SMES IN MEDICAL TECHNOLOGY GLOBAL PRODUCTION NETWORKS: THE CASE OF CZECHIA¹

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This case study of the medical technology sector in Czechia places a major focus on the position of Czech firms, particularly SMEs, in global production networks and their internationalization. The medical technology (MedTech) industry is on the rise in Czechia, although in relative terms it is part of a relatively less important category. Three types of MedTech firms have been identified in Czechia: branches of TNCs, mostly domestically-owned innovative SMEs, and local SMEs focusing on low-value production. Despite there being several innovative and successful firms, production is dominated by low-value disposables and medical and surgical products. Apart from exports, other forms of internationalization are rare and occur mostly among a number of innovative firms. With a few exceptions, production facilities are established in neighboring post-communist countries. The low levels of internationalization are mostly related to the nature of local SMEs as well as the limited ambitions of local firms. With more sophisticated products Czech SMEs could focus more on Eastern European countries outside the EU, where Czechia has historical economic ties and the regulatory requirements are likely to be less strict. An industry move towards connected health solutions is also an opportunity for start-ups focusing on health applications.

Keywords: medical technology industry, Global Production Networks, SMEs, Czechia, internationalization

JEL-codes: L21, L68, O30, O52, F2, F14

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1. INTRODUCTION

Global Production Networks (GPNs), or the more widely used term Global Value Chains, came to the attention of researchers in the 1980s, when the growth of world trade was not accompanied by an increase in GDP. Today, at least 50% of world trade consists of intermediate or semi-finished goods moving between stations in an internationally-dispersed value chain or network (de Backer – Miroudot 2013). SMEs play a big role in GPN (Kaplinsky – Readman 2001) and foreign trade is the most important form of internationalization among them (European Commission 2018). The role of SMEs in GPNs and the way they are incorporated into GPNs has attracted research interest (e.g. Pietrobelli – Rabellotti 2010; Kaplinsky – Readman 2001).

Whereas major attention in GPNs has been given to key industries like automotive, electronics or clothing (Sturgeon et al. 2008; Dedrick et al. 2009), the medical technology industry has so far attracted limited attention (e.g. Bamber – Gereffi 2013; Weber et al. 2010). Despite the fact that it is among the smaller industries, its growth rates and potential, innovative nature, and the rise of several emerging countries make it an interesting research area. Furthermore, medical technology exports are on the rise in Czechia.

Czechia has become integrated into GPNs over the last twenty years and its participation is now among the highest in the world. The major factors were cheap but skilled labor, in close proximity to powerful industrial neighbors, like Germany. There is thus a large role played by foreign companies, particularly in manufacturing, where they account for about 50% of value added (OECD 2016). Domestic firms participating in GPNs are usually SMEs at the position of second or third tier suppliers (Pavlínek – Žižalová 2014).

The aim of this paper is to assess the role of Czech SMEs in medical technology (MedTech) production networks. Furthermore, attention is given to successful domestic SMEs and whether and how SMEs internationalize. The paper is thus a case study of the Czech MedTech sector based on international trade data, official statistics of the MedTech industry, firm-level data as well as interviews. The paper proceeds as follows: in Section 2 the literature on GPNs, SMEs and their internationalization, particularly in Czechia, and the specifics of the MedTech industry are described. Section 3 discusses the data and the methodology of the paper. In Section 4 the specifics of the MedTech industry in Czechia are analyzed with major attention given to SMEs. The final section concludes the paper.

2. LITERATURE REVIEW

2.1. Global production networks and the role of SMEs

This research draws on two streams of literature: literature on global production networks and global value chains (e.g. Kaplinski – Readman, 2001; Gereffi et al. 2005, Humphrey – Schmitz 2002; Yeung – Coe 2015), and SMEs and their internationalization (e.g. Johanson – Wiedersheim 1975; Lu – Beamish 2001; Coviello – Munro 1997).

GPNs are used to describe the distribution of individual production steps to firms around the world. They are simultaneously the cause and the effect of economic globalization. Enabled by the spread of communication technology and cheap transport, it has resulted in the progressive fragmentation and division of labor over greater distances (Dicken 2015; Baldwin 2006). This leads to an increase in trade with intermediate or semi-finished goods, crossing borders several times before reaching their final consumer (de Backer – Miroudot 2013). GPN terminology is mostly used among economic geographers (e.g. Coe et al. 2008; Dicken 2015). Economists and policy-makers more often use the term Global Value Chains (GVCs), introduced by Porter (1985). Despite some differences between the terms, their meaning is very similar (see Coe et al. 2008). Major attention in the GPN literature is given to value added, power relations and embeddedness of GPNs (Vlčková 2017).

The main goal of firms in GVCs/GPNs is to improve their position in the network, so-called upgrading (Humphrey – Schmitz 2002). Since the initial GPN concept particularly neglected the causal drivers of GPNs and their dynamic configurations, Coe and Yeung (2015) came up with the GPN 2.0 framework, which overcomes some of these limitations. GPNs include all kinds of actors, from transnational corporations (TNCs), small and medium-sized enterprises (SMEs), states, supranational organizations (such as the EU) to non-governmental organizations (NGOs), the labor force or consumers. In this paper, especially the role of SMEs in MedTech GPNs will be analyzed.

