Sanction war: The geopolitical implications of sanctions on firm performance

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ABSTRACT

Research summary: The literature regarding sanctions emphasizes the need for clarification regarding its economic impacts. Despite many harrowing reports regarding the decoupling efforts of both China and the U.S., no significant decline in ROA for Western firms operating in the semiconductor industry has been found in the period after the introduction of sanctions on October 7, 2022. Previous literature has not taken into accounts the firm-level performance metrics, which are used in this research. I argue that, despite the external geo-political environment undergoing changes, firms operating in this industry have so far managed to retain the profitability witnessed in prior quarters.

Managerial summary: With the introduction of a sweeping set of sanctions on October 7, 2022, the American government established a coherent strategy of maintaining US-firm dominance in the semiconductor industry. This industry has increasingly become the centre of attention, as numerous examples of government policies aimed at decoupling with adversary states have influenced the market environment. Besides providing stimuli for firms to invest in research and development and set up more fabrication facilities in the US, it also aimed at curtailing China's technological development by prohibiting multiple European and American companies from exporting advanced microchips, and EUV-equipment to Chinese (and Russian) companies. This study examines the impact of these export controls on the financial performance of firms operating in the industry and related upstream and downstream sectors. Previous research has largely focused on the macroeconomic effects of sanctions. This research analyses the effects of sanctions on the sanctioning countries' firms, during the team period from early 2020 to early 2023. Contrary to the hypothesis that sanctions would have a negative effect on the profitability of firms in the sender countries, the findings seem to suggest that firms actually experienced growth in ROA during and after the introduction of sanctions.

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INTRODUCTION

"The relevant question is whether my adversary should buy a bullet knowing that I can nullify his investment with a bullet-proof vest. He has wasted his money if the vest is cheap, made a splendid investment if my vest is expensive, and if asked what he accomplished by buying his bullet should have the good sense to say that he imposed a cost on me, not that he hoped to kill me and was frustrated. – Schelling (1967)"

In recent years, we have been reminded constantly of the West's dissatisfaction with adversary governments through their use of sanctions. In fact, the number of sanctions has steadily doubled annually in the years 2011-2021 (Garoupa and Gata, 2002). The last 300 of the 405 actives sanctions in place in 2022, were introduced in the decade prior (Felbermayer et al., 2020). The use of these economic modes of coercion date back a long time, from trade embargoes restricting the United in the early nineteenth century Kingdom during the Napoleonic wars, to the most recent comprehensive embargo on Russia after the Russian invasion of Ukraine. Sanctions in the form of embargoes derive their power to weaken nation-states or political blocs from the target's dependence on international trade (Hufbauer et al., 2008), and may serve as either an alternative or complementary strategic tool during times of war.

Objectives of sanctions can be complicated and multi-faceted. Historically, literature held a somewhat one-dimensional view stating that the objective of economic sanctions is simply to economically incentivize a change in the target's undesirable behaviour. "Success" was subsequently measured by the degree of desired change (Baldwin, 1999). Recent literature has proposed numerous objectives beyond economic coercion. The definition of sanctions has expanded to include such incentives as constraining a target's ability to act in a certain manner (Pape, 1997).

The literature regarding economic sanctions is unsurprisingly growing with the number of sanctions being put in place, as many scholars find new sources of data to examine. The comprehensive trade embargo curtailing the Russian industry from key intermediate Western inputs has acted as such a case-study and led to the discovery that Western sanctions had decreased the operating revenues with as much as 25% for some Russian firms (Ahn & Ludema 2020). Moreover, many employees of these firms had to be sacked in order to cut costs. Economic sanctions research is highly contextual as there are many examples of different countries with different economic conditions and levels of dependency on international trade. Such examples include the UN embargo against North

Korea in 2006, and against Iraq in 1990, as well as the U.S. embargo against Cuba in 1960 and Iran in 1979.

Although supporters of sanctions, specifically targeted sanctions, celebrate the usefulness of such measures without the need to resort to violence, there is a cost to be paid for such restrictions, often being referred to as collateral damage in the literature (Crozet & Hinz, 2016). Firms from sanctioning countries engaging in international trade with the sanctioned countries are directly affected by their loss of customers, as per example the Western firms that, until recently, supplied the intermediate inputs to the aforementioned Russian firms, or indirectly, through the often-imposed countersanctions. There is particular interest as well in R&D intensity, stating that for firms from countries targeted by the sanctions it may help in export diversification which offsets the negative effects (Liu et al, 2023), whilst worsening the negative effects for firms from the countries on the sanctioning side (Allen, 2021).

Both the legitimacy and effectiveness of international sanctions has been put into question (Pape., 1992), while others claim that there is ample evidence for its usefulness, depending on its implementations and the specifics of the restrictions, some say they are mere symbolic gestures (Rogers, 1996). Moreover, there is the general notion that in the long term, sanctions induce self-sufficiency for the target country. Such targeted countries which may not import their goods from American or U.S.-allied firms will instead invest their funds in domestic firms or firms not contributing to sanctions. This may in the long run harm the U.S. technological competitiveness. Even though the literature on international sanctions is extensive, significant gaps remain concerning their firm-level effects. Many studies have also mainly focused on economic repercussions in which the sanctioning country has an economic size far greater than the targeted country. Less is known about the effectiveness of sanctions when the economic size of the two parties is more on par. The majority of studies tend to focus on macroeconomic or country-level outcomes, such as GDP or trade flow disruptions (Hufbauer et al., 2008). However, less is known about how firms are affected and how they can counteract such effect with strategic adaptations. Even more sparsely represented in the literature, are the effects on the firms on the side of the sanctioning country. Though a recent study has highlighted the adverse effects on stock volatility for such companies from sanctioning countries, whose export of goods are being restricted by sanctions (Allen, 2020), little is known about other firm-level indicators such as ROA. The unintended consequences of export control sanctions on metrics measuring financial competitiveness of sender firms are very poorly understood, and there is a high likelihood that the contemporary geopolitical

escalation will result in more sanctions. Such lack of understanding may have grave repercussions for domestic firms operating in industries affected by sanctions. Therefore, the research question of this paper is: *how do sanctions affect the profitability, measured in the return on assets of firms from the sanctioning countries, specifically in the semiconductor industry?*

As of currently, China is only responsible for 15.2% of global chip fabrication capacity (Khan & Flynn, 2020), however, if adjusted for quality, this figure becomes merely 3.0%, while Taiwan and the United States' shares are 42.8% and 21.3% respectively. China's "Made in China 2025"-policy devised to close this gap, mandates competitiveness of Chinese latecomer firms to be on par with Western firms (Guo et al, 2018). The innovation literature gives an extensive examination of such latecomer firms' technological accumulation through technology transfer or outward FDI, and explains much of their incentives to globally expand (Kim, 1997). The technological gap between emerging multinational enterprises (EMNEs) such as the ones from China, and advanced-country multinational enterprises (AMNEs) is decreasing rapidly, as latecomer firms leverage their specific institutional environment, cross-border knowledge building and country-specific advantages to create firm-specific advantages required to globally compete with established market leaders and dictate new technological frontiers (Guo et al, 2018; Porter, 1990). Technological spillover, through the acquisition of technological assets from incumbent multinational enterprises has helped EMNEs with developing much of its technological capabilities. In the semiconductor industry, frequent technological disruptions provide windows of opportunities, as technological standards become obsolete and resources become redundant, effectively levelling the playground, especially for such EMNEs, (Castellaci, 2006; Perez and Soete, 1998). Such conditions cause the multidirectional cross-border transfer of technological assets to be impeding the long-term competitive advantage of incumbent firms. Although the fabrication of semiconductors has a long history of secrecy (Miller, 2020), its further decrease of transparency through export control sanctioning marks a profound change.

