it. The difference, in this case as well as for other technologies, is surely due to the impossibility to use the specific technology in a specific business, but part of the gap is probably due to a superficial knowledge about the potential and impacts of technologies.

Table 1: Knowledge and use of digital technologies

Technology	Manufacturing		Construction		Tertiary	
	Knowledge	Use	Knowledge	Use	Knowledge	Use
Robotics	52,66%	26,59%	32,08%	4,04%	29,81%	7,68%
Industrial Internet of Things	37,04%	13,84%	21,49%	9,37%	33,06%	9,25%
Smart products	27,35%	5,23%	23,05%	9,37%	28,86%	7,78%
3D printing	58,57%	8,34%	44,06%	1,56%	52,27%	6,68%
Big data	25,60%	9,49%	28,18%	12,94%	36,49%	20,96%
Mixed reality	32,45%	6,36%	30,66%	4,04%	37,60%	16.96%
Virtualisation of IT systems	39,93%	16,87%	40,32%	30,22%	55,56%	45,21%

Source: own elaboration on University Ca' Foscari of Venice data.

6.1 Additive manufacturing

As concerns additive manufacturing, what emerges is that it is used in less than 10% of firms and it is weakly integrated in business processes. We observed a negative relation between integration of 3D printing and firms' dimension, i.e. stronger the integration smaller the firm. There is no significant impact of the technology on labor market. Very few jobs were created and in most cases its introduction did not required particular adjustments in labor organisation. Furthermore, 3D printing is still linked to prototyping, with more than 90% of firms using it for that scope. Less than 30% of respondents declared to use additive manufacturing for fabrication of finished or usable products.

To examine the integration of additive manufacturing technologies in firm's activities use level and integration level were asked. The first one refers to the intensity of use of additive technologies, while the second one refers to the relative relevance of additive manufacturing in relation to other technologies that are used within the firm. We can have three different use levels:

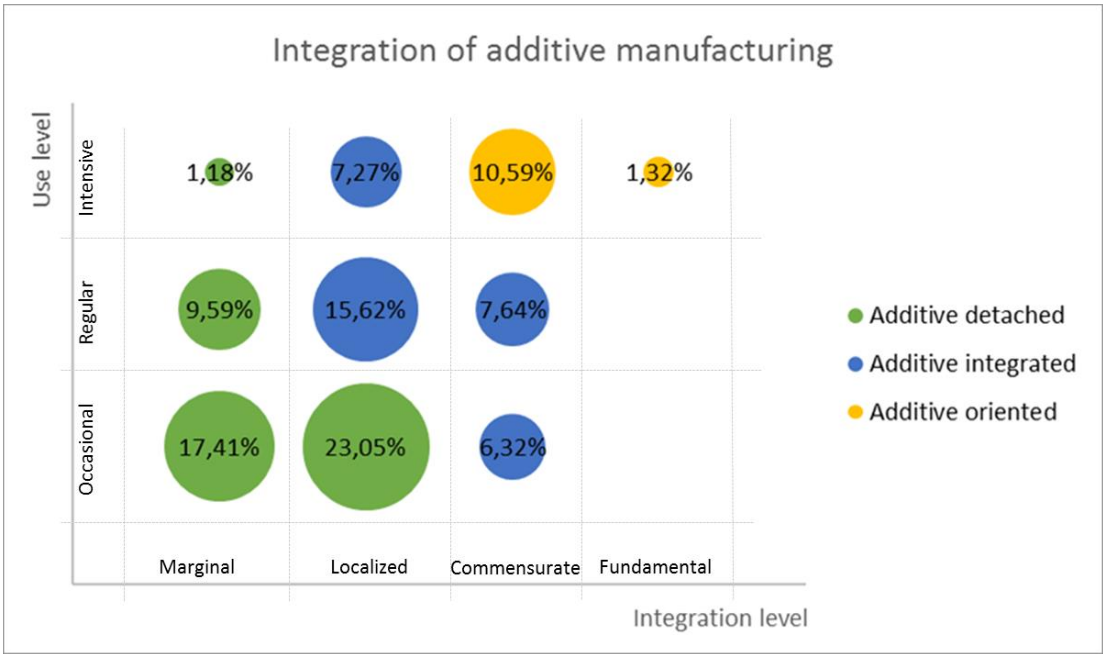
- **Occasional**: the technology is used only in particular cases, that cannot be attributed to the every-day activity of the firm;
- **Regular**: the technology is used in repetitive and recurring way during the production process;
- **Intensive**: the technology is used in constant and stable way during the production process.