Another research stream on which this paper draws is SMEs and internationalization. SMEs comprise more than 90 per cent of all enterprises in the world, and account for 50 to 60 per cent of total employment (Kaplinsky – Readman 2001). Furthermore, they have a positive impact on GDP per capita, the share of exports to GDP and patents per population (Cumming et al. 2014). SMEs have thus different features than large companies. On the one hand, they have less capital and information, on the other, they are more dynamic and flexible. The major constraints that SMEs face include: access to market; access to training; col-

laboration and cooperation building; and access to finance (Gereffi – Fernandez-Stark 2016).

It is well known that international operations are not only typical for large corporations (Johanson – Wiedersheim 1975). The motivation of firms to internationalize is often distinguished between push (internal to the firm) and pull factors (external to the firm). SMEs' internationalization can take several forms, from basic export activity, to launching sales subsidiaries abroad, to establishing production units (Welch – Luostarinen 1988). Foreign trade is the most common form of internationalization among SMEs and export-oriented SMEs have higher growth of turnover and employment than SMEs catering for the domestic market only (European Commission 2018). For SMEs to participate in world trade requires that they cooperate to achieve collective efficiency (Lu – Beamish 2001). Establishing financial, technological and commercial relations with the partners in the network enables the firms to extend their activities internationally (Coviello – Munro 1997). It can be either horizontal, such as exporting as a network of firms, or vertical, for example, exporting through incorporation in GPNs (Kaplinsky – Readman 2001). The growing role of GPNs in the last three decades has enabled the internationalization of SMEs, particularly in many emerging economies. The position of SMEs in GPNs is nonetheless highly dependent on the types of GPN governance. In captive and hierarchy GPN, the position of SMEs is the least advantageous (Gereffi et al. 2005). There are several entry barriers for SMEs in terms of participation in GPNs, as they often lack capabilities and cannot provide production in the volumes required by TNCs. SMEs are further affected by pressure on TNCs to reduce their number of suppliers and their inability to improve capabilities (upgrade). In the last few decades, a new type of company, which becomes international right after inception, has also emerged, contrasting with the traditional internationalization theories. These new companies have been termed international new ventures (McDougall et al. 2004) or born globals (Knigh – Cavusgil 1996).

In Czechia, research on GPNs is widespread, particularly due to its heavy dependence on exports (exports of goods and services reach 80% of GDP, according to World Bank 2018a). Furthermore, around two thirds of these exports are part of GPNs (OECD – WTO 2016). The large scale integration into GPNs, not only in Czechia but also other Central European countries, has been enabled by large FDI inflows since the end of the 1990s mainly from Western European countries. Central Europe offered a suitable geographic location, cheaper and qualified labor force, an industrial tradition, a stable economic and political situation as well as investment incentives and later integration into the EU (Myant – Drahokoupil 2011; Vlčková 2017). The automotive industry, as the major exporting industry, has been mapped in detail (e.g. Pavlínek et al. 2009; Pavlínek – Žížalová

2014). SMEs in Czechia have become integrated into these GPNs, particularly in the automotive industry. Studies show that there exist spillover effects from TNCs to SMEs, although they are selective (Pavlínek – Žižalová 2014; Javorcik – Spatareaunu 2009).

Private SMEs in Czechia were non-existent before 1990 and emerged only after the fall of communism. Existing SMEs were privatized (as part of small privatization), some were restituted and many new SMEs emerged (Myant – Drahokoupil 2011). Currently, there are over 1.1 million SMEs, which account for 59% of employment and 53% of value added (MPO 2016), signifying their lower productivity. So far, in terms of internationalization of Czech firms, a few studies have emerged. In general, personal and business contacts are crucial for identifying opportunities in international markets (Chandra et al. 2009). In transition economies, the role of networking is even higher due to lower levels of trust (Myant – Drahokoupil 2011). According to Musteen et al. (2010), international contacts provide Czech SMEs with foreign market knowledge, which can enhance performance in the early stages of internationalization.

2.2. The medical technology industry

The MedTech industry covers over 500,000 products, from inexpensive syringes or bandages to expensive magnetic resonance machines or electrocardiographs. According to the WHO (2016), it includes: “all instruments, appliances, and materials that are designed for diagnostic and/or therapeutic purposes to monitor, treat, prevent or alleviate disease, injuries or handicap and that do not strictly achieve their action by pharmacological, immunological or metabolic means.” Due to the broad variety of products, Bamber and Gereffi (2013) distinguish four groups of products based on sophistication: disposables (syringes, needles, bandages, surgical gloves, etc.), medical and surgical instruments (dental instruments, dialysis, defibrillators, medical furniture, etc.), therapeutic devices (artificial body parts, hearing aids, implants, etc.) and diagnostic and imaging equipment (ultrasound, electrocardiographs, MRI, X-rays, etc.). However, with upcoming technological changes (such as digitalization), convergence products have emerged, combining medical devices, pharmaceutical products and ICT. For example, hospital beds can already perform diagnostic tasks or even apply drugs. Additionally, some products are sold as integrated solutions involving medical devices, training, consulting and other services. Thus, these categories can become increasingly blurred.

