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How could semiconductor multinational corporations navigate the evolving macroenvironment in relation to geopolitical risk and institutional pressures? NVIDIA case study

Professor Paolo Boccardelli
SUPERVISOR

Professor Francesco Galietti
CO-SUPERVISOR

Stefano Leone - 759201

CANDIDATE

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Summary

Introduction

As we approach what many analysts consider the end of the globalization era, the forces driving this shift are becoming increasingly clear. The macroenvironment, particularly the geopolitical climate, plays a pivotal role in this transformation. In recent years, political tensions between global powers like the United States and China have escalated, leading to shifts in trade policies, economic sanctions, and strategic realignments. These actions signal a retreat from the integrated global economy that characterized the last few decades. Within this framework, multinational corporations (MNCs), which were the leading actors of globalization, are caught in the crosshairs of geopolitical manoeuvring.

This thesis examines how these macroenvironmental forces, particularly geopolitics, are influencing one of the key industries of this strategic rethinking, the semiconductor one, with a focus on NVIDIA as a case study. The aim is to investigate how firms in this sector navigate the complexities of a world where political considerations increasingly dictate the direction of global value chains (GVCs) and business strategies. Therefore, the research question that this thesis seeks to answer is: "How could semiconductor multinational corporations navigate the evolving macroenvironment in relation to geopolitical risk and institutional pressures?"

The work is structured as follows: in the first chapter, the theoretical framework of multinational corporations and global value chains is presented, supported by data and by an analysis of the MNC-government relationship. The second chapter delves into the relevance of geopolitical risk in the current world and its impact on MNC strategies and GVCs. The third chapter shifts to an overview of the semiconductor industry and an explanation of its strategic relevance due to the crucial role which plays in AI's developments and the consequent techno-nationalism; the chapter then presents the case study of NVIDIA, the leader of the semiconductor industry, assessing the strategies which led it to the top and particularly the design of its value chain. Chapter 4 brings together strategic insights and expert perspectives on the semiconductor industry, emphasizing geopolitical issues and their impact on the NVIDIA case study. It then explores the potential future implications of the research, addressing upcoming challenges and opportunities. The chapter wraps up with a concise overview of the main findings, acknowledges the study's limitations, and suggests directions for future research. The conclusion will offer a synthesis of the findings, revealing how AI is at the core of these geopolitical concerns and the redefinition of global value chains, with significant managerial implications for decision-makers navigating such evolving environments.

CHAPTER 1: Multinational corporations and Value Chains

1.1 The key actors of international business: the multinational corporations (MNCs)

Multinational corporations (MNCs), also called Multinational Enterprises (MNEs), are the main players in international business thus having a significant impact on the worldwide economic environment. These industrial behemoths have unrivalled reach, operating in numerous countries and continents and exercising significant influence over economies, governments, and society around the world. MNCs thrive on their capacity to harness global resources, technology, and knowledge, allowing them to navigate varied markets and seize opportunities. MNEs use their vast operations to foster innovation, create jobs, and enable the cross-border movement of products, services, and capital.

A multinational corporation is defined as a corporation that "engages in foreign direct investment (FDI) and owns or, in some way, controls value-added activities in more than one country" (Dunning & Lundan, 2008). This definition is shared by many other authors (Markusen, 1995; Caves, 2007; Buckley & Casson, 2009; Hart & Spero, 2013) who, over the years, have demonstrated a similar perspective characterising MNC as firms that gain significant control over businesses in at least two countries through outward foreign direct investment.

In a similar manner, some of the most important international organizations, like UNCTAD, IMF and OECD, identify the MNCs based on a simple criterion: the so-called "10 percent threshold", meaning that an MNE is created once an enterprise resident in one economy owns 10 percent or more of the ordinary shares or voting power for an incorporated enterprise, or the equivalent for an unincorporated enterprise, that is resident in another economy It is noteworthy that these organizations define the concepts of MNC and FDI in an almost identical way, in the sense that both concepts could be viewed as synonymous to some extent (OECD, 2008; IMF, 2009; UNCTAD, 2023a).

Historically speaking the first MNCs are often identified into the trade companies of the 17th century, private companies which followed the trade and military expansion of the host countries in Africa, Asia and the Americas.

However, the modern concept of MNC should be traced back in the 19th century, after the industrial revolution. Only the combination of industrial capitalism, capital-intensive manufacturing methods, improved storage and transportation led to increased foreign investment by US and European corporations, particularly to meet the expanding demand for natural resources. The expansion of companies abroad has also been made possible by advances in information and communication

technology (ICT), which have enabled a faster and less costly flow of information, a key element in coordinating and managing activities over long distances (Dunning & Lundan, 2008).

The literature on MNCs and, more generally, the academic field of international business (IB) is extensive and constantly evolving, therefore a complete overview of all the possible drivers of IB activities would be impossible. Nevertheless, an important synthesis of the diverse theoretical explanations on why a firm becomes multinational is provided by the so-called OLI framework or eclectic paradigm by Dunning (2001). This paradigm encompasses various explanations of the activities of enterprises engaging in cross-border value-adding activities. This framework's rationale is based on three types of advantages linked to MNE activity.

First, MNEs must have ownership advantages (O), such as proprietary technology and knowledge, unique designs, brand names, and production processes. These advantages help MNEs overcome the liability of foreignness, which is their unfamiliarity with local conditions. This largely explains why MNEs are concentrated in knowledge-intensive industries.

Second, MNEs pursue location advantages (L) tied to specific areas (cities, regions, countries). On the supply side, these include abundant natural resources, a large and inexpensive labour force, and access to specialized knowledge from universities, research organizations, and suppliers. On the demand side, market size and growth potential are key factors that attract companies to certain locations, with demand factors often being the most important for international investment.

Third, internalization advantages (I) must be present; companies must find it more beneficial to vertically integrate abroad rather than rely on arm's-length contracts with external partners, such as suppliers. This need often arises from the necessity to protect proprietary technology and knowledge in countries with weak contract enforcement and intellectual property rights.

Given that, we can now categorize four types of MNEs activities, thanks to the taxonomy proposed by Dunning and Lundan (2008):

1. Natural resource seekers;
2. Market seekers;
3. Efficiency seekers;
4. Strategic asset or capability seekers.

Before moving to the taxonomy, two *caveat* are in order.

Firstly, it was already clear to the authors, that this division by objective was not always applicable, since, back in 2008, but even more so today more than 16 years later, MNCs pursue a variety of goals, and the majority of them use FDI that blends elements from two or more of the aforementioned

categories. Moreover, this classification could also be more complex since each kind of MNE activity could be aggressive, in which the business engages proactively to achieve its strategic objectives, or defensive, in which it protects its market position by responding to rivals' or foreign governments' actions.

Secondly, the explanations driving production overseas could also shift, for example, a company's motivations for making offshore investments may change as it gains expertise and recognition as a foreign investor. Most businesses first make foreign investments to get natural resources or break into new markets. But as their multinational footprint grows, companies might leverage their overseas businesses to strengthen their position in the global market by increasing productivity or gaining access to fresh sources of competitive advantage (Dunning & Lundan, 2008).

Natural resources seekers

The MNCs falling under this category embark on a foreign expansion in order to acquire specific resources of a higher quality at lower cost than could be obtainable in their home country, thus these enterprises will be more profitable and competitive in the markets they serve. Enterprises are mainly seeking three types of resources and based on this, further categorisation is possible. There are the companies looking for physical resources, the ones looking for plentiful supplies of cheap and well-motivated unskilled or semi-skilled labour and finally the ones looking for some kind of technological capability, management or marketing expertise and organisational skills (Dunning & Lundan, 2008).

Primary producers and manufacturing companies fall under the first category, they engage in FDI aiming at cost minimisation and supply sources security, pursuing upstream value chain activities. The resources in question are usually raw materials like fossil fuels, copper, zinc, diamonds but also agricultural products like rubber or tobacco. With this in mind, one can give numerous examples of natural resource-seekers multinationals: the oil multinationals like Exxon, Royal Dutch Shell or Chevron, the diamonds one like De Beers, tobacco's MNEs like Philip Morris and we could go on. It is noteworthy that this kind of foreign investment has been particularly notable in latest years. Chinese MNCs for example, have heavily invested in Africa, securing supply of raw materials like cobalt (Sanfilippo, 2010). This mineral is a critical resource in the modern world due to its crucial role in lithium-ion batteries for electric vehicles and electronics, and its possible applications in renewable energy storage, aerospace, and medical devices, thus these investments attracted geopolitical concerns from the United States.

In the second group we have MNEs who seeks abundance of cheap workforce. The companies which engage in this kind of FDI are manufacturing and service enterprises from countries characterised by

high real labour costs that establish or acquire subsidiaries in nations with lower labour costs thus achieving a cost minimisation. MNCs like the American Apple, but also semiconductors companies which will be discussed extensively later, have offshored the production stages towards developing countries like China, India or nations from Southeast Asia (Financial Times, 2023a). Often, host nations have established so-called Free Economic Zones (FEZs) or Special Economic Zones (SEZs) to draw in such production.

The need for businesses to obtain organizational skills, management or marketing competence, and technological capability drives the third type of resource-seeking FDI. This kind of FDI includes joint ventures in the high-tech sector formed by Korean and Taiwanese businesses with US or EU companies, for example in 2023 the Korean Samsung and the American General Motors announced a $3 billion investment to build a joint venture electric vehicle battery manufacturing plant in the U.S (Shepardson & Yang, 2023).

Market seekers

Market seekers MNC are those firms that make investments in a certain nation or area with the aim of expanding their customer base and markets, frequently with the goal of taking advantage of export potential or reaching new customer segments. Most of the time, exports from the investment company will have already supplied all or a portion of these markets for foreign production, are no longer best supplied by this route, either because of tariffs or other cost-raising impediments imposed by host countries, or because the scale of the markets now justifies local production. Market-seeking investments could also be made to maintain or defend existing markets or to develop and expand into new ones. In addition to considering market size and growth potential, there are four primary reasons that might drive firms to pursue such investments (Dunning & Lundan, 2008).

One key reason is when their main suppliers or customers establish production facilities abroad, prompting firms to follow them overseas to retain their business (Dunning & Lundan, 2008). An example of this kind of FDI is that by auto-component suppliers which are ‘forced’ to set up manufacturing subsidiaries in the markets of their customer, just think of the suppliers of Volkswagen or Toyota which followed them in the US or Ford suppliers which instead moved from the US to Europe.

The second motive for market-seeking FDI is the frequent need to tailor products to local tastes, cultural norms, or adapt them based on available resources and capabilities. Additionally, without understanding the local language, business customs, legal requirements, and marketing practices,

foreign producers may be at a disadvantage compared to local firms in selling consumer goods -think of pharmaceutical products for example, they require an important customisation to comply with the different national legislations- as well as those selling intermediate products.

The third driver, individuated by Dunning and Lundan, for supplying a foreign market from a nearby facility is that it can be more cost-effective than doing so from a distance. This decision depends heavily on the specific activity and country. Goods that are expensive to transport and can be produced efficiently in small quantities are more likely to be manufactured close to major consumption centres, unlike those that are cheap to transport and benefit from economies of scale. Companies from countries far from key markets are more inclined to pursue market-seeking FDI than those close to these markets (e.g., French or Dutch investments versus US investments in Germany). Additionally, government regulations, import controls, or strategic trade policies may also drive firms to relocate their production facilities.

The last reason for market-seeking investments, but perhaps the most important, is that an MNC may find it necessary, as part of its global production and marketing strategy, to establish a physical presence in the leading markets where its competitors operate (Dunning & Lundan, 2008). Consequently, most large MNEs in industries dominated by international oligopolists (such as oil, automotive, pharmaceuticals, semiconductors, accountancy, and consulting) establish operating units in North America, Europe and Asia, the most important markets worldwide. One could make such a strategic market-seeking investment for aggressive or defensive purposes. A defensive FDI is when an MNE invest in a certain market because the industry leader did so. For instance, the magnitude of the Chinese market's potential has drawn previously unimaginable levels of foreign investment, some of which has followed the lead players in the industry and some of which has followed important consumers' investments. Investing in a growing market with the goal of advancing a company's worldwide interests is instead an aggressive FDI. The FDI in Eastern Europe in the 1990s followed this reasoning, expanding into markets previously foreclosed due to their membership of the Soviet bloc (Dunning & Lundan, 2008).

But the host governments' encouragement of market-seeking FDI is still, without a doubt, the single most significant factor. Governments have typically used tariffs or other import restrictions as their tool to attract such investments. Most first-time industrial and service investments in history were made in order to get around these kinds of trade restrictions. Additionally, governments have tried to encourage foreign investment by providing a variety of incentives ranging from tax concessions to subsidised labour and capital costs and favourable import quotas (Dunning & Lundan, 2008).

However, the role of institutions in the international business context will be examined extensively later.

Efficiency seekers

Efficiency seeking MNC aim to increase cost effectiveness through supply chain optimization or moving production to less expensive markets. Usually, this kind of FDI stems from previous resource seeking and market seeking FDI; efficiency seekers MNCs seek to rationalise this structure of established investments in order to achieve economies of scale and scope and at the same time risk diversification (Dunning & Lundan, 2008). Efficiency-seeking FDI can be categorized into two main types.

The first type seeks to exploit differences in the availability and relative cost of traditional factor endowments across various countries. This type accounts for much of the labour division within MNEs operating in both developed and developing nations, where capital-, technology-, and information-intensive activities are concentrated in developed countries, while labour- and natural resource-intensive activities are located in developing countries.

The second type of efficiency-seeking investment occurs in countries with broadly similar economic structures and income levels. It aims to leverage economies of scale and scope, as well as differences in consumer tastes and supply capabilities. In this context, traditional factor endowments are less influential in driving FDI. Instead, factors such as 'created' competences and capabilities, incentive structures, the availability and quality of supporting institutions, the characteristics of local competition, consumer demand, and macro and micro government policies play a more significant role (Dunning & Lundan, 2008).

Strategic Asset seekers

The strategic asset seekers MNEs consists of those that engage in FDI, typically by acquiring the assets of foreign corporations, to promote their long-term strategic objectives, particularly bolstering or enhancing their global competitiveness. This group comprises first-time foreign direct investors looking to gain access to or acquire some kind of competitive power in a foreign market, as well as existing MNEs pursuing an integrated global or regional strategy (Dunning & Lundan, 2008). The main goal of strategic asset-seeking investment is to expand the acquiring firm's global portfolio of tangible assets and human capital, rather than always taking advantage of particular cost or marketing advantages over rivals, though these may occasionally be significant. These acquisitions are seen as means of either preserving or enhancing the company's ownership-specific advantages (the “O” of

the OLI model) or undermining those of their rivals. This kind of FDI shares some goals of the efficiency-seeking ones, namely the strategic asset MNE aims to capitalize on the benefits of common ownership of diversified activities and capabilities, or similar activities and capabilities in diverse economic and potential environments (Dunning & Lundan, 2008).

However, as the name suggests, strategic considerations may be the dominant motive for this FDI. One firm may acquire another or form an alliance with another with the only purpose of preventing an industry rival from doing so. Two rival companies could merge in order to bolster their combined strength in the face of a more threatening competitor. A MNC could acquire all or the vast majority of suppliers of a particular raw material to create an ownership competitive advantage over its competitors. Another one could apply the same reasoning but implementing it in the opposite direction, seeking to acquire the majority of distributors who will be forced to better promote the owner products over other ones. In order to provide its clients with a wider variety of items, a MNE could acquire a company that produces a complementing range of goods or services. Another MNC could associate with a local firm if it thinks it can better acquire contracts from the host government. All of these are instances of strategic foreign direct investment meant to enhance or preserve the investing company's long-term competitive advantage (Dunning & Lundan, 2008).

Further classification: Horizontal and Vertical MNCs

After summarising determinants and the theories, identified in the literature, by which a company becomes multinational, a further classification is possible, adding to what has already been said above, and that is to divide MNCs into horizontal and vertical MNEs.

Horizontal MNCs aim to locate production close to their customers to reduce trade costs while achieving economies of scale. These are multi-plant companies that produce similar goods in both their home and host countries, thereby reducing export costs (market-seekers MNCs).

In contrast, vertical MNCs carry out different production stages in various countries, a trend that has grown in importance within global value chains (GVCs) due to decreasing coordination and transaction costs across borders (efficiency-seekers MNCs). In vertical MNEs, production in one country provides inputs for production in other countries, with the location of these stages based on the relative cost-effectiveness of production factors, often driven by economies of scale or access to specialized knowledge (Cadestin et al., 2018).

Now, in light of the aforementioned analysis of FDI drivers, we move on to the most important one, which was briefly stated before: host government actions.

1.2 The macroenvironment of MNC: the role of institutions in the international business context

Governments play a crucial role in driving foreign FDI by creating favourable conditions that attract multinational corporations. Through policies and incentives such as tax breaks, grants, and subsidies, governments can make their countries more appealing to foreign investors. Additionally, the establishment of stable political and economic environments, robust legal frameworks, and efficient regulatory systems further enhances a country's attractiveness for FDI. Infrastructure development, including transportation, communication, and energy, is also crucial in supporting and sustaining foreign investments. Moreover, governments can engage in bilateral and multilateral trade agreements to reduce barriers and facilitate smoother investment flows. By actively promoting their countries as investment-friendly destinations and implementing strategic policies, governments can significantly influence the inflow of FDI, spurring economic growth and development. However governments could also do the opposite, implementing protectionist policies in order to advantage domestic firms vis-à-vis foreign companies or they could impose FDI restrictions to limit the entry and operation of MNCs in a manner analogous to capital controls, tariffs, or nontariff barriers.

A theoretical framework of the MNC-Government interrelation

Given that, understanding the attitude of countries' governments and the one of international organizations is probably the most important challenge that a MNC face during its activity. Since diverse countries have diverse attitudes and behaviours toward different sorts of foreign investors, or even the same foreign investors throughout time, is not possible to identify a standard relationship between a MNE and a government. Nevertheless, it is still possible to create a framework of analysis based on the main attitudes and actions taken by governments over time.

We can say that countries could either adopt a more confrontational or a more cooperative stance towards MNCs. The motives of a certain stance vis-à-vis another are to be found in the objectives pursued by the two actors of this relationship. As Dunning and Lundan (2008) rightly pointed out, while MNEs as a category seek similar economic goals (which allowed the previous classification of resource/market seekers), governments pursue a wider range of goals where the economic ones are just a part. Certain objectives could probably be in line with MNCs' objectives, for instance, the improvement of local assets or the creation of new jobs. Others, like the promotion of safety, regional development, the goal of economic autonomy, and the preservation of cultural values, may call for measures that could lower profits or put MNEs and their affiliates at additional financial risk.

Moreover, in the recent years, the 'non-economic' goals such as environmental policies, social ones like the ones tackling the gender pay gap or, more generally, the concept of sustainable development have assumed a primary spot in the political agenda of governments worldwide (Dunning and Lundan, 2008).

If the goals of the two actors differ significantly it is likely that the relationship will be more confrontational. In this situation the ability of the two sides to bargain and negotiate will determine the eventual result. On the other hand, the more importance governments place on reaching objectives similar or coherent to the ones of MNEs, the more probable it is that the interaction will be cooperative (Dunning and Lundan, 2008).