Moreover, China's approach to the semiconductor industry shows the use of state subsidies to achieve strategic economic goals. Reports suggest that Chinese firms receive substantial government funding, access to low-interest loans, and tax incentives to enhance their competitiveness (Howell et al., 2018). These measures allow Chinese companies to operate below market costs, under-pricing international competitors and gaining market share despite lacking comparable technological capabilities. The United States has long viewed China's state subsidies as a breach of the principles of fair trade established under the World

Trade Organization (WTO) framework. While the WTO prohibits subsidies that distort international markets, enforcement has proven difficult, particularly in sectors where state involvement is opaque or disguised (Hopewell, 2019). The U.S. has also been critical about the mistreatment and repression of Uyghurs in the Xinjiang province, resulting in numerous accounts of U.S. officials calling for action (BBC, 2022).

Semiconductors and manufacturing equipment for the creation of semiconductors represent the most important factor in modern technology, enabling automated computing power. It drives innovative efforts in artificial intelligence and defense systems that require high levels of computing power, as well as telecommunications and many consumer devices. An electric car for instance, already requires 8.000 semiconductors. In 2021 alone, the global semiconductor market was worth more than 550 billion USD, with China emerging as the largest consumer (Technode, 2023). Globally, the U.S. has played a pivotal role in developing technologies to manufacture and design these chips. Its allies in Asia, namely Japan and South Korea have also played big roles in the manufacturing of semiconductor and semiconductor manufacturing equipment. The global semiconductor supply chain is characterized by its interdependence and is the result of many years of political and economic tugging. Although historically the high-end of this global value chain has been dominated by the U.S. and its allies, Chinese firms have challenged this order.

Moreover, semiconductors also provide the backbone for advanced weaponry. Their significance in potential future conflicts makes internationally oriented firms uniquely vulnerable to sanctions. The nation-island of Taiwan serves as an exemplary case to depict the significance of internationally oriented firms operating in the semiconductor industry. This island houses, arguably, the most significant firm in all of the chip industry, namely TSMC, which fabricates chips with unrivalled precision and is responsible for the fabrication of 90% of the world's most advanced semiconductors. Whilst China pushes for reunification with the mainland, the USA seeks to retain sovereignty for the Taiwanese (Miller, 2022). For many Western "fabless" firms, TSMC is a crucial partner, enabling eco-centric competition (Sarma & Sun, 2016). China, on its part, views its precarious position of dependence in the global value chain, and its strategic severance of TSMC from Chinese firms due to American concerns, as a matter of national security. In the past decade, the country has spent more money on semiconductors than on crude oil (Sheng, 2021). With the introduction of quantum computing and AI, the strategic demand of these chips is set to increase, with semiconductors forming the critical component of technological advances. China's "Made in China 2025" economic mandate is established to reach technological independence, with one of its main

goals being to development the capabilities of creating advanced chips independently. The US's position in the high-tech industrial categories of export goods is being threatened by such endeavours and as a result, the US is perceiving China less as a partner within the global value chain, and more as a strategic rival (Liu, Wang, Wang, Yao, 2023).

For those reasons, the slumping of respective competitive advantages of American firms in the semiconductor industry, the government subsidies that seem to run contrary to market-practices, accounts of espionage (O'Conner, 2024), and a general fear of the advanced chips being weaponized in a potential fight over Taiwan, that a series of export control and tariff sanctions has been enacted by subsequent U.S. presidents against China, which sought to slow down the technological accumulation of China's EMNEs, by preventing advanced technological assets from being sold to Chinese firms. This study prefers the terminology of sanctions over mere export control restriction to the coercive nature of the implemented policies. Specifically, its goals to persuade China to abandon its goals of setting up a semiconductor equipment sector that rivals the American one without the need for American technologies. Its de-Americanization and decoupling efforts depicted in the "Made in China, 2025"-report are seen by Pentagon officials as a severe threat to American foreign interests. This rhetoric is not limited to words written in policies, but also by the numerous occasions of state-backed espionage against companies operating in the semiconductor manufacturing equipment industry, as well as reverse engineering efforts of acquired Western equipment. Moreover, the exorbitant financial sum dedicated to the indigenization of technological innovation speaks for itself (Allen, 2024).

Western dependence

Western firms following the OLI (ownership-location-internationalization) framework have exploited their superior assets abroad for the purpose of deriving competitive advantages from them (Dunning, 1980). These AMNEs, in ownership of knowledge-based assets, or firm-specific advantages, in their market seeking efforts, found a huge consumer-base in China. In 2021, China spent almost $ 350 billion on semiconductors, most of which were advanced, and another $40 billion on chip manufacturing equipment (Technode, 2023). Nvidia obtained 20% of its revenue, prior to the Chips act sanctions, from selling advanced AI-related chips to Chinese firms, while ASML obtained 14% of its revenue selling ultraviolet lithography equipment to Chinese firms (Bloomberg, 2022). Intel, a company specialized in memory chips was so reliant on foreign sales to China (27%), that after

sanctions were imposed, they were forced to divest parts of their facilities (Mccoll, 2024). For years the cost of production for chips has continued to rise, eliminating many competitors in the process. Now only a small number of AMNEs, which exist solely due to its enormous economies of scale can compete (Khan & Fly, 2020). Moreover, their value-adding activities in the global value chain are highly specialized. These are among the firms investigated in this paper, as they originate from the sender countries (S) and operate in the industry affected by sanctions.

This paper seeks to address questions in the sanctions debate regarding the potential domestic economic harm that happens as an unintended consequence of imposing sanctions on adversary governments. It does so in the context of the ensuing Trump-government, which is expected to enforce many sanctions than, especially in the semiconductor sector, which is of utmost strategic and military importance. Moreover, it is an especially interesting industry due to its unique characteristics best depicted by Moore's law. This observed relationship predicts the number of transistors in an integrated circuit to double every two year. The semiconductor industry is incredibly capital intense and technologically complex, making it an intriguing case for studying sanctions.

The industry has already received attention from export control policy advisors. Between 2010 and 2022 the amount of U.S. firms supplying foreign firms, affected by sanctions aimed to curtail the access to technology of adversary governments has grown from 0 to nearly 125 (Federal register, 2024). Research has found that these U.S. technology-supplying firms are more likely to terminate commercial relations with customers in a sanctioned country. This likelihood of termination with a foreign firm is somewhere between 50 to 75 percent. The long-lasting decoupling effects are also significant. This path-dependency that is set in motion by introducing export controls lead to a decline of 60 to 68% of relationships formed with customers located in sanctioned countries. U.S. suppliers are becoming more aware of the decoupling effects of such export control restrictions. Currently, a raging debate is ensuing regarding the dangers of such decoupling efforts due to lack of alternatives in the form of friend shoring of reshoring. The decoupling efforts have resulted in serious strain in the global value chain. The effects on U.S. firms in semiconductor and telecommunication industries is well document and shows a -2.5 percent cumulative abnormal return in the two weeks after the sanctions were imposed (Bracket et al, 2024). Global supply chains are thus increasingly under strain by the efforts of governments to create strategic self-sufficiency through decoupling. The preventing of selected goods from being exported to adversary governments triggers a reconfiguration of supply chains, both

domestically and globally. In its efforts to minimise the adverse effects on firms from allied countries, the U.S. granted some companies in South-Korea and Taiwan, the places where some of the most advanced computer circuity is being manufactured, the rights to continue production in Chinese facilities for one more year. In January 2023, it also appealed to its allies in Japan and the Netherlands to announce multilateral export control restrictions.

