Department of Business and Management

Chair of Managerial Decision Making

THE RESHORING PHENOMENON AND THE CRISIS IN THE SEMICONDUCTOR INDUSTRY

Prof. Luigi Marengo
Supervisor

Prof. Luca Vitali
Co-Supervisor

Monica Proietti - 743281
Candidate

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To my father,
the silent force behind my successes.

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INTRODUCTION

In recent decades, a change in global dynamics has been observed. Trade between countries has increased, interconnections and ties have strengthened, and borders between individual states have been fading. This trend is called Globalization.
It is possible to find the causes of these new dynamics and world configuration in the various events that have shaped world history. Starting with the discovery of America, which was the first real opening of human and geographic limits and boundaries, through the Industrial Revolutions that favored and encouraged trade and transportation, to the invention of the Internet, which changed the game by facilitating the almost instantaneous exchange of information and goods.

In this new, open and interconnected world configuration, companies have changed their strategies, adapting to the new possibilities offered. It is in this scenario that internationalization strategies find their roots, encountering in the interconnection between countries a way to expand their territory of action, their market and reach consumers on the other side of the world. Subsequent to the decision to open their territorial boundaries, companies find themselves deciding where to locate their business. In this case, companies may prefer to locate parts of the business in the home country, or to move it to other countries, outside their own territory, in order to find locations where it is possible to reduce the costs incurred, this strategy is commonly called offshoring. As companies found themselves making these choices and the location of their business began to be fragmented, a new configuration of a company's value chain was born: the Global Value Chain. The latter exactly incorporates the new configuration of international enterprises, in that it presents a fragmentation and dispersion of the activities that form the enterprise's value chain.

Likewise, the purpose of this analysis is to highlight the new trend that, instead, is characterizing business dynamics, namely reshoring. Recent events, such as the Covid-19 pandemic and the disruptions it entailed, have challenged the great and encroaching fragmentation and dispersion of enterprise value chains. Hence, they have found themselves wanting to bring all parts of their business back home, so as to have more control over it and face the disruptions that have emerged due to the blockage of transportation and trade.

One of the most important crises that has erupted and is still ongoing is in the semiconductor industry. With the term “semiconductor” reference is made to the microchips that are present in any electronic device and allow it to function; thus, these are fundamental products in everyday life, starting from

personal uses to strategic, defense and necessary government needs. The shortage that is being experienced right now, due to the paralysis of the production of this specific product during the various lockdowns of the pandemic, has caused serious and extensive damage both to companies for the production of the electronic devices and to governments, as they are needed for defense and security devices. It is in this scenario that reshoring is related to the semiconductor crisis.

As anticipated, this corporate strategy is a recent trend that has also developed in response to the general uncertainty due to this type of crisis, which is why this paper aims to go into whether the largest leading semiconductor companies have implemented reshoring strategies to cope with the semiconductor crisis.

The first chapter traces the birth and evolution of globalization through the different scholars' conceptions, starting with the discovery of America and arriving to the present, identifying the most important and significant milestones that have enabled the increasingly linked interconnection between states. From the situation that has characterized the world and thus the environment surrounding businesses, we go into detail to analyze how this trend has affected business strategies and organizations. Then, international strategies and ways for businesses to expand and establish themselves in foreign countries are presented. From there, the journey continues by going into more and more specifics, focusing on the main rationales behind the location decision of firms, such as cost reduction and higher profit. This is why the offshoring strategy is presented, through an analysis of the driving forces and the main types of the strategy that have developed over time. Hand in hand with new business strategies that take advantage of globalization to find more cost-effective solutions and, at the same time, expand their territory, value chains are being reconfigured. Indeed, the fragmentation and dislocation of parts of an enterprise's business give rise to a new type of value chain, namely the global value chain. The new configuration is then analyzed, through driving forces and different typologies of it, also discussing extensively of its weaknesses, occurred and highlighted mostly because of the Covid-19 pandemic.

The second chapter focuses on the analysis of the reshoring strategy, the central theme of the paper. The reshoring phenomenon is presented as that corporate strategy opposed to offshoring, through which business parts previously brought and located in foreign countries are reported in the home country. This phenomenon creeps in as a potential strategic response to the challenges of globalization and the complex dynamics of global supply and production chains. The chapter then goes ahead with the description, the driving forces and the various typologies of the phenomenon that have developed

over time, dealing also with the theme of reshoring in relation to sustainability, now central theme both in the external environment and internal to companies. To conclude, the trends that are mainly characterizing the two economic powers, the United States and Europe, are highlighted.

The third chapter deals with the second central theme of the paper, that is, the semiconductor industry and the crisis that has triggered in it. The chapter aims, therefore, to present what semiconductors are and their importance in the global landscape, which is why it has been important to bring this issue to light. Next, the chapter goes into detail to better understand the value chain of this specific product as highly particular, due to its high specialization and, at the same time, its extensive fragmentation and dislocation of the various activities of the value chain. In addition, the market composition and the main trends of this complex and relevant industry are presented. Before going into detail, then, of the crisis we analyze the various global dynamics that are at the basis and necessary to better understand the crisis and the various difficulties between the countries that have intensified this period of high tensions. Finally, it is presented the crisis that has characterized the global landscape of the semiconductor industry resulting in a major shortage that has shut down various industries, moving all the previous balances and creating serious hardship. The chapter ends with the main actions implemented to cope with the chip shortage by the two economic powers considered in the second chapter, namely the United States and Europe,

The fourth and final chapter presents an analysis carried out in order to better understand what the business dynamics were to face the crisis and if it was thought to approach the strategy of reshoring as a possible solution to the aforementioned crisis. For this reason, it was considered necessary to analyze the behaviors and strategies implemented by the top 10 leading companies in the semiconductor industry. Specifically, a focus is then made on each individual company considered, also motivating the criterion used in the choice. In order to have a better overview of the crisis, which have impacted the part of the value chain related to the production of the chips, the locations of the semiconductor production stage were analyzed. Then, the analysis continues by identifying where each company located the factories of the two main semiconductor manufacturing stages, analyzing them separately. Subsequently, it deemed necessary to analyze the factories under construction and those announced for future construction, so as to understand how companies are moving in the localization of their enterprises. To better understand if reshoring strategies can be identified, a further focus has been made on closed or decommissioned companies. In conclusion, the final considerations were made in the light of the data obtained. Therefore, the analysis was carried out in order to obtain

a complete picture of whether companies have decided to move or not the location of production plants in response to the crisis and if possible reshoring strategies can be recognized.

1 INTERNATIONALIZATION, OFFSHORING AND GVCs

1.1 Globalization and international strategies

In recent times, increasing global integration has been observed. That is, various historical events, such as the discovery of America and the Industrial Revolutions, have encouraged an ever-closer connection between states. This has been fostered, therefore, both by the discovery of new territories and the invention of new tools, that have facilitated transport and the exchange of information and goods. Especially in recent decades, with the invention of technology and the Internet, people no longer looked at the world as a collection of separate states, but the world as a single state.

In this section, globalization and the resulting new configuration of corporate strategies are presented.

1.1.1 Globalization and multinational enterprises

It is not possible to talk about the location decisions of companies, such as offshoring and – the opposite – reshoring, without mentioning the macroeconomic context that has contributed to their development: Globalization.

Globalization is the trend that has characterized the last decade and it refers to the process that led to the creation of a global market, where products, services and capitals are internationally traded.

Firstly, it is necessary to give a definition of this phenomenon. The Organization for Economic Co-operation and Development (OECD)[1] defines Globalization as "a dynamic and multidimensional process of economic integration whereby national resources become more and more internationally mobile while national economies become increasingly interdependent."

This term has started to be widely used in 1980s, when the interdependences between countries have been accelerated by the technological advances. Nevertheless, it is a view shared by several scholars that this phenomenon began many years earlier.

Some scholars attribute the "big bang" of the globalization process to many decades ago, specifically to the dates 1492 (the discovery of the Americans by Christopher Columbus) and 1498 (The circumnavigation of Africa by Vasco da Gama), considering the period after 1500 as the inauguration of "a genuinely global epoch of world history" (Bentley 1996) opening doors to international trade. According to this interpretation, the sociologist Andre Gunder Frank stated that "there was a single global world economy with a worldwide division of labor and multilateral trade from 1500 onward".

[1] The OECD is an international organization of 38 members founded in 1961 to discuss and develop common solutions to economic and social problems.

Others attribute the birth of globalization to times even before 1500, like Jerry Bentley that took into consideration the trade networks and large volumes of commerce that reached almost all regions of Eurasia and sub-Saharan Africa (Bentley 1999) or Janet Abu-Lughod who referred to the *pax Mongolica*[2] that led the trade and exchange move relatively freely from northwestern Europe to China in the century before 1350.

Instead, other scholars such as Rourke and Williamson in their working paper "When did globalization begin?" stated and demonstrated that before 1800 the international economy was fragmented and poorly integrated and the process of globalization began in the early nineteenth century. In this period, thanks to the steam revolution and the Industrial Revolutions, transport increasingly facilitated the exchange of goods between countries, making it cheaper and cheaper.

Despite this, from the early 1900s onwards, due to the two major World Wars, globalization took a step backwards, slowing down considerably, only to resume its course at the end of the World War II, when different agreements were stipulated with the aim of regulating the world trading system.

In 1947 the General Agreement on Tariffs and Trade (GATT) was signed by 23 countries to establish the basis for a multilateral trading system aimed at promoting global trade liberalization, and after this followed eight more agreements to regulate free trade between countries more and more effectively. In 1995, this agreement will be included in the newly created World Trade Organization (WTO), an international organization born for promoting free global trade by opening up national markets and progressively removing barriers to global trade in goods and services.

At the same time, from 1944 to 1970s, the Bretton Woods agreements were in force. In Bretton Woods 44 countries came together to set up the system that regulated monetary and financial relations between nations, with the establishment of the World Bank and the International Monetary Fund, having the task of balancing international payments. This compromise highlighted a desire for a world in which different states are increasingly interconnected, through the rise of a fully agreed monetary order, designed to govern monetary relations between independent states.

From 1970, international trade was definitively liberalized, giving way to an ever-increasing interdependence between states, which will promote the emergence of large companies operating internationally. The factors that encouraged this permanent opening were the rapid increase in technological innovation and government trade policy liberalization. The promotion of trade liberalization by governments aims at removing economic and financial barriers to stimulate the connection between different economies. It is clear that this decision has an impact on price of goods,

[2] With this term reference is made to the ease of cultural exchange and trade between the West, the Middle East and the Far East between the 13th and 14th centuries under the Mongol Empire (1206), which covered most of the territory from East Asia to Central Europe.

allowing a drop on tariff rates and, consequently, boosting the decision of companies to invest abroad. This has also been encouraged by technological, transport and communication developments and, so, an increasingly ease of exchange between countries. Moreover, with a greater and global market, opportunities to reduce costs and exploit market synergies increase significantly.

For these reasons, globalization promoted the internationalization of companies.

In this framework, a new era began with the international business, a term that refers to the all the commercial transactions which occur between two or more regions, countries and nations across their political boundaries (Radebaugh & Sullivan, 2007).[3] Business is no longer seen as a matter of a firm established in its home country and that operates only in its national borders, but the perspective widens with a new concept of doing business incorporating links between nations.

Companies that operate with an international perspective are called multinational enterprises (MNEs). A multinational enterprise is a company or corporation which has a relevant number of resources and works in various business activities through a network of branches located in different countries (Cavusgil et al. 2008).[4] These types of enterprises were born accordingly to the benefits given by globalization, that is to say the ease of reaching different countries where companies can exploit lower costs. Moreover, the blurring boundaries of a firm can increase the possibility to earn bigger profits, through the exploitation of broader markets. Finally, a firm that reaches other countries can benefit from unexplored or unexploited regions where it can establish itself and become the new market leader.

1.1.2 Entry strategies and international strategies

When a company decides to open its boundaries and start working internationally, it has to decide how to enter the new market abroad, with respect to its scope and its internal characteristics.

The different foreign market entry strategies are classified in two main groups: non-equity mode and equity-mode. The difference between these two types of strategies is based on the use or non-use of equity when the investment abroad is made. The consequence of the use of equity is a higher level of risk due to a direct investment with an equity capital of the firm, but at the same time it gives a higher market control and expected return on investment.

According with the degree of equity involved, it is possible to identify six entry modes.

[3] Ristovska K., Ristovska A. (2014) The impact of Globalization on the Business, *Economic Analysis*, Vol. 47, No. 3-4, 83-89.

[4] Ristovska K., Ristovska A. (2014) The impact of Globalization on the Business, *Economic Analysis*, Vol. 47, No. 3-4, 83-89.

Exporting

The first entry mode, which is the most used, is exporting. Exporting is the act of producing goods or services in one country and selling them in a different country. There are two main types of exporting: direct and indirect. While the indirect export uses other agents to sell abroad, for the direct one is the firm itself who is involved in distributing its products or services in the other countries. This type of entry mode is the least risky, given the fact that there is no economic investment in the other country. Indeed, in this case there is neither the establishment of a subsidiary in the new country nor transfer of know-how, companies just produce their products at home and sell them abroad.

Licensing

The second entry mode is licensing. Licensing is based on the stipulation of a contract by which one company (licensor) grants another company (licensee) the right to use a patent, trademark, know-how or any other important element constituting intellectual property to manufacture a certain product and, possibly, the right to market it, against payment of a fee. In this case, the firm doesn't have to bear the development costs and risks associated but, at the same time, the licensor doesn't have the tight control over the licensee, which can lead to lose the proprietary technology or it can compromise the image of the main firm.

Franchising

The third entry mode is franchising. Franchising is a contract between two independent parties whereby one party (franchisor) grants the other (franchisee), in return for payment of a fee, a set of rights (such as trademarks, names, patents, know-how, assistance and consultancy, etc.) by incorporating the franchisee into a networked system articulated over the territory, for the purpose of marketing goods or services. Licensing and franchising are two very similar agreements, but the main difference is that with the latter the main firm has a tight control over the franchisee. For this reason, the franchisee has to submit to certain rules and standard dictated by the franchisor. Moreover, franchising tends to be longer and usually requires greater financial investment.

Joint Ventures

Another entry mode is through the creation of a joint venture. Joint ventures are contractual agreements between two or more parties for the realization of a project for which the partners (parent companies) undertake to make the necessary investments. It is a new company created by two or more operators of different nationalities for the realization of clearly specified activities and is therefore set up with a precisely defined time horizon. In this case, one partner is the main firm which wants to

enter the market in a new country, while the other one is a firm established in the country of destination. Consequently, this kind of entry mode gives to the main firm the benefit of exploiting the local partner's knowledge of the host country's competitive conditions, culture, language, political and business systems. Being part of the agreement two or more firms, costs and risks are shared but, at the same time, the main firm risks giving control of its technology to its partner and the shared ownership can lead to conflicts and battles for control.

Direct investments

Another entry mode is through a direct investment in the destination country. A direct investment involves 100% ownership of the stock of the subsidiary. There are two types of direct investment: greenfield strategy or brownfield strategy. While with the greenfield strategy the main company create a new organizational unit, with the brownfield strategy the company acquires an established firm. The main difference between these two strategies is the level of risk and the entry speed, both lower for the brownfield strategy.

Strategic alliances

The last entry mode is through a strategic alliance. Strategic alliances are agreements between two or more separate companies, that can be actual or potential competitors, to cooperate for specific business objectives. Differently from the joint ventures, which are structured alliances, this type of entry mode is usually created for short periods and the major objective is the exchange of technology.

Once a company is established in the new market abroad, the strategy to pursue has to be defined. In a global market, a company typically faces two types of competitive pressures: pressure for cost reductions and pressure for local responsiveness. The first one refers to the need of lowering costs in order to be competitive abroad, while the second one refers to the request to respond to local customers' needs and preferences.

In this framework, characterized by these two pressures, it is possible to identify four main different strategies that a company can pursue, when operating in an international context, according to its needs and goals.

International strategy

When both pressure for cost reductions and pressure for local responsiveness are low, a company should pursue an international strategy. This kind of strategy involves the selling of the products abroad with only minimal local customization. In this case, the company considers the global market

as one big market where it offers its standardized product achieving economies of scale, which allow the firm to reduce costs.

Global Standardization strategy

When pressure for cost reductions is high while pressure for local responsiveness is low, a company should pursue a global standardization strategy. In this case, a firm focuses on increasing profitability and profit growth by reaping the cost reductions that come from economies of scale, learning effects and location economies, with minimal attention to local needs.

Localization strategy

When the pressure for local responsiveness is high and the pressure for cost reduction is low, a company should pursue a localization strategy. This type of strategy is based on adapting the company's products or services to meet different local tastes and needs. Typically, this strategy is well suited when there are significant differences in consumer tastes and preferences across nations, and so a firm decides to focus on satisfying all the different needs with little attention to cost reduction.

Transnational strategy

The last strategy is the most complex because it balances both pressures. Indeed, when both the pressure to reduce costs and the pressure to be locally responsive are high, the transnational strategy is the most appropriate. In this case, a company tries to simultaneously achieve low costs and differentiate its product offering across markets with respect to local differences.

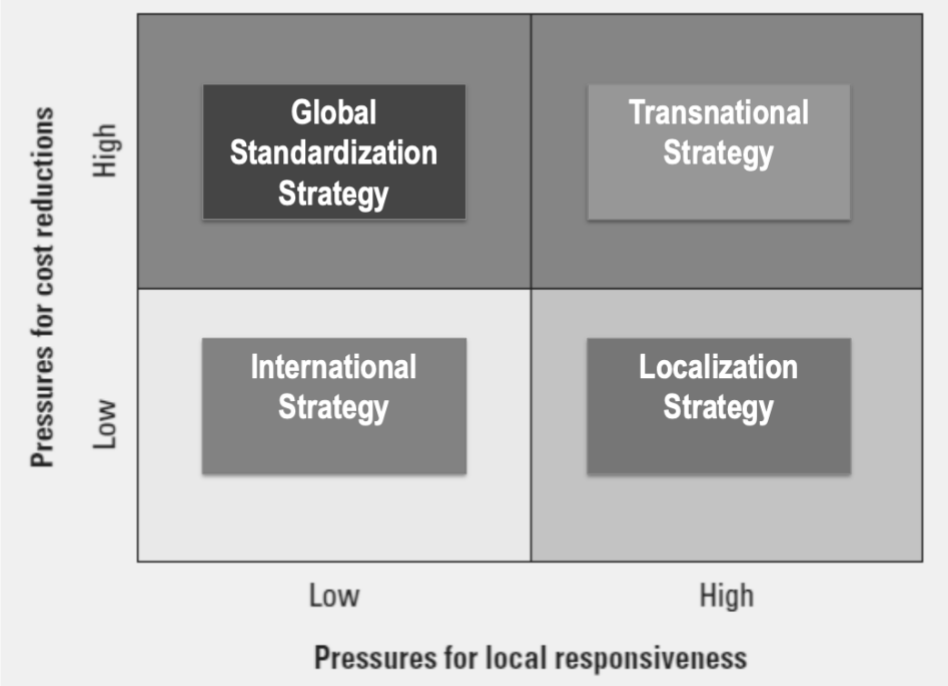

Figure 1. Strategies of international business.
(Source: Bartlett, C.A. and Ghoshal, S., 1989)

1.2 The offshoring phenomenon

During the internationalization process, after choosing the mode of entry and the strategy to be used, the company chooses where to locate each activity of its value chain. Thanks to the advantages of globalization, it has been shown that it is favorable to move part of the production process abroad, where lower costs can be exploited, and higher returns can be achieved.

In this sub-section, the phenomenon of offshoring is examined.

1.2.1 Description and driving forces

In relation to globalization and the new conceptualization of the business, strategic location decisions of companies have changed. While before the opening of markets companies did not question themselves if locate part of the company structure outside the home country, with the new trend companies started to think how they could exploit the interconnection of countries and the new technologies, through which international trades proved easier.

Starting from 1990s with the first wave and with the maximum expansion in the early 2000s, a new phenomenon called *offshoring* has developed, with the main objective of reducing costs through a reconfiguration of business processes.

The term offshoring refers to the situation in which a firm decides to locate an activity outside of the company's boundaries. The main reasons for locating an activity outside the firm's boundaries are

varied. One of the most important rationales is certainly the choice of a location where the company can reduce its costs, thus increasing its performance and, therefore, the competitiveness of the company itself. Indeed, the initial impetus for offshoring was believed to be precisely to find countries where labor or raw materials cost less, in an effort to make higher profits.

In line with this view, it is possible to see in the table below that the main countries as final destination for offshoring in 2021 are India and China, showing the highest score especially with regard to “financial attractiveness” and “people skills and availability”. Whereas the highest score for "business environment" and “digital resonance” is held by the United States, which, on the other hand, is very deficient for the “financial attractiveness”.

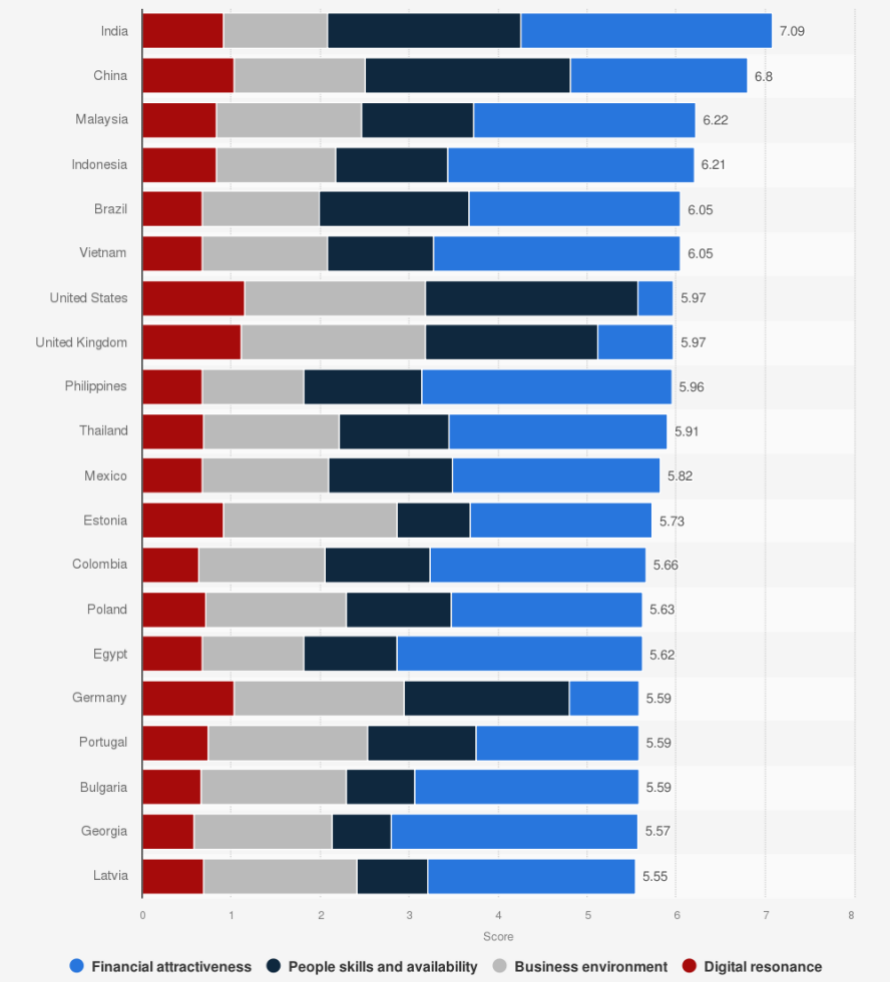

Figure 2. Leading countries in offshore business services worldwide 2021. (Source: Statista)

The driving forces that made offshoring increasing favorable and popular are grouped in different environmental conditions: economic driving forces, political-legal conditions, socio-demographic driving force, technological driving forces (Hitt et al., 2002).[5]

- Economic driving forces comprise those factors related to wage differentials between countries, interest rates, development of capital markets, capital costs and the emergence of technology centers. All these factors promote the increasingly use of offshoring model, due to the fact that a firm can exploit better economic conditions in other countries.
- Political and legal driving forces refer to taxation, labor and competition laws, and trade barriers. These factors are consistent with the development of globalization and the liberalization of markets. For example, the liberalization of international trade and, so, the removal of trade barriers favored the interconnection between countries. The ever-increasingly openness of markets also resulted in exploitation of labor conditions and environmental regulations due to the difference in laws between countries. In this framework, the conditions for the rise and development of offshoring have been increasingly supportive.
- Socio-demographic driving forces are mainly population size, age structure, education levels and work force motivation. These driving forces are related to the new human resources pools and workforce centers that have emerged and that have favored the exploitation of new countries by firms.
- Technological driving forces is the last category in which advances in technologies, such as internet, mobile telecommunication and transportation infrastructure developments are grouped. With respect to these advances, international exchanges and trades are facilitated. Firstly, these new technologies eliminated geographical distances through creation of bridges and, consequently, the relocation of activities have been facilitated. Secondly, the transfer of any product and, as a result, logistics has become less and less expensive.

To conclude, the offshoring phenomenon is encouraged by some external factors that shape the international environment. All the economic, political and legal, socio-demographic and technological drivers presented in the list above contributed to the development of the offshoring model.

[5] Jahns, C., Hartmann, E., & Bals, L. (2006). Offshoring: Dimensions and diffusion of a new business concept. *Journal of Purchasing and Supply Management*, 12(4), 218–231.

1.2.2 Types of offshoring

As Jahns, C., Hartmann, E., & Bals, L. stated in their working paper "Offshoring: Dimensions and diffusion of a new business concept", the terms "offshoring" and "outsourcing" are wrongly used as synonyms. With the aim of highlighting the differences between these two practices, they elaborated a framework to better understand it.

The relevant elements for differentiating them are "contractual/legal dimension" and "geographic dimension". The former refers to the degree of ownership of the model, divided in three types: "buy" that relies on a third-party provider, "make" identified as fully owned subsidiary, and "hybrid" as joint ventures. The latter is divided in "onshore", "nearshore" and "offshore". The onshore dimension represents the "in-house" activity of a firm, that can be on the premises of the firm – onsite – or outside the premises but in the same country – offsite. For what concerns nearshore and offshore, it is similar to onshore, given the fact that relies on internal premises of the firm, but it refers to the countries near the home country – nearshore – or countries far away from the home country - offshore. According to this matrix, there are different offshoring business models concerning the offshore geographical dimension.[6]

- Firstly, *Offshoring Outsourcing* regards the selling of projects by the main firm to a third-party provider far away from the home country. In this case there is a disaggregation of the supply chain due to the fact that the main company gives away a step of the internal processes.
- Secondly, *Offshore Development Centers* is the business model centered in the creation of a joint venture with another firm. It is a hybrid form through which the main company still has an involvement in the project.
- Thirdly, *Captive Shared Services* concerns the "in-house" activity, since they are kept internally, but the location is outside the home country.

[6] Jahns, C., Hartmann, E., & Bals, L. (2006). *Offshoring: Dimensions and diffusion of a new business concept*. Journal of Purchasing and Supply Management, 12(4), 218–231.

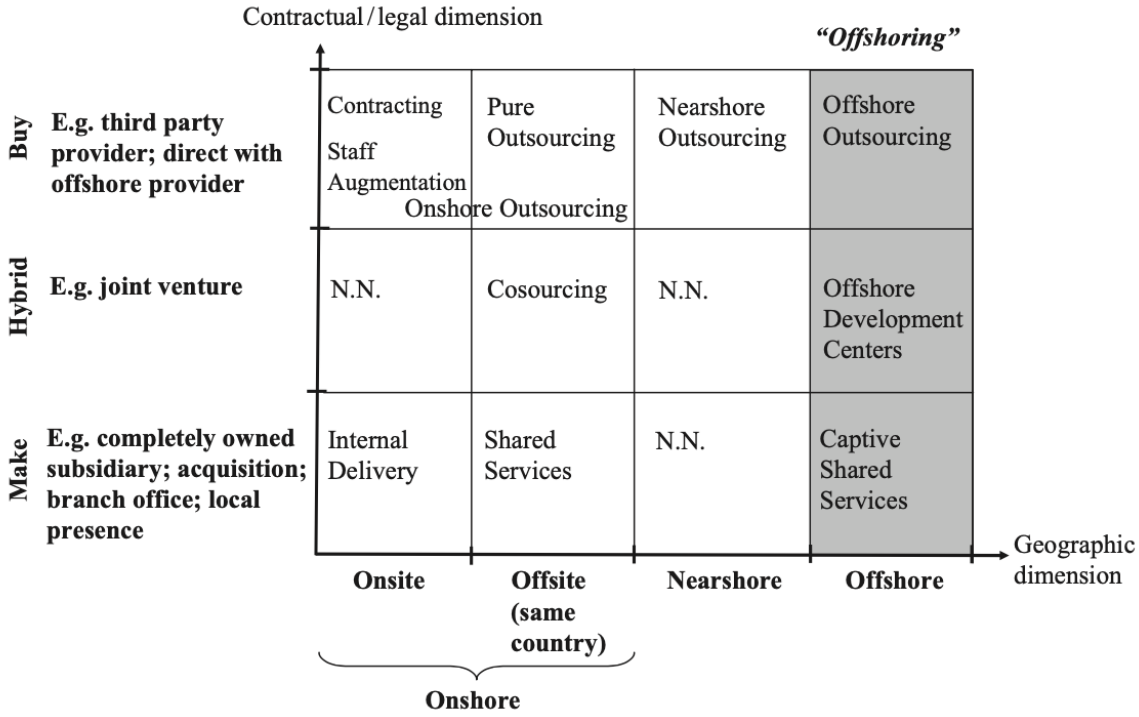

Figure 3. Differentiation offshoring business models.
(Source: Jahns, C., Hartmann, E., & Bals, L., 2006)

This matrix demonstrates that offshoring is characterized by three different business models, which incorporates offshoring outsourcing. When talking about "outsourcing", the reference is made to that kind of business model that relies on a third-party provider and so a disaggregation of the firm's value chain is required. Whether it refers to the act of bring an activity outside the borders of the home country but keeping it within company activities, "offshoring captive shared services" or "captive offshoring" is the appropriate term.