This last paragraph lays the groundwork for briefly summarising what has been one of the dominant paradigms to explain the relationship between MNCs and institutions, namely the bargaining model proposed by Vernon (1971). An extreme synthesis of this model is that since the goals of the two actors are different, each party seeks to exploit the resources of the other in pursuit of its own objectives, thus a bargaining-based competition is necessary to achieve an agreement.

The bargaining outcome depends upon the value of the opportunity costs perceived by both country and MNC, meaning the MNE's assessment of the location advantages offered by the country, and that by the country of the ownership advantages offered by the MNC. When the MNE's opportunity cost is minimal and the host nation's government values the firm's contribution to achieving its social and economic objectives, the MNC is undoubtedly in a strong position. In contrast, the host nation is likely to be in a stronger position when it can provide the company with resources, competencies, and markets, or when it can generate or access those resources on its own (Dunning & Lundan, 2008).

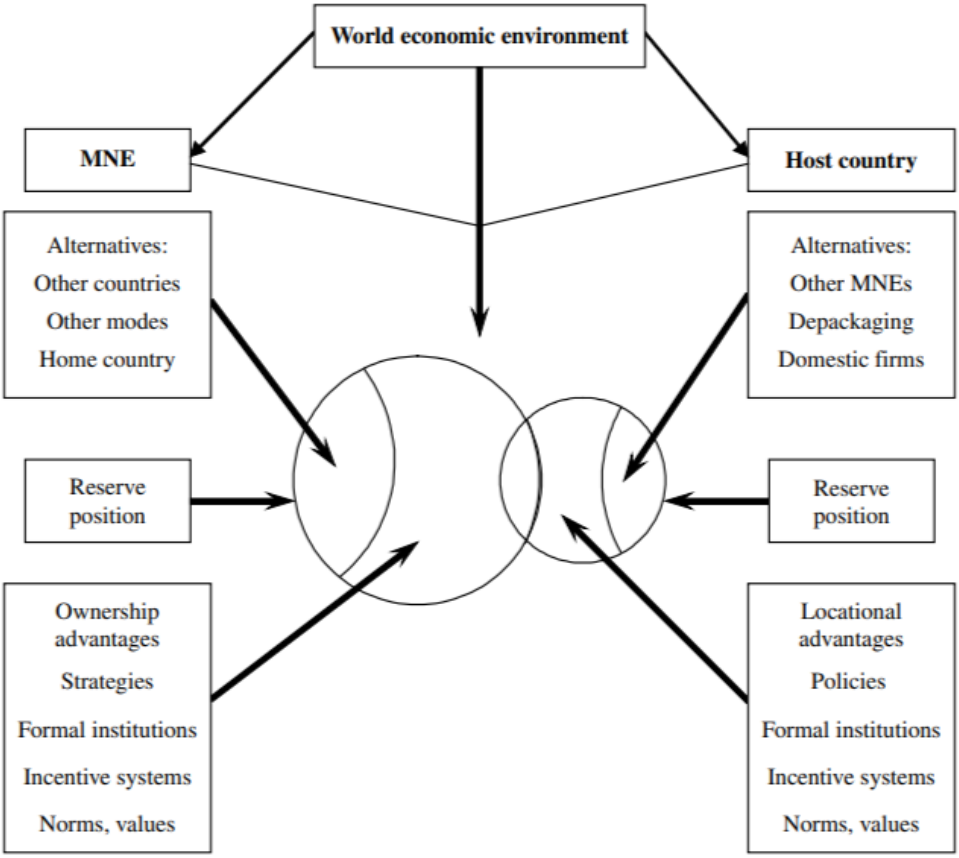

Fig. 1: MNEs and host countries – a bargaining framework[1]

This paradigm proved to be extremely representative of the 1970s and 1980s period and the underpinning logic is still very valid nowadays, however the period at the turn of the 21st century and after was characterised by a more cooperative climate between MNCs and governments mainly due to the heightened strategic interdependence of the two actors. This interdependence's growth is caused by many reasons:

- Many governments in emerging economies emphasized the productive use of indigenous resources to align with the demands of globalization, thus avoiding counterproductive measures against MNC activities that generate social wealth.
- The market-oriented policies, such as deregulation and liberalization, adopted by governments worldwide in the 1990s, created a favourable environment for a cooperative MNC-host countries relation. While this liberalization offered more opportunities for MNCs, governments also started to rely on them to help upgrade newly opened sectors.

[1] Dunning, J. H., & Lundan, S. M. (2008). Multinational enterprises and the global economy.

- Heightened competition to attract inbound FDI among emerging economies encouraged cooperation. This shift implies that the bargaining power of governments relative to MNCs changed in favour of the latter, putting pressure on governments to be more cooperative with MNCs to increase FDI inflows (Strange, 1996).
- Moreover, security concerns and geopolitical tensions which characterize modern times are forcing nation states to establish a more cooperative stance towards MNCs since they could be powerful allies or significative obstacles to geopolitical manoeuvring (this will be analysed extensively later in the thesis).

If both sides work together, this interdependence can lead to mutual synergies. These anticipated benefits to both parties are important because they dictate whether to flip from a competitive stance to a cooperative one or vice versa. Cooperative activities, in contrast to competing actions, do not ignore chances to realize positive sum gains through successful teamwork (Lado et al., 1997). When there is competition, each tries to maintain control over its own resources and leverages this advantage in negotiations. When there is collaboration, each party aims to achieve resource complementarity in order to strengthen the other's reciprocal support (Lado et al., 1997).

MNCs and government collaboration occurs at four distinct levels: national internationalization, industry competitiveness, firm capabilities, and individual productivity (Luo, 2004).

- Through a variety of initiatives, governments depend on MNEs to integrate their economies into the global economy. MNCs profit from this openness in turn by leveraging the comparative advantages of the host nation and enabling the efficient flow of production factors within their global networks.
- At the industry level, the success of MNEs in a host country depends on robust competitive factors such as resource availability, market demand, and related industries. These factors are significantly influenced by government policies, including interest rates, education, infrastructure, taxation, antitrust regulations, and information technology. MNCs play a crucial role in enhancing the host country's industrial landscape, driven by these governmental frameworks. MNCs collaborate with governments to develop advanced resources like a skilled workforce, a strong scientific foundation, and a thriving information industry. They also work together to enhance related industries, including supply chains and technological infrastructure.
- At the business level, cooperation focuses on improving organizational capabilities. Many emerging market governments provide incentives such as tax exemptions, free land use, and

local talent recruitment to attract MNEs' R&D centres. In return, governments rely on MNCs to introduce technological and managerial expertise.

- Finally, both parties collaborate to boost individual productivity which enhance the efficiency of the firm and the GDP of a country.

However, the MNC-government relationship is not as polarised as these frameworks describe it: in the current world it does not exist a pure competition or a pure cooperation (Luo,2004). Therefore, the more accurate definition of the current relationship between the two actors is coopetition, as described by Luo (2004). Within this framework is the one both the competitive dimension and the cooperative one coexist at the same time, MNCs and host governments cooperate in some aspects while competing in others as companies in the same industries have been doing for years.

The direct involvement of nation states: Bilateral Investment Treaties (BITs) and Regional Trade Agreements (RTAs)

Host governments could also choose to be more involved in the international business environment and they could do so either wanting to influence the flow of FDI or the trade. Although trade and FDI are different concepts, the dividing line between the two is more faded than ever or rather both are two sides of the same coin. Trade and FDI are distinct aspects of global production. International trade entails the exchange of goods and services across borders, whereas FDI involves the transfer of production capabilities across countries (Pandya, 2016).

Wishing to influence these two dimensions, countries could sign Bilateral Investment Treaties (BITs) or Regional Trade Agreements (RTAs). These treaties significantly impact the international business environment faced by MNEs since the strength of the interstate political ties between the home and host nations also affect the return on their FDI. Thus introducing BITs and RTAs is fundamental to understand the development of MNCs business trajectories.

BITs are agreements between two countries regarding promotion and protection of investments made by investors from respective countries in each other's territory. The promotion and protection are achieved by stipulating standards of treatment, such as fair and equitable treatment, protection from expropriation, and mechanisms for dispute resolution (UNCTAD, 2024a). Although BITs have been in existence since the end of World War II, their number grew exponentially over the years, to date there are 2835 bits of which 2222 in force (UNCTAD, 2024a). The motives of this growth are to be found

BITs significantly impact the macroenvironment in which MNCs operate, influencing several key aspects of their international business strategies. They provide a legal framework that protects foreign investments, significantly reducing political and regulatory risks. By ensuring fair and equitable treatment, BITs create a stable environment that encourages MNEs to invest in new markets. This stability is vital for MNCs as it allows them to plan long-term investments with reduced uncertainty. Additionally, BITs often include mechanisms for dispute resolution, such as international arbitration, which provide a neutral ground for resolving conflicts. This feature reassures MNEs that their investments are safeguarded, making riskier markets more attractive. Thanks to all these benefits a BIT could act as a substitute for good domestic institutions (Neumayer and Spess, 2005).

BITs also promote economic integration by facilitating cross-border investments. They encourage MNCs to leverage host countries' comparative advantages, possibly enhancing global supply chain efficiency. Moreover, these treaties often lead host countries to improve their regulatory environments, aligning with international standards. This alignment results in more favourable business conditions, benefiting both MNEs and local economies. Finally, BITs foster strategic partnerships between MNCs and local firms, driving technology transfer and skill development. These collaborations enhance the competitive landscape and contribute to the overall economic growth of host countries (Boffa et al., 2019).

Moving on to the RTAs it is possible to see a similar trajectory to the one of BITs, meaning that these treaties have been in existence since the 1950s[2] and they exponentially grew in number, suffice it to say that as of 1 May 2024 there are 371 RTAs in force (WTO, 2024).

Regional Trade Agreements (RTAs) are formal agreements between two or more countries within a specific geographic region, designed to facilitate trade and economic integration. These agreements aim to reduce or eliminate trade barriers, such as tariffs and quotas, and often include provisions for investment, regulatory cooperation, and other economic activities. By promoting closer economic ties, RTAs enhance the flow of goods, services, and capital among member countries (WTO, 2024).

[2] The literature agrees in identifying the ancestor of the European union, the European Coal and Steel Community formed in 1951 as the first example of a regional trade agreement. Other examples are the North American Free Trade Agreement (NAFTA) which includes Canada, Mexico, and the United States or the ASEAN, a free trade area currently comprising Brunei Darussalam, Cambodia, Indonesia, Lao People's Republic, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam.

RTAs play a vital role in shaping the macroenvironment for multinational companies since they comprise neoliberal features which positively influence their strategies and operations across multiple dimensions (Gathii, 2011).

Firstly, RTAs significantly expand market access by reducing trade barriers and providing preferential treatment to member countries. This enhanced access allows MNCs to enter new markets with reduced costs thus increased competitiveness. The removal of tariffs and quotas allows firms to offer their products at more attractive prices, thus increasing their market share in member countries. Moreover, RTAs contribute to cost efficiency for MNEs by streamlining trade processes and harmonizing regulations. This standardization of customs procedures, lowers the costs associated with cross-border trade, resulting in a major efficiency in the allocation of resources and an improvement of the overall operational performance of MNCs (Gathii, 2011)..

In addition, RTAs facilitate the integration of regional supply chains. By eliminating barriers to the movement of goods and services, these agreements enable MNEs to optimize their supply chains across multiple countries. This integration leads to cost savings, improved logistics, and enhanced production efficiency, as companies can source inputs from various member states. Investment opportunities also expand under RTAs, as they often include provisions that protect and promote foreign direct investment. These agreements create a stable and predictable investment environment, encouraging MNCs to invest in member countries. Such investments not only drive regional economic growth but also provide MNEs with strategic advantages, such as access to local resources and talent (Boffa et al., 2019).

In conclusion, Regional Trade Agreements are critical for multinational companies, providing enhanced market access, cost efficiencies, supply chain integration, investment stability, and regulatory cooperation. These factors collectively enable MNCs to expand their global presence, improve competitiveness, and achieve sustainable growth in an increasingly interconnected world.

Now, after providing the theoretical foundation on MNCs and FDI, the discussion will move towards an overview of the international business context more focused on data, in order to offer a more practical exemplification of the relevance of MNEs in the current interdependent world.

1.3 Data about Multinational Corporations

As a major contributor to global production, exports, GDP, and employment, MNEs are essential to the functioning of the world economy. In relation to these macroeconomic indicators MNCs account

for nearly one-third of worldwide production, half of global exports, over one-third of the world GDP, and roughly one-fourth of employment (OECD, 2018).

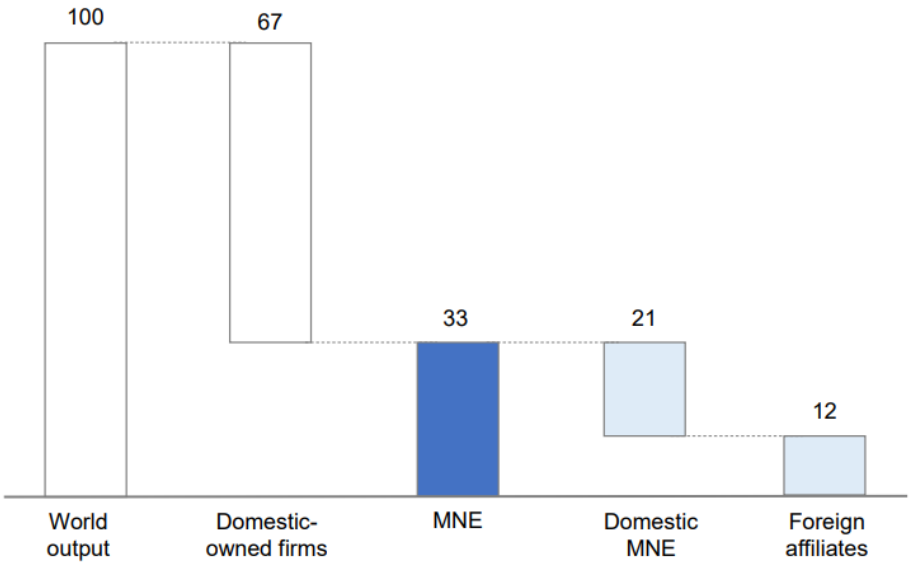

Fig. 2: Decomposition of global gross output by ownership status, 2014[3]

The trajectory of FDI is a critical indication to evaluate economic trends in the dynamic world of international business, particularly with regard to MNCs thus the UNCTAD World Investment Report (2024b) will be the key contributor to this section.

In terms of global FDI flows, at the end of 2023 the amount accounted for $1.33 trillion, registering a more than 10% lower than in 2022. In 2024, the global landscape for international investment was challenging. Declining growth prospects, economic fragmentation, trade and geopolitical tensions, industrial policies, and the diversification of supply chains altered FDI patterns, leading some MNEs to be more cautious about expanding abroad. Despite this, the largest MNEs maintained high profit levels, which continued to be evident in reinvested earnings—a major component of FDI.

[3] Cadestin, C., et al. (2018), "Multinational enterprises and global value chains: New Insights on the trade-investment nexus"

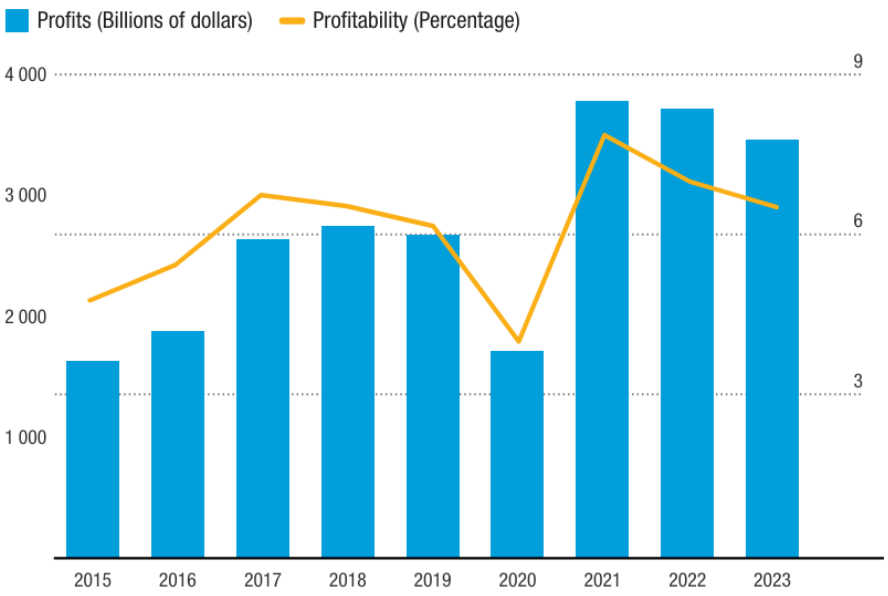

Fig. 3: Profits and profitability level of the largest firms 2015-2023[4]

Also, the rise in greenfield project announcements in 2023 had a positive impact on FDI (UNCTAD, 2024b). Only in developing nations the number of announced greenfield investments increased by 15%. Conversely, the ones in developed countries decreased by 6%. These data suggest that there may be moderate growth in GDP and in the trade in goods in 2024, 2.6 percent and 2 percent, respectively (UNCTAD, 2024b).

Variable	2021	2022	2023	2024[a]
Gross domestic product	6.2	3.0	2.7	2.6
Trade in goods	10.0	3.8	-0.6	2.0
Gross fixed capital formation	7.4	-2.9	1.3	2.8
Foreign direct investment	64.7	-16.4	-1.8	
Memorandum:				
Foreign direct investment value (Trillions of dollars)	1.6	1.4	1.3	

Fig. 4: Growth rates of global gross domestic product, gross fixed capital formation, trade and foreign direct investment[5]

The relevance of these data is not only to be found in the macroeconomic forecasts that these numbers suggest, but more importantly the drivers that formed these values. In this sense, it is crucial to know

[4] UNCTAD, based on data from Refinitiv
[5] UNCTAD for foreign direct investment, gross domestic product and trade, and IMF for gross fixed capital formation

that the increase in these new project announcements was driven by specific sectors: the value chain-intensive ones. Among these industries we find the automotive, electronics, and machinery sectors, which all experienced significant growth, mirroring the impact of supply chain restructuring pressures. In critical minerals extraction and processing for example, the number and value of investment projects nearly doubled (UNCTAD, 2024b).

Moreover, global economic fracturing trends are influencing the investment strategies of manufacturing MNEs. The investment behaviour of the top 100 non-financial MNEs indicates that, since 2019, the geographical distribution of manufacturing projects, especially in strategic sectors, has shifted towards locations closer to major MNE home markets in Europe and the United States. Meanwhile West Asia, North Africa, and Central America are emerging as key locations for manufacturing MNEs (UNCTAD, 2024b).

Since we have frequently discussed the concept of increasing global economic interdependence and it was mentioned in the paragraphs above, it is necessary to digress to the concept of the global value chain and the crucial role it plays.

