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The Potential for High-tech Exports from Selected EU Member States to China and the Related Opportunities Arising from the Belt and Road Initiative

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Abstract

The EU's economic relations with China are characterised by a significant trade deficit. Enhancing EU exports of high-tech products, in particular, to China is the best way out of this imbalance. In doing so, EU countries can take advantage of the opportunities provided by the Belt and Road Initiative (BRI) that intends to improve connectivity between Europe and Asia.

Objective: This study aims to identify the untapped potential for high-tech exports of selected EU countries in trade with China and to evaluate the opportunities arising from the BRI in utilising this potential.

Research Design & Methods: To assess the overall high-tech export potential of selected EU countries to China, the export gap was calculated using the concept of revealed comparative advantages.

Findings: Among the examined EU countries, Hungary and the Czech Republic were found to have the greatest high-tech export growth potential to China. The largest export gaps were recorded in electrical machinery and equipment.

Implications & Recommendations: The findings of the study can be used by European businesses to adjust their export strategies. It can also be used by government institutions of the studied

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countries when designing their economic and trade policies, particularly vis-à-vis China and the BRI initiative, within the field of supporting infrastructure projects, as well as high-tech industries.
Contribution & Value Added: The study contributes to the literature on the potential of EU export growth to China that has not been sufficiently explored yet. The novelty of the study is in identifying specific high-tech commodities with the highest potential for export to China.

Keywords: European Union, China, export potential, high-tech products

JEL: F10, F50, P45

Introduction

China's ambition to become the leader of the world's strongest economies is evident. It was one of the reasons for launching the most significant initiative in modern Chinese history, the Belt & Road Initiative (BRI), in 2013 to revive the ancient Silk Road using the most modern technologies.

The BRI aims to increase China's and allegedly also its trading partners' economic and trade potential by improving connectivity between Europe and Asia. The BRI can, therefore, be understood as a mutual connection of countries and economies, especially those of the Eurasian continent, through various projects.

China actively promotes its interests in the European part of the continent, which is largely represented by the EU. Therefore, it is extremely important for the future of the EU to cooperate effectively with China within the BRI so that it is a "win-win" cooperation for both parties. This need is especially evident when looking at the EU's high trade deficit with China. Enhancing EU exports to China, in particular, high-tech products, is the best way out of this imbalance. In the high-tech sector, the EU and its member countries achieve comparative advantages, while China remains a significant importer of a variety of their products. Therefore, this article aims to identify the unused export potential of selected EU countries in trade with China in high-tech products and to evaluate the opportunities arising from the BRI in utilising this potential.

Currently, we can observe that the opportunities arising from BRI implementation differ depending both on the country's economic characteristics and its approach to the initiative. For this reason, we selected several EU countries, including Germany, France, Italy, the Netherlands, Greece, Hungary, the Czech Republic, and Slovakia. Germany and France represent the largest economies in the EU and are China's most important trade partners among the member countries. Together with the EU authorities, they share concerns that key elements of China's trade and industrial policy, such as infringement of intellectual property rights, forced technology transfer, a lack of investment transparency, and a lack of reciprocity, are economic threats to the EU. They are also concerned about the influx of Chinese investment and its alleged implications, particularly political influence, control of key transport hubs, and access to sensitive technologies. Although they are sceptical about the BRI, they cannot be excluded from the initiative because of their economic size and geopolitical position.

Hungary, the first EU country that officially joined the BRI, the Czech Republic, and Slovakia represent EU member states with a positive attitude towards the BRI. They are involved in the 16+1 platform for cooperation among China and the Central and Eastern European (CEE) countries. They were the first EU countries to sign cooperation memoranda with China in 2015. In deepening cooperation with China, they are primarily motivated by economic factors, especially interest in Chinese investments. Improving relations with China gives these rather small and economically weak European countries, which in the past were influenced by Russia and currently depend economically on Germany, more strategic and economic freedom.

Following the CEE countries, other EU economies with key European ports, such as Greece, the Netherlands, and Italy, joined in supporting the BRI initiative. Italy and Greece represent indebted EU countries. They welcome participation in the BRI as they expect that, thanks to Chinese help, they can overcome their own economic problems. Italy was the first G7 country to join the BRI, drawing public criticism from both Germany and France. However, according to the Italian Minister of Economic Development, Luigi Di Maio, such cooperation can contribute to reducing the trade imbalance between Italy and China (Astana Times 2019). Greece is another EU country that welcomes BRI cooperation. Although European creditors imposed austerity measures on Greece in 2010, China has invested in Greece since 2009 in the port of Piraeus. Piraeus has thus become the busiest port in the Mediterranean and is one of the key hubs of the BRI. The Netherlands has a unique position as an important European re-export hub, and it sees the BRI as an opportunity to improve that position.