The approach taken by this research is to analyse firm-level profitability in the semiconductor and the special machinery industry over a period of approximately three years, before and after smart sanctions were introduced. I begin by explaining the definition and application of sanctions in a historical perspective. Sanctions are here modelled as a limit of a firm's access to foreign intermediate inputs (Ahn & Ludema, 2020). This limitation of access to foreign markets, particularly that of the Western companies producing semiconductors result in a loss of clientele for said firms. The artificially induced shrinkage of demand results in operational inefficiency due to the inability to decrease supply in the short-term. Firms from sanctioning countries must thus, according to this logic, absorb a decrease in efficiency, depicted in a company's return on assets (ROA). I then drew from detailed firm-level panel data to test this theory, which allowed me to analyse the return on assets-rate, as well as their research and development expenditure relative to operating income, of 246 firms over a period of three years, the last half year being during and after the introduction of sanctions. A time fixed effects model is used to examine the temporal impact of sanctions on firm performance while accounting for unobserved heterogeneity across firms. By dividing the timeline into a pre-sanction period and post-sanction period, this approach isolates the effect of sanctions on the return on assets (ROA) and evaluates the degree to which firms in the semiconductor and special machinery industries experienced measurable changes in profitability. My main arguments were that due to the external shock generated by sanctions, sales revenue would drop in the short-term, leaving firms with overcapacity and operational inefficiencies. This, I expected, would have reduced profitability for firms in the quarter in which sanctions were announced and the quarter after. However, contrary to my expectations, an increase, rather than a decrease in profitability, measured using return on assets (ROA), was measured in the statistical analysis. The results did suggest a negative correlation between research and development expenditure relative to operating income and return on assets in the measured period. Although this study tests only a single hypothesis, post-hoc analysis sought to differentiate between firms from the two industries, by creating an interaction term of the sanction and the industry dummy variable. This analysis found no significant evidence. These findings provide valuable insights for policymakers that will

inevitably have to deal with international sanctions and ant to minimize collateral damage to domestic firms, as well as managers who aim to adopt strategies as a reaction to sanctions, and finally scholars studying the consequences of sanctions on the sending country's economy in the form of the economic actors that are firms.

THEORETICAL BACKGROUND

What are international sanctions?

"Sanctions are unilateral or collective actions against a state considered to be violating international law, designed to compel that state to conform to the law." (Daoudi and Dajani, 1983, p. 5-8). These sanctions may take the form of a metaphorical "diplomatic slap on the wrist" and "more extreme measures such as covert action or military measures" (Hufbauer, Schott and Elliot, 1990, p 11). A vast variety of sanctions exists in both form and execution and includes minor actions such as a refusal of diplomatic recognition and the boycotting of athletic and cultural events (Davis & Engerman, 2003), as well as more severe sanctions such as the appropriation of properties of the targeted country and withholding financial services such as we have seen after the Russian invasion of Ukraine. The form of sanction most often used, and which has had the greatest impact over time, is forced restriction on international trade.

Historical background

Historically, in fact, sanctions were almost wholly dedicated to restrictions on international trade, primarily by the use of *pacific blockades.* Such blockades consisted of a naval force, deployed by a country or group of countries in order to block any commercial activity with the targeted nation-state. Typically, such comprehensive embargoes were used as a method to disrupt military consolidation through the acquisition of goods. In the oil embargo-case of 1940-1941, in which the U.S. unilaterally restricted any oil exports to Japan in order to weaken its military capabilities, we see use of such a selective embargo. Since Japan had no domestic oil production, the magnitude of these export controls was much more severe, eventually leading to war. In more recent times, however, the use of sanctions is more diverse, varies more in success rate, and can take more "softer" approaches, such as in the case of the Japan-U.S. trade dispute in 1995, where the dominant form of sanctioning was, in fact, self-oriented (Baron, 1997). There, the U.S. government imposed punitive tariffs to

Japanese goods because of the targeted country's perceived "non-transparency and discriminatory barriers." Although the composition of countries in these examples are the same, their relationships were wildly different, as in the former case they were on the brink of war, whilst in the latter case they were formal allies. This serves to show how international sanctioning has become more frequent and accepted.

The implementation of sanctions consists of two parties, specifically one imposing the sanctions (S, for sending party), and the designated party (T, for targeted party) which the first party deems to be violating the rule of international law. Sanctions in the form of trade-embargoes may take the form of "*restriction of export of the targeted nation"* and "*restriction on the import of the targeted nation"* (Davis & Engerman, 2003, p.190), but most often is a combination of the two. The former may be exemplified by the EU's decision to impose import tariffs on "unfairly subsidized" electric vehicles from China's car manufacturing firms BYD, Geely and SAIC (European Comission 2024). In such a case, the countries(S) of the EU seek to restructure the market environment by reducing the financial ability of firms(T) due to their loss of market share, while simultaneously protecting domestic businesses(S) from international competition (Baron, 1997). The latter example, which will be the focal type of restriction discussed in this paper, limits the import of goods for a targeted nation. The curtailing of imports for a sanctioned country may range from a total ban of all commodities (comprehensive export controls) to only a selection of goods (selective export controls), most often dedicated to military equipment or sophisticated technological materials required for "a state's military and productive capacity" (Davis & Engerman, 2003, p.190). Generally, one refers to the selective restriction of import of the targeted nation, I.e., export controls of the flow of goods designated to the targeted nation, as smart sanctions. Whereas in its earlier stage sanctions were more comprehensive, now, "smart" sanctions are often concentrated to coerce decision-making elites (Cotright and Lopez, 2002; O' Sullivan, 2003).

Building on the resource-based view (RBV), Morgan, Vorhies & Schlegelmilch, (2006) made significant additions to the export-related studies, particularly by noting that, by operating in international import and export markets, firms acquire and allocate their resources and capabilities more heterogeneously. Under these assumptions, firms acquiring their tangible and intangible resources through imports may sustain a competitive advantage as their performance is increased due to the rents accumulated from the exploitation of a greater variety of resources and capabilities (Hult, Ketchen & Slater, 2005). The strategic orientation, particularly the degree of a firm's international orientation determines, for a large

part, their vulnerability to international decoupling. Firms whose performance rests for a larger degree on imported intermediated inputs, for instance, production technology and equipment are particularly at risk. The accessibility and affordability of the desired intermediate inputs decreases post-sanction and determines, together with the dependence, the magnitude of the external shock experienced by firms operating in the targeted nation (T). The dynamic capabilities framework posits that the firm's ability to reconfigure resources and adapt to changing environments are important skills (Teece, Pisano & Shuen, 1997). Export controls compel firms to reassess and potentially alternate their operational strategies and adapt to a changing geopolitical scene. Export controls also limit the imitative innovative strategy for EMNEs, especially for firms conducting high-quality innovation (Nuruzzaman et al, 2019; Bhattacharya et al, 2017). Such innovation inhibition may be due to a loss of confidence in financial sources (Wen et al, 2024). Similarly, human capital in the form of talent mobility is also restricted to firms on entity lists, thereby limiting the disseminating of state-of-the-art technology. The Chinese ICT industry has suffered from sanctions mostly through higher operating costs and reduced innovation efficiency (Wang et al, 2024), especially for firms with greater economic ties to American firms. These decreases in innovative capacities for Chinese firms have been measured in a lower amounts of patent applications. So, economic sanctions, which under Miyagawa's (1992) definition seek to punish actors that undermine internationally established rule, are in such cases successful in limiting the operating ability of firms(T), by increasing the costs and availability of required intermediate inputs and by limiting the market access of firms(T).