1.3 Global Value Chains (GVCs)

In this paragraph the new configuration of the value chain of the international firms, resulting from the dispersion of activities outside the company's boundaries, is presented.

First of all, it is necessary to introduce the general concept of the value chain.

The value chain of a firm is the structure that includes all the processes and activities needed to the creation and selling of a product or a service and its related value. It was firstly introduced by Michael E. Porter, who gave a precise configuration of how a value chain of a firm could be. He divided the firm's activities in two main categories: primary activities and support activities. The former is the category composed of those vital activities for the competitive advantage of a company as well as those activities without which it is not possible to create value, and they are: inbound logistics, operations, outbound logistics, marketing & sales and service. The latter is the group of those

activities that support the first ones and help the enhancement of the final product, such as: firm infrastructure, human resource management, technology development and procurement. The margin is the earning of the firm, given by the difference between the revenues for the selling of the products or services and the cost of these activities, used for creating them.[7]

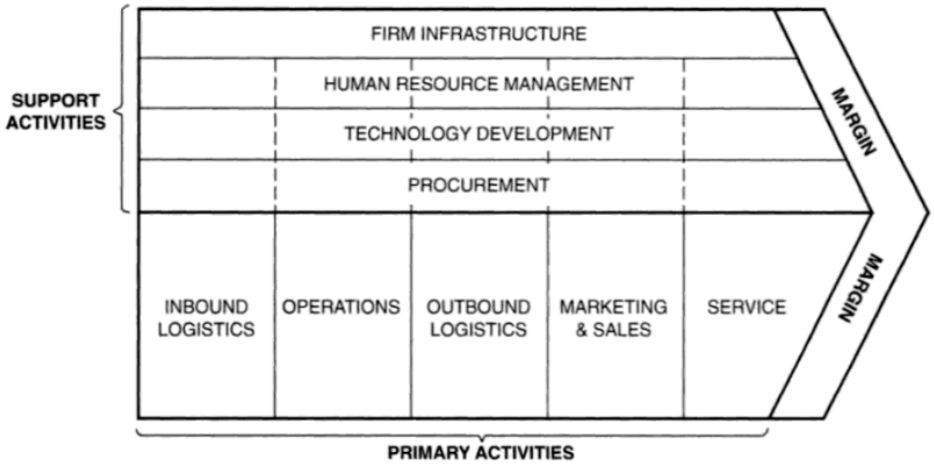

Figure 4. The generic value chain.
(Source: Porter, M. E., 2001)

With this configuration, Porter presents a model that lets the firm understand how the same is creating the value of the product and its competitive advantage.

1.3.1 Description and driving forces

After having analyzed what a firm's value chain is, it is possible to talk about the new international configuration of international business: Global Value Chain.

With the trend of globalization and, so, with the presence of firms in a global market, there is no more a completely all in-house value chain, but it is dispersed around the world. Therefore, since the early years of this century, the ability of companies to 'fragment' the value chain into specific activities has increased, with the aim of locating each of them in the most productive and convenient geographical areas. In this context it is possible to talk about Global Value Chain.

The term "Global Value Chain" (GVC) describes the situation in which the various activities of the production process (design, production, logistics, marketing, market services and the various support activities) are carried out in many different and not necessarily neighboring countries.[8]

Thus, starting from Porter's general value chain, reference is made to a configuration that does not have all activities in the home country, but gives the possibility to have parts of the process located

[7] Porter, M. E. (2001) The value chain and competitive advantage. *Understanding business processes*, *2*, 50-66.

[8] Caroli M., (2020) *Gestione delle imprese internazionali*, McGraw-Hill Education.

in other countries, in some cases close to the country of final distribution. However, the decision to take production steps outside the company's borders is often traced back to an analysis of competitive resources. Companies usually move those activities that are not part of their competitive advantage away from the company's borders, as greater distance implies less control. It is, therefore, common to keep close those areas that are part of the set of core resources and capabilities that form the competitive advantage of the company.

According to Caroli, the factors that have favored its widespread diffusion can be grouped into three categories:[9]

1. The high geographical fragmentation of operations, which is possible thanks to the reduction of transport and logistics costs and the sharp increase in efficiency and effectiveness of communications, including international ones.
2. The strong and widespread liberalization of trade and productive investment between countries.
3. The development of new large geographical areas in which it was convenient to locate production activities instead of their home territory.

This new configuration of the internal structure of companies not only has positive effects within the company itself, such as a reduction in production costs, but has also favored work in emerging countries. In fact, the fragmentation of production activities abroad has created jobs for those companies and emerging countries that otherwise would not have been able to enter a global market.

1.3.2 Types and governance of Global Value Chains

It is possible to subdivide the types of global value chains into two: buyer-driven and producer-driven. Regarding the first type, the value chain is typically driven by marketing, design and distribution activities and the production steps are generally outsourced. While the second type is based on research and development activities (R&D), typical of high-technology sectors being their competitive advantage. Thus, in this case, the company presides over these activities, while fragmenting and outsourcing those further downstream.

Global value chain management is effective if, although carried out by business units located in different geographies, it remains highly integrated. To this end, governance mechanisms are essential. Governance is defined by Gereffi et al. "as non-market coordination of economic activity".[10]

[9] Caroli M., (2020) *Gestione delle imprese internazionali,* McGraw-Hill Education.

[10] Gereffi G., Humphrey J., Kaplinsky V., Sturgeon T.J., (2001). Introduction: Globalisation, Value -Chains and Development, *Institute of Development Studies*.

Governance is the central element in the analysis of the global value chain, as it describes who the participating actors are and the relationships between them and how corporate power is divided in relation to the distribution of profits and risks.

Within the value chain, the main company holds the power. In the 'producer-driven' type of chain, as seen above, power is held by the final-product manufacturers, whereas, in the 'buyer-driven' type of chain, power is held by the final-product marketers.

Gereffi, in its paper "Why the world suddenly cares about global supply chains", synthesizes in a matrix the various forms of GVC governance, in relation to the role played by lead firms.

In the matrix, it can be seen that the links between the various industry activities that are part of the chain are represented as a line that starts from the loosest form identified in that of the market and arrives at a hierarchical structure. In between are the other three types: modular, relational and captive.[11]

- *Market governance* is characterized by simply transactions in which agents are relatively independent. Price is the central element that governs transactions and suppliers make products with little coordination with buyers.
- *Modular governance* involves an exchanging of information due to the fact that suppliers create products based on complex customers' specifications, but these are relatively easy to codify. With the information flow, buyers and suppliers reduce coordination costs.
- *Relational governance* requires a higher frequency of interactions between buyers and suppliers since the main characteristic is the complex and no easily transmitted information. Knowledge sharing based relationships, interactions, mutual trust and social ties are at the basis of this type of governance.
- *Captive governance* exists when there are a group of small suppliers that rely on one or few buyers both for resources and market access. Conditions and rules, in this case, are completely set by the lead firm or the few buyers.
- *Hierarchy governance* is the representation of an integrated firm where chain is vertical integrated and the managerial control is all within the lead firm, which create products in-house.

[11] Gereffi G., & Lee J. (2012) Why the world suddenly cares about global supply chains. *Journal of Supply Management*, 48(3), 24-32.

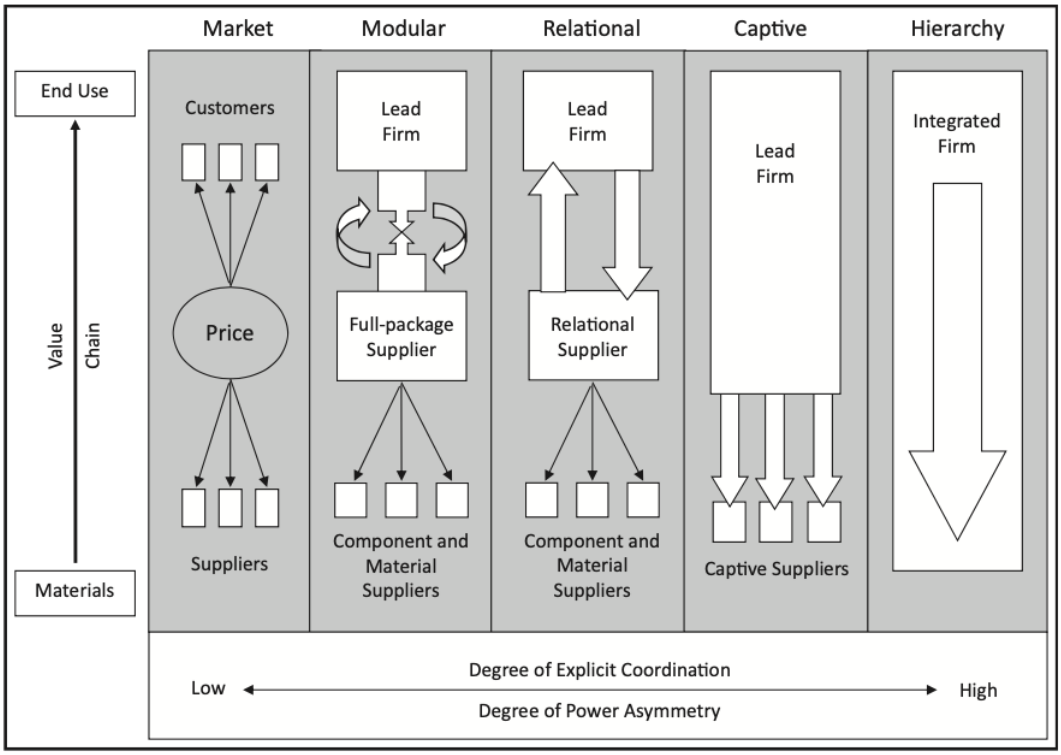

Figure 5. Five types of Global Value Chain Governance.
(Source: Gereffi G., & Lee J., 2012)

1.4 Effects of Covid-19

When talking about the global value chain, it is necessary to consider global dynamics but, above all, exogenous shocks that can alter the global balance. This is because, as the activities of the various companies are geographically dispersed, it is essential to monitor not only the situation in firm's home country, but also in all those in which the company operates. The strong interconnections and interdependencies between countries and companies bring with them many benefits, such as those discussed in the previous paragraphs, but also risks. Having strong links with suppliers and firms located all over the world can expose companies to great fragility when the balance is upset.

One shock the world has had to face recently is that of the Covid-19 pandemic. This type of shock is one of the biggest and most influential that can affect and destroy global business-to-business dynamics. Moreover, it is not a financial crisis, for example, whose damage is limited to the industry, but also affects people's health.

This pandemic crisis came at a time of 'plateauing of GVC expansion' when the initial push for internationalization and global value chain models was slowing down. The decision by many companies to transfer parts of the value chain abroad had begun to saturate the market, leading to higher wages in the initially emerging markets. In addition, digitalization, automation of production and the economy's greater service orientation, together with a demand for greater sustainability and

fluctuations on transportation costs, were the reasons why the phenomenon of bringing activities home, the so called 'reshoring', was gaining momentum.[12]

This is when the Covid-19 pandemic breaks out. People forced to stay at home, the lack of workforce because of the illness, and then the physical lack of necessities. The rush for groceries, such as the lack of safety equipment needed to circulate, like masks and gloves, and medical equipment to care for people. It is impossible to prepare for this kind of shock, and if suppliers are few, with an explosion of demand the system could only go into crisis. This shock highlighted the fragility of global value chains: when there is a shock of this caliber at global level, companies break down. The fact that various activities are located across countries in lockdown, that transports are blocked, and that economic activities are restricted, creates enormous inconveniences for companies. Moreover, the fact that global value chains require strong integration between countries, those linked with China have certainly taken a bigger hit. The question is whether global value chains could have facilitated the spread of the pandemic and shock. It is in this context that the evaluation of a return home of activities is made.

In the figure below the Global Value Chain Participation Rate is represented, which is an estimate of how much an economy is connected to global value chains for production and foreign trade, thus participation in international trade. In this case the global economy is considered as a whole.

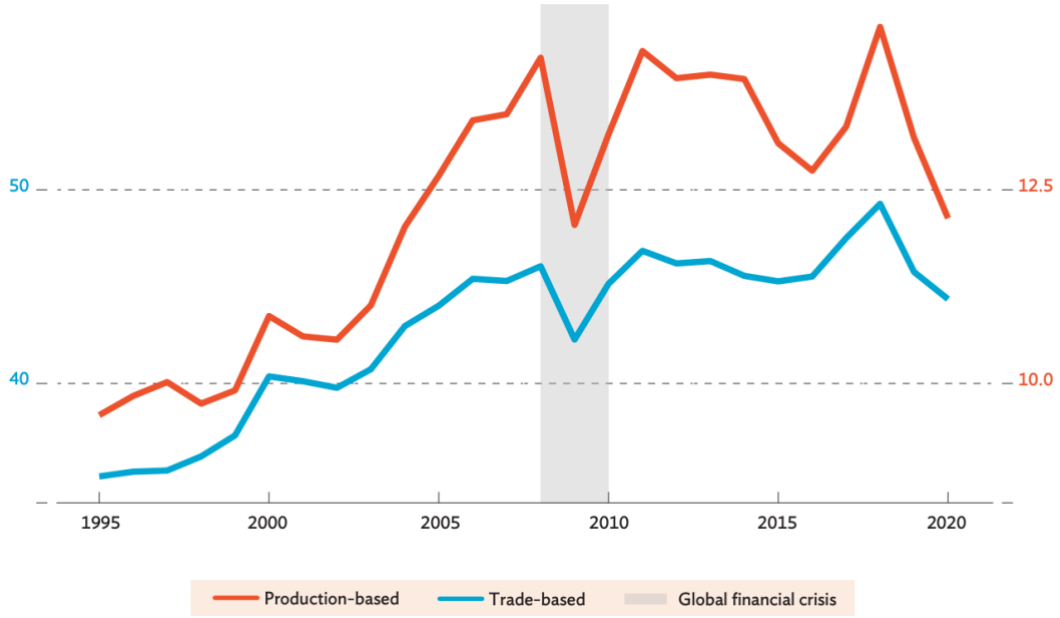

Figure 6. Global Value Chain Participation Rates, World, 1995-2020.
(Source: Alvarez, J. B., et al, 2021)

[12] Arriola, C. et al. (2020), "Efficiency and risks in global value chains in the context of COVID-19", *OECD Economics Department Working Papers*, No. 1637, OECD Publishing, Paris.

It is, therefore, possible to see that in periods of shocks such as the 2007 global financial crisis and the Covid-19 pandemic, the index drops rapidly. In fact, the financial crisis of 2008 caused a momentary closure among international trade, and, as a result, a partial reshoring that lasted until 2010, at which time the borders reopened. The same behavior can be seen following the Covid-19 pandemic, where there is a sudden fall of the same magnitude as in 2007.

From this point on, various analyses have opened: some believe that more localized production kept close to national borders can bring greater security in relation to these shocks and, in general, stability; while others believe that it is necessary to have as many suppliers as possible and, therefore, to relocate as much as possible.

Regarding the latter, reference is made to the theme of concentration/diversification. As in finance, the more one tends to diversify, the greater the dispersion of risk, so the less the risk's exposure. The same concept is applied to this analysis: that is, the concentration of many hubs in the same country increases the possibility of being exposed to risk and volatility and, thus, the rapid propagation of the shock along the value chain.[13]

The OECD carried out research in 2021, in its paper "Global value chains: Efficiency and risks in the context of COVID-19", to understand how global value chains react to shocks, and thus their costs and benefits, analyzing the difference between 'interconnected' and 'localized' regimes. The former is a regime in which production in the global value chain is fragmented. Whereas the second presents a regime in which incentives to find foreign inputs are reduced, as happens during shocks and as happened during Covid-19, and firms are limited in passing from one input source to another, implying a consequent rigidity of the international supply chain. The reasons for the reduction in a shock can be found in the fact that tariffs on imports rise rapidly and the fact that national subsidies are always used that favor local production. In this case, the OECD assumes an increase of 25% in import tariffs on all traded products and 1% of GDP directed to labor and capital in domestic non-service sectors in each country, for what concerns the national value-added subsidies. So, for what concerns the localized regime, domestic production is encouraged while the international trade is disincentivized.[14]

[13] Arriola, C. et al. (2020), "Efficiency and risks in global value chains in the context of COVID-19", *OECD Economics Department Working Papers*, No. 1637, OECD Publishing, Paris.

[14] OECD (2021), "Global value chains: Efficiency and risks in the context of COVID-19", *OECD Policy Responses to Coronavirus (COVID-19)*, OECD Publishing, Paris.

To do this research, the model used by the OECD is the computable general equilibrium (CGE) trade model METRO, which is a multi-country, multi-sector computable general equilibrium model that traces international interdependencies in a theoretically and empirically consistent framework and incorporates several features of GVC participation such as trade of intermediate and final products and trade in value added.[15]

The first analysis was done on the effects of switching to a localized regime, focusing in particular on the effects of this choice on key economic variables, such as trade, production and real GDP. The results show that in a localized regime, thus where economies are much less interconnected, levels of economic activity and incomes are significantly lower. This suggests that a localization of the value chain would add greater GDP losses to the already general losses due to the pandemic. According to this study, the decision to move to a localized regime would reduce global real GDP by more than 5%, compared to what an interconnected regime would suffer. This supports the argument that the reduction of barriers and globalization had beneficial effects on outputs and jobs around the world.
In the table below, it is possible to see all the countries taken into consideration and the variables examined. The values of the individual variables in the localized regime are shown as a percentage of the respective value in the interconnected regime. Thus, it results that all countries considered have a reduction in all variables analyzed (real GDP, domestic production, import demand, export demand).

[15] OECD (2021), "Global value chains: Efficiency and risks in the context of COVID-19", *OECD Policy Responses to Coronavirus (COVID-19)*, OECD Publishing, Paris.

Country	Real GDP % change	Domestic production % change	Import demand % change	Export demand % change
Argentina	-2.9	-3.2	-13.5	-8.3
Australia and New Zealand	-8.8	-8.6	-21.7	-19.6
Brazil	-2.5	-2.5	-16	-15.2
Canada	-13.1	-15.1	-25	-30
China	-2.6	-2.4	-23.4	-18.4
France	-5.1	-5.6	-9.9	-12.5
Germany	-5.1	-5.4	-11.4	-9.6
United Kingdom	-12.2	-13.4	-24.4	-33
Italy	-3.2	-3.5	-9.6	-9
European Union (24)	-4.2	-4.4	-7.9	-7.4
Indonesia	-3.2	-3.8	-21.3	-18.6
India	-1.1	-0.7	-11.4	-14.8
Japan	-3.9	-4.8	-20.4	-21.8
Korea	-7.4	-9.1	-24.1	-22.5
Mexico	-5.9	-8.2	-23.1	-26.8
Russia	-3.4	-2.9	-22.1	-11.2
South Africa	-6.9	-6.8	-22.2	-20.7
Turkey	-5.2	-7	-16.7	-29.5
United States	-6.9	-7.1	-20	-28.3
Latin America	-5.5	-6	-22.8	-21.8
South East Asia	-10.8	-15.2	-28.1	-28.8
Rest of the world	-6.3	-7.5	-20.2	-17.2
World	-5.5	-5.9	-18.1	-17.8

Figure 7. Both the global economy and all national economies would be smaller in a localized regime. (Source: OECD METRO database and simulations, 2021).

The second analysis was done on the different propagation of a shock between the interconnected and the localized regime. The basic assumption is a 10% increase in the costs of imports and exports. This assumption, as in the previous analysis, was made by mimicking the dynamics experienced during lockdowns to contain the Covid-19 pandemic. In the table below, it is possible to see the averages of absolute values of percentage deviations from the baseline for each regime. The variables considered for this analysis are real GDP, real production and real consumption.

The results identify the value chains of localized regimes as more vulnerable to shocks. All three variables show much higher deviations from the baseline situation in the localized regime. This can be related to a lower flexibility of this regime type, which involves less adaptation at the time of an alteration of the equilibrium. Whereas, in the interconnected regime, the shock is mitigated by the reference to the international market and the benefits obtained from a diversification of supplies.

	Interconnected	Localised
Real GDP	0.63%	1.03%
Real production	0.66%	1.30%
Real consumption	1.77%	2.70%

Figure 8. Shocks result in an overall drop in the stability of key economic variables in the localized regime. (Source: OECD METRO database and simulations, 2021)

As a conclusion to this analysis, the OECD has shown how a more interconnected regime with links and interdependencies between countries can benefit companies. A global value chain, diversified across countries and suppliers, can benefit from greater diversification, thus a reduction in the risk of shock propagation and, consequently, a paralysis of the value chain. It has therefore been shown that in a time of crisis, greater flexibility in the value chain is necessary.

This, however, goes against the trend that has increasingly taken hold in the wake of the Covid-19 pandemic, namely reshoring. The characteristics of the Covid-19 pandemic, such as disruptions and blockages in transportation or material shortages due to lockdowns in many countries, have destroyed the global value chain by fostering self-sufficient economic systems. The decision to bring back activities previously located in different countries was encouraged following the disruption caused by the pandemic. Indeed, the first action on the part of companies faced with a pandemic of this caliber was to decide to bring the various activities back home and internalize the value chain to protect against future shortages, but this, with a long-term view, is not considered by many to be the correct choice.

Thus, there was evidence of a push for reshoring by many companies due to the effects of the pandemic, but the ideas are highly controversial, as many find themselves in the analysis carried out by the OECD which does not recommend a return home of activities. In fact, even UNCTAD economist Piergiuseppe Fortunato in his article "How Covid-19 is changing global value chain" (2020) believes that the reshoring phenomenon is not only related to the pandemic, but is driven by many other drivers, such as automation. Moreover, according to him, coping with shocks such as the pandemic requires diversification, strengthening regional value chains to reduce vulnerability and increase resilience, and requires more massive government action through regulation and more specific governance frameworks.

2 THE RESHORING PHENOMENON

2.1 Reshoring

As analyzed in the conclusion of the first chapter, one of the effects of the pandemic on global value chains has been an increase in the relocation of activities previously transferred abroad - *the reshoring phenomenon*. In this section, reshoring as a location decision following a previous offshoring of activities is, therefore, introduced and presented.

2.1.1 Description and driving forces

Reshoring entered the scenario of international companies long before the recent crisis. In fact, the first examples of reshoring date back to the period after the Great Recession of 2008, when companies had the need to implement strategies to reduce costs and create jobs for people left unemployed. It was in the United States, the country where the financial crisis erupted in 2008, that reshoring kicked off with great debates about, and with the hope that it would re-grow the manufacturing sector in the country. Whereas, in Europe, the situation is slightly different: as European manufacturing has been less impacted by offshoring activities, discussion of this new phenomenon has been less prominent. Nevertheless, over time, Europe has also fully incorporated this phenomenon into business strategies. It is now possible to consider reshoring as the opposite phenomenon and one that should be studied in relation to offshoring. In fact, according to the definition given by Fratocchi et al. (2014), the term “reshoring" refers to a “generic change of location with respect to a previous off-shore country”. Fratocchi, therefore, uses this term in a generic sense, differentiating it from the term "back-reshoring" which instead defines as “decision to relocate in the firm's home country production or supply previously off-shored”.

Many agree with a more generic definition of reshoring such as that of Fratocchi et al. (2014), while others such as Gray et al. (2013) identify reshoring as “bringing manufacturing back home from a current location that is, de facto, not home”. The latter definition coincides with the term "back-reshoring" according to Fratocchi. In this thesis the term "reshoring" is used taking the definition of Gray et al.

To better understand what reshoring is, Fratocchi et al. in its paper “Offshoring and backshoring: a multiple case study analysis” (2017) have defined its basic characteristics based on the different definitions in the literature:[16]

[16] Di Mauro C., Fratocchi L., Orzes G., Sartor M. (2017) Offshoring and backshoring: A multiple case study analysis, *Journal of Purchasing and Supply Management*, 24, 108-134.

a) it is the reverse decision that follows a previous offshoring decision;
b) it does not require the permanent closure of the foreign establishment of the offshore business;
c) is essentially the decision to relocate, regardless of the degree of ownership, thus either its own or given to a supplier.

In recent years, more and more companies have decided to pursue productive repatriation, and the reasons for companies to make this choice can be a wide variety.
From a theoretical point of view, it is possible to identify the reasons in the 3 basic theories underlying location decisions.

- Transaction Cost Theory (TCT) developed by Coase in 1937 and reworked by Williamson in 1975 and then in 2008, is based on the identification of a greater need for coordination and incentive costs for offshore locations, given the great distance and, therefore, the greater cost of organization. In cases where various business activities are geographically located far apart, there may occur episodes of opportunistic behavior or mismanagement by the supplier or subsidiary. Thus, this results in greater cost in coordination and, consequently, when is no longer favorable, a need to bring the activity back in house.
- Resource-Based View (RBV) "sees firms with superior systems and structures being profitable not because they engage in strategic that may deter entry and raise prices above long- run costs, but because they have markedly lower costs, or offer markedly higher quality or product performance" [17]. According to this theory, therefore, the set of resources and skills is the determinant of a company's competitive advantage. Consequently, it turns out that when a firm does not have the ability to develop or transfer the tangible and intangible critical assets abroad or cannot access or exploit the resources of the host country, reshoring decision is considered.
- Dunning's eclectic paradigm is based on the consideration of three key factors when a company decides to invest in a foreign country: *ownership-specific advantage*, *location-specific advantage*, *internalization advantage*. The first one refers to all company's internal tangible and intangible assets that form the basis of its competitive advantage, such as knowledge, skills and capabilities, or even physical assets. The second refers to resource endowments or assets that characterize a particular location and which, therefore, the company finds valuable to combine with its own unique assets. The last, on the other hand,

[17] Teece, D.J., Pisano, G. and Shuen, A. (1997), "Dynamic capabilities and strategic management", Strategic Management Journal, Vol. 18 No. 7, pp. 509-533.

refers to the control that results from internalizing foreign activities value chain activities.[18] Thus, according to this theory the reshoring decision is made at the time when there are changes in location-specific advantages, such as changes in host or home location characteristics, or if there is a deterioration during the time of ownership or internalization advantages that had initially favored the offshoring decision.

It has been possible to see how the various theories developed over time and prior to the onset of the reshoring phenomenon can motivate the tendency of firms to have taken this path.

At the same time, the internal motivations of companies can be found through research done by the Research Group Uni-CLUB MoRe Back-reshoring in 2015 aimed at gathering empirical evidence from secondary sources to better understand the reshoring phenomenon and the underlying motivations.

The database used by the Research Group contains 294 cases related to 254 enterprises, as 25 of them have implemented more than one reshoring initiative. The sample of cases was collected by obtaining substantial equality in the number of evidence between the US and the EU, in order to have the most balanced analysis. The table below shows and analyzes the reasons stated by companies that decided to relocate their production back home.

Factors	Motivations	N of firms
Costs	Logistics costs	95
	Labor costs' gap reduction	70
	Total costs' gap reduction	54
	Customs duties for re-import	3
Logistics	Delivery time	78
	Minimum order size	13
Global crisis effects	Global crisis impact	26
	Unions' pressure at the home country	9
	Low domestic capacity utilization	8
	Poor financial and economic performance	5
Elements related to country of origin	Made in effect	87
	Subsidies for relocation	28
Internal business and entrepreneurial elements	Firm's global reorganization	43
	Offshored activities' control complexity	32
	Focus on innovation strategies	20
	Need of larger organizational flexibility	17
	Emotional elements	8
Marketing and sales	Customers' service improvement	53
	Proximity to customers	36

Figure 9. Motivation of reshoring.
(Source: personal elaboration based on Uni-CLUB MoRe Back-reshoring, 2015)

[18] Dunning, J.H. (1980), "Toward an eclectic theory of international production: some empirical tests", Journal of International Business Studies, Vol. 11 No. 1, pp. 9-31.

The most relevant factor is “Logistics”, understood not only in terms of cost, but also in terms of procurement. Although offshoring can be attractive to reduce labor costs by searching for countries where it costs less, the long distance between activities can increase logistics costs, both as operating costs but also as procurement delays. In these cases, companies believe that bringing assets back home can cut these excess costs. Moreover, another reason regarding costs is the labor costs’ gap reduction. As just mentioned, the difference in labor cost was a decisive reason to proceed with the offshoring. Since emerging states have been increasingly exploited by developed countries, the gap between the two costs has narrowed. At a time when the cost of labor comes to have a very similar price, it goes without saying that companies prefer to have the business in the home country to eliminate logistical and transport costs.

Another factor with a very high result is “Made in effect”, the positive impact that repatriation of production has on the perceived value by customers. This effect characterizes more the industries of fashion, where the attention from the customers towards the quality of the product is elevated.

2.1.2 Types of reshoring

Gray et al. (2013) in their working paper “The reshoring phenomenon: what supply chain academics ought to know and should do” identify reshoring as a location decision through which the company decide to bring back home an activity that is located not home.

They elaborate a framework for identifying the various types of reshoring could exist. The matrix created for the classification is based on the mode of ownership that the business has in the country of offshoring and that it will have once it returns to the home country (*outsourced* or *in-house*).

According to this, the four groups are:

- *In-house reshoring* refers to an activity carried out in a fully owned subsidiary abroad and relocated back home.
- *Reshoring for outsourcing* includes those activities carried out in a subsidiary wholly owned abroad and relocated in the company's home country but outsourced to a local supplier.
- *Reshoring for insourcing* takes into account activities previously located abroad where they are operated by an offshore supplier[19] and relocated to a fully owned subsidiary in the home country.