The MedTech industry is highly innovative. MedTech products typically have a lifecycle of only 18–24 months and almost 8% of patent applications to the European Patent Office are in the field of medical technology, more than in any

other sector (MedTechEurope 2016). On average, 10% of GDP is spent on health care in Europe (MedTech Europe 2016). It is also a constantly growing sector (by 5% per year on average in Europe) with further strong growth potential. This is affected mainly by ageing populations and increasing health care expenditures. Whereas global demand is concentrated in developed countries, emerging economies with rising incomes (particularly ageing in China) represent new growth opportunities (Araujo et al. 2011 in Bamber – Gereffi 2013). Similar to other industries, rising costs (of the health care system in general) have pressured for new strategies in terms of production and procurement (Graves 2011). This has contributed to the rise of MedTech production in several countries, firstly in Ireland, then later in emerging economies such as Costa Rica, Mexico or the Dominican Republic. These countries have become integrated into MedTech GPNs, which is also demonstrated by their rising exports, especially in disposables (see *Table 1*). Location decisions, apart from costs, availability of labor force and distance to the market are also affected by regulation. With increasing product sophistication, the regulatory requirements are much stricter (Weber et al. 2010). This is associated with higher vertical integration and it is one of the reasons why many activities are still kept in-house. The MedTech sector also faces several challenges, particularly those associated with shifts in reimbursement, consumer empowerment, digital enablement and the competitive landscape.

Similar to other industries, highest value added is generated through complex and innovative activities, particularly by research and development. This is further affected by regulatory requirements. R&D increases with product sophistication. The lowest value added generating segments include production and manufacturing (see the so-called smiling curve). Distribution, marketing and sales are

Table 1. Largest exporters of MedTech products in 2014

Rank	Exporter	Value (mil. USD)	Share of total
1	USA	51989	21.9%
2	Germany	35039	14.8%
3	Netherlands	21528	9.1%
4	China	15478	6.5%
5	Belgium	12995	5.5%
6	Switzerland	10896	4.6%
7	Japan	10328	4.4%
8	France	10244	4.3%
9	Ireland	9798	4.1%
10	Mexico	8258	3.5%
28	Czechia	1118	0.5%

Source: UN Comtrade (2016)

versatile from wholesale distributors to general procurement consortia or directly to hospitals (particularly in terms of high value added products). The sector is closely related to other services, such as consulting or training or providing clean room conditions.

Overall, the industry is dominated by lead firms, such as J&J Medical Devices, GE Healthcare, Siemens Medical or Medtronic, which account for almost 40% of the global market. Other companies in the top ten include Baxter International Inc., Fresenius Medical Care AG & Co., KGAA, Koninklijke Philips NV, Cardinal Health Inc., Novartis AG or Covidien plc (MDD Online 2017). SMEs account only for about 20% of the market. In Europe, there are over 26,000 MedTech companies, particularly in Germany, the UK, Italy and Switzerland. Over 95% are SMEs, mainly those that employ fewer than 50 people. Employment exceeds 650,000 people, with relatively (per population) the highest employment in Switzerland, followed by Ireland and Denmark (Medtech Europe 2016). Regulatory standards create an entry barrier for SMEs, particularly in the case of more sophisticated products. On the other hand, SMEs have been found to be twice as likely to launch radical innovations in the market as new firms (Bamber – Gereffi 2013; Forfås 2009). This is also one of the reasons for the widespread M&As of these innovative companies with regulatory compliance on new technologies. M&As have also been widespread in recent years among big corporations, such as Abbott's acquisition of St. Jude Medical or Alere (EY 2016).

3. DATA AND METHODOLOGY

In this paper, an interpretative qualitative case study is employed to explore SMEs in the MedTech sector in Czechia. We follow the global production networks framework. The GVC/GPN framework focuses on products, processes, labor, technologies, standards, regulations/policies and specifics of the locations as well as sectors. Both top-down and bottom-up approaches are combined (Gereffi – Fernandez-Stark 2016). There are no detailed and reliable datasets on the Czech Med Tech industry. Therefore, a combination of qualitative (firm-level) and quantitative (country-level) data is justifiable. Furthermore, such mixed methodology has been widely used for mapping value chains/production networks (see, e.g. Kaplinsky – Morris 2001; Pavlínek et al. 2009). A similar case study has been conducted on the MedTech industry with major focus on Costa Rica by Bamber and Gereffi (2013). We therefore compare the MedTech industry in Czechia to the situation in Costa Rica, and also Mexico and Ireland.