On the other hand, the economic burdens and enforcement costs for sanctioning countries(S) as a result of decoupling may be high as well, due to the bilateral nature of trade between firms. Firms(S) from sanctioning countries with commercial ties to targeted firms(T) are, in fact, the economic agents to whom the measured are aimed at (Allen, 2021). Despite the intent of the sanctioning government to coerce a foreign entity, domestic firms(S) are the actors that are obliged to change their exporting and collaborative practices. They, therefore, undergo a dwindling of market share, as their competitiveness is undercut by tariffs in the case of retaliatory sanctions, or their goods are banned from export altogether, causing them to lose sales revenue (Pape, 1997). The aforementioned trade dispute of 1995 has likely had an estimated reduction of exports to the target country by fifteen to nineteen billion USD (Hufbauer et al, 1997). U.S. businesses, as a result, had to scale down with a loss of, all else equal, 200,000 jobs. U.S. export controls in high-technology items such as semiconductors have caused the greatest reduction of export for American firms, with about 5% lost exports.

Besides the immediate effects of sanctions, many have claimed that a sudden break of commercial activity weakens the international reputation of Western sanctioning firms, causing longer lasting competitive disadvantages. Firms from other, non-sanctioning countries may replace these "unreliable suppliers." Firms(S) that are not allowed to export also lose future clientele as they will not be able to supply replacement parts or related technologies (Hufbauer et al, 1997). These firms will lose the potential funds required to invest in technological advancements and as such, lose their position as hegemonic market-leaders. If these firms do not engage in behavioural adaptation their reputation is tarnished in their home country. Firms that evaded sanctions and were caught doing so suffered long lasting reputational damages. The institutional theory suggests that organizations align their behaviour with the rules and norms imposed by external institutions in such a manner (DiMaggio & Powell, 1983).

Liu et al (2023) have highlighted the prominent role of research and development expenses in sanction episodes. During the Sino-US trade war, technological innovation ability, measured using research and development expenses has been found to successfully mitigate the negative effects of export controls, as they are more capable of finding alternative export markets despite the experienced trade shocks. Previous literary work has already highlighted that R&D correlates with higher profitability of firms that export, especially in high-tech industries (Sanyal, 2004). Especially for firms with country-specific advantages such as low labour costs, these firms threaten the dominance of Western competitors.

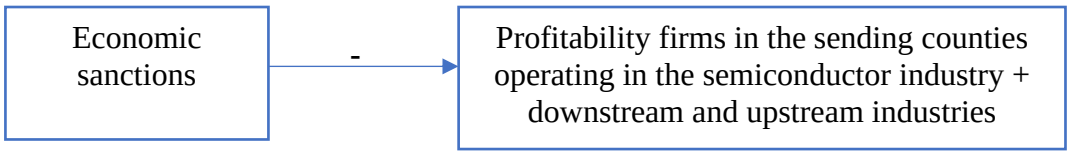
Additionally, sanctions and threats of sanctions in the preliminary stages of international disputes result in market uncertainty. Sanction guidelines are often ambiguous by nature in order to promote flexibility for the sender government in subsequent enforcement. During the time of its unfolding, uncertainty and risk looms (Webb, 2020). This uncertainty creates unfavourable financial accounting, requiring firms to pay investors more as there is a greater risk of default (Campbell and Taksler, 2003). The overall costs to debtors thus increase. The phenomenon in which sender countries harm their own domestic economic agents has been called a form of collateral damage (Crozet & Hinz 2016), well-illustrated by the adverse effects on European firms in the agricultural sector exporting to the Russian Federation. Their loss in foreign sales revenue was significant, whilst trade diversion to mitigate the negative effects of export controls was very small in magnitude and was often combined with price reduction. Such external shocks, thus cause overall profitability to decrease in the short-term, as a firm will either see a reduction in their exports, a reduction in

price of their goods, higher inventory costs, higher financing cost, or a combination of the aforementioned. In the short-term, before a firm may scale down, the sales revenue will decrease, causing the net operating income to diminish, while the total assets remain even. Accordingly, I propose the following hypothesis:

Hypothesis 1: *Introducing export control sanctions negatively inlfuences the return on assets (ROA) of companies from sending countries in the semiconductor industry or downstream and upstream industries.*

The metric for profitability chosen in this study is return on assets (ROA). This metric has been chosen for its telling nature about the financial health of a company relative to its size, as it captures the increased costs as well as reduced income. Since the industries examined only number 2, the main limitation of this metric, namely its variability across industrial sectors is irrelevant in this case. The proposed conceptual framework is visible in figure 1.

Figure 1 Conceptual framework



METHODS AND RESEARCH DESIGN

Context and Background

The focal sanctions investigated in this research paper will be the export controls barring semiconductor smaller than 7 nanometers from reaching mainland China. On October 7, 2022, the United States Chamber of Commerce introduced a set of export controls designed to hinder firms from China and its allies, by cutting their access to these highly advanced chips and semiconductor manufacturing equipment (SME). These export controls, which went into effect officially on the 11th of November, were not significantly different in intent from the earlier sanctions against China (Benson, 2023), however, it significantly changed the implementation of the sanctions.

Prior to this event, there were already sanctions in place, for instance against the Chinese firm Huawei, which was placed on the U.S. entity list in 2019 (Federal register,

2019). Despites its impressive strides towards technological self-sufficiency, this firm has still been found to compromise sanctions. This became clear when a Canadian research firm found Huawei was using advanced chips devised for AI-training applications that were created by TSMC, a firm, which under strict sanctions is not allowed to do so (Pan, 2024). The sanctions introduced on October 7 were partly designed to patch the holes which were at the time still present, but also to increase the severity of the sanctions. By evaluating the sanctioning efforts in the past, it became clear that through circumvention, many advanced chips were still finding their way to China, most notably through the use of Chinese subsidiary firms. The updated embargo list contained an additional 43 countries to which expanded licensing requirements were now mandatory. These countries were considered to have a high transshipment risk, such as Kyrgyzstan, a country which showed an anomalous increase in chip trade since sanctions to China were introduced (Benson, 2023). Furthermore, the updated sanctions presented an adjustment to the thresholds for which chips were covered in the regulations. It now included the A800 and H800 chips, produced by Nvidia specifically with the intent of complying with the rules, as well as Intel's Gaudi2 chips. Besides making the threshold more stringent on chips export, particular consideration was given to the future chip manufacturing potential of Chinese firms with the introduction of a ban on various pieces of semiconductor manufacturing equipment (SME). These updated sanctions restricted the export of equipment used for the fabrication of chips under a 16-nanometer size on top of the already existing restrictions on deep ultraviolet lithography equipment (DUV). Third and finally, the extended set of sanctions expanded the entity list by adding thirteen Chinese firms. These entities were deemed to be threats to the U.S. national security and U.S. foreign policy objective due to their active role in the development of artificial intelligence. All U.S. exports, regardless of the producer or type of technology, to a firm on the entity list is prohibited. In practice, many firms outside of the U.S. adhere to the entity lists due to the Export Administration Regulations (EAR), which restricts any product that relies on U.S.-origin technology, to U.S. export controls. Although there is more room for other Western firms to maneuver in terms of trading with Chinese firms, there is a clear alignment of strategic interest between firms from the rest of the West, and American foreign policy.