1.4 Global value Chains: role in international trade and evolution

Over the last few decades, the emergence and growth of global value chains (GVCs) have transformed international trade. This concept emerged thanks to the same factors which caused the spread of MNCs, namely the information and communication technology revolution, countries' shift to free trade oriented policies, and political developments leading to the consolidation of the market economy worldwide. Together, these factors increased the number of foreign parts and components that businesses employed in their production processes and the amount of intermediate input manufacturers that sold their goods abroad rather than just to domestic consumers.

A Global Value Chain is defined as "a series of stages involved in producing a product or service that is sold to consumers, with each stage adding value, and with at least two stages being produced in different countries" (Antràs, 2020).

Thus, in a GVC, the production process is broken down into a sequence of distinct steps, each contributing incremental value. These steps can include various activities such as the extraction of raw materials, manufacturing of components, assembly, marketing, and distribution. The integration of foreign value added is crucial in this context, as it reflects the extent to which different countries contribute to different stages of production while the dispersion of production stages across multiple countries highlights the interconnectedness and interdependence of global economies. This international division of labour allows MNCs to optimize their production processes by leveraging

the comparative advantages of different countries, such as lower labour costs, specialized skills, or access to specific resources. Consequently, GVCs represent a significant globalization of production processes, extending beyond national borders and facilitating a more efficient allocation of resources on a global scale (Antràs, 2020).

According to Dicken (2015), MNCs function more and more as networks inside GVCs that host their international production. While there are occasions when the borders and organizational structures of GVCs and MNEs coincide, this is not always the case. Multinational corporations have significant strategic and operational flexibility when they operate as a network across borders. Extensive cross-border exchanges and transfers of products (goods and services), capital, people, activities, and knowledge occur in the strictly intra-firm networks between headquarters in home countries and affiliates in host countries. There are segments of the MNE network that concentrate on production activities, such as vertical MNEs that produce inputs for other affiliates in the network, and horizontal affiliates that primarily engage in sales. Furthermore, some affiliates will be more active in financial and tax operations, innovation and R&D, or other support functions rather than only production or sales (Cadestin et al., 2018).

Given this introduction it is clear that GVCs are fundamental and radically impactful in international trade, however it is useful to analyse this relationship even further.

A significant feature of Global Value Chains is the cross-border vertical integration of production within the same MNCs. Vertical integration involves a company managing multiple stages of the production process internally. This can be achieved through mergers and acquisitions (M&As) or establishing new operations (greenfield investments). Such integration enables MNEs to oversee and control a greater segment of their global value chains. Trade preferences and, thus, trade policy decisions are inextricably influenced by the vertical integration of production inside GVCs (Anderer et al., 2020).

One of the most relevant takeaways from analysing the link between GVCs and trade is that trade policy is no longer simply about the traditional conflict between exporters and import-competing industries (Anderer et al., 2020). As exporters become more dependent on imported intermediate goods to produce their exports, their involvement in GVCs grows. The latest estimates by UNCTAD is that between one-third and two-thirds of global trade is intra-firm (UNCTAD, 2023b).

This shift means that trade policy preferences are now shaped not only by international trade relations but also by international production processes which are encompassed in GVCs (Baldwin, 2014). Therefore, ultimately GVC alter trade policymaking since it empowers an already powerful

constituency: MNEs. MNCs thus will likely influence countries in adopting more liberal trade stances, implementing BITs or RTAs (Anderer et al., 2020).

These expectations are confirmed by an empirical study by Blanchard, Bown and Johnson (2017) which shows that GVCs alter tariff policies. This happen because value chains weaken the connection between the country of origin of the value-added content contained in final goods and the location of production (the L advantages extensively described before). GVCs alter the best tariff policy because import tariffs are by definition applied based on the place where goods are made. Governments are less motivated to distort the terms-of-trade (for final items) when domestic content in such goods is strong, which lowers import taxes. A portion of the benefits of protection are transferred back up the value chain to foreign suppliers when there is a large percentage of foreign content in local end goods. Optimal tariffs are further reduced by this mechanism.

Although GVC is a relatively new concept, its evolution is rapid and non-stopping. Therefore, is fundamental to shift the analysis towards the latest development in Global Value Chains which will help us understand the possible strategic directions which MNCs will take.

GVC evolution and the impact of digitalization

The evolution of Global Value Chains represents a transformative shift in the organization of global production and trade. Initially conceptualized as linear, sequential processes where firms sought cost advantages through offshoring and outsourcing, GVCs have progressively become more complex and networked over time. This evolution has been driven by technological advancements, particularly in information and communication technologies (ICT), which have facilitated the fragmentation of production processes across multiple countries and firms. As a result, GVCs now encompass intricate webs of interdependencies among suppliers, manufacturers, and service providers globally. The evolution of GVCs has also been shaped by changes in global trade policies, economic integration initiatives, and shifts in consumer preferences towards customization and faster delivery times. Furthermore, the rise of services and digital goods in GVCs has blurred traditional distinctions between manufacturing and services, adding layers of complexity to their structure.

This framework is not set in stone as this evolutionary path is an ongoing one and it will likely reshape global trade due to the influence of the decisions of major economic players: MNCs and nation states (Zhan, 2021).

Testifying to these developments comes in support of the data provided by UNCTAD in the latest World Investment Report, which underscore the centrality of the MNEs' production network today (2024b). Two pieces of data stand out in this regard:

- the global production networks of MNEs are estimated to govern about 80 per cent of global trade;
- the production of foreign affiliates as a share of global output is more than 6 per cent, and the sales of foreign affiliates are higher than the value of global exports.

While the former is fairly self-explanatory, the latter needs further comment. The fact that the sales of foreign affiliates exceed the value of global exports indicates that MNCs increasingly produce and sell locally through their foreign affiliates rather than relying solely on exports. This underscores that world trade is radically changed in the sense that GVC accounts now for more than 50 per cent of global trade (World Bank, 2020).

In recent years, a key feature emerges in each of the trade and investment reports, namely that GVC and FDI developments are also and especially read with a focus on digitalization.[6] But how digitalization is impacting on MNCs strategies?

The major impact that the literature has recognized and continues to study carefully, is the increase of opportunities. This expansion could be in the number of firms which can become multinationals and integrate into the global networks that are GVCs.

In this sense the work of Gopalan, Reddy & Sasidharan, (2022) represents a significant empirical demonstration of how digitalization is critically supportive of broadening the pool of firms that can go global. This happens, in synthesis, because digital technologies have enabled firms to streamline operations across geographically dispersed units within GVCs at much cheaper cost. The simple access to an high-speed internet connection and the creation of a website allows Small-Medium Enterprises (SME), which would otherwise be excluded, to be 6-10 percent more likely to participate in GVCs thus becoming MNEs (Gopalan et al., 2022).

Another study, from Lee, Falahat & Sia (2019), showed that companies who can capitalize on the digitization trend will be able to expand internationally before other companies. The implication of this study is massive in terms of business strategy. A SME implementing a digital strategy is, potentially, more competitive than even a larger firm. Therefore, even an established MNC that has made huge investments in the past could see its competitive advantage eroded if it does not reorganize its organization and strategies with implementation of digital features.

Loonam and O'Regan (2022) add that digital platforms have become central to orchestrating value creation within GVCs. Technologies like big data, artificial intelligence, and the Internet of Things

[6] Among these international institutions we can count the above cited UNCTAD and World Bank but also the OECD dedicate entire sections of reports or either full dedicated report on the digital dimension of investments.

are enabling new levels of connectivity and innovation. Digital platforms, by facilitating the integration of dispersed global resources and partners, are reshaping the way businesses operate across borders. The study draws attention to the strategic challenges of managing boundaries within these platforms to balance openness with value protection. It also emphasizes the need to shift focus from firm-level strategies to broader ecosystem-level interactions. Successful digital platform implementation in GVCs depends on the alignment of capabilities across these ecosystems and strong governance to foster engagement and participation.

Finally Hannibal and Knight (2018) theorise probable significant shifts in global production due to the adoption of additive manufacturing (AM) technologies, meaning the 3D printing. Traditionally, global value chains were characterized by centralized ownership and control by MNEs that outsourced activities to various suppliers across the world. However, the spread of AM is likely to decentralize production, enabling smaller-scale manufacturing at local or regional levels. This shift could lead to a new structure where individual households, municipalities, and smaller firms take on production roles, reducing the dominance of large MNEs.

In an OLI paradigm perspective, we should then affirm that the key impact of digitalization is that the L advantages in a digital world are less and less relevant by the day. The digital dimension is, by nature, borderless and thus a MNE should be able to pursue its strategies regardless of the geography of its investments. However, this does not happen, and the Global Value Chains are facing disruption, maybe, more than ever. The contradiction is obvious and forces MNCs to make a greater effort in understanding the macroenvironment by once again taking into consideration the actions of states and their strategic aims.

CHAPTER 2: Geopolitics, Geoeconomics and MNCs

Geoeconomics: the application of power politics by economic means

2.1 Understanding geopolitical risk and its relevance in contemporary megatrends

Geopolitical risk has for some years been recognized as a key element of a comprehensive and up-to-date risk analysis (Engle & Campos-Martins, 2020). Its centrality has been recognized by many scholars who have provided various definitions in recent years. Engle & Campos-Martins (2020) broadly define geopolitical risk as "the exposure of one or more countries to political actions in other countries", a definition that encompasses all events which have potential financial consequences worldwide like trade disputes, cyberattacks, terrorist acts, military operations, and climate change or political decisions like the Brexit. Caldara and Iacoviello (2022) provided a similar definition identifying geopolitical risk as "the threat, realization, and escalation of adverse events associated with wars, terrorism, and any tensions among states and political actors that affect the peaceful course of international relations". Caldara and Iacoviello's definition of geopolitical risk is intentionally broad, encompassing a variety of situations from initial threats to their realization and subsequent escalation. Although they use the term "risk", their comprehensive approach acknowledges the interconnected nature of geopolitical events, making it challenging to distinguish between aspects like threat, realization, and escalation.

These definitions are particularly well-suited to representing the complexities of the current geopolitical landscape, marked by persistent tension and widespread concern over potential geoeconomic confrontations. Caldara and Iacoviello's inclusive approach aligns with Engle and Campos-Martins' recognition of geopolitical risk as a central element in modern risk analysis. This comprehensive perspective is crucial in understanding the intricacies of contemporary global dynamics, where the boundaries between threat, realization, and escalation are increasingly intertwined. The ongoing conflict between Ukraine and Russia, alongside the ever-present risk of geoeconomic confrontations, underscores the relevance and applicability of these definitions in accurately reflecting the volatility and interconnectedness of today's geopolitical environment.

Thanks to the initial understanding of geopolitical risk just achieved, it is possible to analyse its relevance within contemporary megatrends. An initial estimate of the crucial role of geopolitical risk is provided by S&P Global Forum (2024), which identifies how this risk is cross-cutting and impactful on today's most important macro trends such as climate change, energy security, deglobalization and cybersecurity. The same prominence is given by more comprehensive global risk analysis reports,

each of which carves out an important space for geopolitical risk. Within this framework, the AXA Future Risks Report (2023) and the 2023 and 2024 World Economic Forum's Global Risks Reports provide in-deep analyses on the importance of geopolitical dynamics in the current risk landscape, shedding light on both their direct implications and their connections with other global challenges.

The AXA Future Risks Report (2023) identifies geopolitical instability amongst the top global risks, alongside with climate change and cyber threats, reflecting the acknowledgement that geopolitical tensions – particularly those involving major international actors – are deeply intertwined with other systemic risks. The document emphasizes the idea that geopolitical instability is no longer a localized concern, but instead a global issue with far-reaching consequences on security and economy. The interconnectedness of these risks represents a crucial issue, as geopolitical tensions tend to escalate other risks, creating a multifaceted web of challenges that are difficult to address individually (AXA, 2023). For example, as countries increasingly resort to cyber capabilities as instruments of statecraft, the lines between cyber warfare and traditional conflicts are becoming blurred, underscoring the need for a more integrated approach to risk management, in which cybersecurity is viewed not just as a mere technical challenge but as a critical component of geopolitical strategy (AXA, 2023).

The 2023 and 2024 World Economic Forum's Global Risks Reports further elaborate on the link between geopolitical risks and global megatrends. In the 2023 Report, geopolitical tensions are described as a significant and escalating risk, driven by factors such as the erosion of multilateralism, the revival of nationalistic policies, and the increasing frequency of geopolitical and geoeconomic confrontations. The document underlines how these tensions are disrupting global supply chains, undermining international cooperation, and worsening economic uncertainty. This is particularly evident in the context of the ongoing war between Ukraine and Russia, which constitutes a key example of how geopolitical conflicts can have profound global repercussions (WEF, 2023).

The 2024 Report develops this analysis by examining how geopolitical risks have changed over the past year, highlighting the deepening fragmentation of the global order, reflected by increasing geopolitical rivalry and the breakdown of traditional alliances. This shift has led to a more volatile and unpredictable international landscape, where the potential for conflict and confrontation has risen consistently. Furthermore, the implications of such tendency cascade into other uncertainty trends, particularly in the fields of energy security, trade, and technology (WEF, 2024). Indeed, one of the key issues addressed by the 2024 Report is the interplay between geopolitical risks and technological advancements. The document suggests that as technological innovation accelerates – especially with reference to artificial intelligence and cyber capabilities – it is increasingly being weaponized in

geopolitical conflicts[7]. This trend is contributing to the rise of new security risks, as countries and non-state actors alike exploit technological vulnerabilities, the so-called chokepoints, to gain strategic advantages. The report warns that in absence of effective international cooperation and governance, these technological threats could escalate into large-scale crises, further destabilizing the global order (WEF, 2024).

Between the two reports it is worth pointing out the evolution of geopolitical risk perception, which reflects a growing awareness of the deepening complexity and interdependence of such risks. The 2023 report presents a world where geopolitical tensions are already high, contributing to significant economic and security challenges. However, one year later the situation has become even more precarious, with geopolitical fragmentation leading to an increasingly unstable global environment for MNCs.

This progression highlights a critical shift in the global risk landscape: while geopolitical threats were previously seen as one of many factors influencing international stability, they are now recognized as a crucial driver of broader systemic risks. The 2024 Report's emphasis on the intersection of geopolitical and technological risks underlines this connection, illustrating how geopolitical instability is not just a background condition but a primary catalyst for other global challenges.

In conclusion, the relevance of geopolitical risk in contemporary megatrends has grown significantly, as evidenced by the analyses presented in the aforementioned reports. As these risks keep evolving, they become more likely to play a decisive role in determining the future trajectory of international stability. A concerted effort from both policymakers and private sector actors will be essential to understand and mitigate such risks, as well as a more integrated approach to risk management.

Since geopolitical risk management represents a relatively new field of study, the next paragraph will address the broader concept of political risk and its impact, a subject already extensively studied by scholars.

2.2 The impact of political risk on the international business environment

The impact of political risk on the international business environment is profound and multifaceted, as it influences both the strategic decisions of MNCs and the overall stability of global markets. Acknowledging and managing these risks represents a crucial challenge for MNEs, as they navigate an increasingly complex and volatile global landscape.

[7] This topic will be deeply analysed in the following chapters.

Kobrin's seminal work *Political Risk: A Review and Reconsideration* (1979) provides an essential starting point to understand the pervasive influence of political risk on the international business environment. His exhaustive examination of political risk highlights the ways in which government actions may impact the operations of MNCs.

Kobrin distinguishes between two forms of political risks: "macro risks," which affect all foreign enterprises operating in a country (e.g., expropriation); and "micro risks," which impact only specific industries or companies (e.g., industry-specific regulations). This distinction is crucial for MNCs as it helps them understand the different levels at which political risks can manifest and influence their operations (Kobrin, 1979).

In addition, Kobrin provides an in-depth analysis of the relationship between political instability and political risk. The author argues that while the former is a source of the latter, they are not synonyms. Political risk arises from unexpected discontinuities in the political environment that directly affect a firm's operations. However not all political fluctuations represent a risk; indeed, only those resulting in significant and unpredictable changes in the business environment pose a concrete threat to business operations (Kobrin, 1979).

Therefore, integrating political risk assessment into the strategic decision-making processes of MNCs is a necessity. Kobrin argues that to effectively manage political risk, it must be included into the overall corporate strategy, so that MNEs could be better prepared to anticipate and respond to political events potentially impacting their business operations. The paper also addresses the issue of the subjective nature of political risk assessment, pointing out that the perception of political risk is often influenced by the decision-makers' experiences, cognitive biases, and the information available to them (Kobrin, 1979), meaning that different firms might assess the same political environment differently, leading to diverse strategic responses. The author suggests that while a better understanding of the political environment may reduce uncertainty, it can rarely eliminate the subjective component from risk assessment entirely.

Fitzpatrick (1983) echoes Kobrin's analysis, highlighting the challenges that firms face in distinguishing between political instability and political risk, stating that while the former could lead to the latter, not all instances of political change necessarily have a negative impact on business operations. Like Kobrin, Fitzpatrick emphasizes the importance of incorporating political risk assessment into the strategic decision-making processes of MNCs. However, he criticizes the methodologies used at the time for being too reactive and based on subjective, ethnocentric perceptions rather than systematic analysis, while calling for more rigorous, process-oriented approaches.

Building on these two reviews of political risk, Giambona, Graham, and Harvey (2017) take the discussion further by focusing on the role of subjective perceptions in political risk management. Their 2017 study highlights how the personal risk aversion of executives significantly influences corporate strategies, particularly the decision to avoid investments in politically risky countries. This emphasis on subjective perceptions aligns with Kobrin's earlier assertion that political risk is partly defined by how it is perceived by business leaders.

However, Giambona, Graham, and Harvey (2017) introduce a more nuanced view by incorporating behavioural and agency theories into the analysis. They demonstrate that executives' personal characteristics—such as risk aversion—can lead to more conservative corporate strategies, which may not always align with shareholder interests. This integration of behavioural theory into the understanding of political risk represents a significant advancement in the field, offering a more dynamic view of how political risk is managed at the corporate level.

Moreover they note that political risk has now surpassed other material risks, such as commodity or input risk, in terms of its importance to corporate executives. This shift underscores the growing recognition that political events—ranging from regulatory changes to political instability—can have severe and far-reaching impacts on business operations, particularly for companies with investments in foreign markets. The authors suggest that as the global political landscape becomes more volatile (multipolarism, trade conflicts…), understanding and managing political risk has become a critical component of corporate strategy (Giambona et al., 2017).

The evolution from Kobrin's and Fitzpatrick's works to that of Giambona, Graham, and Harvey reflects broader shifts in the field of international business. The authors emphasis on the need for a systematic approach to political risk assessment has been complemented by newer studies that recognize the importance of subjective perceptions and behavioural factors in decision-making. The inclusion of agency theory in the latter study also highlights the growing recognition of internal corporate dynamics, such as the potential misalignment between executives' and shareholders' interests, in shaping responses to political risk (Giambona et al., 2017).

2.3 The impact of political risk on MNCs strategies

The impact of political risk on business strategies is a significant area of study in international business literature, as it directly influences how MNCs plan, execute, and adjust their operations in different geopolitical environments. Political risk can shape various aspects of business strategy, from market entry decisions to operational adjustments and exit strategies.