Intermediates which are an important part of GPNs cause double counting of exports. Traditional trade data do not reflect these specifics. Therefore, recently,

several datasets based on input-output models have emerged (e.g. OECD-WTO TiVA, WIOD, see Vlčková 2015), although these datasets are so far only available for around 30 industries and do not provide sufficient detail on the MedTech sector. A widely used approach is case studies of specific industries at the firm level (e.g. Hummels et al. 2011; Pavlínek – Žižalová 2014). Since this paper is a case study of the MedTech sector, micro (firm-level) data will be used in combination with macro (country-level) data.

In terms of country-level data, the OECD-WTO TiVA dataset will only be used to identify the position of Czechia in GPNs in general. Highly disaggregated trade data from UN COMTRADE (classification HS96) are used to identify the MedTech products that Czechia exports. Although this kind of data do not usually allow for the distinction between intermediate and final products, these are the only data available. Another problem is that the MedTech sector (as other sectors) also includes services, for which trade data are highly aggregated and of low quality. However, most of these services are embodied in the products (around 40% of the total value added of industrial products intended for export originate from the service sector; see OECD-WTO 2016) and firm-level analysis will help to identify it. The revealed comparative advantage will also be assessed in terms of Czech exports to identify the relative importance of the MedTech sector as well as individual product categories. NACE classification is used to identify the MedTech industry, specifically NACE 32.5: Manufacture of medical and dental instruments and supplies and NACE 26.6: Manufacture of irradiation, electro-medical and electrotherapeutic equipment. The Czech Statistical Office compiles detailed statistics within these categories, including the number of enterprises, employment, value added, R&D and others.

The firm-level data will be based on three sources. Firstly, it will be the data available from databases, such as Magnusweb or Amadeus. These provide information on the financial situation as well as number of employees, year of establishment, etc. Secondly, data from official firm web pages are used. Last but not least, findings from detailed interviews with six MedTech companies and also MedTech association representatives are utilized. All this information will serve as the basis for assessing the internationalization of MedTech SMEs. In most cases, the MedTech products are split into the four categories used by Bamber and Gereffi (2013). Additional data and information are also collected from the news, MedTech reports or cluster reports.

4. MEDTECH PRODUCTION NETWORKS IN CZECHIA

4.1. MedTech industry and the role of SMEs

Czechia focuses on exports of manufactured products and its comparative advantage is derived mostly from labor-cost effectiveness, favorable geographic location and industrial tradition (Vlčková 2017). The share of exports to GDP is very high (80%) as well as the role of manufacturing (24% of GDP). This is also reflected in its high participation in GPNs, which is among the highest in the world (currently 65%), although the backward linkages dominate and services embodied in exports in Czechia are far below the developed countries' average (48% versus 58% in the EU28).

The MedTech industry has a long tradition in Czechia. It started in the first half of the twentieth century and later gained significance for outstanding inventions, including the cardiology defibrillator, the polarograph (for which Jaroslav Heyrovský won a Nobel Prize in 1959) or hydrogel contact lenses. The production of medical technology since the 1950s has focused mostly on ECG machines, sterilizers, anesthetic devices and laboratory devices.

After the fall of communism, the industry went through a transformation process. It has witnessed significant growth in recent years and MedTech exports have increased tenfold since 1996, although its share of Czech exports is below 1 per cent (UN Comtrade 2017). In general, exports of MedTech products are dominated by developed countries, although several emerging economies have also become significant exporters, such as Mexico or Costa Rica (see *Table 1*). In international comparison, Czech exports rank at the 28th position. Nonetheless, production and exports are dominated by the group of disposables and medical and surgical products. More specifically, medical wadding, gauze, dressings; surgical and medical instruments; hospital furniture and needles and catheters accounted for almost 80% of exports in 2015. The share of therapeutic and diagnosis products, which are much more complex with higher value added, has risen considerably less. Currently, the major export product group is medical and surgical products and the share of disposables is stagnating (*Figure 1*). This is related to the high volume of exports of hospital furniture, particularly of the LINET Group, producing hospital beds (see below). However, the only category where Czechia has revealed comparative advantage ($RCA > 1$) is still disposables, although in terms of medical and surgical products, the RCA will probably also exceed 1 soon. Overall, Czechia remains a net importer of MedTech products, even though the balance has gradually reduced (MPO 2016) and it is likely that exports will surpass imports soon. This is because Czechia largely imports so-

Figure 1. The evolution of Czech MedTech exports based on product category

Source: UN Comtrade (2016)

phisticated and expensive MedTech products such as irradiation, electro-medical and electrotherapeutic equipment.

Despite the growth of the MedTech sector, its share of manufacturing in Czechia is only about 1 per cent. *Table 2* lists the evolution of the sector (NACE 26.6 and 32.5) since 2005. Currently, there are over 2,600 MedTech companies in Czechia which employ 1.2% of the manufacturing workforce. Thus, these companies are on average smaller in size compared to the whole manufacturing sector. Other indicators (such as revenues, turnover, output and assets) confirm this. Value added increased four times over the period, but its share of manufacturing production remained stable (around 1 per cent). There is a slight increase in the number of companies over the period, but decreasing value added per employee. This points to more labor-intensive low value added production and could be related to the establishment of TNC branches focusing on assembly of disposables in recent years. However, despite the rising share of employment in companies under foreign control, their value added per employee as well as average wages are higher (see *Table 2*). Foreign-owned companies are much bigger in size and can thus achieve scale economies. Declining value added per employee must be hence related to operations of small domestic companies and needs to be further explored.