[19] The term “offshore supplier" refers to the kind of supplier working in the country of offshoring that a company relies on.

- *Outsourced reshoring* involves those activities carried out by offshore supplier in a foreign country and relocated to a supplier in the company's home country.

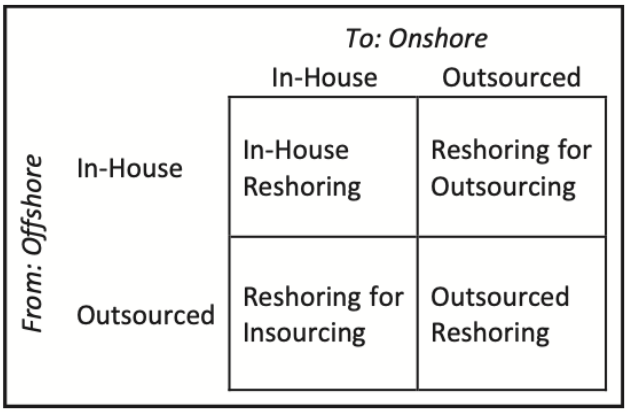

Figure 10. Reshoring Options.
(Source: Gray et al, 2013)

It is also possible to divide the reshoring types according to the geographical point of view. Depending on the country of reshoring, there are two main categories:

- The term *back-reshoring* refers to the relocation of an activity to the company's home country.
- The term *near-reshoring* refers to the relocation of an activity to a country closer to the home one.

Thus, as mentioned in the previous paragraphs, reshoring is a location decision following an offshoring process, since a company's activity located in a foreign country must exist. In fact, what differentiates reshoring from a generic location decision is that it is a reversion from a previous offshoring or outsourcing decision.

As a result, the decision to reshore an activity has many different starting points. Depending on the type of offshoring or outsourcing previously used for that specific activity, reshoring can follow different paths, eight specifically.

In these paths the starting point is always the basic situation that is the home-located business, which can be wholly owned - thus in-house - or operated by a supplier - thus outsource. This is followed by the different possibilities of offshoring, analyzed in the previous chapter, and then the final choice of the right way to reshore.

Domestic In-house → Offshore In-house → Domestic In-house
Domestic In-house → Offshore In-house → Domestic Outsource
Domestic In-house → Offshore Outsource → Domestic In-house
Domestic In-house → Offshore Outsource → Domestic Outsource
Domestic Outsource → Offshore In-house → Domestic In-house
Domestic Outsource → Offshore In-house → Domestic Outsource
Domestic Outsource → Offshore Outsource → Domestic In-house
Domestic Outsource → Offshore Outsource → Domestic Outsource

Figure 11. Typology of Reshoring Phenomenon.
(Source: Gray et al, 2013)

2.1.3 Reshoring like a way to be sustainable

In the recent period, with the emergence of new global trends and needs, such as the climate crisis and the geopolitical situation, global balances have changed. Related to this, the motivations driving location decisions have undergone changes in accordance with external changes.

A key issue affecting the world, and one that relates broadly to the production of enterprises and their dynamics, is that of sustainability. Consequently, among the drivers toward reshoring, it is possible to identify the need to meet climate standards and, more generally, minimum social conditions. Thus, it is deemed to talk about sustainability in relation to reshoring.

Sustainability is defined as the ability to "meet the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations, 1987). Starting from an ecological concept is possible to arrive at a more comprehensive conception of the phenomenon, encompassing within 3 factors: economic, environmental and social[20]. In other words, sustainability is considered as an overall well-being of the present generations, which will not have to be at the expense of the next generations, ensuring good conditions in all three areas necessary for achieving a good status.

As is extensively discussed in the paper “Does sustainability matter for reshoring strategies? A literature review” by Fratocchi in 2019, sustainability is at the core of enterprises' activities, as production activities impact all three dimensions of sustainability. Consequently, the decision of where to locate a production activity has a strong impact on the sustainability of the enterprise. For

[20] Sustainability rests on three basic pillars: environmental, social and economic. The environmental pillar includes regulations and laws that address environmental issues, such as the management of land, oceans, forests and all natural resources. The social pillar refers to initiatives, public policies and regulations that support social issues, such as poverty, peace, diversity, education and many others. The economic pillar refers to the ability to ensure economic efficiency for companies and to generate income and employment for the livelihood of the population.

instance, place an activity where labor is exploited and workers are forced to perform under minimal or, even, absent conditions reflect on a lack of social sustainability, as it does not guarantee a minimum required lifestyle. Or again, once a company decides to locate a business in another country, it must consider the emissions that require continuous transportation to join the great distances, otherwise it runs the risk of incurring a disregard for environmental sustainability. In the case of the above situations, therefore, the company will have to decide to relocate activities to follow sustainability standards. Despite the few studies still available on a strong correlation between sustainability and reshoring, debates on the impact of sustainability on reshoring decisions have increased in recent years.

The paper "Reshoring & Sustainability – Beyond the Horizon" (2020) of the Reshoring Institute[21], delves well into the link between sustainability and reshoring decisions, analyzing the factors of the phenomenon in relation to the sustainable or non-sustainable impact it may have.

The first point to highlight, the most tangible, are the emissions that are produced daily by the transport that activities over large distant territories require. With the fragmentation of value chains, and, therefore, with activities located in far-flung places, the transport of products from the factories to the final consumer is becoming more and more substantial. The most polluting emissions from these transports refer to carbon dioxide (CO_2), a gas that greatly increases pollution. This gas is emitted on a daily basis and has been projected to increase between 50% and 250% by 2050[22]. Based on this, bringing activities closer together and making them local can lead to lower emissions of pollutants and, thus, foster better environmental quality. Reshoring, therefore, is a location decision that can foster greater environmental sustainability.

Another point about environmental sustainability is 'regulatory compliance', namely respect for environmental requirements. When a company decides to move its production activities to developing countries, where production costs are lower but at the same time environmental regulations are not stringent, the risk of worsening environmental pollution increases. That is, the demand for activities in those countries where there are no stringent environmental rules is increased, creating pollution havens. In this case, reshoring prompts companies to consider the long-term effects on the environmental impact of their location decisions. In other words, companies are required to consider not only cost reduction, but also the implications their decisions may have on the environment. It is,

[21] Reshoring Institute is a non-profit organization dedicated to helping companies bring manufacturing back to America.

[22] Olmer N., Comer B., Roy B., Mao X., Rutherford D. (2017) Greenhouse Gas Emissions from Global Shipping, 2013-2015, *The International Council on Clean Transportation*, ICCT.

therefore, necessary to comply with environmental regulations and, this, can be promoted by companies avoiding the creation of so-called 'pollution havens'.
The third point analyzed by the paper is that concerning 'agile manufacturing'. This term refers to the use of lean operations with the aim of accelerating the response to consumer needs. Specifically, this is ensured through proximity to the market, highly integrated roles of human capital and with a streamlined and lean production. This model of organizing a company makes it possible to reduce waste, both in terms of product and resources, and allows it to keep pace with innovations and the changing demands of consumers. Therefore, in accordance with agile manufacturing, reshoring practices help the implementation of this model, helping to increase efficiency and reducing environmental waste.

In conclusion, there are no in-depth studies yet about the relationship between sustainability and reshoring, but is an area that is increasingly demanding attention, especially as a result of the importance that sustainability has come to play.
Reshoring decisions can be fundamental and of great support for achieving the sustainability requirements. In addition to those highlighted, also in terms of social sustainability this phenomenon can improve the sustainable requirements. The decision to bring home the activities that are placed in developing countries, where minimum working conditions are not respected, is another point that combines sustainability and the benefits that reshoring can give.

2.2 Trends in the US and Europe

The phenomenon of reshoring is relatively young and still little explored. It already existed before the pandemic, but certainly the latter gave it a big boost. Despite this, the trends in different countries are also different according to their policies and priorities, so it is necessary to go and analyze the trend of the phenomenon in two major economies, the United States and Europe.

2.2.1 United States

As mentioned earlier, the US companies were among the first to initiate massive reshoring policies following the 2008 financial crisis. The main rationale was to create new jobs for people who had been out of work due to the crisis. From that point on, many initiatives were encouraged first by then-president Barack Obama and then by the birth of the Reshoring Initiative.
The Reshoring Initiative was founded in early 2010 to support reshoring decisions by helping companies that want to bring operations back to America figure out how to meet the needs of their

customers. The initiative promotes reshoring in all its forms and FDI (Foreign Direct Investment) by providing tools for companies to choose the right location to locate their operations.

According to the report "Multiple Supply Chain Risks Accelerate", done by the Reshoring Initiative in 2022, with the collection of data until 2021 and projections for 2022, the reshoring trend continues to grow, increasing job announcements year after year.
In fact, as can be seen in the graph below, from 2010 onward reshoring has created more and more job announcements, with some declines, but from 2019 to 2022 the growth has been exponential, arriving at 219,283 jobs in 2022 only from reshoring. If even FDI are taken into consideration in the calculation of total job announcements, in 2022 the number increases until 350,000, more than 50 times the jobs in 2010.
Despite this, it is evident how the reshoring phenomenon has been accelerated by the pandemic. If until 2019, in fact, FDI created more jobs than reshoring, from 2020 onward the trend has completely reversed leading to an explosion of reshoring decisions.

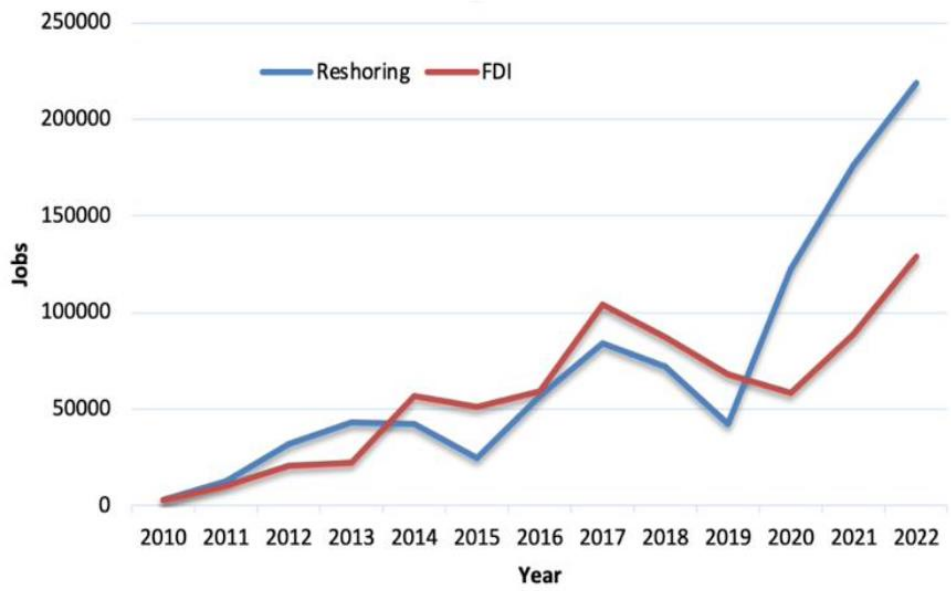

Figure 12. Job announcement Per Year, Reshoring vs. FDI.
(Source: IH 2022 Data Report by Reshoring Initiative)

The exponential growth in recent years comes from a combination of factors. The first among all has been the support from the government to produce essential products following the severe shortages experienced during the pandemic and the dramatic increase in freight cost and delivery time. Moreover, other factors are the firms' awareness of the total cost of offshoring, which is not always

convenient, and in addition, especially during the pandemic, there was a recognition of the great dependence on China, which has brought great shortages of product and damages in production.

Another relevant aspect of reshoring and one that changes and adjusts with respect to movements in the external environment are the factors underlying companies' choice to reshore.
In the table below it is possible to observe the changes in the decisive factors from 2021 to 2022.

Factors trending up	% up	Factors trending down	% down	Top factors, all maintaining high ranking over both years	Overall ranking
Social/ethical concerns	700%	Tariffs	-82%	Government Incentives	1
Walmart	700%	Total cost	-81%	Skilled workforce availability/training	2
Inventory	300%	Lead time/Time to market	-70%	Supply chain interruption risk/Natural disaster risk/Political instability	3
U.S. price of natural gas/chemicals/electricity	300%	Impact on domestic economy	-56%	Proximity to customers/market	3
Freight cost	129%	Under-utilized capacity	-54%	Eco-system synergies	5
Automation	107%	Quality/rework/warranty	-22%	Infrastructure	6
Manufacturing/engineering joint innovation (R&D)	59%				
Green considerations	32%				

Figure 13. Factors Trends from 2021 to 2022.
(Source: IH 2022 Data Report by Reshoring Initiative)

It is evident that these factors adjust to the demands of external changes, as can be seen in the fact that social and ethical concerns rose 700% due to the recent focus on ESG[23]. Furthermore, another growing trend is "Walmart," the U.S. multinational retail store company, due to the announcement in 2021 of its large investment in its U.S. business relocation initiatives. Then there are inventory shortages, increased transportation costs due to rising fuel prices and the lockout due to the pandemic, automation, innovations in manufacturing and engineering, and green considerations related to the climate crisis and a growing demand for attention to sustainability.
As for trending down factors like tariffs, total cost and quality can be explained by a reduction in reshoring in China. In any case, like for the under-utilized capacity that is improved thanks to a greater

[23] The term ESG refers to the three corporate areas of Environmental, Social and Governance, each of which has specific criteria such as environmental commitment, adherence to corporate values, and whether a company adheres to accuracy and transparency in its actions.

exploitation of the total ability, so for all the factors trading down the motivation lies in a gradually improvement of these management's problems.
To conclude, the factors that maintain a high rank in both years summarize the main problems that explain the reshoring decision. The biggest push is given by government incentives, which help reducing costs and help businesses not need subsidies. Then, the skilled workforce/availability, fostered with an increasing focus on the creation of talent and workers, the supply chain interruption risk, proximity to customers/market, eco-system synergies and infrastructure are the main relevant factors characterizing the decision process of reshoring.

Regarding the industries more characterized from this phenomenon, it is useful to notice that initially the reshoring was taken into consideration when the offshore activities were not efficient in terms of machinery, transportation equipment and appliances. On the contrary, in recent times, due to crises and shortages that have caused serious damage, the reshoring industries are those for which relying only on imports is highly risky, such as the semiconductor industries, pharmaceutical, electric batteries.
According to the report of Reshoring Initiative, the first ranked industry in the Jobs by Top 10 industries ranking is "Electrical, Equipment, Appliances & Components" with 124,319 jobs, having 77,077 jobs of difference with the second one, covering the 37% of jobs. The boost of the industry is evident by looking at the growth trend, starting with 3% of jobs in 2019, having 21% of jobs in 2021 and arriving at 37% in 2022. The second largest industry is "Chemicals" with 47,242 jobs, resulting in 14% of jobs and the trend is less vertical, observing a slight increase of percentage of jobs from 2019 to 2022 from 11% to 14%. Then in the third place there is "Transportation Equipment" and in the fourth one there is "Computer & Electronic Products".

2022					2021				2019 (pre-pandemic)		
Rank by 2022 jobs	Industry	Jobs	Companies	% of jobs	Rank by 2021 jobs	Industry	Jobs	Companies	% of jobs	Jobs	Companies	% of jobs
1	Electrical Equipment, Appliances & Components	124,319	224	37%	1	Electrical Equipment, Appliances & Components	55,309	213	21%	3,630	56	3%
2	Chemicals	47,242	324	14%	2	Computer & Electronic Products	43,194	223	17%	15,161	124	14%
3	Transportation Equipment	47,077	212	14%	3	Chemicals	35,534	326	14%	11,313	121	11%
4	Computer & Electronic Products	30,196	182	9%	4	Transportation Equipment	30,372	187	12%	37,898	165	36%
5	Medical Equipment & Supplies	22,962	93	7%	5	Medical Equipment & Supplies	29,510	185	11%	3,975	17	4%
6	Fabricated Metal Products	13,788	52	4%	6	Machinery	24,235	71	9%	2,916	42	3%
7	Hobbies (subset of Miscellaneous)	9,823	22	3%	7	Food & Beverage	10,034	59	4%	1,689	23	2%
8	Castings/Foundries - Subset of Primary Metal Products	7,242	36	2%	8	Fabricated Metal Products	7,948	86	3%	5,534	71	5%
9	Primary Metal Products	6,271	58	2%	9	Primary Metal Products	5,936	71	2%	5,024	48	5%
10	Plastic & Rubber Products	6,112	88	2%	10	Furniture and Related Products	4,451	40	2%	3,531	40	3%

Figure 14. Jobs by Top 10 Industries by Year.
(Source: IH 2022 Data Report by Reshoring Initiative)

In conclusion, then, it is possible to see a trend that has exploded in the face of the Covid-19 pandemic but continues to grow, having found important resources in the reshoring strategy. During the crisis there was a realization of the heavy reliance on countries where costs are lower, but which led to great hardships and shortages, such as China. Because of this, the U.S. believes it is necessary to continue to encourage reshoring policies, so as to prevent the recurrence of similar situations. Moreover, the geopolitical dynamics and imbalances that have been created just with China, and, in addition, the war between Russia and Ukraine, brings the US closer and closer to a need for independence. For these reasons, U.S. President Joe Biden is encouraging U.S. companies to follow these policies. Indeed, plans have been launched aimed at upgrading the nation's infrastructure, creating new jobs and addressing climate change, and most importantly, revitalizing the U.S. manufacturing sector. What is on the horizon in the United States, then, is a strengthening of production, through reshoring policies, with the aim of regaining the great independence of a large self-sufficient state that can cope with crises and shocks independently.

2.2.2 Europe

To analyze the trend of reshoring in Europe is considered the Eurofound initiative "European Reshoring Monitor" through which a database of 253 reshoring cases in Europe from 2014 to 2018 was created with the aim of identifying, analyzing and summarizing the reshoring phenomenon in Europe.

The case analysis carried out showed that more than 85% of cases are in the “Manufacturing” sector, then "Information and communication" and finally “Financial and insurance activities”. Thus, the manufacturing sector is the most affected by the reshoring phenomenon, and for this reason it is interesting to analyze which manufacturing industries are found to have taken this path.

As can be seen in the summary table below, the industry that has taken decisions of reshoring the most in the manufacturing sector and, therefore, comes first is "Wearing apparel". Next there are the "Food product" and "Machinery and equipment" industries.

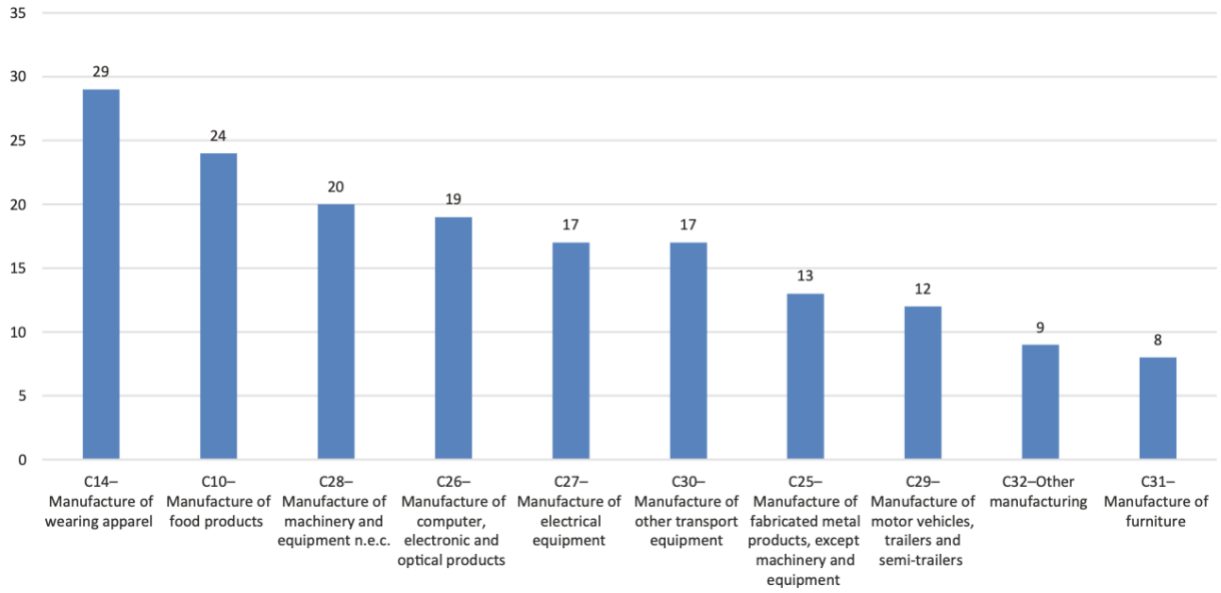

Figure 15. Case frequency by industry (only for manufacturing companies).
(Source: European Reshoring Monitor)

In the previous subchapter, the drivers encouraging this phenomenon were analyzed, but it is interesting to see in Europe at the beginning of the phenomenon, so from 2014 to 2018, what were the drivers that pushed companies to reshoring.

As is summarized in the table below, the most recurring reasons from companies are "Firm's global reorganization", "Delivery time" and "Automation of production process”. Differently from the motivations found by Fratocchi et al. 2014, where “Logistics costs” and “Labor costs’ gap reduction”

were at the top of the motivation, in this survey only appear after half of the ranking. While “Made in effect” is one of the top reasons in both surveys.

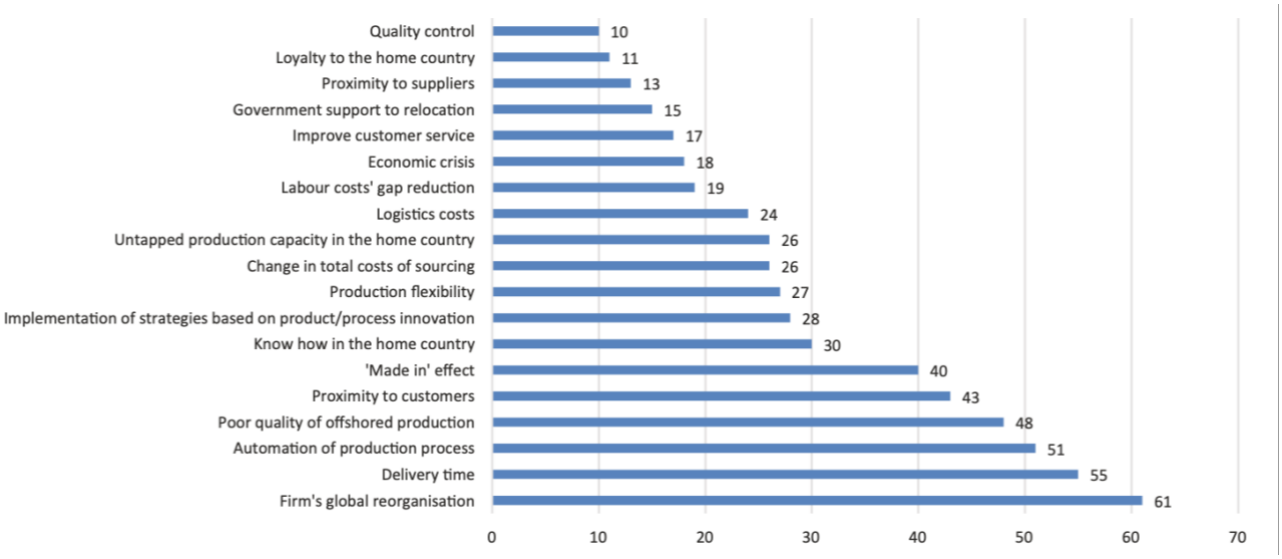

Figure 16. Reshoring motivations.
(Source: European Reshoring Monitor)

A relevant indicator when analyzing reshoring is the impact that the phenomenon has on employment levels. In this analysis, only for 99 cases has been possible to analyze this data because of lack of information in the remaining cases.

So, with respect of the 99 cases analyzed, 12,840 new jobs have been created. In the first 3 years, the level of jobs created is stable, while there is a huge increase in 2017, the year that garners the most jobs, while 2018 suffers a rapid decrease managing to create only 454 jobs.

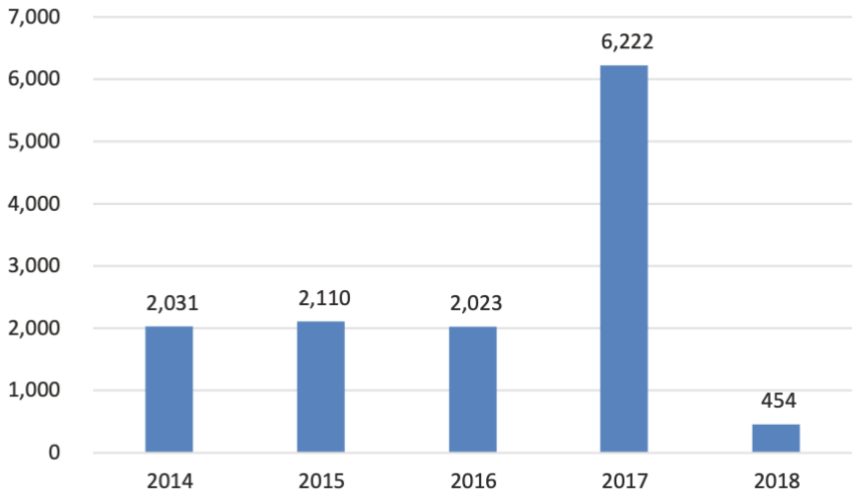

Figure 17. Number of jobs created.
(Source: European Reshoring Monitor)

To resume, cases and trends of reshoring in Europe up to the year 2018 have been presented, which compared to America highlighted a still a narrower phenomenon. Moreover, regarding the future, Europe has a less focused view on reshoring. While America continues to promote the latter through many initiatives, including from the government, Europe is still uncertain about the evolution of reshoring.
As mentioned earlier, the European Monitor Reshoring initiative ended in 2018 and, after that, little importance to reshoring has been given. Nevertheless, the debate on reshoring in Europe in the wake of the Covid-19 pandemic has picked up, giving new insights into its future.

In the study “Post Covid-19 value chains: options for reshoring production back to Europe in a globalized economy” of the European Union, 2021, an in-depth discussion is made about the phenomenon of reshoring and how it may evolve as a result of recent economic changes, digital transformation, and the turbulent geopolitical environment.
In the wake of the pandemic crisis, there has been discussion about the resilience of Global Value Chains and how it can be fostered. By the term "resilience", reference is made to the definition given by the OECD in 2019, with which it identifies “the ability of households, communities and nations to absorb and recover from shocks, whilst positively adapting and transforming their structures and means for living in the face of long- term stresses, change and uncertainty”. Thus, the debate centers on how companies with a global value chain dispersed across countries can cope and restart, either by reshoring or by an increasingly diversified strategy across countries.
According to Gereffi, in order to strengthen and enable good resilience in the face of shocks, companies should diversify rather than relocate activities back home, exactly as the research presented at the end of the first chapter. This is because, greater diversification of both suppliers and geographies can help achieve economies of scale, lower costs and have more opportunities for innovation.
Even according to two other economists, Baldwin and Evenett (2020), reshoring is not the right solution. Local production, in fact, can also be disrupted by a crisis and, as a result, would need to import products from outside. In addition, they deal with the topic of economic inefficiency given by higher production costs due to the choice of local production. They conclude, therefore, by calling for diversification rather than a return to local production for greater risk mitigation.
Nevertheless, evidence in the aftermath of crises presents the opposite behavior of firms. Indeed, when there are shortages of materials, disruptions in production and blockages in transportation, companies cannot continue to rely solely on foreign countries. This is why a dependence on international cooperation is discouraged, while it is necessary to be able to support oneself to cope

with these shocks. Thus, reshoring could help states ensure that level of self-sufficiency and non-dependence internationally.
In addition, another element of discussion is efficiency. It is believed and discussed that reshoring, in addition to not helping resilience, is also inefficient because of the high costs it brings to keeping production at home. Instead, as argued in the EU paper, there is a need to take a broader view by also considering environmental and social factors. While it is true that offshoring helps to find locations where the cost of production is lower, in terms of social costs the choice is onerous. In fact, in developing countries environmental standards are lower and long-distance transportation worsens environmental externalities. Another element to consider is the worse condition of labor rights, which brings with it negative externalities on the social condition of developing states. All these elements contribute to far higher social costs, bringing the costs related to offshoring greater than those required for relocation. Thus, as far as efficiency is concerned, it is wrong to consider only production costs, without going to analyze what they entail. Therefore, the solution proposed in the report is to raise the required environmental standards, but reshoring is also considered, which could reduce the problem of production sustainability. The latter decision could also push states where offshoring had previously taken place to raise and upgrade environmental sustainability requirements.

Another factor presented in the paper “Post Covid-19 value chains: options for reshoring production back to Europe in a globalized economy” of the European Union, 2021, that would require the implementation of reshoring as support is the so-called "open strategic autonomy". This concept was introduced by the Commission in the Global Strategy for the EU's Foreign and Security Policy of 2016, but then taken up after the crisis by Covid-19 and refers to the need for diversification in certain sectors of global supply chains. Nevertheless, it is specified that in support of strategic autonomy there must always be a balance with continued openness to foreign investment. The decision to proceed with a strategic autonomy, which is always open, however, is due to the return of geopolitics. The latest issues between China and the U.S. have brought strong tensions into the world balance, especially this strong impact is due to the role that China has come to play in recent years, namely the key supplier of a huge range of essential goods and commodities. Recent research by the Commission found that Europe has strong import dependencies for 30 metals needed, both from China but also from Turkey and Brazil. This has alarmed the European Union as a result, especially, of evidence obtained from the recent pandemic crisis.
Along with this, another red flag is China's increasing activity in acquiring foreign companies, including European ones. In the face of these reasons, Europe has decided to take increasingly stringent measures to identify, study and comment on foreign investments brought in by Member

States. The aim is to safeguard Europe's security and public order through, therefore, the introduction in 2020 of a screening mechanism for foreign investments and purchases by foreign companies. The introduction of this screening, according to the study, could lead to a slowdown in offshoring activities with the introduction of reshoring, although the latter still seems to be well-defined in the European perspective.