Political risk significantly influences the strategic decision-making processes of MNCs. When assessing potential markets for investment or expansion, firms must consider the political environment as a critical factor. High levels of political risk can deter investment, as firms seek to avoid situations where their assets might be seized, or their operations could be disrupted by abrupt changes in government policies. Even in markets where the potential for high returns exists, political risk can temper enthusiasm for investment, leading companies to adopt more conservative strategies or to require higher returns to compensate for the increased risk (Dunning & Lundan, 2008).

Moreover, political risk affects not only initial investment decisions but also the ongoing operations of MNCs. For instance, a sudden change in government policy might impose new tariffs, restrict profit repatriation, or introduce unfavourable labour laws, all of which can undermine the profitability of a business. These risks require companies to remain vigilant and adaptable, continuously monitoring the political landscape and adjusting their strategies accordingly (Dunning & Lundan, 2008).

The impact of risk also changes in relation to the experience of the MNC. The general expectation is that experience reduce risk, meaning that as MNEs gain experience in international markets they learn and adapt to what were once perceived as risks by developing some coping mechanism, or more organically, an enterprise risk management system (ERM)[8]. However, Liesch, Welch, and Buckley (2011) argue that, contrary to this expectation, increased exposure can sometimes reveal new uncertainties and risks, leading to complex decision-making challenges. The authors propose a coevolutionary framework which explain how firms steer their internationalization process. The factors involved in this coevolution process are uncertainty and risk.

In the context of internationalization, uncertainty and risk are closely linked but distinct concepts. Uncertainty refers to the unpredictable and often ambiguous aspects of entering new markets, where outcomes cannot be easily foreseen due to a lack of information or inherent unpredictability. Risk, on the other hand, involves identifiable threats that can be assessed and managed through specific strategies (Liesch et al., 2011).

The coevolutionary framework suggests that as MNCs expand into new and diverse international markets, they face a dynamic interplay between uncertainty and risk. Initially, firms encounter high levels of uncertainty as they enter unfamiliar environments with unknown variables. To navigate this, MNCs engage in uncertainty acclimatization, a process of gradually adapting to the new conditions by learning, gathering local knowledge, and developing flexibility in their strategies. This

[8] For a comprehensive theoretical framework for Enterprise Risk Management see Håkan Jankensgård's paper, *A Theory of Enterprise Risk Management* (2019).

acclimatization helps firms reduce the perceived uncertainty over time, allowing them to better understand the local context and identify specific risks (Liesch et al., 2011).

As firms become more familiar with the new environment, the nature of the uncertainty begins to shift, and previously ambiguous situations start to crystallize into more tangible risks. At this stage, the focus of MNCs moves toward risk accommodation—the process of developing and implementing strategies to manage these identified risks. This might include diversifying supply chains, forming local partnerships, or adopting specific risk mitigation measures such as insurance or compliance strategies (Liesch et al., 2011).

However, the process does not end there. As MNCs address these risks, they may encounter new layers of uncertainty, particularly as the external environment continues to evolve due to political, economic, or cultural changes. This ongoing evolution requires firms to continuously refine their approaches to both uncertainty and risk. The coevolutionary framework emphasizes that uncertainty and risk do not exist in isolation; rather, they influence each other in a cyclical manner. As MNCs manage one set of risks, new uncertainties emerge, necessitating further adaptation and strategic adjustment (Liesch et al., 2011).

Thus, together with other internationalization factors—such as the resources available to the firm; the domestic and international context; managerial oversight or agency—risk influences the pace, direction, and content of internationalization (Liesch et al., 2011).

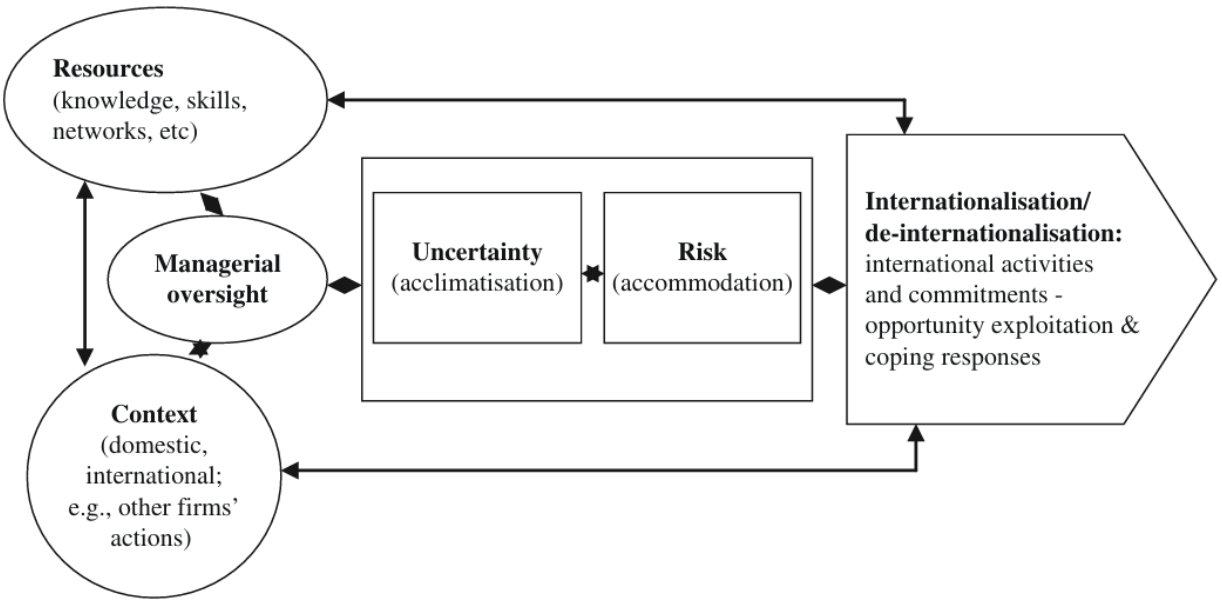

Fig.5: Uncertainty and risk—Coevolution in internationalisation[9]

[9] Liesch, P. W., Welch, L. S., & Buckley, P. J. (2011). Risk and uncertainty in internationalisation and international entrepreneurship studies: Review and conceptual development.

The above-summarised paper provides a general theoretical basis for understanding why and how risk impacts the strategies of MNEs, it nevertheless lacks the specificity needed to concretely analyse how geopolitical risk impacts them. In this sense, the study by Choer Moraes & Wigell (2022) fills this gap in the literature by addressing the so-called "corporate geoeconomics", a shared dimension between state and non-state economic actors where also the latter has relevant agency power.

MNCs are increasingly responding to geoeconomic confrontations by adopting a variety of strategic approaches to navigate the complexities of state-driven economic policies. These responses are shaped by the evolving nature of global economic relations, where states are more frequently using economic tools to achieve strategic objectives, often at the expense of market-oriented principles that have dominated international business over the past few decades. The resurgence of geoeconomics, characterized by the strategic use of economic power to further national interests, has prompted MNEs to rethink their strategies (Choer Moraes & Wigell, 2022).

Keeping in mind the dynamic nature of the context, the authors identify three possible MNCs reactions to the current geoeconomic situation:

- Business as usual;
- One company, two systems;
- Patriotic capitalism (Choer Moraes & Wigell, 2022).

One prominent corporate response to geoeconomic confrontations is the attempt to maintain "business as usual." Many companies strive to limit state interference in economic activities, seeking to preserve their operations in a global market that is increasingly influenced by national security concerns. The authors provide the example of major industry associations in Germany and the United States, which have expressed reluctance to support decoupling from China, emphasizing the importance of maintaining economic ties despite growing geopolitical tensions. These companies argue that overly restrictive state measures could harm their global competitiveness also underlining the apolitical nature of their economic activities. Moreover the authors provide instances in which MNCs did not merely protest but chose to push back government measures, such as Toyota who reportedly refused Japanese subsidies to relocate their facilities outside of China (Choer Moraes & Wigell, 2022).

Another strategic response is the adoption of a "one company, two systems" approach. This strategy involves companies adapting their operations to comply with the divergent regulatory and strategic demands of different states. For example, Tesla's decision to establish a manufacturing presence in China, despite escalating US-China tensions, reflects a calculated effort to navigate the geoeconomic divide while capitalizing on the lucrative Chinese market (Choer Moraes & Wigell, 2022)

In contrast, some corporations have embraced what is known as "patriotic capitalism." These firms align themselves more closely with their home governments' strategic objectives, often advocating for geoeconomic measures that protect their national interests. The US semiconductor industry's push for government subsidies and protections, framed as necessary for national security, exemplifies this approach. By aligning with state priorities, these companies not only secure government support but also position themselves as essential players in their countries' strategic economic sectors (Choer Moraes & Wigell, 2022).

The evolving corporate strategies in response to geoeconomic confrontations underscore the dynamic interplay between state actions and corporate interests. As states increasingly prioritize economic autonomy and strategic control, MNCs must navigate this complex landscape by balancing their global ambitions with the need to adapt to new geopolitical realities. The concept of corporate geoeconomics, as articulated by Choer Moraes and Wigell, provides a valuable framework for understanding how firms are responding to these challenges, highlighting the intricate relationship between business strategies and state-driven geoeconomic policies.

The geoconomic lens allow also to analyse the disruption which global value chains have been experiencing in recent years and that will likely continue to experience in the near future.

2.4 The impact of political risk on GVCs

The COVID-19 crisis has sparked a new debate regarding global value chains (GVCs), questioning whether the extensive globalization of production has created new economic vulnerabilities. Immediately the World Economic Forum has recommended "aggressively evaluating near-shore options to shorten supply chains and increase proximity to customers' as a response to COVID-19."[10]

Farrell and Newman (2019) introduce the concept of weaponized interdependence to describe how states could leverage their positions within global networks to exert coercive power over other states and non-state actors. In the context of GVCs, this concept explains how dominant states, like the US or China, can exploit the interconnectedness of global supply chains to achieve strategic objectives. For example, by controlling critical nodes in supply chains, the so-called bottlenecks or chokepoints, states can disrupt the flow of goods, impose sanctions, or apply pressure on other states and corporations that depend on these supply chains.

This ability to weaponize interdependence creates significant vulnerabilities for MNCs, which operate within GVCs. MNEs that rely significantly on global networks for production and distribution

[10] "Coronavirus is disrupting global value chains. Here's how companies can respond", World Economic Forum, 27 February 2020.

may find themselves caught in geopolitical conflicts, where their operations are threatened by state actions that exploit these interdependencies. This scenario was vividly illustrated during the COVID-19 pandemic, where disruptions in global supply chains exposed the vulnerabilities inherent in heavily interconnected and interdependent production systems (Farrel & Newman, 2019).

The strategic manipulation of interdependencies by states can lead to disruptions that force companies to rethink their supply chain strategies, often moving toward greater regionalization or localization to mitigate risks. This shift can lead to a reconfiguration of GVCs, where the previous emphasis on cost-efficiency is balanced against the need for resilience and security in the face of geopolitical challenges.

Another useful concept for analysing the impact of geopolitics on GVCs, complementary to the previous one, is the one of "balancing dependence" by Choer Moraes and Wigell (2022), meaning those "state policies that seek to reduce economic dependencies on foreign actors, both public and private".

The interplay between weaponized interdependence and corporate geoeconomics provides a comprehensive lens through which to understand the evolving dynamics of GVCs in the current geopolitical context. As states increasingly wield economic interdependence as a tool of coercion, and as firms adapt to these new realities, the structure and functioning of GVCs are undergoing significant changes. These developments underscore the importance of integrating geopolitical considerations into the management of global supply chains, ensuring that firms can navigate the complexities of a more fragmented and politically charged global economy.

Apple offers a compelling example of how geopolitical tensions, and the evolving dynamics of global value chains (GVCs) can drive strategic shifts in corporate operations.

Historically, Apple has relied heavily on China as the manufacturing hub for its products, particularly the iPhone. However, recent geopolitical developments, including the U.S.-China trade war, rising labour costs in China, and increasing regulatory uncertainties, have prompted Apple to rethink its global value chain strategy. For years, China has been the cornerstone of Apple's manufacturing strategy. The company's major suppliers, including Foxconn and Pegatron, operate massive production facilities in China, assembling millions of iPhones, iPads, MacBooks, and other products. This concentration of production in China allowed Apple to benefit from economies of scale, a highly skilled workforce, and well-established infrastructure, making it a cost-effective and efficient manufacturing location (Grimes & Sun, 2016).

However, this reliance on China also exposed Apple to significant risks. The U.S.-China trade tensions, which escalated with the imposition of tariffs on billions of dollars' worth of goods, including electronics, posed a direct threat to Apple's profit margins. Moreover, the Chinese government's regulatory environment and its strategic use of economic policy to further national interests have added layers of uncertainty to Apple's operations (Steinbock, 2018).

The U.S.-China trade war, which began in 2018, marked a turning point for Apple. The imposition of tariffs on Chinese goods imported into the United States increased the cost of manufacturing in China and heightened the risk of further economic sanctions. This situation was compounded by the broader geopolitical rivalry between the two nations, which has introduced greater unpredictability into the business environment (Steinbock, 2018).

In response to these challenges, Apple began to explore strategies to diversify its global value chain, reducing its reliance on China. This strategic shift can be understood through the lens of weaponized interdependence. The U.S. government's use of tariffs and trade restrictions exemplifies weaponized interdependence, where economic ties between nations are leveraged as tools of coercion. For Apple, this meant that its deep integration with China's manufacturing ecosystem became a vulnerability, as it exposed the company to the risks of geopolitical manoeuvres beyond its control. To address the risks associated with its dependence on China, Apple has gradually shifted parts of its production to other countries, particularly India and Vietnam[11]. The shift toward India and Vietnam highlights a move toward the regionalization of supply chains. Instead of relying on a global hub like China, Apple is creating regional production bases that can serve local markets more effectively while mitigating cross-border risks. This strategy reduces the complexity and risk associated with long-distance logistics and cross-border trade barriers.

Geopolitics has increasingly become a critical factor shaping GVCs, with recent events like the COVID-19 pandemic and the U.S.-China trade tensions highlighting the vulnerabilities of interconnected global production networks. As states increasingly leverage economic interdependence for strategic purposes, multinational corporations are being forced to reconsider their supply chain strategies. In the coming years, the influence of geopolitics is likely to drive further regionalization of GVCs, with companies prioritizing resilience and security over pure cost efficiency.

[11] https://asia.nikkei.com/Business/Business-Spotlight/Apple-moves-closer-to-China-despite-supply-chain-shifts and https://www.forbes.com/sites/qai/2023/01/01/apple-to-diversify-its-supply-chain-by-producing-macbooks-in-vietnam/

This shift will likely result in more localized and flexible supply chains, designed to mitigate risks associated with geopolitical instability and ensure continuity in an increasingly fragmented global environment.

CHAPTER 3: The most relevant geoeconomic battlefield: semiconductors industry

3.1. Purpose of the study and methodology: the single case analysis approach

This paragraph describes the methodology used to conduct research on the role of geopolitical risk in MNCs strategies, with a specific focus on the semiconductor industry and NVIDIA as a case study. The objective of the research is to answer the following question: "How could semiconductor multinational corporations navigate the evolving macroenvironment in relation to geopolitical risk and institutional pressures?"

The purpose of this study is to understand how the macroenvironment, specifically the geopolitical scenario, is impacting the strategies and influencing the business trajectories of MNCs through the case analysis of the semiconductor industry. This study has already explored in the previous chapters the characteristics of MNEs, the relevance of geopolitical risk and its potential impact, and the case analysis will serve as a starting point for the research in this matter. To understand if and how geopolitics impacts, the lens of geoeconomics will be applied to the geopolitical confrontation between the US and China for technological supremacy, in relation to the 'quest' for AI and the crucial role that semiconductors play.

Case selection rationale

This study focuses on the semiconductor industry as its strategic relevance makes it a neuralgic point of intersection between technology, GVCs and geopolitics. Thus, the centrality of this industry makes it a fitting environment for investigating the impact of geopolitical risk on business strategy. The reliance of major economies on semiconductor technology has led to increased government interventionism, with countries seeking to balkanize supply chains and reduce dependency on foreign suppliers. This idea is being translated into policies such as the implementation of protectionist measures, trade restrictions, and government subsidies aimed at bolstering domestic production capabilities.

The geopolitical significance of the semiconductor industry provides a unique lens through which to explore how MNCs respond to evolving institutional pressures and geopolitical risks. Moreover, current research on global value chains often focuses on how disruptions are impacting the production capacity of semiconductor firms, but there is less exploration of how companies are strategically responding to capitalize on new opportunities. This gap in the literature is significant, as it is essential for understanding market dynamics and international relations. In this context, the resurgence of *realpolitik* and the implementation of protectionist measures strongly questions the economic

paradigm of globalisation which has been experienced so far. The current landscape is characterized by a conflict between economic priorities, such as economies of scale and cost-benefit analysis, and geopolitical concerns, including the cost of sanctions and uncertainty. This tension is shaping the strategic decisions of firms in critical sectors like semiconductors. Within this framework, NVIDIA is the leading player in the semiconductor industry. Its position as global leader in graphics processing units (GPUs), a necessary hardware for the implementation of artificial intelligence (AI) technologies, puts it at the forefront of technological innovation, while also making it extremely vulnerable to geopolitical factors. In summary, the selection of the semiconductor industry and NVIDIA as a single case study is driven by the industry's strategic importance, the intersection of technology and geopolitics, the significant role of NVIDIA, and the broader implications for business strategy. This focus will provide valuable insights into how MNCs in general could navigate the evolving macroenvironment.

Methodology and data sources

This thesis adopts a single case study approach corroborated with interviews with experts of business management and of the semiconductor industry. Considering the essence of the subject matter, a qualitative methodology is more suitable than a quantitative one, nevertheless including quantitative data such as trade statistics or revenue streams in this research.

The research methodology is grounded in a single case study approach, a widely recognized method in qualitative social research. According to Yin (2009), a case study is an empirical inquiry that examines a phenomenon within its real-world setting, making it particularly suitable for exploring complex issues that cannot be easily quantified. This approach allows for a detailed understanding of real-life situations, such as organizational behaviours and social interactions (Yin, 2018). One of the major advantages of this method is its capacity to integrate multiple data sources, including interviews, observations, and document analysis, which enhances the credibility and validity of the research findings (Stake, 1995). By employing multiple sources of evidence, case studies enable a comprehensive and nuanced view of the research problem, fostering a deeper understanding of the context and dynamics involved.

Eisenhardt (1989) highlights another significant advantage of the case study approach: its potential for theory building. Through iterative data collection and analysis, case studies can generate new theoretical insights and refine existing theories, making them especially valuable in fields where theoretical frameworks are either underdeveloped or inadequate. This iterative process involves constant comparison between empirical data and emerging theoretical constructs, allowing researchers to develop theories that are well-grounded in real-world observations. Furthermore, the

flexibility inherent in the case study method enables researchers to adapt their inquiry as new insights emerge, ensuring that the research remains relevant and responsive to the complexities of the phenomenon under investigation.