The information on R&D shows a similar trend – around 1% of all expenditure on R&D and 1% of firms executing R&D from the manufacturing sector are in the MedTech industry. Although the number of firms undertaking R&D has increased significantly since 2005, only 27 of them do formal research. Most

Table 2. Data on MedTech manufacturing production in Czechia

Year/indicator	MedTech sector (NACE 26.6 and 32.5)				Share of manufacturing (%)			Share of companies under foreign control (%)		
	2005	2010	2015*		2005	2010	2015*	2005	2010	2015
Number of companies	2,237	2,162	2,666		1.5	1.3	1.6	3.3	4.5	3.4
Number of employees (FTE)	11,384	12,382	13,203		0.9	1.2	1.2	42.5	48.9	53.1
Average wage (CZK)	16,037	22,195	25,018		87.8	96.4	94.2	102.8	101.5	107.1
Revenues (mil. CZK)	11,192	18453,909	24777,823		0.5	0.5	0.5	42.7	49.7	53.1
Turnover (mil. CZK)	14253752	17771,105	23047,402		0.5	0.5	0.5	42.5	49.2	59.8
Output (mil. CZK)	9710199	15992,600	20186,790		0.5	0.5	0.5	50.4	52.0	57.4
Costs (mil. CZK)	12603,052	16605,877	22686,464		0.4	0.5	0.5	43.1	49.8	58.6
Assets (mil. CZK)	1170,573	14374,441	21135,965		0.6	0.6	0.7	19.5	40.3	47.1
Value added (mil. CZK)	2153,950	7132,549	8454,881		0.9	1.0	0.9	43.9	50.4	56.9
Value added per employee	189,215	573,487	640,598		90.5	81.9	73.4	102.8	101.5	107.1
Expenditure on R&D (mil. CZK)*	68	232	289		0.5	1.4	1.1			
Number of R&D workers (FTE)*	102	275	289		0.5	1.9	1.8			
Number of firms executing R&D*	16	26	27		1.0	1.2	1.1			

Source: Czech Statistical Office (2016)

* Data on R&D are from 2014

companies that engage in R&D invest between 1 to 10 million CZK per year. In comparison to R&D expenditure, almost 2% of R&D workers are in this sector. This could be related to the more specific nature of the MedTech sector, which is highly regulated. Further new solutions often need to be developed in cooperation with doctors, who are, in most cases, the final users. What the data also point out is the fact that in comparison to the manufacturing sector as a whole, a much bigger role is played by public finances in supporting R&D. Almost 17 per cent of R&D is funded from public sources, indicating that MedTech firms are able to take advantage of several programs, such as EU structural funds or the programs of the Technological Agency of the Czech Republic (TAČR).

The MedTech industry is highly innovative. Short production cycles thus require continuous improvements and breakthroughs in scientific and technological progress in cooperation with academic institutions as well as customers (Simoens 2009). Hence, firms are highly vertically integrated, intellectual property is strictly guarded and research is usually carried out in company headquarters. In captive GPNs, typical for the MedTech sector, suppliers are dependent on larger, dominant buyers and the relationship is typified by a high degree of control and monitoring from lead firms, which makes upgrading less probable (Gereffi et al. 2005). The possibility that suppliers and branches of MedTech TNCs in Czechia will upgrade to high value added activities, like R&D, is thus less likely. The MedTech GPNs differ from the automotive ones, where independent suppliers are more widespread, though quasi hierarchical or captive GPNs in terms of governance or also typical. Even in the automotive sector, upgrading was highly selective and very uneven among Czech suppliers (Pavlínek – Ženka 2011). In Czechia, there is an extensive network of research institutes and technical universities with specialized departments focusing on research in the area of biomedicine and clinical technology, educating highly-qualified specialists (such as the International Clinical Research Center of St. Anne's University Hospital Brno). Some fields, such as "instruments and instrumentation", are among areas where Czech research produces above-average results (Jurajda et al. 2015). Nonetheless, innovative MedTech companies focusing on sophisticated diagnostic appliances are lacking. Several MedTech companies have been cooperating with universities or academies of science, although cooperation between companies and universities/research institutions in Czechia has so far been limited. Limitations were identified on both sides, mostly due to the mismatch of needs and misunderstanding (TAČR 2015). One company has mentioned that they cooperate with local universities only on less complicated tasks and, for more complex R&D, they collaborate with foreign high quality institutions. R&D expenditure has risen considerably in Czechia, although business expenditures are much lower than in developed countries. Furthermore, venture

capital investment, crucial for highly innovative sectors such as MedTech, is far below the EU average, making Czechia a “moderate innovators” (European Commission 2016). The R&D data do not confirm the innovative character of the Czech MedTech sector. Hence, in order to explore the nature of the MedTech sector in Czechia, we need to examine the firms in detail.

