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The Impact of Internationalization on Firm Performance of High-Tech Companies in Poland in the Context of Covid-19

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This study aims to examine the impact of the internationalization of high-tech companies on their firm performance against the COVID-19 crisis in Poland. The research covers the period of 2018-2020 (3 years) and encompasses 591 firm-year observations, with 192 high-tech firm-year observations (64 companies) and 399 non-high-tech firm-year observations (133 companies). To find out the differences between subsamples, the U Mann-Whitney test was implemented. At the same time, correlation and regression analysis were exploited to highlight the impact of the crisis, internationalization, and the company's status on firm performance. Our research shows that, in Poland, the COVID-19 crisis had a generally weak impact on internationalization and firm performance. However, in a high-tech subsample, we find an increase in profitability during the COVID-19 crisis. Both subsamples show an increase in financial liquidity ratios during the COVID-19 crisis. The study also demonstrated that internationalization has a weak impact on firm performance. At the same time, the company's status (high-tech) positively impacts internationalization, financial liquidity, and company growth.

Keywords: *Internationalization; High-Tech Companies; Firm Performance; COVID-19; Crisis.*

Introduction

Current findings on the relationship between firm performance and internationalization are inconclusive. There is some research showing positive and some revealing negative relations between internationalization and firm performance. Indeed, some research sees „J", „U" or „S" shaped relations between internationalization and firm performance (e.g. Lu & Beamish, 2004; Contractor, 2007). Trying to untangle the confusing findings between internationalization and firm performance, attempts include bringing more factors into the research. Among others, these are age, size, stage of a company life cycle that the company starts to internationalize, the stage of internationalization, the form of internationalization, and different measures of internationalization.

The main research question is how crisis and internationalization affect the firm performance of high-tech companies in Poland. The aim of the paper is, hence, to find the impact of high-tech company internationalization on their firm performance during the COVID-19 crisis in Poland. This study includes the measurement of internationalization, the status of the company (high or non-high-tech), firm performance, and crisis management altogether in one research. Additionally, the research attempts to depict the specific characteristics of the high-tech company and to establish what changes come about in its behavior during crisis time.

We attempt to add new dimensions to the relationship between internationalization and firm performance.

First, we add in the technology capability of the company. We believe that the explanation for the inconclusive results in assessments of interdependence between internationalization and firm performance might lie in the level of technology capabilities. High-technology industries are now considered fundamental for economic development, and policymakers in many countries pay attention to their development. This is especially true during the fourth industrial revolution (Industry 4.0). Existing research has revealed that technologically advanced companies start to internationalize early due to difficulties with product placement in niche home markets (e.g. Knight & Liesch, 2016; Neubert & Van Der Krogt, 2017). That is why there is already some research on certain aspects of high-tech company internationalization (high-tech sturt-ups firms – Neubert & Van Der Krogt, 2017; newly founded technology-based firms NTBFs – Pinkwart & Proksch, 2013). However, this stream of research lacks the firm performance aspect.

Second, in this paper, the definition of firm performance is wider than in existing research. In it, we take into account profitability, financial liquidity, and growth measures. In contrast, most of the previous research focused on profitability alone as the measure of firm performance.

Third, our research covers an emerging market player – Poland, while most of the previous research tackled mature markets. Our research was conducted on companies listed on the Polish stock exchange from manufacturing industry. Poland is perceived as an emerging player with the aspiration to be a developed country, and Poland's economy withstood the global financial crisis of 2007-2009 quite well

(Biec *et al.,* 2010; Pawelec, 2016). Moreover, Poland is known in the EU market as a country with low material costs and low labor costs (Afonina & Chalupsky, 2014). Additionally, Poland has a large internal market, while other countries from Central and Eastern Europe (such as the Czech Republic and Slovakia) are oriented towards export and depend on revenues from foreign markets (Grodzicki, 2014; Inflation Report, 2020).

Fourth, the study attempts to establish the impact of the COVID-19 crisis on the internationalization and firm performance of Poland's high-tech companies. This crisis was specific (when compared to the global financial crisis of 2007-2009) as we faced cuts in the global supply chains that impacted the opportunity to internationalize. Existing research show that high-tech companies are able to undergo crisis times (especially global financial crisis) better than other companies (Almor, 2011). This is also true for internationalized high-tech companies (Colombo *et al.* 2016). Still, this crisis is different from previous crises and that is why we wondered how the COVID-19 crisis changed the firm performance of international-oriented firms regarding levels of technology advancement (high-tech versus non-high-tech).

So far, there is a little assessment of firm performance, internationalization, and high-tech companies included altogether in one research. Additionally, most of the research refers to mature economies. We wondered what the situation is in an emerging market such as that of Poland. Poland is one of the Eastern and Central European post-communist countries and is the leading country in economic transition. Poland was coined a "green island" as it dealt with the Global Financial Crisis of 2007-2009 much better than any other European country. As most of the research refers to the global financial crisis (GFC) of 2007-2009, we wonder how the COVID-19 crisis affected both the internationalization and firm performance of high-tech companies. This is especially important as the COVID-19 crisis was different from GFC's with regard to cutting global supply chains. This means that it has a strong impact on internationalization. Additionally, the COVID-19 crisis develops good conditions for new technology and high-tech companies' growth. There is a scarcity of research on Polish companies and the impact of the COVID-19 crisis so far. We think that, contrary to the GFC crisis, the COVID-19 crisis has more severe consequences for Polish companies. We believe that the future is going to be more troubled for most of the world's economies and finding out how the companies manage difficult times will give new knowledge on whether and if yes, how state aid should be distributed.

To conduct the analysis, data of companies listed on Poland's Warsaw Stock Exchange (WSE) was collected. The sample took in 197 manufacturing companies, including 64 high-tech companies and 133 non-high-tech companies. The research covers the period of 2018-2020 (3 years). The research period of 2018-2020 tackles the period of normal times (2018-2019) and crisis time (2020). The sample constitutes a balanced panel. Ultimately, 591 firm-year observations, with 192 high-tech firm-year observations and 399 non-high-tech firm-year observations were obtained.

To describe the differences between the subsamples, the U Mann-Whitney test was implemented. Differences in behaviour between high and non-high-tech companies were assessed, as were differences between pre-crisis and crisis times. Subsequently, regression analysis was implemented. Pooled OLS and panel regression analysis for the total sample and in subsamples (high and non-high-tech) were both employed.

The rest of the paper is organized as follows: in the Literature review section, a review of the theory and empirical evidence relating to internationalization, firm performance of high-tech companies versus non-high-tech companies, and the impact of the crisis, is presented. In the Methodology section, the variables, empirical data, and methodology are discussed. The Results section presents our descriptive statistics, correlation matrix, and regression analysis results. The discussion of the findings with previous ones is included in the next section. The Conclusion section presents the summary and findings implications.

Literature Review

Internationalization and Firm Performance

Internationalization also called 'geographical diversification' or 'international expansion' is connected with entering foreign markets. Potential benefits of international expansion include volume economies, intelligence gathering, product improvement, operational flexibility and stability, tax arbitrage, and organizational advantages (Ruigrok & Wagner, 2004; Schwens *et al.,* 2018). The benefits of internationa lization are present for companies internationa-lizing their activity with regard to both home country and host country. That is why internationalization support measures are included in many governments aid programs.

There is abundant research on the benefits and costs of internationalization both on macro and micro levels (e.g. Salomon & Jin, 2006). Such research is included in industrial economics (e.g. Porter, 1985), financial economics (e.g. Morck & Yeung, 1991) and resource-based views of the firm (e.g. Hamel & Prahalad, 1990).

One of the aspects of internationalization benefits is its impact on firm performance. At the very beginning, the research on the relationship between internationalization and firm performance emphasized the benefits of internationalization. The research in the 1970s hypothesized a linear positive relationship between internationalization and firm performance. Later, in the 1980s and 1990s, researchers realized that internationalization can increase risk of failure (Ruigrok & Wagner, 2004; Bausch & Krist, 2007; Schwens *et al.,* 2018).

As a result of these ambiguous findings, researchers have kept on investigating the internationalization and firm performance nexus. So far, inverted-J curve, standard U curve (Lu & Beamish, 2004) or inverted-U curve (Majocchi & Zucchella, 2003; Papadopoulos & Martin, 2010), horizontal S curve (Contractor, 2007) and M curve (Mendoza *et al.,* 2019) relations have been proposed.

Indeed, many attempts were made that aimed at explaining the non-linear relations between internationa-lization and firm performance. Some included not only the degree of internationalization (a firm's percentage of foreign sales to total sales), but also other forms of internationalization (Costa *et al.,* 2015), e.g., greenfield

investment (Doukas & Lang, 2003). Zahra and George (2002) identified and investigated three areas of internationalization: the degree of internationalization, the scope of internationalization, and the speed of internationalization. Another set of factors affecting the relations between internationalization and firm performance is connected with describing firm performance. Some researchers have focused on a firm's growth, some on its survival (e.g. Sapienza *et al.,* 2006), and some on its profitability.