Selecting cases strategically is also a key advantage, as it allows researchers to focus on cases that are particularly illustrative or insightful. Flyvbjerg (2006) asserts that such strategic case selection can enhance the generalizability of the findings by providing in-depth insights into specific instances that exemplify broader patterns.

The choice of a single case study approach is due to its significative effectiveness when investigating unique or exemplary instances that can illuminate broader theoretical issues (Yin, 2018). As Priya (2021) points out, the interaction between theory and case study research is crucial, as it allows for the testing and refinement of theoretical frameworks, thereby contributing to the advancement of knowledge in the field.

As mentioned before, to gain a comprehensive understanding of the issue, this study involved individuals with specialized expertise, all of whom have a deep understanding of the semiconductor industry. In particular the interviewees were a university professor specialised in business management and firms' internationalisation (expert n.1), a university professor specialised in business management and GVCs (expert n.2) and a public official specialised in microelectronics and semiconductors, specifically those for AI (expert n.3).

The in-depth interviews were a significant data source for this thesis since they allowed the author to gain valuable insights on an industry characterised by an incredible dynamism and transformative nature. More in detail the author, prior to the interviews, conducted an analysis based on the latest in-depth reports from consulting firms about the semiconductor industry and the AI impact on the environment, current literature, company reports and relevant newspaper articles from international media outlets covering real time developments related to this thesis' topic. Then the interviews were prepared.

The interviews were anonymous and carried out via telematic means (1 instance) and in presence (2 instances), with participants being made aware of the purpose of the interview. Each participant was asked the same set of questions to ensure that individuals with different expertise were interviewed on the same topic. This approach aimed to collect comparable data, while preventing errors that could arise from using different procedures for each respondent. The method was that of the semi-structured interview. This approach generates rich and extensive qualitative data, offering a thorough insight of participants' experiences and perceptions. Semi-structured interviews enabled effective questioning

while allowing for flexible digression to explore specific themes more deeply, which is essential for qualitative research. This approach is beneficial because it provides the interviewee with greater freedom of expression while giving the interviewer the opportunity to leverage the nuanced expertise of the participants. It also allows the interviewer to closely examine specific insights that may emerge from the participants' responses. The responses were later capitalised thanks to a content analysis methodology particularly suited for the inductive nature of this case study (Elo, Kyngäs, 2008).

The interviews were conducted over a time from July to August 2024. Each lasted about 40 minutes and was structured on 8 questions divided into four blocks. The first part focused on an overview of the semiconductor industry, this contextualization is essential to understand the key characteristics of the sector and the possible future trajectories. The second block of questions focused on AI and its transformative effects on the industry. In the third block, questions focused on the geopolitical attention to semiconductors and the possible effects of national policies on GVCs. Finally, the fourth block focused on the present and future relationship between semiconductor MNCs and Governments.

In conclusion, the content analysis of the interviews together with the gathered documentation allowed the author to gain a comprehensive and articulate view of the semiconductor industry internal and external dynamics, which were later applied to the NVIDIA case study and to analyze the macroenvironment influences on MNCs.

3.2 Overview of the semiconductor industry

The semiconductor industry is arguably one of the most delicate and crucial sectors of the 21st century, if not the most. Semiconductors, also known as integrated circuits (IC), are referred to as "the brain of modern electronics"[12], as they serve as the essential components required for electronic devices to perform calculations and operate effectively. The demand for semiconductors has been steadily increasing, driven by the growing adoption of electronics and the rise of new technologies such as 5G, the Internet of Things (IoT), and artificial intelligence (AI)[13]. The latest reports estimate the global semiconductor market size to be $611 billion and it is forecasted to reach, by the end of 2024, the amount of $680 billion (Fortune Business Insights, 2023; World Semiconductor Trade Statistics, 2023).

Since semiconductors are highly complex products to design and manufacture, the industry is characterized by both high R&D and high capital intensity, ranking in 2019 as the top industry investing in these categories with 22% R&D as percentage of revenues and 26% Capital Expenditure

[12] https://www.semiconductors.org/industry-impact/
[13] https://www.statista.com/outlook/tmo/semiconductors/worldwide

as percentage of revenues respectively (see figure 1). These levels of investments translate in an industry requiring a global scale and an high level of specialisation (Varas et al., 2021).

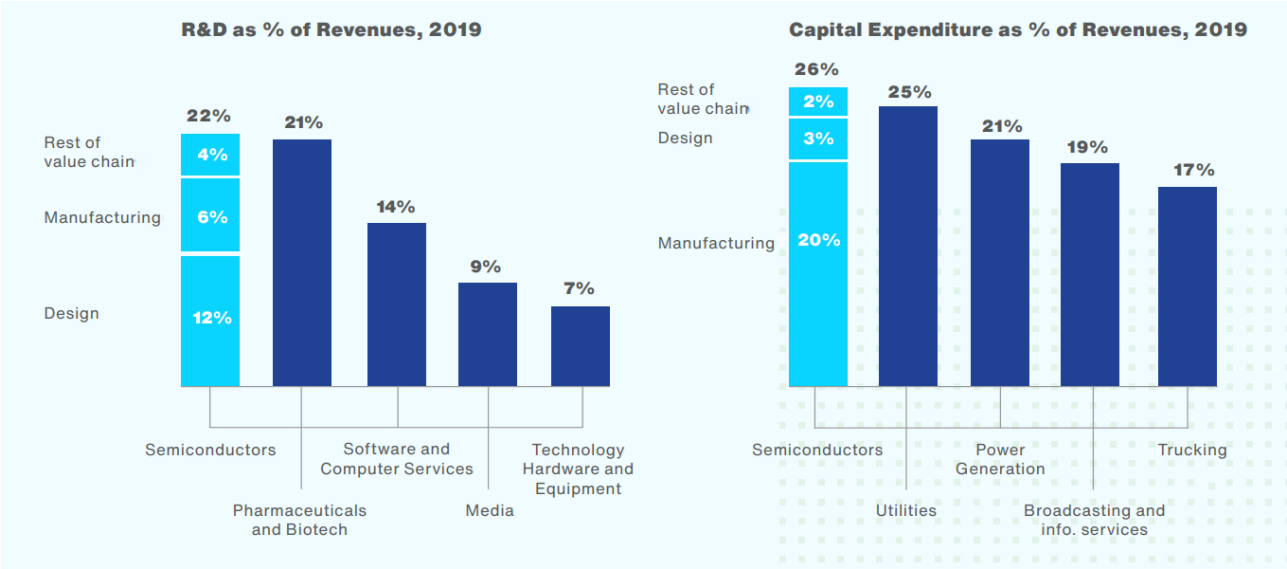

Fig. 6: Intensity in R&D and Capital Expenditure of the semiconductor industry[14]

Since the semiconductor industry's inception in the 1960s, its structure has evolved from one dominated by vertically integrated firms handling all stages of production. The dramatic increase in technological complexity and the need for scale to support the substantial investments required to sustain innovation—both in design (through R&D) and manufacturing (through capital expenditures)—have led to the rise of specialized companies mentioned before. Nowadays, semiconductor firms may concentrate on a single layer of the supply chain or integrate vertically across multiple layers. However, no single company or even an entire country is fully vertically integrated across all stages of production (Varas et al., 2021).

The semiconductor supply chain consists of three main stages: chip design, wafer fabrication (front-end manufacturing), and back-end manufacturing (including assembly, testing, and packaging). These stages rely on five key inputs: electronic design automation (EDA) tools, intellectual property (IP), semiconductor manufacturing equipment (SME), specific chemicals and materials, and wafers. The production process begins with the design of the chip, which requires specific IP to establish a theoretical foundation for the new chip's design. EDA tools are used to carry out the design tasks. The second stage is wafer fabrication, where the new design is transformed into a physical integrated circuit using specialized equipment (SME), chemicals, and materials. These materials are primarily silicon compounds or other multi-compounds that are processed into wafers.

[14] Varas, A., Varadarajan, R., Goodrich, J., & Yinug, F. (2021). Strengthening the global semiconductor supply chain in an uncertain era.

Once the wafers are produced, the final stage involves assembling the wafers and integrated circuits, followed by testing and packaging them. The completed semiconductors are then shipped to the company that commissioned their production (Varas et al., 2021).

This value chain is translated into four possible business model for semiconductor companies depending on the level of specialisation in the value chain: integrated device manufacturers (IDMs), fabless design firms, foundries and outsourced assembly and test companies (OSATs) (Varas et al., 2021).

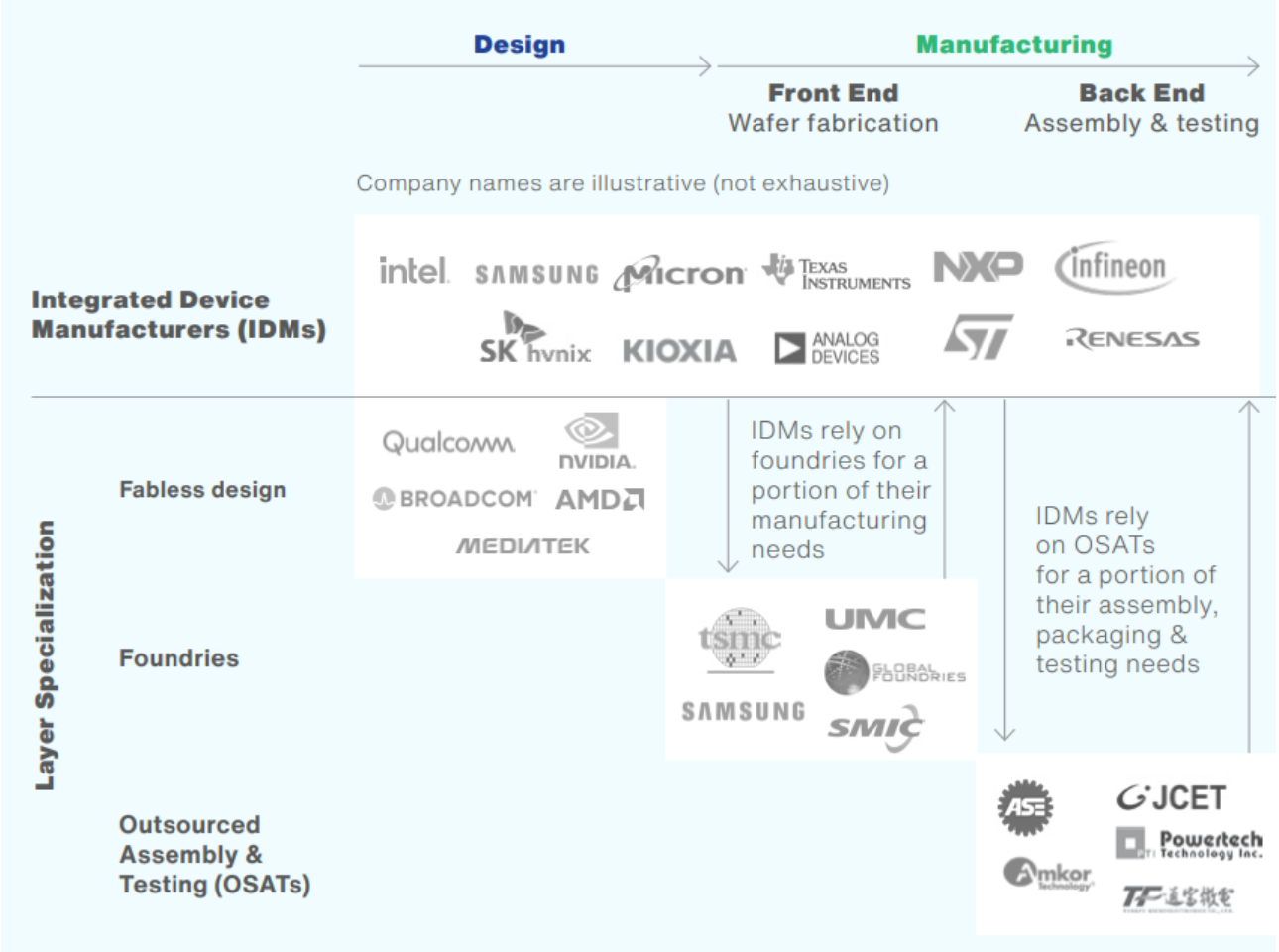

Fig.7: Semiconductor firms business models[15]

The IDM model consist in a firm which owns the multiple layers of the value chain, meaning that they perform design, manufacturing and assembling in-house. This model was predominant in the early stages of the industry however the high fixed costs described before caused most of the players to specialise in either the design stage or the manufacturing one making the fabless-foundry model the predominant one (Varas et al., 2021).

A fabless firm is a company that prioritizes investment in R&D over capital-intensive manufacturing. These firms focus on the research and design of new chips, which they later commercialise, while

[15] Varas, A., Varadarajan, R., Goodrich, J., & Yinug, F. (2021). Strengthening the global semiconductor supply chain in an uncertain era.

outsourcing the manufacturing stages—both fabrication and assembly, packaging, and testing. Fabless firms create demand in the market for front-end and back-end manufacturing by relying on foundries for fabrication and on OSAT companies for assembly, packaging, and testing. This specialization helps explain how companies with such high costs can not only survive in the market but also thrive with significant profit margins. (Varas et al., 2021).

The above-described characteristics also caused a geographic specialisation of the industry, whose supply chain is dispersed globally with three macro areas involved: the US, Eastern Asia and Europe. While these areas have emerged due to different regions having strengths in certain types of end electronics devices or applications[16]—and thus benefiting from proximity to their end markets—geographical specialisation is also due to the comparative advantages that these regions have developed over time (Varas et al., 2021).

The United States leads in semiconductor R&D (fabless firms) due to its strong ecosystem of technical universities, high-skilled engineering talent, and access to capital. This has fostered a thriving innovation environment, especially in chip design, where U.S. companies hold a significant market share. On the other hand, East Asia, including Taiwan, South Korea, and mainland China, hosts approximately 75% of global semiconductor manufacturing capacity (foundries). Taiwan, with its historical focus on the semiconductor industry since the 1970s, has become a major hub, home to leading foundries like TSMC. Government incentives, such as tax credits and direct support, have been crucial in developing these capabilities. Finally, the segment of assembly, packaging, and testing the semiconductor supply chain of is less capital-intensive than wafer fabrication. It relies more on labour costs, which are substantially lower in East Asia compared to the U.S. and Europe. As a result, countries like China, Taiwan, and Singapore dominate this segment, housing the majority of the world's capacity (OSAT companies). As technological innovation in advanced packaging increases, however, the importance of labour costs may diminish, and other factors could become more decisive (Varas et al., 2021).

This geographic specialisation of the industry has also been recently addressed by Mario Draghi (2024), during the presentation of the report on the Future of European competitiveness in the European Parliament. In this report the former European Central Bank President dedicated a section to semiconductors particularly highlighting the EU's dependence on non-European players for critical components of the semiconductor value chain.

[16] The United States is a global leader in the design of electronic devices, such as smartphones. Europe leads in the automotive sector, which is increasingly reliant on chips, and is also a key hub for semiconductor manufacturing equipment (SME). East Asia includes China and Taiwan, which are the largest global hubs for manufacturing electronic devices, as well as Japan and South Korea, which have strong positions in both the automotive and consumer electronics sectors.

While the EU has strengths in areas such as sensors, power controls, and automotive microcontrollers, it lacks capabilities in advanced processors, including high-performance computing and graphics processing units (GPUs). This leaves Europe's AI industry heavily dependent on U.S. companies like NVIDIA (Draghi, 2024).

Additionally, Europe currently has no semiconductor foundries producing below the 22-nanometer node, with global market leaders like TSMC and Samsung holding the largest share of the market. This means that around 75-90% of semiconductor production occurs in Asia, making Europe highly reliant on East Asian countries for both wafer production and key materials, including germanium and gallium, which are essential for advanced chip manufacturing. This geographic concentration of supply, combined with increasing geopolitical tensions, has led to concerns about the resilience and security of Europe's semiconductor supply chain (Draghi, 2024).

In order to summarise this overview of the semiconductor industry it will now be used Porter's Five Forces analysis, which provides a valid framework for understanding the dynamics of the semiconductor industry and its profitability. Here's how each of the five forces impacts the profitability of the semiconductor industry:

1. Threat of New Entrants: Low

- The industry is characterised by high barriers to entry which protect existing players from new competitors, helping to maintain profitability. The significant capital investment required for manufacturing facilities and the advanced R&D, limit the number of new entrants to almost zero. Additionally, the industry's reliance on economies of scale makes it challenging for new entrants to compete on cost and efficiency. Finally, the industry requires significant technological expertise and intellectual property (IP) to produce advanced semiconductors. Established players hold numerous patents and have developed specialized knowledge, making it difficult for new companies to enter and compete. The overall effect is that established companies face almost zero competition experiencing an oligopoly, allowing them to maintain higher margins.

2. Bargaining Power of Suppliers: High

- Suppliers play a crucial role in the semiconductor industry, providing essential components, raw materials and equipment. The industry relies heavily on a few suppliers for highly specialized equipment, such as photolithography machines, with companies like ASML (Netherlands) holding a near-monopoly in extreme ultraviolet (EUV) lithography

equipment.[17] Furthermore the supply of critical raw materials like silicon, rare earth elements, and chemicals is concentrated among a few suppliers meaning that any disruption in supply chains can have significant impacts on semiconductor production as it happened with the COVID pandemic (Mohammad et al., 2022).

3. Bargaining Power of Buyers: Moderate

- Major tech firms such as Apple, Samsung, and automotive manufacturers are key customers and have significant bargaining power due to their purchasing volumes. Thus, these companies can negotiate prices and demand high-quality and custom solutions. However, the vast and growing number of applications for semiconductors (consumer electronics, automotive, industrial applications, etc.) diversifies the customer base, reducing the overall bargaining power of any single buyer.

4. Threat of Substitutes: Low

- There are no direct substitutes for semiconductors in their core applications. The growing dependence on digital technology, AI, and electronics ensures that the demand for semiconductors remains strong indeed as said before it grows year by year. The increasing complexity and specificity of semiconductor applications (e.g., GPUs for gaming and AI, microcontrollers for IoT) further reduce the likelihood of substitutes emerging.

5. Industry Rivalry: Moderate

- The semiconductor industry is highly competitive due to its significant concentration. However, the high barriers to entry and the growing market demand make the competition less fierce. Moreover, the specialisation of the industry represented by the fabless-foundry model, creates an environment which is characterised by many submarkets with established market position for the firms.

The industry's profitability is thus a balancing act between maintaining technological leadership, managing supply chain costs, and innovating faster than competitors. Successful companies are those that navigate these forces effectively, leveraging their strengths to maintain a competitive edge and sustain profitability.

[17] One of the chokepoints in the semiconductor GVC that is being weaponised as it will soon be explained.

3.3 Role of semiconductors in AI

The overview of the industry would not be complete without a brief detailed analysis of the main factor leading to the raise in the demand, and attention, of semiconductors: AI.

Artificial intelligence (AI) is increasingly becoming a transformative force in the semiconductor industry, driving demand for advanced hardware and reshaping market dynamics. As AI applications expand across sectors such as healthcare, automotive, finance, and consumer electronics, the need for powerful, efficient, and specialized semiconductors has grown substantially. AI relies on high-performance computing capabilities, which are provided by a new generation of chips specifically designed to handle the complex computations required for machine learning and data processing (Batra et al., 2019).