Three major groups of MedTech firms were identified. First, there is a small group of subsidiaries of transnational corporations. These firms, in general, are among the biggest TNCs. There are only 85 of them, but they account for over half of employment (see *Table 2*). They focus on low-value assembly of disposable products and they have limited linkages to local firms and usually no R&D units. Many of them have emerged quite recently, taking advantage of investment incentives provided by Czechia. Firms like Smith Medical, Fresenius HemoCare CZ s.r.o. or Mölnlycke Health Care AB together received over 800 million CZK (almost 30 million EUR) in the form of corporate income tax relief (Czechinvest 2016). Other foreign subsidiaries include HARTMANN-RICO a.s., Gerresheimer Horšovský Týn spol. s.r.o., Arrow International or Lohmann & Rauscher s.r.o. Only Olympus Medical Products Czech spol. s.r.o., runs a research center.

The second group of firms are innovative firms, mostly Czech-owned. With a few exceptions, they are SMEs. Among these, LINET Group SE is a leader and significantly affects the MedTech export structure. LINET Group are the world's third largest producers of hospital beds (the biggest in Europe). This originally Czech company is now a part of LINET Group, located in the Netherlands, although Czechs have still retained 50% of ownership. LINET is a highly innovative company, with its own R&D team and many patented solutions. Medin a.s. engages in the production and distribution of medical instruments and implants. BMT Medical Technology s.r.o. is a part of the German MMM Group and produces and develops particularly steam and hot air sterilizers. Gama Group a.s. is a part of KOH-I-NOOR holding a.s. and focuses on the development and production of disposable medical, laboratory and veterinary products. Innovative SMEs in this group also include BioVendor – Laboratorní medicína, a.s. (laboratory technology), Beznoska (implants, tools, and surgical utensils), Ella CS (Biodegradable stents) or UJP Praha a.s. (radiotherapeutic devices).

The third most frequent group consists of SMEs with no R&D, usually Czech-owned. Some of these firms were established in the early 1990s or they existed before and were privatized. They usually do not have more than 50 employees and they focus particularly on the production of disposables for the local markets as well as exports. These firms include, for example, Invaz s.r.o. (bandages, gauze products), Klatro s.r.o., (handling carts), MPH Medical devices (tubings), or Panep s.r.o. (cotton gauze, surgical drapes, sets).

This distinction of firms confirms that, with a few exceptions, most of the MedTech production in Czechia is still concentrated in low-value added manufacturing of disposables. Furthermore, the role of foreign branches of TNCs is increasing, although disposables dominate in this case as well. MedTech is, in general, a knowledge-based industry. The lack of qualified labor force is considered to be one of the main limitations among Czech MedTech companies. Each stage of the GPN requires different skill levels of workers (Gereffi – Fernandez-Stark 2016). The supply of tertiary educated people is crucial, since with increasing product sophistication, the need for R&D and trials increases due to, among other factors, regulatory requirements. These standards create considerable entry barriers in the MedTech sector, particularly for SMEs. Overall, in order to upgrade to higher value activities and improve the position of Czech MedTech producers on global markets, several crucial aspects, such as a sufficiently qualified labor force, the institutional setting or overall business environment, need to be improved.

If the situation in Czechia is compared to other emerging MedTech exporters, significant differences can be observed. The medical technology industry has developed in Costa Rica because TNCs established production operations there. The motivations were driven by a competitive labor, favorable trade and investment regimes and proximity to the US market. Local firms in the sector are less frequent and focus mostly on low value added activities, such as packaging, which limits prospects for functional upgrading (Bamber – Gereffi 2013). MedTech production in Mexico is labor intensive (manufacturing and assembly), mostly mature products and for exports to the United States, with over 90% under a preferential tax regime. We can find support at the country as well as regional level for the MedTech industry in order to upgrade (education, programs for local suppliers, etc.). Despite some success, most production continues to be labor intensive. Mexico exports particularly disposables and therapeutic products (Bamber – Gereffi 2013). In Ireland, MedTech manufacturing operations began in the 1990s, with mostly by US-based companies serving the European market. MedTech exports now represent 10% of Irish exports (Irish MedTech Association 2017). Ireland has a favorable business environment and the government strongly supports the development of local suppliers in GPNs. Due to rising costs, some lower value production was relocated (disposables) in 2006. Ireland has been able to upgrade to higher value added activities with the increasing role of R&D and, although disposables dominated in exports before 2006, now therapeutics are the major export category. Furthermore, product development is concentrated in Irish start-ups, despite the huge number of MedTech manufacturing TNCs (Forfás 2009). In Czechia, the motivations for TNCs to establish operations are very similar as in some of the aforementioned countries (relatively cheap labor,

EU membership, proximity to Germany). However, the role of TNCs is much smaller, their investment is more recent and the industry has existed before. It needs to be stressed that MedTech exports for Costa Rica, Mexico and Ireland are significantly higher than for Czechia.