In conclusion, then, with no data available on reshoring in Europe after 2018, the paper analyzed provides a clear view of the topic and debates about it.
Available evidence has shown a weak trend of the reshoring phenomenon before the Covid crisis due to automation, additive manufacturing, or due to proximity needs or quality issues. A different trend occurred as a response to the pandemic crisis, where many companies considered withdrawing production phases abroad due to the severe disruptions experienced. At the same time, it is argued that advances in new technologies may improve the efficiency in outsourcing or offshoring practices and those economic factors that are a driver for reshoring may also change over time, or at any rate be decisive only for some industries. By virtue of this, in Europe it is unrealistic to think that there will be a surge in the reshoring phenomenon anytime soon, as announced and encouraged by the U.S. government.
Regarding, on the other hand, a greater need for strategic autonomy as a response to recent geopolitical issues, reshoring is being considered as a decision to support a strategy that can strengthen European independence and its enterprises, with the aim of safeguarding against greater power held by other states. In addition, it is believed that the green transition to cope with the climate crisis will likely require increasingly short and regionalized value chains, and thus the reshoring tool may prove to be a favorable strategy.

3 THE SEMICONDUCTOR INDUSTRY AND THE CHIP SHORTAGE

3.1 Semiconductors and their importance

Since the technological revolution and the appearance of electronic devices in our everyday lives, a new industry has developed and taken hold, growing exponentially year after year: *the semiconductor industry*. The importance of the semiconductors lies in the fact that these tiny chips are the ones that enable the operation of electronic devices, from the smallest to the largest. This chapter then discusses semiconductors, their importance, the industry that has developed and the recent global semiconductor shortage that has impacted companies and countries.

3.1.1 Semiconductors

Nowadays, electronic devices are what most characterize people's lives and give them the means to cope with innovations and the evolution of the world. Electronic tools such as TV, cars, radio, and household appliances are now an integral part of people's lives and have facilitated and improved their way of life. At the roots of electronic devices and their functioning there are the semiconductors. Semiconductors[24], or also called integrated circuits (ICs), chips or microchips, are highly specialized components underlying the functionality of electronic devices. A chip is a collection of billions of electronic circuits that have been reduced in size and are placed on a thin wafer of semiconductor material. These circuits include different electronic components, like active discrete devices (transistors, diodes), passive devices (capacitors, resistors), and their interconnections.[25] They are made from pure elements, typically silicon or germanium, or compounds such as gallium arsenide, and through a process called doping, small amounts of impurities are added to cause large changes in the conductivity of the material.[26]

The first microchip was invented in U.S. by engineer Jack Kilby in 1958, who then succeeded in printing and joining in this small piece of semiconductor material all the necessary elements (millions of resistors, capacitors, inductors, and transistors) for the operation of an integrated circuit. From that point forward, new discoveries have sought to make chips more and more efficient at lower and lower costs, keeping pace with the continuing innovations in the field of technology made possible by these very small platelets. More specifically, from the discovery of the first microchip, the number of

[24] The term "semiconductor" is used as a synonym for microprocessors, chips or microchips whose definition is expressed above, and not to the material itself.

[25] Varas, A., Varadarajan, R., Goodrich, J., Yinug, F. (2021) Strengthening the global semiconductor supply chain in an uncertain era, Boston Consulting Group (BCG) & Semiconductor Industry Association (SIA).

[26] Semiconductor Industry Association (n.d.) *What is a Semiconductor?*

transistors per wafer of a logic chip has increased about 10 million times, resulting in a 100,000-fold increase in processor speed and a cost reduction of more than 45% per year for the same performance.[27] These improvements combined with innovations in engineering such as materials technology have enabled the creation of increasingly powerful devices while at the same time using smaller and smaller factors. A curiosity to give an example of what is being talked about is the fact that today's smartphones have more computer power than the computers used by NASA in 1969 to send Apollo 11 to the moon. Or again, the memory that today's smartphones can get to store is greater than that of a 2010 data center server.

Semiconductor development has been encouraged not only by academic and industrial research, but also by the federal government, which has begun to require ever-better semiconductors for use in the military, space, and defense industries. These small chips comprising billions of components are what enable computers and smartphones to function as run software applications, but they also enable memory storage, exchange and processing of so much complex data, feature necessary for defense purposes, and therefore exploitable by governments. In fact, the increase in demand for semiconductors and the required advance in technology is not only related to the operation of electronic devices ranging from smartphones to automobiles to home appliances, but they are also essential in other key industries such as defense weapons systems and aerospace technology. Thus, for reasons of national defense, semiconductors have also become an important issue in relations between countries, which exploit these elements to increase and improve their technology in the country's defense.

The semiconductor industry is made up of a wide variety of product types, but it is possible to classify semiconductors in 3 broad categories: Logic, Memory, DAO (Discrete, Analog and Other).[28]

The Logic category accounts for 42% of industry revenues and are those integrated circuits that work with binary codes (0 and 1) that represent the fundamental building blocks or "brains" of computing. This category includes Microprocessors, General purpose logic products, Microcontrollers and Connectivity products.

The Memory category accounts for 26% of industry revenues and groups those semiconductors used for storing information required for the performance of any computation. These semiconductors,

[27] Varas, A., Varadarajan, R., Goodrich, J., Yinug, F. (2021) Strengthening the global semiconductor supply chain in an uncertain era, Boston Consulting Group (BCG) & Semiconductor Industry Association (SIA).

[28] Varas, A., Varadarajan, R., Goodrich, J., Yinug, F. (2021) Strengthening the global semiconductor supply chain in an uncertain era, Boston Consulting Group (BCG) & Semiconductor Industry Association (SIA).

therefore, are responsible for retaining the information in memory, and then be used by the devices, and these memories could be Dynamic Random-Access Memory (DRAM) or NAND.

The third category is DAO (Discrete, Analog and Other) and represents 32% of the industry. These semiconductors are those that transmit, receive, and transform information dealing with parameters such as temperature and voltage.

In the figure below it is possible to see the distribution of the three categories of semiconductors according to the application market, referring to the 2019 data given by the BCG&SIA report "Strengthening the global semiconductor supply chain in an uncertain era".

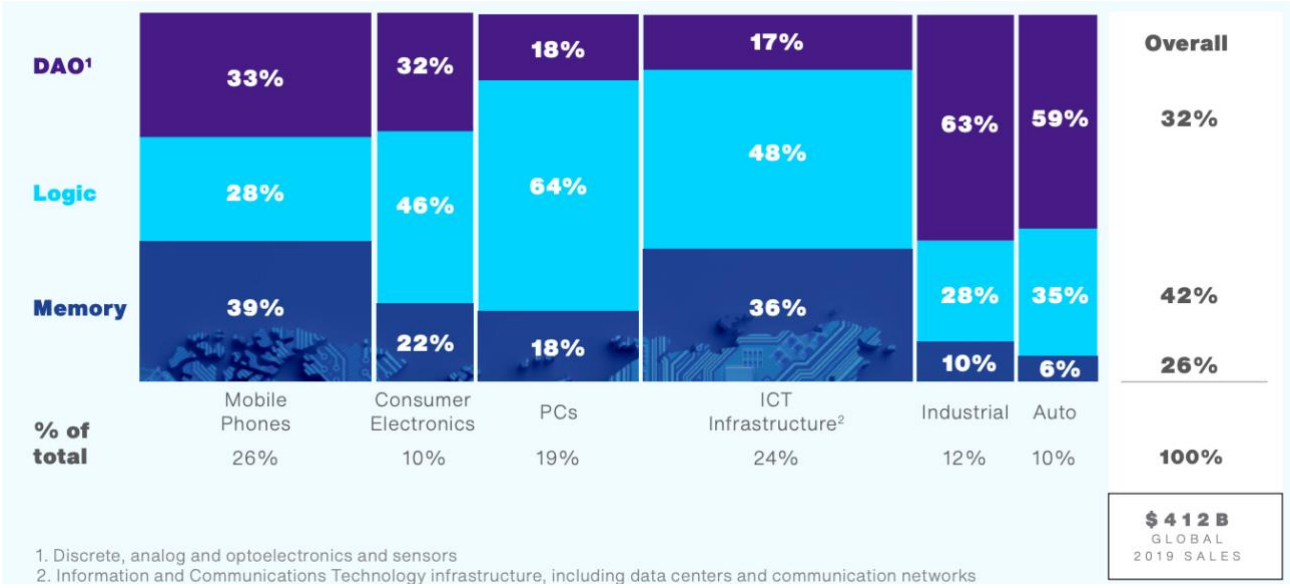

Figure 18. Global semiconductor sales by application market, 2019.
(Source: Strengthening the global semiconductor supply chain in an uncertain era. BCG/SIA, 2021)

3.1.2 The semiconductor value chain

Since semiconductors are highly complex and specialized products, their value chain reflects these characteristics, thus resulting in an extremely complex and globalized creation and production process.

The semiconductor value chain can be summarized in 4 main stages and supported by materials and equipment suppliers. The 4 main steps are: Pre-competitive Research, Design, Front end Manufacturing, Back end Manufacturing.[29]

- The first stage is the *Pre-competitive research*. The value chain of a semiconductor begins with research, which is critical for highly specialized and complex products such as these. The

[29] Varas, A., Varadarajan, R., Goodrich, J., Yinug, F. (2021) Strengthening the global semiconductor supply chain in an uncertain era, Boston Consulting Group (BCG) & Semiconductor Industry Association (SIA).

purpose of this research is to identify materials and chemical processes that can lead to improvements and advances in design architectures and technology, encouraging better power and efficiency. Unlike the company's intrinsic research and development to improve its product, pre-competitive research is basic research whose results are shared with the scientific community. Typically, this type of research accounts for 15-20% of total R&D investment.

- The second stage is the *Design*. The chip design step is the development of nanometer-scale integrated circuits, or the chip that enables the operation of electronic devices, such as computing, storage, connectivity to networks and power management. Design activity is highly knowledge- and skill-intensive; in fact, this activity covers 65% of total R&D investment. With increasing innovations and improvements, chips have become more and more efficient but at the same time more and more complex, consequently development costs have increased dramatically. As an example, the total development cost of a new system-on-chip for a high-end smartphone, including the features needed to process audio, video, and a fast wireless connection, could exceed $1 billion.

After the second stage, the time of the manufacturing stage of the microchip has arrived. It is divided in Front end and Back end.

- Therefore, the third stage is the *Front end Manufacturing*. It is in this step, then, that chips are fabricated, with what is known as “wafer fabrication”. From the chip design in silicon wafers, nanoscale integrated circuits are printed by highly specialized semiconductor manufacturing facilities, the latter called "fabs". Each wafer contains multiple chips of the same design, but the actual number of chips per wafer depends on the size of the specific chip. The manufacturing process is very complex and requires a high degree of specialization of inputs and equipment so as to have the result achieved on miniature scales. The process is, moreover, lengthy, as the number of steps can vary from 400 to 1400, and the average time to finish a semiconductor wafer is about 12 weeks but can go up until 14-20 weeks for more advanced processes. As already mentioned, this manufacturing process is highly capital intensive due to the complexity of both the chip and the tools needed for its creation. Indeed, a semiconductor fab of a standard capacity requires from $5 billion to $20 billion capital expenditure. As a result, wafer fabrication is the stage that requires more costs, accounting for 65% of the total industry capital expenditure.
- The fourth and the last stage is the *Back end Manufacturing*. In this step, the chip is permanently assembled, packaged and tested. Specifically, the obtained silicon wafer is converted into a finished chip that is ready to be assembled with others in electronic devices. Then, the silicon wafer is divided into individual chips, which are then packaged in protective

frames and enclosed in a resin shell. Finally, the chips are carefully and rigorously tested before being shipped to electronic device manufacturers. Unlike the Front end stage, in this step are required less investments regarding specialized facilities, in fact normally the average investment is 15% of annual revenues in facilities and equipment and typically accounts for 13% of the total industry capital expenditure.

As mentioned above, the semiconductor value chain has an ecosystem of 3 more suppliers, which are essential for the provision of inputs. These support activities are EDA & Core IP, Equipment & Tools and Materials.[30]

- The first category is the *Electronic design automation* (*EDA*) & *Core IP*. These types of suppliers are to support the design phase. Electronic design automation suppliers provide refined software and services such as applications to support design. These elements are critical to achieving a competitive level of modern and advanced semiconductor design. Instead, Core IP vendors are those who license reusable layout design units with predefined interfaces and functionality needed to be included in the chip layouts.
- The second category are *Equipment & Tools*, which are to support both the Front end and the Back end manufacturing. The supplier category of equipment is critical to semiconductor manufacturing, as it enables chip fabrication. Semiconductor manufacturing, being a complex process, uses more than 50 different types of equipment, like automated machine and tools, according to the various needs of the different typologies of chips' production.
- The third category represents *Materials*, which supports both Front end and Back end manufacturing. Materials are the necessary inputs for semiconductor fabrication, and manufacturing companies rely on specialized suppliers who provide them. Typically, semiconductor fabrication requires the use of more than 300 different inputs, according to the need of the development of advanced and complex technologies.

[30] Varas, A., Varadarajan, R., Goodrich, J., Yinug, F. (2021) Strengthening the global semiconductor supply chain in an uncertain era, Boston Consulting Group (BCG) & Semiconductor Industry Association (SIA).

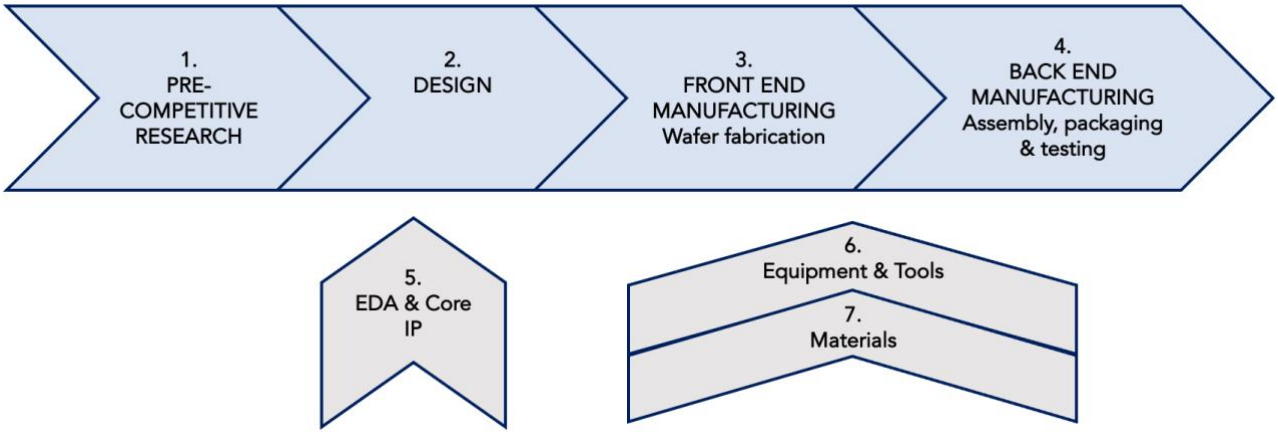

Figure 19. Semiconductor value chain.
(Source: Personal reworking based on the Report Strengthening the global semiconductor supply chain in an uncertain era. BCG/SIA, 2021)

According to the value chain of the semiconductors, companies nowadays can either concentrate on a single layer of the value chain or integrate vertically across several layers. For this reason, it is now necessary to observe the different business models that semiconductor firms can have.

According to the level of integration and by the type of related business model, the typologies of semiconductor enterprises can be of 4 types: Integrated device manufacturers (IDMs), fabless design firms, foundries and Outsourced assembly and test companies (OSATs).[31]

- The first category is the *Integrated device manufacturers* (*IDMs*). Companies identified as IDMs are those vertically integrated across multiple parts of the value chain. Indeed, they have within them all stages of the value chain such as design, manufacturing and assembly, packaging and testing activities. At the same time, some IDMs may have some parts of the value chain outsourced and are thus called "hybrids". Initially, in the first decades, this type of business model was the predominant one, but with the advance of technological innovations, then investment in both R&D and capital expenditure, a new need was created, namely, to combine specialization and cost reduction at the same time, and this led to the emergence of the second model: fabless companies. Examples of IDMs companies are the giants of the semiconductor industry Samsung and Intel.
- The second typology of firms are *Fabless design firms*. They specialize and focus on design and outsource the rest of the value chain, i.e., fabrication, assembly, packaging and testing. Usually, therefore, this type of firms outsources the manufacturing stage to foundries and OSATs type firms. This kind of company emerged as the industry expanded around the 1990s,

[31] Varas, A., Varadarajan, R., Goodrich, J., Yinug, F. (2021) Strengthening the global semiconductor supply chain in an uncertain era, Boston Consulting Group (BCG) & Semiconductor Industry Association (SIA).

when the advent of innovations made it increasingly difficult to manage both the large R&D expenditure on design and the capital intensity of manufacturing. A well-known company which owns this business model, focusing on the design stage, is Apple.

- The third category is *Foundries*. Foundries are those companies that provide only the manufacturing stage of the semiconductor value chain, focusing and specializing in high technical manufacturing expertise. These types of firms are the ones targeted by fabless firms or hybrid IDMs that want to outsource the manufacturing supply chain. With this business model, companies can spread the risk related to the significant up-front capital investment necessary to construct modern fabs across a wider customer base of design firms and IDMs. Although certain IDMs with significant manufacturing skills may also choose to create chips for others in addition to their own, most foundries are solely focused on manufacturing for third parties. The company that nowadays is saturating the market by owning more than half of the market share is the Taiwanese company TSMC.
- The fourth and final category includes *Outsourced Assembly and Test companies* (*OSATs*). This type of company provides assembly, packaging and testing under contract for both IDMs and fabless firms. The creation of this category originated in the U.S. in the 1960s since it requires lower capital intensity and lower-skilled labor, and thus there was the possibility of offshoring very easily, reducing costs.

This classification and division of the various possible business models of semiconductor companies highlights the complex and specific stages of the value chain that this type of product requires. Thus, complexity is reflected in the variety of business models, as some companies manage to specialize in some parts of the production chain rather than others. All this is, therefore, justified by a strong demand and need for investment and specialization in each of the various stages of semiconductor creation. It is unrealistic that one firm could specialize in each stage of the value chain, because of the substantial investment that would require it.

Following the same logic, the semiconductor value chain is truly global. The high specialization required in every stage of the value chain, leads not only to have different business models with focus and specialization on certain activities, but also to distribute them globally. As it is unlikely that a single company can have large investments and specialization on all the activities necessary to produce chips, so it is unlikely that a single country can be highly specialized on all stages of production.

As presented in previous chapters, with globalization and the advent of innovations and new technologies, the world is increasingly interconnected. This is reflected in the various industries,

which can take advantage of this new global configuration to reduce costs and offer a highly specialized product.

Specifically, in the semiconductor industry, the investments required are so high, because the product is knowledge and skills intensive, that distributing and fragmenting the value chain in different countries where cost reductions can be achieved is deemed necessary. In fact, each country has specialized knowledge of a particular activity. According to the data provided in 2021 by Kahn S. M., Mann A. and Peterson D. in their paper "The Semiconductor Supply Chain: Assessing National Competitiveness", it is possible to analyze how the different stages of the value chain are dispersed around the world and which are the main powers who hold the ownership of the various steps.

As for the R&D spending, the U.S. leads the market with more than 50% market share, and this spills over into the other stages of the value chain, as it has a competitive and advantageous position regarding knowledge of innovations and improvements. Therefore, starting from the first stage of chip production, the US is the leader in the Design stage, owning 74% of the design activities conducted thanks to its strong capabilities in R&D.

Regarding Equipment and its processing, necessary both for wafer fabrication and for assembly and packaging, US owns about 41% of the total Semiconductor Manufacturing Equipment, followed by Japan with about 31% and the Netherlands with about 18%.

The segment of Materials in semiconductor industry is made of raw materials and manufactured materials.[32] Regarding the Raw materials, Chinese firms are the dominant suppliers with a market share of 41%, while the semiconductor materials collectively is carried out 57% in East Asia, including Taiwan, South Korea and Japan, and the US.

As for the two manufacturing steps of the value chain, they are mainly carried out in two different locations. While the Front end, and thus semiconductor wafer fabrication, is 56% conducted in East Asia, the Back end, and thus assembly, packaging and testing, is quite distributed between Taiwan, United States and China. More deeply, China benefited from a wave of offshoring for this activity, due to a low specialization required, and developed a strong ATP industry, resulting in its 38% of market share of global semiconductor assembly.[33]

[32] The term "Manufactured materials" refers to those materials used in the semiconductor manufacturing that uses raw materials as inputs.

[33] Kahn S. M., Mann A., Peterson D. (2021) *The Semiconductor Supply Chain: Assessing National Competitiveness,* The Center for Security and Energy Technology.

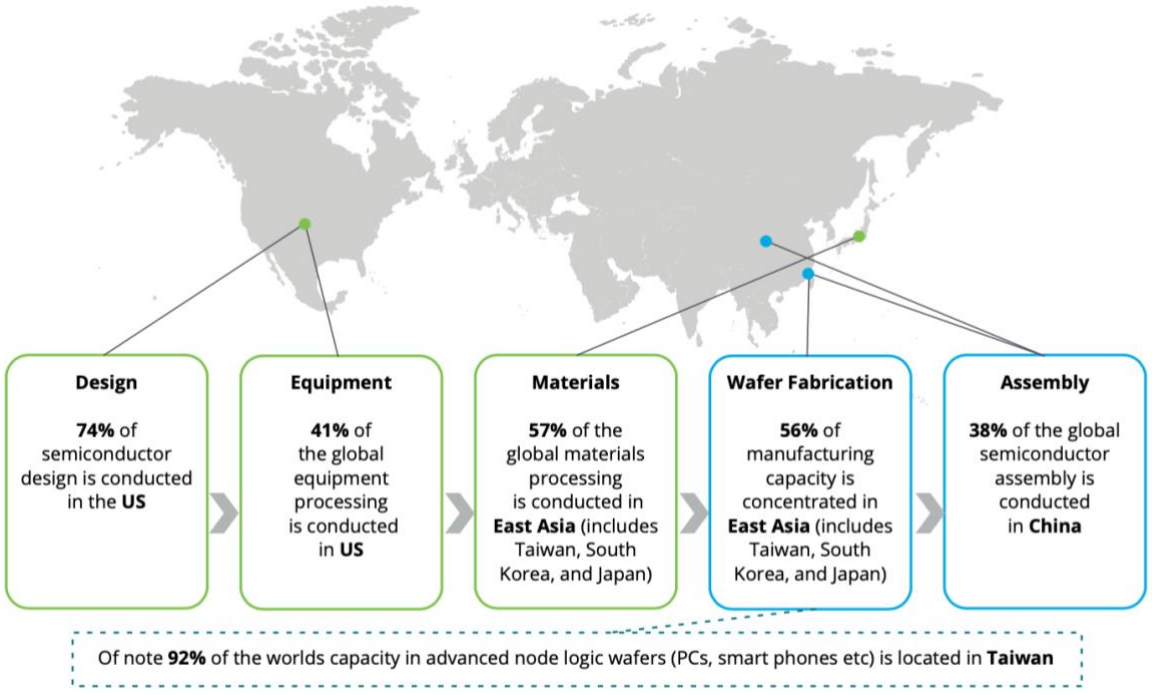

Figure 20. Semiconductor supply chain by activity and region.
(Source: Deloitte)

According to the geographical dispersion of the value chain of a semiconductor, it is possible to observe that a journey of a processor requires time and connections between very distant places. As the figure below shows, the typical journey of a smartphone application processor requires the involvement of different and distant geographic areas.

Starting from the design phase, usually the licenses IP for software are given by European companies (1) and then arrive in the US where the actual design of the application processor takes place (2,3). At this point, in the U.S., a smartphone company decides to use that chip design to operate its smartphone (4). Meanwhile, companies in US, Japan and Europe develop highly specialized equipment (5) and materials are processed in a journey that starts from US, passing through Japan and arriving in South Korea (6,7,8). Finally, in Taiwan the wafer with the big number of integrated circuits is created (9) and in Malaysia the wafer is sliced into individual chips and packaged (10). In China the chip is assembled with the smartphone (11), and, at the end, the smartphone is sold in US (12) thus ending the long journey.[34]

[34] Varas, A., Varadarajan, R., Goodrich, J., Yinug, F. (2021) Strengthening the global semiconductor supply chain in an uncertain era, Boston Consulting Group (BCG) & Semiconductor Industry Association (SIA).

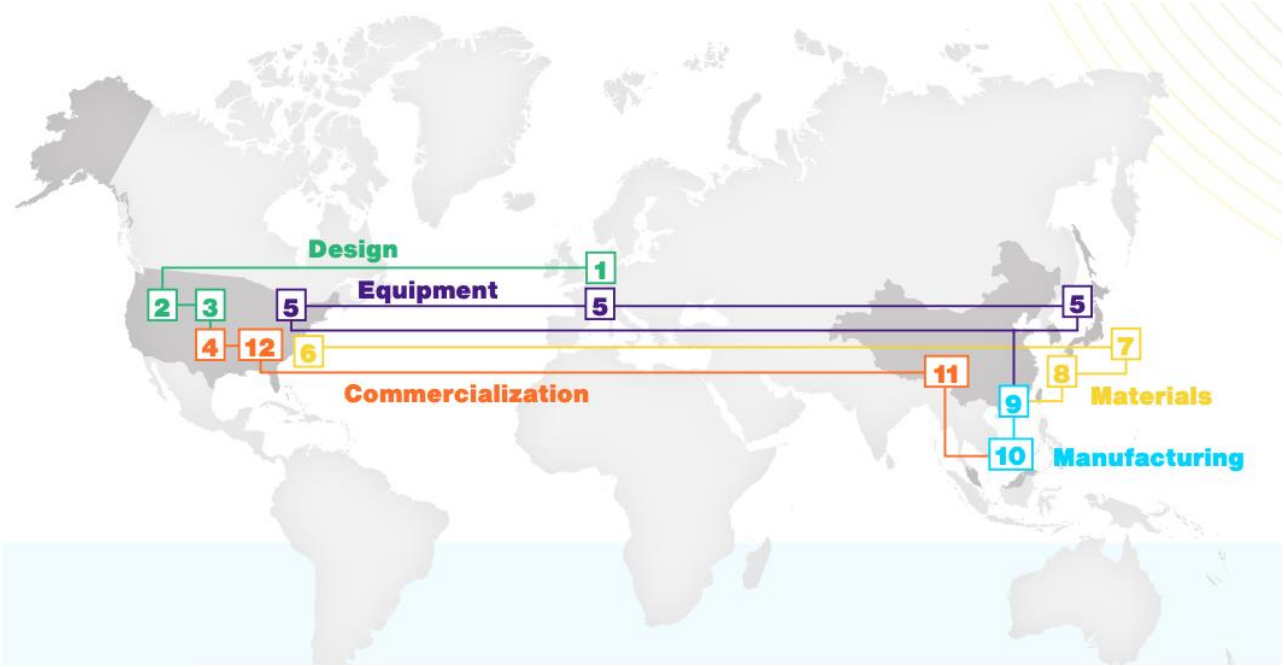

Figure 21. The global journey of a smartphone application processor.
(Source: Strengthening the global semiconductor supply chain in an uncertain era. BCG/SIA, 2021)

3.1.3 The semiconductor market

The semiconductor market is, therefore, one of the most relevant markets that has entered the last three decades and has experienced exponential growth. Chips became necessary for the development of PCs, the Web and online services, and the smartphone revolution. At the same time, they are needed for home appliances and automobiles, as well as for national security. According to the SIA report "2022 State of the U.S. semiconductor industry", semiconductors are mostly demanded for PC/Computers, with a global semiconductor demand share in 2021 of 31.5%, and for Communication[35] with a 30.7% of share. Subsequently, the Automotive and the Consumer[36] have very similar share, being very close with respectively 12.4% and 12.3%, followed by the Industrial with 12% of share. Lastly, in the last end-use with the lowest share there is Government with 1% of share. The end use that has had the fastest growth in recent years has been Automotive one, which in fact figures with an annual growth of 37.9%, almost ten points ahead of the others. Indeed, the new technologies and innovations that are being implemented in automobiles and the fact that they are very large, so they require a big number of semiconductors compared to, for example, a smartphone, have allowed this to come in third place within a few years.

During the last three decades, chips made possible the advancement in technology and development of new and more powerful devices, which have had enormous economic advantages. For instance,

[35] With "Communication" reference is made to the smartphone industry.

[36] In "Consumer" are included TVs, cameras, printers and gaming.

between 1995 and 2015, it is projected that the development of semiconductors contributed directly to $3 trillion in global GDP and indirectly to an additional $11 trillion[37]. Because of how crucial semiconductors have become to the modern world, there is still a large market for them.

In the graph below, sales of the semiconductor market between the 1987 and 2023 are exhibited. According to data provided in November 2022 by the World Semiconductor Trade Statistics (WSTS), the semiconductor market has experienced a constant growth throughout the all period with a CAGR[38] (1987-2023) of 8.16%. The total market size reached an amount of US$580 billion in 2022, up 4.4% from 2021. Nevertheless, in 2023, the semiconductor industry is projected to have a slight fall of 4.1% to US$557 billion, caused by a decline in the Memory segment of 17%.