These AI chips, including Graphics Processing Units (GPUs), and custom-designed AI accelerators, are critical for enhancing the speed, efficiency, and capabilities of AI systems. As a result, the semiconductor industry is not only catering to traditional computing needs but is also at the forefront of technological innovation, enabling the rapid development and deployment of AI technologies. This shift underscores the central role that semiconductors play in advancing AI and highlights the importance of continuous innovation and investment in semiconductor technologies to meet the evolving demands of the AI-driven economy (Batra et al., 2019).

In the ecosystem described above, there is one application of AI which has received more attention than the others: Generative Artificial Intelligence also known as GenAI.

GenAI "*describes algorithms (such as ChatGPT) that can be used to create new content, including audio, code, images, text, simulations, and videos"* (McKinsey, 2023). A description provided by a GenAI tool itself aligns with this characterization: "*Generative AI refers to a class of artificial intelligence systems designed to generate new content, such as text, images, music, or even code, based on patterns learned from existing data. Unlike traditional AI, which primarily focuses on analysing data and making predictions, generative AI creates new data that resembles the input it was trained on"* (ChatGPT, 2024). The tool here was used for a simple task, such as providing a description, but its applications are far broader and more significant, the potentialities are so vast that the impact of this technology is still unknown.

Nonetheless, there are few data which unveil the impact of this technology. For example Deloitte (2024) estimated that the demand for specialized chips that accelerate AI model training and inference is expected to reach over $50 billion in 2024, making up about 8.5% of total chip sales. These chips, including high-performance GPUs and CPUs with advanced packaging technologies, are crucial for

data centres and edge computing applications. The report also predicts that AI-related chip sales could potentially reach $400 billion by 2027, underscoring the importance of this segment for the industry's future growth (Deloitte, 2024). Players in the industry itself are also investing in AI tools that could help them by "*adding intelligence to large, complex data models and accelerating the planning, development, and execution of chip design and manufacturing*" (Deloitte, 2023a). The estimates of these investments amount to $300 million in 2023 and they are expected to reach and surpass $500 million in 2026 (Deloitte, 2023b).

Although the potentiality of AI, both from a producer and a consumer perspective, are unlimited and unknown, companies that can innovate and produce efficient AI chips will be key players in the rapidly evolving digital landscape and continued investment in AI chip development, alongside advancements in related fields such as quantum computing and new materials, will be critical to sustaining the momentum of technological innovation (Viswanathan, 2020).

3.4 US-China competition: techno nationalism on semiconductors

As should be clear by now semiconductors form the core of every modern technology, spanning from cell phones and cars to medical and military equipment. Consequently, supremacy in semiconductor production is nearly synonymous with technological dominance. Given the diverse applications and the convergence of technological progress with advancements in strategic sectors like the military and healthcare, the significance of semiconductor development becomes fundamental in achieving economic and geopolitical strength, particularly in an era marked by geopolitical uncertainties. This premise is where the race for technological supremacy intersects with the ongoing *de facto* superpower competition between China and the US.

On one hand, Washington stands as the affirmed global superpower and the current technological hegemon, striving to maintain its position despite the intense challenges posed by Beijing's advancements.

The US semiconductor industry plays a pivotal role in driving America's economic strength and competitiveness, national security, and technology leadership. Semiconductors were invented in America and US companies are still in the lead in global markets, commanding nearly half of the world's chip sales (Peters, 2022). In contrast, China, as the challenger in world dominance, aspires to transition from being the world's semiconductor factory to becoming the foremost innovator globally. This aspiration is notably encapsulated in the Made in China 2025 (MiC 2025) industrial upgrading plan, introduced by Li Keqiang in 2015, which places significant emphasis on technological

innovation and self-sufficiency, particularly in the IC sector[18]. Over the past decade, the Chinese Communist Party (CCP) and Chinese businesses have consistently implemented measures and strategies to realize the self-sufficiency goals outlined in MiC 2025, with the ultimate aim of achieving technological supremacy. Substantial progress has indeed been made towards this objective.

Of course, this progress has not been welcomed by the US due to the concern of being surpassed by China as the technological hegemon and more importantly as the global superpower. This framework is the perfect scenario in which techno nationalism thrives. Techno nationalism is defined as "*the proactive engagement of states in high-tech industries to support domestic companies, enable them to have or maintain a dominant position in the GVC, and utilize their global market power as a mechanism for diplomatic power projection"* (Park, 2023).

This approach has become increasingly relevant in the 21st century, as technological capabilities (think of AI) are seen as critical to geopolitical power. The U.S. resurgence of technonationalism in response to China's growing technological capabilities and ambitions is evident in policies like the CHIPS and Science Act, which aims to boost domestic semiconductor manufacturing and reduce reliance on foreign supply chains (Park, 2023). Before moving to the Chips Act, it should be also taken into consideration the US-China trade war as expression of techno nationalism. The US, especially under the Trump administration, in a period of direct geopolitical confrontation with China, recurred to their, "policy of first resort" (Drezner, 2021): economic sanctions.

The tycoon's administration took sanctions to a new level: little more than a year after taking office he banned Huawei and ZTE equipment from being used by the US government due to concerns about their ties to the Chinese government and the potential for their products to be used for espionage or other malicious activities. This act was only the tip of the iceberg since, in the following years, the White House, claiming that Chinese companies represented a national security threat, started a broader securitization process targeting Chinese Telecoms companies involved in building the 5G infrastructure (Friis & Lysne, 2021).

Ultimately this process resulted in the addition of Huawei and other affiliated foreign companies to the Entity List under the Export Administration Regulation (EAR), meaning that American companies now needed a governmental license to do business with Huawei. The purpose of these restrictions is to curb the dissemination of sensitive technologies and safeguard the interests of US national security. The underlying reasoning behind prohibiting certain firms from engaging with specific Chinese

[18] https://isdp.eu/content/uploads/2018/06/Made-in-China-Backgrounder.pdf

semiconductor companies is rooted in the concern about a potential civil-military fusion, the infamous 'dual use'. This apprehension is based on the idea that advancements in the semiconductor industry could extend into the military domain, thereby placing the US at a tactical disadvantage (Friis & Lysne, 2021).

The change of residents in the White House, from Trump to Biden, has not coincided with a change in geoeconomic policies, on the contrary, the competition for semiconductor leadership has become fiercer than ever under Biden's presidency. On October 7, 2022, the new president expanded the export controls under the EAR imposing new restrictions on the export of certain semiconductor products like specific semiconductor manufacturing equipment and software. This represented a massive policy shift because US semiconductor policy has traditionally been market-driven and laissez-faire while with these policies the American administration has decided to abandon this liberal mindset and to retain control of crucial choke-points technologies of the global supply chain[19].

It is quite clear that these sanctions, motivated by abstract national security, are an expression of precise geopolitical objectives, however, it remains unclear if and how these restrictions will impact Beijing.

Semiconductors represent a crucial technological vulnerability for both China and the United States, as they heavily rely on each other and Taiwan for cutting-edge semiconductor devices. Since these two states are interdependent in terms of semiconductors, American sanctions could seem like a double-edged sword: in the short term the Middle Kingdom would be harmed, but possible retaliation would damage Washington too. However, there is a reason why the last two White House administrations, both the Republican and the Democratic one, have taken measures so potentially damaging to the national economy: the awareness of the existence of an asymmetric trade relation.

To explain this trade relation, and consequently the rationale behind the American geoeconomic move, it is useful to apply the concept of weaponized interdependence developed by Farrel and Newman which was mentioned in the previous chapter: "Asymmetric network structures create the potential for "weaponized interdependence," in which some states are able to leverage interdependent relations to coerce others. Specifically, states with political authority over the central nodes in the international networked structures through which money, goods, and information travel are uniquely positioned to impose costs on others." (Farrel & Newman, 2019)

First, the trade relation between the two economic giants is asymmetric: as seen before, Washington relies on China just for the manufacturing of the semiconductors while Beijing desperately needs

[19] https://www.csis.org/analysis/choking-chinas-access-future-ai

American designed chips to achieve the goals outlined in the MiC 2025. For China is impossible to replace American chips with others due to the advanced technological design of those. The US instead can encourage or even coerce national companies to relocate their semiconductor production elsewhere since the manufacturing process does not require 'Chinese expertise'.

Second, the US have 'political authority' over the most important and technologically advanced semiconductor companies operating in the global technology industry (Intel, NVIDIA, Qualcomm, Micron…). If one of these companies were to violate the aforementioned export control ban it could face significant fines and penalties, as well as damage to their reputation and loss of business, therefore is evident how this legislation forced these companies to limit their business with China.

Thus, the union of these conditions enabled the White House to weaponize this technological chokepoint allowing them to block or, at the very least slow, the Chinese race toward technological leadership.

This weaponization seems to be having the desired effect, at least on the economic level. Since the US issued one of the broadest export controls on semiconductor technology to China in a decade, Middle Kingdom's semiconductor industry has seen its market value tumble. At least 13 China-listed semiconductor firms saw market value decline more than 10% since the American export ban, and five saw a more than 20% decline[20].

Technonationalism is also perfectly embodied in the recently announced CHIPS and Science Act, a landmark policy that embodies the principles of technonationalism. It aims to bolster U.S. competitiveness in the semiconductor industry through subsidies, research investments, and stricter export controls on critical technologies. These measures are designed to maintain the U.S.'s technological edge and counter the perceived threats posed by China's rapid advancements in semiconductor capabilities (Luo & Van Assche, 2023).

The CHIPS and Science Act represents a significant investment in U.S. industrial policy, with a total budget of $280 billion, of which $54 billion is dedicated to the semiconductor sector. This funding includes $39 billion for the construction of manufacturing and packaging facilities and $11 billion for research and development initiatives. These initiatives include establishing a National Semiconductor Technology Center, a National Advanced Packaging Manufacturing Program, and a Manufacturing USA Semiconductor Institute to encourage public-private collaboration. An additional $2 billion is

[20] https://technode.com/2022/10/14/chinese-semiconductor-firms-bear-heavy-fallout-of-us-chip-sanction/

allocated to the Department of Defence for coordination and information-sharing efforts (Donnelly, 2023).

Moreover, the Act introduces a manufacturing investment tax credit to offset cost differences between domestic and offshore chip production, aiming to support U.S. businesses. Recipients of these funds are prohibited from producing in countries deemed national security threats, such as China. Concerns over potential Chinese aggression, particularly in Taiwan, have further shaped U.S. chip policy, leading to comprehensive export controls on both advanced and older generation chips to limit China's semiconductor and computing capabilities efforts (Donnelly, 2023).

At the same time the US is coordinating with allies such as Netherlands and Taiwan, to manage global supply chains strategically. For example, the Chip 4 Alliance is a strategic partnership formed by the United States with its Northeast Asian allies—South Korea, Taiwan, and Japan—to counter China's growing influence in the global semiconductor industry and other high-tech sectors. Each member of the alliance has a specific role based on their strengths: the U.S. leads in chip design, intellectual property, and core technologies; South Korea focuses on memory chip production; Taiwan is responsible for non-memory chip production; and Japan handles chemical materials, chip fabrication equipment, and parts (Park, 2023).

The alliance aims not only to coordinate technological and production roles but also to implement a concerted approach to the semiconductor industry's GVC. This includes efforts to diversify supply chains, protect intellectual property rights, and control the export of advanced semiconductor products and manufacturing equipment (Park, 2023).

A key element of the alliance's strategy is the control of chokepoints, such as the export restrictions on advanced chip technology to China, highlighted by the involvement of Japan's Tokyo Electron and the Netherlands' ASML. These companies hold critical positions in the global market for advanced semiconductor manufacturing equipment, making their cooperation essential for the success of the alliance's efforts to limit China's technological advancements. The alliance's success will depend on the commitment of its member states to collective goals and the U.S.'s ability to coordinate these diverse interests while managing intra-alliance competition. The case of ASML, which has a monopoly on advanced EUV lithography tools, illustrates how control over specific technologies can influence the entire global semiconductor production and distribution network (Park, 2023).

The rise of this techno-geopolitical uncertainty, as evidenced by the CHIPS Act, has significant implications for MNCs. Luo & Van Assche (2023) suggest that companies must adopt geo-strategic approaches, enhancing their supply chain resilience and reconfiguring their global operations to

mitigate geopolitical risks. Corporate diplomacy and strategic alignment with national policies become essential as firms navigate the complex interplay of economic, technological, and political factors in the global market.

In conclusion, the current techno-geopolitical uncertainty marks a decisive moment for MNCs in the semiconductor industry. The sweeping national policies being implemented worldwide present significant opportunities for these firms to enhance profitability and strengthen their market positions. However, the ability to capitalize on these opportunities will depend on MNCs' adeptness at navigating the complex and evolving landscape of global trade restrictions, government incentives, and strategic alliances. Those that can effectively manage these challenges and align their strategies with the shifting priorities of different nations will not only secure their place in the market but also emerge as leaders in the next era of technological innovation. On the other hand, firms who will focus too much on the geopolitical situation could lose focus on the innovation side, marking their own downfall. Thus, MNEs should reach a rather difficult compromise, trying to preserve their global business model in a world where deglobalization and regionalisation seem the dominant trend in the political macroenvironment.

3.5 Case Analysis: NVIDIA Corporation

Firm's history

NVIDIA Corporation is an American technology MNC which has drawn the global spotlight for the past few years for its pivotal role in the race for AI and which, just three months ago, on June 18 2024, became the world's most valuable company, surpassing both Apple and Microsoft, with its market capitalization of $3.335 trillion (Reuters, 2024a).

Although its reign at the top of the chart was brief[21], NVIDIA is currently one of the most successful multinational companies in the world and is receiving special attention due to its strategic importance in global value chains. Nevertheless, NVIDIA's path to this position has been long and challenging.

The firm was founded on April 5, 1993, by Jensen Huang, Chris Malachowsky, and Curtis Priem, three electrical engineers which envisioned that the future of the 'newborn' computing industry would pass by accelerated computing and graphics (NVIDIA, 2024a). The effort of the industry at the time was directed at the general-purpose computing while the three engineers looked at graphics-based processing, which was used in the videogame industry, as the path to the future. The reasoning behind

[21] At the time of writing (06/09/2024) NVIDIA is the third most capitalised company in the world at $ 2.65 trillion after achieving on Tuesday (03/09/2024) the steepest ever single-day decline in market value for a U.S. company losing $279 billion (Reuters, 2024b).

this research focus can be found in Huang words: "*We also observed that video games were simultaneously one of the most computationally challenging problems and would have incredibly high sales volume. Those two conditions don't happen very often. Video games was our killer app—a flywheel to reach large markets funding huge R&D to solve massive computational problems"* (Fortune, 2017).

After two years, in 1995, NVIDIA published its first product, the NV1, a multimedia card for personal computers whose purpose was to support the programming of the graphics used in gaming. However, this product was a business fiasco due to a failure to accurately read the market. The graphics' programming at the time consisted of assembling three-dimensional polygons called primitives, and the commonly used shape was the triangle. The three founders decided instead to develop a hardware optimized for quadrilaterals. This choice backfired when, shortly after the commercialization of the NV1, Microsoft announced that the graphics programming on its software would only support triangles. Since Microsoft was the principal operating system used for the development of videogames, NVIDIA found itself with an almost non-existent market bringing the company on the verge of bankruptcy (Witt, 2023).

The turning point was in 1999, when the firm announced its newly invented chip, the GeForce 256, presented by NVIDIA as the first world's first graphics processing unit (GPU), set to revolutionize the 3D graphics of the gaming industry (CNN, 1999). The GPU proved to be very successful in enhancing the quality of the image on screen and allowed NVIDIA to gain credibility in the gaming industry, such a credibility that, in 2000, the firm earned it the contract to develop graphics processors for Microsoft's gaming console, X-Box (NVIDIA, 2024b).

GPUs are exceptionally well-suited for handling a large number of small tasks simultaneously, a technique known as parallel processing. For instance, GPUs can manage millions of pixels on a screen at once, making them indispensable in graphics rendering. These characteristics not only allowed NVIDIA to become the dominant firm regarding hardware for videogames graphics, but also had implications for computing in general. In 2006, researchers at Stanford University uncovered a surprising new use for GPUs: they realized that this hardware could also accelerate complex mathematical operations in ways that traditional central processing units (CPUs) could not. This discovery opened the door to possibilities far beyond gaming and visual rendering (BBC News, 2023).

At this critical juncture, NVIDIA's co-founder and CEO, Jensen Huang, made a pivotal decision that would significantly impact the evolution of AI. Seeing the untapped potential of GPUs, Huang chose to invest heavily in developing a tool that would make GPUs programmable, thus expanding their

capabilities beyond graphics processing. This decision resulted in the creation of CUDA, an informatic architecture which allowed GPUs to perform parallel processing for a variety of new applications (NVIDIA, 2024a) transforming them from single-purpose hardware into powerful, versatile processors. This innovation was integrated into NVIDIA's chips, which, although unnoticed by the average gamer, provided researchers in computer science with a powerful tool for high-performance computing on consumer hardware (BBC News, 2023).

This newfound capability proved to be a game changer in AI research. One of the earliest breakthroughs came in 2012 with the development of AlexNet, an AI model designed for image classification. AlexNet's training, which required processing vast amounts of data, was accomplished using just two of NVIDIA's programmable GPUs. The task, which would have taken months on a large array of traditional CPUs, was completed in just a few days, demonstrating the immense computational power of GPUs in accelerating neural network processing (BBC News, 2023).

This discovery—that GPUs could greatly accelerate AI tasks such as neural network training—quickly spread throughout the computer science community. Researchers began adopting GPUs in growing numbers to run this new type of AI workload, leading to rapid advancements in AI capabilities. The flexibility and power of programmable GPUs soon became essential tools in fields ranging from machine learning and autonomous systems to deep learning and robotics. NVIDIA's foresight in developing programmable GPUs not only revolutionized AI research but also helped lay the foundation for modern AI technologies that continue to drive innovation today. This pivotal shift in the role of GPUs marked the beginning of a new era in computing, where AI has become one of the most transformative forces in technology and beyond (BBC News, 2023).

A decade later, on November 30, 2022, OpenAI released a public demo for Chat GPT, an AI chatbot which attracted in just five days a million users and many more after, *de facto* moving AI exposing the potentiality of machine learning and generative power to the general public and starting the AI frenzy and tech companies 'gold rush' (Marr, 2023).

Within the current scenario, NVIDIA applied with perfection the old economic strategy summed up by the motto "during a gold rush, sell shovels'. Months before the release of Chat GPT, NVIDIA launched the H100, a GPU based on the Hopper architecture (hence the name), designed for large scale AI models more commonly known as Generative AI. However, the chip's price of $40.000 per unit seemed too much for a single chip, this until Chat GPT happened because in Huang's words "*it created instant demand*" (Financial Times, 2023b).

The H100 demand grew astronomically, driven by the Big Tech giants especially those of cloud services like Amazon, Microsoft and Google. The increase in the demand was so high that NVIDIA's GPUs became, in Elon Musk's sarcastic words, '[…]considerably harder to get than drugs" (Financial Times, 2023b).

