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THE EFFECT OF 3D PRINTING ON THE GLOBAL VALUE CHAIN:
A cross-country survey

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GLOSSARY

3DP	3D-printing
AM	Additive Manufacturing
CAD	Computer Aided Design
FDI	Foreign Direct Investment
GVC	Global Value Chain
ICT	Information & Communication Technology
IT	Information Technology
MNE	Multinational Enterprise
NACE	Numbers used for All Industries and service activities in the European Community
RFID	Radio Frequency Identification
SME	Small-Medium Enterprise

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ABSTRACT

The past decades have been characterized by mature companies sending managers to countries where labour, engineering and management costs were lower than developed nations'. Despite the past decades, a trend inversion comes to light. This is due to critical changes in international conditions and technological improvements. In particular, 3D printing technology able to cut out retailers, intermediaries, and manufacturers of tangible goods and, therefore, to strategically reshape the Global Value Chains (GVCs). In particular, through the reunification of R&D activities with production process, 3D printing may fulfil the increasing tailor-made products demand that cannot be achieved anymore through long-offshored supply chain, resulting in reorganization of the GVC in terms of governance and location (reshoring). Thus, the investigation of the impact of 3D printing on the reshape of GVC is investigated, by taking in consideration 3D printing implementation and companies' degree of investment in 3D printing.

The data for empirical analysis was collected through an Internet-based survey. The sample firms were contacted through emails and by phone. The sample consisted of 201 international companies that perform activities at least across two countries. The results of the study indicate that 3D printing and degree of investment in the technology has always an impact on governance the GVC. Instead, as concerns relocation decision, the relationship is valid dependently on foreign sales intensity. Thereby, the firms implementing 3D printing technology tend to reshape GVC; however, the investment has to be strategic in order to gain a process innovation rather than only a product development.

This research is part of the "3D printing and Global Value Chains" – cooperation project between University of Vaasa and Università di Pavia and three companies.

KEYWORDS: 3D printing, Global Value Chains reshape, offshoring, reshoring.

1. INTRODUCTION

The past decades have been characterized by mature companies sending managers to countries where labour, engineering and management costs were lower than developed nations' (Tate et al., 2014). In particular, manufacturers were attracted by the possibility to capitalize the lower labour costs and favourable Governmental systems in the offshore countries (Hautala, 2013). However, recent evidences show a different business environment characterized, on one hand, by the raise of wages in less-developed countries, long lead-time and high transportation costs, which lead to bring manufacturing back home (Sarder & Nakka, 2014). On the other hand, 3D printing (3DP) that represents a disruptive technology, "which allows three-dimensional objects to be printed from digital data … in sequential layers using different materials" (Deloitte, 2013:1). Indeed, this technology enables companies to exploit significant cost advantages and to react to the market demand promptly. Due to the easiness in prototyping, Waller and Fawcett (2014) point out that the greatest benefit is related to the possibility to ensure customization for a mass production. However, the buzzword "mass customization" is just one side of the coin. The key is that "3D printing enables innovation in terms of manufacturing for design as opposed to the historic mindset of designing for manufacture. This is the changer game that plays a vital role in bringing manufacturing back to the country", hence implying a reshape of the entire GVC (Lockwood, 2014:1). Hence, the interest of this research is to explore companies, which decide to reshape governance and / or location of their activities due to the implementation of 3DP technology.

This thesis is a part of larger research project named as "3D printing and Global Value Chain" jointly organized by University of Vaasa, University of Pavia, and supported by Engineering consulting group, SellTek and 3DAM Lab, behaving as external partners. The project's objectives and research problems have also guided this thesis.

1.1 Background of the research study

Since the 70s, offshoring was the subject of broad discussion and research study. To move the manufacturing in low-cost countries was necessary in order to keep the competitive advantage in a global market scenario (Zelaschi, 2014). Most of the literature is

dominated by studies of the offshore location option: one of the most used model is the Dunning's eclectic paradigm (1977, 1988). This latter provides a holistic framework to analyse the main driving factors in Foreign Direct Investment (FDI) process (Dunning & Robson, 1987). Some examples are low labour costs, better skills, low availability of internal resources, and flexible employment legislation of the host country (Gerbl et al., 2015; Hätönen, 2009).

Despite the past decades, a trend inversion comes to light. This is due to critical changes in international conditions. According to a study by Boston Consulting Group (2011), China's manufacturing cost advantage over the U.S. is decreasing. The wages in emerging economies are increasing by 15% to 20% a year because of the higher market rivalry for the same resources. It is expected that the higher the U.S. productivity and the weaker dollar will close the so called "cost gap between U.S. and China" (Sirkin et al., 2011.) Moreover, according to Harry Moser, the Original Manufacturers Equipment (OEM) should consider Total Cost of Ownership (TCO): Moser refers to the hidden costs like freight, duty, carrying costs, etc., which undermine the aforementioned offshoring advantages. As consequence, the companies have started to revise the offshoring strategy (Trebilcock, 2013.) Thus, earlier researchers have investigated the main antecedents of reshoring and governance changes (Kinkel & Maloca, 2009). Some examples are lower operational flexibility, high inventory levels, reduced responsiveness to customized products by consumers, high delivery time and partners' opportunistic behaviour (Fratocchi et al, 2013; Rogerson, 1992).

1.2 Research Gap and justification of the project

Different empirical studies prove that, nowadays, companies are more willing to revise their strategy in terms of governance structure and location decision, comparing to the past. For example, a survey by Deloitte Consulting shows that 70% of their survey respondents choose to reshape their governance because of negative experience with outsourcing, and 25% want to increase control over activities, bringing manufacturing back in-house (Sarder & Nakka, 2014). In addition, from a sample of 843 Danish manufacturing companies, 2.1% have back-reshored production to Denmark. Among the most common responses in the survey, there are unsatisfactory quality by outsourcing activities; geographical distance from the external supplier and need to defend core tasks. Furthermore, the increased level of automation in Denmark affects the decision to revise company's structure. In particular, in Arlbjørn (2013) reports findings showing that 47.5% of companies are able to maintain jobs in-house due to automation implementation. At the same time, the recent technological achievement promises significant benefits for the companies. Indeed, 3DP technology, through the reunification of R&D activities with production process, may fulfil the increasing tailor-made products demand that cannot be achieved anymore through "long-offshored supply chain" (Trebilcock, 2013). Therefore, a disruptive reshape of the GVC is predicted and it brings several strategic implications for all business organizations.

The reason behind the increasing attention to this new trend relies on the fact that the ability to coordinate the GVCs is the key for multinational enterprises' (MNEs) success (Oviatt and McDougall, 1994). The relevance of 3DP is due its capability to cut out retailers, intermediaries, and manufacturers of tangible goods (Lipson and Kurman, 2013). In particular, three main technology drivers seem to capture the MNE's attention: type of materials, need for customization and for speedy delivery, and low cost. 3DP technology grants the above benefits and, for this reason, has "the potential to reshape the Global Value Chain, by altering geographic span and density" (Laplume et al., 2016:2).

However, not only the private sector may be affected by the strategic implications of 3DP. Even policy makers are interested in academic research concerning the potential implications of the changes in GVC due to the technology disruption. For example, the

Italian Government started to think about 3DP as crucial tool in order to support the creation of a companies' network. In particular, in a context characterized by small-medium enterprises (SMEs), like the Italian economic environment, the technology is able to integrate firms both vertically and horizontally, in order to move from a centralised production toward a distributed one, strengthening the Italian system (Federmanager, 2016).

The reshoring has been studied in the recent years (Kinkel, 2012; Kinkel and Maloca, 2009; Kinkel and Zanker, 2013). Specifically, significant attention has been paid on the motivations, which push companies to bring manufacturing closer to headquarter's country, and, consequently, to revise the governance structure, either moving the activity back in-house, or even increasing the outsourcing volume (Deloitte, 2014; Fratocchi et al., 2013; Fratocchi et al., 2014; Laplume, 2016). As contrast, the role of new technological improvements, in particular of 3DP, as crucial antecedent for reshoring activities, received less attention (Margulescu and Margulescu, 2014).

Previous studies have only conceptualized that the easiness in prototyping through 3DP adoption and the cheaper manufacturing costs may theoretically imply cost savings, making offshoring labour unnecessary, and outsourcing less convenient (Stratasys, 2014). The new facilities would be located near the customer, and therefore, increasing the market responsiveness (Robinson, 2014.) However, no empirical studies testing whether a relationship between the 3DP technology and GVC reshape exists. One reason could be the novelty of the two phenomena: on one side, the reshoring, and on the other side the 3DP. The difficulty in analysis is twofold: first, because the reshoring advantages are still objective of research; whereas the offshoring benefits are well-known and broadly proved by companies' experiences. The research task is even more complicated because 3DP is a recent topic for academic studies where the real advantages are still subject of discussion. Moreover, majority of studies have focused on the technological impact rather than on the strategic role that 3DP plays in reshaping the Global Value Chains (GVCs), and overcoming the common application of 3DP in prototyping phase. Furthermore, there is a lack of quantitative studies. Indeed, plenty of theoretical research have focused on

definitions of the inversion trend, leading to a lack of statistical analysis at a global level (Laplume, 2016).

Hence, a gap in the existing literature regards the role of innovation technologies in general, and 3DP in particular, as driving factor of GVC reshape trend. The 3DP is based on a process called additive manufacturing (AM), which is able to change GVC bringing several benefits: one example is the increase of job creation and employment in developed countries (Arlbjørn, 2013). In particular, the AM is a process in which different layers of the material are added to produce the final product; in particular, Waller and Fawcett (2014:1) define 3DP as the way, which "make long-talked-about mass customization a reality". In addition, the technology of 3DP enables company to bring manufacturing back to home, since it shrinks the product life cycle through eliminating the intermediate steps between research / design phase and the final product, and reducing the time needed for the prototyping and testing phase. In this way, it is ensured higher effectiveness and speedy for the product launch can be more effective (Deloitte, 2015).

1.3 Research Questions and objectives of the study

In the past decades, the offshoring initiatives have spread among MNEs, due to the promised cost advantages of producing in low cost countries, leading to "geographical diversification of the value chain as a whole, as well as locational concentration of individual GVCs activities" (Hautala, 2013; Laplume, 2016:7). However, the cost advantage itself has suffered the global competition for the same resources leading to a reshape of the GVC configuration. Additional problems have arisen due to, for example, the difficulty in coordinating several actors and subcontractors, resulting in "unexpected product quality, availability and logistics problems" (Planetmagpie, 2012:9). Whereas, the recent business practices are more oriented toward the vertically disintegration and a fine-sliced global production network, which the 3DP may partially affect (Laplume, 2016).

Therefore, the research problem of this Master's Thesis is to identify and analyse the main reasons behind the company's GVC reshape decision; in particular, it is intended to investigate how the companies are currently behaving in respect to 3DP adoption and GVC reshape, and whether the first variable may impact on the second. Indeed, the 3DP technology enables company to readily react to the increasing demand for highly customized product and, through easy and cheap prototyping, it makes unnecessary the offshoring of manufacturing and labour. Although, previous studies have conceptualized some assumptions regarding 3DP and GVC reshape (Laplume, 2016; Arlbjørn and Mikkelsen, 2014; Cooper, 2012), a deeper analysis and empirical study are required. Hence, from this background, two thesis's research questions are formulated as follows:

1) *What is the current state of company adoption of 3DP and what are their plans for the future?*
2) *Is the implementation of 3DP technology in a company associated with the changes in its GVC activities?*

In order to answer to the Research Questions, a set of objectives is laid down as follows:

1) To deepen concept, benefits and strategic implications of 3DP;
2) Why reshoring is spreading as opposed to offshoring;

3) To examine which are the main reasons that lead to reshape GVC activities.
4) To examine the impact of 3DP on the GVC reconfiguration;

To reach these objectives, an overview of the existing literature is conducted. In particular, the literature review aims at deepening 3DP antecedents and implications, outsourcing, offshoring and reshoring. To answer to the research questions set, a quantitative empirical research is conducted by collecting the data from an online cross-country survey.

1.4 Scope of the study

The empirical study is concentrated on a cross-country survey of companies that are asked to provide information regarding their degree of awareness and implementation of 3DP, location and governance changes. The context of the study is global, indeed, the idea is to figure out the geographic dispersion of the phenomena analysed.

By definition, reshoring implies that companies operate internationally; therefore, the scope is to consider companies that conduct activities, at least, across two countries. The sample size of the study does not affect the validity of the study since it is heterogeneous in terms of geography, size and industrial sector where firms operate. Moreover, as the European Manufacturing Survey (EMS) in 2009 shows, firms that reshore are usually large in size (Fratocchi, et al.: 2013). Therefore, the target are companies that have a number of employees at least up to 10 employees. Furthermore, in order to get significant results that can be generalized to the whole population, large enough sample size is required. Finally, the quantitative analysis and a deductive approach is used.

1.5 Structure of the study

The study is divided into a theoretical and empirical part. After this introductory chapter, the theoretical setting of the thesis are laid down.

The theoretical approach of the Master's thesis encompasses concepts of offshoring, reshape of GVC, reshoring, and industry 4.0, where the centre of interest is 3DP technology. GVC reshape and 3DP are the focus of this research, but the offshoring challenges and internationalization problems represent a useful starting point in order to understand why the GVC inversion trend is emerging.

The empirical part of this study is presented in the chapters three, four and five. In the chapter three, it is explained the methodology used in order to conduct this research. In particular, it is described along the research philosophy, approach, strategy and design and how data were collected. The goal of the chapter four is to figure out the main findings through a descriptive analysis (RQ1) and regression analysis (RQ2).

Finally, in the chapter five the conclusions, theoretical contributions and personal future research suggestions are also presented.

2. LITERATURE REVIEW

This section discusses the concepts of 3DP, GVCs, governance and location decision within the chain, and the recent trends, as reshoring, in a "3DP perspective". More specifically, the purpose is:

1. To explain within the broad context of Industry 4.0 what 3DP means, and the advantages of this promising technology;
2. To understand reasons behind the decision to revise governance and location strategy versus the past trend;
3. To analyse and clarify the GVC reshape phenomenon, with reference to the 3DP effect;

In particular, it is necessary to start from the initial reasons behind the opposed outsourcing and offshoring, since they have characterized the business world in the past decades. The material for the study is collected from scientific literature.

2.1 Industry 4.0: the third industrial revolution

In order to contextualize the research study, it is crucial to talk about the fourth wave of technological improvements, the new industrial technology, labelled as "Industry 4.0" or third industrial revolution (Boston Consulting Group, 2015). Indeed, the first industrial revolution started in Britain with the mechanization of the textile industry; the second wave occurred when Henry Ford conceptualized the moving assembly line, start the age of mass production up. Now a set of technologies are emerging: clever software, new-engineered materials, collaborative robots, new processes and web-based services define the third industrial revolution. (Economist, 2012)

Industry 4.0 is "the next phase in the digitization of the manufacturing sector, driven by four disruptions": big data management, increase of computational power and connectivity; increased need for analytics ad business-intelligence capabilities; new forms of human-machine interaction (e.g. YuMi by the Swiss giant ABB), touch-interfaces, augmented reality and 3DP. In BCG report additional five technological achievements are added: simulation of products and materials through 3D printer, horizontal and vertical system integration, Industrial Internet of Things (IoTs), cybersecurity and cloud. However, according to the McKinsey survey (2015), over 300

manufacturing companies, only 48% are ready for Industry 4.0, contrastingly to the suppliers' responses who are prepared for seventy-eight percent (ABB, 2015; BCG, 2015; McKinsey, 2015: 1). To summarize, Industry 4.0 is based on the so called "nine pillars of Industry 4.0" (Table 1).

Table 1. The nine Pillars of Industry 4.0 (own elaboration)

Pillars of Industry 4.0	**Definition**
1. Big data and Analytics	It refers to the analytics on a large database, which respond to the increased need to optimize production quality, save energy, and improve equipment service. Thereby, the ability to analyse data prom different sources are crucial for real-time decisions in an Industry 4.0 context.
2. Autonomous Robotics	The robots autonomy, flexibility and cooperation with the human beings are expecting to represent the keystone for increasing firms' productivity. This is due to the new concept of robot that is not closed in a cage, but they can work side by side with human, learning by them.
3. Simulation	The simulation of products, materials and design is expected to play a crucial role in optimization goals, since by testing products in the early phase of prototyping; the operators are able to test the machine settings for the assembly phase.
4. Horizontal and vertical system integration	It refers to the higher integration among companies, departments, functions and capabilities, enabling truly automated supply chains.
5. IoTs	This term relies on the enrichment of devices with embedded computing using standard technologies. In this way, the devices are able to communicate and interact, enabling real-time responses and more reactive customer service.
6. Cybersecurity	Reliable communication infrastructure, which results from the higher need to protect sensible data, threaten by cybersecurity.
7. Cloud	Since Industry 4.0 will require bigger flows of data sharing across firms' boundaries, more cloud-based software are required
8. AM	This disruptive manufacturing process, which add layer-by-layer materials for building the final product, will be used for the production of small batches of customized products, reacting to a mass customization era.
9. Augmented Reality	It refers to a set of services which transcend the tangible reality, supervising company's activities through a mobile device

2.1.1 The potential impact of Industry 4.0

To understand what potential impacts to embrace the revolutionary mindset of Industry 4.0 may have, it is common to analyse Germany as point of reference. Indeed, Germany is in pole position among the most responsive country to technology disruptions, and it is outperforming in terms of number of robots engaged in the industrial processes (Roland, 2014). According to the BCG report (2015), four main area of economic improvements are highlighted: 1) *higher productivity*, with an increase of 40%, and an increase from 15 to 25% of conversion costs[1], excluding cost of materials. 2) *Revenue growth*: due to the increased demand for data application and highly customized products. 3) *Employment*: it is expected that the employment rate will increase of 6%, with additional percentages for mechanical-engineering sector. 4) Finally, *Investment*: the adoption of Industry 4.0 will require from 1 to 1.5 percent of the manufacturers'' revenues as investments. Furthermore, significant impacts will be recorded for producers and manufacturing-system suppliers. The former will be able to optimize manufacturing processes through integrated and IT systems; specifically, production automation will be ordered virtually in one integrated process. As regard the latter, a greater modularization will affect the organization due to larger use of cloud and embedded devices; moreover, they will need online portals to download big data and to cooperate with suppliers in real-time. Finally, they will face with the demand for new international standards in order to define the interconnectivity of machines, products, parts and individuals within the digital factory context. (BCG, 2015)

In order to support companies in facing with this new era, McKinsey company have elaborated the so called "digital compass" (see Appendix 3). It consists of 8 drivers and 26 layers of Industry 4.0. In this way, companies are able to manage what they need in order to be in line with the new innovation era. (McKinsey, 2015) Overall, the following

[1] **Conversion Costs**: "include direct labour and overhead expenses incurred due to the transformation of raw materials into finished products where "overhead costs" are defined as the expenses that cannot be directly attributed to the production process but are necessary for operations, such as electricity or other utilities required to keep a manufacturing plant functioning throughout the day" (Investopedia, 2016).

table shows how dimensions of the business trade will be affected by the implementation of the "Factory 4.0".

Table 2. Main trade dimensions affected by the Industry 4.0 implementation (adapted from Roland, 2014; EPRS, 2015)

Products: Mass customization	The production process will present new features as freedom and flexibility. It is stated that it will be possible to create products tailored to segment-by-one customers, with marginal costs. The production will be small-lots oriented thanks to rapid prototyping and higher ability to configure machines to adapt the customers/suppliers specifications
Process: interconnected	It is referred to the increasing dispersion of production locations, where suppliers are concentrated in small areas, enabling speedy in information sharing. This impact relies on the "industrial democracy" where information and physical barriers are lowered, enabling small and medium enterprises, SMEs, get access to large market easily.
Business models: fragmented value chains	According to the European Parliament report (2015), the European countries will compete only on the innovation side, leveraging on their ability to satisfy the customer-driven demand
Skills: social and technical skills	Going toward an innovation era, both technical and social skills will be required where core firm's competency is to provide continuous training and development in the workplace.
Globalization toward clusters	Selected hotspots and clusters will be selected rather than a global presence with open production areas ("maker-space").

2.1.2 3D printing and the AM process

As aforementioned, 3DP may "make long-talked-about mass customization a reality" (Waller and Fawcett, 2014:1). It enables company to bring manufacturing back home and it may lead to the change from Supply chain to Demand chain. Indeed, managers start to think about demand chain management which means that the value chain has to be designed according to the customer backward (demand pull), rather than starting from the factory outward (supply push). In this way, firms are more responsive to customers' demands and may reduce waste in time and returns. (Christopher and Ryals, 2014)

The label "additive manufacturing" (AM) refers due to the production process that is different from the traditional manufacturing, which consists of taking materials away from a block (raw material) in order to gain the desired shape. As contrast, with AM, different layers of the material are added to produce the final product. As result, the 3D-printer may reduce the amount of materials that has to be used and assembled to produce a finished product (Waller and Fawcett, 2014.) Specifically, the core of the 3DP relies on "the use of digital models stores as Computer Aided Design (CAD) files, … which are then split into digital cross-sections that are successively (additively) printed into 3D objects". These cross-sections can be represented by liquid, powder, paper, etc. whose printed quality depends upon the thickness of each layer. In particular, the main difference with the traditional manufacturing process regards the lack of set-up of the machineries, because, with a different CAD file, it is possible to produce a different item (Nyman and Sarlin, 2013: 5.) The current AM notion is based on the Hull's "stereolithographic", which was the first no subtractive manufacturing process, but building products from bottom up. "Additive manufacturing is a little more complex, but can be thought as a computer controlled hot glue gun that uses a carefully calculated and measured combination of basic elements that bond together as they are laid down, by adding each layer to the previous". (Kietzmann et al., 2015)

The slogan "if you can draw it, you can print it" resume the main *advantage* that makes 3D-printing a disruption in the current way of thinking manufacturing processes (Kietzmann et al., 2015). According to Waller and Fawcett (2014), the firms' benefits rely on 1) more efficient inventory and materials management, 2) shorter development

cycles, and higher agility, 3) ensured customization, 4) better spare parts management and 5) better infrastructure design. These are explained in the Table 3 below (Waller and Fawcett, 2014).

Table 3. Main advantages of 3DP (Adapted from Waller, and Fawcett, 2014).

Advantage	**Description**
Inventory and Materials Management	Since additive manufacturing uses less raw materials in the production process, it requires also less efforts for inventory management, transportation, warehousing and purchasing. On the other hand, the raw materials for 3D-printing are more expensive, which is one of the main trade-offs that need to be considered.
Development cycles, forecasting and agility	Due to the rapid prototyping through 3D-printing, the normal product development process cycle time is lower. The shorter product development process lead to lower time horizon for forecasting and lower inventory costs. Similarly, it enables the company to be more agile and reactive to the market changes.
Postponement and customization	Manufacturers are able to print highly customized products and better respond to demand: this affect the supply chain management in terms of faster cycle continuous improvements based on the feedback received from customers.
Spares management	Because, hypothetically, through 3d-printer, manufacturers may print parts as needed
Infrastructure design	From above, it is understandable that a higher percentage of raw materials is required. However, these are less expensive to hold, with less probability in damages than finished goods.

It is important to mention also the increase in designer creativity in their product development. The best scenario shows that tomorrow, customers will be able to not only download a manual with instructions, but also the parts needed if something goes wrong. In this way, manufacturers will gain double advantages:

- to gain the market share of parts suppliers;
- To speed up the replacement and repair process. (Kietzmann et al., 2015)

In addition, increased part complexity and waste reduction are granted. The former relies on the shape matter. Indeed, the 3D printer is a “single tool” which do not require

changing any aspect of the process: this makes the shape complexity free, because there are no additional costs or lead time in respect to a simple-shaped item. The latter regards the "green" characteristics. This is due to the manufacturing process: since it consists of adding material layer-by-layer, only the needed parts are used and the outcome is zero waste. (Campbell et al., 2011)

Furthermore, 3DP technology bundles all the stages of manufacturing into a single machine. Indeed, the supply chain "unbundling is driven by fundamental trade-off between gains in specialization and costs of dispersal…that is seriously undermined by radical advances in the direction of mass customization and 3D printing by sophisticated machines" (WTO, 2013: 48). Moreover, the bond "one machine, unlimited product line" make 3DP even more interesting. It is useful compare this advantage with the expensive investments and long factory downtime that are required in traditional manufacturing when product line is changed.

Even more crucial, it is the reshape of the GVC. Indeed, disruptive change in supply chain and business models are forecasted: this is due to the combination between the aforementioned flexibility with the higher proximity to the point of consumption. This latter may result in a reshaping of the supply chain, by eliminating, for example, distribution, warehousing and retails. Therefore, new supply chains and retails opportunities are expected (Bassan and Srinivasan, 2012.) Furthermore, the easiness in prototyping and the cheaper manufacturing costs imply factories tend to back-reshore manufacturing from low-cost countries to the home country. Indeed, 3DP and the reshoring trend allow cost savings, making offshoring labour unnecessary. The new facilities would be located near the customer, and therefore, increasing the market responsiveness. (Robinson, 2014)

On the other side, 3DP shows three main *drawbacks*:

1) It involves a *short series of goods*; therefore, the mass production is not achievable because of long time production for a single item. However, it is argued that if the mass production is decentralized, then the demand would decrease, favouring the high-tailored items, manufactured near the end-user, rather than in one factory that produces hundreds of thousands of standardized products.
2) Linked to the previous disadvantage is the cost matter. Indeed, the costs for producing 10 items is the same as for 10.000 pieces (Nyman and Sarlin, 2013).
3) Low quality materials available and low repeatability of 3DP. Due to the novelty of the technology, the current materials are not appropriate for the industrial manufacturing application. Moreover, parts made with different machines may produce items showing different properties (Campbell et al., 2011).

Even though it is not possible to predict what 3DP will bring in the future, it is easy to forecast how the commercial manufacturing will change. Five main trend in the commercial manufacturing are recognized.