The continued growth of the market can be attributed to the increasing spread and consumption of electronic devices around the world. In addition, with new technologies such as Artificial Intelligence and Machine Learning, new possibilities for the market to develop and increase are on the horizon.

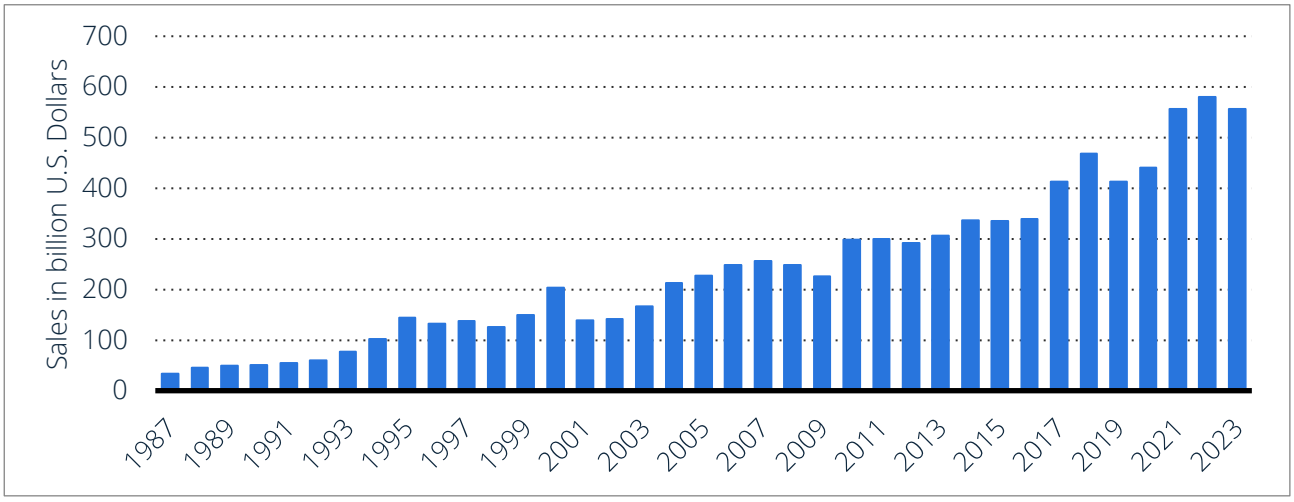

Figure 22. Semiconductor market size worldwide from 1987 to 2023.
(Source: Statista)

Compared to the geographical distribution, it is possible to observe how the market is distributed between the major regions. Since 2001, electronic equipment production has all been concentrated in the Asia Pacific area, multiplying its share year after year. Indeed, according to data provided in November 2022 by the World Semiconductor Trade Statistics (WSTS), the largest share appears to belong to Asia Pacific with a total of US$336 billion, followed by a gap of about US$200 billion from Americas, then Europe with US$43 billion and, finally, there is Japan with US$48 billion.

[37] SIA (2022) *2022 State of the U.S. Semiconductor Industry*.

[38] Compound Annual Growth Rate.

Fall 2022	Amounts in US$M			Year on Year Growth in %		
	2021	2022	2023	2021	2022	2023
Americas	121,481	**142,138**	**143,278**	27.4	17.0	0.8
Europe	47,757	**53,774**	**54,006**	27.3	12.6	0.4
Japan	43,687	**48,064**	**48,280**	19.8	10.0	0.4
Asia Pacific	342,967	**336,151**	**311,005**	26.5	-2.0	-7.5
Total World - $M	555,893	**580,126**	**556,568**	26.2	4.4	-4.1
Discrete Semiconductors	30,337	**34,098**	**35,060**	27.4	12.4	2.8
Optoelectronics	43,404	**43,777**	**45,381**	7.4	0.9	3.7
Sensors	19,149	**22,262**	**23,086**	28.0	16.3	3.7
Integrated Circuits	463,002	**479,988**	**453,041**	28.2	3.7	-5.6
Analog	74,105	89,554	90,952	33.1	20.8	1.6
Micro	80,221	78,790	75,273	15.1	-1.8	-4.5
Logic	154,837	177,238	175,191	30.8	14.5	-1.2
Memory	153,838	134,407	111,624	30.9	-12.6	-17.0
Total Products - $M	555,893	**580,126**	**556,568**	26.2	4.4	-4.1

Figure 23. WSTS Forecast of the Regional Semiconductor market.
(Source: World Semiconductor Trade Statistics)

Taking into consideration, however, the industry as a whole and not just electronic equipment production, the situation is slightly different. According to the data provided by SIA in its 2022 Factbook, it is possible to observe that the country that holds the leading position is the U.S. with a 46% of share in 2021, after losing about 19 points of market share because of strong competition emerged over time. Next there is Korea with a relevant share of 21%, followed by the other major countries with minority shares between 7% and 9%.

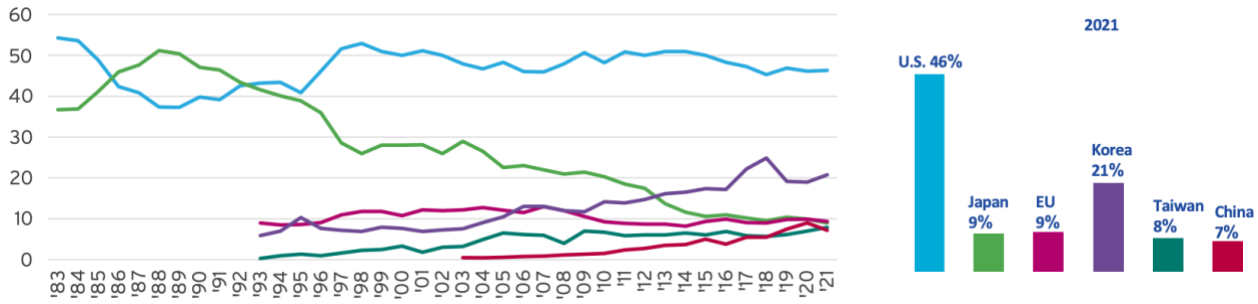

Figure 24. Overview of the Semiconductor industry from 1983 to 2021.
(Source: SIA 2022 Factbook)

For what concerns the data given by Statista about the key players forming the market, in line with the geographic distribution highlighted above, the largest semiconductor vendors result to be U.S. companies, going for more or less 50% of the global market. Therefore, as can be seen in the chart below, the companies with the largest market share in 2022 are the giants Samsung and Intel with respectively 10.9% and 9.7% of market share, leaders in the market since the birth of the industry. In

addition, it can be noticed that the other companies with a significant share of the market, apart from the South Korean company SK Hynix in third place, are all from the United States such as Qualcomm, Micron Technology, and Broadcom. Immediately after the leading U.S. companies, the market shows the presence, on the other hand, of large companies from Asia-Pacific countries, thus respecting the great importance of these countries in the industry.

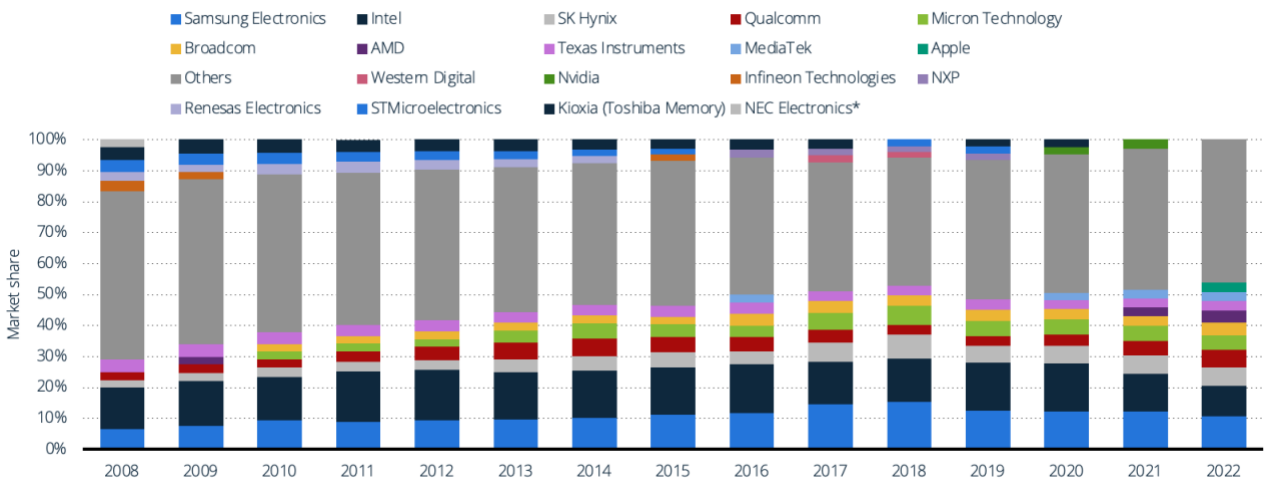

Figure 25. Semiconductor companies market revenue share worldwide from 2008 to 2022. (Source: Statista)

Taking into consideration, however, only the semiconductor manufacturing stage, which is the step of the supply chain where the crisis has crept in, the Taiwanese manufacturer Taiwan Semiconductor Manufacturing Company (TSMC) is the leader in the market with 58.5% of market share by itself. Next, the Samsung company is the second with higher market share, albeit much lower than the leader, showing 15.8% of market share. Then, there are United Microelectronics Corporation (UMC), another Taiwanese company, the US foundry Global Foundries, and the Chinese foundry Semiconductor Manufacturing International Corporation (SMIC). An interesting observation is that the top 5 leading companies in the market are all foundries, thus specializing in chip stage manufacturing, except for the second in the ranking, Samsung, which, by contrast, is an IDM company. This highlights the company's ability to establish itself just behind the giant TSMC despite the fact that it does not specialize in manufacturing but has all steps of the value chain in-house.

Taiwan Semiconductor Manufacturing Company (TSMC) is, therefore, a leader in the manufacturing sector, being a foundry and thus specializing primarily in manufacturing. The company was founded in 1987 in Taiwan and is founded on the principle of producing semiconductor chips without using its own name, precisely to avoid competing with its customers. In fact, its purpose is for the success of its customers, so as to gain confidence and have more and more market share in semiconductor manufacturing. Its power is, likewise, supported by having giants such as Apple, Tesla, Intel, Ford,

Toyota and Alibaba among its largest partners. In addition, the choice to be a foundry that does not use its own name for its chips has allowed the emergence and spread of fabless companies, that is, semiconductor companies that only do the design, outsourcing all other stages of the value chain.[39]

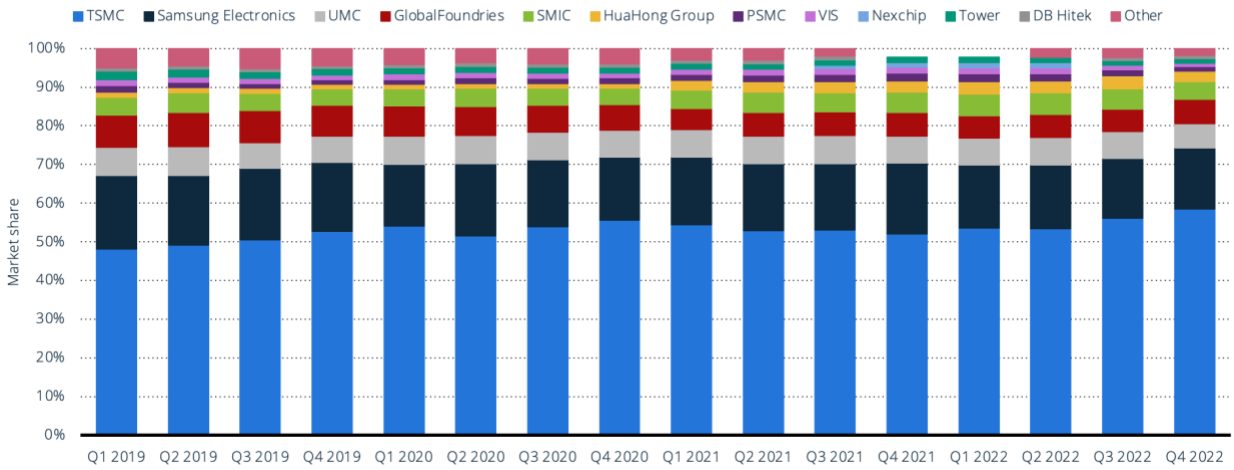

Figure 26. Leading semiconductor foundries revenue share worldwide from 2019 to 2022, by quarter. (Source: Statista)

3.2 Global dynamics

In order to better understand the context in which the semiconductor industry fits and in which the crisis will then unfold, it is crucial to focus on the geopolitical situation, which witnesses high tensions between the world's two major powers, the U.S. and China.

The high-tension manifesting today between the two superpowers dates back to 2018, when the Trump administration decided to start limiting the Chinese control over the global market. As a matter of fact, since the beginning of the 21st century, China has been increasing its market power and international control. More precisely, China joined the World Trade Organization in 2001. This allowed the country to establish itself in the global market, overcoming most of the other powers and arriving at ranking second only to the U.S., attracting industries from all parts of the world. One of the main reasons for that finds its roots in its cheap labor policies, which fuels great global export.

As long as China remained a cheap factory, the U.S. did not perceive the Chinese attitude as a threat. As a consequence, on the contrary, U.S. became a strong trading Chinese partner. However, after a few years of trade partnership, the 2010s marked a severe change in the two power's attitude. This was due to the Chinese expansionist military moves. After that, the first superpower began to worry. In addition, another factor that contributed to the emergence of tensions is the completely different economic behavior of the Chinese government from Western rules. More specifically, although the

[39] TSMC official website.

Chinese economic model is similar to the Western consumerist and liberalized one, the State plays a major and important role. In fact, Chinese companies receive major economic boosters and many other subsidies from the State, as well as the valuation of the yen managed in a way that makes imports favorable at the international level. So, there is a dumping phenomenon of the exports in favor of Chinese enterprises which results in an unfair competition.

Moreover, another key factor is that China does not recognize intellectual rights, and thus the importance of ownership of patents and licenses. Because of this, there has been a lot of intellectual property theft: in particular, China bought various types of products from the Western world, such as trains, cars and machineries, and then through the reverse engineering phenomenon[40] understood the structure in order to produce, implement and develop the industry by themselves. In the face of this, the U.S., but also several European states, lost tens of billions every year due to the stolen ownership by Chinese companies. So, the real crisis factor with China was precisely its goal to go from being purely a manufacturing state to develop their own autonomous industry, making it a powerhouse capable of escalating the global market.

In 2017, just before the beginning of the Trade war, the United States owned roughly a US$350 billion deficit[41] in the balance of payments of U.S. trade in goods with China; therefore, it was importing US$350 billion Chinese products. Throughout the years, this deficit has been progressively growing as many U.S. companies that manufactured in America and did business with China had become larger and larger.

[40] The "reverse engineering" is a process by which the structure and design of a product is studied and understood to replicate it. The name refers to the way in which it takes place, that is, it starts from the final product and goes all the way down to its physical information.

[41] United States Census Bureau (n.d.) *Trade in Goods with China*.

Figure 27. U.S. Trade Deficit with China for Goods.
(Source: Hout T. (2021) A New Approach to Rebalancing the U.S-China Trade Deficit)

For all the above-mentioned reasons, it was Donald Trump himself, after becoming America's president in 2016 with his "America First" motto, who wanted to initiate a curbing of the power now held by China, noticing its increasingly overbearing role internationally and its unfair practices and, therefore, concerned that it might endanger U.S. leadership.

Thus, in 2018, U.S. President Donald Trump initiated a Trade war with China by imposing a 25% tariff on Chinese imports, getting as a counter-response the same imposition from China on U.S. imports, by establishing a tic-tac-toe mechanism. After a series of escalations, which also resulted in the ban on the sale of chips to Huawei Chinese company, accused of threatening U.S. national security, in 2020 the Trump administration agreed with the Chinese government on a de-escalation policy, known as Phase One. Phase One corresponds to the agreement signed by the two powers on January 15th, 2020, which led to cut tariffs imposed in the last round of 2019 and the promise from China to proceed with the purchase of an established amount of U.S. goods. In addition, it enshrined intellectual property protection, technology transfer, establishment of food trade modalities, transparency, trade rates and a bilateral mutual reinforcement mechanism between the two governments.[42]

In the following years, China failed to buy back all the goods promised in the signed agreement, and the new U.S. administration, headed by Biden, did not implement a policy of détente but, on the

[42] Bown C.P. (2021) The US-China Trade War and Phase One Agreement, *Peterson Institute for International Economics (PIIE).*

contrary, decided to maintain the previously imposed tariffs. Subsequently, other external factors such as the Covid-19 pandemic, the Taiwan issue and the global semiconductor shortage have increasingly rekindled tensions between the two powers.

By analyzing the entire geopolitical chessboard, it is necessary to dwell on the importance that the island located in the Pacific Ocean, namely Taiwan, has gained over the years.

Taiwan is an island in front of mainland China. In 1945, when the II World War ended, Japan returned Taiwan to China, according to the Treaty of San Francisco. Meanwhile, a civil war broke out in continental China between nationalists and communists. In 1949, nationalists, known as the Kuomintang (KMT) party, lost the war and, as a result, were forced to flee the continental region by heading to Taiwan and the islands that composed the Taiwan archipelago, founding the Republic of China. As well as then stabilizing in Taiwan, all the great diplomacy of those years, the nationalists, brought with them all the possessions, the Chinese gold reserve, as well as the Forbidden City golds, thus transferring the main Chinese wealth to Taiwan.

In continental China instead, Mao Zedong took over the leadership creating the People's Republic of China.

By this action, the two factions separated from each other, and from this time on, both of them began to defend their supremacy. On the one hand, the People's Republic of China, then present-day China, defined Taiwan as its own separatist autonomous province. On the other hand, the Republic of China, defined itself independent and with a control over mainland China. However, throughout the years, the international community started increasingly recognizing China, then the People's Republic of China, at the expenses of the Republic of China, until the loss in 1971 in the U.N. Security Council of Taiwan’s seat against the People's Republic of China, thus losing even more international legitimacy, even that of U.S. in 1949.

Nowadays, de facto, Taiwan is only recognized by 13 states internationally (plus the Vatican), since its government operates independently. However, the question of land ownership still remains open. Nevertheless, both the historical, the economical and the geographical factors compel China and Taiwan to cooperate and maintain connections through embassies with which they exchange relations. Indeed, still today pacts are signed between Taiwan and China. Therefore, they are working together for their aims: for China it means to still have ownership of Taiwan, while for the latter it means to maintain a strategic alliance with one of the major powers in the world.

Meanwhile, Taiwan is cultivating its economic and strategic own power, by increasingly growing and becoming essential for most exchanges. Its strategic geographical position is what encourages the

most this growth, since it is in the middle of the exchanges between the East and the West. For this reason, U.S. found themselves obliged to provide a silent support in terms of defense since 1987.

The continuous growth of the island led firstly to the dropping of martial laws and population restrictions, and then in the early years of the 2000s, to the provision of the Constitution and the establishment of a real and structured democracy on the island. In conjunction with this, its very strong economic development made Taiwan one of the four Asian tigers[43]. So, with a total population of only 23 million, Taiwan manages to have an economy with a per capita GDP higher than Switzerland and Sweden and to be a hub for international trade, thanks to harbors through which 30-40% of the world's goods transit, a world leader in semiconductor production and other advanced technological components. Therefore, Taiwan's role over the years has shifted from being a purely territorial dispute, to become an economic issue. This is because the wealth generated by Taiwan alone is extremely high and positions it as one of the best countries globally.

Lately, the tensions are not only given by the economic and strategic power the island is increasingly gaining, but also by political issues that are getting more and more exacerbated. In line with this, tensions were rekindled with the United States when in 2022 the U.S. House Speaker Nancy Pelosi went on a 20-hour visit to the city of Taiwan, resulting in a very harsh reaction from mainland China. Thus, the latter accused the U.S. of inserting itself into a conflict that does not concern their business, adding the fact that they don't even recognize Taiwan as an independent state. Nevertheless, de facto, the United States provides security to Taiwan for what concerns the defense, such as armaments, ships and planes because of any possible attack from mainland China. In the event that the conflict between China and Taiwan arises, significant repercussions globally would involve, both on the semiconductor concerns and on the whole international trade, because of the importance lined by Taiwan as an international hub of goods, logistics and trade. Moreover, this would not be favored by the United States, which would lose one of its outposts as well as an extremely important trading partner, thus fueling the already rigid and unstable ties.

Taiwan is now a territory of wealth, as the most important and essential products today, namely semiconductors, are manufactured on the island. Taiwan's semiconductor foundry has more than 50% market share, thus bringing Taiwan to the center of the semiconductor industry in the whole. The powers had to begin to consider the economic and strategic importance that Taiwan has gained over time, which is why it is now at the center of relations and tensions between the most powerful countries.

[43] Asian tigers were defined at the end of 1990s as those Asian countries with strong and uninterrupted economic development such as South Korea, Singapore, Hong Kong, and precisely Taiwan.

In conclusion, the dynamic in which the semiconductor crisis is exacerbating and fits in, is a situation of very unstable geopolitics made of tensions and labile ties, which incorporates structural problems and conflicts that have plagued international relations for many years. It is precisely this complexity of tensions and the fact that the main actors involved are these powers, that both encourages the emergence of semiconductor scarcity issues and still amplifies the difficulties in resolving them.

3.3 Semiconductor shortage and countries' policies

Since the Covid-19 pandemic, the semiconductor industry has faced several complications, resulting in a substantial crisis known as the semiconductor chip shortage. In fact, as a result of innovations and sudden change of habits due to various lockdowns, the demand for semiconductors exploded as the demand for electronic devices suddenly increased. All this has caused a major chip shortage, which has led to serious disruptions in all the industries that requires microchip for the operation of the products. As a result of this shock, countries have reacted and are putting maneuvers in place to try to contain it as much as possible and find solutions to get back into balance.

3.3.1 Scenario of the semiconductor shortage

The semiconductor industry has suffered and is still suffering from a major shortage. Among the main reasons listed is definitely the Covid-19 pandemic. In fact, the latter has caused substantial surges and disruptions in demand. During the spring of 2020, the outbreak of the pandemic required global reconfiguration to try to counter this huge shock. The peculiarity of this shock, that is, a virus affecting people's health and thus the need to stay at home, has had an unprecedented impact on countless industries. In particular, the industries most affected have been those on which semiconductors operate. Indeed, the shortage has not only spilled over to electronic devices for work or transportation, but also health devices such as machinery to attend to people's illness. This has made the semiconductor shortage a substantial global problem. The need, therefore, to stay at home has drastically increased the demand for all the devices needed to work from home, such as computers, phones, but also devices normally used in the home, such as TVs and home appliances. In addition, the fact that many countries and regions have gone into lockdown have significantly disrupted the semiconductor supply, creating disruptions in both manufacturing and other stages of the value chain. Again, the reduction in transportation, like closure of airports, has also affected the value chain, which as mentioned before requires many steps between different nations far apart, and thus the joining of the various stages has been interrupted with many delays.

Despite this, the semiconductor industry has been classified as "essential", given its importance to health devices as well, and this has allowed operations to continue and try to stem the severe crisis.

Therefore, according to data collected in the SIA report "2021 State of the U.S. Semiconductor Industry", the semiconductor industry has operated fab utilization considerably above the typical utilization level of 80% throughout the shortage, as it is possible to see in the graph below. Front-end semiconductor fabrication facilities often run above 80% capacity utilization, with some fabs running as high as between 90% and 100% only in periods when market demand is high, such as in a cyclical market upturn like the one the market during the pandemic. Moreover, the industry has been steadily increasing fab utilization over the previous years and it was projected to increase in 2021, in order to meet the increasingly market's rising demand. In summary, the semiconductor industry has utilized fab utilization and operated fabs at their maximum capacity in order to fulfill the growth in demand as quickly as feasible. Nevertheless, this was not enough to stem the crisis, which also has other reasons at its roots.

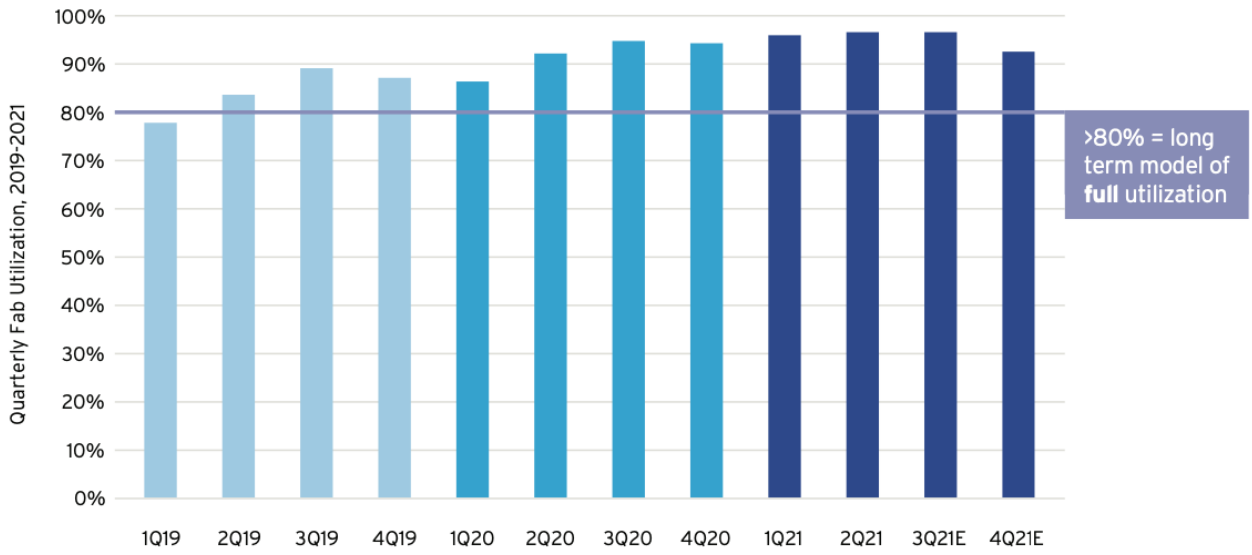

Figure 28. Percentage of the semiconductor fab utilization 2019-2021.
(Source: SIA 2021 Report)

After having highlighted the Covid-19 pandemic as the main reason behind this shortage, there are two other supporting reasons that have fueled the spread of the crisis.

The first is the complexity of the semiconductor supply chain. As explained above, the high specialization of this type of product requires a very complex supply chain, both in terms of steps and location. In fact, the requirement of several stages executed in different parts of the world makes the value chain extremely challenging and complex, consequently exposed to many vulnerabilities. Since a global value chain is exposed to a type of global shock such as a pandemic, it will logically suffer from the serious complications. As discussed in the chapter of the global value chain, a fragmented and dispersed value chain could increase and spread the shock and difficulties along the entire value

chain, failing to stem it. For example, transportation problems have greatly slowed the flow of different stages in different parts of the world, as well as different tax laws, import controls and regulations can slow down the process.

The second supporting reason can be identified in geopolitical problems, which have amplified the effects of the shortage. In addition to the tense global dynamics mentioned above, new tensions between the most influential and powerful countries, U.S. and China, have been exacerbated with the emergence of semiconductor scarcity. As well as the tensions due to Trade War, in May 2020 the U.S. government has banned all microchip manufacturers that use U.S. patent instrumentation or design software, primarily Taiwan's TSMC, from selling their products to Huawei, accusing her of being a threat to national security, and has also lobbied to reduce trade with other Chinese companies. In addition, it is pushing to bring the production of microchips used in the military of the U.S. military directly to U.S. soil, so as to keep its security under control. Both U.S. and China, in any case, are investing in the sector to make themselves more independent of Taiwan's factory, but it is a long and expensive process. At the same time, China currently leads the market for processing rare earths, resources that are equally crucial to the production of electronic products. So, the two superpowers are closely connected in the technology production chain, and tensions and political issues between them caused the crisis to spread quickly.

As for the consequences of the worldwide semiconductor shortage, there are more than 169 sectors impacted. Taking up the classification of end-users mentioned in the market section, it is possible to analyze the impact of the crisis on them.

Starting with the *Computers* sector, the pandemic had a major impact on its demand, causing it to suddenly rise for a sudden people's need to work from home. This led to an excess of the demand which, however, couldn't be fully met for the shortage of microchips. Evidence is given by a drop of 5% in PC shipment worldwide in the fourth quarter of 2021, compared to the result of the fourth quarter in 2020, due to the chip shortage that caused disruptions and interruptions in the procurement of semiconductors, thus in the supply chain.[44]

As for the *Communications* sector, then the smartphone industry, the absence of chips has greatly reduced production volumes. In fact, smartphone sales plummeted by 12.5% in 2020, and despite a recovery in the first half of 2021, sales fell again in the second half of 2021. Indeed, some sales planned for 2021, were rescheduled to 2022.[45]

[44] Gartner (2022, January 12th) *Gartner Says Worldwide PC Shipments Declined 5% in Fourth Quarter of 2021 but Grew Nearly 10% for the Year.*

[45] Gartner (2022, March 2nd) *Gartner Says Global Smartphone Sales Grew 6% in 2021.*

In the *Consumer* sector, the lack of sufficient chips has caused TV prices to rise and the suspension or delay of the release of new types of cameras, planned to be released in 2021, as Canon was forced to do with the new EOS R8 model by apologizing to customers. In addition, in the printer industry, semiconductor shortages have also led to serious complications, again leading the Canon company to offer toners without chips to customers, announcing that it is suffering from massive problems in semiconductor supply.[46]

For the *Industrial* sector, the greatest impact was felt by the healthcare industry, as since they were not replaceable products, and semiconductors were essential to their manufacture, there was a great difficulty in production, in addition to the fact that they were not ready to receive such high demand suddenly.