Since then, NVIDIA has established itself as one of the most important players in the semiconductor industry, and more in general of the tech industry, carving out a role as the dominant and almost unrivalled supplier for AI implementations.

Financial Data and markets performance

NVIDIA has experienced rapid growth, driven by the increasing demand for GPUs in gaming, professional visualization, AI, and data centres. As mentioned at the start of the case analysis, NVIDIA recently claimed and lost the number one spot for most capitalised firm worldwide and currently sits at the third spot with a market cap of $ 2.65 trillion (Reuters, 2024b).

Though market capitalization gives a quick snapshot of Nvidia's performance, the most accurate representation of its exceptional growth is captured in the below summarised financial data[22]:

- **Revenue**: For the fiscal year ending 2024, NVIDIA generated $60.9 billion in revenue, which compared to the $27.0 billion of the previous year marks a significant growth of 126% in one year;
- **Gross Margin:** The company registered a 72.7% Gross Margin in 2024 compared to the 56.9% of 2023, achieving a 15.8 increase in just one year;
- **Earnings per Share (EPS):** The EPS experienced the most significant increase going from a $1.74 in 2023 to $11.93 in 2024, up 586% year on year;
- **Operating Income**: In 2024, NVIDIA's operating income stood at $33.0 billion, highlighting its strong profitability, up 681% compared to the $4.2 billion of the previous year.

[22] All the data provided in this section were collected from the company annual reports for fiscal years 2023 and 2024, which NVIDIA has made publicly available on its website at the following link: https://investor.nvidia.com/financial-info/annual-reports-and-proxies/default.aspx

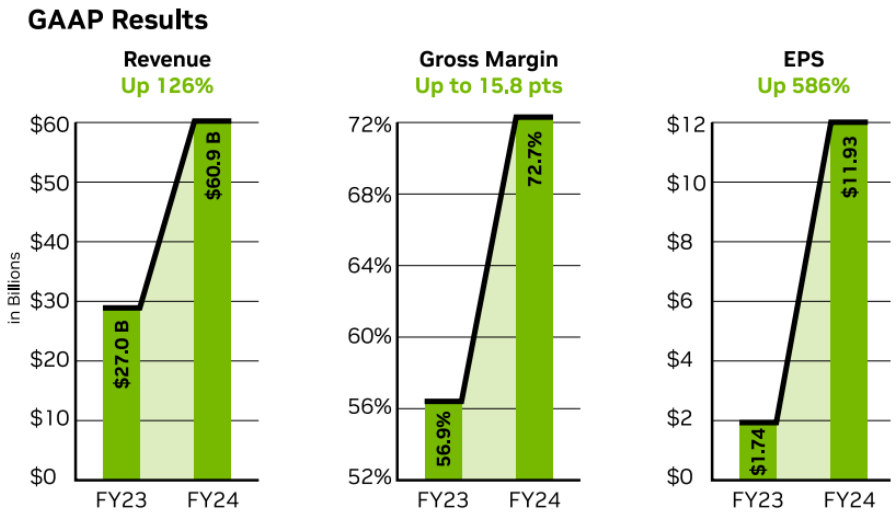

Fig. 8: 2024 results compared with 2023 results[23]

NVIDIA's extraordinary performance is to be attributed to its dominance in the GPU segment of the value chain. This segment frequently appears across various industry value chains, thus unbundling revenues by customer category can provide a more comprehensive understanding of the company. The unbundling results in four categories:

- **Data Centres**: In the data centre segment, the company registered $47.5 billion revenues, marking a 217% increase year-on-year, largely driven by demand for the NVIDIA Hopper GPU computing platform, which is used for training large language models (LLMs) and AI applications.
- **Gaming**: NVIDIA is the dominant player in the gaming GPU market, with its GeForce brand being the preferred choice for gamers worldwide. The revenue for this segment in 2024 accounted for $10.4 billion. A 15% increase from the previous year, supported by strong demand for the GeForce RTX 40 Series GPUs.
- **Professional Visualization**: NVIDIA provides graphics solutions to industries such as architecture, engineering, and entertainment. The Quadro GPUs are used in fields requiring advanced visualization and 3D rendering capabilities. In this segment there was a modest 1% increase year-on-year, from the $1.5 billion revenue of 2023 to the $1.6 billion revenue of 2024.

[23] NVIDIA. (2024). *2024 annual report*. https://s201.q4cdn.com/141608511/files/doc_financials/2024/ar/NVIDIA-2024-Annual-Report.pdf

- **Automotive**: The company has commercialised the NVIDIA DRIVE platform, which aims to revolutionize autonomous vehicles by providing AI-based solutions for self-driving capabilities. Although this market is still emerging, it holds substantial long-term potential for NVIDIA. The revenues accounted for $1.1 billion, a 21% growth from the 2023 data.

NVIDIA International Value Chain

NVIDIA is an American company headquartered in Santa Clara, California and falls in the category of vertical MNC due to its fabless manufacturing strategy. Thus, the company does not own facilities offshore like the traditional MNC, instead it relies on contracts or partnerships with specialised manufacturers employed in both the front-end and the back-end stages of the chip production. This strategy allows NVIDIA to focus on product design, marketing, and customer service (NVIDIA, 2024c).

The manufacturing contractors make NVIDIA's value chain, a global one, since the vast majority of the facilities are concentrated in the Asia-Pacific region. As disclosed by the company itself, the Santa Clara giant use foundries such as Taiwan Semiconductor Manufacturing Company Limited (TSMC) and Samsung Electronics Co., Ltd. (Samsung) to produce semiconductor wafers. With regards to the memory components, the firm purchases them from Micron Technology, Inc., SK Hynix Inc., and Samsung. Finally, NVIDIA relies on independent subcontractors and contract manufacturers like Hon Hai Precision Industry Co., Ltd., Wistron Corporation, and Fabrinet to perform the assembling, testing, and packaging of the final products (NVIDIA, 2024c). Unbundling this geographic concentration sheds light on how the resilience of this value chain could be severely tested by current geopolitical dynamics, more in detail:

- TSMC's fabs are primarily located in Taiwan, with major facilities in Hsinchu, Taichung, and Tainan. The company also has subsidiaries in Nanjing, China and in Washington, U.S.[24].
- Samsung has semiconductor manufacturing sites located in South Korea, notably in Hwaseong, Pyeongtaek, and Giheung, and also operates fabs in Austin, Texas, and Taylor, Texas[25].
- Micron deviates from this trend. Although the firm has facilities in Taiwan, Japan, and Singapore, the majority of its fabs are located in the home country, the United States, with major operations in Boise, Idaho, and Manassas, Virginia[26].

[24] https://www.tsmc.com/english/aboutTSMC/TSMC_Fabs
[25] https://semiconductor.samsung.com/foundry/manufacturing/manufacturing-sites/
[26] https://www.micron.com/about/locations

- SK Hynix's manufacturing is carried in four production sites, the main ones are located in South Korea, with major operations in Icheon and Cheongju, while the other two semiconductor fabrication facilities are in Wuxi and Chongqing, China[27].
- Hon Hai, more commonly known as Foxconn, carries the vast majority of its assembly and testing activities in China, with 'four technology parks' located in Shenzhen, Shandong, Henan and Sichuan. Additional factories are present in the U.S., India, and various countries across Southeast Asia[28].
- Wistron has a similar geographical footprint, with manufacturing facilities in China, Taiwan, and other locations across Asia, including India and Vietnam[29].
- Fabrinet's manufacturing operations are primarily based in Thailand, where it operates large-scale facilities for assembly and testing[30].

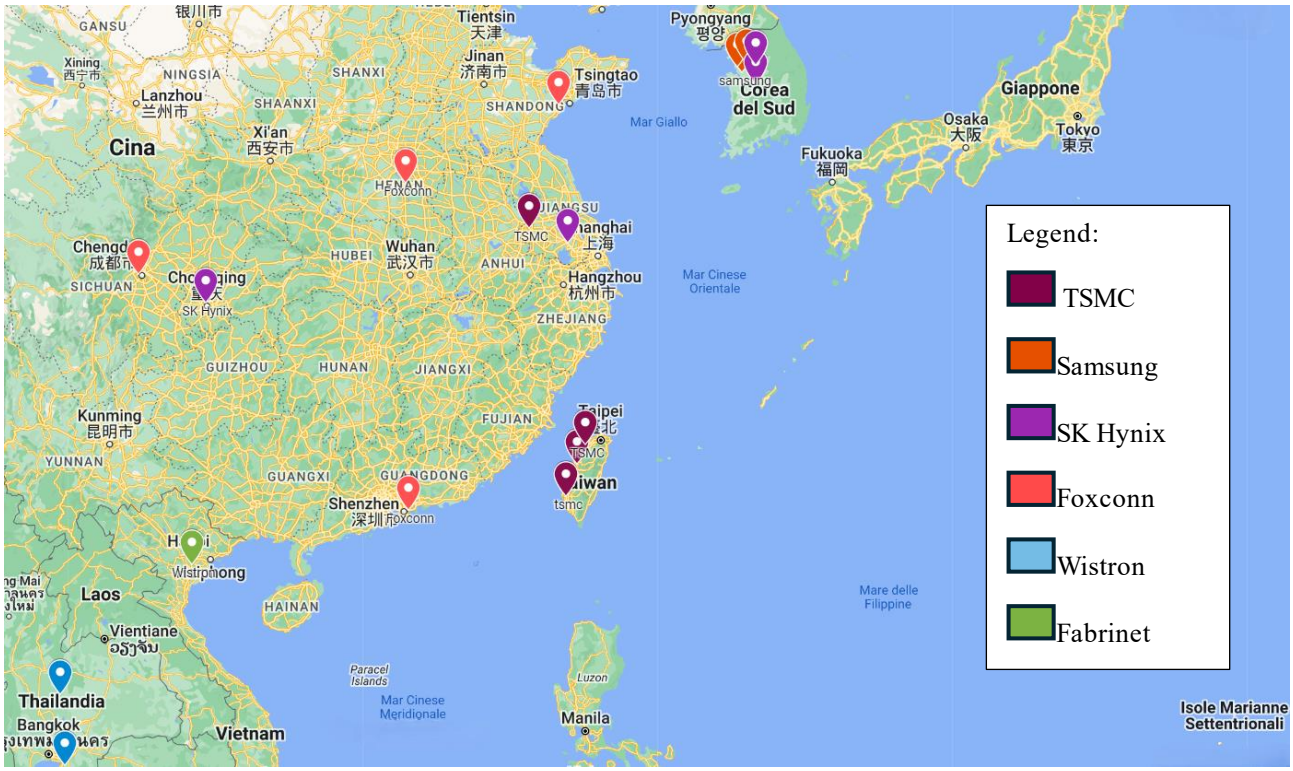

Fig.9: Location of NVIDIA suppliers' facilities[31]

3.6 NVIDIA evolution in the GPU market and the rethinking of its value chain

As mentioned before NVIDIA is the dominant player in the GPU market, since the invention in 1999 the firm was able to maintain its advantage and also widen the gap with possible competitors

[27] https://www.skhynix.com/company/UI-FR-CP06/
[28] https://www.foxconn.com/en-us/about/worldwide
[29] https://www.wistron.com/en/AboutWistron/GlobalOperation
[30] https://fabrinet.com/about
[31] Created by the author

registering 80% market share at the end of 2023 (Statista, 2024). This almost monopolistic situation is the result of thirty years of constant R&D, made possible by the fabless strategy which was crucial to maintain a quick pace of innovation.

NVIDIA's dominance in the GPU market is exemplified by the latest AI chips: the aforementioned H100 and the latest Blackwell. On 18 March 2024, a little over a year since the launch of the H100, Huang announced the Blackwell GPU; this chip features 208 billion transistors, compared to the 80 billion of last year's H100, highlighting its substantial increase in processing capability. Huang emphasized that the new chip is twice as powerful for training AI models compared to the current generation of GPUs and offers five times the capability in "inference" — the speed at which AI models, like ChatGPT, can respond to questions (Financial Times, 2024a). Even though the chips was only announced and not yet commercially available, the Blackwell instantly became 'the' commodity for AI with customers already lined up and Tech Giants like Amazon Web Services, Dell Technologies, Google, Meta, Microsoft, OpenAI, Oracle, Tesla expected to adopt NVIDIA's latest GPU and thus placing billion dollars orders[32].

The Blackwell is the first GPU resulted from the accelerated innovation pace announced by Huang in October 2023, when he vowed that NVIDIA would shift its GPU's releasing schedule from one every two years to a one-year rhythm (Financial Times, 2024b). This intention was further displayed by Huang's announcement in June 2024 that the company was already developing a new GPU, Rubin, while the Blackwell is still in the production phase. The decision to disclose the next wave of products before Blackwell has even begun shipping to customers highlights how the firm is rapidly working to cement its dominance in AI processors (Financial Times, 2024c).

In an effort to strengthen its position as the leading supplier of AI chips, NVIDIA is also expanding its software suite by introducing tools designed to enhance AI application development on its hardware. The company is launching a new addition to its CUDA platform, known as NIM microservices, which allows businesses to deploy a variety of AI models specifically optimized for NVIDIA's chipsets[33].

While maintaining a competitive advantage through continuous technological development is undoubtedly an effective strategy, it also places a significant strain on the value chain, since suppliers are forced to adapt to this accelerated pace and NVIDIA fabless-foundry business model makes no exception.

[32] https://nvidianews.nvidia.com/news/nvidia-blackwell-platform-arrives-to-power-a-new-era-of-computing
[33] Ibid

The design of new GPUs impact both the front-end and back-end manufacturing, increasing the complexity of producing the semiconductor wafer and also the assembling part due to the additional elements to be integrated. However, an additional number of components can be managed without significant issues due to the know-how of workers involved in backend manufacturing. The situation is different, however, when it comes to front-end processes characterised by the extreme engineering challenge to fit into the confined space of a chip wafer, the required power for the latest AI GPUs.

This is exactly what happened to NVIDIA in August, when the rumour spread that its foundry, TSMC, was facing issues in the production of the Blackwell chip, with the risk of delayed shipments (Financial Times, 2024d). These rumours (which caused the market value drop mentioned before) were later confirmed by Huang himself, admitting that there were problems related to the 'mask', the template that imprints a chip's design on to a silicon wafer. Nonetheless the issue was resolved and the CEO announced that mass production started, and that the first Blackwell GPUs would be shipped from 2024 last quarter (Financial Times, 2024b).

Nonetheless this is a clear example showing the fragility of such a decentralized value chain. NVIDIA's dependence on third parties' foundries makes it extremely vulnerable to any supply chain disruption. This is a critical issue acknowledged by NVIDIA itself, which outlines the potential risks associated with its decision to remain a fabless company[34].

NVIDIA has implemented some measures to mitigate risks associated with its GVC. First of all, as seen before, the company relies on a variety of third parties, more than one for each supply stage, reducing the possible disruption caused by issues of a single subcontractor. Moreover NVIDIA, in response to the extraordinary demand in recent years, has adopted the business practice of conducting capacity planning well in advance. This approach ensures significant inventory reserves to mitigate the impact of any potential supply disruptions (NVIDIA, 2024c).

In addition to these business practices, the firm is actively working in order "*to enhance the resiliency and redundancy of our supply chain"* (NVIDIA, 2024c). An example of this active engagement is NVIDIA recent announcement of a more significant partnership with its foundry, TSMC, aimed at speeding the manufacturing process thanks to NVIDIA's GPUs. Together with Synopsis, the leader in the silicon to systems design, NVIDIA will provide TSMC with advanced chips and software to accelerate computational lithography, a key step in the mask production process. The increased speed

[34] NVIDIA. (2024). p.18, ANNUAL REPORT PURSUANT TO SECTION 13 OR 15(d) OF THE SECURITIES EXCHANGE ACT OF 1934 For the fiscal year ended January 28, 2024. https://s201.q4cdn.com/141608511/files/doc_financials/2024/q4/1cbe8fe7-e08a-46e3-8dcc-b429fc06c1a4.pdf

of the process translates into additional capacity to employ to reduce the risks of disruptions while building a stronger relationship with one of its key manufacturers[35].

Finally, NVIDIA suppliers' concentration in the Asia-Pacific region, make its value chain in the eye of the geopolitical storm between U.S. and China. However, in this case the mitigation possibilities for NVIDIA are little due to, once again, the choice of be a fabless firm.

The trade-off is evident, on one side this choice allowed NVIDIA to concentrate on R&D which ultimately was the crucial reason for its market dominance, on the other side it has prevented NVIDIA from being able to choose the location of its manufacturing facilities, as it does not own any. Therefore, the GPU Giant is unable to autonomously rethink its GVC but has to work and build stronger partnerships with his Asian suppliers. NVIDIA can also look at this situation with the hope due to its buyer's power. Within this framework it is relevant that TSMC has announced huge investment in the US, planning to build facilities in Arizona that would bring the manufacturing closer to NVIDIA (Financial Times, 2024e).

Nonetheless, the business implications of this AI boom, along with its associated geopolitical concerns, have yet to fully unfold, raising significant questions about what the future holds for NVIDIA and other semiconductor multinationals.

[35] https://nvidianews.nvidia.com/news/tsmc-synopsys-nvidia-culitho

CHAPTER 4: Case discussion

How the geopolitics-AI nexus is redefining Global Value Chains

The intersection between AI and geopolitics is the key factor, which is increasingly reshaping the structure of GVCs, prompting a rethinking of supply chain strategies that began with the disruptions caused by the COVID-19 pandemic. The pandemic revealed the vulnerabilities of highly interconnected and geographically dispersed supply chains, created by decades of increasing international expansion of MNCs, leading to a geopolitical re-evaluation of dependence on specific regions and actors.

This paragraph introduces the discussion on how Tech MNCs' value chains are and will be impacted by AI and the geopolitical concerns raised by it. Using insights from the interviewed experts, this chapter will explore the roots of these concerns and will inductively examine, through the NVIDIA case study, the role of AI, particularly generative AI, in reshaping global value chains in the semiconductor industry. As mentioned in the methodology, the interviewees were a university professor specialised in business management and firms' internationalisation (expert n.1), a university professor specialised in business management and GVCs (expert n.2) and a public official specialised in microelectronics and semiconductors, specifically those for AI (expert n.3).

First of all, geopolitical concerns around semiconductors are quite recent, all experts agreed on individuating the pandemic as the trigger for this attention. Prior to COVID, the focus of US technonationalism was primarily on 5G infrastructure and Huawei, such as with Trump's export controls, rather than on chips. However, the central importance of semiconductors became clear with the significant delays in component deliveries, which impacted a wide range of industries. Expert n.3 pointed out that this alignment of numerous value chains around semiconductors forced governments worldwide to "[…] *recognize their previous lack of awareness, their ignorance, realizing that everything, both in civilian and military sectors, now revolves around hardware."* He also underlined that in the post-pandemic era, the rise of AI as a critical technology has amplified these concerns, with nations now prioritizing control over AI-related industries, such as semiconductors, due to their strategic importance for national security and economic competitiveness.