1) *Time-to-market shrinks*. This will due to the faster and easier phase of prototyping that enable companies to be flexible, which is a required feature in order to keep the competitive advantage.
2) *Superior capabilities of the products*. Products will be "smaller, lighter, stronger" by incorporating 3D-printed components. Moreover, due to the decrease in trade barriers and the strong competition, companies will be forced to outperform in order to survive in the market.
3) *Open design is here to stay*. The principle called "co-creation" refers to the communities of end users who share their opinions and ideas: these will be available to everyone who wants to prototype and manufacture a product. The challenge among the competitors will regard how well they prototype the idea and ensure quality, rather than on how good is the idea (like the traditional concept of manufacturing).
4) *Customization is the new normal*. Because 3DP is based on the concept of customization, the expectations of customers will raise, perceiving customization as the norm.

5) *The economics of offshore change*. The economies of scale through offshoring in low-cost countries will be challenged by the just-in-time production near the point of consumption, with 3DP. (Bassan and Srinivasan, 2012)

In particular the last point represent the research problem it is intended to solve with this study. However, it is not obvious that manufacturers will choose just one between the two possibilities mentioned before (low-cost countries advantage *versus* just-in-time production). It is possible to gain competitive advantage through an appropriate combination between the two: for example, through low-cost and high-volume components connected with specialized just-in-time production, on the site of assembly. (Bassan and Srinivasan, 2012)

2.2 Global Value Chains (GVCs)

Whereas the international division of labour has existed for centuries (Ricardo, 1817; Smith, 1776), multinational enterprises (MNEs) did not take off until 1960s when US companies started offshoring labour-intensive manufacturing activities to low-cost countries (Laplume et al., 2016). Additionally, over the last 30 years, the global trade scenario was characterized by disruptive changes because of the increase in technological complexity, liberalization of the trade and the decrease in transportation and communication costs. These antecedents have resulted in a highly fragmented trade landscape and, therefore, in the emergence of the GVCs, where the production of components is accomplished across country borders (Cheng et al., 2015.) The label "global value chains" was applied to the famous value-chain template by Porter (1985) who specified that GVCs may have a dispersed and concentrated governance. This latter refers to the global specialization of value-chain activities of multinational companies (Porter, 1986). Independently on the governance choice, the common GVC features rely on the global specialization coordinated by a MNE, which implies geographical diversification of the value chain and locational concentration of individual value-chain activities (Laplume et al., 2016). This phenomenon occurred within the economic globalization trend, which has been driven over time by a mix of economic policies, multilateral agreements and international politics behaving as push factors for country's outward orientation. Therefore, the spreading of GVCs has become a strategic asset in order to survive in the new global trade context, by exploiting the benefits resulting from technology improvements and economic specialization (Primo Braga, 2013.) In particular, the development of ICT has been the main driver behind the ever-increasing importance of GVCs. Indeed, the higher coordination costs of activities performed across countries are decreased thanks to Internet and improvements of communication infrastructures. In other words, the higher fragmentation of the trade has led to a new "trade-investment-services-know-how nexus" of intermediate goods, capital, ideas and services, which need reliable transportation networks, trade facilitation and knowledge-based services (OECD, 2014:12.)

A GVC consists of a set of "interconnected markets for goods and services through which goods are produced outside the boundaries of the final firm. These networks rely on the

unbundling (e.g. slicing of tasks) of different stages of the production process" (Primo Braga, 2013: 2). In other words, "a GVC involves combining imported intermediate goods and domestic goods and services into products that are then exported for use as intermediates in the subsequent stage of production" (Cheng et al., 2015: 74-75). According to Cheng et al. (2015), a standard GVC encompasses a set of stages from the product conception toward assembly operations and, finally, to sales and aftersales activities. Moreover, according to World Economic Forum, the relationship between added value captured and GVC position is characterized by a curve with a smiley shape, as it is shown in the following figure.

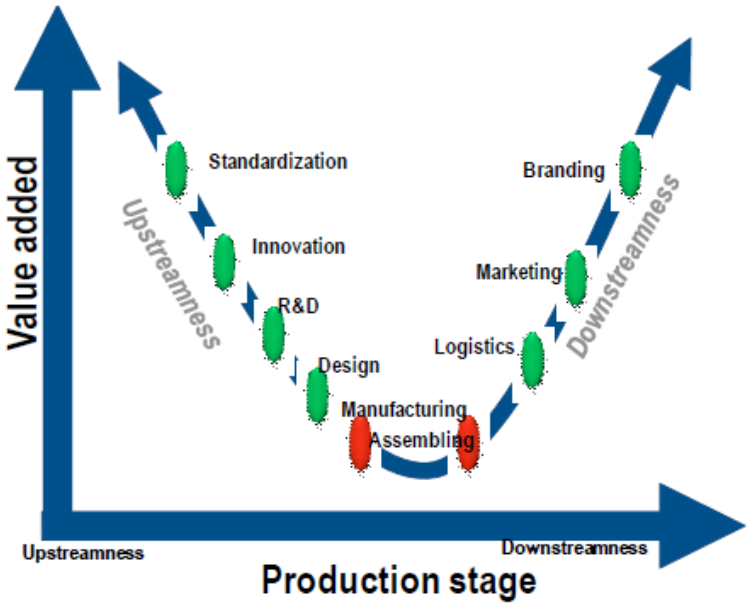


Figure 1. Relationship between value added and GVC position (adapted from Cheng, 2015).

The figure above shows that the firm is able to capture highest added value in two specific stages: 1) R&D in the upstream and 2) marketing in the downstream, with a small share of captured value in the assembly stage (Cheng et al., 2015). The recent trend regarding the GVC participation shows that a significant change has been recorded over time. According to Koopman et al. (2010) the score of GVC participation can be assessed through an index which represents the ratio between the sum of foreign value added in domestic exports (backward participation) and domestically produced intermediates to be used in third countries (forward participation). In particular, contrary to the past, the

Association of Southeast Asian Nations (ASEAN) market is registering a considerable increase in GVC participation. This current scenario is confirmed by Cheng et al. (2015) who shed light on two main findings relying on the analysis of a unique Organisation for Economic Co-operation and Development-World Trade Organization database on trade in value added for GVCs, enhancing 57 countries. First, among the ASEAN countries, China have increased its own value added share through GVCs. Close to the China, the Korean market is getting more engaged in high-tech manufacturing. Second, advanced and emerging markets have moved toward upstream activities in GVCs, even though, regarding the high-tech manufacturing the Asian advanced economies show a faster pace than the emerging markets.

As concerns why GVCs still matter, it is important to highlight the importance of joining GVCs. It relies on the firm's need to be engaged in just-in time delivery and flexibility to the ever-changing demand. As contrast, the costs may increase due to delay in conducting trade across company's borders. Indeed, several risks are linked to the GVC participation. First, it would mean a decrease of domestic gross exports. Second, by sourcing abroad, the production could require less labour-intensive activities, and therefore, resulting in job losses (Hijzen and Swaim, 2007). Third, to join GVC would resulting in getting locked into particular segments, without exploiting the opportunity to upgrade its own position. Finally, the pressure for lower costs can lead to an impoverishment of environmental, occupational and health standards, as well as, an unstable demand for labour. (OECD, 2014)

However, GVC's benefits overcome the difficulties because, according to Baldwin and Yan (2014), to join a GVC brings significant improvements in terms of productivity. This latter result from the division of production and tasks specialization, enabling firms to exploit their own comparative advantage and granting the increase in economies of scale and scope. A logical implication from the previous discussion regards the possibility to the Asian market to escape the "middle-income trap" and for low-income countries to increase the growth per capita (Cheng et al., 2015.)

2.2.1 GVC: past trends

The GVCs have revolutionized the world since a new mindset was laid down. The poor economies are able to join an existing supply chain instead of investing to build their own. In particular, by offshoring the labour-intensive manufacturing stages, it was launched a growth-era for the emerging markets (Cattaneo et al., 2010; Baldwin, 2011). The unbundling process engaged the offshoring or outsourcing of entire manufacturing stages, which means respectively, to exploit a foreign country or external supplier's skills. This trend has its roots in economist like Adam Smith who stated that the specialization pays by boosting the productivity (WTO, 2013.) Furthermore, Lanz et al. (2012) points out that by offshoring business services, a shift of local task content occurs. The higher import penetration of business services allows the country to switch from communication-information tasks toward task related in managing the operations with new equipment and, therefore, toward more ICT-related tasks. Hence, in order to deeply understand why outsourcing and offshoring phenomenon have been the most common choice in the past decades, it is necessary a critical review of the literature. This insight is crucial in order to answer to the research question regarding the inversion trend of revising localization and governance structure. Hence, it is necessary to understand the issues and challenges companies that outsourcing and offshoring face with. Furthermore, the roots of the GVC phenomenon are laid down in order to create a link with the next generation of GVCs, which follows in the next paragraph.

2.2.2 Outsourcing and Offshoring: two different but interrelated concepts

First, it is necessary to examine in-depth the definitions of outsourcing and offshoring; indeed, the main purpose is to avoid overlapping and confusion between the two phenomena, although they are interconnected. As it follows, Figure 2 shows the main strategy options to cross firm and country boundaries (Srivastava et al., 2008).

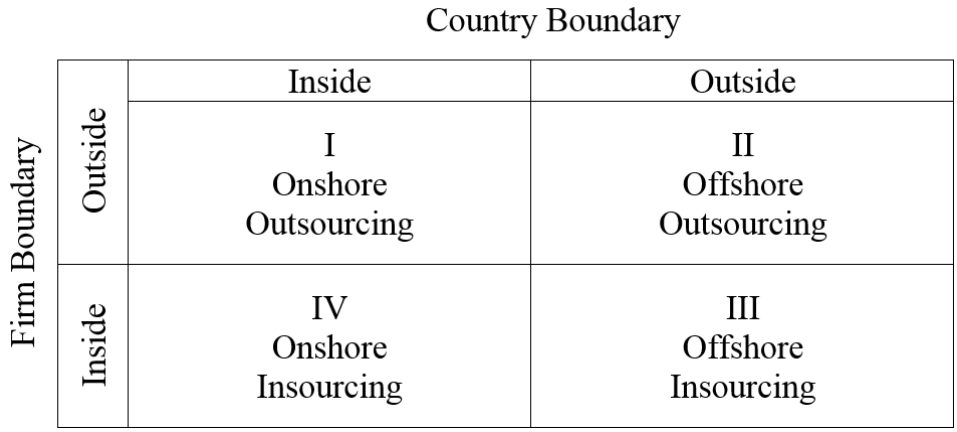


Figure 2. The boundaries of outsourcing and offshoring (Srivastava, et al.: 2008).

On one hand, as Figure 2 illustrates, arranging a process across firm boundaries relies on outsourcing decisions; on the contrary, insourcing refers to a process kept inside the firm. On the other hand, if the company chooses to cross country boundaries, the options are to offshore or to onshore: this distinction refers to holding the process respectively outside or inside the country. In addition, it is important to specify that offshoring projects can be both outsourced and insourced (quadrants II and III). For example, an offshoring-insourcing initiative refers to the company's decision to place the production in a host country, but using a parent company's subsidiary. Hence, in this case, the company arranges the manufacturing across the country boundaries, but keeping ownership of the process. (Srivastava et al., 2008)

As regards sourcing decisions, the first step a company should follow is to decide whether arrange a process inside or outside the firm's boundaries. In general, the company's decision to keep in-house tasks and responsibilities for a process refers to insourcing, whereas, in outsourcing, an external vendor is in charge of the activity (Hautala, 2013.) The literature of supply chain management calls this step "make or buy" decision (Balakrishnan et al., 2005). Moreover, Lei and Hitt (1995:836) provides the definition of outsourcing as "the reliance on external sources for manufacturing components and other value-adding activities". Similarly, Kotabe (1992:103) defines outsourcing as "the extent of components and finished products supplied to the firm by an independent supplier".

Gilley et al. (2000) argue that outsourcing could include any process of a firm in which an external supplier provides goods or services. In addition, to define outsourcing as merely procurement decision is limited; rather, outsourcing relies on a strategic decision to reject internalization. Indeed, one of the main consequences deriving from outsourcing is the reduction of the firm's involvement (vertical *dis*integration). Moreover, the authors suggest excluding those companies that have no choice, but they are forced to acquire parts or components from an external supplier because of lack of capital or expertise, for example.

On the other hand, offshoring relies on the relocation of a company's activities overseas (Aron and Singh, 2005; Pyndt and Pedersen, 2006). According to Gordon and Zimmerman (2009), offshoring implies that "(1) firms move production of services from within the firm to outside the firm to a location outside the country. (2) The firm switches from purchasing services from an outside source within the home country to a source outside the home country or some combination involving a move of activity outside the country". Therefore, this approach refers to a company that transfers process to owned subsidiaries or strategic suppliers abroad.

In addition to the differences in definitions, a central difference between outsourcing and offshoring is the motivations behind the firm's choice. Indeed, the firms can focus on the core businesses by outsourcing all activities that they do not want to develop further (Slaughter and Ang, 1996). Contrastingly, offshoring enables the company to give up services to those suppliers who show better skills or cheaper price than in-house production (Hirschheim et al., 2004). In particular, this practice enables firms to choose from a wider range of labour skills (Rao, 2004). To sum up, even if outsourcing and offshoring are different concepts, they are strictly interrelated. The main difference between outsourcing and offshoring relies on the different nature of decision a company takes: the former refers to sourcing decisions ("*make or buy*" decision) (Hautala, 2013; Hätönen, 2009). The latter refers to location-decision. However, it is important to highlight that these may be combined: hence, for example, a company can opt for offshore-outsourcing or offshore-insourcing. Moreover, the distinction between offshoring and outsourcing is clear from an ownership perspective: the former denotes

the manufacturing transfer from a foreign country to an owned subsidiary; hence, the company keeps the ownership (Lewin and Peeters, 2006). The latter consists of giving up control and ownership to a third party (Bettis et al., 1992). In order to explain the outsourcing decision process and the reasons why a company chooses outsourcing, the following framework is provided (Kremic et al., 2003).

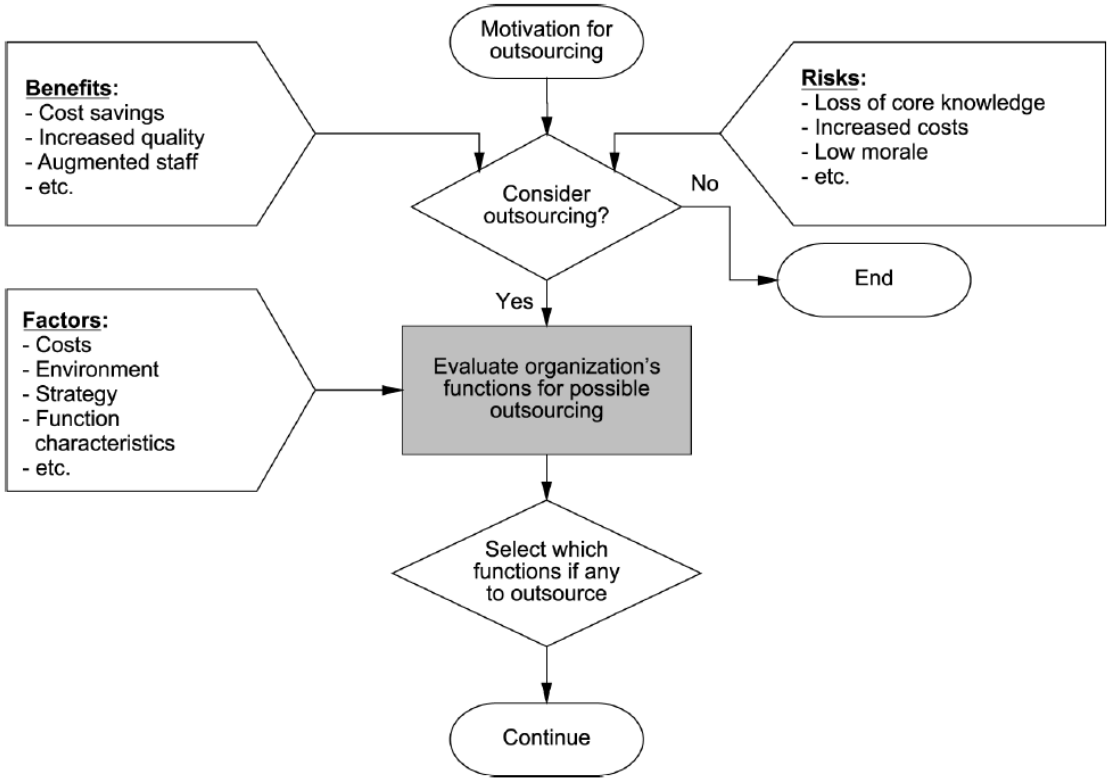


Figure 3. Outsourcing decision framework (Kremic, et al.: 2003)

Figure 3 illustrates the main steps in outsourcing decision-making process, risks and benefits of the evaluation process. According to Kremic T. et al. (2006), it is possible to identify three main categories of motivations for outsourcing: 1) cost, 2) strategy; 3) politics. Most of the literature refers to cost savings as the main driving factor for outsourcing decision (Arnold, 2000; Aubert et al., 1996; Bienstock and Mentzer, 1999; Bergsman, 1994; Brandes et al., 1997; Fan, 2000; Kriss, 1996; Laarhoven, 2000; Vining et al., 1999; Willcocks, 1995). These assumptions are based on Transaction Cost Theory (Coase, 1937; Williamson, 1975), the Resource-based View (e.g. Barney, 1991; Wernerfelt, 1984) and theories of the organization and the firm (e.g. Caves, 1971; Hymer,

1976). In particular, a cost saving occurs when the costs of producing goods or services through an external supplier are lower than costs a company faces with own manufacturing, even if there are additional transaction costs in the operation (Bers, 1992; Harler, 2000). This mechanism is due to the occurrence of economies of scale and specialization that enable companies to reach higher level of efficiency, and, therefore, higher returns (Ashe, 1996). However, some authors argued that the empirical evidence shows how cost savings are overestimated and, sometimes, even higher after outsourcing (Anderson, 1997). Indeed, by outsourcing, the firm has to face additional indirect costs: transaction costs, contract generation, procurement and costs for monitoring the supplier's' behaviour after the contract (Vining et al., 1999). The strategy-driven outsourcing refers to the choice of those companies, which outsource in order to gain strategic advantages, by exploiting better skills of the external supplier. In this way, firms can fulfil the home organization lack of capabilities (Abraham and Taylor, 1993.) Moreover, companies may take advantage of complementary resources and capabilities owned by external suppliers (Gottfredson et al., 2005). Furthermore, through outsourcing, the focal firm, usually placed in developed countries, is able to leverage its power in the commodity chain in order to extract higher profits (e.g. Nike which has the power to switch supplier as it applies brand rights on its suppliers) (Buckley and Strange, 2011). Summing up, Table 4 of main benefits and risks of outsourcing is provided.

Table 4. Main Benefits and Risks in outsourcing (adapted from Kremic, et al.: 2006).

Benefit	**Risks**
Cost savings	Unrealized savings or hidden costs
Reduced capital expenditures	Poor selection of partner
Capital Infusion	Loss of knowledge/skills
Transfer fixed costs to variable	Loss of control/core competence
Increased speed and flexibility	Power shift to supplier
Access to latest technology/infrastructure	Supplier problems
Access to skills and talent	Losing customers, reputation, opportunities
Increase focus on core functions	Uncertainty environment
Better management	Poor employee issues

In this study, this overview is crucial in order to understand why companies tend more and more to reshape GVC activities, contrastingly to what they have done until now. For example, the underlying reasons of offshoring are strongly linked to the reshoring initiatives: indeed, there is no reshoring without a previous offshoring decision.

By combining the location and governance decision, Gerbl et al., (2015) provide an interesting distinction of the main location options a company has when it outsources services. These are:

- local outsourcing;
- nearshore outsourcing;
- offshore outsourcing.

The first refers to the case a company outsources to a vendor who is situated in the same client's nation: in this way company benefits of similar language, time zone and geographical proximity (McIvor, 2008). A firm prefers to choose the second option when

it wants to exploit both the same advantages of the first option and labour costs cheaper than those in client's home nation (Rottman and Lacity, 2006). The last location option involves a distant country; however, the company can gain profits by exploiting significant cheaper labour costs (Aron and Singh, 2005). Most of the literature is dominated by studies of the offshore location option, and the previous researches are mainly focused on Dunning's eclectic paradigm (1977, 1988). The latter provides a holistic framework to analyse the main driving factors in Foreign Direct Investment process (Dunning and Robson, 1987). The model is based on the assumption that outsourcing company's benefits rely on three main categories of factors:

- ownership advantages ('O'), which indicates who is going to produce abroad;
- locational factors ('L'), affecting the decision where to produce;
- Internalisation factor ('I'), addressing the question "why" a company should internationalize. (Dunning, 1988).

According to Hätönen, J. (2009), Dunning's eclectic paradigm includes several locational advantages that home or host country can gain, but it describes a linear approach. Indeed, other authors describe the outsourcing process as reciprocal, and independent on location-specific variables.

Moreover, Damanpour, F. (1992) states that the larger the firms' size is the more companies are able to benefit opportunities in new markets (Damanpour, 1992). Indeed, big firms are able to compensate the greater risk that they take when offshore activities because of the possibility to have a greater access to resources (Aron et al., 2005). Furthermore, the degree of financial leverage influences the company's decision to offshore. This variable refers to the company's attitude to borrow money. Hence, firms that already have a significant debt burden are more likely to avoid the offshoring strategy (Srivastava et al., 2008.)

2.2.3 Outsourcing and Offshoring: issues

In this paragraph, it is presented a brief overview of the main issues of outsourcing and offshoring. Rilla and Squicciarini (2011) describe that it is possible to refer to two different categories of risks: risks related to the client, and those related to the vendor. For a client involved in offshoring activities, e.g. R&D, the main risks and challenges

refer to the difficulty in coordination different activities over a large physical distance. These risks are: the risk of losing know-how, that is tacit knowledge; the risk to choose a location, which may not be the best appropriate for the company's needs; the absence of appropriate Intellectual Property Rights may lead to the loss of competitive advantage. (Beulen et al., 2005; Dossani and Kenney, 2007; Lewin et al., 2009; Rilla and Squicciarini, 2011). As concerns giving control over an activity to an external supplier, there could be moral hazards problems, which means that the supplier or client misbehave in using the transferred knowledge. For the vendor, usually situated in a developing country, the risks, which precede the outsourcing decision, may be difficulty in changing own management in order to perform the client's activities; inability to manage cultural differences and to understand partner's' expectations and goals; the risk associated to an unrealistic future perspective (Rilla and Squicciarini, 2011.) Finally, it is important to mention also the common problems in running business across country boundaries: these are different languages, accents, ethnicity and time zones (Ellram et al., 2008). According to several researches, half organizations fails in reaching the expected financial benefits. One of the most common mistake is misunderstanding which process has to be outsourced/offshored. For this reason, Aron and Singh, (2005) introduce the risk evaluation through ranking the business processes according to how much value these create for the customers and for the organization.

After this general overview of the most common challenges companies outsourcing / offshoring have to face with, it is possible to have a clear idea about why, in the recent times, they have started to revise their strategies. Thus, this latter consideration is better explained in the following paragraph that is more focused on the topic of the research study: the reshape of GVC.

2.3 GVC in a changing world: future trends

According to the WTO (2013) report, the GVCs structure is rapidly evolving, due to the impact of two trends: 1) income and wage convergence and 2) technological innovations as computer integrated manufacturing and 3DP. As it turns out from the UNCTAD World Investment Report (2013), the repositioning trend may resulting from a realignment of locational factors. In particular, four trends are highlighted: a) rising wage costs in developing countries, weakness of the dollar, 3DP solutions, and decrease of energy costs in the economy, in particular due to the shale gas, which is improving the USA's competitiveness. Indeed, the evidences prove that the divestment is a significant phenomenon. France, Germany, Japan, UK and USA are among the countries, which have included divestment as part of their FDI dataset. For example, in the UK, the net equity outflows, which refers to the difference between gross equity outflows and equity divestments, were only $53 bln (see Appendix 1), therefore, a significant decrease in respect to the past. (UNCTAD, 2013)

In particular, the scientific press has focused on reshoring; however, the term is still agnostic and it is common to run the risk of overlapping terms that alternatively refer to location or governance decisions. Specifically, the location strategy regards the decision about *where* manufacturing has to be performed, independently of *who* is performing the activity itself (Gray et al., 2013). The latter refers to the governance structure choice adopted by the firm, which could be outsourcing or insourcing (in-house); in other words, it concerns whether the activity is performed by an external supplier or the firm on his behalf (Fratocchi et al., 2014). As it follows, a clarification about the main theoretical models and definitions is provided.

2.3.1 The reshape of the GVC: reshoring and governance changes

In the academic literature, several definitions are used in order to categorize changes in location and governance. In particular, several authors have identified the reshoring with terms that, sometimes, overlap location and the governance changes. Holz (2009) conceptualizes backshoring as "the geographic relocation of a functional, value creating operation from a location abroad back to the domestic country of the company" (2009:156). On the other side, Kinkel and Maloca (2009:155) argue that backshoring is the "re-concentration of parts of production from own foreign locations as well as from foreign suppliers to the domestic production site of the company". Recently, Kinkel (2012:696) specified that it consists of re-concentration of the firm's capacities "trying to exploit the benefits of higher capacity utilisation and a superior relation of variable costs to fix at their existing location". Whereas, backshoring or insourcing refer to the opposite direction of the aforementioned offshoring and outsourcing (Arlbjørn and Mikkelsen, 2014). Additional definitions used are de-internationalization and foreign/international divestment. More specifically, Reiljan, (2004) distinguishes the former that addresses issues related to operational activities; and the latter that takes in consideration also problems due to target market or product dimension. On the contrary, Frynas, J.G. et al. (2011) refer to these concepts as synonymous.