As for profitability, it might be conceptualized on the basis of accounting or be market-based (Ruigrok & Wagner, 2004; Karasiewicz & Nowak, 2014). There are also factors connected with corporate governance included in the research (Muliyanto & Marciano, 2018), knowledge management system (Pouresmaeili *et al.,* 2018), and many others. Some papers also include operational data (such as company market share, employment, and employee productivity). Moreover, some researchers consider a company's relationship between internationalization and firm performance (Bausch & Krist, 2007; Marano *et al.,* 2016). This research notes that small and medium enterprises differ from larger firms in certain aspects and indicate that small-size companies face more disadvantages than large firms in firm performance after internationalization.

For the purpose of the research, hypothesis H1 was formulated:

H1: *the level of internationalization is positively related to firm performance.*

High-Tech and Internationalization

One of the factors affecting the lack of consistent findings on the relations between internationalization and firm performance might be the sectoral heterogeneity of internationalized companies (Contractor *et al.,* 2007). As there are many classifications of sectors, we think only of one of them – that one referring to the technology capacity, and whether the company of concern could be considered to be part of the high-technology sector.

The high-tech sector is important for the development of every economy. This sector, depending on the country, produces approximately 30% to almost half of the GDP of Czechia, Slovakia, Hungary, and Poland (Grodzicki, 2014). However, high-tech companies are subject to high uncertainty of capital investment results and thus investors are exposed to high risk. It is unknown how or when the high-tech project will transfer technological achievements into products (Zhang *et al.,* 2013). High-tech usually are riskier as their activities are connected to uncertainty (Mina *et al.,* 2013), as well as larger information asymmetry. Liang (2011) in describing high-tech companies, selected the following characteristics: (1) uncertainty coming from developing the leading technologies, rapid replacement of technology, and short-term product life cycle; (2) a high value of human resources and a high level of personal organization; and (3) a high correlation between the values of intangible assets, such as proprietary technology, the strength of innovation, quality of human resources and others. High-tech firms are specific due to their high level of intellectual work - connected with creative thinking, with advanced degrees in science (Rogers, 2001).

The resource-based theory (RBT) suggests that firms with unique resources are more prone to transfer their products to foreign markets in search of greater profitability (Wang *et al.,* 2008). High-tech companies have niche products with limited domestic market capacity and that is why they internationalize (Neubert & Van Der Krogt, 2017). Indeed, existing research shows that high-tech firms are more likely to internationalize. The technological capability helps them to operate in difficult environments and different countries (Yiu *et al.,* 2007; Rhee, 2008). Zahra and Garvis (2000) believe that high-tech companies need to develop technological knowledge alongside the internationalization process. The development of technological knowledge not only influences a high-tech venture's ability to adapt its product to local market conditions but also to identify emerging technological changes (Zahra, 1996; Zahra & Garvis, 2000). The basic condition for the development of high-tech companies is the existing knowledge pool that they can use to widen and deepen their technology advancement (Zou *et al.,* 2010).

According to Saarenketo *et al.* (2004), there are three main drivers of the internationalization of high-tech companies. First, high-tech companies frequently operate on a market niche, and to earn they need to expand to foreign markets. Second, firms bear high R&D costs before any sales are made. Thus, firms must grow quickly to cover these initial expenses. Third, the competition is very intense and products get older quite quickly.

There is quite a large number of research proving that high-tech firms do not enter international markets according to the Uppsala model. Instead, they implement rapid internationalization. Apart from the rapid internationalization of high-tech companies, this process leads to the ex-post increase in innovative productivity (Salomon & Jin, 2006). This means that rapid internationalization demands further rapid learning (learning-by-exporting) (Saarenketo *et al.,* 2004).

The issue of the rapid internationalization of high-tech companies is intensively researched among young and small and medium companies (SME). Such companies are called 'born-global firms' (BGF - Knight & Liesch, 2016), 'high-tech start-ups firms' (HSF – Neubert & Van Der Krogt, 2017), 'international new ventures' (INV - Neubert & Van Der Krogt, 2016), and 'lean global startups' (LGS – Neubert, 2018) or 'newly founded technology-based firms' (NTBFs – Pinkwart & Proksch, 2013). Due to their small size, HSFs are expected to carry out early and fast internationalization to become profitable and to survive (Trudgen & Freeman, 2014; Neubert, 2016). In contrast, BGFs must manage innovation processes and, at the same time, develop for the international market to achieve higher profitability (D'Angelo *et al.,* 2013; Lemminger *et al.,* 2014; Cavusgil & Knight, 2015).

Technology plays a crucial role as a success factor for new ventures, both in domestic and international markets (Zahra, 1996; Yiu *et al.,* 2007). Technology is perceived as a strategic factor affecting new ventures' ability to gain market share. Moreover, it is believed to be the factor for achieving long-term competitive advantage through implementing high technology in innovation and the introduction of new products (Lee *et al.,* 2001; Ghauri &

Cateora, 2006; Hsieh & Tsai, 2007). Advanced technology can provide the capabilities to differentiate their products from competitors' offerings when entering new markets. Advanced technology can provide the capabilities to achieve cost advantages with similar products or services (Covin *et al.,* 2000). Moreover, advanced technology helps new ventures in domestic and international markets (Rhee, 2008). New ventures are believed to be more flexible and ready to learn faster and acquire advanced technology through exposure to international markets. In turn, international markets contribute to new ventures subsequent growth and profitability (Zahra & Garvis, 2000; Spence & Crick, 2006).

It should be noted that recent entrepreneurship studies focus on the significant impact of technology capability on the speed at which international new ventures are established (Pla-Barber & Escribá-Esteve, 2006; Acedo & Jones, 2007), and their performance (Gleason & Wiggenhorn, 2007; Zahra & Hayton, 2007). For example, Schwens and Kabst (2011) found out that if newly established high-tech companies enter foreign markets earlier, the firm's performance is higher. In addition, Kiederich and Kraus (2009) also state that newly established high-tech companies in the international market are more profitable than newly established present only in domestic one.

For the purpose of the research, hypotheses H2, H3, and H4 were formulated:

H2: *there is higher internationalization of high-tech companies (compared to non-high-tech companies).*

H3: *there is a better firm performance of high-tech companies (compared to non-high-tech companies).*

H4: *there is a positive impact of internationalization on the firm performance of high-tech companies (compared to non-high-tech companies).*

Impact of the Crisis on Firm Performance of Internationalized High-Tech Companies

During the financial crisis of 2007+, international trade contracted exceptionally deeper than any other macroeconomic category. The world trade reached 30% drop from September 2008 to January 2009. Moreover, the world GDP contracted less than 3% over the same period (Bricongne *et al.,* 2012). The drop in international trade resulted from the fall in demand and financing difficulties (supply side). This is because a significant fraction of trade is in durable goods; thus, exports are two to three times more volatile than GDP (Engel & Wang, 2011). The drop in demand was also caused by the consumption of more national than imported goods during a crisis.

Given the crisis's financial aspect, the banking sector's troubles restricted access to external financing (Ivashina & Scharfstein, 2010). Indeed, even in normal times, finance is particularly important for trade (Bricongne *et al.,* 2012). Researchers have recognized that difficulties in access to external financing during a crisis have a negative impact on internationalized companies (Auboin, 2009). Amiti and Weinstein (2011) find that the decrease in financing explains one-third of the 1993 Japanese export collapse following the banking crisis. More general cross-country evidence from 23 past banking crises suggests that export growth is slower, especially in sectors reliant on external finance (Iacovone & Zavacka, 2009).

While economic and financial crises have an impact on internationalization, they also have an impact on the firm performance of internationalized companies. However, this impact is slighter than for non-internationalized companies. Costa *et al.* (2015) find that in crisis times, Italian internationalized companies have a better performance both in terms of value-added and employment dynamics. This is also true for, e.g. the UK (Gorg & Spaliara, 2014) and Thailand (Vithessonthi & Tongurai, 2015).

Internationalized companies' relatively better firm performance might be explained in several ways. The internationalization strategy typically involves, even in normal times, more risks for firms when compared to the companies present only in the domestic market (Johanson & Vahlne, 2009). However, firms tend to accept the risks and invest sufficient resources to be better prepared (Yu & Lindsay, 2016). Thus, internationally oriented firms tend to have more resources, knowledge, and capability than domestically oriented firms. As the result, international firms have better investment opportunities than domestic firms (Vithessonthi & Tongurai, 2015). The research also shows that concerning internationally oriented companies, strong international connections, such as being foreign multinational corporation subsidiaries or having foreign ownership, have a positive impact on firm performance (Kim, 2019; Eppinger & Smolka, 2020).