Data and design

All my firm-level data came from a singular source: Orbis database. I conduct my analysis on a longitudinal financial sample of 24,098 firms of Western origin (OECD) primarily

operating in industries identified using the United States Standard Industrial Classification (US SIC) codes:

- **Semiconductor and related devices industry (US SIC: 3674)**
- **Special machinery Industry (US SIC: 3559**

The sanctions under question listed both semiconductors, as well as semiconductor manufacturing equipment (SME) to fall under export controls. Since the interest of this study are firms on the sending(S) side of sanctions, I include only those firms expected to take part in the sanctions, i.e., those from Western origin. The first filter was geographical area, as I only wanted to include firms from the OECD. The next step was to isolate the industries, so the dataset was filtered for *United States industry primary industrial classification code* (US SIC). I opted here for primary code, rather than secondary code as it made the sample size comparatively much smaller, and since I was using Orbis I could only export a finite amount of data. After these steps I added the variables Return on Assets (ROA) and Research and Development expenditure ratio compared to total operating income for a total of twelve time periods. Firms with US SIC-codes of the semiconductor industry, as well as the industry responsible for the creation of manufacturing equipment (SME), impacted by sanctions, with these origins were the focal unit of analysis and numbered 24,098 in the database. After omitting samples with missing data regarding the ROA and R&D, I was left with a sample size of 246 firms. Interestingly, I found that 28% of the firm sample were of American origin, 27,5% were South Korean, 27% were Japanese, and only 13% were European, indicating the promise of these renowned “Asian Tigers” in the semiconductor and semiconductor manufacturing industry.

I consider this sample to more or less represent the broader population of very large semiconductor firms. It should be noted that after omitting the data, I was left with a sample size of which 97% was categorized as a very large firm. The indicators for a very large firm are:

- An operational revenue of more than 100 million USD
- Total assets of more than 200 million USD
- Number of employees more than 1000

As the cost of production has risen enormously of producing semiconductors over the years, it is likely that the majority of these firms are large. The missing data thus does not cause diversity to be excluded. Moreover, publicly listed firms of this size tend to have more data available.

RESEARCH DESIGN

Since the sanctions were announced on October 7, 2022 and put into effect a little more than a month later, the event falls entirely within the fourth quarter of 2022. For that reason, this analysis focuses on quarterly financial data of firms to assess the sanctions' effect on return on assets (ROA) using a panel data fixed effect model. Fixed effects were chosen after a test was conducted to ensure and validate the appropriateness of using a fixed-effects model over a random-effects model. The Hausman test, which evaluates whether random-effects provides consistent estimates by comparing it to a fixed-effects model provided results which indicated that I should reject the null hypothesis of consistent and efficient effects due to correlations between the individual effects and explanatory variables (X^2= 34.93, p = 0.000) (see appendix table 4).

This study employs twelve time periods with intervals of a financial quarter, or three months (Q1, Q2 …. Q11, Q12). The reason this number of periods was chosen was due to fact that these sanctions were already foreshadowed in the lobbying and negotiating that has happened internationally, between Washington and Beijing, and domestically between the semiconductor industry and Washington, prior to the actual date at which the sanctions were announced. Firms may have very likely prepared for the eventuality and therefore, logically a longer time period should be taken into account. Unfortunately, Orbis allows only so much data to be exported, so the number of periods that could be added were limited.

The event of interest, namely the introduction and implementation of the sanctions occurs during Q11 and presumably has lasting effects after. This divides the timeline into a pre-sanction period (Q<11) and a post-sanction period (Q=11, 12).

1. **Pre-sanction period (sanction = 0)** Covers the first financial quarter of 2020, until the third financial quarter of 2022, i.e., ten quarters prior to the sanctions.
2. **Post-sanction period (sanction = 2):** Covers financial quarter four of 2022 and financial quarter one of 2023, encompassing the announcement and enforcement of the sanctions, as well as an entire financial quarter afterwards.

The model controls for firm-specific unobservables by including fixed effects. Moreover, a control variable has been added: R&D expenditures relative to total operating income, which represents the technological capabilities of a firm. In the second model I created an

interaction term between the sanction and the industry category of a firm in order to examine whether sanctions had a different effect on these industries. This additional analysis serves to provide deeper insight into the specifics of sanction effects. This is particularly interesting as the SME industry may experience both direct and indirect effects of sanctions.. Moreover, an additional post-hoc model was created which excluded outlier values for the dependent variable that were potentially unusually high or low.

Variables

Dependent variable

ROA: The company's economic performance was assessed by analysing net income proportionate to the total assets. For each financial quarter, the ROA was added. This metric was chosen over others due to its telling nature of a firm's financial health relative to its size.

Explanatory and control variables

Sanctions: The primary independent variable is included categorically to measure to effects of sanctions. This is a dummy variable that changes with the time periods, showcasing how ROA is affected during the pre-sanctions period (sanction = 0), and the post-sanctions period (sanction = 1). As the announcement and reinforcement of the sanctions happened relatively early in Q3 2022, I opted to make a dummy variable, rather than a more nuanced categorical variable with multiple categories.

Innovative capabilities (Research and development expenditure relative to operating income): To capture the impact of innovation efforts on firm performance, R&D expenses relative to their operating income from all financial quarters under investigation were included as a control variable. This measure reflects the relative R&D budget of a firm. As has been suggested before by Allen (2021), R&D budget may reinforce the negative effects of sanctions on exporting firms in Western high-tech industries.

Standard industrial classification code (primary): This study has incorporated only the firms with a primary standard industrial classification code, meaning that the primary business of these firms is either semiconductors or special machinery. This variable is incorporated as a dummy variable where 0 = semiconductor and 1 = special machinery.

Statistical Model

The fixed effects regression equation used in the analysis is as follows:

$$ROA_{it} = \beta \cdot Sanctions_t + \gamma_1 \cdot \frac{R\&D\ expenditure}{operatingincome}_{it} + \epsilon_{it}$$

RESULTS AND FINDINGS

Table 1 shows the descriptive statistics. There is a large difference between the lowest value of ROA (-98.646) and the highest value of ROA (79.491) witnessed in the sample, also visible in the standard deviation which is relatively high (12.692). The Dummy variables sanctions and standard industrial classification code give a respective mean of 0.167 and 0.432, indicating the number of quarters under sanction relative to number of quarters without sanctions, as well as the amount of firms operating in the *semiconductor industry*, relative to the *special machinery industry*. A mean of 0.432 means therefore that 43.2% of the firms in the database were operating in the *semiconductor industry*, as opposed to 56.8% in the *special machinery industry.* None of the variables seem to have a degree of correlation, however, in order to access whether there was a multicollinearity issue, I performed a diagnostic test using the "vif" command in Stata. The results of this procedure are visible in table 2. Both models showed no sign of multicollinearity, with the highest mean VIF being 1.53. This is much lower than the cut off of 10, established as a general rule of thumb. This indicates that there is no multicollinearity affecting my results.