In addition, Calof and Beamish (1995) defined de-internationalization process as a natural behaviour due to the company's exposure in an international context. On the other hand, Benito and Welch (1997) define the phenomenon as "any voluntary or forced actions that reduce a company's engagement in or exposure to current cross border activities". However, an interesting contribution consists of separate "partial" and "full" de-internationalisation. The former occurs when only some of the subsidiary's value chains activities are internalised, the latter when the whole subsidiary is shut down. Hennart, et al. (2002) foreign divestment is generally perceived as a negative experience. In their findings, Boddewyn and Torneden (1973:26) conceptualized foreign divestment as "a reduction of ownership percentage in an active direct foreign investment on either a voluntary or involuntary basis". Therefore, the authors refer to the whole subsidiary (full de-internationalisation). As contrast, the latter definition was argued along the time. Indeed, different scholars argue that divestment may be driven by "reallocation or

concentration of productive resources at a national, regional, or global level" (Benito, 2005:1336). Therefore, this means that authors define international divestment as relocation of the production activity at the firm's home market, exactly as the case of back-reshoring (Fratocchi et al., 2013). This is proved in the study of Belderbos and Zou (2006), even if they always refer to the case of a company headquartered in a country A (e.g. Italy), which closes the manufacturing activities in a country B (e.g. Romania) and it moves to another country C (e.g., China). Therefore, what Fratocchi, et al. define "further off-shoring" (Fratocchi et al, 2013). Finally, Holz (2009) recognizes that the concept of de-internationalization and foreign/international divestment share some common features but they are not synonymous.

As concerns the governance Holz (2009) defines backsourcing as the phenomenon which occurs when the activity, previously performed by a foreign external supplier is relocated to an external supplier in the same firm's home country. The same concept is expressed with the term "external back-shoring" (Kinkel and Maloca, 2009) or "outsource back-shoring" (Kinkel, 2014). As opposite, the insourced alternative is "internal back-shoring" (Kinkel and Maloca, 2009) or "captive backshoring" (Kinkel, 2014).

On the other side, Gray et al. (2013) clarifies that the two reshape of GVCs as follows:

- *In-House reshoring* refers to the location change of activities from a host-country based wholly owned subsidiary back to a wholly owned subsidiary in the home country;
- *Reshoring for outsourcing* means that the company prefers to relocate the activities from an owned subsidiary placed abroad to a home-origin country external supplier;
- *Reshoring for insourcing*: the relocation consists of regaining in-house an activity previously executed from an offshore external supplier;
- *Outsourced reshoring*. Here the main change regards the external supplier: from a foreign to a home-country based external supplier (Gray et al., 2013)

Fratocchi, et al. (2014) argue that the back-reshoring is "a voluntary corporate strategy regarding the home country's partial or total relocation of (insourced or outsourced)

production to serve the local, regional or global demands". More specifically, the authors' aim is threefold:

1) first, to highlight the voluntariness of this strategy;
2) second, to include also the case of partial repatriation;
3) Third, to specify that it is a strategic decision, although refers to functional activities. (Fratocchi et al. 2014: 56.)

However, since the risk of overlapping terms related to governance and location is high, Fratocchi, L. et al. (2014) suggest a comprehensive reshoring framework along two steps in internationalization process (Table 5). It considers the concept of "international relocation", because the reshoring relies on decision to perform the manufacturing activities in a global context (Gray et al., 2013). Taking into account this model, the international relocation is an incremental strategy that changes over time and it consists of two main steps. 1) The first step consists of the internationalization decision, which is related to the choice of governance structure (in sourcing or out-sourcing) and geographical distance from the home country (near the home country or far away, that is near-shore or offshore). 2) At this point, the international relocation occurs and the company may choose among three alternatives:

a) To move production to a country geographically farther from the headquarter's country, *further offshoring*. E.g. when an Italian firm, moves from Poland to India.
b) To transfer production from a country to another geographically closer to the headquarter's country, defined as *near-shoring*. For example when an Italian company moves from China to Romania.
c) To move production back to the firm's headquarter country, that is *back-reshoring*. E.g. for when an Italian firm decides to bring the manufacturing back in Italy.

Table 5. A multi-step representation of the internationalization process (Adapted from Fratocchi, et al: 2014).

<table>
<tr><th>Step</th><th>Definition</th><th>In-sourcing</th><th>Out-sourcing</th></tr>
<tr><td rowspan="3">STEP 1: Initial International relocation of production</td><td>Near-shoring: a foreign country situated in the firm's region</td><td colspan="2">When a French company locates its (in or out-sourced) activity in Romania.</td></tr>
<tr><td rowspan="2">Off-shoring: a foreign country far away from the firm's home country</td><td colspan="2">An Italian company locates its (in or outsourced activity) in India.</td></tr>
<tr><td>a) Offshore-insourcing</td><td>b) Offshore-outsourcing</td></tr>
<tr><td rowspan="4">STEP 2 (Reshoring): relocation of earlier off-shored production.</td><td rowspan="2">Back-reshoring: when the production is moved back in the firm's home country</td><td colspan="2">A Canadian company initially off-shores its (in or outsourced) production to Poland and then it moves back to firm's home country.</td></tr>
<tr><td>c) Internal back-shoring;
d) Captive Back-shoring;
e) In-house re-shoring;
f) Re-shore for insourcing</td><td>g) Back-sourcing;
h) External back-shoring;
i) Outsourced re-shoring;
j) Re-shoring for outsourcing.</td></tr>
<tr><td>Near-reshoring</td><td colspan="2">A US company initially off-shores its (in or outsourced) activity to China and then relocates it in Mexico.</td></tr>
<tr><td>Further off-shoring</td><td colspan="2">A German company initially of-shores its (in or outsourced) production to Morocco and then relocates it in India.</td></tr>
</table>

In conclusion, in this thesis it is deemed necessary to combine the model of Fratocchi et al. (2014) regarding the explanation of the location change, and definitions of Gray et al. (2013) concerning the change in governance structure. Therefore, since both aspects (governance and location) are the focus of this thesis, a proper combination of the two framework is necessary. In particular, in this thesis:

- *Reshoring* regards any type of change of firm's location;
- *Further-offshoring* implies the firm's decision to go even further the current location;
- *Near-reshoring* means that the company decides to move activities closer to the headquarter's country;

- *Back reshoring*, regards the decision of bringing GVC activities in the headquarter's country;
- *Outsourcing,* regards the company's decision to give the governance of a GVC activity away from its own control, hence to an external supplier;
- *Insourcing or backsourcing* means that the firm prefers to regain the control of the activity, previously outsourced.

2.3.2 Reason behind the reshape of the GVCs

Among the reasons that made reshoring phenomenon increasingly important, there are: a) Labour costs, b) lead-time and c) geographical proximity to the Demand. More in depth evidences report a lower inflation of US wage (+3%) than Chinese (+20%). This is due to a market rivalry, because of higher competition for the same resources. Indeed, as regards costs of labour, the stability in labour costs are getting crucial in location decisions; as well as the ratio between labour outcome and productivity per labour dollar. Moreover, most of industries are concerned with long lead-time (interval between the order placement and the receipt of the shipment); since the transportation time exerts high impact on lead-time, through reshoring, companies may lower down it. Yet, firms want to reduce the lead-time in order to save costs of inventories and to be more reactive to the demand fluctuations. Hence, the closer proximity of the manufacturing to the end customer enables the company to be more flexible, therefore, to have a higher competitive advantage (Sarder and Nakka, 2014; Tate et al., 2014.) As particularly concerns with U.S. case, the lower energy costs (natural gas and diesel fuel) make United States a promising market. In contrast, China is much higher dependent on imports of energy. Furthermore, the higher usage of automation in manufacturing contributes to increase the shortages of skilled labour in China. Therefore, skilled labour is required as mean for the success. (Tate et al., 2014) Among factors that may determine any kind of reshoring decision, Margulescu and Margulescu (2014) describe:

- the narrowing gap between developed countries and "low cost" countries;
- problems due to distance between design and manufacturing; slower reaction to market Demand;

- Lower costs of implementation of new ICT (e.g. 3D-printing and industrial robots) and problems of supply chain management.

According to Kinkel and Maloca (2009) findings, in a sample of 13.426 companies, with a response rate of 12.4%, 72% face with lack in flexibility and delivery ability with offshoring. In addition, the increasing problems in foreign production facilities bring to a higher attention to protect stocks. Moreover, underestimated expenses for quality control and coordination costs mirror the recent trend to reshore activities. Also high coordination costs (16%), insufficient quality of infrastructure on site (15%) and lacking availability of qualified personnel (9%) rank among the motives behind reshoring: however, the relative importance of these reasons has decreased because the management's offshoring benefits evaluation is more realistic. To sum up, here the most common motivations leading to reshore GVC activities (Table 6).

Finally, the non-profit corporation founded in 2010 by Harry Moser facilitates the companies' trend inversion. Indeed, the Reshoring Initiatives organization is an institution in charge of collecting documentation of companies' experience after bringing manufacturing back to home from a host country in order to increase employment rate in U.S. The Harry Moser's goal is to convince OEM (Original Equipment Manufacturers) that it is their interest to revise the offshoring decision and, to exploit this opportunity; the organization's founder offers an innovative software named as Total Cost of Ownership Estimator. This software application quantifies all the costs the manufacturers has to sustain, which are freight, duty, travel, carrying costs of extra inventory quality, intellectual property, opportunity, impact on innovation and others. In particular, the calculator measures the gap between manufacture at home versus host country. Concerning this gap, Moser states that if there is 30% of difference between offshore and reshore costs, it is unlike that a reshoring initiative will close this gap. On the contrary, if the difference is almost 5% or 7%, so lean or automation implementation may fill in the gap. (Trebilcock, 2013; Reshoring Initiative, 2016)

Table 6. Motivations for reshoring (Fratocchi, et al.: 2013).

Reduction of costs' gap between host and home country	- labour costs	Ritter & Sternfels, 2004 Leibl et al., 2009 Powell, 2011 Sirkin *et al.*, 2011 Kinkel, 2012 Kinkel & Zanker, 2013 Dachs & Kinkel, 2013
	- freight costs	Goel & al., 2008 Leibl *et al.*, 2011 Dachs & Kinkel, 2013
Elements related to operational elements	- reduced operational flexibility	Kinkel *et al.*, 2007 Dachs & Kinkel, 2013 Kinkel & Zanker, 2013
	- purchase order rigidity post issuance	Ferreira & Prokopets, 2009
	- penalization for late orders	Ritter & Sternfels, 2004
	- container-size minimum orders	Ferreira & Prokopets, 2009
	- high inventory levels	Ferreira & Prokopets, 2009
	- reduced responsiveness to customer demand due to the physical separation of engineering	Accenture, 2011
	- production and delivery time impact on product life cycle (i.e. fashion industry)	Ritter & Sternfels, 2004
	- supply chain coordination costs increase	Leibl *et al.*, 2011 Kinkel & Maloca, 2012 Dachs & Kinkel, 2013
Quality	- poor product quality	Agrawal *et al.*, 2003 Kinkel & Maloca, 2009 Leibl *et al.*, 2011 Kinkel, 2012 Dachs & Kinkel, 2013 Kinkel & Zanker, 2013
Competences availability	- lack of well-prepared technicians and skilled workers at the host country	Couto *et al.*, 2008 Kinkel & Maloca, 2009 Shiry *et al.*, 2009 Leibl *et al.*, 2011 Sirkin *et al.*, 2011 Kinkel, 2012 Dachs & Kinkel, 2013
Host country elements	- national/regional subsides for relocation	Sirkin *et al.*, 2011
	- home (US) labour market flexibility	Amighini *et al.*, 2010 Sirkin *et al.*, 2011
	- high unemployment rates at the home country	Sirkin *et al.*, 2011
	- laws regarding taxes, employee benefits, torts and pollution abatement	Leonard, 2008 Shiry *et al.*, 2009
Financial elements	- exchange rate risk (US dollar against Chinese Yuan)	Leibl *et al.*, 2011
Knowledge elements	- loss of know-how in the host country	Dachs & Kinkel, 2013

According to Harry Moser, one of the main offshoring problems which lead to back-reshore is the recent trend which consists in focusing on *mass customization* and product differentiation that cannot be pursued through "a long offshored supply chain"(Trebilcock, 2013). Therefore, the recent business trends boost the company to reshape also its GVC. Furthermore, many advantages are offered by the recent achievements, able to revolutionize the way of doing business. This change is also known as Industry 4.0 or the third industrial revolution, which includes a set of technology improvements where 3DP plays a crucial role. Indeed, this may combine, on one side, higher responsiveness to consumers' demand for more customized products and, on the other side, the companies' need to save costs and get higher returns.

Minority of studies have provided reasons behind in-sourcing. According to Deloitte survey (2014) on 22 global companies in more than a dozen industries, 48% professionals of the surveyed companies terminated an outsourcing agreement and 34% brought an outsourced activity in-house. This is explained by the maturity of the outsourcing market and by an overestimation of the outsourcing capabilities, according to the interview of the CTO of a Texas-based MB Trading. In the same interview it is pointed out that in-house team are able to outperform in respect to the outsourcing suppliers, and with no differences in costs (Goulart, 2013). Moreover, according to O'Byrne (2015), eight main reasons push toward backsourcing:

1) Expected cost saving are not realised;
2) The quality level requirement are not met by the provider;
3) Customer satisfaction is not ensured;
4) Political and public issues
5) Changing overseas marketplace conditions;
6) Opportunistic behaviour and risk to breakdown outsourcing relationship;
7) Issues related to technology transfer;
8) Concerns regarding the provider security.

2.4 GVC reshape and the role of innovation

To finalise the literature overview, it is important to link the two phenomena objective of this discussion: GVC and 3DP. Thereby, in this final section is divided into:

- first, a general overview about how GVC and innovation are strictly linked;
- second, considerations about GVC in a "3DP perspective" are developed.

An important driver of GVCs is the investments in innovation. Most of the value creation in a GVC occurs in the upstream activities like concept development and R&D, as well as in certain activities in the downstream activities like marketing and branding. This is due to the involvement of tacit and non-codifiable knowledge, engaging management of know-how. In particular, the National Systems of Innovation (NSIs) promote innovation in order to upgrade the firm's position in the GVC and attract more FDI in manufacturing. As the OECD report (2014) shows, countries like USA and UK have increasingly invested in the so called knowledge-based capital rather than in tangible assets (see Appendix 2). However, also emerging markets are devoting higher shares in R&D: e.g. China (7.5% of GDP), Brazil (4% of GDP) and India (under 3%).

Innovation implication encompasses a set of profits due to the higher complexity in replicating the products by the competitors. This is proved by the success of Apple that has gained high profitability due to significant investments in design development. Furthermore, in this way companies are able to capture the highest share of value added in the GVC. For example, Apple captures between one-third and one-half of an iPod's retail price against the developing emerging markets, which gain a lower slice of the GVC pie (OECD, 2014; Dedrick, et al., 2010; Cheng et al., 2015.) Furthermore, the higher investments in KBC would imply new business models and organisational forms, and job creation. According to the OECD report, it is reported that "young firms (5 years old) accounted for most net job creation over the past decade, with older, typically losing jobs" (OECD: 38). Based on this introduction, to narrow down how innovation may bring strategic implications in a GVC is necessary. In particular, in this thesis, the focus is 3DP technology and to what extent it may reshape a GVC, by bundling "all stages of manufacturing into a single machine" (UNCTAD, 2013: 47).

2.4.1 GVC in a 3DP perspective

The coordination and management of GVCs play a crucial role for the MNEs companies (Oviatt and McDougall, 1994). However, the new information technology era is changing the traditional idea of doing business across countries (Globerman et al., 2001). E-commerce, big data, Internet of Things, AM are few of several interrelated concepts that are spawning the next industrial revolution, also called Industry 4.0 (Economist, 2012). In particular, according to Laplume et al. (2016) the information age may have disruptive consequences on the GVC geographic configuration, in terms of span and density.

The 3D printer manufacturers state that developing countries may exploit 3DP advantages to upgrade their position in the GVC, getting higher slice of the value added captured. As contrast, there is scepticism in the academic world, arguing that 3DP will lead to single-user company and so, to the replacement of the current industrial production processes (Gershenfeld, 2008; Moilanen and Vadén, 2013; Lipson and Kurman, 2013.) In addition, even though the technology is still objective of research and tests, it is recognized that 3DP is cheaper than labour-intensive "cut and mould" manufacturing processes (Berman, 2012; Nyman and Sarlin, 2013). Laplume et al. (2016) also theorize that three main factor may drive the spread of this technology: 1) type of materials, need for customization and quick delivery, and low costs. Moreover, the authors consider also what are the antecedents of the "global factory" (Buckley and Ghauri, 2004). In particular, the focus is on the determinants of a GVC's geographical configuration: 1) factor cost differentials, 2) scale economies, 3) factors that impede global specialization (Laplume et al., 2016).

Factors-cost differentials. Specifically, two factor-cost differentials are considered in order to assess whether offshoring is still the most suitable option. Indeed, until now the offshoring was linked to the labour arbitrage due to the considerable wage differentials among countries. However, it is argued that with 3DP labour inputs may play a marginal role, leaving more room to other inputs costs-differentials, like capital differentials. The following figure shows how the 3DP value chain would be organised.

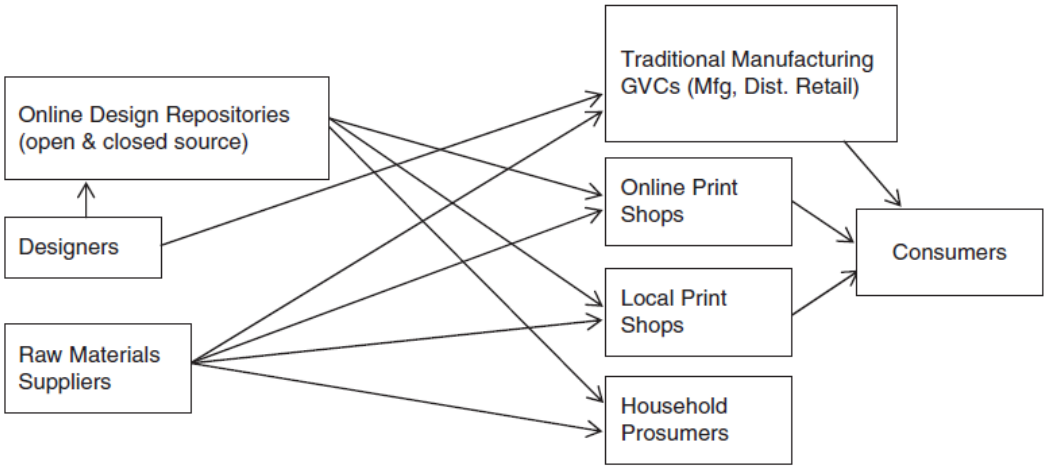


Figure 4. 3DP value chain (Laplume et al, 2016)

Thereby, it will be necessary to assess whether capital differential are equal or lower than wage differentials. Since, according to the comparison between interest rate differentials with wage differentials, two possible scenarios may occur:

1) $\Delta i = \Delta w$ across countries[2]. If there are no differences between interest rates and wages differentials, the capital-intensive 3DP would be still dispersed geographically and the global specialization would persist.
2) $\Delta i < \Delta w$ across countries. In this scenario the capital costs arbitrage will undermine the global specialization gains. (Laplume et al., 2016)

The following figure shows the labour and cost differentials according to the statistics over 5-year period time (2008-2012).

[2] *Δi* refers to the differential of the interest rates across countries, in order to assess the arbitrage opportunities in terms of cost of capital. *Δw* refers to the differential of wages across countries, in order to assess the arbitrage opportunities in terms of cost of labour.

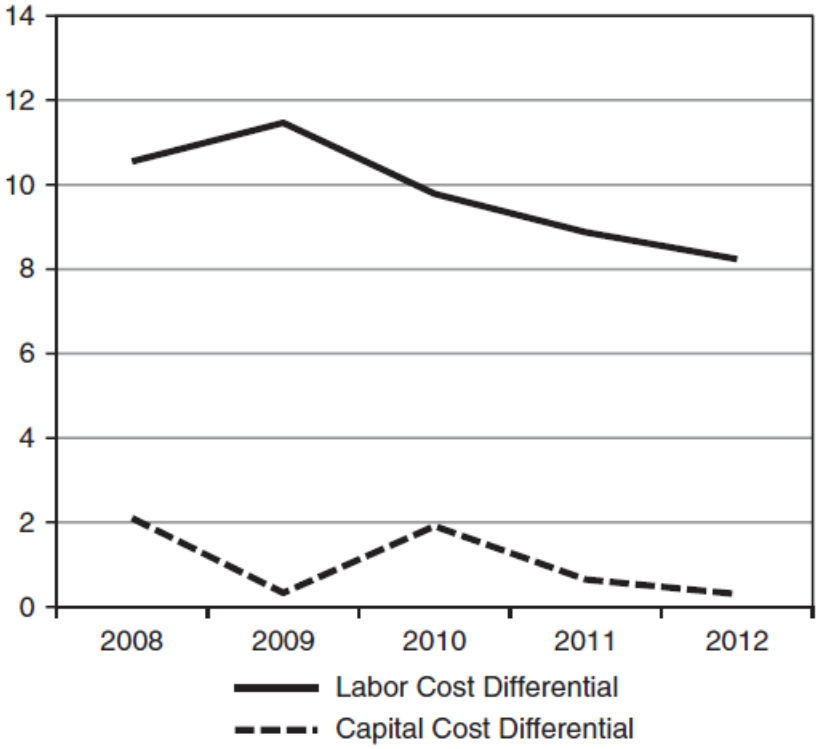


Figure 5. Labour Cost Differential versus Capital Cost Differential (Laplume et al., 2016)

As the Figure 5 shows, after the pick in 2009, the labour-cost and capital cost differentials distance between emerging and developed countries is diminishing. According to the expectations, the labour cost differentials between developed countries (USA, Germany, UK and Japan) and emerging economies (China, Mexico, Brazil and India) is still considerable. In 2012 the labour costs average of the first group was still 8 times higher than EEs. Despite these data, the worldwide capital costs differential are considerably lower than labour cost differentials. These evidences present a realistic perspective, by providing data that would favour a geographical dispersion of the GVCs. In other words, due to the fact that 3DP requires significant capital investments, and considering the low capital costs differentials, it is expected more a small-scale local production and rather than dispersed. (Laplume et al., 2016)

Scale Economies. As regard firm-specific features as scale economies, manufacturers may gain higher profits if they can exploit a large labour pool (von Weizsäcker, 1993). Due to problems of producing closer to the end users, entrepreneurs who wanted to exploit

scale economies advantages had to move the production abroad. In addition, sometimes a minimum efficient technical scales (METS) are required (Kim and Mauborgne, 2005). However, it is argued that with 3DP METS are significantly lower than traditional manufacturing processes (Laplume et al., 2016). 3D printers ensure the production of complex geometries and variety, which require techniques that traditional manufacturing processes cannot grant; moreover, the 3D printer cost justifies the cost of producing a single high-value item, despite the most technological machines, which require several units of the product to justify the initial investment. (Nyman and Sarlin, 2013; Laplume et al., 2016)

Globalization Challenges. Among the others, three main reasons may impede the globalization: 1) technology inseparability, 2) trade barriers and 3) import barriers. Nowadays, a significant share of trade is covered by *the intermediate goods* that is linked to a vertical disintegration of the MNE (Kleinert, 2003). Indeed, the configuration of the GVC depends on how many separable layers are needed in order to have the final product. Despite the traditional manufacturing processes, 3DP disruption refers to the opportunity to produce entire product in one stage, which imply a more compressed value chain, where products are printed all in one shot, e.g. Local Motors. In the recent context, the Governments have increased import and trade barriers as import substitution strategy, worsening those companies that trade across countries. As contrast, this new trend favours 3DP because the inputs are represented by low-tariffed raw materials rather than high-tariffed intermediate goods. In conclusion, governmental regulations and trade challenges push for a greater 3DP implementation, which secure higher and fast profits, by reshaping the GVC configuration. This latter is expected to be shorten, enabling firms to concentrate production near to customers, and therefore, increasing their responsiveness to the ever-changing demand. (Laplume et al., 2016)

2.5 Theoretical Framework and hypotheses development

In this section it is provided the theoretical framework of the 3DP adoption and GVC reshape and hypotheses are developed. First the framework is presented and discussed in two parts. The first covers the discussion of how 3DP impacts on the governance of the GVCs. The second gives insight into the effect of 3DP on reshoring phenomenon. The four hypotheses are also presented after the discussion of each issue.

In the framework the 3DP adoption and degree of investment of the firm influences the firm's decision to change the governance of the GVC, with particular reference to outsourcing and insourcing. The more firms decide to adopt 3DP, the more firms are willing to reshape GVCs governance (Manner-Bell and Lyon, 2014; Berman, 2012). Moreover, the degree of investment distinguishes two type of companies' behaviour: 1) those that implement 3DP for product development and therefore, that are less willing to reshape the governance of the entire GVC, 2) those that implement 3DP in a consistent way, because for process development purposes (McKinsey, 2014).

As concerns reshoring decision, the more 3DP technology is adopted, the more companies tend to relocate GVCs activities, closer to the customer demand and so they are more willing to revise their offshoring strategies (Gibson et al., 2010; Walter et al., 2004; Hadar and Bilberg, 2012).

2.5.1 Relationship between 3DP and the reshape of the governance of GVCs

First, it is important to highlight that 3DP could be considered as antecedent or push factor of two major trend in reshaping the governance of the GVC: outsourcing or insourcing. According to the academic literature, both trend are supported by 3DP adoption. Indeed, academic researchers agree that 3DP is a disruptive tool to decrease the supply chain complexity and, thus, decrease the number of actors that are involved (Cohen, Sargeant and Somers, 2014; Janssen et al., 2014; Nyman and Sarlin, 2014; Petrick and Simpson, 2013). The CEO of McKinsey Company (2014:4) states, "there is a real opportunity from process innovation side. It will require clients and companies to really develop the capabilities of scanning the world for new technology advances and understanding … how to access those technologies, either through developing capabilities internally, or more often, with partnering".