Economic crisis is often associated with high environmental uncertainty levels and significant downward demand shifts (Cerrato *et al.,* 2016). Thus, investments in innovative activities become increasingly risky for firms. This is due to doubled uncertainties (the uncertain external environment and uncertain financial results of commercializing new products and services). There is a justified fear that new products and services could fail to bring sufficiently high payoffs to cover production costs (Cruz-Castro & Sanz-Menéndez, 2016; Fernandes & Paunov, 2015). In the GFC, the problems endured by the banking sector spilled over the whole world and strongly affected the non-financial sectors, including the high-tech sector. Firms in high-tech industry sectors involved in innovative activity faced credit rationing, and the general process of applying for finance became more complex (Cowling *et al.,* 2015). Moreover, in the aftermath of the financial crisis in 2009, banks started to rely on low-risk scorecards (Moreira, 2016). Based on a survey of 100 technology-based small firms, North *et al.* (2013) surveyed 100 technology-based small firms. They discovered that equity and debt have become less available since the GFC. Investors set more restrictive criteria ('changing lending standards'). Later, Lee *et al.* (2015), using a large sample of UK SMEs, confirmed this finding. Moreover, their analysis shows that innovative and non-innovative SMEs have more difficult access to finance in the post-GFC era.

Uncertainty and changes in investor behavior since the GFC have impacted the firm performance of high-tech companies. Afonina & Chalupsky (2014) found that in the Visegrad countries (Czechia, Hungary, Slovakia, and Poland), the high-tech sector during the GFC strove for a high level of liquidity, rather than strong profits. The Visegrad Group high-tech companies thus tried to hold the

appropriate level of liquid assets, helping them to minimize their liquidity risks and survive the crisis.

Still, the situation is not so gloomy. Innovation literature notes that the innovative capacity of individual firms depends significantly on external competitive pressures (Kafouros, 2008; Hansen & Winther, 2014). Competing in markets with high levels of instability requires different resources and innovation strategies compared to those needed to succeed in stable markets (Lee & Makhija, 2009). Colombo *et al.* (2016) note that high-tech entrepreneurial firms reacted to the economic crisis through investments in further product innovation and expansion into international markets. Cowling *et al.* (2015) assume that economic turbulence creates an opportunity for Schumpeterian creative destruction. Economic turbulence enhances product or process innovation. Thus, high-tech companies are more willing to (and more capable of) take advantage of this opportunity, expecting long-term economic benefits. What is more, Zouaghi *et al.* (2018) in assessing a panel of manufacturing firms in Spain for 2006–2013, saw that companies with advanced technology and knowledge capabilities better mitigate the effects of the financial crisis.

These findings emphasize the value of high-tech capabilities as coping mechanisms during financial downturns. Knowledge and capabilities support high-tech firms' orientation toward developing advanced technological and scientific know-how (Satta *et al.,* 2016). Having knowledge and capabilities allows them to remain competitive in their rapidly changing business environments (Garcia Martinez *et al.,* 2017).

Evidence shows that advanced technology increases internal innovation efforts and knowledge pool. These increase dynamic capabilities that provide firms with sources of competitive advantage (Zahra & George, 2002). And these enable them to overcome adverse economic conditions (Zouaghi *et al.,* 2018). Moreover, findings suggest that the technological intensity in manufacturing sectors creates a suitable environment for knowledge creation. This leads to better adjustments to external economic pressures and new market situations (Berchicci, 2013; Adcock *et al.,* 2014; Colombo *et al.,* 2016).

Piva *et al.* (2012) and Colombo *et al.* (2016) reveal that high-tech companies with international presence made more significant investments and expanded their presence in international markets during the crisis. Hence, prior internationalization gave companies specific capability resources (Bingham & Eisenhardt, 2008; Wu & Lin, 2010) that were altered in crisis times and enabled further inroads into international markets. In addition, prior internationalization gave companies learning advantages (Autio *et al.,* 2000) because internationalization exposed them to diverse and exogenous factors (Sapienza *et al.,* 2006). Thus, it can be said that international companies can learn quickly how to adapt to the conditions of foreign markets (Hitt *et al.,* 1997) and how to behave internationally (Weerawardema *et al.,* 2007).

Companies present in the international market that have already learned how to operate internationally are likely to make and implement decisions quickly and easily in response to the crisis. Piva *et al.* (2012) and Colombo *et al.* (2016) noted that companies that already possess a resource base oriented towards international sales and have more experience in operating internationally enjoy an advantage in crisis time when compared with firms that are novices in the internationalization process.

For the purpose of the research, hypotheses H5, and H6 were formulated:

H5: *there is higher internationalization of high-tech companies both in pre-crisis and crisis periods.*

H6: *there is a better firm performance of high-tech companies both in pre-crisis and crisis periods*

Methodology

The paper aims to find out how crisis changes the internationalization and firm performance of high-tech companies. We had to make several decisions on how to identify high-tech companies, as well as how to measure internationalization and firm performance. We had to decide on what method should be implemented to show the differences between the subsamples of high-tech and non-high-tech companies (H2, H3, H5, and H6) and to show the relationship between variables and the impact of independent variables on the dependent ones (H1, and H4). To sum up our research concept, we present Figure 1 with the main constructs and the hypotheses statement

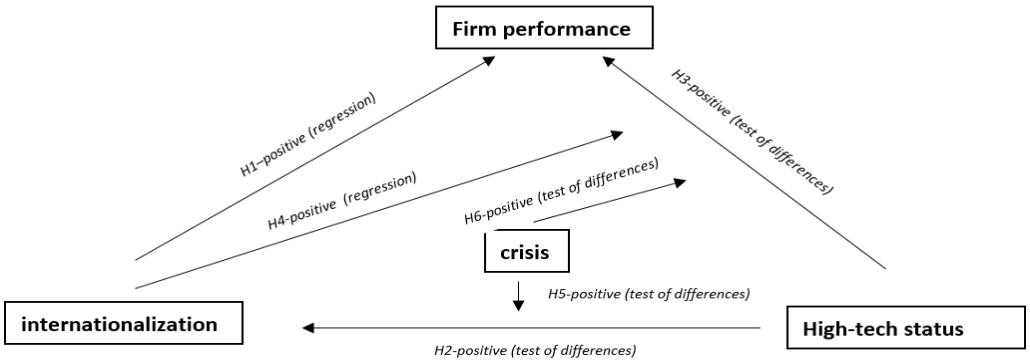

Figure 1. The Concept of the Research
Source: authors' own elaboration

Our research plan covers several steps. The steps of our empirical analysis are described in Figure 2.