Table 2 showcases the results of the hypothesis test for ROA of firms operating in industries under sanctions. Model 1 includes only the dependent variable, the explanatory variable and control variable R&D. Since I am using a fixed-effects model, the within R^2 is the most meaningful metric to indicate the predicting value of the model. In this case, it is rather modest (0.110), indicating a low predicting value. I found that the variable *post-sanction period (sanctions =1)* i.e., the time-effect on ROA of the financial quarter in which the sanctions were introduced and implemented (Q4 2022,) and one financial quarter after (Q1 2023), significantly and positively correlated with ROA (β = 0.873, SE = 0.414, *p* =

0.035). This suggests that firms experienced an increase in profitability in the last two period, contrary to what my hypothesis suggests. Conversely, the *research and development* variable significantly and negatively correlated with ROA (β = -0.569, SE = 0.032, *p* = 0.000). This means that for every one percent the expenses of research and development increases, relative to the total operating revenue of the firm, the ROA of that firm is likely to decrease with 0.569%. The constant is significant and positive (β = 8.758, SE = 0.352, *p* = 0.000), suggesting that the firms had an ROA of 8.758%, if all independent variables are zero.

Post hoc analysis and alternative model

The description for the United States standard industrial classification code (US SIC) 3559 is as follows: "Special industry machinery, not elsewhere classified. Establishments primarily engaged in manufacturing special industry machinery, not elsewhere classified, such as smelting and refining equipment, cement making, clay working, cotton ginning, class making, hat making, incandescent lamp making, leather working, paint making, rubber working, cigar and cigarette making, tobacco working, shoe making, and stone working machinery, and industrial sewing machines, and automotive maintenance machinery and equipment." (US department of labour, n.d.). Netherlands-based ASML is an invaluable producer of semiconductor manufacturing equipment (SME), specialized in the design and manufacturing of highly developed EUV-lithography equipment. The primary standard industrial classification code (US SIC) used for this company is 3559. The sanctions of October 7th, 2022, initiated by the Biden administration apply to advanced semiconductors, but crucially also aim to limit the future production capacity of Chinese semiconductor fabs, by applying export control restrictions on semiconductor manufacturing equipment (SME) in tandem with the Dutch and Japanese government (Allen, 2024).

I introduced the interaction variable sanctions * standard industrial classification code into model 2 to inquire whether the effect of the sanctions on ROA was different depending on which industry a firm operates in. The statistical model for this alternative model is as follows:

$$ROA_{it} = \beta \cdot Sanctions_t \cdot US\ SIC_i + \gamma_1 \cdot \frac{R\&D\ expenditure}{operatingincome}_{it} + \epsilon_{it}$$

First, the within-R^2 went up by 0.0003, not visible in the table due to the rounding of three decimals. I found that this time the coefficient of post-sanctions period (sanctions = 1) was insignificant and positive (β = 0.581, SE = 0.551, p = 0.292). This means that there is no significant evidence to suggest that the ROA of firms changed in the last two periods measured (Q4 2022, Q1 2023), i.e., since sanctions were introduced and implemented. Research and development expenses relative to operating income remained significant and negative (β = -0.571, SE = 0.032, p = 0.000). Indicating that firms with a higher R&D budget relative to their operating income had lower increases of ROA in the measured period. The interaction term sanction* standard industrial classification code had no significant effect on ROA (β = 0.674, SE = 0.837, p = 0.421), meaning that there is no significant evidence to suggest that the firms operating in the special machinery industry experienced a different effect of the sanctions on their ROA as opposed to firms operating in the semiconductor industry. Lastly, the constant remained significant and positive (β = 8.758, SE = 0.352, p = 0.000), suggesting that the firms had an ROA of 8.758%, if all independent variables are zero in model 2.

TABLE 1: Descriptive statistics and correlations

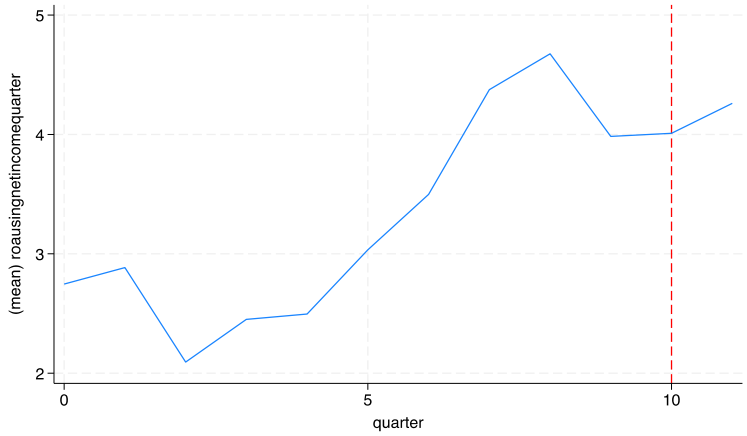
	Mean	**S.D.**	**Min**	**Max**	**1**	**2**	**3**	**4**
Return on assets (ROA)	3.376	12.692	-98.646	79.491	1.000			
Sanctions	0.167	0.373	0	1	-0.274	1.000		
Research and development expenses relative to operating income	9.679	12.642	-19.786	94.26	0.0268	-0.002	1.000	
Standard industrial classification primary code	0.432	0.495	0	1	0.0749	-0.294	0.000	1.000

TABLE 2 Fixed effects regression estimates of ROA

	Model 1			**Model 2**		
Variable	**coeff.**	**Std. Error**	***p*-value**	**coeff.**	**Std. error**	***p-value***
Sanction						
Post-sanction period (sanction =1)	0.873	(0.414)	(0.035)	0.581	(0.551)	(0.292)
Control variables						
Research and development expenditure	-0.569	(0.032)	(0.000)	-0.571	(0.032)	(0.000)
Standard industrial classification primary code*sanctions				0.674	(0.837)	(0.421)
Constant	8.747	(0.352)	(0.000)	8.758	0.352	(0.000)
Observations	2887			2887		
Groups	246			246		
$\boldsymbol{R^2}$						
Within	0.110			0.110		
between	0.077			0.077		
Overall	0.075			0.075		
Mean VIF	1.000			1.53		

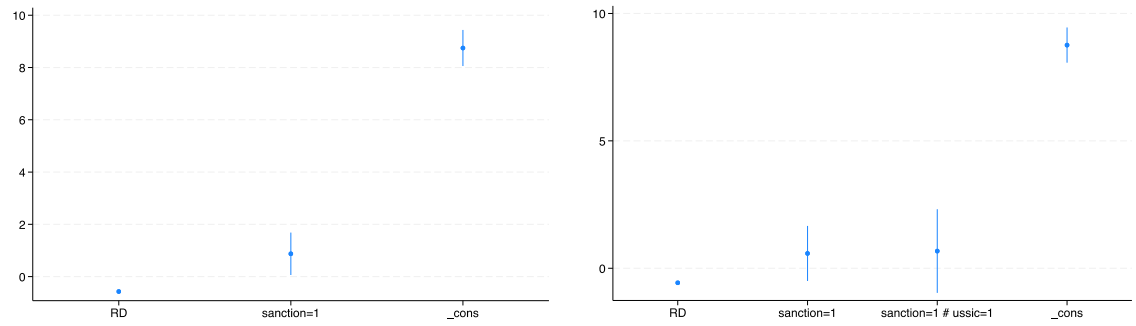
in order to clarify these results and make them more interpretable, I have made a graph which shows the mean increase in ROA over the time period in model 1(figure 1), where the red line indicates the introduction of sanctions. As is clearly visible from this graph, there is no decrease of the mean ROA after the introduction of the sanctions, on the contrary in fact, there is an increase.