4.2. Internationalization of MedTech SMEs

Between a quarter and a third of European SMEs were involved in exporting or importing, whereas in other modes of internationalization less than 8% were active (European Commission 2018). Among Czech SMEs, exports dominate and several MedTech associations, which support MedTech companies in their expansion in domestic and foreign markets, operate in Czechia. This is because scale economies require SMEs to cooperate with each other to achieve so-called “collective efficiency” (Schmitz 1995). The Association of Manufacturers and Suppliers of Medical Devices (AVDZP) has over 90 members and focuses on industrial development and exports, and the Czech Association of Medical Devices Suppliers (CzechMed) has 23 members and concentrates on the regulatory framework, ethics and reimbursement. Furthermore, there are two other associations – The Czech Association of Manufacturers and Suppliers of In Vitro Diagnostics (CZEDMA) and The Community of Producers and Vendors of Medical Devices.

The large-scale participation in GPNs in Czechia suggests that MedTech companies will also be linked to GPNs. Subsidiaries of TNCs generally source most of their inputs from abroad (backward linkages). Domestic firms also source inputs from abroad, particularly those of higher quality/sophistication, with supplying industries ranging from chemicals and metals to electronics. Many producers export intermediates. Internationalization, in terms of exports, is thus widespread, since two-thirds of MedTech production is exported (CzechInvest 2016). The major export markets for Czech MedTech products are EU member states, particularly Germany, followed by Belgium and France. The United States are the second biggest export destination for medical and surgical products, due to large exports of the LINET group’s products (hospital beds). Slovakia, due to its close historical ties, is also in the top five. However, as Table 3 indicates, there are differences in export markets in terms of product sophistication. The most sophisticated therapeutic and diagnostic products are much more often exported to the Central and Eastern Europe (CEE) region, particularly the Russian Federation, Slovakia, Poland or Bulgaria, compared to disposables. This points to the fact that for more sophisticated Czech MedTech products, getting access to emerging countries can be easier because they have less strict regulatory requirements on MedTech products. Exporting to emerging markets, such as the BRICS

Table 3. Top five destinations for Czech MedTech exports, based on product category, 2015

All MedTech products (100%)		Disposables (41 %)		Medical and surgical products (51%)		Therapeutic products (2%)		Diagnostic products (5%)	
Germany	29%	Germany	30%	Germany	31%	Slovakia	23%	Russian Fed.	18%
Belgium	10%	Belgium	24%	USA	7%	Switzerland	20%	Germany	13%
France	8%	France	12%	France	6%	Poland	13%	USA	13%
Slovakia	6%	Sweden	6%	Sweden	6%	Italy	11%	Netherlands	12%
Sweden	5%	Slovakia	5%	Austria	5%	Russian Fed.	10%	France	11%

Source: UN Comtrade (2016).

countries, has thus shown to be an opportunity for innovative Czech MedTech firms. Another challenge is the fact that whereas low value products tend to be distributed through wholesale distribution channels, high value products, such as MRI or electro-cardiographs, are likely to be sold directly to the hospitals (Bamber – Gerrefi 2013). Thus, finding a local partner is often necessary. Lead firms in the MedTech sector often acquire new products through mergers and acquisitions (Simoens 2009), which represents a further opportunity for innovative Czech SMEs.

Higher forms of internationalization, such as launching sales or production branches abroad, are rather rare and are to be found in the second group of firms (innovative). Most of them establish foreign branches only in the form of dealerships, particularly in neighboring (post-communist) countries, like Slovakia, Poland and the Russian Federation. This is driven by getting access to their markets and possibly also cheaper labor costs. A few successful innovative firms also have production facilities in Germany or Austria. According to interviews with Czech MedTech companies, they benefit from their membership in MedTech associations through sharing information or possibly getting access to governmental delegations abroad. MedTech companies also benefit from services offered by other institutions: EGAP (The State Credit Insurance Corporation) provides them with export guarantees, CzechTrade provides information on foreign markets or supports participation in trade fairs and The Czech Export Bank provides other incentives or financing. One of the representatives of a Czech company, which also undertakes R&D, stated as a considerable limitation the fact that Czech hospitals prefer foreign products. This makes exports impossible when they do not have references from the home market. Furthermore, new regulation requires domestic producers of the least dangerous MedTech products, which do not get implanted, to register them, whereas importers do not need to. This gives domestic producers a competitive disadvantage. Apart from bureaucracy, MedTech SMEs also face other constraints typical for Czech SMEs, such as exchange rate risk, competition or rising costs (AMSP 2017).

Overall, according to research by TAČR (2015), a quarter of firms in Czechia do not have any ambitions in terms of their development and cost competitiveness is crucial for them. This is probably the case of most Czech MedTech companies producing disposables. Another reason for keeping production local in the case of Czech-owned firms is, according to one manager, the fact that they are “a Czech company with Czech managers.” Other problems that hinder upgrading and internationalization include stagnating productivity and the unavailability of skilled workers, the latter being related both to the settings of the education system as well as very low unemployment rates. Furthermore, a problem among Czech SMEs with R&D units is the fact that the R&D workers they trained are often poached by TNCs establishing their own research centers in Czechia (Vlčková 2017).