In the past decades, as the technology emerged and made the world interconnected, the companies' need to outsource and offshore became pressing. Indeed, the firm's reaction to the increasing internationalization trend implied partnership with suppliers across the globe, in particular for labour costs reasons (Garrett, 2004). However, "in the not-so-distant future, 3D printers could transform it to a globally connected, yet totally local supply chain" (Crump, 2016:1). It is broadly acknowledged that there is a huge leap between the traditional manufacturing process that is based on the mass production principle and the one-off process that regards more the concept of mass customization. Whereas, there are reliable forecasts according to which the technology advancement will allow the company to close this gap. When this were to happen, there would be significant changes in the supply chains. It is further pointed out that once the 3D printer costs become affordable it will lead to strategic implications for the logistic industry, reshaping the governance of the GVC, moving from giving activities in outsourcing to the insourcing trend (Manners-Bell and Lyon, 2014.) Finally, for those companies which concern with intellectual property issues, 3D-printing grants security and privacy snice it enables in-house production (Berman, 2012).

On the other hand, the trend of outsource internal activities is expected to increase as well. Indeed, another Silicon Valley is going to emerge, colloquially defined as "Print Valley".

This phenomenon is because "3D-printer provider supply the same kinds of service that traditional 2D paper-and-printed-matter copy centres have provided for decades, simply adding the third dimension to their offer". Thereby, this phenomenon decrease significantly the firms' need to have control over their own assets, thus preferring to outsource the demand of those services and "free capital locked up in property, plant and equipment (PP&E) assets", thus, enabling a high degree of specialization and industrial clusters. (Janssen et al., 2014: 11)

Furthermore, it is highlighted the strong linkage between the degree of investment in 3DP and the governance change. Indeed, there are significant differences between the mere 3DP adoption and the application for industrial processes. Indeed, despite the ever-increasing diffusion of "semi-professional" 3D printers, the industrial application has lower penetration. Therefore, according to Bax and Willems Consulting Venturing (2016:!), it is needed a higher degree of investments aimed at improving quality of fabricated objects, easier-to-use solutions and offer added-value applications. In fact, even though it is acknowledged that "3DP drives competitive advantage to business today – e.g. Airbus, Avinent, GE, … - however, it is commonly used to fabricate scale models, tooling and small parts, mock-ups and prototypes, personalized or customized products". This is confirmed by what McKinsey (2014:2) points out regarding what companies should do in respect to 3DP adoption: they should "really thinking about …, the right kind of technology innovation and investment, and the right kind of joint development of new technologies for manufacturing in order to truly take advantage of the opportunities at hand". Indeed, even though, currently, 3DP is more addressed toward a product development, it is suggested to use the technology for a strategic process innovation, in order to exploit significant advantages.

As regard how 3DP may affect the firm business model, Rayna and Striukova (2016) highlight four different, incremental, stages where it is possible to adopt 3DP: 1) rapid prototyping, 2) rapid tooling, 3) direct manufacturing and 4) home fabrication. At every stage it is associated an incremental degree of investment in 3DP. The findings prove that a limited impact on business model and firm organization is expected by the first two stages. Contrastingly, the last two stages that are resource-intensive, lead to a process

disruption and push companies to reorganize their structures. (Rayna and Striukova, 2016) In other words, a strategic implementation of the 3DP technology implies that managers should think about it is wise or not to wait for this "fast-evolving technology to mature" before a large amount of resources is invested (D'Aveni, 2015:1). Famous examples of companies implementing 3DP strategically are General Electric, Siemens and Airbus that are using 3DP technology for fuel nozzles or Airbus for aircraft parts or Skoda that used 3DP for marketing purposes (Chabaud, 2016; Mohr and Khan, 2015). In conclusion, a PwC (2015) report that rapid prototyping will be still important but it is not the game-changer. Companies should pivot to printing more products that are finished and, hence, to implement 3DP technology strategically, with massive investments in the downstream phases of GVC like production and distribution.

Thus, the following hypotheses are set:

Hypothesis 1: The adoption of 3DP is associated with changes in the firm's governance of their Global Value Chain
Hypothesis 2: The investment in 3DP is associated with changes in the firm's governance of their Global Value Chain.

2.5.2 Relationship between 3DP and reshoring phenomenon

As concerns the relationship between the 3DP adoption and reshoring phenomenon, majority of the literature agree with acknowledging the crucial role that 3DP plays in terms of relocation decisions (Crump, 2016; Janssen et al. 2014, Margulescu and Margulescu, 2014; Gibson et al., 2010; Walter et al., 2004; Hadar and Bilberg, 2012). Thanks to 3D printing capability to shrink the product life cycle, and therefore, to move manufacturing away from low-wage countries, it is ensured the proximity to the customer demand, that is, commonly, in high wage areas such as Europe and United States. In this way, companies are able to increase their responsiveness, quality control, and, on the other hand, to reduce time-to-market and the supply chain complexity. What was once made through complex assembling activities can be easily realised by 3D printers and therefore, it can eliminate the need for high volume production. (Crump, 2016; Janssen et al. 2014)

Furthermore, according to Robinson (2014:1), if the 3DP adoption implies an "overhaul of global supply chain, the lower cost could make offshoring labour unnecessary" and "offshored manufacturing in a lower cost market could be replaced by manufacturing facilities located on domestic soil, therefore increasing the reshoring of a lot of lost manufacturing facilities". To sum up, the decrease in the cost of implementation of new manufacturing technologies that will cut down the use of labour will gradually diminish the importance of a major reason for manufacturing offshoring. (Margulescu and Margulescu, 2014)

Authors generally agree that 3DP will disrupt logistics and inventory sector (WTO, 2013; Janssen et al., 2014; Kianian, Larsson and Tavassoli, 2013; Manners-Bell and Lyon, 2012; World Economic Forum, 2013). "Through the enablement of reshoring and local-for-local manufacturing hubs, 3D printing could initiate a reduction in demand for global transportation, supported by a substitution of physical flow by digital file transfers" (Mohr and Khan, 2015: 155). With the possibility to reshore and local source activities, the technology can turn the GVC on its head (Lipson and Kurman, 2013; Mohr and Khan, 2014; Nyman and Sarlin, 2014)

Moreover, the same considerations already discussed in the previous section about the degree of investments in 3DP are valid even in this case. In particular, according to the study conducted by Abeliansky, et al. (2015:25) it is stated “the wider the adoption of 3D printing in industrial processes around the world could eventually lead to “glo-calization” (shipping parts and components internationally becoming less important), a force that probably counteract the ongoing globalization”. Thus, the hypotheses are formulated below:

Hypothesis 3: The adoption of 3DP is associated with the company reshoring its GVC activities.

Hypothesis 4: The investment in 3DP is associated with the company reshoring its GVC activities.

3. METHOD

This chapter presents the research methodology of the thesis. In particular, the methodology choice was influenced by the research project this thesis is part of, since there was the possibility to join a research team to gather data. This introduction is followed by the Research approach definition and design, followed by data collection method and sample description. The chapter ends with the reliability and validity of the study.

3.1 Research Philosophy and Research Approach

The research approach in this thesis is deductive and relies on the philosophy of positivism. Indeed, the research is a quantitative research and, therefore, the positivism philosophy enables the researcher to consider the data as the "truth". According to Saunders et al. (2009) the philosophy of positivism relies on observing and predicting outcomes, concerning with "law-like generalisations similar to those produced by the physical and natural scientists" (Remenyi et al., 1998:32). These principles fit with the thesis structure since there are no other means to understand if the respondents provided answers to the survey properly. Therefore, it is argued that there is no a complete freedom from the inclusion of the researcher's own values (Burrell & Morgan, 1992).

As regard the research approach, the first research question pursues exploratory goals regarding the current state of 3DP adoption and reshape of GVCs and, therefore, it produces descriptive analyses. Whereas, the second research question involves a deductive approach since it aims at investigating whether an impact between the two variables exists (Saunders et al., 2009). Thus, a set of hypotheses is laid down and tested through the empirical study, in particular, thanks to regression analysis. The research approach choice is due to the matter of fact that this study is part of a larger project. Indeed, according to Gill and Johnson (2002) this kind of research should use a structured methodology in order to enable other researchers to replicate the data and findings and to increase the reliability of the study.

3.2 Research Design

To think about the research design is crucial for a researcher, since it means to turn the research questions into research objectives and it provides the framework for data collection and analysis (Robson, 2002; Bryman and Bell, 2007:40). When the researcher has to think about the research questions, it is inevitably necessary to consider the purpose of the research. According to the research process, the purpose is descripto-exploratory. Indeed, on one side, the exploratory study enables the researcher to understand "what is happening; to seek new insights; to ask questions and to assess phenomena in a new light" (Robson, 2002:59). On the other side, the descriptive research may be an extension of the exploratory studies and it provides a portray of the current state of the phenomenon analysed (Robson, 2002; Saunders et al., 2009).

A deductive approach is used in order to develop hypotheses, based on existing theory (Ghauri & Grøhaug, 2005:109). The goal is to figure out whether a relationship between independent and dependent variables exists, by taking in considerations factors that are acknowledged as crucial in the literature review. In other words, the hypotheses are formulated according to former researches. However, due to unexpected findings, the research exploits additional *post-hoc* analyses to help to shed light on unexpected findings. This approach enables the researcher to contribute in developing theory based on the data collection, where the hypothesis previously formulated are not supported at all (Wilson, 2013). Moreover, the research type is quantitative since it fits with the deductive approach. Indeed, the approach concerns with developing hypothesis based on existing theory in order to test it, to solve the research problem of this thesis and reach the set of objective that are laid down (Ghauri & Grøhaug, 2005:109). In other words, after studying the theory and deducing the hypotheses regarding relationship between the independent and dependent variables, the empirical research is carried out in order to understand whether the hypotheses are supported.

The research strategy is the survey. Indeed, it allows the collection of a large amount of data "from a sizeable population in a highly economical way" (Saunders et al., 2009:144). In addition, it fits best to the situation where information is needed from hundreds of companies: the survey ensures efficiency in terms of costs and time (Miller,

1983:81). Moreover, due to the novelty of the phenomena analysed, the sample size needs to be large enough to ensure the generability of the results. The rationale behind this choice regards the double goals the survey enables to reach: first, allows to collect data and analyse these using descriptive statistics; second, this strategy may lead to suggest possible reasons for particular relationships between variables and therefore, to produce models and theories (Saunders et al., 2009.) Thus, the first goal is what it has been done until now, by describing the current state of the companies' behaviour in respect to 3DP and GVC reshape. The second goal consists of trying to elaborate theoretical models through the dependency analysis between the variables. The questionnaire was jointly developed by University of Vaasa and University of Pavia, from scratch developed by a research team of four students and two supervisors. The questionnaire consisted of 25 questions divided into 4 main sections: 1) Company Profile, General Information, 3) Global Value Chain Section and 4) 3D Printing section where the focus is to map to what extent the firm is involved in 3DP projects. The survey, in English, was piloted to a group of 10 companies and six professors of University of Pavia and Vaasa. According to the feedbacks gathered, the survey was edited and refined in order to translate it in Italian language. Hence, the final version of the survey was available both in English and in Italian.

The question types can be generally categorized as closed questions, both with single or multiple answers, with given list of options (Saunders et al., 2009). The exception regards the "General Information" section and country where the firms operate today, where they have been asked to type the answer. Moreover, the possibility to type additional reasons behind their actions was left open, through the label "Other, specify". In order to keep a high response rate, it was decided to force only two questions: 1) the first regards the questions about the current situation about the firm's GVC and if any change occurred over the last three years; 2) the second concerns the firm's involvement in 3DP projects. In this way, on one side the respondent was forced to be focused on the questions that were crucial for the research's purposes; on the other side, it was ensured the higher probability to get completed and not partial surveys. The drawbacks of this choice relate to the loss of data that could be avoided by forcing additional questions. On the other hand, it was not an issue the situation where a respondent even though could not find the

best option among those listed, could provide an answer anyway. Indeed, as aforementioned, this issue was solved by giving the respondents the possibility to specify in a text entry box the option that fits better with their opinion.

The research choice step refers to the way in which the researcher decides to combine both quantitative and qualitative techniques and procedures, distinguishing mono-method versus multiple method (Saunders et al., 2009). In the study it is combined single quantitative data techniques (questionnaires) with quantitative data analysis procedures, therefore, a mono-method is selected. Moreover, due to the time constraints, data are cross-sectional. Furthermore, the cross-sectional study leads to the adoption of the survey strategy (Easterby-Smith et al., 2008; Robson, 2002).

3.3 Research Techniques: type of Questionnaire

According to Saunders et al. (2009), there are different types of self-administered questionnaires: internet-mediated, intranet-mediated, postal, mail and delivery and collection questionnaires. The questionnaire used for this project has been realised through an online platform, the Qualtrics software, and sent via e-mail to a wide number of companies. The choice of the questionnaire is influenced by different factors:

- "characteristics of the respondents from whom you wish to collect data;
- importance of reaching a particular person as respondent;
- importance of respondents' answers not being contaminated or distorted
- size of sample you require for your analysis, taking into account the likely response rate;
- types of question you need to ask to collect your data;
- Number of questions you need to ask to collect your data" (Saunders, et al. 2009).

The addressees are figures of responsibility inside companies such as managers, as they take strategic decisions and have the necessary knowledge to fill in the questionnaire. In this sense, the accuracy of data collected turns out to be higher. Therefore, it is important to reach the right person inside a company, but is not so important which company will complete the questionnaire. These requirements about the respondent make internet-mediated questionnaire the best choice, because it offers a greater control on who will respond. Indeed internet-mediated questionnaires, especially those sent via e-mails, increase the probability that the respondent will be the one to which the e-mail is addressed, because most users read and respond to their own mail at their personal computer (Andrews, et al., 2003). The size of the population is huge, counting roughly 478.000 companies; despite the width of the target companies, the rate of response is medium-low. Indeed, in roughly two and half months, out of 500.000 email sent, 969 firm received the email and started the survey, but only 201 answers were recorded, giving the survey a response rate of 20,74%.

This consideration prove that the internet-mediated questionnaire is the best choice because other options would be too expensive and require too much time. Moreover, this

type of questionnaire has a higher response rate respect to other self-administered questionnaires. However, in order to ease the understanding and the probability to have it completed, it was crucial to ensure that the number of questions addressed was low and formulated in a suitable way. Other advantages of the chosen questionnaire type are:

- Time reduction in order to reach a certain number of people. This is important especially because the targeted respondent are geographically dispersed. Expected respondents, in fact, come from all over the world;
- It is not expensive, because there is not the cost of printing and replicating the questionnaire. It is done once and then the link to the questionnaire is sent via e-mail to expected respondents;
- It facilitates data entry and analysis because data that will have to be analysed are still on a computer. (Saunders et al., 2009)

One of the most important step when designing a questionnaire is to create valid and reliable questions. In particular, "the question must be understood by the respondent in the way intended by the researcher and the answer given by the respondent must be understood by the researcher in the way intended by the respondent" (Foddy,1994). For this reason, questions have been revised many time to be sure that the respondent is able to interpret the question in the intended way.

The survey starts with an introductory page, with a general overview and the instructions to complete the questionnaire. This page contains five main information, as shown in the following figure: a) aims, b) why to join our survey, c) confidentiality and privacy, d) effort required and e) expected respondent (Appendix 5). It was decided to include this page, in order to increase the response rate (Dillman, 2007).

3.3.1 Survey questions

The first section deals with the company profile. This is very important because enables to understand who the respondent is, the headquarter, the sector, and the current situation of the company. The question about the company sector is a list where different industries

can be selected. In particular, the sectors chosen are elaborated starting from considering the Orbis NACE classification. Indeed, in order to make homogenous the sample, regardless the source of the contacts, the variable "NACE Rev 2 Code" from Orbis e-database was selected. However, it is given the possibility to select "Other" and specify a different sector. The last two questions regard the degree of internationalization of the company, which is investigated through the Foreign Sale Intensity, and the R&D expenditure, in order to have a clear idea of the level of involvement of the company in foreign activity and in innovative projects.

The second section deals with the general information. It contains questions about company's governance and location of activities. A value chain model has been used. First of all, companies are asked to present their current situation about governance and location. The main aim of this section is to build a path to let the respondent answer only to those questions they are interested in. They have to specify, for each of the listed phase, if they perform the activity in-house (or by a controlled company) or by outsourcing to a third party (Appendix 6). They also have to provide information about the most relevant locations in which each activity is performed today.
In the third section, companies are asked to provide information about changes in governance and location. In particular, for both of them, they have to specify if they have experienced any change in the last five year or if they are planning to do it within five years. The companies that have experienced changes or that are planning to make changes have to answer this section. Those that have already experienced a change in the last five years have to specify the year and the impact of these changes in terms of quality, costs and time-to-market. (Appendix 7). The same is done for those that have planned to change governance or location.

The fourth section deals with 3D Printing/Industry 4.0. The goal of this section is "To assess the degree of companies' involvement in 3D printing technologies over time. The respondent is asked to provide information concerning the technology implementation along the Value Chain" (Appendix 8). At first, all companies are asked if they have implemented 3D printing solution in the last five years or they have planned to do it within five years. For each activity, it is asked how much companies have already invested in

3D printing technologies. Then, companies are asked to state how they consider their awareness degree about the potentialities of 3D printing solutions, evaluating it from 0 (nothing) to 4 (high). They also have to provide an estimate of the impact, or of the expected impact, of the implementation on quality, costs and time-to-market. The last question is about the reason that have led to the decision to implement, in the past or in the future, 3D printing technologies.

3.4 Data selection process

Since this thesis is part of a large project in collaboration with a research team, in this section the entire process of data selection is described. First, some light is shed on the protocol used in contacting the sample firms and then the sample is explained in more details. The data for this project was collected through an Internet-based survey. It was based on three main contacts databases:

1) The first includes 500 companies that fit perfectly with the research purpose. Indeed, this group of contacts are involved either in 3DP projects or in change in GVC, or in both;
2) The second includes companies gathered through the intermediation of companies like SellTek, Engineering and the 3DAM Lab, protected by an Non-Disclosure Agreement contract.
3) The third database was created by exporting the contacts included in the e-database Orbis; in particular, the purpose was to increase the likelihood to have a large sample. Of course, there were defined some *ex-ante* criteria for the selection process of the target firms.

The data was collected from the middle of April 2016 till the mid July 2016. Each researcher followed the same path in managing the data collection. Furthermore, those particularly interesting for the research purposes were informed directly by phone of the potential benefits resulting from the participation to the survey. Therefore, after received their availability to fill in the survey, the email with the link to the survey was sent.

As regard the database of 500 companies and from Orbis database, due to the huge amount of data, it was not possible to contact by phone each company; on contrast, it was adopted the opposite approach: first, it was sent the survey and, then, firms that were not part of the population were screened out from the sample. The software applications used to deliver the survey enabled the researchers to track the activity of the respondents. Entirely automatic, the software highlighted firms that had not opened or had interrupted the answering and it planned an email reminder. No one selection was pursued about the email recipient, since the survey treats all the activities of the GVC and, therefore, the team has left the opportunity to split the survey according to the role position covered in the company.

The population consists of global companies, which operate at least across two countries. As aforementioned, few criteria were selected in order to understand the target companies, showed as follows.

1) *Criteria 1:* industry sectors. Starting from considering the NACE Rev 2 Code of Orbis, the industry sectors selected have common features: they are the most common sectors involved in 3DP solutions or Reshoring Initiatives. Indeed, 11 industry sectors were excluded because do not fit with the research purposes. Examples are: "Crop and animal production, hunting and related service activities", "Fishing and Acquaculture", etc.
2) *Criteria 2*: country. Even though the research purpose was to spread the survey worldwide, the research was refined by targeting two main continents: Europe and America. In particular, these two were divided into geographical area resulting into 6 main areas: 1) North America, 2) South America, 3) North Europe, 4) East Europe, 5) West Europe and 6) South Europe. However, due to the possibility for the respondent to forward the survey to the person who could fill in it properly, answers from Asia, Oceania and Africa were recorded as well.
3) *Criteria 3*: type of entities. According to the scientific literature, two main type of entities are active in the field that is analysed. These are industrial companies and Foundation / Research institutes.
4) *Criteria 4*: Status. Only active companies were chosen;

5) *Criteria 5*: Last Available Year. The two last years were the object of the research by choosing 2014 and 2015.
6) *Criteria 6*: number of employees. Since the phenomena analysed do not engage micro-companies, a minimum threshold was fixed. Therefore, the company has to have at least 10 employees.
7) *Criteria 7*: Directors / Managers Contacts (DMC). In order to find the addresses of the email, the team has decided consider a) Senior Management, b) Administration department, c) Sales and Retail Management, d) R&D/Engineering, Product/Project/Marketing Management, e) Operations and Production, f) Quality Assurance, g) Purchasing and Procurement, h) IT and Information Systems.

From the initial population of 478.000 firms, roughly 10.000 could not receive the email because the email bounced and, therefore, the email address wrong. Additional 467.000 were not interested at all in participating to the survey because they have never opened the link to the survey. At the end, roughly 1000 answers were recorded, with a low response rate (0.1938%). Indeed, 969 survey were started; however, 87 were started and not finished and 882 were completed. To these 882, additional 86 from the Italian version were registered. Overall 969 survey finished were downloaded. At this point, 762 companies were screened out because they did not provide a survey properly completed. Additional 10 firms were combined into 5 because they represented duplication of data. For this operation, there were considered the survey better filled in, which means that the survey with the highest number of responses was kept. However, the doubles of the same company were overlapped in order to combine the answers and try to increase the completion rate of the survey. At the end, 201 responses were recorded and considered as useable sample for the research analysis.

3.5 Sample Description

Overall, as aforementioned, the data sample collected counts 201 responses. Even though the research team has set only America and Europe as geographic criteria, additional continents were recorded. In particular, the following chart shows the geographic dispersion of the respondents according to the single country (see Appendix 4), divided by macro-area (see Figure 6). For research purposes, this sample turned out to be very interesting, as it allowed analysing in a heterogeneous way a significant number of companies. In details, participants come from Australia, Bosnia and Herzegovina, Brazil, Bulgaria, Colombia, Czech Republic, Finland, Germany, Greece, Hungary, Italy, Lithuania, Luxembourg, Macedonia, Romania, Russia, Serbia, Slovakia, Slovenia, South Africa, Sweden, Turkey, UK and USA (see Table 7). However, by considering countries divided per macro-area, it is evident that the highest percentages of responses come from Southern Europe with 29.63%, North Europe and East Europe with 21.76% of the entire sample. Overall, Europe is the major represented continent counts 157 answers, covering three-quarters of the sample. Following, America is the continent major represented with an overall percentage equal to 13.42%, counting 29 responses in absolute values.

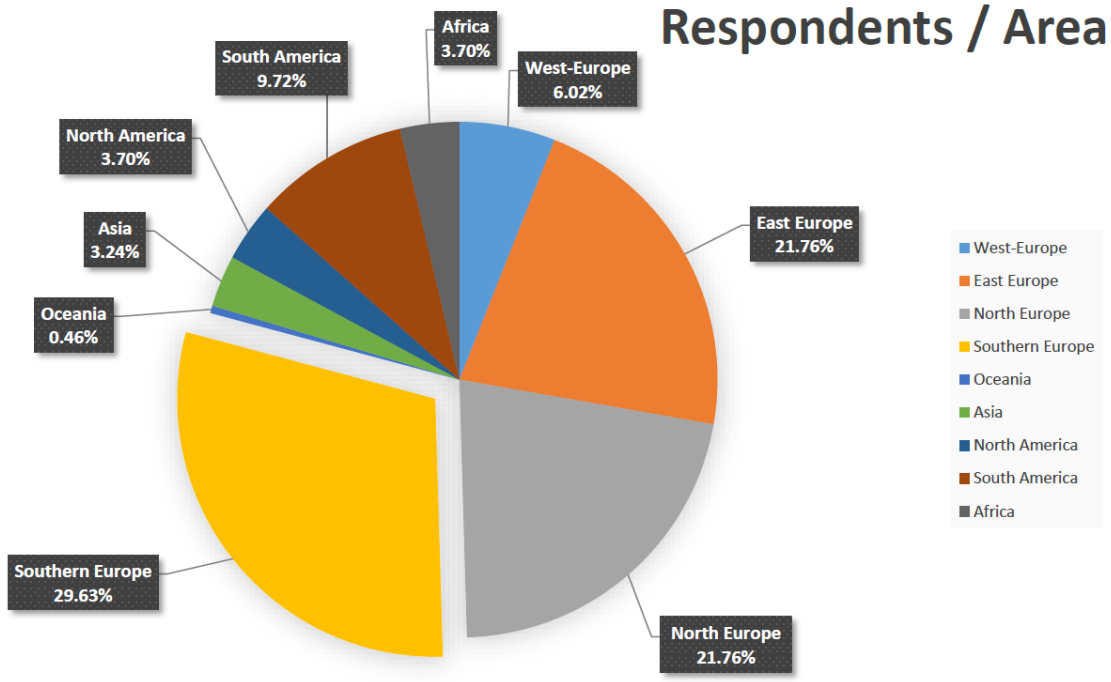


Figure 6. Respondent's geographic dispersion per macro-area

As shown in the table below, the highest number of responses recorded is represented by Italy, due to the highest number of qualified contacts the team could exploit thanks to the intermediation of SellTek, 3DAM and Engineering.

Table 7. Absolute values of the responses divided by macro-area

Europe								Oceania		Asia	
West-Europe		East-Europe		North Europe		Southern Europe					
Belgium	1	Belarus	1	Denmark	1	Bosnia and Herzegovina	1	Australia	1	Singapore	1
Luxembourg	1	Slovakia	3	Iceland	1	Malta	1			Turkey	6
Austria	2	Bulgaria	4	Sweden	1	Spain	1				
France	2	Russia	5	Latvia	2	Serbia	2				
Germany	7	Czech Republic	6	Finland	6	Slovenia	2				
		Hungary	6	UK	10	Macedonia	7				
		Romania	22	Lithuania	12	Greece	13				
						Italy	37				
	13		47		33		64		1		7

However, surprisingly high number are registered also for Romania (22), Greece (13) and Lithuania (12). Thus, further considerations have to be discussed for the East-Europe countries. Overall, it is noticeable that:

1) *The phenomena analysed are widely spreading in Europe (>80% of the sample*)
2) *The increasing industrialization trend in South America may explain the relatively high percentage of Latin American companies involvement in the phenomena analysed.*
3) *Low wages, duty and freight costs, transportation and delivery-time issues may explain why East-Europe companies are significantly involved in the phenomena analysed.*

In order to have an insight of the surveyed firms' size, it was considered the variable "Number of Employees_2015". In particular, the respondent was asked to provide the number of employees for 3 years (2013, 2014 and 2015) in order to have a clear indicator of the firm's growth. However, according to the UE standard, it was given a class in order to define the Small-Medium Enterprises (SMEs)

Table 8. SME categories (EU website)

Legenda	# employees	Frequency	# companies	# companies (%)
Small	10	27	27	18%
Medium	50	102	75	51%
Medium-big	250	129	27	18%
Big	79000	148	19	13%
Overall			**148**	**100%**

As Table 8 shows, out of 201 valid responses, roughly 74% of firms provided indicators regarding their firm's size. In particular, the following histogram shows the distribution of the surveyed firms according to the EU categories (see Figure 7).