The hardest hit sector that has suffered a severe drop in production is the *Automotive* sector. In fact, during the first nine months of 2021, global car production plummeted by 26%.[47] The problem in this industry was that the orders planned for the year 2020 resulted insufficient. That is to say that the sharp drop in orders during the pandemic lockdown period caused to expect a much lower demand than to what turned out to be, thus causing supply to fail to meet demand. Semiconductors, therefore, were not sufficient to cover the large number of cars to be produced. In addition, more than a thousand chips are needed to produce a car, and for electric vehicles even more, which, with the shortage of semiconductors, made car production increasingly complicated.

The last sector is the *Government*. This sector has also been impacted, as defense and aerospace, health, energy, utilities and financial services are included in government. With regard to security, in particular, semiconductors are essential for the production of advanced military instruments and infrastructures, which have also suffered from a shortage of products necessary for their operation.

To conclude, the semiconductor crisis is not just about the absence of a particular product, but affects all sectors currently considered to be key. This, has resulted in the crisis spreading across multiple industries and involving multiple states, leading it to be both an economic and geopolitical issue. For these reasons, the governments of various countries had to begin to curb this increasingly negative trend. In particular, U.S. and Europe decided to implement similar measures in order to make themselves sufficient and succeed in coping with the crisis internally.

[46] Canon (2022) *Interim Toner*.

[47] J.P.Morgan (2023, April 18th) *Supply chain issues and autos: When will the chip shortage end?.*

3.3.2 US Chips Act

Following the substantial shock and disruptions in the semiconductor industry, along with geopolitical tensions, the US found it necessary to move forward with a law aimed at revitalizing domestic production of the semiconductors. In addition, the drop of U.S. in the semiconductor manufacturing capacity from 37% in 1990 to 12% in 2021[48] alarmed the U.S. by needing a new plan to recover its production capacity lost over time to innovations brought forward by other countries.

Thus, on August 9, 2022, the CHIPS and Science Act was signed into law by U.S. President Joe Biden, after being approved by the Senate and House of Representatives. The purpose of this act is to strengthen U.S. manufacturing and bring production back to the territory, to boost again the US competitiveness in economy, national security, supply chain resiliency and technology leadership. To do this, it was deemed necessary to invest mainly in research and development, which is crucial for this type of industry.

As can be read in the first sentences of the Act:

> The act establishes and provides funding for the Creating Helpful Incentives to Produce Semiconductors (CHIPS) for America Fund to carry out activities relating to the creation of incentives to produce semiconductors in the United States. […] The act establishes and provides funding for the Creating Helpful Incentives to Produce Semiconductors (CHIPS) for America International Technology Security and Innovation Fund to (1) provide for international information and communications technology security and semiconductor supply chain activities, including to support the development and adoption of secure and trusted telecommunications technologies, secure semiconductors, secure semiconductors supply chains, and other emerging technologies; and (2) carry out the Multilateral Semiconductors Security Fund and the Multilateral Telecommunications Security Fund. (H.R.4346 - *Chips and Science Act 2022*)

The CHIPS and Science Act is articulated in 3 main divisions:

1. Chips Act of 2022
2. Research & Innovation
3. Supplemental appropriations to address threats to the supreme court of the United States

[48] The White House (2022, January 21st) FACT SHEET: Biden-Harris Administration Bringing Semiconductor Manufacturing Back to America.

The major objective of the Act is to booster U.S. leadership in semiconductors. Specifically, the investments planned, provided for American semiconductor research, development, manufacturing and workforce development, are $52.7 billion, and are articulated as follows:[49]

- $39 billion in manufacturing incentives aimed at boosting semiconductor production in us again, along with the use of new technologies, equipment and material suppliers.
- $13.2 billion in R&D and workforce development.
- $500 million to support international information communications technology security and semiconductor supply chain activities.

Moreover, it includes a 25% tax credit for new manufacturing investments underwritten, with the aim of lowering the difference between investing in the U.S. and investing abroad, thus achieving benefits for the U.S. economy, national security, supply chain and technology leadership.

Together with the main aim of supporting the semiconductor manufacturing, this Act has also other objectives as:[50]

- To incentivize U.S. global leadership in technologies. Given the fact that new technologies are spreading worldwide, U.S. seeks to have a primacy from artificial intelligence to computing, both for its economic competitiveness and its national security. The aim is, both in the semiconductor industry and in the other technological ones, to obtain a leader position and to ensure that the U.S. innovations are made in house.
- To promote regional economic growth and development, to which $10 billion are addressed, in order to invest in the local innovation and technology hubs.
- To encourage U.S. innovation in wireless supply chains, to which $1.5 billion is addressed, in order to promote wireless technologies and become leader in this sector.
- To increase STEM[51] opportunities, with the aim of encouraging people to work in good-paying skilled jobs, expanding geographic and institutional diversity of research institutions. It is important for a country that wants its primacy in high technological and innovative industry, to have high-skilled workers.

At the same time of the document signing, companies announced about $50 billion in investments in U.S. semiconductor manufacturing. Among them, Micron decided to invest $40 billion in memory chip manufacturing, while Qualcomm and GlobalFoundries have announced a partnership of $4.2

[49] The White House (2022, August 9th) FACT SHEET: CHIPS and Science Act Will Lower Costs, Create Jobs, Strengthen Supply Chains, and Counter China.

[50] The White House (2022, August 9th) FACT SHEET: CHIPS and Science Act Will Lower Costs, Create Jobs, Strengthen Supply Chains, and Counter China.

[51] With STEM reference is made to the education based on Science, Technology, Engineering and Mathematics.

billion in order to increase the chip manufacturing production. This wave of companies' investments is to be observed as a consequence of the boost made by the government, standing for the importance and relevance of the Act.

Moreover, already at the end of 2020, many semiconductor companies had announced new projects in order to increase the capacity of the U.S. semiconductor manufacturing, resulting in the construction of 15 new fabs and the extension of various fabs across 12 states, and relevant investments in semiconductors materials.

3.3.3 EU Chips Act

In the face of the crisis in the semiconductor industry, the European Commission on February 8, 2022 released a proposal for a European Chips Act with the aim of preserving Europe's digital sovereignty and to address semiconductor shortages and strengthen technological capabilities.

> The proposal aims at reaching the strategic objective of increasing the resilience of Europe's semiconductor ecosystem and increasing its global market share. It also aims at facilitating early adoption of new chips by European industry and increasing its competitiveness. For this, it needs to attract investment in innovative production facilities, have a skilled workforce, but also be in the position to design and produce the most advanced chips that will define the markets of tomorrow, develop capabilities and have the possibility to test and prototype innovative designs through pilot lines in close collaboration with its industrial vertical sectors. These are necessary steps, but not sufficient unless the Union has the analytical capability of increasing the knowledge of the policy makers of the value chain and is capable to benefit from increased capacity to serve the common interest of the single market in case of crisis. The objective is not to become self-sufficient, which is not an achievable target. We must strengthen our strengths, develop new strengths and work with third countries in a supply chain where interdependencies will remain strong. (European Commission (2022) *Proposal for a Regulation of the European parliament and of the council: establishing a framework of measures for strengthening Europe's semiconductor ecosystem (Chips Act)*)

According to the proposal, the CHIPS Act would allocate €43 billion in public and private investments with the aim of doubling the current European semiconductor market share from 10% to 20% by 2030.

The proposal is based on 5 main strategic objectives:[52]

[52] European Commission (2022) *Proposal for a Regulation of the European parliament and of the council: establishing a framework of measures for strengthening Europe's semiconductor ecosystem (Chips Act)*.

1. Strengthening European leadership in research and technology.
2. Strengthening European innovation capability in the design, manufacture and packaging of advanced chips and their transformation into commercial products.
3. Establishing an appropriate framework to substantially increase European production capacity by 2030.
4. Coping with skill shortages, attract new talent, and support the emergence of a skilled workforce.
5. Developing an in-depth understanding of global supply chains of semiconductors.

In order to achieve these objectives, the initiatives proposed are:[53]

- To establish the "Chips for Europe" strategic initiative designed to support the innovation and the development of technological capabilities in all the European Union, with the aim of spreading new cutting-edge technologies for creating better and more powerful semiconductors.
- Creating a legal framework to ensure security of supply by attracting investment and advanced production capacity in the manufacture of semiconductors. This initiative includes a chip fund to ease the access for start-ups to finance themselves, for encouraging innovation and attracting investors.
- A coordination mechanism between Member States and the Commission to monitor market developments and anticipate crises through the study of weaknesses and bottlenecks.

On April 18, 2023, the Parliament and the European Council reached the political agreement, which awaits formal approval by the two co-legislators.[54] The European Union has, therefore, welcomed the proposal made by the Commission on February 8, 2022, as they believe it is essential for Europe itself that it be able to develop its expertise in technology and, specifically, in the semiconductor sector, an essential and strategic industry in today's situation.

Even before the agreement of the Chips Act, as happened in U.S., over €100 billion planned both private and public investments have been announced, including the giant Intel. At the same time, after the political agreement, on April 28, 2023, other €7,4 billion investments[55] have been announced by STMicroelectronics, an Italian French IDM company, and the U.S. foundry GlobalFoundries to

[53] European Commission (2022) *Proposal for a Regulation of the European parliament and of the council: establishing a framework of measures for strengthening Europe's semiconductor ecosystem (Chips Act)*.

[54] European Commission (2023, April 18th) *Commission welcomes political agreement on the European Chips Act* [Press Release].

[55] European Commission (2023, April 28th) *EU Chips Act triggers further €7.4bn investment in advanced semiconductor manufacturing in Europe - Statement by Commissioner Thierry Breton*.

support the advanced semiconductor manufacturing in Europe. This is evidence of the fact that such an announcement succeeds in enhancing the importance of the industry by encouraging an incentive for investment.

So, in conclusion, in the face of the semiconductor crisis that has heavily affected varied relevant industries, governments of various countries have decided to curb. Both the United States and Europe have decided to encourage investment in the semiconductor industry. While the United States has long been a leader in the industry and therefore wants to once again regain the market share lost to this shock, Europe, which has always depended heavily on other states, has decided to take advantage of the opportunity to try to make more and more room for itself in the industry.

4 PRODUCTION LOCATION STRATEGIES IN THE SEMICONDUCTOR INDUSTRY

4.1 Production location strategies of leading companies in the semiconductor industry

Within the global geopolitical context, the semiconductor sector has become increasingly important to the point of becoming one of the key sectors on which states move. For this reason, it is the interest of this thesis to analyze the current situation in the semiconductor market by paying attention to the location of production facilities and strategies related to them. The purpose of the analysis is, therefore, to show and analyze the geographic landscape of semiconductor manufacturing in order to understand how companies decide to strategically locate manufacturing facilities to cope with the semiconductor crisis, with a focus on detecting reshoring strategies.

In order to carry out this analysis, a sample of firms was selected so as to study their production strategies. The choice of the sample was based on two criteria. The first was economic in nature in that firms with the highest revenues in the market were considered. The second criterion underlying the selection of firms was technical in nature. In fact, in order to refine the search for the sample of firms, firms were selected according to the business model that characterizes them. Therefore, to do so, within the 4 types of business models that characterize semiconductor firms (IDM, Fabless, Foundry and OSAT), a selection was made so as to exclude Fabless and OSAT, because these two types of firms do not have the manufacturing stage within the firm itself and for that reason do not have the necessary characteristics for this analysis.

Once this macro-sample of firms belonging to the IDM and Foundry categories was obtained, the 10 firms with the highest revenues of the industry were selected.

The sample of 10 firms consists of 6 IDM firms and 4 Foundries firms. Of these 10 companies, 4 are from the United States, 2 are from South Korea, 2 are from Taiwan, 1 is from China, and 1 is Italian-French.

Companies forming the sample are listed below:

1. Samsung
2. Taiwan Semiconductor Manufacturing Company (TSMC)
3. Intel
4. SK Hynix
5. Micron Technology
6. Texas Instruments Incorporated
7. United Microelectronics Corporation (UMC)

8. STMicroelectronics NV
9. GlobalFoundries Inc.
10. Semiconductor Manufacturing International Corporation (SMIC)

The reason why this procedure was chosen is because the purpose of the analysis is to understand if reshoring strategies are options chosen and considered by the largest semiconductor companies to counter the semiconductor crisis that has affected the whole world. Thus, it became necessary to study the different geolocations of each company's manufacturing plants and whether they have decided to undertake specific strategies in order to counter the shortage of microchip production and manufacturing, that is currently fragmented and dispersed among various countries far apart.
With the purpose of understanding the production localization strategies of the companies examined, it is necessary to briefly analyze the history of each company in order to grasp its main characteristics. Next, the locations of each company's manufacturing plants will be identified and analyzed to show an overall picture of the geographical situation of semiconductor manufacturing. Finally, by analyzing whether there are new constructions and in which location, it is possible to study the behavior of firms and, therefore, the outcome of the analysis.

In the semiconductor market, Samsung and Intel are the market leaders as far as semiconductor vendors are concerned. In fact, as mentioned above, according to 2022 market data it appears that they have 10.9% and 9.7% market share, respectively. While, when talking about the foundries, the Taiwanese TSMC owns more than 50% of the market share, resulting in the undisputed leader in the semiconductor manufacturing stage.

Samsung is a South Korean multinational corporation founded in 1938 that made its debut in electronics in the 1960s. The strength of this company has been to follow all technological and market trends and evolutions, starting with TVs and moving up to smartphones and increasingly smart home appliances. The company is highly diversified, and this is reflected in its presence in the semiconductor industry as well. In the semiconductor market, the company presents an integrated business model, categorizing itself among IDMs. In fact, it carries out internally all stages of a semiconductor's value chain. Its portfolio, indeed, is highly diversified in the development and advances in Memory, in the investment in R&D for providing a better and cutting-edge design of semiconductor microchips and in the development of increasingly efficient foundry solutions, including in collaboration with R&D, to offer increasingly advanced efficient mass production.

Intel is a U.S. multinational company founded in 1968, specializing in the production of electronic components. Indeed, although it offers a broad product portfolio, it is nonetheless less diversified than Samsung, which faces several large markets. The company, therefore, is specialized in the provision of the most complex devices with advanced manufacturing technology, offering a wide portfolio including Accelerators, Memory, Platform products, Connectivity and Boards and systems. Intel is also an IDM company; in fact, it accommodates all stages of the value chain, from design to manufacturing, seeking to offer increasingly powerful and cutting-edge products with a data-centric overview.

Taiwan Semiconductor Manufacturing Company (TSMC) is the Taiwanese giant founded in 1987 that specializes in microchip manufacturing. The company is the world's largest manufacturer of microchips, owning more than 50% of the market share in terms of semiconductor manufacturing and having the giant Apple and other major Fabless companies such as Qualcomm and Broadcom as its largest customers. In fact, unlike the two aforementioned giants, TSMC is a foundry, that is, it does not have all the steps of the semiconductor value chain at its core but, on the contrary, it specializes only on a certain stage of the value chain, namely the manufacturing stage. The company seeks to provide ever-innovative products, through a continuous increase of its technology in advanced fabs and its production capacity.

SK Hynix is a South Korean company founded in 1983 and ranked third among the largest semiconductor vendors. In fact, this company like the two big giants has a vertically integrated business model in that it is involved in both manufacturing and research and development to offer increasingly advanced and competitive products. Although it is the third company with the most market share, it has a narrower portfolio than the others, focusing on 3 specific types of semiconductors, namely dynamic random-access memory (DRAM), flash memory (NAND), and CMOS image sensors (CIS) chips.

Micron Technology is an American company founded in 1978 as a company specializing in semiconductor design. Later, it decided to add the manufacturing stage and consequently opened foundries, transforming its business model into a vertically integrated company such as IDMs. Micron ranks fifth among companies with the largest market share, offering the broadest and most innovative portfolio among the largest semiconductor companies. Its strength is to be leader in innovative memory solutions, offering advanced memory and storage technologies.

Texas Instruments Incorporated was founded in Texas in 1930 as Geophysical Service Incorporated, a company initially engaged in geological surveys for the oil industry, and only during World War II did it enter the electronic equipment business. Today, Texas Instruments is one of the leading multinational semiconductor companies, offering products with differentiated applications in both personal and enterprise end-user. The company is involved in the creation of semiconductors in its entirety, starting from design, through manufacturing, testing and final sale, which is why it is classified in the type of IDM. This company is particularly relevant in the semiconductor world because the first modern microchip was invented by one of the company's TI engineers, Jack Kilby, in 1958.

United Microelectronics Corporation (UMC) is a semiconductor manufacturing company established in 1980 in Taiwan created from a spin-off of ITRI[56]. Initially, the company began as an IDM and then decided to focus only on microchip manufacturing, thus downsized its business model to a pure-play foundry. The UMC foundry, therefore, ranks third among semiconductor foundries with the most market share, behind the Taiwanese giant TSMC and the Samsung company, but second if only pure-play foundries are considered. Its manufacturing solutions include Logic and various specialty technologies, offering specialized product to serve upcoming markets such as 5G, Artificial Intelligence and Internet of Things.

STMicroelectronics NV is a French-Italian company originally established as SGS-Thomson Microelectronics NV from the merger of two Italian and French semiconductor companies in 1987. The company offers microchips developed with advanced technologies and invests in research and development to deliver innovative products in step with evolving industries and customer needs, with a particular focus on sustainability. In fact, their products are developed and follow an environmentally friendly design process fully developed by the company. For this reason, the company presents a vertically integrated business model, thus classifying itself as an IDM company.

GlobalFoundries Inc. is a U.S.-based company founded in 2009 and is ranked fourth among the world's largest foundries, third if only pure-play foundries are considered and so excluding Samsung. Thus, its main activity is to produce high-tech microchips and it collaborates with leading fabless companies to develop the best and advanced technologies for its products. Indeed, its portfolio is

[56] The Industrial Technology Research Institute (ITRI) is a nonprofit organization that focuses on research in the field of applied technology.

characterized by a wide range of differentiated technology platforms offering feature-rich process technology solutions.

Semiconductor Manufacturing International Corporation (SMIC) is a Chinese semiconductor manufacturing company established in 2000, partially owned by the Chinese state. It is the leading chip manufacturer in China and ranks fifth among the largest global foundries serving the fabless companies' market, fourth if only independent foundries are considered. As a pure-play foundry, therefore, it deals purely with the semiconductor manufacturing stage, and its major customers include China's leading telecommunications company Huawei and major semiconductor fabless companies.

After presenting the companies that are part of the sample, the analysis goes on to identify the production facilities of each company in order to give an overall view of the stage distribution of semiconductor manufacturing.
The analysis, in the first instance, focused on a study of the current situation of the companies' location and then were analyzed the individual strategies undertaken relatively at the new factories' construction, investigating whether companies have implemented dynamics similar to those of reshoring.
In order to conduct the study, it was necessary, therefore, to detect the location of the production chains of each individual company considered. The semiconductor manufacturing stage, as mentioned earlier, is characterized by two steps, thus the front end with wafer fabrication and the back and with assembly, packaging and testing. In order to capture all the differences in the two types of manufacturing, it deemed necessary to analyze them separately.

Starting from the first step of manufacturing, namely the wafer fabrication, the figure below shows the location of the "fabs"[57] of the 10 companies in the sample, they totaled 70 wafer fabrication sites.

[57] A "fab" is the production site where the wafer fabrication is done.

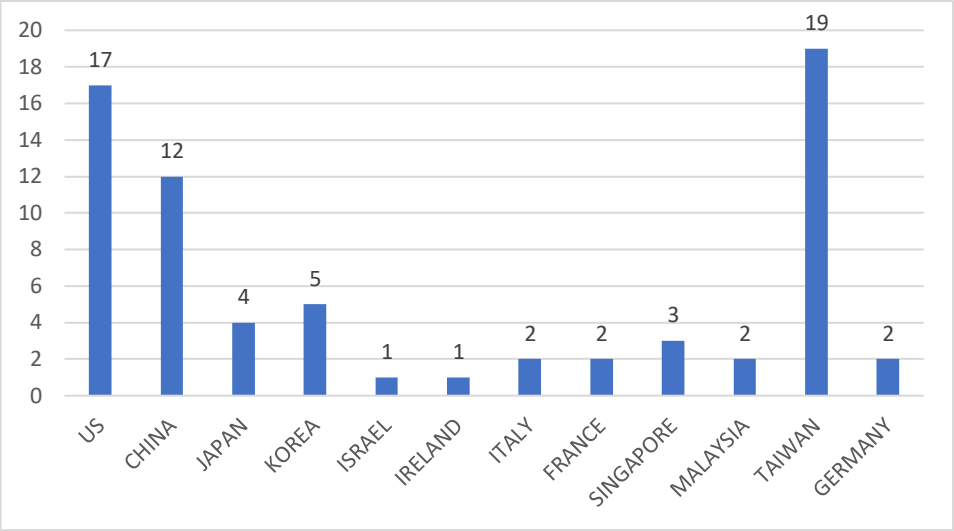

Figure 29. Number of wafer fabrication plants by country.
(Source: Personal elaboration)

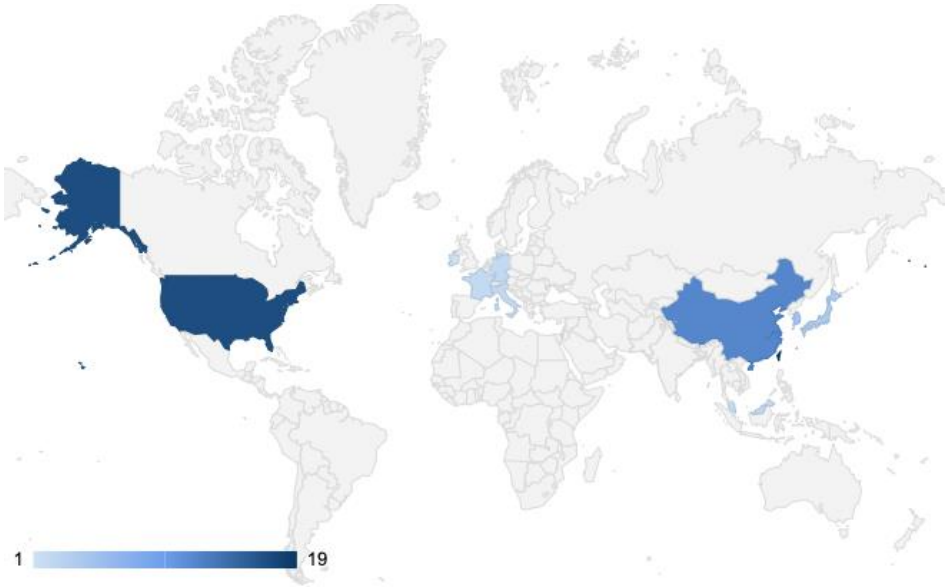

Figure 30. Geographical distribution of the wafer fabrication plants.
(Source: Personal elaboration)

As the graph and the figure show, the distribution of fabs is highly skewed with a concentration in the United States, China and Taiwan. This figure unequivocally justifies the strategic importance of these countries. Taiwan, as easily expected from the presence of the giant TSMC, has the largest number of production sites with a total of 19, followed by the U.S. with 17 and China with 12. The graph also shows the inadequacy of Europe's means, which in its entirety has only 7 production sites. In general, it can be seen that the center of microchip production is located in Asia, given the high presence also in Korea and Japan, as well as Malaysia and Singapore. Nevertheless, the US remain a relevant manufacturing site for the semiconductors, due to their importance in the discovery of microchips and their supremacy in the market. This evidence is in line with the geographical

distribution of the first step of the semiconductor manufacturing analyzed in the third chapter of this thesis, where it resulted that the concentration of the locations were mainly in East Asia, with a 56% of market share.

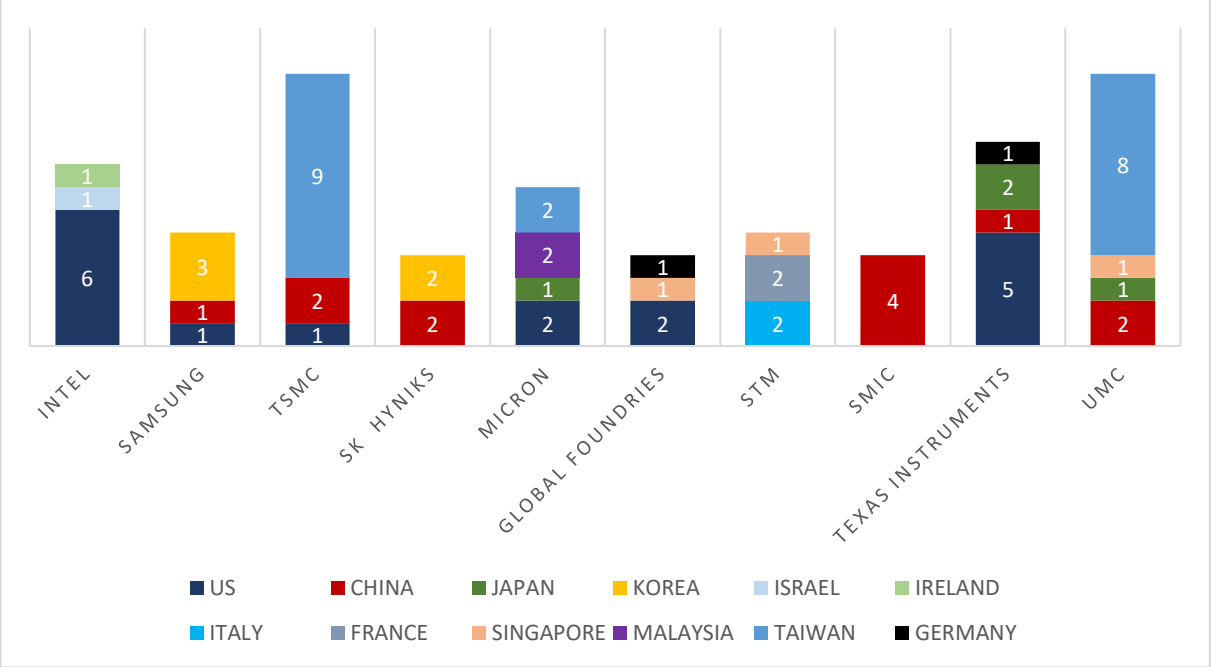

Figure 31. Companies' location of wafer fabrication plants by country.
(Source: Personal elaboration)

Going into detail, it was necessary to analyze not only the geographic distribution in aggregate but the production locations of each individual firm, and then relate this to the nationality of the companies themselves. As can be seen, there is a strong domestic production component for each firm. Indeed, each company tends to have most of its production facilities within its home country. More specifically, 9 out of 10 companies have a percentage equal to or greater than 50% of production sites located in the home country. Nevertheless, out of 70 production sites in the sample, 25 are located outside the firm's home territory. So, in other words, only a 35% of the production sites are relocated abroad.

This consideration is highly relevant when talking about wafer fabrication, since it represents an extremely important phase of chip production for companies, as well as one of high strategic importance. Due to the high specialization and being a highly knowledge- and skill-intensive stage, companies prefer to locate the wafer fabrication step close to home. In addition, the geographical breakdown shows very clear how companies at this juncture find themselves operating in most cases with countries with which their government has friendly relations, again for the reasons of high

importance of the stage just stated. This aspect should be emphasized because it forms the basis of the eventual strategies implemented by firms in reshoring.

Turning to the back-end analysis, thus considering assembly, packaging & testing, the situation changes diametrically, since location of production sites is no longer concentrated in a few states. The total number of production sites in the second manufacturing stage amounts to 34, this is because not all the companies considered also follow this production part. In fact, among the companies in our sample, only 7 out of 10 have the back-end manufacturing stage in their value chain.