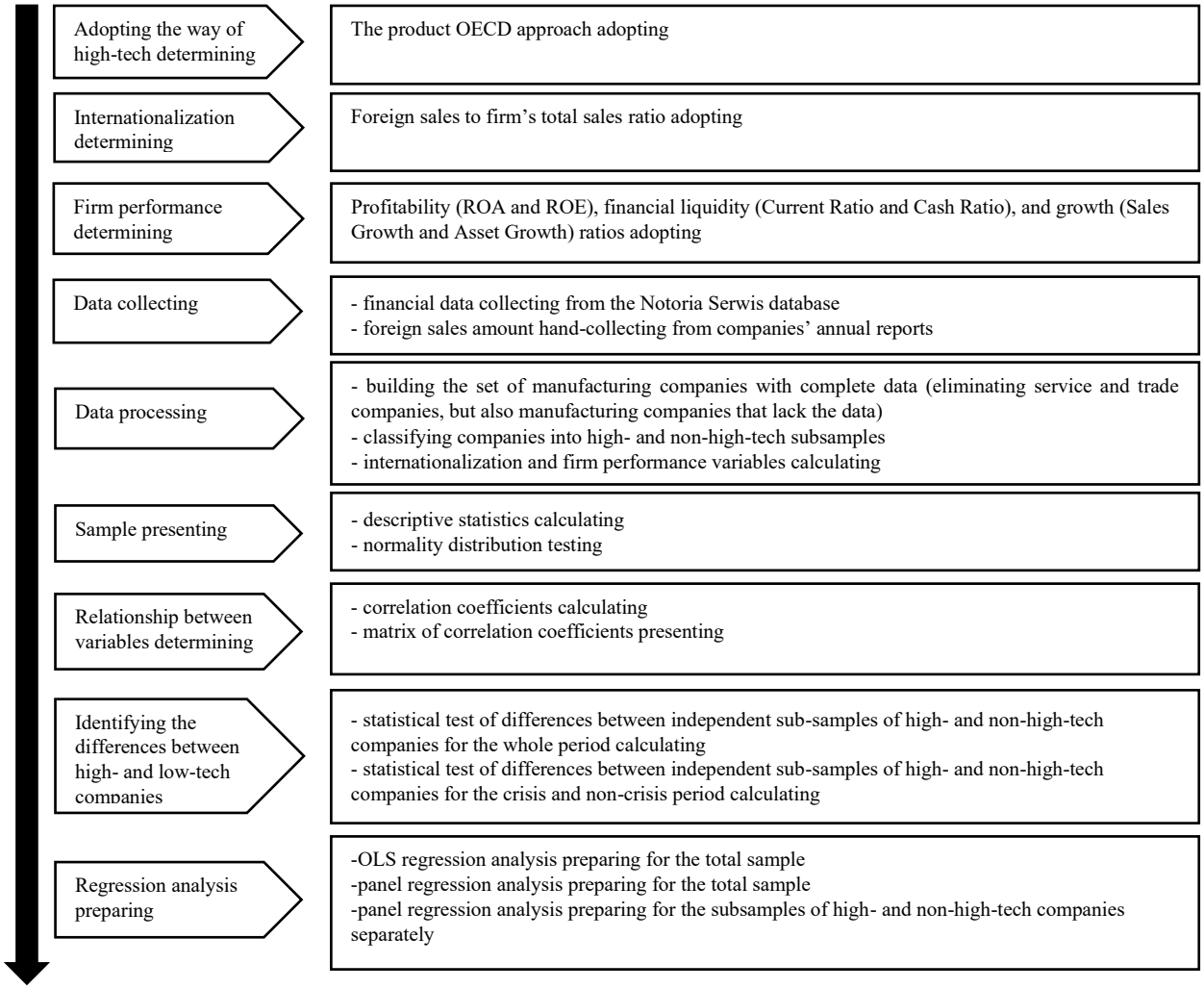

Figure 2. The Research Plan
Source: authors' own elaboration

High-Tech Status of the Company

There are at least four criteria that distinguish high-technology companies or sectors. These criteria are R&D intensity, the technological intensity of products, patent activity, and the percentage of jobs in certain occupations. Hatzichronoglou (1996), in OECD's STI Working Paper, proposed two approaches – sectoral and product. The first is based on research and development spending as compared to sales or value added of industries. As a result, 22 industries were classified into four groups: high-technology, medium-high-technology, medium-low-technology, and low-technology. High-technology industries (according to the sectoral approach) are: 1) aerospace; 2) computers and office machinery; 3) electronics-communications; 4) pharmaceuticals. This approach has a limitation – the same industry can be high-technology in one country and medium-technology in another. That's why a product approach was proposed by the Organization for Economic Cooperation and Development (OECD). According to this, a high-technology sector is one that produces high-tech products. Using product criteria, nine high-technology product groups can be identified: 1) aerospace; 2) computers-office machines; 3) electronics-telecommunications; 4) pharmacy; 5) scientific instruments; 6) electrical machinery; 7) chemistry; 8) non-electrical machinery; 9) armament. The OECD approach was cited by The Executive Committee of The Commission on Strategic Development in Hong Kong (2007). The Committee also presented a methodology used in Mainland China that is a form of the product approach – the high-tech industry comprises enterprises that produce or sell high-technologies that account for more than 60% of their annual gross revenue. This attitude is assumed by Wach (2016); Afonina & Chalupsky (2014); Colombo *et al.* (2015).

Eurostat's Glossary (2020) describes the sectoral and product approaches but also adds to these the patent approach. Herein, high-tech companies or sectors have high-tech or biotechnology patents. Based on the International Patent Classification (IPC), the following technical fields are recognized as high-technology IPC groups: 1) aviation; 2) communication technology; 3) computer and automated business equipment; 4) lasers; 5) micro-organism and genetic engineering; 6) semiconductors. This approach was applied by Cowling *et al.* (2015) in their investigations.

The personnel criteria approach was chosen by the U.S. Bureau of Labor Statistics (Wolf & Terrell, 2016). According to their approach, the high-tech industry is defined as an industry with a concentration of workers in STEM (Science, Technology, Engineering, and Mathematics) occupations. The share of STEM workers in the company or sector is 2.5 times more than the average in the U.S. economy. As the average for the whole country was 5.8% at that time (2016), the cut-off point between the technology classes was set at 14.5%. Ultimately, we adopted the product OECD approach. We defined a company as being high-tech if the company's products are connected with aerospace [product codes:

7921+7922+7923+7924+7925+79293+(714-71489-71499)+87411],

computers-office machines [75113+75131+75132+75134+(752-7529)+75997],

electronics-telecommunications [76381+76383+(764-76493-76499)+7722+77261+77318+77625+7763+7764+7768+89879],

pharmacy [5413+5415+5416+5421+5422],

scientific instruments [774+8711+8713+8714+8719+87211+(874-87411-8742)+88111+88121+88411+88419+89961+89963++89967],

electrical machinery [77862+77863+77864+77865+7787+77844],

chemistry [52222+52223+52229+52269+525+57433+591],

non-electrical machinery [71489+71499+71871+71877+72847+7311+73131+73135+73144+73151+73153+73161+73165+73312+73314+73316+73733+73735],

and armaments [891-] (Hatzichronoglou, 1996). Based on information from official companies' websites, we checked what products are manufactured by companies. If the products could be assigned to any of the abovementioned nine product groups, we considered the company to be high-tech. If not, then the company was treated as a non-high-tech. Accordingly, high-tech companies have the value 1, otherwise 0. If it was unclear at a glance whether the product falls into one of these nine groups, we used Standard International Trade Classification, Revision 4 (2006) to verify it. The procedure was as follows. Firstly, we found the product on the SITC list and checked its SITC code. Then we checked if the product's code falls into codes assigned to any high-tech product group. If yes, we assumed it is a high-tech company (value 1). If not, then it meant it is a non-high tech company (value 0).

Internationalization

The most common measure of internationalization is showing foreign sales to a firm's total sales (Pouresmaeili *et al.*, 2018; Batsakis *et al.*, 2018; Karasiewicz & Nowak, 2014; Ficici *et al.*, 2014; Contractor *et al.*, 2007; Liu *et al.*, 2019; Boermans & Roelfsema, 2016; Lecerf & Omrani, 2020). But there are other ways to measure internationalization, i.e: ratio of foreign assets to total assets (Pouresmaeili *et al.*, 2018; Liu *et al.*, 2019); firm's overseas subsidiaries to total subsidiaries (Pouresmaeili *et al.*, 2018; Mendoza, 2019; Liu *et al.*, 2019); the proportion of foreign sales variable and the dispersion of foreign sales across geographic regions (Pacheco, 2019); a number of foreign countries where the firm has affiliates (Mendoza, 2019); the

performance of any sort of international activity (at least exports) (Wach, 2016); international experience of top managers (Pouresmaeili *et al.*, 2018; Genc *et al.*, 2019); the portion of overseas employees (Liu *et al.*, 2019); entry mode (Genc *et al.*, 2019); years of internationalization (Genc *et al.*, 2019); the number of countries that the firm is exporting to (Genc *et al.*, 2019).

Ultimately, we adopt an internationalization ratio reflecting foreign sales to the firm's total sales to identify the internationalization of the company. We did not classify the companies into sub-samples according to the level of internationalization. We included internationalization (continuous variable) in our research as the independent variable. The more sales revenues are obtained from selling abroad the higher value of the internationalization ratio.

Firm Performance Variables

Among the firm performance measures that have been applied by researchers are profitability ratios: Return on Equity (ROE) (Afonina & Chalupský, 2014; Mendoza, 2019; Karasiewicz & Nowak, 2014; Ficici *et al.,* 2014; Contractor *et al.,* 2007); Return on Assets (ROA) (Afonina & Chalupský, 2014; Pacheco, 2019; Mendoza, 2019; Batsakis *et al.,* 2018; Karasiewicz & Nowak, 2014; Ficici *et al.,* 2014; Contractor *et al.,* 2007; Riahi-Belkaoui, 1998); Return on Sales (ROS) (Pouresmaeili *et al.,* 2018; Karasiewicz & Nowak, 2014; Ficici *et al.,* 2014; Contractor *et al.,* 2007); Return on Earnings before Interest, Taxation, Depreciation, and Amortization (REBITDA) (Pacheco, 2019). In some research, financial liquidity ratios have been used. These include the current and quick ratio, and solvency ratio (Afonina & Chalupsky, 2014). Some studies use sales or profit growth (Pouresmaeili *et al.,* 2018). Ultimately, we adopted several measures of firm performance: profitability (ROA and ROE), financial liquidity (Current Ratio and Cash Ratio), and growth (Sales Growth and Asset Growth). We did not classify the companies into sub-samples according to the firm performance. We included all these continuous variables in our research as dependent variables.

The higher the value of profitability, the better the firm performance is. Higher profitability means the higher ability to generate profits from capital invested in total assets by the company or in equity by owners. The higher the profitability, the higher the company's efficiency.

Higher growth ratios mean a higher pace of increasing the company's sales revenue or assets. The growth ratio results from the changes in the customer's demand – the higher the customer's demand, the higher the sales growth and demand for extra assets to achieve higher sales revenue.

The cash ratio reflects the company's safety. The higher the cash ratio and financial liquidity ratio, the higher the independence from external sources of financing and changes in access to financing.

However, there is a threshold value for financial liquidity ratios. According to corporate finance theory, a good financial liquidity current ratio is between 1.2 and 2,

meaning the business has twice as many current assets as liabilities to cover its debts. A current ratio below 1 means that the company doesn't have enough liquid assets to cover its short-term liabilities. A current ratio higher than 4 means that the company possesses too many liquid assets, and thus, they are sufficient to cover short-term debts, but they give rise to additional costs of maintaining current assets (e.g., stock storage costs).