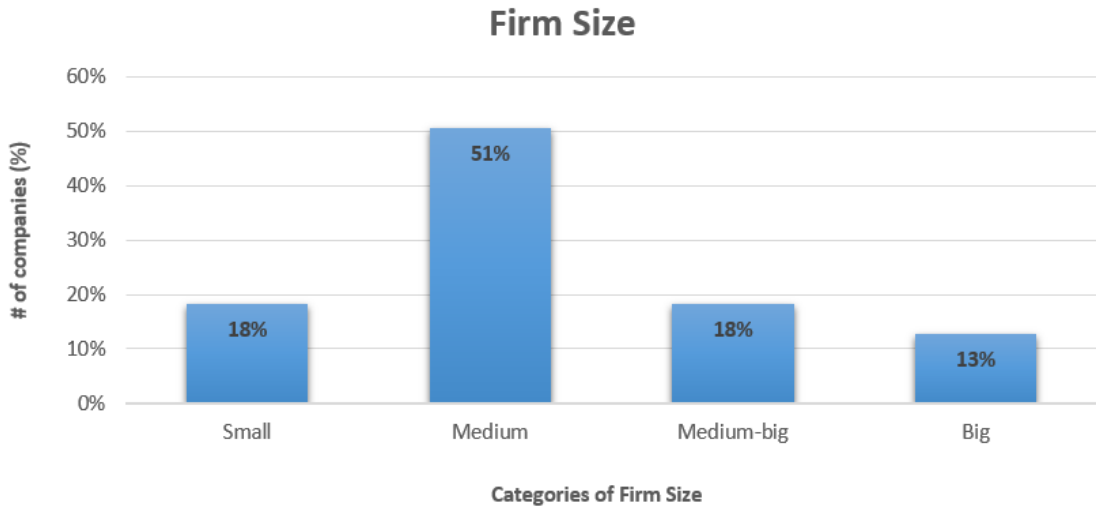


Figure 7. Firms' size according to the EU SME categories

As it is clear in the figure, the sample is split in half: medium-sized companies on one side (51%) and, on the other side, companies that have or less than 10 employees or significantly big, with an overall percentages of 49%. In conclusion:

Medium-big companies represent the 70% of the sample because, currently, only highly capitalized firms are able to both do structural adjustment in the GVC and implement 3DP technology. On the other side, the relatively high percentage of small companies (20%) may highlight a trend where changes in location and technological improvements represent an innovative way to gain competitive advantage.

Three additional indicators are presented in order to describe the research sample: a) industry sector, b) degree of R&D expenditure and c) Foreign Sales Intensity. As highlighted in the Figure 8, the highest percentage of the sample is represented by ICT and R&D companies (15.61%). This data was expected due to the phenomena analysed, in particular related to 3D printing technologies which naturally imply an higher degree of involvement of the firm whose core is the innovation technology. In addition, Wholesale & Retail with 9.70% represents a big percentage, even though it is quiet unusual. Yet, low percentage were recorder for the Automotive (3.38%), Aerospace (1.69%) and Healthcare (6.33%), contrastingly to the expectations according to literature

analysed: however, it is important to mention that the number is low maybe due to the evidence that the companies involved in 3DP projects are giant of the market and therefore, limited in number. This could due to privacy matters and the unwillingness to share sensible data even though they are published in aggregated form. Furthermore, it is noticeable the evidence that the category "Other" covers a high percentage (10.97%). As follows, the main industry sectors that were not included in the predefined list of the closed question: engineering and Architecture, woodworking, value add distributer, accessibility services, bunkering, mining and metallurgy, advisory, ship building, energy services, tourism, capital goods, outdoor product distribution and rescue equipment.

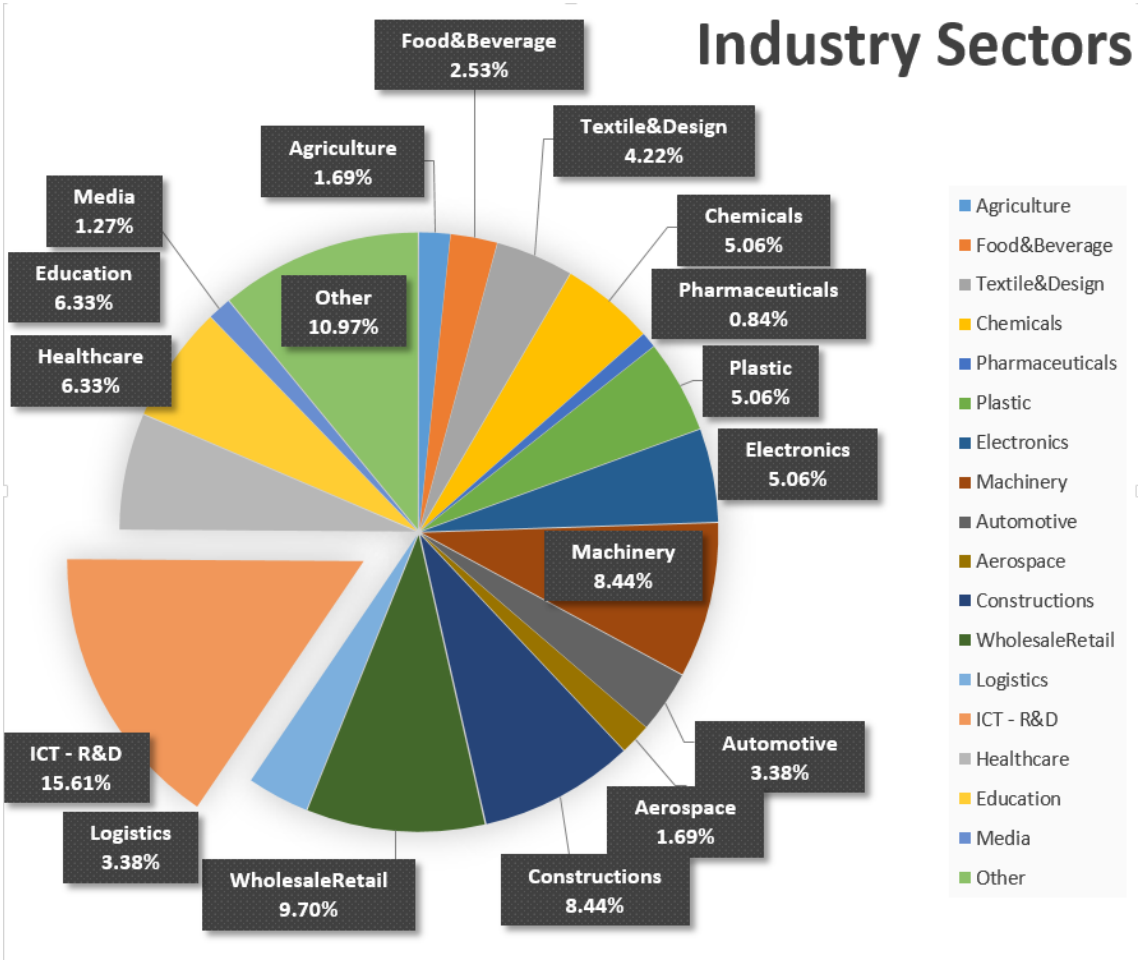


Figure 8. Pie chart of the industry sector of the sample

Overall:

Surprisingly, industry sectors where it is acknowledged high technological improvements are required (e.g. automotive, aerospace and healthcare) are less represented in the sample. Whereas, the percentage of companies performing in wholesale and retail sector is significant. This finding may be related to the core business of retail companies that are focused on consumer's customization need that 3DP technology may ensure.

As aforementioned, it is necessary to shed some light on the degree of R&D investments of the sample. In particular, four main ranges are defined (see Table 9).

Table 9. R&D expenditure ranges and number of companies per each category

Cod	Answer	#companies	# companies %
1	< 5%	100	50.76%
2	5 - 10%	44	22.34%
5	>20%	28	14.21%
3	10-15%	18	9.14%
4	15-20%	7	3.55%
		197	**100.00%**

Out of 201, the 197 companies have provided their R&D expenditure. In particular, percentages of the company per each range is better showed in the following histogram (see Figure 9).

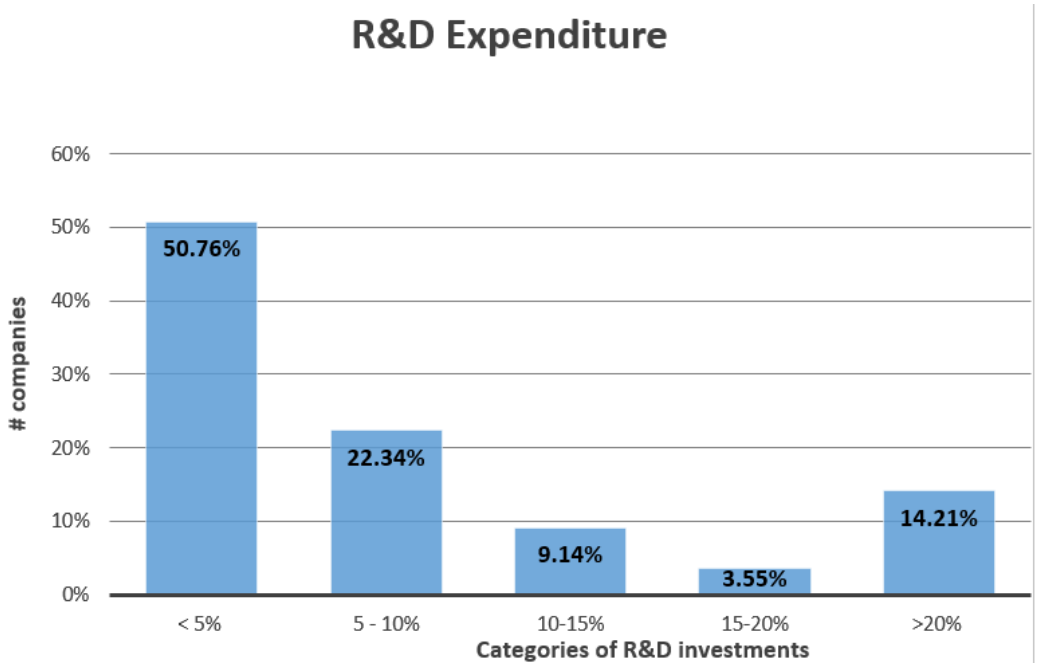


Figure 9. Percentages of companies per each range of R&D expenditure

As shown, more or less half of the sample reported that they do not invest in Research and Development, or at least it is not their primary need. Even if we consider together companies that invested less than 10%, the resulting sample covers the 73.1% of the sample. *Therefore, the sample is divided into two main groups showing that companies tend either to do not invest or invest in significant proportions in R&D.*

Finally, a general overview of the Foreign Sales Intensity is necessary. Foreign sales intensity can be defined as the ratio of foreign sales over total sales. In particular, the ranges are defined as follows.

Table 10. Ranges of the Foreign Sales Intensity

Cod	Answer	# companies	# companies (%)
1	0-20%	115	57.21%
3	21-40%	20	9.95%
4	41-60%	14	6.97%
5	61-80%	11	5.47%
6	81-100%	41	20.40%
		201	**100.00%**

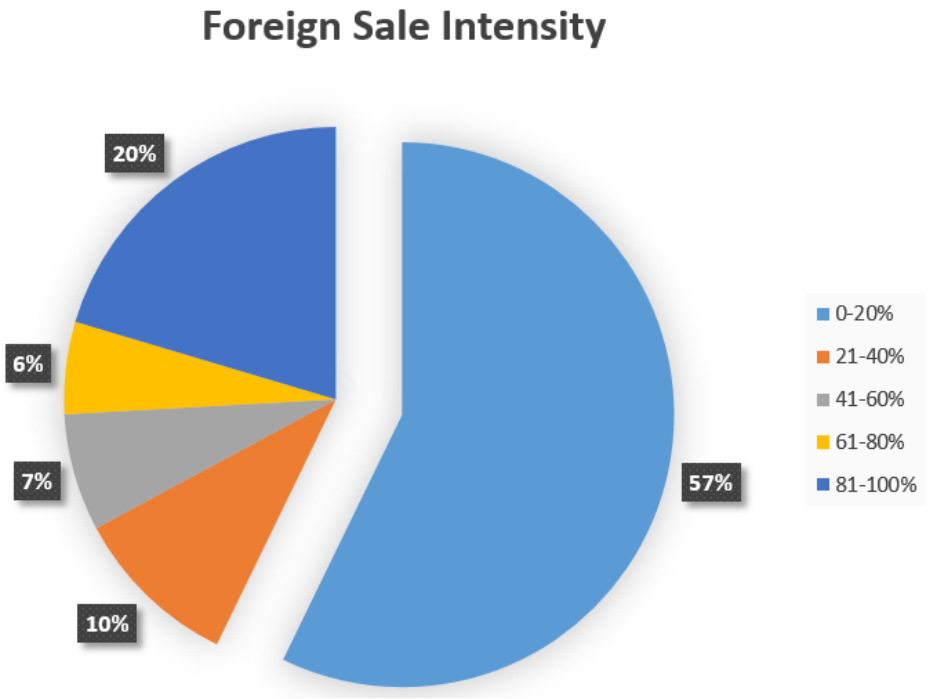


Figure 10. Percentage distribution of the companies according to the Foreign Sales Intensity

In particular, the graph above shows the foreign sales intensity of the sample. Interestingly, it is pretty well-balanced between foreign and domestic companies since almost the half (57%) are domestic or anyway firms with a low percentage of foreign sales intensity (less than 20%). While the rest of the sample consisted of companies that significantly invest in the international markets, overall counting for 43% of the sample.

3.6 Reliability and validity

The credibility of research findings depends upon two main conditions: reliability and validity. The former occurs whether it is possible to gain "the same answer by using the same instrument to measure something more than once (Bernard, 2011: 54). The latter relies on whether the findings are really about what it is supposed to be about (Saunders et al., 2009).

According to Easterby-Smith et al. (2008), to secure the reliability, three main conditions should occur:

1) The measures should lead to the same results in other occasions,
2) Similar observations should be achieved by other observers
3) The process followed from the raw data to the final findings should be transparent.

In other words, it assesses the stability of the measurements (Sekaran 1992:173). Moreover, the reliability issues relies on the subjectivity: the more the researcher adopts a subjective approach the more the reliability is compromised (Wilson, 2013). Since the questions included in the survey belongs to a project, jointly developed by several researchers who study the same phenomenon, the reliability is increased. Furthermore, the questionnaire was intended to exclude subjectivity by avoiding questions asking the respondent's opinion through, for example, Likert scale.

In running the research project, two main errors may occur: a) random error and b) systematic error. The former relies on the error is unpredictable and it may be due to the large number of parameters beyond the researcher's control and that interfere with the research findings; the latter has an observable pattern. Random error may be decreased through the increase of the sample; vice versa, it is not possible for the systematic error. (Boslaugh, 2012) Specifically, in case of a survey, the additional risk refers to the situation in which a respondent may not understand the questions as the researcher has thought (Ghauri and Grøhaug, 2005). Therefore, particular attention was given about the questions formulation, by avoiding technical terms or, if it was necessary, by providing a definition and an example of what the respondent is asked to answer. In addition, in order to increase the reliability of the survey, it was given the possibility to split the survey in

different sections that had to be filled in according to the respondent's position and knowledge within the firm. Moreover, since the study engages the activities of a GVC, the survey was sent only to those companies, which run their business at least across two countries. Finally, a preliminary screening and selection of the target recipient was executed in order to grant the respondent's familiarity with the business vocabulary.

Generally, many reasons may lead the respondent to lie or avoid questions (Gaiziuniene and Cibulsksas, 2013; Ghauri and Grøhaug, 2005). In particular, the respondent's may do a mistake by accident (subject or participant error), or on purpose (subject or participant bias) (Saunders et al., 2009). The former is due to the lack of respondent's knowledge; however, the research team has tried to avoid this risk by deciding of not forcing the questions, except for those that were the core of the research. In this way, on one side, the issue to get wrong answer is addressed; on the other side, the main risk is to lose data and ruin the efforts. The second mistake refers to the probability to gather wrong information because of the respondent's concerns about his boss's behaviour. To address this issue, the introduction of the survey aims at ensuring the respondents about the confidentiality and anonymity of the data. Furthermore, it is specified that the results are used only in aggregated form.

As aforementioned, validity is among the most important issue in social science and in social research methodology (Denzin and Lincoln, 2002). "The validity of a scale refers to the degree to which it measures what it is supposed to measure". Unfortunately, there is no one clear-cut indicator of a scale's validity. The validation of a scale involves content validity, criterion validity and construct validity.

- *Content Validity*: refers to "the adequacy with which a measure or scale has sampled from the intended universe or domain of content.
- *Criterion validity* concerns the relationship between scale scores and some specified, measurable criterion.
- *Construct validity* involves testing a scale not against a single criterion". (Pallant, 2005: 7)

In other words, the validity assessment is a validation process that has to be performed to the measurements before they are taken in use and it consists of evaluate a) content validity, b) Construct Validity and c) Discriminant Validity. The first refers to the researcher capacity to ask right questions/items; the second to the capacity of the items to measure the same thing; the third one refers to the fact that measures used in the project differs from other concepts. In this study the questionnaire was formed according to the previous studies on the same issue. This increases the validity as the same questions have been used also before in several other scientific research.

4. **FINDINGS**

In this chapter, the results of the analysis are presented, based on data obtained through the online questionnaire. In particular, the paragraphs 4.1 and 4.2 address the first research question. Whereas, the paragraph 4.3, the regression analysis, aims at answering to the second research question.

4.1 3DP Analysis: degree of implementation, reasons and trade barriers

In order to answer to the first research question, it is provided a general overview of the surveyed companies' behaviour in respect to the new trend of adopting 3DP technology. Indeed, this first descriptive analysis may grant critical inputs for future further research of this under-searched theme.

In the survey, the companies were asked to indicate whether they have implemented other advanced manufacturing solutions, like: digital sensors, big data, cloud computing, crowd sourcing, robotics/advanced automation, Internet of Things, RFID and artificial intelligence. Surely, the focus is 3DP and, therefore, a deep analysis of the current state of 3DP implementation is presented.

In particular, out of 201 responses, 192 provided the answer about their behaviour in respect 3DP solutions, with a quiet low implementation rate equal to 29.68% (57 out of 192). Therefore, considering 192 as the 100%, the following relative percentages are provided.

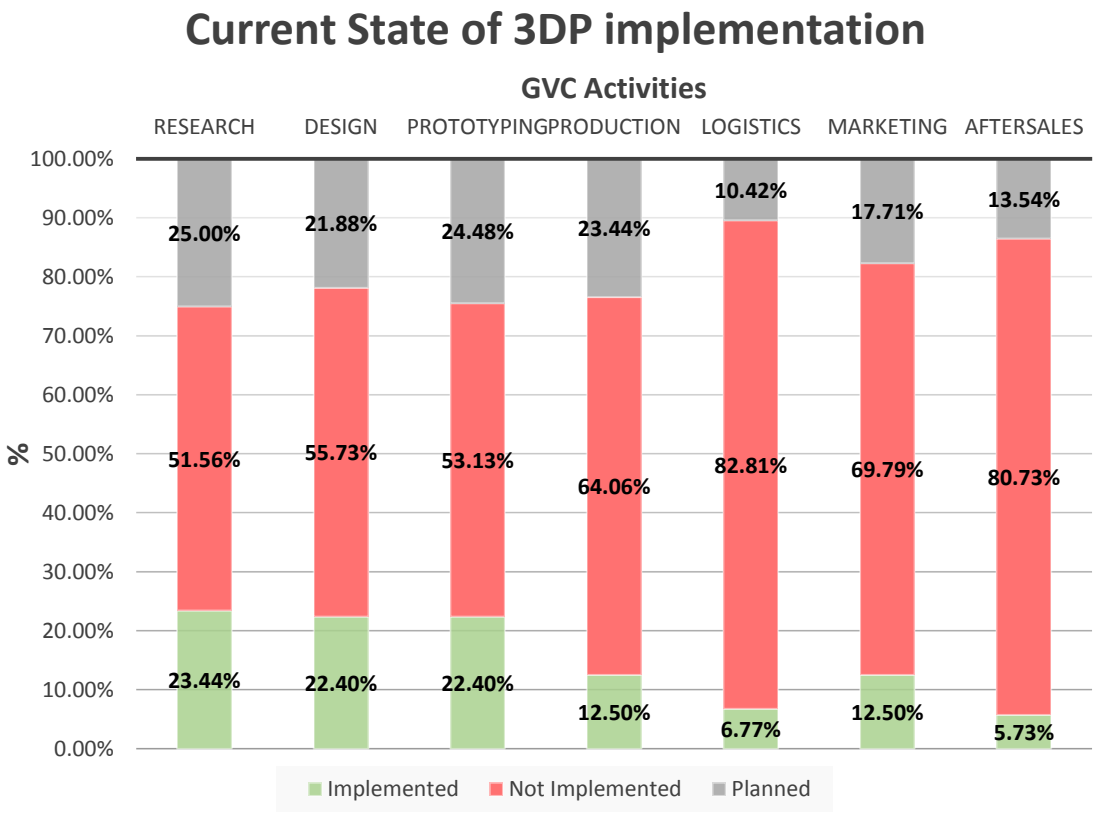


Figure 11. Current state of 3DP implementation according to the GVC activities

As it is shown in the Figure 11, the highest percentages show a scenario where companies prefer to not implement 3DP solutions. Even though, singularly, percentages of "Implemented" and "Planned" are low, if we sum both the percentages, overall the answers "yes adopted" and "planned" represent one half of the sample per each of the single activity. However interesting insights come from a "horizontal" comparison between the seven activities. By comparing activities of those companies, which decide to implement 3DP, and those that have planned to do, it is clear that in both scenarios research, design, prototyping and production receive more attention than marketing, aftersales and logistics. This may be due to the current state of the technology and to the material used with the 3D printer, which fit better with the first phase of the GVC.

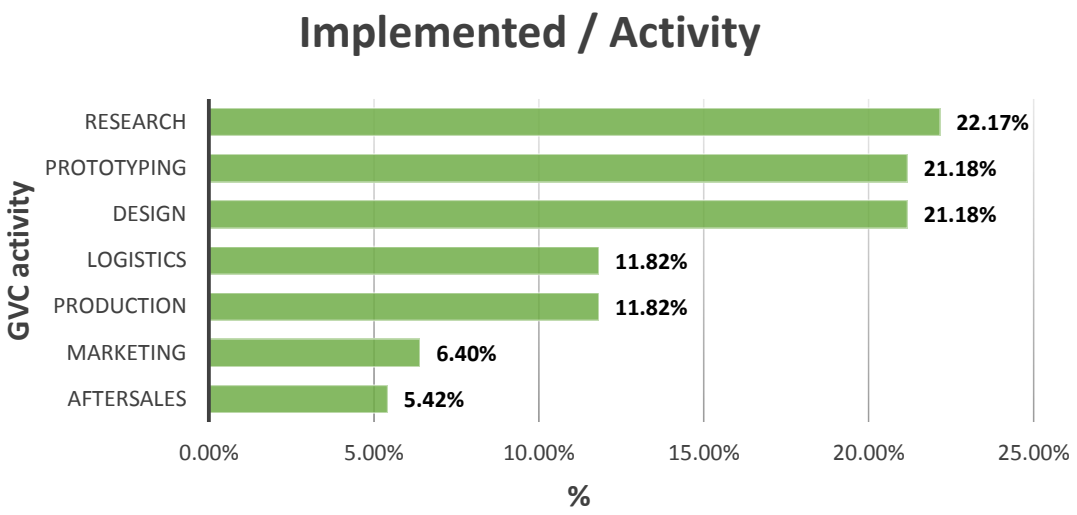


Figure 12. Where companies implement 3DP in the GVC

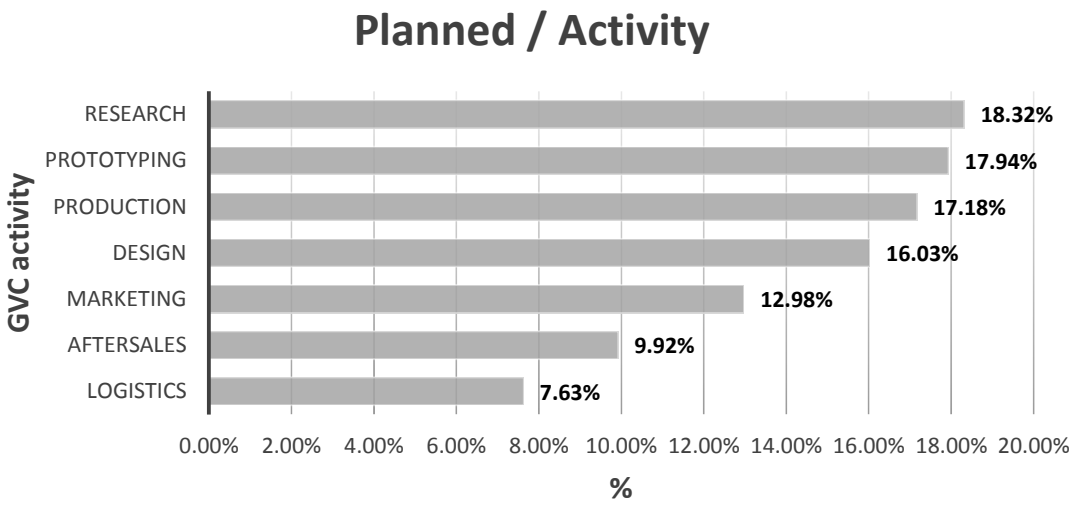


Figure 13. Where companies plan to implement 3DP solution in the GVC

In conclusion:

The current state of 3DP implementation shows that companies are more willing to adopt the technology in research, design and prototyping and less in marketing and aftersales. By comparing the current state with the future scenario (Figure 13):

1) *Further investments are addressed in research, design and prototyping. Since this finding is in line with the current state of 3DP implementation, this may imply*

that, as a matter of fact, companies have gained added value thanks to 3DP implementation; thus, they are motivated to further invest in these phases

2) *Production is going to receive an increasing attention in terms of 3DP implementation because it enables the long-talked-about mass customization a reality, opposing to the traditional mass production.*
3) *Even though less compared to the production, also marketing phase is going to increase the degree of 3DP implementation. This may be due to the recent trend of using the label "Industry 4.0" as core of companies' marketing strategy.*
4) *The findings related to Aftersales activity confirm that the usage of 3DP in Aftersales activities is not fruitful; thereby, they are not willing to invest further.*

At this point, for completeness purposes, it is necessary to shed light on the reasons behind the company's implementation of 3DP. To highlight the importance of each reason across activity is necessary in order to capture the most important ones and try to provide a critical overview of this important aspect of the survey.