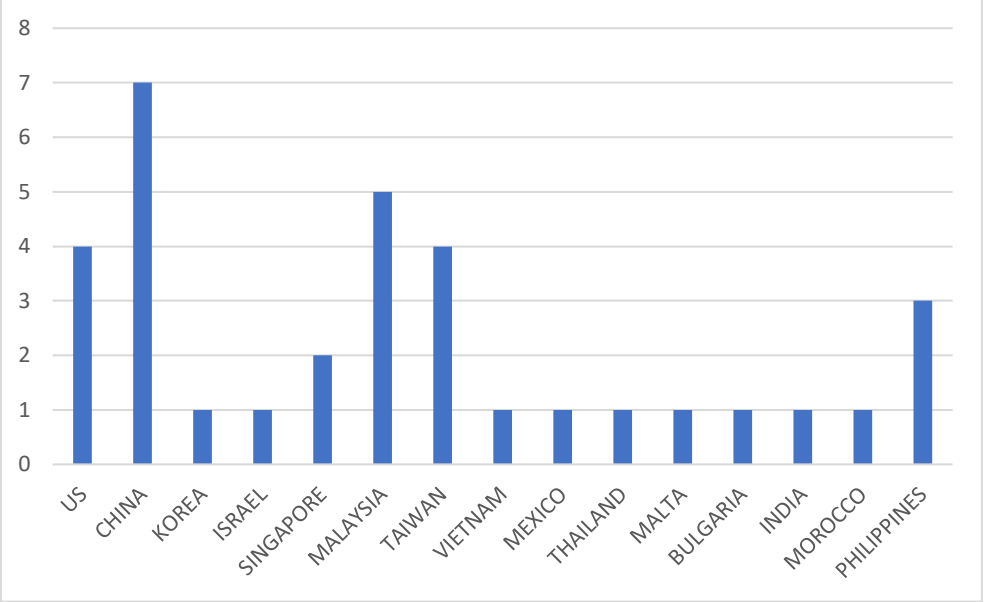

Figure 32. Number of assembly, packaging and testing sites by country.
(Source: Personal elaboration)

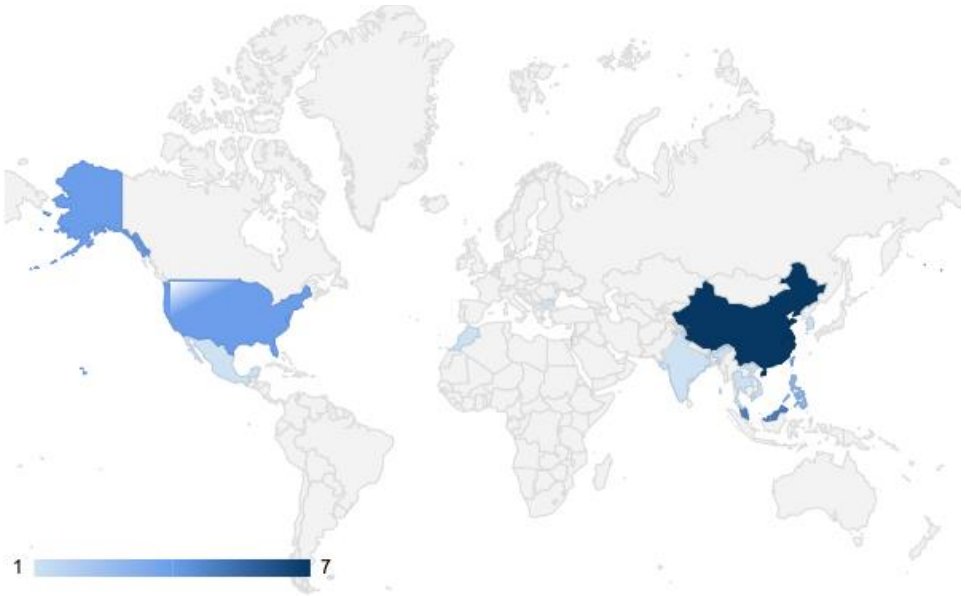

Figure 33. Geographical distribution of assembly, packaging and testing sites.
(Source: Personal elaboration)

It can be seen from the graph that the number of countries involved in this second stage of the manufacturing process is significantly higher than in wafer fabrication and most of them do not coincide with the companies' countries of origin. This element is due to the degree of specialization of technical components required for this stage of production, which appears to be lower than for the first one. Following this logic, therefore, companies are more likely to relocate production to even distant countries while trying to reduce costs, by not requiring necessary strictly control over the stage and high-skilled workers.

In this context, China excels in the number of production sites located in its territory, amounting to 7. This figure is in line with the global distribution of back-end manufacturing previously exposed, as it had been found that manufacturing plants are purely concentrated in China, the US, and Taiwan. As can be seen, therefore, this figure is reflected in the distribution of back-end manufacturing in the sample considered, noting China, the US, Malaysia, and Taiwan as poles of concentration.

Moreover, the sample considered is composed of Chinese companies but also of U.S. companies that outsource the assembly, packaging and testing of their chips to Chinese plants. Indeed, the 7 back end production sites located in China are of US, Chinese, Korean and European companies. As mentioned in the third chapter, China benefited from a wave of offshoring of this precise stage of the semiconductor value chain, this due to the low skills and knowledge required, at the same time developing a strong assembly, packaging and testing industry in the country.

After having analyzed the current global and company-based location of the two phases of semiconductor manufacturing, it is deemed necessary to analyze the next strategies undertaken by companies regarding the opening of new manufacturing facilities. In order to do this, the analysis was divided into two stages of work progress, "under construction" and "future construction". In the first category are analyzed the fabs' constructions that have been announced in the past and are under construction, with an upcoming opening. While the second category includes those fabs buildings for which an upcoming construction has been announced, but the latter has not yet begun.

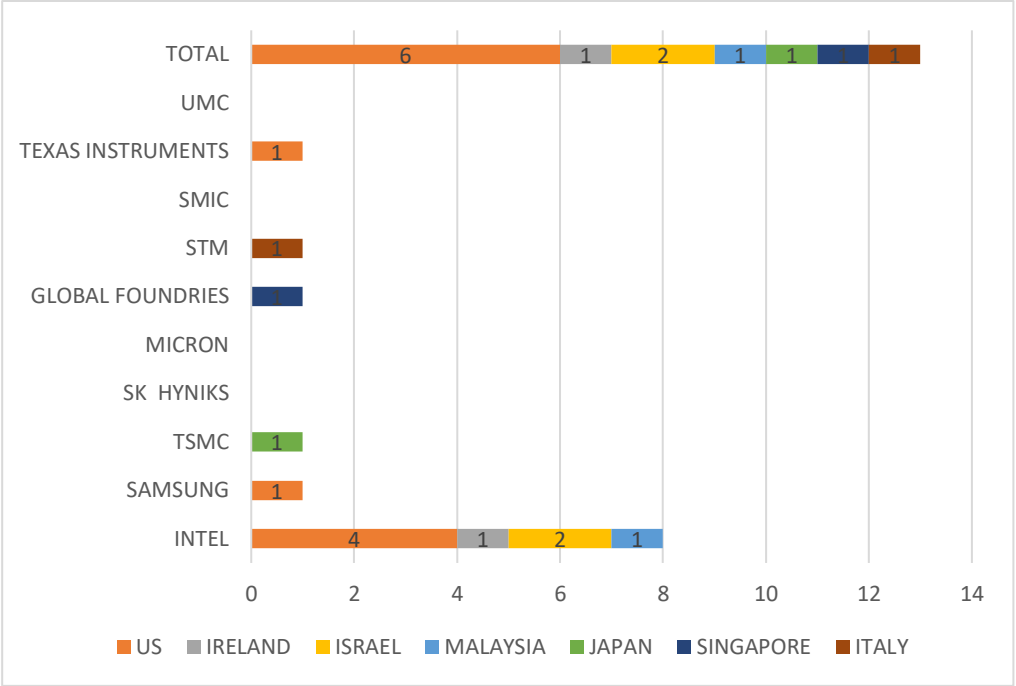

Figure 34. Companies' location of under construction fabs by country.
(Source: Personal elaboration)

The results show that 6 out of 10 total enterprises of the sample have initiated projects to build and implement a total of 13 new fabs. It can be seen from the graph that the location of new construction is purely concentrated in the United States, with a total of 6 new fabs. Specifically, the companies that have planned to open new fabs in the United States are Intel, Samsung, and Texas Instruments, two U.S. and one South Korean. These data provide evidence of market trends both prior to the drafting of U.S. and European incentives for a revitalization of the semiconductor industry and after. In particular, it is possible, therefore, to see that the US CHIPS Act is encouraging companies to open new manufacturing facilities in the Americas in order to redevelop U.S. leadership in the semiconductor industry. The rest of the locations where companies started to build new production facilities are in Asia and Europe, in line with the geographical location that has always characterized the production of the semiconductor industry, but with a new opening towards Europe and a significantly lower flow toward Asia that characterized the sector.

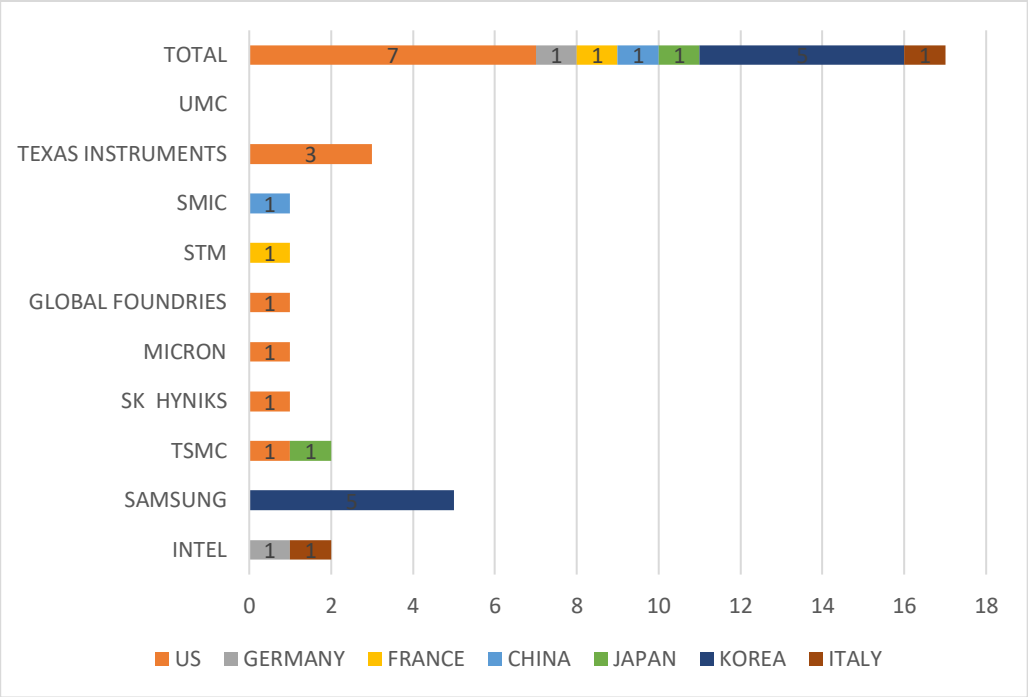

Figure 35. Companies' location of future construction fabs by country.
(Source: Personal elaboration)

Regarding announced future construction fabs, from the sample taken, 9 out of 10 companies have announced to open new fabs over the next few years, only Chinese UMC has no plans.

In terms of geographic concentration, the United States is also a target for the opening of upcoming fabs soon, by U.S., South Korean, and Taiwanese companies. South Korea also shows a high number of upcoming new fabs, but they are all from the giant Samsung, the South Korean company, which then decides to focus on opening new fabs in house. In addition to the usual targets such as America and Asia, there are few investments in Europe, as Intel plans to invest in building two new fabs, one in Germany and one in Italy. It is possible, therefore, to see how the CHIPS Acts announced by countries to address the semiconductor shortage and, at the same time, to revalue the semiconductor industry in their own market, are encouraging companies to invest in the United States and Europe.

Another fact that appears evident from these analyses is the almost total absence of new investments towards China and Taiwan. It is possible to address the lack of investment in the Taiwanese island, world leader in the semiconductor industry, to the fact of the increasing geopolitical tensions previously analyzed and the ever-increasing dominance of the island, whose heavily dependence led to the scarcity of the supply manufactured semiconductors around the world. While the lack of investment in China, represents a clear trend of a practice of redefining the distribution chain, with the aim of immunizing themselves from the risk of operating in China. This risk, as mentioned in the previous chapter, is given by Chinese unfair behavior such as the theft of patents and the Trade war with the US.

There is therefore a clear change from the dynamics of the last 10-15 years, which has seen considerable investment in the states of Southeast Asia and specifically in China, while today there are evidence from the sample that Asian companies tend to invest in opening new factories in the United States. The two possible determinants of this behavior are the US CHIPS Act, which has encouraged companies to invest in the opening of semiconductor manufacturing sites in the US, and the importance of having business relations with them, as potential US customers are among the world leaders and, therefore, an attractive market. Of relevance are the policies of Intel and Global Foundries which are the only two that shows a strategy in which dynamics similar to those of reshoring can be identified. The two US companies, in fact, in recent months have abandoned production activities in China and started investments to restart them in the United States.

To continue the analysis, it deemed necessary to study whether companies have undertaken similar reshoring activities, with the aim of analyzing them. To do this, in the first instance were taken into consideration companies that have decided to announce investments at home, and then the study continued by identifying whether they have closed or divested factories outside the home country in the recent past.

Of the 9 out of 10 companies in the sample that have started or announced future construction of new fabs, it turns out that only 3 have recently closed foreign factories, and they are Intel, Global Foundries and Samsung. After analyzing the recent dynamics of these three companies, however, it is necessary to focus on Samsung as its strategy is outside the scope of this thesis' study.

Indeed, Samsung announced in February 2021 the closure of its fabs in Austin, Texas, due to power issues. But at the same time, Samsung, in addition to having announced the creation of 5 new fabs in Korea, is investing $17 billion in building a new fab in Taylor, Texas.[58] As a result of these actions undertaken, the company does not show a reshoring-like dynamic, consequently it is excluded from the analysis.

In conclusion, the evidence showed that the only companies that have closed factories abroad and, consequently, announced constructions in the home country, with dynamics similar to those of reshoring strategies, are Intel and Global Foundries.

Going into detail, it is important to consider the case of Intel, which is the one that best represents and encapsulates a policy of strengthening American semiconductor leadership. The American company has, in fact, firstly announced in 2020 the sale of its manufacturing fab in China, and then

[58] Samsung (2021, November 24th) *Samsung Electronics Announces New Advanced Semiconductor Fab Site in Taylor, Texas.*

undertaken in March 2021 a new corporate strategy to strengthen the company's own competitiveness, called *IDM 2.0*.

The company then signed an agreement on October 20, 2020, under which SK Hynix, the Korean semiconductor company, will acquire Intel's assets and manufacturing facility in Dalian, China, for $9 billion, with Intel's final exit by 2025.[59]

Subsequent to this decision, in early 2021, Intel announced its new *IDM 2.0* strategy, with which it will strengthen its presence in the United States. This strategy aims to strengthen the company to make it able to offer increasingly innovative products, positioning itself as a product leader. "We are excited to be partnering with the state of Arizona and the Biden administration on incentives that spur this type of domestic investment" said Intel's CEO Pat Gelsinger.[60]

In order to accelerate the new strategy, Intel announced a plan to expand manufacturing capacity, beginning with the construction of two new fabs in Arizona. The investment is about $20 billion with job creation more than 20,000 direct and indirect jobs. The opening of the fab and, therefore, production is projected to begin in 2024. Moving on with its strategy, in January 2022, Intel announced another investment, resulting in $20 billion with the construction of 2 new production plants in Ohio, with the aim of both addressing the semiconductor shortage and strengthening the U.S. semiconductor ecosystem, encouraged by the CHIPS Act.

Through this Intel strategy, it is therefore possible to identify the decision of a company that has become increasingly independent and that, aided by a US protectionist policy, has decided to close a production plant in China, due to the tensions that have emerged, and then invest in your own country. Faced with this, it is therefore possible to observe this strategy as a dynamic similar to reshoring, albeit with different motivations from the classics that characterize this strategy. Despite this, it is clear that the US grounded plan to revive their supremacy in the semiconductor industry is beginning to bring results.

Another evidence of behavior similar to that described in the reshoring strategy, comes from the U.S. company Global Foundries. It, in fact, had announced a joint venture in 2016 with the government of Chongqing, China, to create a new fab in order to expand its global footprint in semiconductor manufacturing.[61] It later decided in 2020 not to proceed with the establishment of a new

[59] Intel (2021, December 29th) *Intel Sells SSD Business and Dalian Facility to SK Hynix*.

[60] Intel (2021, March 23rd) *Intel CEO Pat Gelsinger Announces 'IDM 2.0' Strategy for Manufacturing, Innovation and Product Leadership*.

[61] Global Foundries (2016, May 31st) *GLOBALFOUNDRIES to Expand Presence in China with 300mm Fab in Chongqing*.

manufacturing facility because of geopolitical tensions between the U.S. and China in previous years. Consequently, in July 2021, the company announced the expansion of its manufacturing capacity in its manufacturing plant located in Malta, New York both through the improvement of its Fab 8, and through the creation of a new one. So, the program is to invest $1 billion to add 150,000 wafers per year in the Fab 8 and to construct a new fab, thus creating more than 2,000 direct and indirect jobs, through the funding of private-public partnerships.[62] The decision to invest on U.S. soil was driven both by a need to increase production capacity to meet the semiconductor shortage and to strengthen the U.S. semiconductor supply chain.

Also in this case, it is possible to highlight behavior that appears similar to the actions that are taken when following a reshoring strategy. In this case, Global Foundries was motivated by political reasons and, at the same time, capacity needs. The combination of these two reasons made the company decide to locate the creation of a new fab in the home country, thus excluding the plant in China. Although not explicitly defined by the company, it is possible to observe this dynamic as similar to corporate behavior in the case of reshoring.

4.2 Final considerations

From the analysis conducted, it is therefore possible to observe that there is no clear trend of reshoring strategies by the world's leading semiconductor companies as a response to the crisis and geopolitical tensions. From the selected sample, in fact, it appears that companies are driven to invest in the semiconductor industry, with the aim of increasing production capacity, nevertheless there is no well-defined trend of reshoring strategy. The only evidence found is that of the U.S. companies Intel and Global Foundries, which have closed or decommissioned plants in China due to US-China tensions and then decided to open new manufacturing plants in the US. Despite this, the other companies followed up with actions to expand production capacity in different countries. What can be seen, however, is a good response to the initiatives launched by the U.S. with the CHIPS Act, as there is a growing trend of investment by U.S. companies in America.

The reasons that may explain that there is still no trend in which companies decide to follow a reshoring strategy can be varied.

The first is identifiable with the high transition costs due to the high specialization required by semiconductors, so it is neither fast nor easily eligible to move production facilities from one country to another. The high level of knowledge and specialization that requires the manufacture of a

[62] Global Foundries (2021, July 19th) *GlobalFoundries Plans to Build New Fab in Upstate New York in Private-Public Partnership to Support U.S. Semiconductor Manufacturing*.

semiconductor therefore makes relocation very complex and expensive, which is why reshoring actions require time, investment and certainty. Relating to this, probably the reasons behind the reshoring strategies, in such case, could be very different from the common ones, which is purely for commercial or strategic reasons. That is to say that, usually, among the most common reasons, as seen in the second chapter, there are cost reduction, reasons of logistics and proximity to the customer ones. Instead, in this case, the reasons that would justify reshoring would be perhaps political in nature. As widely discussed in the previous chapter, in fact, three of the main fundamental states in the semiconductor industry are at the center of tensions and problems, which are reflected on international trade and production. As the semiconductor value chain is global and fragmented, it is influenced by the political links between the various powers. So, according to this, the reason behind localization decisions in this specific industry could be more a political one, thus departing from the common motivations behind reshoring.

This second ground of appeal gives rise to a third, which is therefore closely linked by a causal relationship, namely the time horizon. Specifically, the possible evolution of events must be considered in strategic business assessments. In this specific case, the semiconductor crisis can be analyzed from two different points of view: the first as a short-term phenomenon and the second as a long-term one. That is to say, at a time when this crisis is being considered as a cyclical shortage of semiconductors due to the explosion in demand, but which will come back when production capacity is being increased, companies do not take into consideration reshoring strategies, which would bring huge costs to the company. Following the same line, the geopolitical tensions that affect the semiconductor market can be dealt with following the same reasoning. On the contrary, if the crisis or geopolitical tensions were to be considered as a structural problem, companies would then have to analyze hypothetical reshoring strategies, as the long-term horizon would deem necessary to think of a reconstruction of the production location to face the shock.

Another point of attention highlighted following the analysis of the sample are the strategies implemented by companies that are not attributable to reshoring but, at the same time, it is possible to observe nearshoring or friendshoring[63] strategies. In relation to this, it is observable by the location decisions of the new sample fabs that companies decide to invest in friendly or allied countries. Examples of this behavior can be identified in the US company Intel, which invests purely in the US and in Europe, or the Chinese company SMIC that invests only in China. This evidence led us to affirm that, although strategies of reshoring are not visible, similar behavior are implemented

[63] With the term "friendshoring" we mean the decision by companies to move production to countries with which they have good commercial relations.

according to the influence of the political issue on localization strategies, therefore deciding to invest in countries with which the ties are peaceful.

The final point is the focal point, that of the time horizon of the analysis too close. The semiconductor crisis is a phenomenon that is still developing and manifesting globally, accentuated by the political crises between China and the United States and the war in Ukraine. This makes it even more cryptic and difficult to analyze and understand possible industry dynamics, especially reshoring being a strategy that takes a long time. For this reason, the analysis suggests a more in-depth study in the future, in order to grasp more specific and detailed aspects that are not yet visible.

In this context, what can be easily observed is that the protectionist dynamic implemented by Western countries, with the CHIPS act of the US and Europe, is bearing fruit with a significant increase in investment and development in the semiconductor industry of the countries concerned. This can be seen from the diverse and widespread creation of new fabs and the prompt response from the largest semiconductor companies, willing to increase production capacity to cope with the crisis that is impacting the whole world.

CONCLUSION

The thesis aims to analyze the phenomenon of reshoring and investigate whether it has been applied as a strategy to counter one of the most important and crippling crises in the global landscape, the semiconductor crisis. From the analysis, it seems clear that leading semiconductor companies still have not considered using reshoring strategies to cope with the crisis, although similar behavior has been verified in two companies, Intel and Global Foundries. The decision to bring manufacturing plants back in house has been mentioned in previous chapters as one of the possible actions to cope with such shocks, so as to immunize against a possible exacerbation of the consequences of the crisis itself.

Semiconductors are a highly specialized product which require a very complex value chain. In fact, as noted earlier, it is almost impossible for the high knowledge required of all stages of the value chain to be concentrated in one state. This is why it is possible to identify the semiconductor value chain as a diffuse and fragmented global value chain. This new value chain configuration, however, seems to be weak and more exposed to criticality when shocks such as the Covid-19 pandemic arise. In fact, having the different stages of the value chain scattered around the world, at the time when a crisis blocking transportation arises, brings countless disruptions and problems in product supply. This is why, in the recent period, the trend of reshoring has taken hold, considering that a more geographically compact value chain can respond better to these kinds of shocks.

In the analysis, the geography of the manufacturing plants of the 10 leading companies in the sector is shown, which appears very fragmented and dispersed around the world, in line with what has been mentioned earlier. The locations of the production plants are mainly in the four world powers, which have faced and still are facing great geopolitical tensions, also due to the dominance in the sector. Indeed, Taiwan is at the center of the semiconductor manufacturing landscape, owning more than 50% of the market share, followed by the U.S., China and Europe. The geopolitical tensions that have weakened relations between the U.S. and China and between China and Taiwan have also had consequences on the redistribution of localization. In this scenario, Intel and Global Foundries, the two companies in which actions similar to reshoring have occurred, have decided to close in China, motivating it also with political issues. Moreover, taking into consideration the target countries of the new and future construction of production plants, it is possible to notice a different trend from the past localizations. Indeed, in the future scenario, the production plants will be built mainly in the US, Europe and few in South Asia. What is particularly relevant is the total absence of Taiwan and the

fact that in China there is only one future construction by a Chinese company. This is clear evidence of a shift in the geography of the semiconductor industry. All this shows that the geographical landscape of semiconductor manufacturing expects to see a redefinition of boundaries and geographical locations, both for political issues and for crisis response, as suggested by the two Chips Act signed by the United States and Europe.

Nevertheless, the redefinition of the semiconductor manufacturing landscape has not yet become a real trend. Various possible reasons have therefore emerged for this scenario. The fact of having high transaction costs and the huge investment required due to the high specialization of the product are a point of attention when re-planning the location of the production plants. It follows that, if the crisis is considered by enterprises as temporary, they are not prepared to undergo similar investments. On the contrary, if it is considered structural and, therefore, it is considered necessary that a return to the home of the productive structures, the companies are inclined and consider the dismantling of foreign production sites to bring them back into the home country. Another point of extreme attention that can be identified as a limitation to analysis is the short time horizon, that is, the fact that the crisis has occurred recently and is still ongoing. For this reason, a future analysis would bring out a clearer picture.

One very noticeable trend, however, is the continued investment in the United States, especially by US companies, which highlights how the policies promoted by President Biden to revive the country as an industry leader are working. Indeed, their aim is precisely to bring semiconductor manufacturing and design back home, to reassert themselves and regain the market share they have lost over time due to the entry of other major powers, such as Taiwan and China. In addition, Europe has also taken action to promote greater investment in the area in order to revitalize and bring Europe into a stronger competitive position. This is identifiable in the decision of both American and European companies to invest in the future construction of production plants in Europe, a demonstration that the typology of actions put in field from the countries succeed effectively to boost investments for the purpose aforementioned.

In conclusion, global dynamics are constantly changing and are influenced as much by innovation as by relations between countries. The paper began with a situation of total openness on the part of countries and, consequently, of companies, showing how an interconnection between states and the creation of global ties has brought new and favorable scenarios for businesses. At the same time, this initial balance has been put to the test by serious and profound shocks that have arisen in recent years

and that have led to an increase in tensions between countries. It is in this scenario that the debate on the strong interconnectedness and almost dependence on global dynamics has taken place, questioning whether the high fragmentation and dispersion of business value chains can cause a weakening of the same and a greater fragility when exposed to shocks. The phenomenon of the reshoring has therefore emerged as possible answer to a structural fragility, thinking that a rapprochement of the various parts of the businesses localized elsewhere could strengthen the companies. It is for this reason that the paper analyzes whether this dynamic has been implemented by companies as a response to a global crisis of major importance in the world panorama such as that of semiconductors. The analysis shows that companies have not yet taken explicit reshoring actions, even if similar dynamics emerge. One of the most important and relevant reasons associated with this result, which is considered as a limitation to this analysis, is the short time horizon between the crisis and this study. The crisis is still ongoing, and a possible reshoring takes time and large investments, which is why it is believed that a similar analysis should be repeated in the future.

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SUMMARY

Globalization and international strategies

In recent times, increasing global integration has been observed, resulting in no longer consider the world as a collection of separate states, but as a single one. Globalization is the trend that has characterized the last decade and it refers to the process that led to the creation of a global market, where products, services and capitals are internationally traded. Several scholars date back the birth of the globalization process to many decades ago. Moreover, thanks to the steam revolution and the Industrial Revolutions, transport increasingly facilitated the exchange of goods between countries, making it cheaper and cheaper. Despite this, from the early 1900s onwards, due to the two major World Wars, globalization took a step backwards, only to resume its course at the end of the World War II, when different agreements were stipulated with the aim of regulating the world trading system. Among these, the most relevant is the General Agreement on Tariffs and Trade (GATT) signed in 1947 to establish the basis for a multilateral trading system aimed at promoting global trade liberalization. Other relevant agreements are the ones of Bretton Woods, where countries came together to set up the system that regulated monetary and financial relations between nations, with the establishment of the World Bank and the International Monetary Fund. This compromise highlighted a desire for a world in which different states are increasingly interconnected, through the rise of a fully agreed monetary order, designed to govern monetary relations between independent states. Thanks to the removing of economic and financial barriers, a consequently drop on tariff rates and technological, transport and communication developments, a new era began with the international business. This term refers to the all the commercial transactions which occur between two or more regions, countries and nations across their political boundaries (Radebaugh & Sullivan, 2007). More specifically, companies that operate with an international perspective are called multinational enterprises (MNEs). A multinational enterprise is a company or corporation which has a relevant number of resources and works in various business activities through a network of branches located in different countries (Cavusgil et al. 2008).

Once a company decides to open its boundaries and start working internationally, it has to decide how to enter the new market abroad. Based on its scope and its internal characteristics, there are different entry modes offering various levels of control, risk and investment required. Indeed, a company can enter a new market using low level of risk and control, as in the case of exporting or brownfield strategy, or taking on more risk and, consequently, requiring also more control, as in cases of licensing, franchising, joint ventures and greenfield strategy.

Then, after entering the new foreign market, the company tries to define the strategy that best fits with its needs and goals. According to two types of competitive pressures, pressure for cost reductions and pressure for local responsiveness, it is possible to identify four main different strategies that a company can pursue when operating in an international context. In fact, the company may decide to focus on the pressure of the need to meet local needs, and thus adopt a strategy aimed at local customization, such as localization strategy, or aimed at cost reduction, such as global standardization strategy. At the same time, it may decide not to worry about either pressure and simply export the product, following an international strategy, or balance both pressures by following a transnational strategy.

Offshoring phenomenon

Starting from 1990s with the first wave and with the maximum expansion in the early 2000s, a new phenomenon called *offshoring* has developed, with the main objective of reducing costs through a reconfiguration of business processes. The term offshoring refers to the situation in which a firm decides to locate an activity outside of the company's boundaries. The main reasons for locating an activity outside the firm's boundaries are varied. One of the most important rationales is certainly the choice of a location where the company can reduce its costs, thus increasing its performance and, therefore, the competitiveness of the company itself. Indeed, the initial impetus for offshoring was believed to be precisely to find countries where labor or raw materials cost less, in an effort to make higher profits. In line with this view, the main countries as final destination for offshoring in 2021 are India and China.

Global Value Chains (GVCs)

The value chain of a firm is the structure that includes all the processes and activities needed to the creation and selling of a product or a service and its related value. With the trend of globalization and, so, with the presence of firms in a global market, there is no more a completely all in-house value chain, but it is dispersed around the world. Therefore, since the early years of this century, the ability of companies to 'fragment' the value chain into specific activities has increased, with the aim of locating each of them in the most productive and convenient geographical areas. In this context it is possible to talk about Global Value Chain. The term "Global Value Chain" (GVC) describes the situation in which the various activities of the production process (design, production, logistics, marketing, market services and the various support activities) are carried out in many different and not necessarily neighboring countries. The factors that have favored its widespread diffusion can be grouped into three categories, namely the ever-increasing geographical fragmentation of operations,

the liberalization of trade and productive investment between countries and the development of new large geographical areas to exploit cost reductions. Moreover, this new configuration of the internal structure of companies not only has positive effects within the company itself, such as a reduction in production costs, but has also favored work in emerging countries. The main issue related with this new configuration is the governance, as it describes who the participating actors are and the relationships between them and how corporate power is divided in relation to the distribution of profits and risks. Global value chain management is effective if, although carried out by business units located in different geographies, it remains highly integrated.