Table 1 presents the set of variables included in our research, with their definition

Table 1

The Set of Variables Included in the Research

Variable	Proxy For	Formula	Exemplary Studies	Source of Data
ROAnet	Firm performance	net profit to total assets	Afonina & Chalupský, 2014; Pacheco, 2019; Mendoza, 2019; Batsakis *et al.,* 2018; Karasiewicz & Nowak, 2014; Ficici *et al.,* 2014; Contractor *et al.,* 2007; Riahi-Belkaoui, 1998	Notoria Serwis database
ROEnet	Firm performance	net profit to equity	Afonina & Chalupský, 2014; Mendoza, 2019; Karasiewicz & Nowak, 2014; Ficici *et al.,* 2014; Contractor *et al.,* 2007	Notoria Serwis database
CurrentRatio	Firm performance	current assets to short-term debt	Afonina & Chalupský, 2014	Notoria Serwis database
CashRatioTA	Firm performance	cash pool to total assets	Afonina & Chalupský, 2014	Notoria Serwis database
SalesGrowth	Firm performance	total sales t1 / total sales t0	Pouresmaeili *et al.,* 2018	Notoria Serwis database
AssetGrowth	Firm performance	total assets t1 / total assets t0	Pouresmaeili *et al.,* 2018	Notoria Serwis database
InternRatioTS	Internationalization	foreign sales to total sales	Pouresmaeili *et al.*, 2018; Batsakis *et al.*, 2018; Karasiewicz & Nowak, 2014; Ficici *et al.*, 2014; Contractor *et al.*, 2007; Liu *et al.*, 2019; Boermans & Roelfsema, 2016; Lecerf & Omrani, 2020	Notoria Serwis database
Crisis	COVID-19 crisis	Dummy variable: 1 if crisis year, 0 otherwise	Eppinger & Smolka, 2020	2018, 2019 -0, 2020 - 1
High-tech	High-tech status	Dummy variable: 1 if a company operates in a high-tech industry, 0 otherwise	Faria et al. 2014	product OECD approach
TangibilityPPE	Tangibility	property, plant, and equipment to total assets	Meliciani & Tchorek, 2019	Notoria Serwis database
DebtRatioTA	Leverage	total debt to total assets	Pacheco, 2019; Mendoza *et al.,* 2019; Muliyanto & Marciano, 2018	Notoria Serwis database
Size	Size	Natural logarithm of total assets	Pacheco, 2019; Muliyanto & Marciano, 2018	Notoria Serwis database

Source: Authors' own elaboration

Sample

To conduct the analysis, we collected data on companies listed on Poland's Warsaw Stock Exchange (WSE). At the end of July 2021, 435 companies were listed. After excluding banks and other financial institutions, and companies from the service sector, we were left with 197 manufacturing companies. Among these companies, we found 64 high-tech companies and 133 non-high-tech companies.

The financial data comes from financial statements provided by Notoria Serwis and covers the period of 2018-2020 (3 years). The data on foreign sales were hand-collected from the annual reports of the sample companies. The research period of 2018-2020 tackles the period of normal times (2018-2019) and crisis time (2020). The crisis time (2020) reflected the COVID-19 crisis and the effects of the cutting of global supply chains due to administrative decisions. The COVID-19 crisis significantly affected and still affects the opportunity to internationalize. That is why we also included the crisis dummy variable in our research (1 if the crisis time of 2020 is 0 otherwise).

The sample constitutes a balanced panel. Ultimately, we have a sample of 197 manufacturing companies and 591 firm-year observations. The sample consists of 64 high-tech companies (with 192 firm-year observations) and 133 non-high-tech companies (with 399 firm-year observations). All data were 'winsorized' at 98% upper and 2% lower percentile.

Methodology

We start with descriptive statistics. Additionally, we conduct the Shapiro-Wilk normality test to decide whether the sample's distribution is normal. We calculated the normality test for all variables reflecting firm performance and internationalization (continuous data). This allows us to decide which correlation method (Pearson or Spearman) and which statistical test of differences (parametric or non-parametric) should be used.

We also calculate correlation coefficients and prepare a correlation matrix to show the relationship between variables. However, correlation coefficients do not show the impact but only the relationship between variables in the sample. Correlation does not allow us to conclude the causation, make predictions, or generalize the results. To show the differences between subsamples (high-tech and non-high-tech) we need to implement a statistical test of differences between two independent subsamples. To show the causation and impact of the independent variables on the dependent ones we need to use another statistical tool (regression analysis).

Subsequently, to describe the differences between the subsamples, we implement the U Mann Whitney test (the U Mann Whitney test is a nonparametric test applied to compare two independent samples to find differences between these two samples). We analyze differences between high and non-high-tech companies and also performance between the pre-crisis and crisis time. Statistical test of differences between two independent groups allows only to compare but not the relation or impact of one variable on another variable.

Thus, the next step is to implement regression analysis. We use both pooled OLS and panel regression analysis. According to Wooldridge (2010), pooled OLS analysis might be biased and does not consider the data's structure (panel data). That is why we conducted regression analysis by using panel analysis. The general formula of the regression model is the following:

$$DV = \beta_0 + \beta_1 IV + \beta_2 CV + \varepsilon_i$$

Where:

DV – dependent variable vector, reflecting proxy for firm performance (profitability, financial liquidity, and growth rate);

IV – independent variables vector, reflecting proxies for internationalization, the status of the company (high or non-high-tech), crisis variable;

CV - control variables vector, reflecting leverage, tangibility, and size;

Beta - coefficient estimate for the independent and control variables;

ε_n- random error term/residual variable.

To conduct the analysis, we used SPSS and Gretl software.

Findings

Table 2 reveals the descriptive statistics of the sample companies. In it, apart from the firm performance variables indicated above, we also present tangibility, leverage and size variables.

Table 2

Descriptive Statistics

	Mean	Median	Sd	Min	Max	Shapiro Wilk test and p-value
InternRatioTS	0.34	0.27	0.33	0.0	1.00	0.879 ***
ROAnet	0.02	0.04	0.17	-0.57	0.66	0.824 ***
ROEnet	0.07	0.08	0.28	-0.83	0.97	0.866 ***
CurrentRatio	2.28	1.47	2.39	0.47	14.31	0.641 ***
CashRatioTA	0.11	0.06	0.14	0.00	0.66	0.671 ***
SalesGrowth	1.10	1.04	0.40	0.42	2.68	0.812 ***
AssetGrowth	1.12	1.05	0.32	0.68	2.47	0.721 ***
TangibilityPPE	0.29	0.27	0.22	0.00	0.70	0.931 ***
DebtRatioTA	0.48	0.48	0.23	0.07	1.15	0.969 ***
TotalAssets (mil PLN)	1,302.7	212.7	3,162.3	7.6	15,478.7	0.415 ***
Total Sales (mil PLN)	1,074.3	191.5	2,417.9	1.3	11,402.8	0.463 ***

Source: authors' own calculations

On average, the foreign sales amount to the app. 30% of total sales. The average profitability is found to be quite low: app. 3% ROA and 7% of ROE. However, the financial liquidity ratios were quite high: the current ratio is higher than 2.0. Moreover, we discovered that the sample companies grow by 10% annually, both in terms of sales revenue and assets. However, the sample companies have quite low tangibility – almost 30% of total assets were invested in property, plant, and equipment. In addition, they demonstrate quite low leverage – the debt ratio represents 50% of total assets. Finally, our work indicated a quite strong differentiation among our sample companies regarding size (total assets and total sales). This means that in the sample there are both big and small companies.

As the p-value of the Shapiro-Wilk test is lower than the alpha level (0.005), we reject the null hypothesis assuming that data are of normal distribution. Thus, we implemented Spearman correlation analysis and applied a non-parametric test for comparing independent groups. Table 3 presents the correlation matrix.

Table 3

Spearman Correlation Matrix

	High/ non-high	Crisis/ pre-crisis	InternRatioTS	ROA net	ROEnet	CurrentRatio	CashRatioTA	SalesGrowth	AssetGrowth	TangibilityPPE	DebtRatioTA	TotalAssets
InternRatioTS	0.073 *	0.017	1									
ROAnet	0.033	0.023	0.147 ***	1								
ROEnet	0.049	0.085 *	0.083 *	0.630 ***	1							
CurrentRatio	0.325 ***	0.047	0.054	0.383 ***	0.226 ***	1						
CashRatioTA	0.437 ***	0.082 *	0.050	0.212 ***	0.197 ***	0.647 ***	1					
SalesGrowth	0.283 ***	-0.014	0.108 *	0.200 ***	0.171 **	0.327 ***	0.335 ***	1				
AssetGrowth	***	0.006	0.023	0.298 ***	0.283 ***	0.475 ***	0.516 ***	0.533 ***	1			
TangibilityPPE	-0.391 ***	-0.021	0.117 **	-0.068 *	-0.041	-0.374 ***	-0.359 ***	-0.273 ***	-0.304 ***	1		
DebtRatioTA	-0.258 ***	0.003	-0.100 *	-0.383 ***	-0.066	-0.618 ***	-0.271 ***	-0.171 **	-0.157 **	0.210 ***	1	
Total Assets	-0.214 ***	0.011	0.040	0.011	-0.006	-0.153 ***	-0.097 *	-0.071	-0.051	0.328 ***	0.083 *	1
Total Sales	-0.238 ***	-0.001	0.075 *	0.027	0.016	-0.167 ***	-0.105 *	-0.063	-0.050	0.308 ***	0.116 **	0.952 ***

*Significance ***, **, * at p-value less than 0.01, 0.05, 0.1 respectively. Source: authors' own calculations*

The crisis variable shows a weak correlation with variables. The internationalization ratio is positively related to profitability and sales growth but negatively to the debt ratio. There are also some relations between the high-tech status of the company and firm performance and firm characteristics. However, to find any difference between high-tech and non-high-tech companies as they constitute two subsamples we need to check the significance of the sample differences.