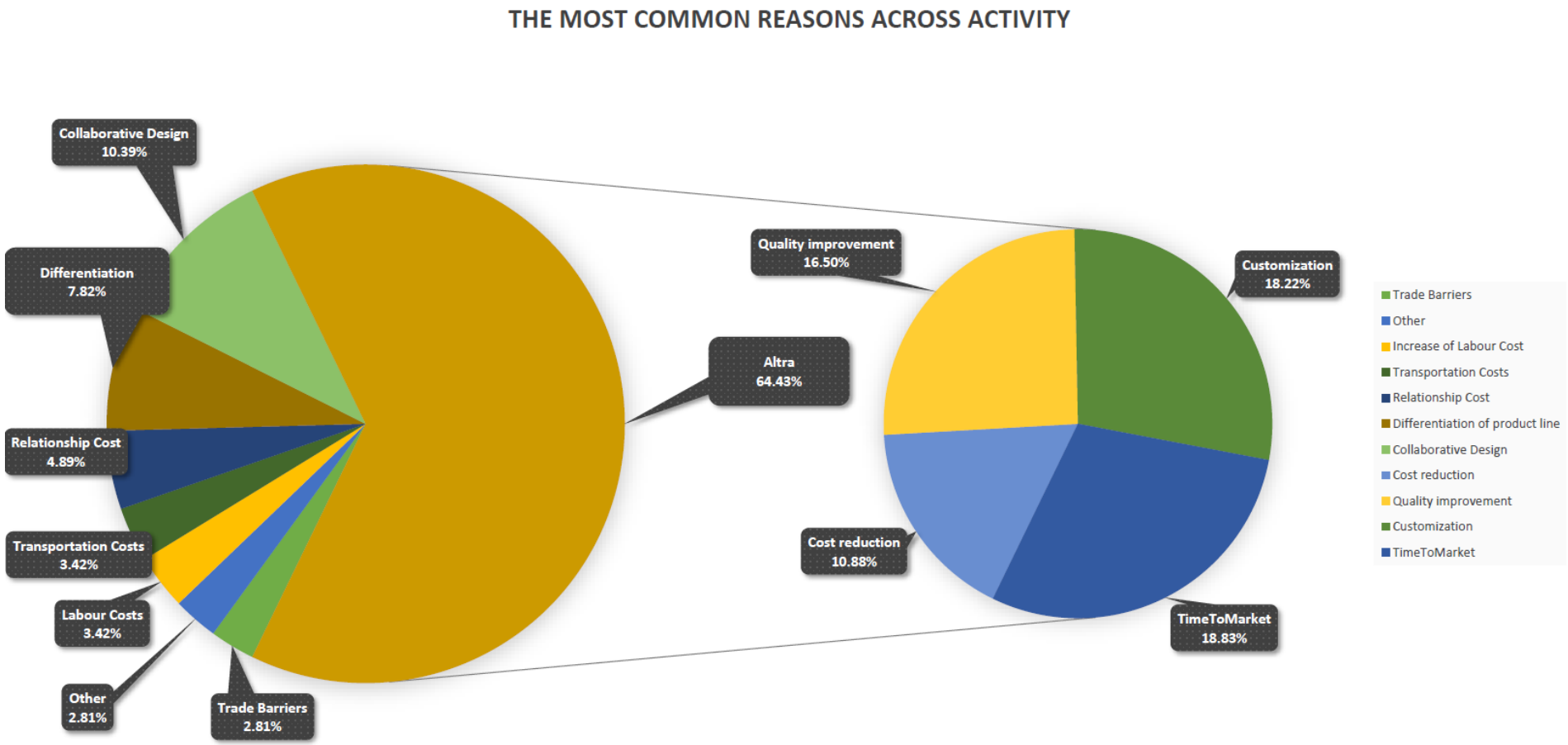


Figure 14. The most common reasons across GVC activity

The graph shows that there is a group of reasons, which represent the biggest part of the pie chart (64.43%) and, therefore, it is the group of the most common reasons behind the decision to implement the 3DP technology. In particular, as expected according to the literature by ordering the reasons according to the percentage, there is:

1) Time to Market;
2) Customization;
3) Improvement of quality;
4) Cost reduction.

Indeed, this proves that *a company is more willing to implement 3DP because it wants to gain advantages in terms of competitiveness and efficiency, rather than to be merely in lines with times.*

Furthermore, the following list of additional reasons were provided by the respondents in the text box "Other":

- Increase in product demand;
- New commercial activity;
- Because 3DP enables the company to use few raw materials and to generate less waste (environmental friendly), product weight, optimisation (lighter components);
- Increase in sales.

Finally, since the degree of investment represents one of the independent variables considered in order to assess the relationship between 3DP and reshape of GVC, the following graph shows the level of 3DP penetration within the company.

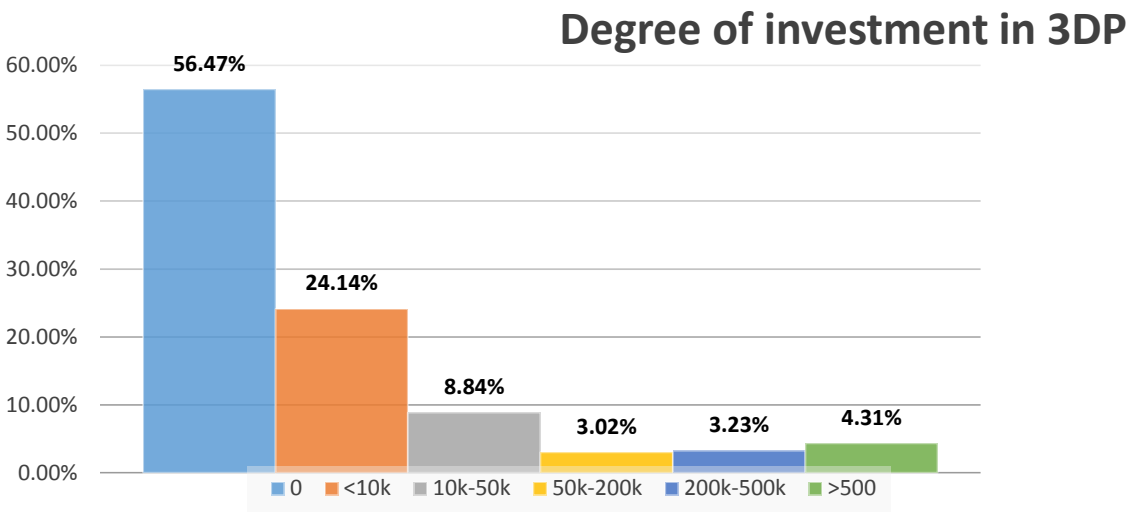


Figure 15. Surveyed companies' degree of investment in 3DP technology

As expected, more than half of the sample is characterized by companies that either do not invest or invest in marginal proportion in 3DP in their company (80.61%). The remaining part of the sample (28% of the surveyed sample have adopted 3DP) is further split into two groups: companies either commit a medium-low proportion of their resources in 3DP (8.84%) or adopt 3DP strategically. This latter explains the high amount of investment of 4.31% of the sample that is higher than 500.000 €.

Thus, the graph shows that, nowadays, companies are early adopters of 3DP technology, which implies that a low percentage of resources is addressed to technology improvements, since the benefits of 3DP in industrial application are still uncertain. However, according to the previous graph (Figure 13), it is expected that the degree of investment will increase, by progressively splitting part of the 56% of the first class (0% of investment) across the rest of the categories.

4.2 GVC Analysis: change in governance and location of GVC

In this section, the respondent is asked to report if either his company has already changed the GVC, or it has planned to do it, or not at all. According to these answers, a different path is displayed on the survey. In particular, for those who have already changed the GVC, it will be asked when the change occurred and for which specific reasons they were pushed to do it. In the case where "it is planned" is chosen, the answers are forecasts. Therefore, the following graph shows what the current companies' behaviour is in respect to the decision to reshape the GVC in terms of *governance*.

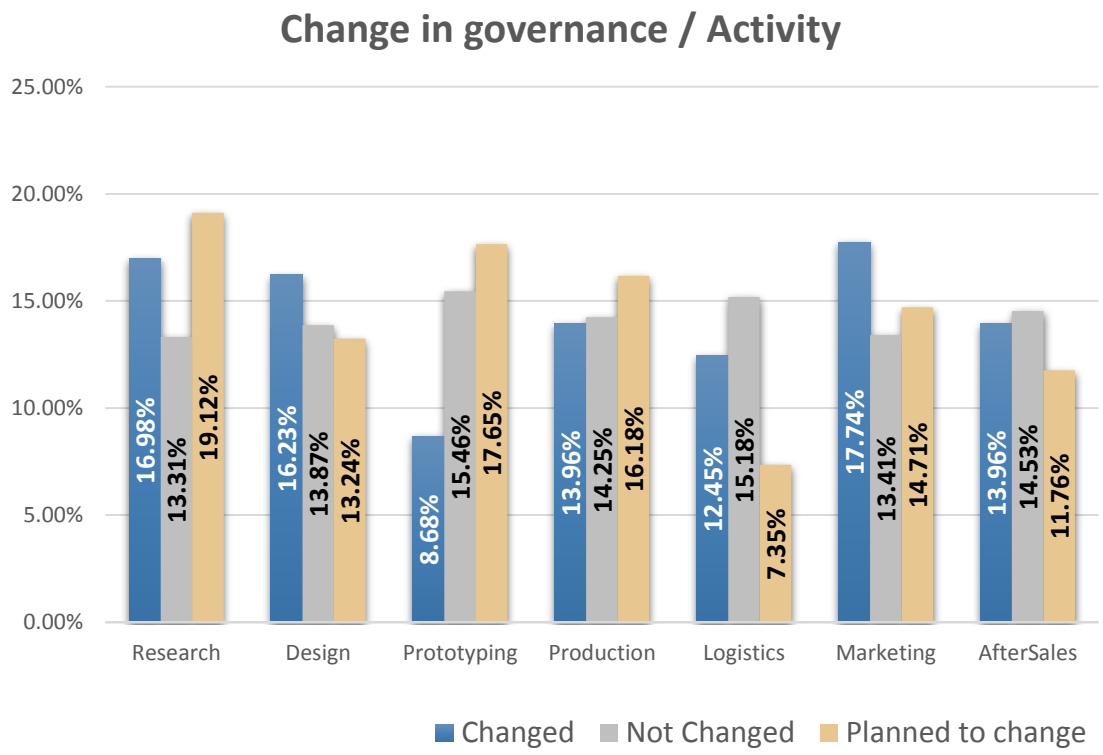


Figure 16. How the company behaves in respect to the decision to reshape the GVC

Three scenarios are represented in the findings:

1) *Changed*: Companies that have decided to reshape their GVC. Particularly interesting are the finding related to marketing and aftersales that are receiving more attention. This may be due to the strategic importance that marketing phase has since it affects the degree of sales (Gereffi and Korzeniewicx, 1994).

2) *Not Changed*: companies that have not changed governance and / Or location of their GVC;
3) *Planned to Change*: if the change have not occurred until now, but the company has planned to reshape GVC within the next five years.

In particular, an insight of the two most interesting scenarios is necessary: companies that have already reshaped the GVC and are going to do it, divided by each of the seven activities of the GVC.

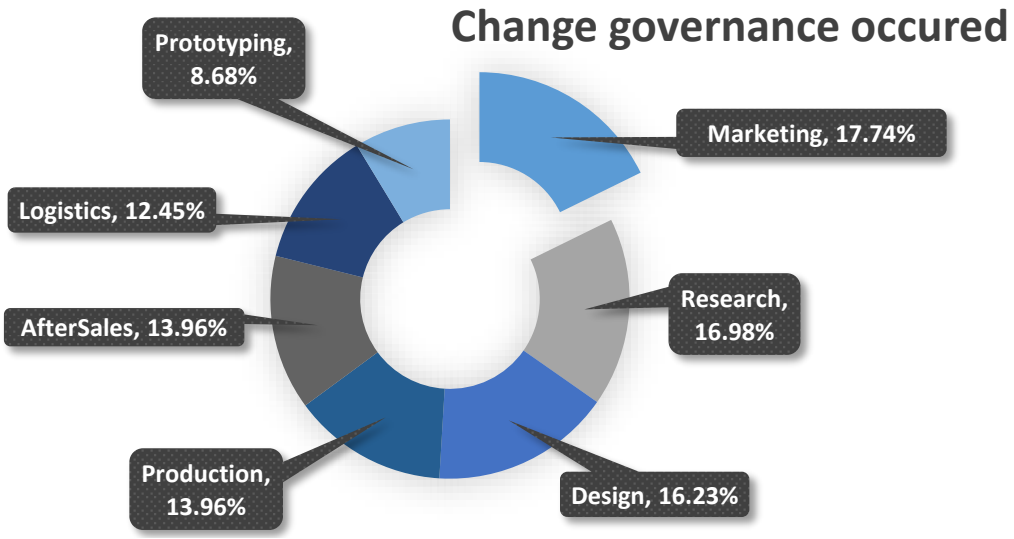


Figure 17. Companies that have already changed the GVC, according to the activity

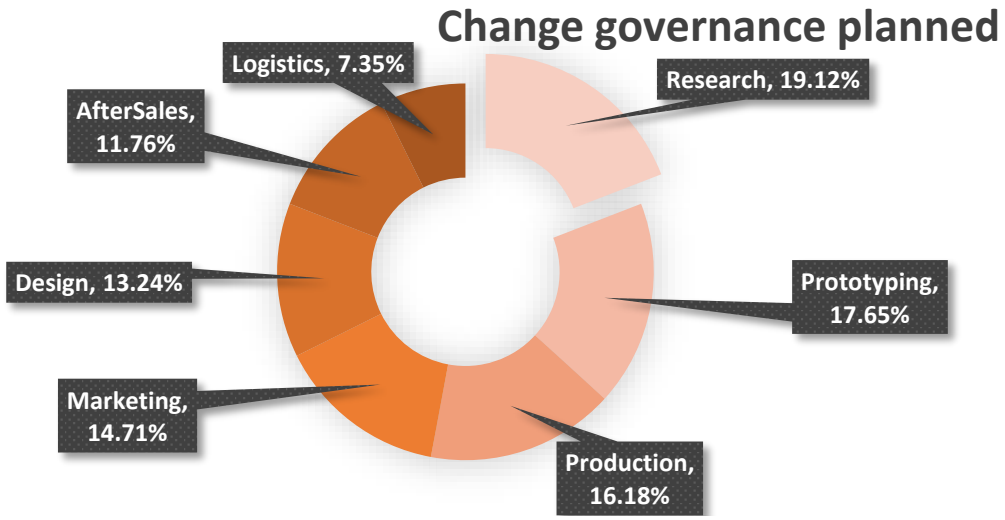


Figure 18. Companies that have planned to change the GVC, according to the activity

For those companies that have already decided to change the governance of their GVC, it is highlighted that, in the most of the cases, the change occurred in the marketing phase (17.74%). On the other side, within the companies that have planned to change the GVC, it is shown particularly interesting is the data regarding production (16.18%).

Therefore, two common features characterize the two scenarios (changed and planned to change):

1) *Research, Design and marketing activities receive the most of the company's attention in case of reshape of the GVC;*
2) *Activities like logistics and aftersales are less involved in strategic decision about governance and location.*
3) *Production governance is getting involved in location and governance change decisions.*

For completeness need, it is interesting to show how the governance of the GVC activities has changed over time. In order to analyse data, it is important to keep in mind that the time horizon considered is of 10 year. In particular,

- Past: 2010 till 2016
- Present: 2016;
- Future (what it is planned within the organizations): 2016 until 2021.

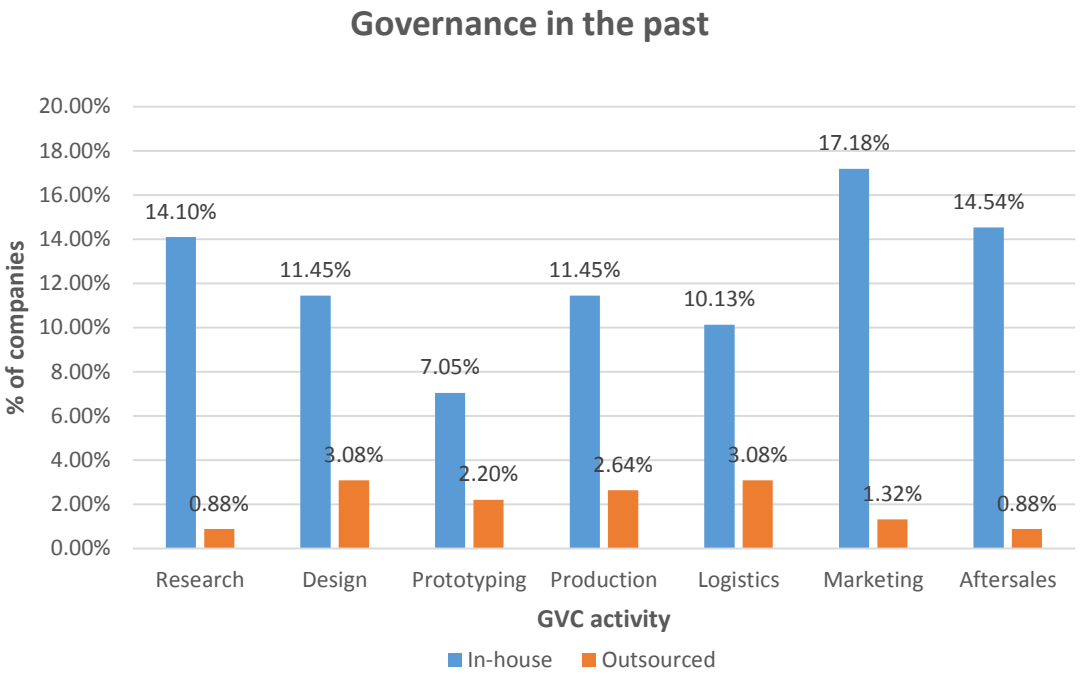


Figure 19. Percentage of companies performing in-house / outsourcing activities in the past

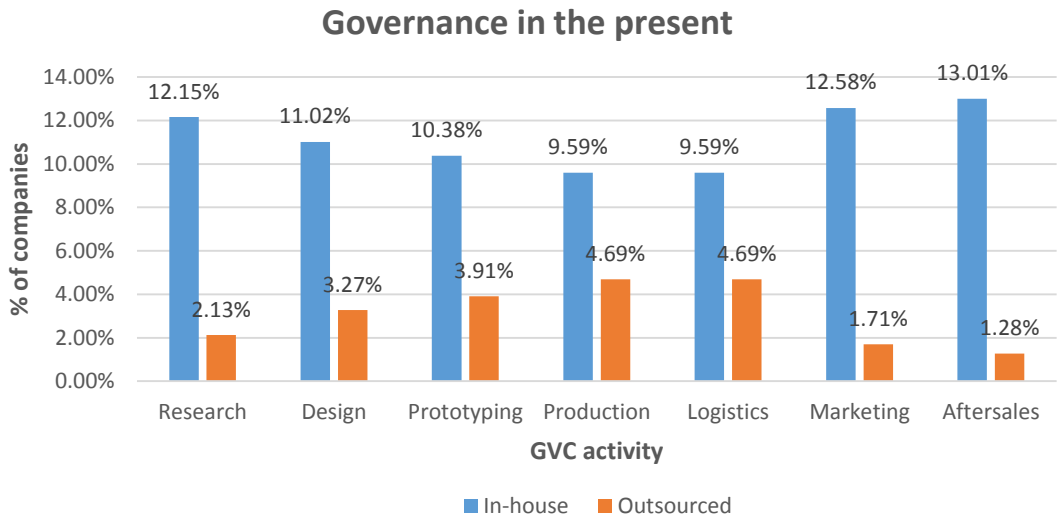


Figure 20. Percentage of companies performing in-house / outsourcing activities currently

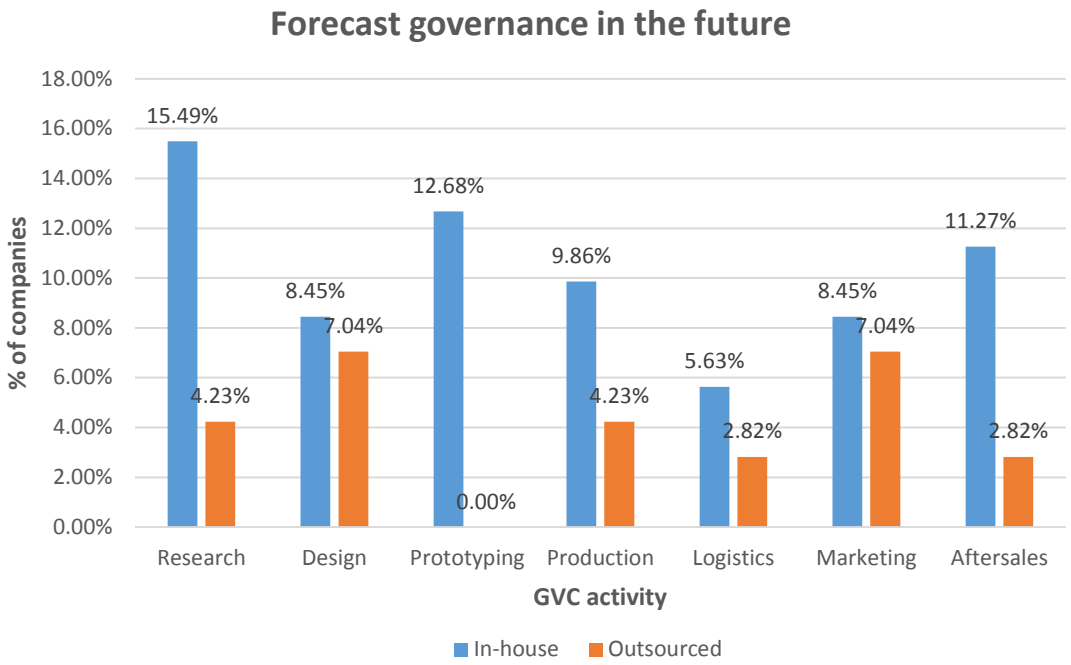


Figure 21. Percentage of companies performing in-house / outsourcing activities in the future

1) *Overall, it is possible to figure out that the "in-house" governance is the most used governance, along the time.*
2) *Contrastingly, to the past, the outsourcing trend increased and therefore, the outsourcing is broadly adopted, among all, in production phase: indeed, in the current state production is outsourced more (4.69%) than in the past (2.64%).*
3) *However, according to the respondents' forecasts the phenomenon of outsourcing is expected to decrease, for production and logistics: respectively, from 4.69% to 4.23%, from 4.69% 2.82%.*
4) *On the other side, it is clear the increasingly trend to give in outsourcing marketing (from 1.71% to 7.04%)*

Furthermore, it is crucial to categorize the type of reshape that respondents did. Indeed, as aforementioned in the chapter 2, the change can be categorize in "insourcing" and "out-sourcing", according to the governance. The following table shows that out of 201 respondents and 1407 possible responses (every respondent could give 7 responses according to the different GVC activities), only 28 changes are recorded. Indeed,

according to the results, 265 changes occurred (Table 11). However only 28 respondents have correctly answered to the survey, giving the possibility to the research team to categorize what type of change they did (Table 12).