Effects of Covid-19

This pandemic crisis came at a time of 'plateauing of GVC expansion' when the initial push for internationalization and global value chain models was slowing down. The decision by many companies to transfer parts of the value chain abroad had begun to saturate the market, leading to higher wages in the initially emerging markets. In addition, digitalization, automation of production and the economy's greater service orientation, together with a demand for greater sustainability and fluctuations on transportation costs, were the reasons why the phenomenon of bringing activities home, the so called 'reshoring', was gaining momentum. This is when the Covid-19 pandemic breaks out. This shock highlighted the fragility of global value chains: when there is a shock of this caliber at global level, companies break down. About this issue, various analyses have opened: some believe that more localized production kept close to national borders can bring greater security in relation to these shocks and, in general, stability; while others believe that it is necessary to have as many suppliers as possible and, therefore, to relocate as much as possible. The characteristics of the Covid-19 pandemic, such as disruptions and blockages in transportation or material shortages due to lockdowns in many countries, have destroyed the global value chain by fostering self-sufficient economic systems. The decision to bring back activities previously located in different countries was encouraged following the disruption caused by the pandemic. Indeed, the first action on the part of companies faced with a pandemic of this caliber was to decide to bring the various activities back home and internalize the value chain to protect against future shortages, but this, with a long-term view, is not considered by many to be the correct choice.

The reshoring phenomenon

Reshoring entered the scenario of international companies long before the recent crisis. It is possible to consider reshoring as the opposite phenomenon and one that should be studied in relation to offshoring. Gray et al. (2013) identify reshoring as "bringing manufacturing back home from a current

location that is, de facto, not home". The motivations of companies pursuing a reshoring strategy can be found through research done by the Research Group Uni-CLUB MoRe Back-reshoring in 2015 aimed at gathering empirical evidence from secondary sources to better understand the reshoring phenomenon and the underlying motivations. The most relevant factor is "Logistics", understood not only in terms of cost, but also in terms of procurement. Although offshoring can be attractive to reduce labor costs by searching for countries where it costs less, the long distance between activities can increase logistics costs, both as operating costs but also as procurement delays. In these cases, companies believe that bringing assets back home can cut these excess costs. Moreover, another reason regarding costs is the labor costs' gap reduction. As just mentioned, the difference in labor cost was a decisive reason to proceed with the offshoring. Since emerging states have been increasingly exploited by developed countries, the gap between the two costs has narrowed. At a time when the cost of labor comes to have a very similar price, it goes without saying that companies prefer to have the business in the home country to eliminate logistical and transport costs. Another factor with a very high result is "Made in effect", the positive impact that repatriation of production has on the perceived value by customers. This effect characterizes more the industries of fashion, where the attention from the customers towards the quality of the product is elevated.

The strategy of reshoring can be pursued through different typologies, based on the mode of ownership that the business has in the country of offshoring and that it will have once it returns to the home country (*outsourced* or *in-house*). Moreover, it is also possible to identify different reshoring types according to the geographical point of view. Depending on the country of reshoring, the *back-reshoring* refers to the relocation of an activity to the company's home country, while the *near-reshoring* refers to the relocation of an activity to a country closer to the home one.

To conclude, what differentiates reshoring from a generic location decision is that it is a reversion from a previous offshoring or outsourcing decision. As a result, the decision to reshore an activity has many different starting points. Depending on the type of offshoring or outsourcing previously used for that specific activity, reshoring can follow different paths, eight specifically. In these paths the starting point is always the basic situation that is the home-located business, which can be wholly owned - thus in-house - or operated by a supplier - thus outsource. This is followed by the different possibilities of offshoring and then the final choice of the right way to reshore.

Reshoring like a way to be sustainable

In the recent period, with the emergence of new global trends and needs, such as the climate crisis and the geopolitical situation, global balances have changed. Related to this, the motivations driving location decisions have undergone changes in accordance with external changes. A key issue

affecting the world, and one that relates broadly to the production of enterprises and their dynamics, is that of sustainability. Consequently, among the drivers toward reshoring, it is possible to identify the need to meet climate standards and, more generally, minimum social conditions. Sustainability is, therefore, at the core of enterprises' activities, as production activities impact all three dimensions of sustainability. Therefore, the decision of where to locate a production activity has a strong impact on the sustainability of the enterprise. For instance, place an activity where labor is exploited and workers are forced to perform under minimal or, even, absent conditions reflect on a lack of social sustainability, as it does not guarantee a minimum required lifestyle. Thus, the company will have to decide to relocate activities to follow sustainability standards.

Reshoring trends in United States and Europe

The US companies were among the first to initiate massive reshoring policies following the 2008 financial crisis. The main rationale was to create new jobs for people who had been out of work due to the crisis. In U.S. it is possible to see a trend that has exploded in the face of the Covid-19 pandemic but continues to grow, having found important resources in the reshoring strategy. In fact, from 2010 onward reshoring has created more and more job announcements, with some declines, but from 2019 to 2022 the growth has been exponential. During the crisis there was a realization of the heavy reliance on countries where costs are lower, but which led to great hardships and shortages, such as China. Because of this, the U.S. believes it is necessary to continue to encourage reshoring policies, so as to prevent the recurrence of similar situations. Moreover, the geopolitical dynamics and imbalances that have been created just with China, and the war between Russia and Ukraine, brings the US closer and closer to a need for independence. Indeed, plans have been launched aimed at upgrading the nation's infrastructure, creating new jobs and addressing climate change, and most importantly, revitalizing the U.S. manufacturing sector.

In Europe, the reshoring phenomenon is still a narrower one, compared to America. According to an Eurofound initiative, "European Reshoring Monitor", a database of 253 reshoring cases in Europe from 2014 to 2018 was created with the aim of identifying, analyzing and summarizing the reshoring phenomenon in Europe. The case analysis carried out showed that the manufacturing sector has been the most affected by the reshoring phenomenon and the most recurring reasons from companies are "Firm's global reorganization," "Delivery time", "Automation of production process" and "Made in effect". The European Monitor Reshoring initiative ended in 2018 and, after that, little importance to reshoring has been given. Nevertheless, the debate on reshoring in Europe in the wake of the Covid-19 pandemic has picked up, giving new insights into its future. Available evidence has shown a weak trend of the reshoring phenomenon before the Covid crisis due to automation, additive manufacturing,

or due to proximity needs or quality issues. A different trend occurred as a response to the pandemic crisis, where many companies considered withdrawing production phases abroad due to the severe disruptions experienced. At the same time, it is argued that advances in new technologies may improve the efficiency in outsourcing or offshoring practices and those economic factors that are a driver for reshoring may also change over time, or at any rate be decisive only for some industries. By virtue of this, in Europe it is unrealistic to think that there will be a surge in the reshoring phenomenon anytime soon.

The semiconductor industry

Electronic tools such as TVs, cars, radio, and household appliances are now an integral part of people's lives and have facilitated and improved their way of life. At the roots of electronic devices and their functioning there are the semiconductors. Semiconductors, or also called integrated circuits (ICs), chips or microchips, are highly specialized components underlying the functionality of electronic devices. A chip is a collection of billions of electronic circuits that have been reduced in size and are placed on a thin wafer of semiconductor material. The first microchip was invented in U.S. by engineer Jack Kilby in 1958, who then succeeded in printing and joining in this small piece of semiconductor material all the necessary elements for the operation of an integrated circuit. From that point forward, new discoveries have sought to make chips more and more efficient at lower and lower costs, keeping pace with the continuing innovations in the field of technology made possible by these very small platelets.

The semiconductor industry is made up of a wide variety of product types, but it is possible to classify semiconductors in 3 broad categories: Logic, that represent the fundamental building blocks or "brains" of computing; Memory, those semiconductors used for storing information required for the performance of any computation; DAO (Discrete, Analog and Other), those that transmit, receive, and transform information dealing with parameters such as temperature and voltage.

Since semiconductors are highly complex and specialized products, their value chain reflects these characteristics, thus resulting in an extremely complex and globalized creation and production process. The semiconductor value chain can be summarized in four main stages and supported by materials and equipment suppliers. The first stage is the *Pre-competitive research*, which is critical for highly specialized and complex products such as these, with the aim of discovering improvements and advances in design architectures and technology, encouraging better power and efficiency. The second stage is the *Design*, through which the chips are developed. Then, there is the manufacturing stage of the microchip, divided in Front end and Back end. In the *Front end Manufacturing* chips are fabricated, with what is known as “wafer fabrication”. From the chip design in silicon wafers,

nanoscale integrated circuits are printed by highly specialized semiconductor manufacturing facilities. Finally, in the fourth and the last stage, the *Back end Manufacturing*, the chip is permanently assembled, packaged and tested. As mentioned above, the semiconductor value chain has an ecosystem of three more suppliers, which are essential for the provision of inputs. These support activities are EDA & Core IP, which provide refined software and services such as applications to support design, Equipment, which enables chip fabrication, and Tools and Materials, necessary inputs for semiconductor fabrication.

According to the value chain of the semiconductors, companies nowadays can either concentrate on a single layer of the value chain or integrate vertically across several layers. According to the level of integration and by the type of related business model, the typologies of semiconductor enterprises can be of 4 types: Integrated device manufacturers (IDMs), those vertically integrated across all stages of the value chain; Fabless design firms, specialized and focused on design while outsourcing the rest of the value chain; Foundries, providing only the manufacturing stage; Outsourced assembly and test companies (OSATs), providing only assembly, packaging and testing. This classification and division of the various possible business models of semiconductor companies highlights the complex and specific stages of the value chain that this type of product requires.

Following the same logic, the semiconductor value chain is truly global. The high specialization required in every stage of the value chain leads also to distribute globally the activities. Specifically, in the semiconductor industry, the investments required are so high, because the product is knowledge and skills intensive, that distributing and fragmenting the value chain in different countries where cost reductions can be achieved is deemed necessary. More specifically, in the Design stage, US is the leader owning 74% of the design activities conducted thanks to its strong capabilities in R&D. While, as for the two manufacturing steps of the value chain, they are mainly carried out in two different locations. While the Front end, and thus semiconductor wafer fabrication, is 56% conducted in East Asia, the Back end, and thus assembly, packaging and testing, is quite distributed between Taiwan, United States and China.

The semiconductor market

The semiconductor market is, therefore, one of the most relevant markets that has entered the last three decades and has experienced exponential growth. For instance, the development of semiconductors, between 1995 and 2015, contributed directly to $3 trillion in global GDP and indirectly to an additional $11 trillion. The total market size reached an amount of US$580 billion in 2022 while in 2023 is projected to have a slight fall of 4.1% to US$557 billion. The continued growth of the market can be attributed to the increasing spread and consumption of electronic devices around

the world. Analyzing the geographical distribution, the country that holds the leading position is the U.S. with a 46% of share in 2021, after losing about 19 points of market share because of strong competition emerged over time. Next there is Korea with a relevant share of 21%, followed by the other major countries with minority shares between 7% and 9%.

For what concerns the largest semiconductor vendors, the companies with the largest market share in 2022 are the giants Samsung and Intel with respectively 10.9% and 9.7% of market share, leaders in the market since the birth of the industry. In addition, the other companies with a significant share of the market, apart from the South Korean company SK Hynix in third place, are all from the United States such as Qualcomm, Micron Technology, and Broadcom.

Taking into consideration, however, only the semiconductor manufacturing stage, which is the step of the supply chain where the crisis has crept in, the Taiwanese manufacturer Taiwan Semiconductor Manufacturing Company (TSMC) is the leader in the market with 58.5% of market share by itself, followed by Samsung showing 15.8% of market share.

Global dynamics

The dynamic in which the semiconductor crisis is exacerbating and fits in, is a situation of very unstable geopolitics made of tensions and labile ties. At the heart of these dynamics, it is possible to identify strong tensions between two of the major trading powers, namely the United States and China. In fact, since the outbreak of tensions in 2018, which kicked off the Trade War, the two powers have been in conflict, consequently affecting the dynamics in the semiconductor industry. In addition, Taiwan has tilted global ties more and more. This is related to the struggling with China since the end of World War II to become independent while managing to become a world leader in the production of semiconductors. The complexity of tensions and the fact that the main actors involved are these powers, both encourages the emergence of semiconductor scarcity issues and still amplifies the difficulties in resolving them.

Semiconductor shortage and countries' policies

Since the Covid-19 pandemic, the semiconductor industry has faced several complications, resulting in a substantial crisis known as the semiconductor chip shortage. In fact, as a result of innovations and sudden change of habits due to various lockdowns, the demand for semiconductors exploded as the demand for electronic devices suddenly increased. So, one of the causes of the major chip shortage is identified in the pandemic crisis, which has led to serious disruptions in all the industries that requires microchip for the operation of the products. There are two other supporting reasons that have fueled the spread of the crisis. The first is the complexity of the semiconductor supply chain. In fact,

the requirement of several stages executed in different parts of the world makes the value chain extremely challenging and complex, consequently exposed to many vulnerabilities. The second supporting reason can be identified in geopolitical problems, which have amplified the effects of the shortage. As a result of this shock, countries have reacted and are putting maneuvers in place to try to contain it as much as possible and find solutions to get back into balance. In particular, U.S. and Europe decided to implement similar measures in order to make themselves sufficient and succeed in coping with the crisis internally.

The US found it necessary to move forward with a law aimed at revitalizing domestic production of the semiconductors. Thus, on August 9, 2022, the CHIPS and Science Act was signed into law. The purpose of this act is to strengthen U.S. manufacturing and bring production back to the territory, to boost again the US competitiveness in economy, national security, supply chain resiliency and technology leadership. Specifically, the investments planned are $52.7 billion, articulated in manufacturing incentives aimed at boosting semiconductor production, R&D and workforce development, supporting international information communications technology security and semiconductor supply chain activities.

In Europe, in the face of the crisis in the semiconductor industry, the European Commission on February 8, 2022 released a proposal for a European Chips Act with the aim of preserving Europe's digital sovereignty and to address semiconductor shortages and strengthen technological capabilities. According to the proposal, the CHIPS Act would allocate €43 billion in public and private investments with the aim of doubling the current European semiconductor market share from 10% to 20% by 2030. The main initiatives are the “Chips for Europe”, a strategic initiative designed to support the innovation and the development of technological capabilities in all the European Union; creating a legal framework to ensure security of supply by attracting investment and advanced production capacity in the manufacture of semiconductors; a coordination mechanism between Member States and the Commission to monitor market developments and anticipate crises.

On April 18, 2023, the Parliament and the European Council reached the political agreement, which awaits formal approval by the two co-legislators. The European Union has, therefore, welcomed the proposal made by the Commission on February 8, 2022, as they believe it is essential for Europe itself that it be able to develop its expertise in technology and, specifically, in the semiconductor sector, an essential and strategic industry in today's situation.

Production location strategies of leading companies in the semiconductor industry

Within the global geopolitical context, the semiconductor sector has become increasingly important to the point of becoming one of the key sectors on which states move. For this reason, it is the interest

of this thesis to analyze the current situation in the semiconductor market by paying attention to the location of production facilities and strategies related to them. The purpose of the analysis is, therefore, to show and analyze the geographic landscape of semiconductor manufacturing in order to understand how companies decide to strategically locate manufacturing facilities in order to cope with the semiconductor crisis, with a focus on detecting reshoring strategies.

In order to carry out this analysis, a sample of firms was selected so as to study their production strategies. The choice of the sample was based on two criteria: the firms with highest revenues in the market and the firms with the manufacturing stage in their business model. Once this macro-sample of firms belonging to the IDM and Foundry categories was obtained, the 10 firms with the highest revenues of the industry were selected. Companies forming the sample are Samsung, Taiwan Semiconductor Manufacturing Company (TSMC), Intel, SK Hynix, Micron Technology, Texas Instruments Incorporated, United Microelectronics Corporation (UMC), STMicroelectronics NV, GlobalFoundries Inc., Semiconductor Manufacturing International Corporation (SMIC).

The analysis, in the first instance, focused on a study of the current situation of the companies' location of manufacturing stage. Starting from the first step of manufacturing, from the sample 70 wafer fabrication sites are totaled. The results of the analysis highlighted a highly skewed distribution of fabs, with a concentration in the United States, China and Taiwan. Taiwan has the largest number of production sites with a total of 19, followed by the U.S. with 17 and China with 12. More in general, it can be seen that the center of microchip production is located in Asia, given the high presence also in Korea and Japan, as well as Malaysia and Singapore. Nevertheless, the US remain a relevant manufacturing site for the semiconductors, due to their importance in the discovery of microchips and their supremacy in the market.

Going into detail, it was necessary to analyze the production locations of each individual firm, and then relate this to the nationality of the companies.

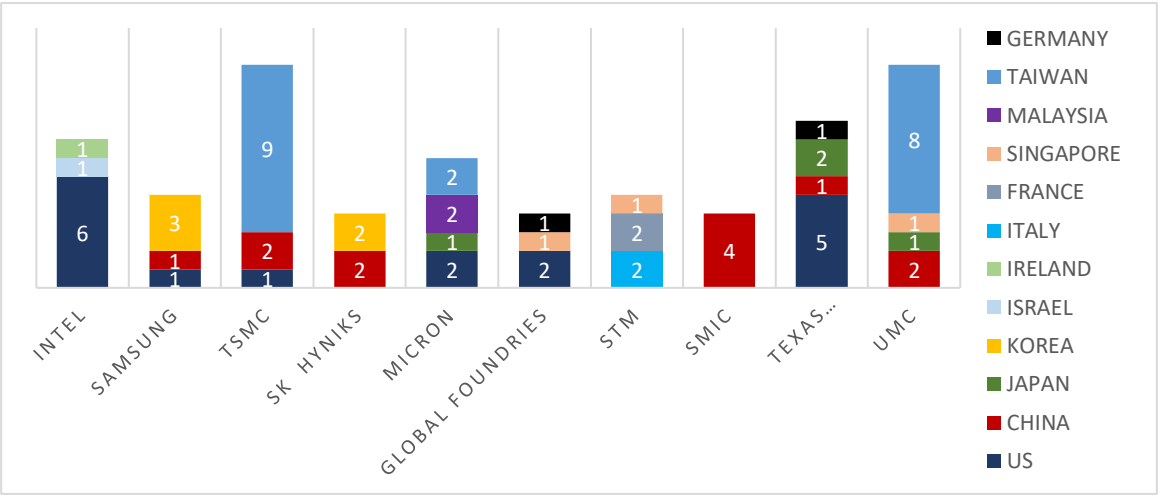

Figure 36. Companies' location of wafer fabrication plants by country.
(Source: Personal elaboration)

From the results, a strong domestic production component for each firm is evident. More specifically, 9 out of 10 companies have a percentage equal to or greater than 50% of production sites located in the home country. Nevertheless, out of 70 production sites in the sample, 25 are located outside the firm's home territory. So, a 35% of the production sites are relocated abroad. This consideration is highly relevant when talking about wafer fabrication, since its high specialization and being a highly knowledge- and skill-intensive stage, make companies to locate the wafer fabrication step close to home.

Turning to the analysis of the second step of manufacturing stage, thus considering assembly, packaging & testing, the situation changes diametrically, since location of production sites is no longer concentrated in a few states. The total number of production sites from the sample amounts to 34, this is because, among the companies in our sample, only 7 out of 10 have the back-end manufacturing stage in their value chain. The most relevant and apparent data is the significantly high number of countries involved in this second stage of the manufacturing process, precisely 15. This element is traceable to the degree of specialization of technical components required for this stage of production, which appears to be lower than for the first one. Following this logic, therefore, companies are more likely to relocate production to even distant countries while trying to reduce costs, by not requiring necessary strictly control over the stage. In this context, China excels in the number of production sites located in its territory, amounting to 7.

Subsequently, it is deemed necessary to analyze the strategies undertaken by companies regarding the opening of new manufacturing facilities. In order to do this, the analysis was divided into two stages of work progress, "under construction" and "future construction".

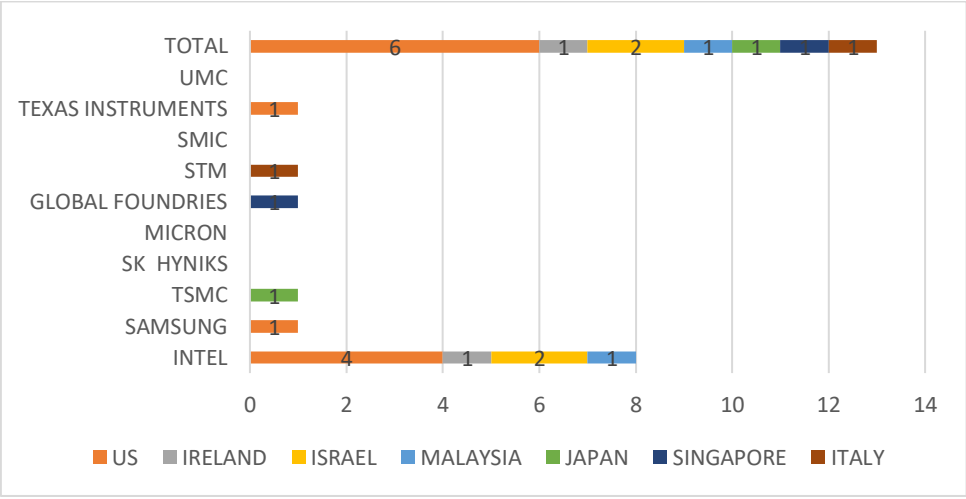

Figure 37. Companies' location of under construction fabs by country.
(Source: Personal elaboration)

The results show that 6 out of 10 total enterprises of the sample have initiated projects to build and implement a total of 13 new fabs. The location of these new constructions appears purely concentrated

in the United States, with a total of 6 new fabs. Specifically, the companies that have planned to open new fabs in the United States are Intel, Samsung, and Texas Instruments, two U.S. and one South Korean. These data provide evidence that US CHIPS Act is encouraging companies to open new manufacturing facilities in the US in order to redevelop its leadership in the semiconductor industry. The rest of the locations where companies started to build new production facilities are in Asia and Europe, in line with the geographical location that has always characterized the production of the semiconductor industry, with a new opening towards Europe.

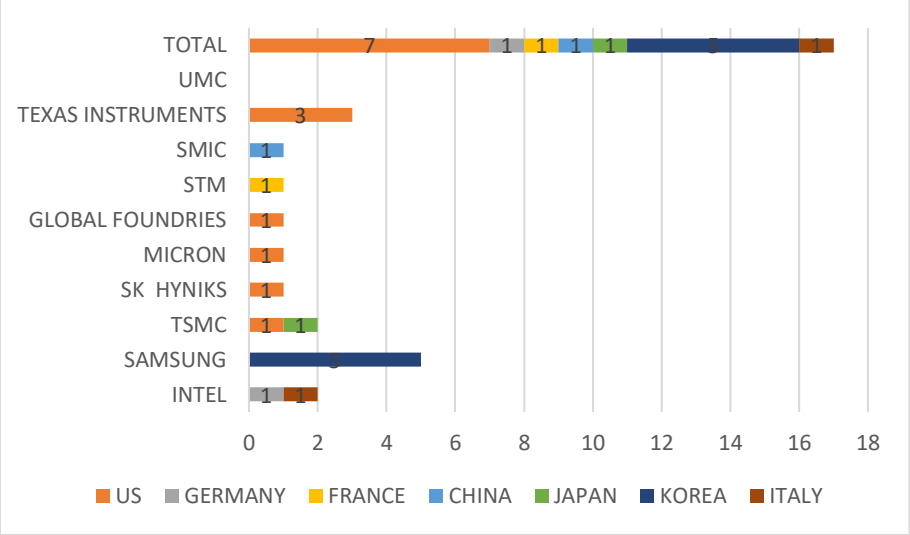

Figure 38. Companies' location of future construction fabs by country.
(Source: Personal elaboration)

Regarding announced future construction fabs, from the sample taken, 9 out of 10 companies result to have announced the opening of new fabs over the next few years, only Chinese UMC has no plans. In terms of geographic concentration, the US is also a target for the opening of upcoming fabs soon, by U.S., South Korean, and Taiwanese companies. South Korea also shows a high number of upcoming new fabs, but they are all from the giant Samsung, the South Korean company, which then decides to focus on opening new fabs in house. In addition to the usual targets such as America and Asia, there are few investments in Europe, as Intel plans to invest in building two new fabs. It is possible, therefore, to see how the CHIPS Acts announced by countries to address the semiconductor shortage and, at the same time, to revalue the semiconductor industry in their own market, are encouraging companies to invest in the United States and Europe. Another fact that appears evident from these analyses is the almost total absence of new investments towards China and Taiwan. It is possible to address the lack of investment in the Taiwanese island to the fact of the increasing geopolitical tensions previously analyzed and the ever-increasing dominance of the island, whose heavily dependence led to the scarcity of the supply manufactured semiconductors around the world. While the lack of investment in China, represents a clear trend of a practice of redefining the distribution chain, with the aim of immunizing themselves from the risk of operating in China. There

is therefore a clear change from the dynamics of the last 10-15 years, which has seen considerable investment in the states of Southeast Asia and specifically in China, while today there are evidence from the sample that Asian companies tend to invest in opening new factories in the United States. The two possible determinants of this behavior are the US CHIPS Act, which has encouraged companies to invest in the opening of semiconductor manufacturing sites in the US, and the importance of having business relations with them, as potential US customers are among the world leaders and, therefore, an attractive market.

To continue the analysis, it deemed necessary to study whether companies have undertaken similar reshoring activities, with the aim of analyzing them. To do this, in the first instance were taken into consideration companies that have decided to announce investments at home, and then the study continued by identifying whether they have closed or divested factories outside the home country in the recent past. Of the 9 out of 10 companies in the sample that have started or announced future construction of new fabs, it turns out that only 3 have recently closed foreign factories, and they are Intel, Global Foundries and Samsung. After analyzing the recent dynamics of these three companies, however, it is necessary to exclude Samsung as its strategy is outside the scope of this thesis' study, since its closure of a plant abroad was later followed by an opening also in that state, thus not attributable to reshoring dynamics.

Going into detail, it is important to consider the case of Intel, which is the one that best represents and encapsulates a policy of strengthening American semiconductor leadership. The American company has, in fact, firstly announced in 2020 the sale of its manufacturing fab in China, and then undertaken in March 2021 a new corporate strategy to strengthen the company's own competitiveness, called *IDM 2.0*. In order to accelerate the new strategy, Intel announced a plan to expand manufacturing capacity, beginning with the construction of two new fabs in Arizona and then in Ohio. Through this Intel strategy, it is therefore possible to identify the decision of a company that has become increasingly independent and that, aided by a US protectionist policy, has decided to close a production plant in China, due to the tensions that have emerged, and then invest in its own country. Faced with this, it is therefore possible to observe this strategy as a dynamic similar to reshoring, albeit with different motivations from the classics that characterize this strategy. Another evidence of similar behavior comes from the U.S. company Global Foundries. It, in fact, had announced a joint venture in 2016 in China to create a new fab in order to expand its global footprint in semiconductor manufacturing. It later decided in 2020 not to proceed with the establishment of a new manufacturing facility because of geopolitical tensions between the U.S. and China in previous years. Consequently, in July 2021, the company announced the expansion of its manufacturing capacity in its manufacturing plant located in Malta, New York. Also in this case, it is possible to highlight behavior

that appears similar to the actions taken when following a reshoring strategy. In this case, Global Foundries was motivated by political reasons, and, at the same time, capacity needs due to the shortage of semiconductors. The combination of these two reasons made the company decide to locate the creation of a new fab in the home country, thus excluding the plant in China. Although not explicitly defined by the company, it is possible to observe this dynamic as similar to corporate behavior in the case of reshoring.

Final considerations

From the analysis conducted, it is therefore possible to observe that there is no clear trend of reshoring strategies by the world's leading semiconductor companies as a response to the crisis and geopolitical tensions. The only evidence found is that of the U.S. companies Intel and Global Foundries. Despite this, the other companies followed up with actions to expand production capacity in different countries. What can be seen, however, is a good response to the initiatives launched by the U.S. with the CHIPS Act, as there is a growing trend of investment by U.S. companies in America.

The reasons that may explain that there is still no trend in which companies decide to follow a reshoring strategy be varied. The first is identifiable with the high transition costs due to the high specialization required by semiconductors, so it is neither fast nor easily eligible to move production facilities from one country to another. Relating to this, probably the reasons behind the reshoring strategies, in such case, could be very different from the common ones, which is purely for commercial or strategic reasons. Instead, in this case, the reasons that would justify reshoring would be perhaps political in nature. This second ground of appeal gives rise to a third, namely the time horizon. Specifically, the possible evolution of events must be considered in strategic business assessments. In this specific case, the semiconductor crisis can be identified either as a momentary, short-term crisis or to a structural, long-term problem. In the first case, businesses wouldn’t take into consideration reshoring strategies, which would bring huge costs to the company, while in the second one would then analyze hypothetical reshoring strategies, as the long-term horizon would deem necessary to think of a reconstruction of the production location to face the shock. Another point of attention highlighted following the analysis of the sample are the strategies implemented by companies that are not attributable to reshoring but, at the same time, it is possible to observe nearshoring or friendshoring strategies. In relation to this, it is observable by the location decisions of the new sample fabs that companies decide to invest in friendly or allied countries. In this context, what can be easily observed is that the protectionist dynamic implemented by Western countries, with the CHIPS act of the US and Europe, is bearing fruit with a significant increase in investment and development in the semiconductor industry of the countries concerned.

The final point is the focal point, that of the time horizon of the analysis too close. The semiconductor crisis is a phenomenon that is still developing and manifesting globally, accentuated by the political crises between China and the United States and the war in Ukraine. This makes it even more cryptic and difficult to analyze and understand possible industry dynamics, especially reshoring. For this reason, the analysis suggests a more in-depth study in the future, in order to grasp more specific and detailed aspects that are not yet visible.