To provide a more in-depth analysis of the differences between the behavior of high and non-high-tech companies, both in pre-crisis and crisis times, we tested the subsamples by applying the U Mann Witney test (Table 4).

Table 4

U Mann Witney Test Results (Mean, Median, Z test)

	Total			Pre-Crisis			Crisis		
	non-high	high	UMW	non-high	high	UMW	non-high	high	UMW
InternRatioTS	0.32 0.26	0.38 0.33	-0.638	0.32 0.27	0.38 0.30	-0.207	0.32 0.25	0.39 0.37	-0.804
ROAnet	0.02 0.04	0.04 0.05	-1.659 *	0.02 0.04	0.02 0.03	-0.732	0.02 0.04	0.06 0.05	-1.881 *
ROEnet	0.05 0.07	0.11 0.11	-1.280	0.04 0.08	0.04 0.08	-0.260	0.05 0.07	0.18 0.12	-2.578 **
CurrentRatio	1.76 1.39	3.35 1.83	-4.898 ***	1.73 1.37	2.93 1.83	-3.969 ***	1.80 1.45	3.77 1.84	-2.858 **
CashRatioTA	0.07 0.05	0.20 0.11	-7.473 ***	0.06 0.05	0.18 0.09	-5.924 ***	0.08 0.06	0.23 0.14	-4.761 ***
SalesGrowth	1.03 1.00	1.27 1.12	-4.625 ***	1.04 1.03	1.25 1.14	-3.464 **	1.01 0.97	1.29 1.11	-3.125 **
AssetGrowth	1.05 1.03	1.27 1.10	-3.839 ***	1.07 1.05	1.21 1.09	-1.105	1.03 1.03	1.32 1.13	-4.270 ***
TangibilityPPE	0.34 0.36	0.17 0.09	-9.615 ***	0.35 0.37	0.17 0.11	-8.005 ***	0.34 0.34	0.16 0.08	-5.316 ***
DebtRatioTA	0.52 0.51	0.40 0.35	-7.502 ***	0.53 0.51	0.40 0.35	-6.190 ***	0.51 0.51	0.40 0.34	-4.184 ***
TotalAssets (mil PLN)	1,774.4 347.3	322.4 91.1	-9.811 ***	1,758.4 345.8	305.1 81.3	-8.309 ***	1,790.4 347.5	339.8 92.6	-5.252 ***
Total Sales (mil PLN)	1,468.3 280.3	255.3 80.1	-9.588 ***	1,487.2 288.2	234,4 66.8	-3.084 **	1,449.5 251.9	276,3 89.7	-4.891 ***

*Significance ***, **, * at p-value less than 0.01, 0.05, 0.1 respectively. Source: authors' own calculations*

We find several strong (with statistical significance) differences between high and non-high-tech companies but not in terms of internationalization. Thus, we do not find confirmation of H2 assuming that there is higher internationalization of high-tech companies than that of non-high-tech companies. Additionally, we see confirmation of H3 assuming better firm performance of high-tech companies as compared to non-high-tech companies, especially in terms of financial liquidity (current ratio and cash ratio) and growth (both asset and sales) but not in terms of profitability. What is important, higher ratios of financial liquidity do not exceed the threshold level.

Although we find no statistically significant differences in internationalization between high-tech and non-high-tech companies, we believe internationalization behavior differs. Figures 1 and 2 present the distribution of the internationalization ratio of high-tech and non-high-tech companies. Grey tones and percentage ranges correspond to different shares of foreign sales revenue.

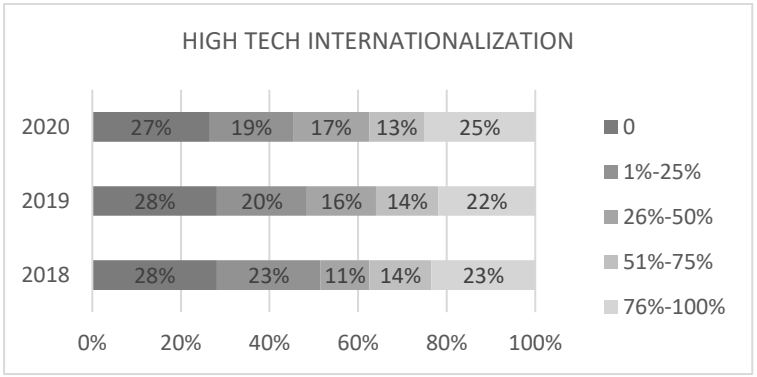

Figure 3. The Distribution of the Internationalization Ratio of High-Tech Companies. *Source: authors' own calculations*

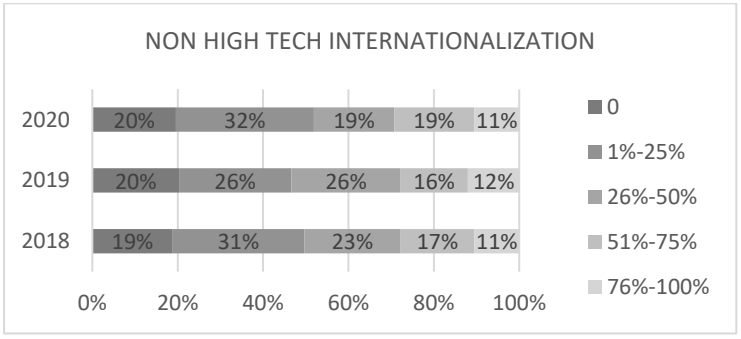

Figure 4. The Distribution of the Internationalization Ratio of Non-High-Tech Companies. *Source: authors' own calculations*

Among non-high-tech companies, more than 70% of companies have an internationalization ratio lower than 50%. While among high-tech companies, slightly more than 60% of companies have an internationalization ratio lower than 50%. But among high-tech companies, there is a higher percentage (almost 30%) than among non-high-tech companies (20%) that do not sell their product/service on foreign markets at all. The high-tech companies with no internationalization belong mostly to the pharmaceutical industry, while non-high-tech to the construction industry. What is important, the internationalization ratio does not decrease in 2020 (the COVID-19 crisis year).

Before the COVID-19 crisis and during the crisis, the high-tech and non-high-tech companies do not differ with statistical significance in the internationalization ratio. Thus, we do not find confirmation of H5 (assuming that we would find higher internationalization among Poland's high-tech than in non-high-tech companies when pre-crisis and crisis periods are compared).

However, we find only partial confirmation of H6 (assuming that Poland's high-tech companies perform better than low-tech companies, both in the pre-crisis and crisis periods). Before the crisis, the high-tech companies have higher financial liquidity (current and cash ratio) and growth (assets growth) but they do not differ in terms of profitability and sales growth. During the COVID-19 crisis, high-tech companies perform better in all terms: profitability, financial liquidity, and growth. What is important, higher ratios of financial liquidity do not exceed the threshold level.

To discern the impact of the company status (high or non-high-tech), crisis, and internationalization on firm performance, we conduct regression analysis. We conduct both OLS and panel regression analysis. Depending on the value of the Hausman test in panel analysis models, we decide to present random effect panel regression analysis results (if a p-value of the Hausman test is higher than 0.100), and fixed effect panel regression analysis results (if a p-value of the Hausman test is lower than 0.100).

Table 5 presents the pooled OLS regression analysis results, while Table 6 provides the panel regression analysis results for the total sample.