Several things can support internationalization among Czech (MedTech) firms. Successful domestic companies provide good examples and also support entrepreneurship among local people, which is low in comparison to developed countries (Ács et al. 2014), particularly due to the country’s communist history. Some of them are international from their beginning (the so-called born globals). Introducing entrepreneurial education as well as supporting e-government policies could help. Other necessary conditions are the improvement of the business environment and overall institutional settings, particularly governmental regulation. Furthermore, there are questions related to the (non)existence of industrial policy in Czechia. The setting of governmental programs that help SMEs develop international networks and ties should be reviewed to maximize the benefits for SMEs.

5. CONCLUSIONS

This case study of the medical technology sector in Czechia placed a major focus on the position of Czech firms, particularly SMEs, in global production networks and their internationalization. The MedTech industry is among the most innovative, with the highest number of patent applications. It is also highly regulated to comply with strict safety standards. Due to ageing populations not only in developed countries, and increasing incomes in emerging economies, it has high growth potential. The MedTech industry has a tradition in Czechia and its exports have risen tenfold over the last twenty years. Despite this it still only accounts for around 1 per cent of the manufacturing sector and less than one per cent of Czech exports. Most of the firms are SMEs focusing on low-skilled, low value production, particularly of disposable products such as wadding, gauze, dressings or needles and catheters. However, production of medical and surgical products

is also on the rise. This is related to the rising production of hospital furniture, especially hospital beds in the LINET Group, the second largest MedTech corporation in Czechia.

Three types of MedTech firms have been identified in Czechia: the branches of TNCs that focus mostly on low-skilled assembly of disposables. These firms usually have no R&D, are less embedded in the local economy and source most inputs from abroad. Although there are only a few of them, they are among the biggest and account for around half of the employment in the MedTech industry. The second group is comprised of innovative firms, which are mostly Czech-owned SMEs. These firms have their own R&D units and often have some patented solutions. The third most widespread group consists of mostly Czech-owned SMEs with no R&D, with production concentrated on disposables, such as bandages, gauze, tubings or surgical sets. Czechia thus differs from middle-income MedTech exporters like Costa Rica or Mexico, where 95% of medical production has been under a preferential tax regime (Bamber – Gereffi 2013). Although Czechia attracts MedTech FDI for similar reasons (favorable geographic location, cheaper costs and investment incentives), the role of TNCs is smaller and several successful domestic MedTech firms are present. Despite the differences between the automotive and Medtech industries, upgrading among Czech MedTech companies is also rather selective as is the case among Czech automotive suppliers.

The internationalization process among Czech MedTech firms has, so far, been limited. Whereas branches of TNCs are international in their nature, the internationalization process in most cases only takes the form of exports, since two-thirds of production is exported. Only some of the more innovative domestic firms have operations outside Czechia. These often take the form of dealerships, mainly in Slovakia. When, rarely, production is located outside the country, it is usually in neighboring countries, such as Slovakia or possibly Poland. The motivations for establishing branches abroad are better access to these countries and also possibly lower labor costs in terms of production. Most of the firms do not have any ambitions for further internationalization. Production in the majority of SMEs is based on low costs, with attention given to optimization of processes in order to lower unit costs even further, while keeping the same product quality.

For upgrading to higher value added activities and products, a qualified labor force is crucial. In addition, for the selection of location by MedTech TNCs, human capital has been identified as the most important factor (Kimelberg – Nicoll 2012). Despite the fact that MedTech TNCs are strongly vertically integrated and captive production networks are typical for this industry, Ireland has been able to upgrade in the MedTech sector, by providing a suitable business environment, supporting networking, entrepreneurship, developing talent and collaborating with convergence sectors, such as ICT and biopharma. Due to the tightened situ-

ation on the Czech labor market, a more open immigration policy towards qualified workers, e.g. from former Soviet countries, is a possible solution. Improving the business environment, particularly the exaggerated bureaucracy, is also crucial. Supporting programs for building international contacts might strengthen the internationalization process, although many of them are already in place. The author believes that providing good examples of domestic firms successful in global markets, such as LINET or Biovendor, can increase the ambitions of local firms and support entrepreneurship in general. Greater focus on the CEE markets, where Czechia has historical economic ties, particularly regarding more sophisticated MedTech products, is another option, especially in countries outside the EU, where the regulatory requirements are likely to be less strict and quality standards lower, enabling Czech producers to compete with lower prices. The Russian Federation is already one of the major export destinations for diagnostic products.

MedTech manufacturing firms were mainly examined in this research. Due to the fast pace of technological progress, the MedTech industry is also undergoing changes to so-called connected health solutions, with a bigger role for ICT and services in general. In Czechia, there are several start-ups focusing on health applications. For such companies, the regulatory requirements are completely different and also the process of internationalization can be much easier. This represents another opportunity for Czech firms to integrate/upgrade in MedTech GPNs. Nevertheless, detailed research among Czech firms connected to the MedTech industry and also in the service sector is needed to provide more information on firms' ambitions, limitations and other aspects.

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