Table 11. Number of governance changes that occurred across GVC activities

	Research	Design	Prototyping	Production	Logistics	Marketing	Aftersales	Overall
YES	45	43	23	37	33	47	37	**265**
PLANNED	13	9	12	11	5	10	8	**68**

Table 12. Type of change the respondents did across GVC activities

	Research	Design	Prototyping	Production	Logistics	Marketing	Aftersales	Overall
Insourcing	2	4	2	1	0	0	0	9
Out-sourcing	3	4	1	2	4	3	2	19
Overall	**5**	**8**	**3**	**3**	**4**	**3**	**2**	**28**

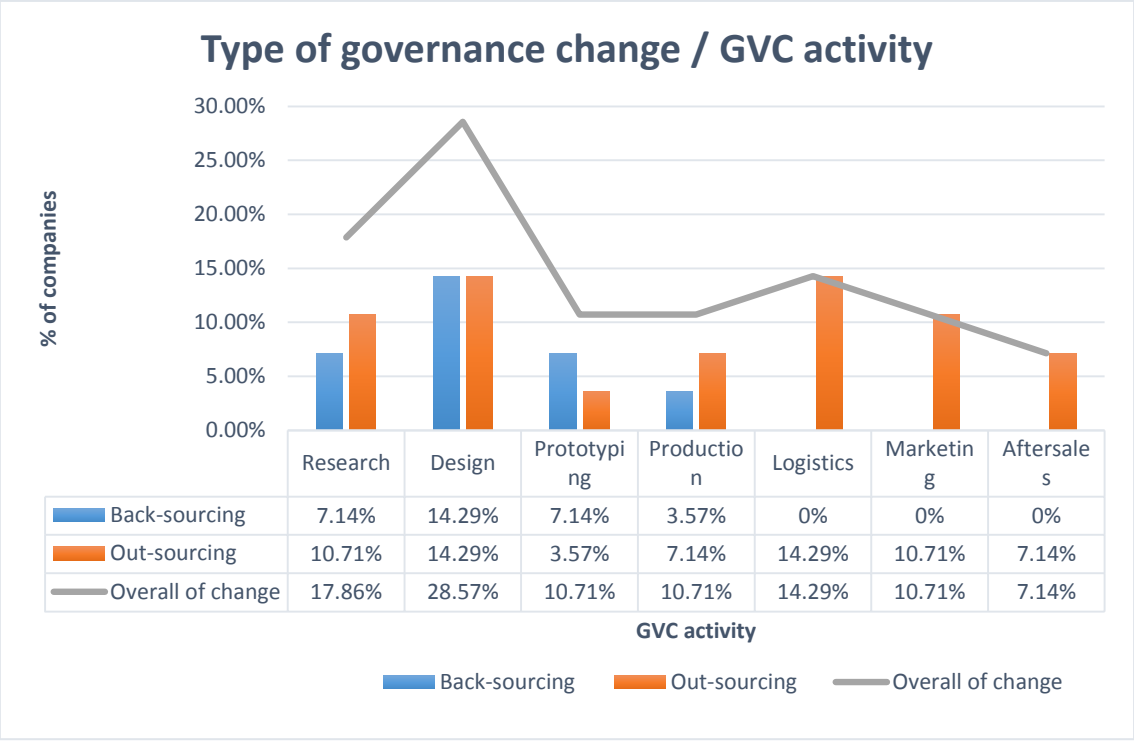


Figure 22. Percentage of companies that have changed their governance.

The graph above (Figure 22) illustrates that the back-sourcing (or insourcing) phenomenon occurred in four GVC activities. Indeed, as already explained in the literature, it refers to the trend where a company decides to bring an activity previously outsourced, back in-house and under its own control. If for research (7.14%), design (14.29%) and prototyping (7.14%) was expected because of the strategic role of these activities in a GVC, it is surprisingly high the data regarding the insourcing of production (3.57%) since, as aforementioned, it has been commonly outsourced in the past decades.

Thus, the data show an inversion trend as opposed to outsourcing that have characterized the past decades. In particular, beside research, design and prototyping, it is interesting how production is receiving significant attention due to both the higher need of skilled labour and to exogenous factors (e.g. complexity of subcontractors' nexus) that push toward a reorganization of the production and a higher control over the activity.

4.3 Regression analysis

In this section, the research goal is to provide the regression analysis of the data, in order to answer properly to the second research question. Thanks to the academic literature, it has been possible to identify hypotheses and clues that allowed the research team to focus on specific data. Where the hypotheses developed in the chapter 2 are rejected, through a *post-hoc* analysis it is possible to figure out interesting unexpected findings by taking in considerations additional variables, which were not considered at first. This type of analysis have led to interesting inputs for further future researches, which are better explained in the Chapter 5. In the regression models, the aim is to provide some empirical evidences on the *impact that 3DP adoption and degree of investment in 3DP has on changes in governance and location of the firm's GVC*.

4.3.1 Regression model methodology and interpretation of values

In statistical modelling, the regression studies the functional relations that occur between two variables: one dependent and one independent variables.
With regression analysis "you can examine the connection between two continuous variables when other variables are held constant (controlled / partial out)" (Tanskanen, 2016:1). The formula representing how the dependent variable is calculated with the regression analysis is the following:

$$\text{Dependent variable} = B0 + B1*\text{independent variable} + \text{error}$$

B1 is the regression coefficients that represents "the mean change in the response variable for one unit of change in the predictor variable while holding other predictors in the model constant" (Frost, 2013:1). Therefore, a dependent variable is the one we want to measure and predict, while independent variables are the explicative ones. In the following regression models, the variables are:

- Independent: 3DP adoption and degree of investment in 3DP
- Dependent: change of governance of GVC and reshoring initiatives.

In particular, the statistics are conducted by using the statistical software Stata. In conclusion, the following Table shows how the variables are operationalised for the regression analysis:

Table 13. Operationalisation of variables for the regression analysis

Variable Name	**Description**	**Operationalization**
Adoption of 3DP	Company which have adopted the 3DP technology in the last 3 years	Dummy Variable: 0= 3DP technology **has been not adopted** over the last 3 years 1= 3DP technology **has been adopted** over the last 3 years
Investment in 3DP	Degree of investment of company implementing 3DP	Categorical Variable: 1=0€ of investment in 3DP 2=<10.000 € of investment in 3DP 3=10.000<x<50.000 € of investment in 3DP 4=50.000<x<200.000 € of investment in 3DP 5=200.000<x<500.000 € of investment in 3DP 6=>500.000€ of investment in 3DP
Adoption of 3DP for Domestic firms	Companies which have adopted 3DP and have not foreign sales	Dummy Variable: 0= in a domestic company (no foreign sales), 3DP technology **has been not adopted** over the last 3 years 1= in a domestic company (no foreign sales), 3DP technology **has been adopted** over the last 3 years

4.3.2 Regression analysis for change in governance of companies' GVCs.

In this section, the results regarding the first set of hypotheses (Hypotheses 1 and 2) are presented and discussed. The Table 14 shows the related results.

First, every column represents a different model. Therefore, in the first column is presented a basic model (1) that does not investigate the research hypotheses yet. Here, the model is built through control variables in order to create a scale of measurement and to compare the findings coming from the investigation of the hypotheses. In particular, the aim is to understand whether, in normal conditions, there is an impact of the control variables on the dependent variable (the reshape of governance). This latter is a dummy

variable where “0” means that the company has not changed the governance in the last 5 years (from 2010 to 2015) and “1” represents the opposite scenario. The control variables chosen are:

1) Companies’ geographic location;
2) Firms’ industry sector;
3) R&D expenditure;
4) Type of company: divided into domestic and international firms. In particular, even though, in the survey there are listed five ranges of foreign sales intensity, it is noticed that the sample is split in two main groups: i) companies with foreign sales intensity less than 20%, and ii) higher than 20% of foreign sales. Therefore the first group i) are defined as “domestic” and the second ii) as “international”.

It is noticeable that no one of the control variables has an impact on the dependent variable; therefore, according to the first model, there are no significant impact on the change of the governance. This is due to the evidence that there is no any number with a significant p-value, signed with the symbols “*”, “**”, “***”, respectively meaning that the p-value is lower than 0.1, <0.05, <0.001. In particular, on one side, it was expected that geographic area does not affect the dependent variable: indeed, this is in line with the evidence that the reshape of governance relies on strategic decisions. On the other side, contrastingly to the beliefs in respect to turbulent sectors like ICTs and healthcare, neither the industry segment does not affect the governance reshape.

The model (2) presents interesting findings by adding the independent variable that is the object of the research problem: 3DP adoption. Even in this case, the variable is a dummy variable, where 0 means that no 3DP is not adopted and 1, 3DP is adopted. Thus, the hypotheses are formulated as follows:

- H_0 (Null Hypothesis): “3DP adoption does not affect the governance change in a GVC”;
- H_1 (Hypothesis 1): “3DP adoption affects the governance change in GVC”.

Table 14. Regression Analysis for testing hypotheses HP1 and HP2

	(1)	(2)	(3)
VARIABLES	**Control Variables**	**HYPOTHESIS 1**	**HYPOTHESIS 2**
North America	-1.192	-1.614	-2.911**
	(1.135)	(1.173)	(1.404)
South America	-0.413	-0.640	-0.778
	(0.885)	(0.896)	(0.902)
West Europe	-1.252	-1.534*	-1.552**
	(0.771)	(0.791)	(0.789)
East Europe	-0.424	-0.523	-0.535
	(0.760)	(0.766)	(0.764)
Chemicals	0.293	0.420	0.418
	(0.697)	(0.695)	(0.709)
Plastic	0.519	0.373	0.628
	(0.659)	(0.676)	(0.714)
Electronics	-0.806	-0.940	-0.820
	(0.758)	(0.791)	(0.813)
Machinery	0.559	0.374	0.247
	(0.578)	(0.588)	(0.594)
Automotive & Aerospace	-1.249	-1.553*	-1.461
	(0.912)	(0.916)	(0.923)
Constructions	-0.502	-0.625	-0.658
	(0.568)	(0.573)	(0.590)
Wholesale & Retail	0.809	0.906*	0.973*
	(0.541)	(0.543)	(0.551)
Logistics	0.907	1.005	1.123
	(0.833)	(0.832)	(0.837)
ICT	0.671	0.702	0.572
	(0.460)	(0.468)	(0.476)
Healthcare	-0.981	-0.897	-0.905
	(0.711)	(0.717)	(0.718)
R&D expenditure	0.0168	-0.0101	0.0107
	(0.120)	(0.123)	(0.125)
Domestic	0.321	0.459	0.462
	(0.341)	(0.352)	(0.361)
Controlled	-0.408	-0.493	-0.458
	(0.471)	(0.478)	(0.488)
Adoption of 3DP		0.808*	0.298
		(0.416)	(0.477)
Investment in 3DP			0.0856**
			(0.0377)
Constant	0.00558	-0.0203	-0.232
	(0.776)	(0.781)	(0.788)
Observations	201	201	201
Pseudo R-squared	0.0895	0.104	0.124

According to the Table 14, it is possible to accept the H_1. Indeed, if the p-value is under the threshold of 0.1 then the variable has significant relationship with dependent variable. In particular, the p-value is lower than 0.1, therefore, it is possible to reject the Null Hypothesis and accept the hypothesis 1. Surely, the p-value is significant but less than other variables with p-value<0.01: this is due to the limited amount of data (companies that have adopted 3DP are 57 out of 201), and because the variables are dummy-variables rather than quantitative. Indeed, the regression model used is the Logit model that is an alternative method to the traditional Ordinary Least Squares (OLS) that implies a linear relation between dependent and independent variable. Here, it is assumed that "there is an unobservable continuous latent variable Y^* and that the observed dichotomous variable Y = 1 if $Y^* > 0$, 0 otherwise" (Maddala, 1992:631). Moreover, the relationship exists and it has positive sign (0.808); therefore, it is possible to state:

Companies that adopt 3DP tend to change the GVC in terms of governance.

At this point, it is crucial to understand whether the variable "adoption of 3DP" has had an impact on the other control variables. Actually, the findings show that there is an impact on the control variable "West Europe", meaning that this phenomenon is less spreading in this macro area (-1.534). Even this data shed light on an interesting consideration: less-developed countries or emerging economies (EEs) are more motivated to reshape the GVC through the 3DP adoption (Gershenfeld, 2008; Moilanen and Vadén, 2013; Lipson and Kurman, 2013). However, it is important to mention that this result is "unstable" that it is referred to the lack of homoscedasticy. Indeed, the homoscedasticy is related to the requirement that the standard error (indicated in parentheses in Table 14) should have the same variance at every level of independent variables (Tanskanen, 2016). This is confirmed by the difference in the standard error with the second model (0.791) and with the first model (0.771).

Furthermore, a further consideration on the goodness of fit of the model should be done. This is represented by the R-squared (R^2) or "coefficient of determination". R^2 coefficient expresses how well the variables included in the models explain the variability of the phenomenon being studied around its mean (Frost, 2013). In our regression model,

coefficients of determination show low values, meaning that, statistically, it can be not considered a strong predictive model. Indeed, the R^2 is 0.104 meaning that the model is able to explain only the 10.4% of the impact; which means that there is a roughly 90% of variables that have an impact but that are not included in this model. However, the research goal is not to find out a valid model able to explain the impact of the independent variable on the dependent one. On contrast, the research goal is to understand whether an impact exists. Indeed, the research purpose is to understand if 3DP adoption affects or not the reshape of the governance, rather than to explore the degree of 3DP importance on the governance. In this perspective, it is possible to understand that 3DP adoption is important for 10%. This was forecasted: the literature lists several reasons behind the governance change (Gereffi et al., 2005). An additional consideration relies on how much is the difference between the R^2 in the scenario (2) and (1), equal to 0.015. This represents the weight of the variables that are added in the second model, specifically, the weight of the variable "3DP adopted". Thereby, the 3DP variable has an impact equal to 1.5% that is quiet low in absolute terms but if we consider the entire set of possible reasons affecting the dependent variable, the data becomes more significant. Finally, it is crucial also to get a proper understanding about how much the R-squared increases across the model. Therefore, the variation (Δ) of the R-squared that is recorded through changing the model is rather important and equal to 16%.

In order to test the hypothesis HP2, the variable "Investment in 3DP" is added. It is noticeable that even in this case there is a positive effect of the new variable, and the impact is also significant due to the p-value that is lower than 0.05. Furthermore, by repeating the same procedure used for the previous hypothesis, and calculating the difference of the determination coefficient across the models, the impact is even bigger (2%) with a variation of 19%. Thus, it is possible to conclude:

The degree of investment in 3DP adoption has an impact on the governance change of the GVC. Thereby, the more companies invest in 3DP, the more they are willing to reshape the governance of GVC.

This means that the investment has to be strategic and not marginal. This finding is supported by the literature that reports that the companies able to practical exploit 3DP advantages are those that adopt 3DP for a process innovation rather than a product innovation (McKinsey, 2014).

However, through an overview of the other variables considered, it is possible to see that the variable "Adoption of 3DP" is no longer significant, and, therefore, it is not a robust measurement. It is possible to argue that in statistics, when a variable that is significant (Adoption of 3DP) becomes not significant when a new variable (Investment in 3DP) is added, it means that it has experienced the impact of the new variable. In statistical terms it is explained by the principle of multicollinearity meaning that "a possible predictor-predictor redundancy phenomenon" occurs (Kock, and Lynn, 2012: 546). In other words, two or more predictor variables are highly correlated, therefore, one can be predicted from the others with a substantial degree of reliability. This is supported by the correlation analysis of "3DP adopted" and "amount investment" variables showed in the following figure:

	D3_ado~d	Amount~d
D3_adopted	**1.0000**	
Amount_Inv~d	**0.5179**	**1.0000**

Figure 23. Correlation analysis of the variables adoption of 3DP and Investment in 3DP

The correlation is equal to 0.5179 that is particularly high. This consideration is interesting since the phenomena analysed are two sides of the same coin. Indeed, the objective of the analysis is whether 3DP adoption influences the decision to change the governance in a GVC, even though in different terms. In statistics, it is common to avoid this problem, by eliminating one of the two overlapping variable: in this case the variable "Adoption of 3DP" since it seems that the impact of the variable "Investment in 3DP" prevails on the previous one.

In conclusion, the second hypothesis make the assumptions more reliable, since it does not matter to adopt 3DP merely for being in line with technological advances, but it is crucial that the company implements the technology in strategical terms.

4.3.3 Regression analysis for reshoring initiative

To explain the second set of hypotheses, the following table is provided. In particular, at first glance, it seems that the hypotheses regarding the impact of 3DP adoption and Amount of investment on reshoring decision are rejected. As done for the previous case, also in this case a basic model is built by using control variables, and, accordingly, no significant results are reported.
Regarding the hypotheses, no significant results are presented in both cases, and so, as preliminary conclusion, it is possible to reject the hypotheses HP3 and HP4, therefore:

Hypothesis 3: the adoption of 3DP has no any impact on the decision to reshore activities (rejected)

Hypothesis 4: The amount of investment in 3DP adoption has no any impact on the decision to reshore activities (rejected)

Table 15. Regression Analysis for testing hypotheses HP3 and HP4

VARIABLES	Control Variables	HYPOTHESIS 3	HYPOTHESIS 4	Moderating effect
North America	-0.442	-0.518	0.0228	-0.0779
	(1.419)	(1.442)	(1.547)	(1.577)
South America	0.0690	0.0318	0.0915	-0.0946
	(1.071)	(1.077)	(1.080)	(1.103)
West Europe	-0.480	-0.528	-0.542	-0.647
	(0.953)	(0.966)	(0.967)	(0.990)
East Europe	-0.0754	-0.0967	-0.0756	-0.131
	(0.934)	(0.935)	(0.938)	(0.960)
Chemicals	-0.181	-0.152	-0.120	-0.164
	(0.934)	(0.937)	(0.927)	(0.946)
Plastic	0.205	0.176	0.0837	-0.0344
	(0.842)	(0.848)	(0.856)	(0.867)
Electronics	0.271	0.253	0.192	0.291
	(0.762)	(0.767)	(0.769)	(0.810)
Machinery	-0.00310	-0.0320	0.0168	-0.203
	(0.728)	(0.734)	(0.742)	(0.750)
Automotive & Aerospace	0.227	0.171	0.121	0.178
	(0.876)	(0.897)	(0.906)	(0.921)
Constructions	-0.258	-0.275	-0.281	-0.406
	(0.702)	(0.704)	(0.707)	(0.709)
Wholesale & Retail	0.361	0.378	0.361	0.446
	(0.612)	(0.615)	(0.617)	(0.624)
Logistics	0.657	0.673	0.618	0.564
	(0.860)	(0.863)	(0.864)	(0.899)
ICT	0.756	0.758	0.836	0.750
	(0.508)	(0.508)	(0.515)	(0.527)
Healthcare	-1.083	-1.066	-1.112	-1.150
	(1.084)	(1.086)	(1.090)	(1.094)
R&D expenditure	-0.0331	-0.0387	-0.0473	-0.0417
	(0.147)	(0.148)	(0.148)	(0.153)
Domestic	0.366	0.385	0.402	0.896*
	(0.411)	(0.416)	(0.421)	(0.508)
Controlled	-0.265	-0.273	-0.306	-0.406
	(0.562)	(0.562)	(0.568)	(0.578)
Adoption of 3DP		0.140	0.403	1.153*
		(0.489)	(0.556)	(0.682)
Investment in 3DP			-0.0431	-0.0331
			(0.0470)	(0.0484)
Adoption of 3DP for Domestic firms				-1.894*
				(1.016)
Constant	-1.514	-1.513	-1.433	-1.660*
	(0.963)	(0.961)	(0.970)	(1.009)
Observations	201	201	201	201
Pseudo R-squared	0.0494	0.0499	0.0544	0.0746

However, a contingent (or moderating) variable is taken into account. In literature, the moderation relies on the possibility to explain an observable relationship between a dependent and independent variable through the inclusion of a third hypothetical predictor, known as "mediator variable" (McKinnon, 2008). In this case, the moderating variable chosen is "Foreign Sales Intensity". In particular, this may be explained through the evidence that the domestic firms (without foreign sales) that are involved in import activities have no an international knowledge about the opportunities they can exploit, so 3DP adoption is not enough to move toward reshoring. Different is the case of those international companies, that tend to relocate opportunities quicker than domestic ones (Devigne et al., 2016)

To test the moderation effect, it is necessary to build a new variable:

$$New\_Var = Var_1 * Var_2$$

Where:

- New_Var= Adoption of 3DP for Domestic firms
- Var_1 = Adoption of 3DP
- Var_2 = Domestic

Therefore, in the new model, three variables are contemplated. There is a moderation effect if the new variable and at least one between Var_1 and Var_2 are significant. Indeed, in the table 15 it is shown that the New Var and Var_1 are significant with p-value<0.1 with a beta coefficient equal to -1.894 and 1.153. However, since the beta coefficient of New Var is negative, it means that the variable 3DP adoption and domestic companies have a negative relationship; viceversa, 3DP adoption and international companies have a positive effect. Thus, following this post-hoc analysis, a further consideration is formulated:

The 3DP adoption has an impact on reshoring initiative, dependently on foreign sales intensity.

To sum up, combining the findings of the Table 14 and 15, it is possible to state:

3DP influences the reshape of the GVC, even though with differences between governance and location. Regarding the governance, the impact is strong and considerable, and it tend to occur in every conditions. As contrast, the 3DP impact on the location changes, reshoring initiatives, depends on the company's internationalization strategy.

5. SUMMARY AND CONCLUSIONS

5.1 Summary

This study concentrated on analysing the 3DP impact on the reshape of the company's GVC. The thesis is part of a larger research project "3D Printing and GVCs" which was jointly organized by University of Vaasa and University of Pavia. It was elaborated around the research questions of what is the current companies' behavior in respect to 3DP adoption and GVC reshape and to what extent the implementation of 3DP technology in a company is associated with the change of GVCs. In this thesis, the focus was on the reshape of GVCs in terms of governance (outsourcing / insourcing) and location (reshoring). Throughout the study it is showed that this area of GVCs and how it may be affected by new technologies, like 3DP, has not been covered yet. Indeed, the in the former researches particular attention was addressed to define the recent trend of reshaping governance and location (Kinkel, 2012; Kinkel, and Maloca, 2009; Kinkel, and Zanker, 2013; Fratocchi, 2014). Moreover, majority of studies have focused on the technological impact rather than on the strategic role that 3DP plays in reshaping the Global Value Chains (GVCs). Indeed, McKinsey (2014) have provided an interesting input where it is crucial to understand that an important difference exists between the 3DP adoption for product development and for process innovation. Finally, although researchers theoretically highlight the importance of the phenomena, there are no empirical studies at a global level (Laplume, 2016). Hence, the objective of this research is to analyse whether a relationship between 3DP and reshape of GVC exists, by conducting an empirical quantitative analysis.

5.2 Key findings of the Descriptive Analysis

The findings show that the degree of 3DP implementation is pretty low (only 28% of the sample): this percentage is further decreased when the degree of investment is considered. Indeed, 18.86% of respondents do a medium-low investment versus roughly 8% of companies that decide to intervene strategically in their own company through a significant 3DP implementation. By comparing activities of those companies, which decide to implement 3DP, and those that have planned to do, in both scenarios *research, design, prototyping and production receive more attention than marketing, aftersales and logistics*.

This may be due to the current state of the technology and to the material used with the 3D printer, which fit better for the first phases of the GVC (Campbell et al., 2011). Moreover, the future perspective show that the investment in the early GVC phases is going to increase because companies have actually gained added value in these phases. Actually, several authors have pointed out the strategic importance of 3DP implementation in design and prototyping (Cohen, Sargeant and Somers, 2014; Robinson, 2014; Waller and Fawcett, 2014). On the other side, production is going to receive an increasing attention in terms of 3DP implementation because it enables the long-talked-about mass customization a reality (Waller and Fawcett, 2014). Indeed, the most common reasons behind the 3DP implementation are decrease of time to market, customization, improvement of quality and cost reduction, that are widely acknowledged as the most advantages 3DP may bring (Bassan and Srinivasan, 2012). Thus, this proves that *if a company is more willing to implement 3DP is because it wants to gain advantages in terms of competitiveness and efficiency, rather than to be merely in lines with times* (D'Aveni, 2015). In particular, Birtchnell et al. (2013), Janssen et al. (2014), Tuck and Hague (2006) and Walter et al. (2014) highlight that the core of the 3DP disruption is related to the "mass customization". This latter is the most attractive alternative to the mass production, which have characterized the second wave of industrialization, and that may lead to remarkable impacts on the downstream sections of the supply chain, like production and distribution (Lockwood, 2014; Waller and Fawcett, 2014; WTO, 2013).

Surprising is the data related to the future trend about a *significant increase 3DP adoption* in *marketing phase. This may be due to the recent trend of exploting the label "Industry 4.0" as core of companies' marketing strategy.* Indeed, as Chabaud (2016) highlights, customers may be curious to explore the new technology, thus their attention is captured more easily. Moreover, it is particularly fruitful for a customer-centric strategy where 3DP enables customer to be directly involved in the final product design. Thus, the "Industry 4.0" label is becoming a symbol of the firm's strategy that is increasingly focused on the customer's need. Surely, the current state shows that *companies are early adopters of 3DP technology, which implies that a low percentage of resources is addressed to technology improvements.* However, the survey conducted by Gartner (2013) proves that early adopters of 3DP technologies gain greater benefits and own a higher competitive advantage *versus* their competitors. *Thus, even though, at the moment, the amount of investment is pretty low, companies reaching the competitive advantage will tend to intervene massively in their processes through the 3DP implementation*.

As concerns the reshape in GVC, *for those companies that have already decided to change the governance of their GVC, it is highlighted that the change occurred in the marketing phase,* which is, together with research and design, the core firm's activities (Gereffi et al., 2005). However, it is doubtless that the recent technological improvement of the recent decades have forced the companies to reshape their core activities, which explains the findings obtained indicating that companies tend to insource research, design and prototyping because of the pressing need to get control over strategic activities (Gereffi and Korzeniewicz, 1990).

Surprisingly, the *insourcing of production is increasing*. Doubtless, the outsourcing continues increasing and it is highlighted that even the vertical disintegration and fine-sliced global production is a recent trend itself that is intended to further increase due to the partial effect of 3DP development (Laplume, 2016). *However, according to the respondents' forecasts the phenomenon of outsourcing is expected to decrease, for production and logistics.* Overall, *the data show an inversion trend as opposed to outsourcing that have characterized the past decades. In particular, this may be due to the impact of external economic factors (like labour and subcontractors) that are pushing*

toward a back-sourcing of activities like production, that have been commonly outsourced until now. As would expected, firms are more willing to regain control over GVC activities, because of the lack of skills and quality of the partners and increasing issues related to outsourcing phenomenon (Goulart, 2013; O' Byrne, 2015).

5.3 Evaluations of hypotheses

In this thesis, the impact of 3DP adoption and degree of investment in 3DP is investigated through the regression analysis in order to figure out whether an impact on the decision to reshape the GVC exists. In particular, the Logit model is used since the variable have dichotomous features. The produced regression models can be used in the evaluation of the hypotheses 1, 2, 3 and 4.