Table 5

Pooled OLS Regression Analysis Results for the Total Sample

	InternRatioTS	ROAnet	ROEnet	CurrentRatio	CashRatioTA	SalesGrowth	AssetGrowth
High/non-high	0.112 ***	-0.012	0.034	0.247	0.086 ***	0.154 **	0.167 ***
Crisis	0.011	0.006	0.046 *	0.251	0.024 *	-0.017	0.001
InternRatioTS	X	0.051 *	0.054	0.270	0.020	0.130 *	-0.012
TangibilityPPE	0.231 ***	-0.058 *	-0.075	-2.140 ***	-0.123 ***	-0.382 ***	-0.318 ***
DebtRatioTA	-0.163 **	-0.299 ***	-0.064	-5.621 ***	-0.084 ***	-0.135	-0.083
Size	0.027 **	0.018 ***	0.020 **	-0.211 ***	-0.007 *	0.002	0.009
F-statistics p-value	7.314 ***	22.874 ***	3.162 **	87.064 ***	35.154 ***	9.678 ***	11.414 ***
R-square	0.059	0.190	0.031	0.472	0.265	0.130	0.150

*Significance ***, **, * at less than 0.01, 0.05, 0.1 respectively. Source: authors' own calculations*

Table 6

Panel Regression Analysis Results for the Total Sample

	InternRatioTS	ROAnet	ROEnet	CurrentRatio	CashRatio	SalesGrowth	AssetGrowth
Type of effects (random or fixed)	random	fixed	fixed	fixed	fixed	fixed	fixed
High/non-high	0.125 *	-0.007	0.033	0.505 *	0.109 ***	0.157 **	0.182 ***
Crisis	0.007	0.003	0.045 **	0.159 **	0.017 ***	-0.159 *	-0.064 ***
InternRatioTS	X	-0.017	0.011	-0.624	0.008	-0.115	0.110
TangibilityPPE	0.140 *	-0.098	-0.081	-2.760 ***	-0.111	-1.398 *	-0.630
DebtRatioTA	-0.121 **	-0.364 ***	-0.055	-5.128 ***	-0.114 ***	-0.553	-0.054
Size	0.047 ***	0.072 ***	0.018 *	-0.594 ***	0.047 ***	0.473 ***	0.629 ***
LSDV R-square	0.949	0.803	0.632	0.901	0.883	0.633	0.838
Within R-Square	0.053	0.111	0.019	0.281	0.123	0.117	0.382
Breusch-Pagan test	500.956 ***	215.975 ***	99.968 ***	341.721 ***	281.939 ***	5.204 *	25.420 ***
Hausman test	5.863 0.210	21.693 0.001	12.350 0.030	24.499 0.000	22.842 0.000	25.092 0.000	124.667 0.000

*Significance ***, **, * at less than 0.01, 0.05, 0.1 respectively. Source: authors' own calculations*

Both approaches (pooled OLS and panel regression analysis) provide similar results. Internationalization seems to have no impact on firm performance. Thus we can not confirm our H1 assuming that internationalization positively impacts firm performance.

Table 7 presents the panel regression analysis results for the high-tech companies' subsample, while Table 8 presents panel regression analysis results for the non-high-tech companies' subsample. Depending on the value of the Hausman test in panel analysis models, we decided to present random effect panel regression analysis results (if a p-value of the Hausman test is higher than 0.100), and fixed effect panel regression analysis results (if a p-value of the Hausman test is lower than 0.100).

Table 7

Panel Regression Analysis Results for the High-Tech Companies Subsample

	InternRatioTS	ROAnet	ROEnet	CurrentRatio	CashRatio	SalesGrowth	AssetGrowth
Type of effects (random or fixed)	random	random	fixed	fixed	fixed	fixed	fixed
Crisis	0.010	0.038	0.165 ***	0.417 *	0.306 **	-0.110	-0.077
InternRatioTS	X	0.020	-0.102	-0.733	0.003	0.604	0.543
TangibilityPPE	-0.010	-0.206	-0.639	-10.424 ***	-0.221	-4.346 **	-2.631 **
DebtRatioTA	-0.239 **	-0.360 ***	0.447	-5.582 ***	-0.117	1.467 **	0.180
Size	0.077 ***	0.035 **	-0.085	0.688 **	0.052 **	0.537 ***	0.607 ***
LSDV R-square	0.924	0.777	0.643	0.891	0.883	0.743	0.854
Within R-Square	0.056	0.021	0.087	0.044	0.148	0.256	0.405
Breusch-Pagan test	139.425 ***	68.872 ***	35.530 ***	90.741 ***	86.167 ***	1.979	10.823 ***
Hausman test	4.235 0.375	6.940 0.25	9.606 0.087	17.514 0.003	12.052 0.034	20.239 0.001	40.178 0.000

*Significance ***, **, * at less than 0.01, 0.05, 0.1 respectively. Source: authors' own calculations*

In the high-tech subsample, we find no impact of internationalization on firm performance. Thus, we find no confirmation of H4 hypothesis (assuming a positive impact of internationalization on the firm performance of high-tech companies (compared to non-high-tech companies).

Table 8

Panel Regression Analysis Results for the Non-High-Tech Companies Subsample

	InternRatioTS	ROAnet	ROEnet	CurrentRatio	CashRatio	SalesGrowth	AssetGrowth
Type of effects (random or fixed)	fixed	fixed	fixed	random	random	fixed	fixed
Crisis	-0.000	-0.011 *	-0.006	0.067 *	0.012 ***	-0.110	-0.077
InternRatioTS	X	-0.052	0.199	-0.293	0.012	-0.605	0.543
TangibilityPPE	0.076	-0.088	-0.325 *	-1.644 ***	-0.082 ***	-4.346 **	-2.631 **
DebtRatioTA	-0.121 **	-0.407 ***	-0.328 ***	-4.075 ***	-0.061 ***	1.467 **	0.180
Size	0.080 ***	0.074 ***	-0.021	-0.087 **	0.006 **	-4.346 ***	0.607 ***
LSDV R-square	0.971	0.783	0.622	0.937	0.776	0.743	0.854
Within R-Square	0.051	0.237	0.057	0.441	0.111	0.256	0.405
Breusch-Pagan test	359.821 ***	118.401 ***	63.035 ***	243.501 ***	141.271 ***	1.979	10.823 ***
Hausman test	14.700 0.002	24.650 0.000	10.158 0.038	0.889 0.926	2.035 0.729	20.239 0.001	40.178 0.000

*Significance ***, **, * at less than 0.01, 0.05, 0.1 respectively. Source: authors' own calculations*

Our work indicates that for both high-tech companies and non-high-tech companies, internationalization has no impact on firm performance. Therefore, we find no confirmation of H4 assuming that there is a positive impact of internationalization on the firm performance of Poland's high-tech companies, as compared to that of non-high-tech companies. To sum up, the results of the verification of our hypotheses are presented in Table 9.

Table 9

Results of the Hypotheses Verification

Hypothesis	Results
H1: the level of internationalization is positively related to firm performance	Not confirmed
H2: there is higher internationalization of high-tech companies (compared to non-high-tech companies)	Not confirmed
H3: there is a better firm performance of high-tech companies (compared to non-high-tech companies)	Partially confirmed (in terms of financial liquidity and growth but not the profitability)
H4: there is a positive impact of internationalization on the firm performance of high-tech companies (compared to non-high-tech companies)	Not confirmed
H5: there is higher internationalization of high-tech companies both in pre-crisis and crisis periods	Not confirmed
H6: there is a better firm performance of high-tech companies both in pre-crisis and crisis periods	Partially confirmed in the pre-crisis period (in terms of financial liquidity and growth but not the profitability) Fully confirmed during the crisis period (in terms of financial liquidity, growth, and profitability)

Source: authors' own calculations

Discussion

The findings on our total sample contradict previous results on the positive impact of internationalization on firm performance, especially those by Pacheco (2019), and Ruigrok & Wagner (2004). However, Pacheco (2019) analyses the period that includes no crisis impact (2010-2016) and only two sectors: textile and wearing apparel in Portugal. While Ruigrok & Wagner (2004) prepared a meta-analysis of previous research combining different periods and economies.

Additionally, our findings on the total sample contradict previous results on the negative impact of the crisis on internationalization. Previous research shows that during any crisis, a company's internationalization efforts decrease (e.g. Auboin, 2009; Amiti & Weinstein, 2011; Karasiewicz & Nowak, 2014), while we find that our sample companies kept rigid their internationalization ratios.

It is worth noting that previous research on the relationship between internationalization and firm performance (profitability) for 313 Polish companies listed on the Warsaw Stock Exchange for the data covering the 2009-2010 period by Karasiewicz & Nowak (2014) shows a negative relation. Their research covers the impact of the GFC crisis during Poland was called a "green island" because it was the only country with positive GDP growth for the whole of the GFC crisis period. The negative impact of internationalization on profitability during the GFC crisis time (Karasiewicz & Nowak, 2014) and our findings on the lack of impact of internationalization on firm performance during the COVID-19 crisis might mean that Polish companies have learned how to deal with the crisis situation.

We also found – for the total sample - that despite of crisis, the profitability and cash holdings increased. However, this was accompanied by the negative impact of the crisis on Sales Growth and Asset Growth. An increase

in profitability with a lower increase in sales was only possible with a strong decrease in operating costs. This finding is quite surprising as, in most cases, the crisis has a negative impact on profitability (Kumar & Zbib, 2022). An increase in cash holding is not surprising, as usually during difficult times the precautionary motives lead to an increase in the cash ratio.