FIGURE 1 Mean ROA over time



To understand and interpret the results of model 1 and alternative model 2, as well as their differences, I have made 2 coefficient plots showing the coefficients of each variable and the constant of both models. Both models and corresponding graphs are similar in that they indicate a significant negative effect of research and development expenditure, as well as a significant constant. However, in the second graph the significance of the sanctions-coefficient is lost, whilst not adding a significant interaction term. In terms of its usability, model 2 does not seem to add much. In neither model there seems be evidence to suggest a negative time-effect after quarter 10, meaning that there is no evidence to support hypothesis 1.

FIGURE 2 Coefficient of variables for both models on the dependent variable ROA



Robustness checks

As I am using the -xtreg , fe command in Stata, I have already accounted for unobserved heterogeneity by including fixed effects. To ensure the validity of the results, I also tested for serial correlation in the panel data using the 'xtdpserial' command in stata. The results revealed significant evidence of serial correlation (Portmanteau test: $X^2(65) = 107.57$, p=0.0007) (appendix Table 5), to address this, I used clustered standard errors at the firm level to make my estimates more robust to both heteroskedasticity and autocorrelation.

As was clear from table 1, there are some outliers present in the dependent variable ROA. (min -98.646, max 79.49). In the figure in the appendix, you can see the graph box of the dependent variable, to better visualize the outliers (appendix figure 4). I decided to see if I could find a significant interaction term if the outliers were to be removed. To remove heavy outliers, I made us of the interquartile range rule (IQR). This function removes all observations below and above a certain percentile. In this case I used the 25th and 75th percentile as lower and upper bounds. The total observations dropped by 320 observations (see table 3).

First, results suggest an increased coefficient of determination for model 3 and 4(R^2 - Within = 0.139). Model 3 shows an increase in significance for the main explanatory variable sanction (β = 0.856, SE = 0.237, p = 0.000). *Research and development* showed a lesser negative effect than model 1, whilst maintaining its significance (β = -0.437, SE = 0.023, p = 0.000). Model 4, designed to test the post hoc interaction term with fewer outliers showed no significant contribution. The main explanatory variable *post-sanction period (sanction =1)* was significant and remained positive (β = 0.920, SE = 0.349, p = 0.008). The *research and*

development expenditure variable remained negative and significant (β = -0.437, SE = 0.023, p = 0.000). Finally, the interaction term still showed no sign of significance, thereby not finding any support for my post hoc theory of different effects based on US SIC symbols.

In the process of obtaining my data from Orbis, I already performed a lot of screening and cleaning of data. Besides, it has been argued in the literature before, that cyclicality and volatility are defining features in the semiconductor industry (Wu et al, 2017). Due to the frequent occurrence of technological change, firms may show high volatility in financial performance (Bekeart, 2003). Firms are required to invest massively in R&D, just to keep pace. It could be argued, therefore, that firms with such outlying values of ROA should still be taken into account for this research, as circumstances require massive investments, and therefore that model 1 is a better fit. I leave this decision to the reader.

TABLE 3 fixed effect regression ROA alternative model

	Model 3			**Model 4**		
Variable	**coeff.**	**Std. Error**	***p*-value**	**coeff.**	**Std. error**	***p-value***
Sanction						
Post-sanction period (sanction =1)	0.856	(0.237)	(0.000)	0.920	(0.349)	(0.008)
Control variables						
Research and development expenditure	-0.437	(0.023)	(0.000)	-0.437	(0.023)	(0.000)

Standard industrial classification primary code*sanctions				-0.118	(0.475)	(0.803)
Constant	7.660	(0.215)	(0.000)	7.663	(0.215)	(0.000)
Observations	2567			2567		
Groups	243			243		
R^2						
Within	0.139			0.139		
between	0.018			0.018		
Overall	0.075			0.019		
Mean VIF	1.000			1.53		

CONCLUSION

Global supply chains are increasingly feeling the effects of geo-political wrangling to harbour strategically important technologies. An increasingly prominent way to hinder adversary firms is through the use of sanctions, such as export controls or adding a firm to the U.S. entity list. Previous literature has attempted to examine how the use of export controls of strategically important goods can affect firms from the sender country (Allen, 2021; Webb, 2020). However, prior research has not yet considered how such sanctions affect the profitability of such domestic firms, instead preferring to examine stock-indices. Furthermore, these papers construed information only about the U.S. and not firms from any other country. An important insight came from Allen (2021), indicating that the compliance considerations for domestic firms are generally present in economic sanctions, but that the adverse effects are generally overlooked or downplayed.

This study aimed to further assess the impact of restrictive export controls considered to be sanctions due to their punitive nature. Specifically, this research was designed to discover the effects of sanctions on the financial performance of firms operating in the semiconductor industry and upstream and downstream industries in the form of return on assets (ROA). While the hypothesis posited a negative impact of sanctions, the results indicate a somewhat counterintuitive finding: Firms from the countries imposing sanctions, that operated in the semiconductor industry or in the special machinery industry, on average,

experienced a growth of ROA during and after the period in which sanctions were introduced. This means that despite the more clarified negative effect sanctions have on stock volatility, the relationship of sanctions with profitability of sender firms is not necessarily a negative one, as suggested by the results of this research. To add to that, this research has found evidence to suggest that research and development expenses relative to operating income (R&D) are negatively correlated with the return of assets (ROA) of firms operating in the semiconductor and special machinery industry in the time period of this study, consistent with the findings of Allen (2021). This negative relationship between R&D expenditures and profitability underscores the tension mangers face when choosing between short-term financial health and long-term innovation and profitability, consistent with studies highlighting those trade-offs during external shocks (Aghion et al., 2005). Lastly, post-hoc statistical analysis was conducted to inquire whether firms in the *semiconductor industry* and the *special machinery industry* were differently affected by sanctions in terms of return on assets (ROA). No significant difference was found.

These findings thus contribute to a broader understanding of sanctions' economic impact, particularly in term of its firm-level effects on companies from countries imposing sanctions in the form of export control restrictions in the time period of early 2020 until early 2023. This research provides results which support the notion that, despite harrowing reports about global chips sales slumping in the period mentioned above, and commercial relations between Chinese and American firms being describe as "chilling" (Stoev, 2024), the Western firms operating in the semiconductor industry did not experience losses of profitability, measured in ROA during said time period. It thus offers significant insights into the crossroads of geopolitical tension and the decoupling of global supply chains. It challenges the widely held assumption that economic sanctions inevitably lead to negative outcomes for its domestic firms. Moreover, the literature regarding sanctions is mostly dedicated to instances in which the sanctioning state is much larger economically speaking. These findings thus add nuance to the overall principle of sanctioning using an example in which the two adversary states are more on par. Furthermore, this study contributes to management science by underscoring the resilience of the firms operating in the semiconductor industry during times of sanctions, as well as the usefulness of considering technological investment especially in times of reduced sales revenue. Moreover, the findings highlight the resilience of Western firms during and after economic sanctions, and adds to the complex mechanisms in which states attempt to protect their technological leadership while simultaneously containing competitors. Furthermore, the results add to the broader literature of economic

sanctions by providing research in a case where the economic and technological capabilities of the sanctioning and targeted states are more on par.