On the other side, there are four different integration levels:

- **Marginal**: the technology is not of a particular importance for the firm's activity, it can be used as a substitute for some productions;
- **Localised**: the technology is important for some specific phases of the production process, but the overall impact is lower than that of other technologies;
- **Commensurate**: the technology is relevant as the others within the firm; the relative relevance among technologies used is the same;
- **Fundamental**: the technology is at the base of firm's activity; it is the core technology of the entire production process.

Through the intersection of these variables we can build a matrix that allows us to identify three groups of businesses. In additive detached firms, additive manufacturing technologies are nearly irrelevant and they are used only sporadically. In this group, we do not expect a significant impact of the technology on the overall activity, economic performance or any other aspect. The secondo group, additive integrated, includes firm where additive manufacturing has its own role and it is one of the many technologies that are used. Finally, additive oriented firms are those that strongly rely on this kind of technology and where its impact is the most significant.

Figure 1: Integration of additive manufacturing in Veneto's firms.



Source: own elaboration on University Ca' Foscari of Venice data.

Italy has a strong potential and good performance in many fast-growing fields of additive manufacturing (Bai *et al*., 2017), but there is no strong penetration of the technology in Veneto at this stage. 51% of firms are additive detached, 37% are additive integrated and only 12% can be considered as additive oriented. The average number of employees is 65 for additive detached, 48 for additive integrated and 19 for additive oriented firms. Looking at the same item from another angle we see that 70% of additive oriented firms reports a turnover lower than €2,5 million. The same share for additive integrated and detached firms is respectively 33% and 39%. If we consider turnovers lower than €10 million, that

percentages become 93% for additive oriented, 78% for both additive integrated and detached. This means that a strong additive orientation is strongly related to small business dimension.

Main reasons of use of 3D printers are those related to personalisation and development of new products. The first one confirms what already seen in other works, where the ability to personalise products is one of the main strengths of additive manufacturing technologies (Lipson and Kurman, 2013; Petrick and Simpson, 2013; Fondazione Nord-Est, 2015). The impact of 3D printing on development of new products (and on development of new performances) is strongly related to rapid prototyping. Indeed, 91% of all users of additive manufacturing technologies declares to use them for prototyping, against 26% that use them for fabrication of usable products. Furthermore, product development and personalisation have a strong relation: almost 50% of firms who have reported impacts on first one have reported also an impact on second one.

On the other side, additive manufacturing has less relevant impact on organisational aspects of a business. Changes in make or buy choices and labor organisation, as well as new market creation, are the less recurring. Creation of new markets seems to be more relevant for small firms, as 42% of those who reported this kind of impact have turnovers lower than €2,5 million.

Additive manufacturing technologies have some particularities that can require new competences (Santolamazza and Pejcic, 2016), but the data we obtained shows a different situation. 77% of tertiary and more than 60% of manufacturing firms reported no changes on labor organisation. Tertiary sector reported no introduction of new competences, against less than 3% of manufacturing. This makes sense as we expect more skilled workers in the first one. At the end, 3D printing is not creating a considerable number of jobs. Furthermore, the introduction of new competences occurred only in additive detached and integrated firms. No additive oriented firm reported new hiring. The last group probably includes firms that had skilled workers with right competences to fully implement additive technologies.