When comparing high-tech and non-high-tech companies we were able to reveal certain specific characteristics of Poland's high-tech companies, especially that Polish high-tech companies are smaller (than non-high-tech companies) with lower total assets and lower sales revenue. Additionally, Polish high-tech companies have higher growth, lower tangibility, and lower debt ratios. Our findings are in line with previous research that shows that high-tech companies rely heavily on growth opportunities (as they have higher sales growth), and on their intangible and highly firm-specific assets (as they have lower tangibility) (Colombo & Grilli, 2007; Mina *et al.,* 2013; Revest & Sapio, 2012). This also explains the low leverage of high-tech companies, as high-tech companies have low tangibility and have more specific assets with low collateral value, and this keeps such companies from seeking bank loans. Compared with previous research - Colombo & Grilli (2007) conducted their research on Italian companies, Mina *et al.* (2013) on UK companies, and Revest & Sapio (2012) on some European countries – Polish high-tech companies behave similarly to those high-tech companies of mature economies. Our findings on higher financial liquidity and lower leverage of high-tech companies (when compared to non-high-tech) are also in line with that of previous research. Since high-tech companies are, at the same time, small companies – these two factors are more likely to face financing constraints than other types of firms (Carpenter & Petersen, 2002). Thus, high-tech companies are supposed to hold higher cash reserves and lower debt ratios. That is why they have higher financial liquidity ratios and lower leverage. Although Carpenter & Petersen (2002) researched the US companies, Polish companies show many similarities to those from mature economies.

Although our sample high-tech companies are much smaller than non-high-tech, they have similar levels of internationalization. This aligns with previous research on the early internationalization of small high-tech companies (e.g. Yiu *et al.,* 2007; Neubert & Van Der Krogt, 2017). Neubert & Van Der Krogt (2017) researched Swiss and Paraguayan companies in the years before the GFC, while our research analyses Polish companies in the years covering the COVID-19 crisis. However, they both lead to a similar picture of high-tech companies over time and borders.

What is important is that we find a lack of impact of internationalization on firm performance (profitability, financial liquidity, and growth) in high-tech and non-high-tech companies. This finding contradicts the previous ones by Costa *et al.* (2015), Gorg & Spaliara (2014), and Vithessonthi & Tongurai (2015), who find that internationalized companies have better firm performance even in crisis times.

Our findings – for the high-tech subsample – show a lack of crisis impact (especially negative impact) on internationalization. This means that the internationalization ratio remained stable during the COVID-19 crisis. However, the same finding is for non-high-tech companies. Surprisingly, we find no impact (especially negative) of internationalization on firm performance in high-tech. These findings are quite surprising as the COVID-19 pandemic was found to disrupt production and complicate the transport of products along the supply chains resulting in losses, and consequently in a drop in global GDP (Kersan-Skabic, 2022).

Similarly to Afonina and Chalupský (2014), who found that in the Visegrad countries (Czechia, Hungary, Slovakia, and Poland) the high-tech sector during the GFC strove for a high level of liquidity (safety) instead of high profits, we find that in the COVID-19 crisis, high-tech companies behaved similarly – they increased their level of financial liquidity to a more extent than profitability. An increase in financial liquidity during crisis times is proved by previous research and confirms precautionary motives protecting companies from the negative impact of crisis situations. Thus, Polish high-tech companies seem to be taking action (increasing cash holding) to protect the company from the possible negative impact of the crisis, with an effort to sustain the level of sales revenue and increase profits and profitability. At the same time, in the non-high-tech subsample, the crisis has led to increased financial liquidity, stability in sales revenue, and a decrease in profitability.

The better firm performance of high-tech companies during the COVID-19 crisis gives a good ground for sustaining strategic capabilities. This aligns with Cowling *et al.'s (2015) findings, which assume* that economic turbulence creates a unique opportunity for Schumpeterian creative destruction. This finding supports previous results showing that companies with advanced technology have the greater ability ("absorptive capacity", "architectural competence") to adapt to both home and international market challenges (Zahra & Garvis, 2000; Spence & Crick, 2006; Pinkwart & Proksch, 2014). This is in line with the convergence theory and the resource-based theory. It should be noted that Zouaghi *et al.* (2018) discovered that high-tech companies' strong capabilities (especially knowledge) enabled them to diminish the negative effects of the GFC. Thus, it can be said that the capabilities held by high-tech companies can support these high-tech firms' orientation toward the development of advanced technology and to remain competitive in changing environments (Garcia Martinez *et al.,* 2017).

We think that the higher financial liquidity of high-tech companies in the pre-crisis period was a fundamental resource that enabled Poland's high-tech companies to be less susceptible to the impact of the COVID crisis. In this way, we support the findings of Colombo *et al.* (2016), who saw that internal resources accumulated during pre-crisis periods act as a factor in enhancing growth and firm performance during crisis times. Our findings support Zouaghi et al.'s (2018) research, which proves for Spanish high-tech companies during the GFC that innovation efforts and knowledge assets are capabilities to tackle adverse economic conditions. Our findings also support the research of Colombo *et al.* (2016) on high-tech entrepreneurs' dynamic capabilities in coping with difficult situations.

Conclusions

Theoretical Contribution and Practical Implications

Our work indicates that the average level of internationalization in Poland's listed companies is 30% of total sales: half of the companies go to the foreign market with less than 1/4 of their sales and half of the companies do so with more than 1/4 of their total sales (median is 27%). The level of internationalization is quite stable both for high and non-high-tech companies and in both the COVID-19 crisis and pre-crisis periods. However, we found no impact of internationalization on firm performance. The stable level of internationalization might result from long-term contractual links with the closest neighbor – Germany (Karasiewicz & Nowak, 2014). Then, cuts in global chains do not affect Polish companies.

Our findings demonstrate that compared to non-high-tech, Poland's high-tech companies have higher profitability (ROA), financial liquidity (Current and Cash Ratio), and higher Asset and Sales Growth Ratios. However, they have lower Tangibility and Debt Ratio, and they are much smaller (both in terms of Total Assets and Total Sales). We also saw a positive impact of the status of the company on firm performance, but only on financial liquidity and growth of sales and assets (but not profitability). This means that Polish companies have the same domestic and foreign sales margin.

During the COVID-19 crisis, our sample companies did not experience negative effects: all sampled companies were profitable and maintained or even increased their financial liquidity, and they also increased their sales and assets. Moreover, they were able to keep their internationalization level, meaning that an increase followed the increase in total foreign sales. Surprisingly, despite the COVID-19 crisis, high-tech companies increased profitability and financial liquidity. However, the increase in the Current Ratio and Cash Ratio might be the result of precautionary motives in an uncertain time.

Therefore, our study's main contribution is that we added to the discussion on the relationship between internationalization and firm performance. We brought into it, two extra factors: company status (high-tech) and crisis environment. In addition, we were able to shed light on the behavior (internationalization) and its result (firm performance) of the high-tech companies of an emerging economy (Poland) during the COVID-19 crisis, especially since it resulted in the cutting of supply chains.

Several managerial implications follow from this discussion and should interest managers. Although we did not confirm the positive impact of internationalization on firm performance, we found a stable level of internationallization during crisis time. This means that internationallization is an important aspect of company diversification and coping with the impact of a crisis. As revealed in our research, high-tech companies have the specific power to handle difficult situations and to develop even during crisis times (during the crisis, the high-tech companies were able to increase profitability). It seems that high-tech companies (managers) possess specific abilities and knowledge to strengthen a company's resistance to difficult situations. This might be useful for developing knowledge and dynamic managerial abilities in non-high-tech companies to enable them to be more resistant in uncertain times. During COVID-19 crisis, high-tech companies (when compared to non-high-tech companies crisis) have higher profitability (ROA and ROE), financial liquidity (Current and Cash Ratio), and higher Asset and Sales Growth ratios. High-tech companies' managers should retain and care for internal resources to enhance adaptability to the radical changes in the business environment.

A social implication of our research is the recommendation for policymakers to support the internationallization process, especially of high-tech companies. The aggregated effect of internationalization of high-tech companies might help reduce the adverse effects of the crisis in maintaining employment and stabilizing the business cycle and budget tax income.

Limitations and Further Research

A main limitation pertains to the search sample comprising only Polish companies. Poland is a specific country as it is a post-socialist country and has an emerging economy with aspirations to be a developed country. Poland's specificity was especially noted during the global financial crisis of 2007–2009 when Poland was coined a "green island" (Jakimowicz & Rzeczkowski, 2019).

Additionally, the sample consists of the listed companies only. While listed companies are obliged to follow specific corporate governance and disclosure regulations. This might impact their behavior, as they want to keep a positive market opinion.

Yet, the limitations indicate future research directions. We think that including private companies might reveal the actual status of high and non-high-tech companies and make the differences more distinctive. We also believe that additional research on different types of economies (developed and developing) and countries is needed. A study of companies from different economies might catch new findings and a deeper look into high-tech company behavior, both in terms of internationalization and crisis resistance. By different economies, we mean other economies from Central Eastern and Southern Europe (post-communist autarkic countries). But, it is also possible to compare developed and mature economies (such as Germany) with developing economies (such as Poland).

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