The hypothesis 1 suggested that 3DP adoption has an impact on the company's decision to reshape the GVC. The logit regression model shows that the direction of the influence is positive, hence, *the more a company implements 3DP the more it tends to reshape the governance of the GVC*. However, it is not possible to determine the cause-effect relationship (see limitations in the paragraph 5.3). The R-squared, however, is pretty low, therefore, the model is able to explain only 10% of the impact.

The previous findings acquire greater significance when the variable degree of investment is considered (HP2). Indeed, *the higher investment the investment in 3DP, the more companies tend to change their governance*. This confirmed by the literature: nowadays, 3DP is more implemented for product development, which implies a low degree of investment, rather than for a strategic process innovation. However, in this latter case it is expected a more likely possibility to exploit significant advantages and impact on the entire GVC structure (Bax & Willems Consulting Venturing, 2016; McKinsey, 2014).

Furthermore, the findings show that *differences are observable according to the geographic macro-area where the company implementing 3DP is located*. In particular, in West Europe it seems that the phenomenon of reshape GVC for 3DP is less spread, that is proved by the negative beta coefficient of the regression analysis. As aforementioned in Chapter 4, this finding implies an interesting consideration: *less-developed countries or emerging economies (EEs) are more motivated to reshape the GVC through the 3DP adoption*. In the literature, some argumentation support this hypothesis. In particular, the 3D printer manufacturers state that developing countries may exploit 3DP advantages to upgrade their position in the GVCs, getting higher slice of the value added captured. As contrast, there is scepticism due to the forecasts that 3DP

will lead to single-user company and so, to the replacement of the current subcontracting networks (Gershenfeld, 2008; Moilanen and Vadén, 2013; Lipson and Kurman, 2013).

On the other hand, contrastingly to the expectations, the findings show that *neither 3DP adoption nor degree of investment in 3DP affects the reshoring phenomenon*. Thus, the hypotheses 3 and 4 are rejected. However, it is figured out *that foreign sales intensity positively moderate the impact of 3DP on reshoring*.

Indeed, former studies prove that cross-border companies have a lower "social and emotional involvement with the project and embeddedness in the local economic and social environment" so that they tend less to exploit better localization advantages (Devigne et al., 2016:1). This is further confirmed by the acknowledgement that offshore firms have better opportunity to survive because they are less sensitive to domestic market conditions (Coucke and Sleuwaegen, 2008).

5.4 Limitations of the study

The limitation of the research study regard, first of all, the type of analysis conducted in order to investigate the research questions.

A limitation that should be always present in the researcher's mind is related to the quantitative analysis. Indeed, it is difficult to obtain information about sensitive topics, like reshape of GVC through structured data collection. It is also pointed out whether the quantitative study may ensure novelty since the sample firms are not interviewed personally. However, in this study, the sample size is large enough to produce statistically significant results. (Lundy, 1996; Saunders et al., 2009)

As concerns, the descriptive analysis used for the first research question, a limitation that should be mentioned is that the approach is static and it does not fit with dynamic phenomenon, like reshoring (Johnson, 1953). In addition, it offers a too simplistic model in order to analyse complex series of data which can have multiple correlations among them and that can be influenced by relevant series of variable (Saunders et al., 2009). However, in our analysis, results obtained by the descriptive analysis represent average trends considered independently, without taking in consideration the dynamic evolution of the GVC reshape over the period considered. However, it is important to mention also the drawbacks of the survey strategy. First, the researcher is dependent on the respondent's willingness to answer (Ghauri and Grøhaug, 2005). Second, the problem to get true answers, which means that, to secure an high quality questionnaire, it should be pilot tested and be subject to validity assessment. Third, it requires the ability to combine all the possible questions in a questionnaire that has not to be too long, otherwise, the risk is to decrease dramatically the response rate. Hence, it may lead to over-simplify the research and to get too broad results. On the other side, if the sample is too small, the results cannot be generalised (Saunders et al., 2009.)

Accuracy of the data is ensured by avoiding subjectivity of the questions. Indeed, only one question requires the respondent's opinion on a Likert-scale from 0 to 4. However, this data does not affect the final findings obtained. Indeed, a shortcoming of the survey technique is related to the fact that the results may be manipulated (Eriksson and

Kovalainen, 2008). In addition, due to the research purposes, only companies, which perform activities across countries, are accepted, so the results cannot be generalized to the whole population, but only to those that operate internationally and are big enough. In particular, companies with less than 10 employees are excluded by the conclusions achieved in this study.

As regard the findings resulting from the regression analysis, it is important to highlight that it is not possible to understand the cause-effect relationship. This is due to the matter of fact that the research used cross-sectional rather than longitudinal datasets, which means that the analysis is developed according to the data collected at the same time (from June to August 2016). Thus, it is not possible to claim that companies reshape the governance after having implemented 3DP or viceversa. The same considerations has to be done for the hypotheses regarding the 3DP impact on reshoring.

Finally, the results may be affected by the unbalanced sample composition. Indeed it is commonly observable that the dataset tend to be split into two main groups of companies that present significant different features: e.g. industry sector, geographic localization and foreign sales intensity. Thus the reliability of the regression model, expressed by the R-squared is low since the variable are dummy-variable.

5.5 Theoretical contributions

The theoretical framework and hypotheses were built on the former research and theory. Because of the limited number of studies of the possible relationship between 3DP and reshape of GVC (e.g. Janssen et al., 2014; McKinsey, 2014; Laplume, 2016) this study offers a crucial starting point for an under searched theme, by combining two relatively recent phenomena: 3DP and reshape of GVC in terms of governance and location.

This thesis contributes in better understanding the advantages that 3DP technology may bring with particular concerns to the impact on GVC. Indeed, in the literature it has been criticized that 3DP is mostly applied for product development rather than for process innovation (McKinsey, 2014; Laplume, 2016). This thesis shows that an impact between the aforementioned phenomena exists: in particular, the relationship is always valid in the case of governance changes; on the other hand, it depends on another variable (foreign sales intensity) in case of reshoring initiative.

Thus, the theoretical contribution of this study regards the findings obtained: it has emerged that the fact that a company implementing 3DP does import is not enough to reshape the GVC. It depends on the location of the sales unit and customer demand that has to be different from headquarter’s country.

5.6 Future research suggestions

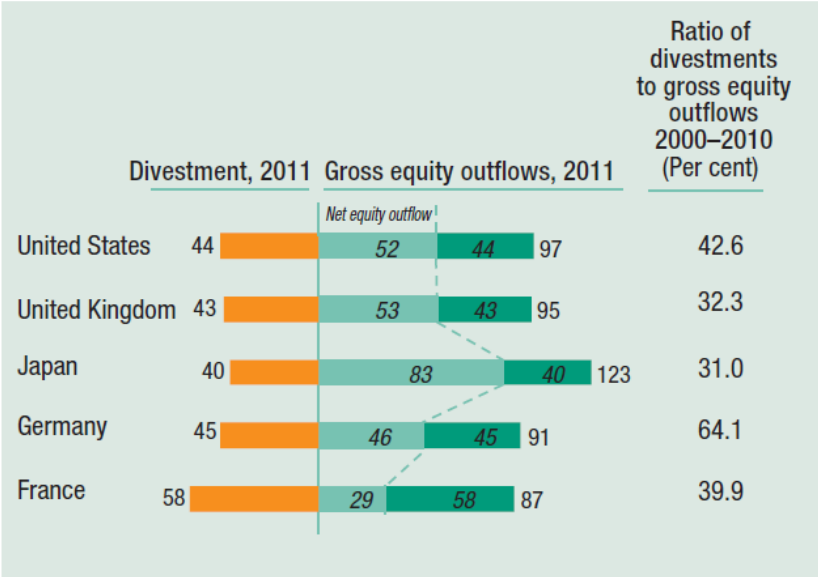
In this research, it is confirmed the impact of 3DP on GVC. However, it would be interesting to research the cause-effect relationship between 3DP and GVC, through a quantitative analysis and by using longitudinal datasets. In particular, this can be done by repeatedly survey the same sample of companies over 3-years time. In this way it may be possible to understand whether a change in GVC occurs and to what extent it is caused by 3DP adoption.

The consideration resulting from the test of hypothesis 2 implies an interesting future research suggestion. Since the relationship between the aforementioned variables is negative in West-Europe, a research question may be "does it imply that emerging economies tend to perform better in terms of degree of innovation and reorganization of GVC? In particular, to what extent 3DP adoption motivates EEs to climb the industrial ladder and gain higher control over the global value chain?"

In this research the degree of investment was used in order to better explain the 3DP impact on the decision the reshape GVC. In particular, the higher the strategic investment in 3DP the more companies tend to reorganize their GVC. However, if the different ranges of degree of investment used in the research can represent a useful starting point, it may be particular interesting to understand what "strategic investment" means. The research study already provides an insight of how degree of investment differs along the value chain. However, it could be interesting to deeply analyse whether there is a difference of investment between the upstream and downstream part of the chain and the reasons behind.

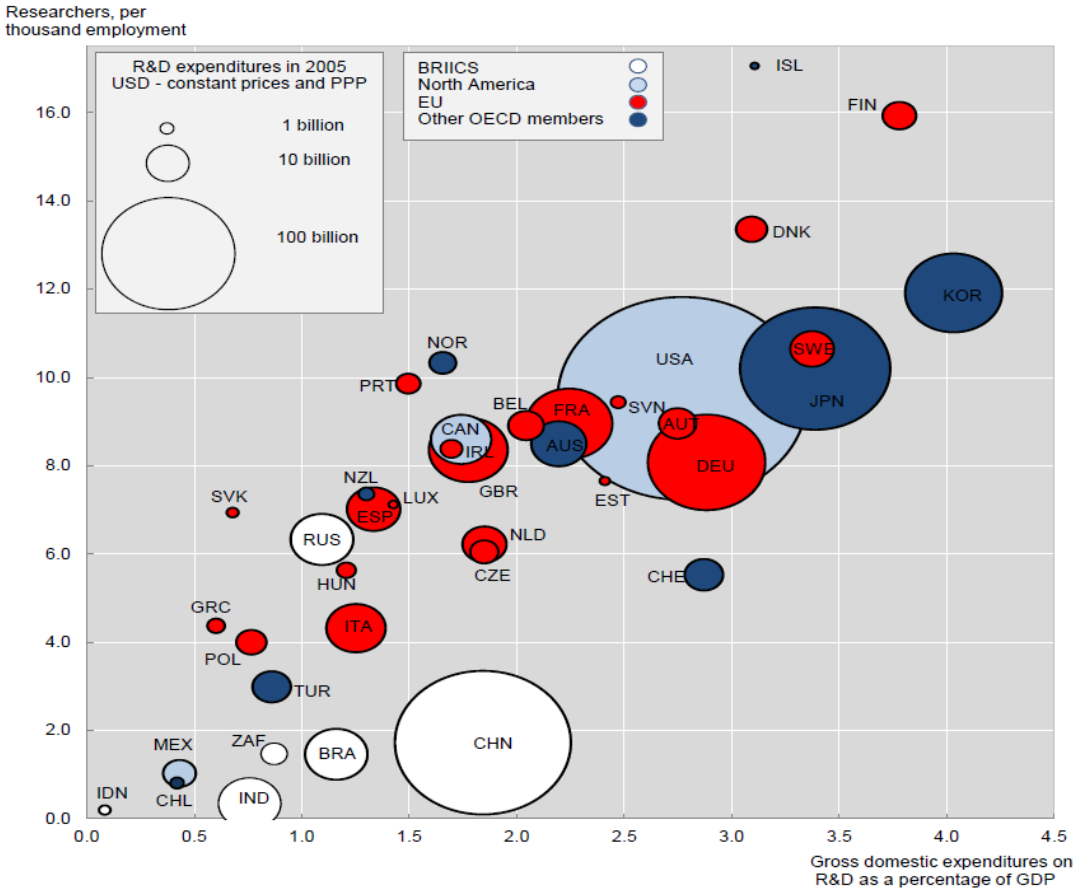
APPENDIX 1: Equity divestment in 2011

Figure I.28. Equity divestment in 2011 and its ratio to gross equity outflows, 2000–2010, from France, Germany, Japan, the United Kingdom and the United States
(Billions of dollars and per cent)



Source: UNCTAD (2013), based on information from the Banque de France; Deutsche Bundesbank, Bank of Japan, United Kingdom Office of National Statistics and United States Bureau of Economic Analysis.

APPENDIX 2. R&D investment in OECD and G20 economies, 2011

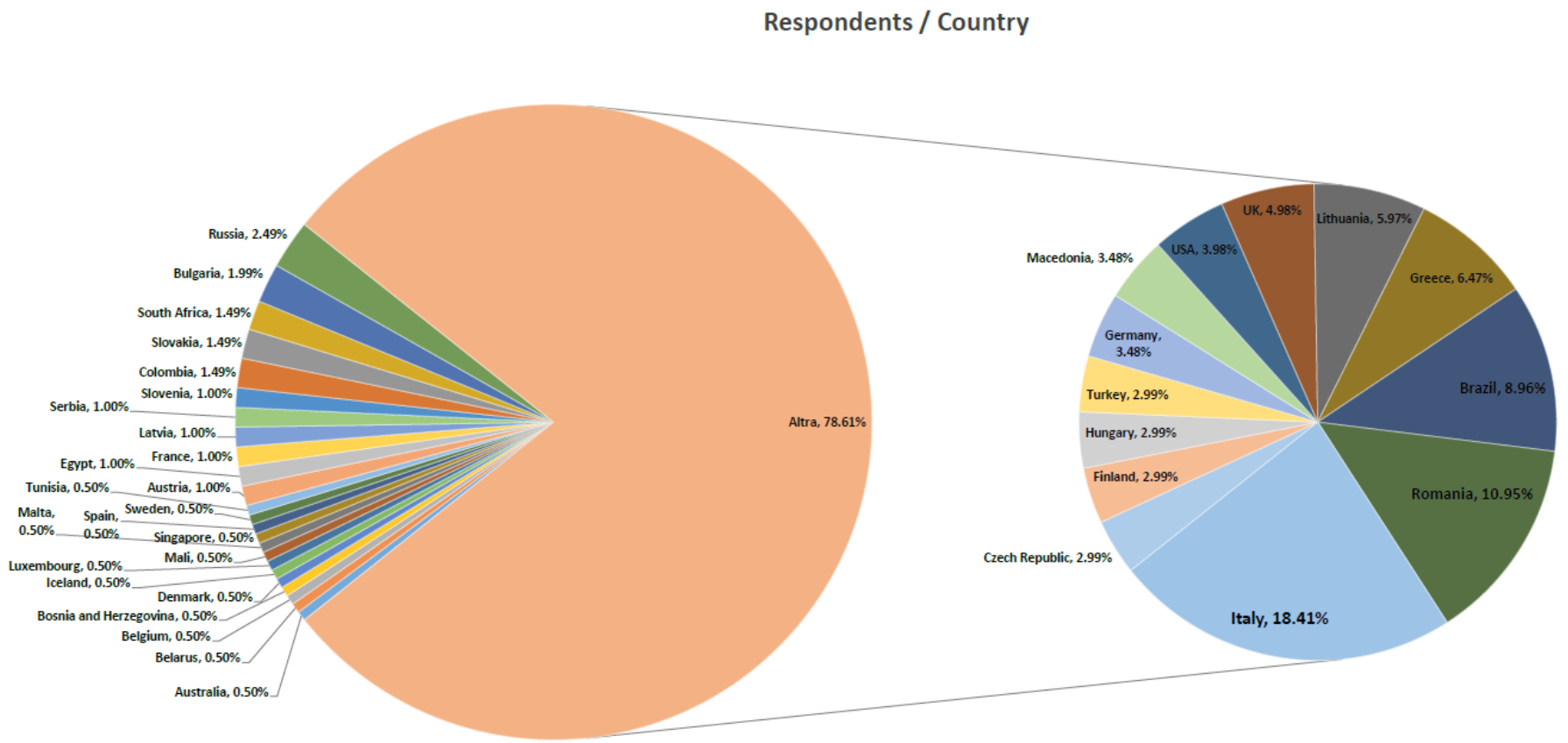


Source. PECD, Science, Technology and Industry Scoreboard 2013

APPENDIX 3. The digital compass as useful tool to match companies' needs

Source. McKinsey & Company (2015)

APPENDIX 4. Respondents' geographic dispersion according to the country



APPENDIX 5. Introductory page of the online survey

INTRODUCTION and INSTRUCTIONS

This survey is developed by the University of Pavia jointly with the University of Vaasa.

AIMS: to investigate and measure how advanced manufacturing systems – in particular **3D printing technologies,** affect the configuration of the **Global value chain** (production, logistics, marketing, etc), as well as their impact on the **firm performance.**

WHY JOIN OUR SURVEY:
a) access to the detailed version of the findings report;
b) on request, a specific report showing the strategic position,strengths and weaknesses of your company compared to the rest of the sample.

CONFIDENTIALITY & PRIVACY: responses are **strictly confidential** since the results will be diffused in an aggregated form only, whilst information about companies will not be used for commercial purposes;

EFFORT REQUIRED: the questionnaire **takes about 10-15 minutes** and consists of 4 sections – a) General Information, b) Global Value Chain, c) 3D Printing / Industry 4.0 and d) company profile.

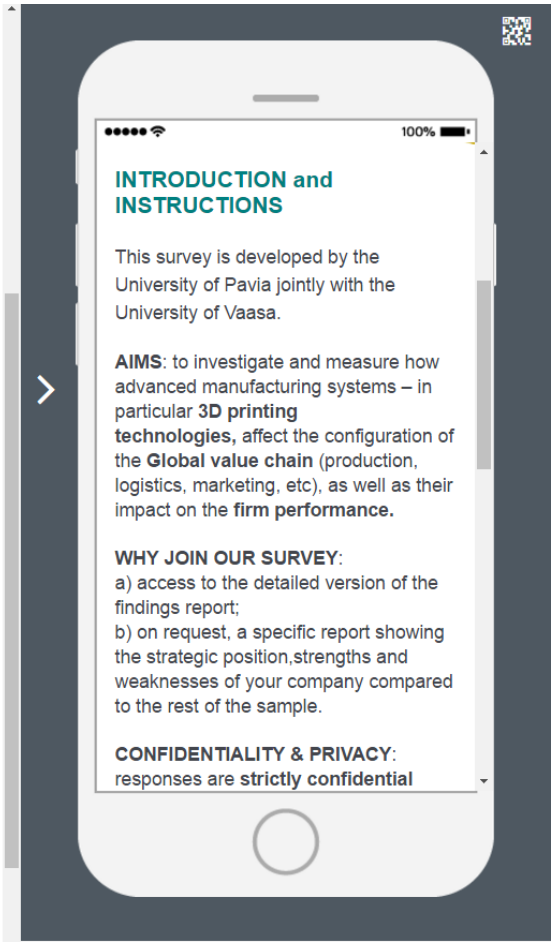
EXPECTED RESPONDENT: manager/expert of the company with a clear understanding of the company's strategy, localization of activities and outsourcing policies, of 3D Printing and other Advanced Manufacturing solutions.

Furthermore, the **possibility to fill in the questionnaire in many sessions at different times** allows to engage more than one person in replying to the questions.

IMPORTANT NOTE: Even if you do not use 3D printing technology, please join our survey and fill in the other questions.

For further information, please contact: stefano.denicolai@eco.unipv.it

Next



APPENDIX 6. Question 2.1 about Governance and Location of respondent's company

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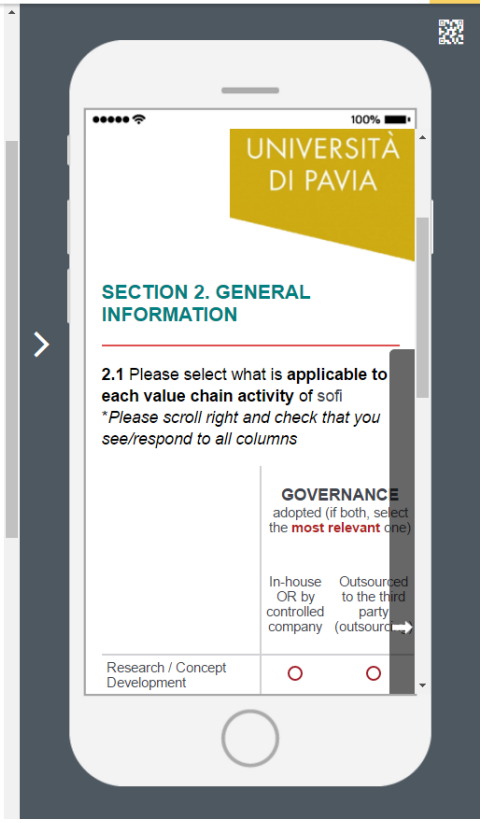
SECTION 2. GENERAL INFORMATION

2.1 Please select what is **applicable to each value chain activity** of sofi
**Please scroll right and check that you see/respond to all columns*

	GOVERNANCE adopted (if both, select the **most relevant** one)		Has sofi experienced any change in **GOVERNANCE** in the last 5 years?			Has sofi experienced any change in **LOCATION** in the last 5 years?		
	In-house OR by controlled company	Outsourced to the third party (outsourcing)	YES	NO	NOT YET, but planned within 5 years	YES	NO	NOT YET, but planned within 5 years
Research / Concept Development	○	○	○	○	○	○	○	○
Design	○	○	○	○	○	○	○	○
Prototyping	○	○	○	○	○	○	○	○
Production (Components & Manufacturing)	○	○	○	○	○	○	○	○
Logistics	○	○	○	○	○	○	○	○
Marketing / Sales	○	○	○	○	○	○	○	○
After Sales / Maintenance	○	○	○	○	○	○	○	○



APPENDIX 7. Question 3.1 investigating the change in governance and location of the respondent's company

SECTION 3. GLOBAL VALUE CHAIN: governance and location of activities and dynamics over time.

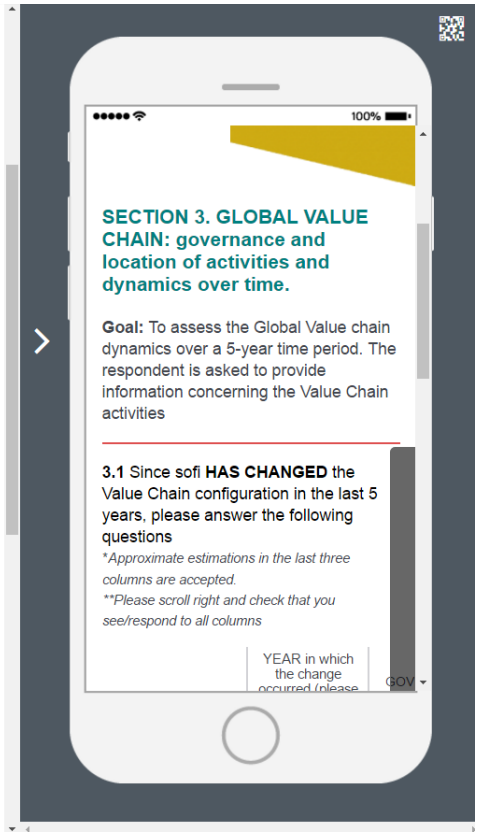
Goal: To assess the Global Value chain dynamics over a 5-year time period. The respondent is asked to provide information concerning the Value Chain activities

3.1 Since sofi **HAS CHANGED** the Value Chain configuration in the last 5 years, please answer the following questions

**Approximate estimations in the last three columns are accepted.*

***Please scroll right and check that you see/respond to all columns*

	YEAR in which the change occurred (please refer to the most recent relevant one)	GOVERNANCE before the change (please specify the most recent relevant one)			LOCATION before the change (*specify the most relevant up to 3*)	What is the IMPACT IN QUALITY due to the change?	What is the IMPACT IN COSTS due to the change?	What is the IMPACT IN TIME TO MARKET due to the change?
		N/A	In-house OR by controlled company	Outsourced to the third party (outsourcing)	Countries (separated by comma)			
Research / Concept Development		○	○	○				
Design		○	○	○				
Prototyping		○	○	○				
Production (Components & Manufacturing)		○	○	○				
Logistics		○	○	○				
After Sales / Maintenance		○	○	○				



APPENDIX 8. Question 4.1 investigating 3DP activities

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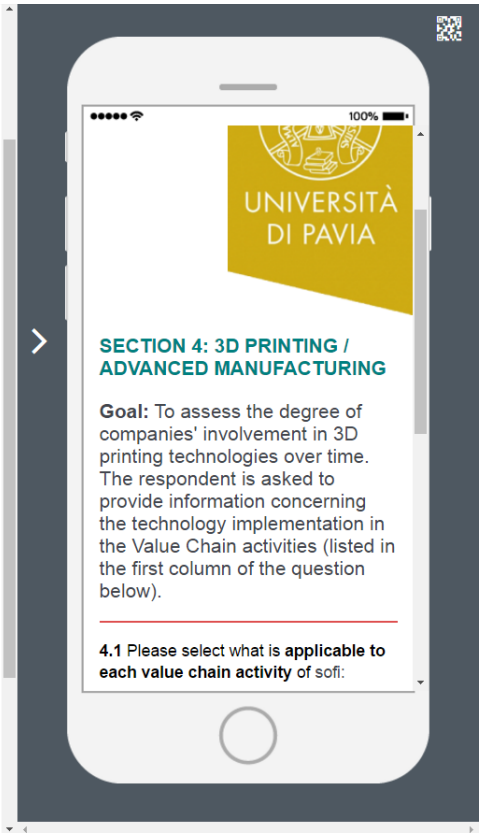
SECTION 4: 3D PRINTING / ADVANCED MANUFACTURING

Goal: To assess the degree of companies' involvement in 3D printing technologies over time. The respondent is asked to provide information concerning the technology implementation in the Value Chain activities (listed in the first column of the question below).

4.1 Please select what is **applicable to each value chain activity** of sofi:

	Has sofi implemented **3D printing solutions** in the last 5 years?		
	YES	NO	NOT YET, but planned within 5 years
Research / Concept Development	○	○	○
Design	○	○	○
Prototyping	○	○	○
Production (Components & Manufacturing)	○	○	○
Logistics	○	○	○
Marketing / Sales	○	○	○
After Sales / Maintenance	○	○	○



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