Concerning the future potential of additive manufacturing, we notice that for about 70% of businesses the technology has a marginal or none potential. There is also a good share, more than 25%, that considers additive manufacturing as being one of the technologies to look at in the future. Finally, there is poor confidence about a fundamental future impact,

especially in construction and manufacturing. What is interesting here is the role of firm's dimension. In construction, bigger firms are more skeptical about the potential of the technology. In other words: higher the future potential smaller the firm. In manufacturing, it is the opposite. The average number of employees increases as the potential also increases, meaning the bigger firms are more confident and/or recognise a higher potential.

6.2 Internationalisation

Internationalisation is among enabling factors considered. It has been observed in literature that the openness to international markets has a positive impact on firm's innovation activities, in both large and small enterprises (Boermans and Roelfsema, 2016). Furthermore, a positive link exists not only between internationalisation and innovation, but also between these two factors and productivity (Altomonte *et al*, 2013). Several empirical works have shown a positive relation between use of digital technologies and export activities, too (Morgan-Thomas and Jones, 2009; Higón and Driffield, 2011; Bianchi *et al.*, 2016; Cassetta *et al.*, 2016). However, almost all of them consider front-end application of digitalisation, using variables such as use of ICT, social media, e-commerce and similar. Very low attention has been put on digitalisation of productive processes.

From the research emerges a positive relation between internationalisation and use of digital technologies in production. This is true for manufacturing and construction, but not for tertiary. Furthermore, the impact of internationalisation is greater for construction than in manufacturing. In both cases lack of import and/or export activities has a negative impact on the probability to adopt one or more technology. The relation can be examined from a dual point of view. Internationalisation is simultaneously a consequence and a requirement for use of I4.0 technologies. An intense competition on international markets needs flexibility and productivity levels that digitalisation allows. At the same time, growing need of global supply chain integration can be satisfied almost exclusively through ICT related technologies.

Table 2: Share of respondents that have export or import activities and use digital technologies.

	Export	*Import*
Construction	30,35%	48,51%
Manufacturing	73,69%	57,95%
Tertiary	8,98%	5,83%

Source: own elaboration on ISTAT data.

6.3 Human capital

An additional enabling factor considered is human capital. Skilled workforce is another crucial aspect for digital innovation, as the technological infrastructure alone cannot generate value. Evidence shows that investments that do not include human capital are less likely to lead to productivity growths, especially in small firms (Díaz-Chao et al., 2015). Positive relation between product, service and process innovations and “innovative human capital” has been observed, too (McGuirk et al., 2015). Although there is no consensus on enhancing innovation (in a broad sense) by improving human and intellectual capital (Buenechea-Elberdin, 2017), digital transformation seems to require it and have a positive impact on it (Cleary and Quinn, 2016). At actual stage, learning by doing and intra-firm training are essential. Education systems in many countries are adapting very slowly to new labor market requests, even if the creation of new professionalisms might be an answer to an already occurring job automation (Frey et al., 2016).

Table 3: Composition of workforce for 2014. Percentages are calculated on stock data.

	Manufacturing		Construction		Tertiary		Total	
	Digital users	Digital non-users	Digital users	Digital non-users	Digital users	Digital non-users	Digital users	Digital non-users
No skills	12,31%	10,91%	10,64%	16,65%	0,49%	3,88%	10,90%	10,80%
High skills	24,85%	21,35%	31,91%	14,01%	62,26%	30,56%	29,42%	21,51%
Medium skills	16,65%	16,93%	21,28%	13,53%	34,71%	54,96%	18,93%	19,44%
Low skills	46,18%	50,81%	36,17%	55,81%	2,55%	10,60%	40,75%	48,25%
High school	45,02%	42,61%	45,47%	30,78%	56,92%	49,69%	46,43%	42,33%
Degree	14,70%	8,05%	15,41%	4,17%	38,06%	34,57%	17,47%	9,77%
No education	1,87%	2,79%	2,98%	5,24%	0,45%	1,61%	1,77%	2,87%
Compulsory	38,41%	46,54%	36,14%	59,81%	4,57%	14,13%	34,33%	45,03%
Sex_F	27,03%	32,44%	16,35%	11,86%	42,90%	56,21%	28,15%	32,74%
Sex_M	72,97%	67,56%	83,65%	88,14%	57,10%	43,79%	71,85%	67,26%
Experience 1 to 3 years	14,65%	12,03%	10,30%	13,89%	20,57%	13,57%	15,04%	12,26%
Experience less than 1 year	14,94%	12,58%	12,32%	20,48%	16,69%	15,85%	14,98%	13,36%
Experience more than 3 years	70,41%	75,39%	77,38%	65,63%	62,74%	70,58%	69,98%	74,38%
Age more than 30	18,91%	14,44%	15,12%	12,57%	23,73%	24,63%	19,21%	15,05%
Age less than 29	81,09%	85,56%	84,88%	87,43%	76,27%	75,37%	80,79%	84,95%
Italian	89,46%	87,65%	91,04%	80,36%	98,54%	96,81%	90,56%	87,81%
Foreign	10,54%	12,35%	8,96%	19,64%	1,46%	3,19%	9,44%	12,19%