Expert n.2 added that this evolving geopolitical landscape is encouraging and even forcing multinational corporations to reconsider the traditional configurations of GVCs, leading to greater emphasis on regionalization, technological sovereignty, and resilience in critical supply chains. In this context, access to advanced technologies is "*increasingly seen as a geopolitical lever, fundamentally altering the dynamics of international trade and of the semiconductor industry*."

Expert n.1's insights completed this preliminary overview, explaining that governments have become more intrusive in the decision-making processes of MNCs. Just a few years ago, these companies enjoyed the freedom to position themselves anywhere on the global map, reflecting the height of globalization. Now, however, states are *"increasingly invoking 'national security' to impose constraints, attempting to ringfence the world into distinct spheres of influence."* Additionally, she emphasized that this very narrative of identifying 'strategic' sectors or layers of production chains is what makes geopolitical risk so potentially impactful on MNCs and GVCs. "*Today, semiconductors are considered strategic, but in the past, industries such as automotive were seen in the same light, and in the future, it is likely that batteries will fall into this category. It is the states that decide which sectors are deemed strategic*".

Currently, the spotlight is on companies like NVIDIA, seen as foundational to AI development. However, the underlying rationale and possible future implications of disruptive innovation like AI extend far beyond the semiconductor industry. These geopolitical interventions, while presently focused on AI and semiconductor production, could reshape the broader business environment as states continue to dictate what constitutes national security and strategic interest. This evolving dynamic poses significant challenges for MNCs, as their global operations could increasingly be subject to state intervention and control, depending on which sectors are prioritized in the future.

This analysis, while initially focused on the internationalization strategies of semiconductor MNCs, has ultimately centred around the key factor driving change both in the microenvironment and macroenvironment: AI. What began as a study of how semiconductor companies like NVIDIA position themselves globally quickly revealed that AI is the pivotal element reshaping the industry.

This study revealed two main implications of AI. This latter is not only introducing unprecedented demand on the semiconductor supply chain but also redefining how MNCs operate in a rapidly evolving global market.

Expert n.3 explained how, historically, the semiconductor companies which emerged victorious in the competitive struggle were the ones who were able to link their product to large consumer market, for example in the 90s semiconductor companies created the electronic hardware of radios and other devices for music reproduction; a decade later Intel emerged victorious creating the chips used in personal computers (PCs) and finally in the 2010s TSMC became the leading semiconductor foundry associating itself with smartphones like Apple.

Thus, the first and striking implication of this AI-driven transformation is the emergence of a vast new market for semiconductors.

Semiconductor MNCs, which historically supplied chips for general computing, gaming, and mobile devices, are now catering to an ever-expanding demand for AI-specific hardware. The growth of AI applications, particularly generative AI technologies, has created an urgent need for high-performance chips capable of handling massive datasets and complex computational tasks. This new market is not only significant in size but also in scope, as AI is rapidly becoming a cornerstone of industries as diverse as healthcare, autonomous vehicles, and finance. NVIDIA is now positioned at the forefront of this AI revolution, with its GPUs being essential for the training and operation of advanced AI systems. This emerging market has caused semiconductor MNCs to adapt their strategies, prioritizing innovation in AI-specific hardware to maintain their competitive advantage in a rapidly growing sector.

Moreover, AI is also reshaping the GVCs of the semiconductor industry since it increases both productivity and capacity. In an interview with the Financial Times (2024b), Huang explained how NVIDIA itself is using AI to accelerate data processing and helping with design of its newest chips saying that the 20,000 engineers who designed the Blackwell GPU felt like 60,000 thanks to AI implementation.

Broadening the perspective to AI's impact on global value chains in general, beyond just semiconductors, the three experts agree that AI introduces transformative capabilities through predictive analytics and data-driven insights. Technologies like machine learning will enable businesses to analyse large datasets, identify patterns, and detect trends, thereby enhancing decision-making. This will allow MNCs to anticipate market shifts and proactively address emerging challenges. AI-powered predictive analytics will also help forecast demand, optimize inventory, and minimize supply chain disruptions by leveraging historical and real-time data to make accurate predictions about consumer behaviour, market trends, and supply chain performance (as mentioned in the previous chapter, NVIDIA has already started implementing these actions to minimize the risks linked to its dispersed supply chain).

Ultimately another significant consequence of this reshaping of the value chain is the effect on the market dynamics. As we have seen AI requires a innovation pace that would be impossible to keep without cooperation between the different players of the industry, an example of this increase in collaboration was the NVIDIA and TSMC one. Although the two companies were already working together in different step of the semiconductor value chain, AI created synergies between the design and the manufacturing process that would beneficiate both.

These implications, although distinct, can be understood more holistically: the emergence of a new market attracts players, and to compete effectively, they must maintain a constant pace of innovation.

To sustain this pace, greater cooperation between players at different stages of the value chain is required. The synergies created through this collaboration, combined with the enhanced predictive capabilities provided by AI, lead to optimized capacity planning, which in turn mitigates potential supply chain disruptions.

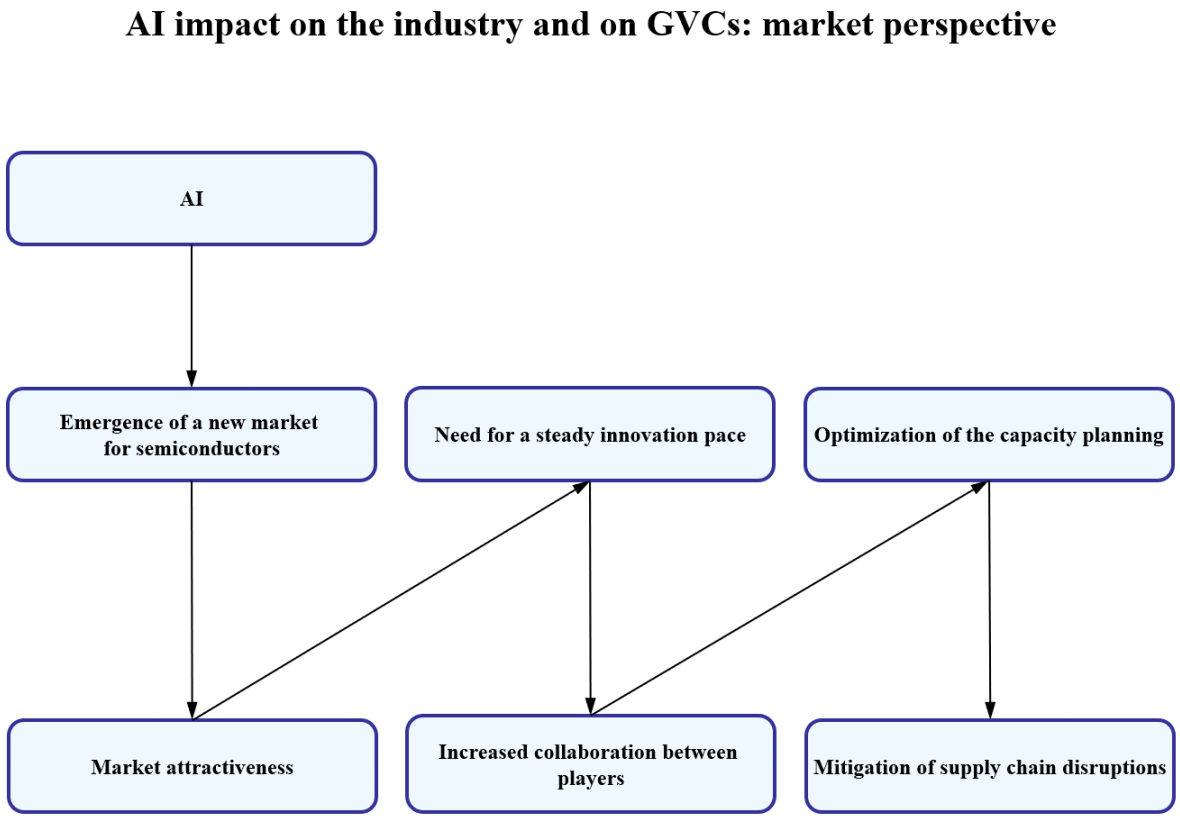

Fig.10: An holistic market view of the AI impact on GVCs[36]

However, the impact of AI on the semiconductor industry extends far beyond the creation of a new market. AI has also drawn intense governmental scrutiny, particularly due to its potential for dual-use—civilian and military applications.

The capacity of AI technologies to revolutionize both industries and defence systems has made it a central concern for national security. Governments are increasingly viewing AI through the lens of strategic importance, leading to heightened interventions in the value chains of semiconductor MNCs. The fear that AI technologies could be used for military purposes has driven states to exert more control over the semiconductor supply chain, often invoking national security concerns to justify their

[36] Created by the author

actions. In particular, countries such as the United States and China, but also the European Union have taken steps to protect their domestic industries, with export controls, subsidies, and policies like the Chips and Science Act aimed at reducing dependence on foreign semiconductor manufacturing.

As a result, AI is playing an indirect role in the regionalization and fragmentation of GVCs. Semiconductor MNCs, which once enjoyed the freedom to operate in a globalized market, are now facing increased pressure to localize their operations. Governments are encouraging, if not forcing, companies to build production facilities within national borders or in regions deemed geopolitically friendly. The rationale behind this push is twofold: on one hand, it ensures that key industries remain under national control in times of crisis, and on the other, it limits the risk of advanced technologies, such as AI, falling into the hands of rival powers.

It is possible to see that these protectionist policies are already having an effect on the GVCs. In the previous chapter was mentioned TSMC announcement to invest in a new manufacturing hub in Arizona, US and expert n.3 mentioned how the Taiwanese company will do the same in Germany.

This fragmentation of GVCs marks a significant shift from the pre-AI era, where efficiency and cost reduction were the primary drivers of supply chain management and where the geography of the value chain was guided by MNEs strategic decisions. Now, MNCs must navigate a complex geopolitical landscape where national interests and security concerns are reshaping their global strategies and the geography of the value chain has become a problem.

These policies are ushering in an era of deglobalization, where global value chains (GVCs) are gradually being replaced by regional value chains that align more closely with geopolitical spheres of influence. Instead of the highly interconnected, globalized production networks that have characterized the past few decades, we are seeing the emergence of more localized and fragmented systems, driven by national security concerns and the strategic importance of key industries like semiconductors. However, it remains impossible for even powerful states like the U.S. and China to internalize the entire semiconductor production process within their borders. The scale economies involved in semiconductor manufacturing are simply too vast for any one country to sustain independently. As a result, international alliances, such as the Chip 4 Alliance discussed in the previous chapter, are becoming increasingly important. These alliances will form the backbone of new regional value chains, where production is concentrated among trusted partners within a geopolitical sphere, allowing countries to maintain access to advanced technologies while mitigating the risks of over-dependence on foreign rivals. This shift towards regional value chains reflects a broader trend of deglobalization, where global cooperation is being supplanted by strategic regional partnerships based on security, political alignment, and economic collaboration.

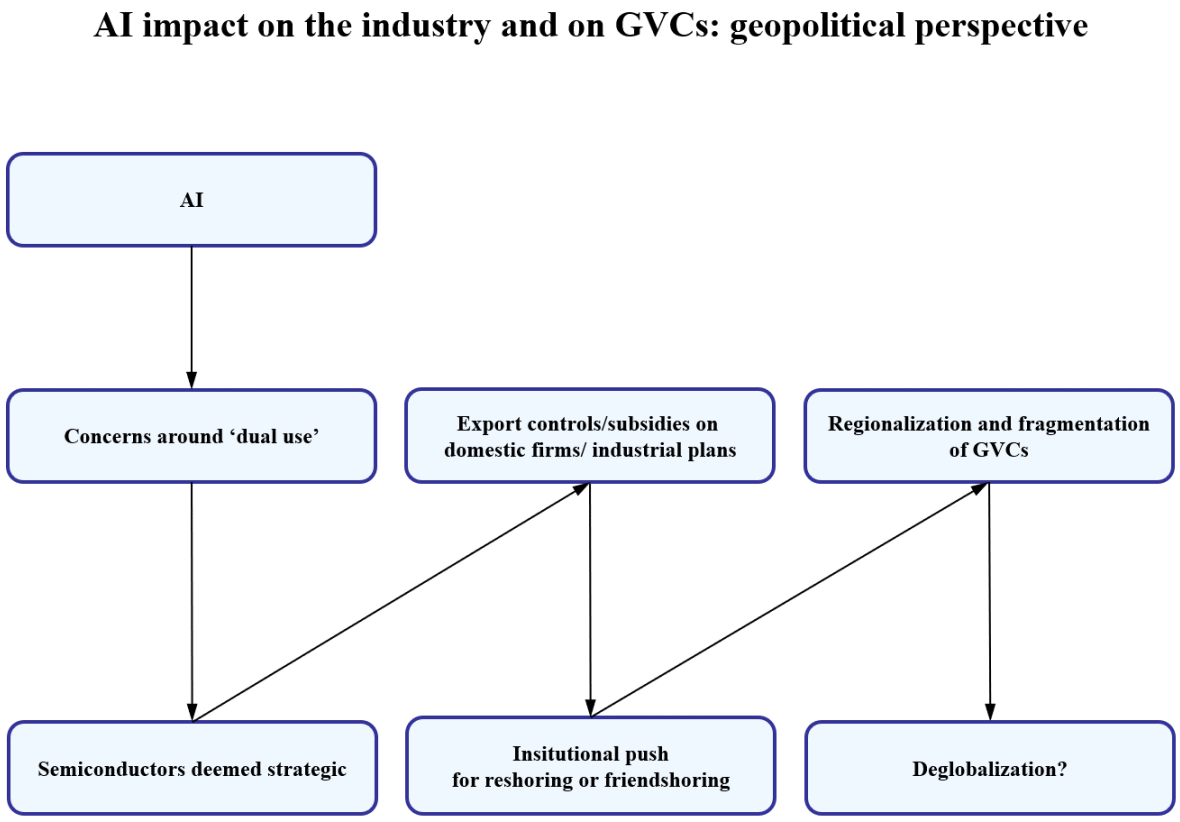

Fig.11: A geopolitical view of the AI impact on GVCs[37]

In conclusion, both perspectives—the commercial opportunity of AI as a rapidly expanding market and its strategic significance—are valid and, in many ways, overlap. However, they create significant challenges for MNCs, which are now under pressure to regionalize their operations in a short period after decades of international expansion. The conflict between the economic interests of MNCs and the strategic priorities of states is unlikely to result in a clear winner. What is certain, though, is that if global value chains once represented the pinnacle of globalization and a period characterized by a relatively harmonious coexistence between private (MNCs) and public (states) actors, with states often making concessions, we are now witnessing a reversal. Today, MNCs are increasingly seeking an optimal compromise as states assert more control and influence over global production networks, signalling a shift in the balance of power between these two key stakeholders.

[37] Created by the author

Limitations of the Study

This study focuses on a single case, NVIDIA, within the broader context of the semiconductor industry. While a detailed case study allows for an in-depth analysis of a particular company, the findings may not be fully generalizable to all semiconductor companies or industries facing similar geopolitical pressures. The reliance on expert interviews, although insightful, presents its own limitations. The perspectives of the interviewees, while specialized, may not capture the full scope of industry-wide or global viewpoints. Additionally, the qualitative nature of this research, though appropriate for understanding complex dynamics, means that some aspects of the discussion remain interpretative rather than quantitatively verified.

Furthermore, the rapid evolution of the AI technology, combined with shifting geopolitical landscapes, poses challenges in maintaining the relevance of the analysis over time. Policies, industry dynamics, and technological advancements are changing quickly, which may mean that findings are subject to becoming outdated or overshadowed by unforeseen developments.

Future Research Directions

Future research could expand on this study by conducting comparative analyses across multiple companies in the semiconductor industry, exploring how different firms respond to similar challenges. A longitudinal study that tracks how MNCs in various sectors navigate the evolving macroenvironment would provide further insights into the broader implications of AI and geopolitical concerns.

Quantitative studies that incorporate data on trade flows, investment patterns, or technological adoption rates could complement the qualitative approach taken in this study. Additionally, future research could benefit from exploring the role of government policies in shaping not only semiconductor supply chains but also the development of new AI technologies. Finally, expanding the geographic scope to include more regions affected by these issues, such as Europe and Southeast Asia, would provide a more global understanding of the interplay between AI, geopolitics, and GVCs.

Conclusion

The initial objectives of this study were to analyse how geopolitical risks affect multinational corporations in the semiconductor industry, using NVIDIA as a case study, and to explore how these companies adapt to evolving macroenvironmental challenges. However, it rapidly emerged in this study that the key driver of the evolution of the industry, also on the geopolitical risk level, is AI.

The results of this study demonstrate that artificial intelligence is fundamentally reshaping global value chains, with a particular focus on the semiconductor industry, as seen in the NVIDIA case study. AI's role extends beyond merely creating demand for high-performance chips; it is at the core of geopolitical concerns and the restructuring of GVCs.

The analysis highlighted two key results. First, the rise of AI is driving a substantial new market for semiconductor companies. Historically, companies like NVIDIA have capitalized on consumer markets for general computing, gaming, and mobile devices, but the rapid expansion of AI applications, such as generative AI, has created an unprecedented demand for AI-specific hardware. Semiconductor firms must now prioritize the innovation of high-performance chips designed for AI applications, which span industries from healthcare to autonomous vehicles. This redefines their competitive strategies and market positioning. Moreover, AI is not only transforming the market but also reshaping the very structure of GVCs. The introduction of AI-enabled predictive analytics has enhanced decision-making processes, enabling businesses to forecast demand, optimize inventories, and prevent supply chain disruptions. AI has also accelerated productivity, with companies like NVIDIA utilizing AI to streamline chip design and manufacturing processes, boosting their overall capacity. The growing interdependence between various players in the semiconductor value chain, such as NVIDIA and TSMC, has fostered deeper collaboration, further strengthening the supply chain's resilience. Second AI has caused deep geopolitical concerns due to its dual-use potential (civilian and military), causing states to exert geopolitical pressures which are prompting a move towards regionalized value chains.

From a managerial perspective, these findings emphasize the need for decision-makers to reassess traditional strategies and adopt a more adaptive and forward-looking approach in response to the evolving macroenvironment. Managers must recognize AI as a central driver of both market opportunities and geopolitical risk. Firms should invest in R&D to create AI-specific hardware that addresses the growing demand across diverse industries. This will help them remain competitive in a market increasingly defined by AI applications.

Moreover, with governments intervening in semiconductor supply chains due to AI's dual-use potential, MNCs will probably shift from a globalized approach to a more regionalized strategy. This prompts managers to build resilience by diversifying production facilities across regions that are geopolitically favourable, thus mitigating the risks of over-dependence on certain regions.

Finally, AI has introduced an innovation pace that requires stronger cooperation between different players in the value chain. Thus, decision-makers should foster strategic partnerships to leverage synergies that enhance productivity and reduce supply chain risks. Firms that can create these collaborative ecosystems will be better positioned to respond to both market demands and geopolitical pressures.

By incorporating these strategies, managers can better navigate the complex landscape shaped by AI and geopolitical tensions, ensuring long-term competitiveness and operational resilience.

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