Discussion

The rationale on which the hypothesis rested may be more nuanced as firms could have pre-emptively insulated themselves against such external shocks by scaling down their production, in order to mitigate the adverse effect of lower sales revenues. As the companies in question are mostly fabless semiconductor designer firms that outsourced fabrication, scaling down operations in the short term may be a goal easier achieved, due to the lesser need of extreme capital-intensive investment (Stoev, 2024). Firms were also having to deal with supply chain issues due to the covid-19 pandemic in 2020, suggesting that strategic adaptations were already considered and in place. As return on assets (ROA) is a relative metric, the figure may still increase despite lower sales revenue. Alternatively, there may have been no reduction in (foreign) sales if the semiconductor firms under investigation were successful in trade diversion or sanction evasion. The demand for advanced chips is growing steadily with downstream industries, such as datacentres, electric cars and AI-services becoming more prominent (Gupta, Porges & Palazzi, 2024). If demand did not falter, either due to a natural growth of demand for semiconductors and SME in domestic or unsanctioned markets, trade diversion, or sanction evasion, firms would not have undergone the adverse inefficiency effects of a reduction in sales. Reports suggest many instances of sanctions evasion, even after the more stringent policies were introduced (RSM, 2024). Furthermore, as the updated sanctions on October 7 suggested, semiconductor firms had designed new chips specifically to pass restrictions, suggesting evidence for elaborate strategies employed by firms, which warrants further investigation.

Lastly, the sanctions imposed on the 7th of October were part of a metaphorical carrot-and-stick incentive scheme, called “the CHIPS and science act”, to artificially increase the market share and competitiveness of incumbent domestic chip and SME-producers relative to up-and-coming Chinese firms in the long-term. The export control restrictions served as the stick, whilst generous tax benefits and subsidies served as the carrot. This may explain part of why the hypothesised variation was not found, namely because of the beneficiary effects of state subsidies offsetting the negative effects of the sanctions. It is therefore also essential to consider the role of these government support mechanisms. The subsidies and tax incentives

have likely mitigated some of the effects of the sanctions on U.S. firms, which represented a substantial share of the sample.

The timeframe considered in this research should receive consideration. This research does not find, or was set out to find, any evidence to suggest any long-term effects of these sanctions. Perhaps the growth of profitability in the form of ROA during the two subsequential (Q4 2022, Q1 2023) would have been higher had there been no sanctions. The goal of these sanctions, at least in part, are long-term domination in the semiconductor by limiting Chinese firms' access to technological assets.

Limitations

This study has several limitations. First, and foremost, the time horizon is relatively short. The eventual effects of these sanctions may take years to fully unfold, as has been suggested by some research (Crozet & Hinz, 2016). By looking further into the future these time-effects would be better assessed, whilst taking into consideration data from further in the past also increases the robustness of the study. By adding quarters prior to the sanctions, a more robust baseline of ROA-growth could be assessed to which later quarters are compared. This would eliminate/reduce the bias produced by other external shocks, such as the covid-19 pandemic.

Secondly, this research paper did not incorporate the intensity of business between firms, i.e., the dependency of foreign sales to Chinese firms. Controlling for this variable might have given different results, as the export restrictions in question would most likely affect the firms that do more business with Chinese firm more negatively. This data could be tied to the multiple occurrences of sanctioning and counter sanctioning that has happened between the U.S. and China, and paint a fuller picture of the decoupling efforts of both powers.

As this analysis focused only on the dependent variable ROA, little insight has been generated about how sales, operating costs or financing costs fluctuated at the time, or the origin of the customer. This research fails to address how companies may have diverted their sales to firms from other countries.

Lastly, the research does not take into account the broader picture of government-level agency. As mentioned before, the U.S. government has gone through considerable efforts in the form of state subsidies to attract and support domestic businesses, which has not been considered in this research.

Future research

This research may be extended upon by conducting similar analyses over longer periods of time. This would paint a fuller picture of how sanctions affect firm-level performance metrics. Longitudinal studies examining data with a longer time horizon may reveal long-term consequences on firm profitability and market competitiveness not found in this research.

Similarly, future research should focus on how firms in the semiconductor industry have adapted their businesses, and which strategies they used to do so. Researchers may for example explore the possible product adaptations, trade diversion or potential sanction evasion strategies conducted by Western semiconductor and SME firms.

Future research should also incorporate multiple variables which the theory posited to have a negative effect on profitability, such as sales revenue, financing costs and inventory costs. This could further shed light on the actual effects of sanctions on firms. Sufficient effort should be given to further examining the decoupling of Western and Chinese firms. Research should thus be done to discover the change in commercial activity between Western and Chinese firms, and how it relates to the innovative growth of Chinese semiconductor firms. Importantly future researchers should incorporate cross-data analysis from government sources about government subsidies. This would provide a more in-depth examination of government policies regarding the semiconductor industry.

APPENDICES

TABLE 4 Hausman Test

	Fixed	Random	Difference	Std. err
RD	-.2752924	-.2752924	0	0
I.sanction	0.8891153	0. .8891153	0	0

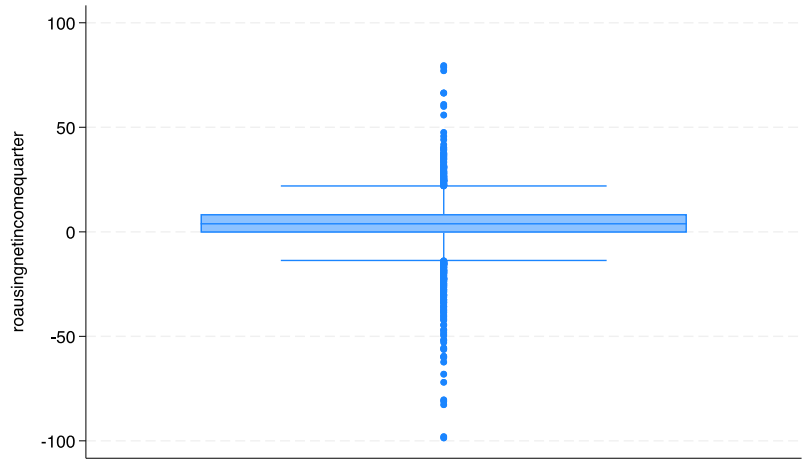
b = Consistent under H0 and Ha; obtained from regress.
B = Inconsistent under Ha, efficient under H0; obtained from regress.

Test of H0: Difference in coefficients not systematic

TABLE 5 Portmanteau test

portmanteau test	chi2(65) = 107.5667
H0: no autocorrelation of any order	Prob > chi2 = 0.0007
collapsed test in seasonal differences	chi2(9) = 45.0739
H0: no autocorrelation of any order	Prob > chi2 = 0.0000
collapsed test in first differences	chi2(9) = 30.3780
H0: no autocorrelation of any order	Prob > chi2 = 0.0004
fully-collapsed portmanteau test	chi2(1) = 14.1761
H0: no autocorrelation of any order	Prob > chi2 = 0.0002

FIGURE 4 Plot ROA



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