Source: own elaboration on Veneto Lavoro data.

Analysis of skill composition of the sample suggests that digital users are characterised by more high-skilled and high-educated workers, when compared to digital non-users. These two characteristics are surely more significant, as confirmed by regression models. Among these two, education level has a higher impact, but the joint impact is even higher. Firm with both high skilled and high educated workers are 23 times more likely to adopt digital technologies than those lacking these categories. The evidence shows also that digital users are hiring workers with a degree and high skills, while letting go those with no skills and low education. In 2012-2014 period, digital users from the sample recorded a net occupational growth, creating 870 jobs. During same years, digital non-users created 279 jobs.

6.4 Financial structure

Analysing the financial structure and ratios, emerges that digital users have generally better productivity index than digital non-users, except tertiary. Value added per employee is higher for firms using technologies, indicating a positive impact of digitalisation on performances. Financial side is less clear. Net financial position is higher for digital users but profitability ratios are quite the same in manufacturing. In construction and tertiary, a positive impact also on ROI and ROE is evident. Low profitability in manufacturing could be explained through a distribution of value added to human capital, thus lowering examined ratios. Nevertheless, this is not true in this case. We observe a decrease in wL/VA ratio when passing from digital non-users to users, meaning that the share of value added attributed to human capital is lower. The stillness of ROI and ROE might be linked to amounts of investments required for implementation of technologies and should be observed over time.

Table 4: Average financial ratios, distinguished between firms who adopt digital technologies and those who do not. Value added per employee and net financial position are in thousands of €.

	Manufacturing		Construction		Tertiary	
	Digital users	Digital non-users	Digital users	Digital non-users	Digital users	Digital non-users
ROS	6,17%	4,78%	5,67%	1,90%	5,75%	1,79%
ROE	13,65%	14,73%	19,61%	8,12%	23,71%	6,92%
ROI	15,47%	15,70%	6,36%	1,35%	32,04%	3,86%
Value added per employee (va)	65,27	56,45	73,89	49,98	60,62	65,08
leverage (L)	1,28%	1,52%	2,34%	1,29%	1,17%	2,07%
Net financial position (nfp)	4.413	669	11.467	1.919	121	973
debt/equity	1,03	0,82	0,70	1,80	0,47	1,37

Source: own elaboration on AIDA data.

6.5 Data and analytics

What clearly emerges from case studies is the lack of comprehension and use of data. The ability to collect and manage several kinds of information is crucial for innovation and exploitation of digital technologies (OECD, 2015). Managing *Big Data* (Lycett, 2013) is the key to gain value through information that is already available and whose potential needs only to be recognised (Fosso Wamba *et al.*, 2015). There is no evidence of a broad

awareness about the importance of collecting the right data. Main barriers to create value through data and analytics are mainly managerial and cultural rather than related to technology (La Valle *et al*., 2011). Overcoming this barrier could lead also to an improvement in intellectual and human capital (Secundo *et al*., 2017). Furthermore, the impact of data management is not limited to already existing business models, but it enables brand new data-driven business models (Hartmann *et al*., 2016).

6.6 Concluding remarks

Digital upgrading of manufacturing is strictly related to Industry 4.0 concept. The last one is typically referred to business models based on hyper-related operations and machines, characterised by high automation of production cycles and work tasks. It comes natural to connect this model to that of the big industry, characterised by standardised products and economies of scale. It is equally clear, however, that this concept doesn't fit very well to small and medium enterprises that historically build upon variety and flexibility their competitiveness. There is therefore a need to define local and different model of Industry 4.0, which cannot and must not distort the productive systems and territorial specialisations. The analysis of the diffusion of digital technologies in Veneto confirms this idea. The companies that best understood the change are those who made the innovation part of themselves. They have chosen a right mix of technologies, adapting processes and corporate culture and enhancing their own peculiarities. This evidence comes from Italy but it can be easily assumed also for other European regions and countries.

In making this "leap" it is important to go beyond the mere technological aspect. The benefits of digital need a much broader view to be fully acquired. The key elements for doing so are skills and governance. The presence of an adequate human capital is an indispensable requirement. Data shows that a right mix of different professional profiles is one of the most important enablers for successful technological implementation. Roles and tasks change. The production line returns to be central, as a site for the customisation of process, where design, virtual reality, industrialisation, and predictive diagnostics intersect. The contents of the work are also changing. To such an extent that some companies realise that it is up to them to learn to interact on new foundations with schools and universities.

They need new skills, also to take advantage of the benefits of connectivity and process-generated data, regardless of business size. The multiple data generated by process sensors offers unprecedented knowledge sources to improve firms' performance: within a complex array that holds together efficiency, flexibility and profitability. Some case studies reveal a change in competitive positioning around the information generated by these processes, leading firms to become top-ranked interlocutors of international clients. This also means "digital manufacturing".

Crucial in this regard are also governance policies. Corporate executives need to have a complete overview, including the technological potential, to handle this transition with a proper organisation and with appropriate directions and strategies. Interestingly, external services contribute to co-define the "vision" on technological potential of their clients, overcoming the lack of entrepreneurial vison.

To identify factors that enable an efficient use of digital technologies is essential to direct companies and public investments. What emerges from the study, and from several case studies, is that true value lies in intangible assets. Specialised workforce, quality relations with suppliers, companies' know-how, wise management and accurate organisation are all factors that allow a profitable exploitation of digital technologies. The adoption of a single technology per se is necessary, but far from being sufficient.

Upgrade of manufacturing passes through an integration of technologies in companies' processes. I4.0 is not a substitute to knowledge and competences within a business, but rather a completion. Combining technological upgrading with firm's specific activity is the key. Companies do not need to revolutionise themselves. What is necessary is to evolve, adopting digital technologies and shaping them to become part of firm's own strategy. In other words: it is the technology that must adapt to the company, not vice versa.

7. Conclusions

The adoption of the new technologies that are part of the so called fourth industrial revolution are expected to cause a new wave of changes so as to trigger a new industrial revolution.

At the moment the EU debate has drawn on the German conceptualisation that defines *"I4.0 describes the organisation of production processes based on technology and devices autonomously communicating with each other along the value chain"* (EU Parliament, 2016).

In MAKERS we advocate for a broader understanding of smart manufacturing that goes way beyond greater efficiency and productivity in the factory, but a new way of organising production between firms, new business models that might engage new forms of entrepreneurship, but also a new way of connecting with consumers and users, a new way consuming or using products.

Indeed, we would argue that the wave of new technologies that is unfolding is likely to cause a shift in the techno-social-economic paradigm, changing the organisation of production and the habit of consumption and use. For these new technologies to trigger a new Kondratievian growth cycle, we need to aspire to see changes across production and societal spheres.

In MAKERS we are working towards conceptualising and providing evidence of a broader and truly game changing formulation of **Economy 4.0** where firms, consumers, users, institutions, communities, people, workers, entrepreneurs engage with each other in the world of production and consumption.

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