Literature review

The potential for EU export growth to China is not sufficiently exploited within the literature. The export potential of some EU countries to China has been investigated by Brenček (2019) and Kašťáková, Luptáková, and Družbacká (2022). Brenček addressed Slovakia's unused export potential to China based on data from 2001 to 2017. He found that Slovakia has the potential to export products from engineering, chemistry, agriculture, the woodworking industry, and metallurgy with a lower level of sophistication compared to the products of Western European countries. To determine the unused export potential, he proposed an export gap index using the concept of revealed comparative advantages. Revealed comparative advantages are based on Ricardo's (1817) classical theory of international trade, according to which trade between countries results from relative differences in labour productivity. This theory is based on the assumption that labour is the only factor of production.

Later, within the neoclassical theory of international trade, the differences in relative endowments of all production factors, including labour, natural resources and capital, have been used to explain countries' comparative advantages. Comparative advantages are useful in comparing relative production costs, explaining the export specialisation of a country, and identifying products that are most likely to succeed in foreign markets. As pointed out by Stellian and Danna-Buitrago (2019), the concept of comparative advantages refers not only to the ability to produce some goods with higher productivity compared to other countries but also, in line with the new trade theory, to increase product differentiation. It can also provide useful information about a country's potential business prospects with new partners. For example, it is unlikely that countries with similar revealed comparative advantages have high bilateral trade intensities, except for intra-industry trade (World Bank 2010). Much research has been based on the concept of revealed comparative advantages, including Balassa (1965; 1986), Vollrath (1991), Hinloopen and Van Marrewijk (2001) and Hoen and Oosterhaven (2006).

Kašťáková, Luptáková, and Družbacká (2022) identified the export potential to China of its largest trading partners within the EU – Germany, France, Italy, and the Netherlands. To identify products that have good prospects of additional export to China, they calculated the Export Potential Indicator using the methodology of Decreux and Spies (2016). The potential EU export value of a specific product to China, according to this methodology, is determined by three factors: supply (i.e. exporter performance in exporting the product), demand for the product (by the importing country), and the ease of exporting any good from one partner to another. The findings of this study indicate that Germany has the largest export potential to China, followed by France, Italy, and the Netherlands. The untapped export potential for these four countries amounts to US$174 billion, of which Germany accounts for US$114.7 billion. The products that the four countries could sell to China the most include mainly cars and car parts, machinery, medicine, and aeroplanes.

In contrast to the two studies above, this study focuses on examining the export gap of EU member states in the high-tech sector because, in the 21st century, these technologies play a key role in achieving competitiveness. EU countries should, therefore, develop their export potential primarily in high-tech products. Over the last two decades, investments in research, development, and innovation have been an important part of EU economic strategies such as the Lisbon Strategy and the "Europe 2020" strategy.

Braja and Gemzik-Salwach (2020) point out that growing global competition for less knowledge-intensive products naturally pushes the EU and its member states to move to knowledge-intensive industries. They state that European business owners must be involved in these industries to win the economic competition at the European and global levels. Similarly, Ribeiro, Carvalho, and Santos (2016) argued that European countries should support the export of high technology. In addition, they state that a shift towards greater diversification of export partners is desirable. Namely, there should be a shift from the most representative countries in the export portfolio, such as the USA, to less representative ones, and countries with higher growth potential, such as China.

The literature contains several empirical studies that look at the BRI initiative in the context of trade between China and the EU. Focusing on nine railway lines, Li, Bolton, and Westphal (2018) examined the impact of transcontinental railways under the BRI on trade between China and its trading partners in Central Asia and Europe. The results showed that railways increase the intensity of trade between China and its trading partners. This applies mainly to the import of Chinese products but only to a limited extent to the export of European and Central Asian products to China. If trade prospers, partner countries can use their comparative advantages, leading to win-win situations. Therefore, trade expansion is a common goal of many countries. The railways under study here are significant factors in achieving this goal.

Liu et al. (2019) investigated the impact of the route of the New Silk Road through the North Sea on China–Europe trade potential. Based on the analysis of the impact of building a sea route and expanding the use of sea routes in trade through a gravity model and regression analysis, they measured the trade potential between China and Europe. The results indicate the Northern Route has a positive impact on the growth of trade potential between China and Europe. The export, import, and overall trade potential of China to Northern European countries has increased significantly, mainly because of route shortening. Germany, Great Britain, the Netherlands, and France, which are China's biggest trading partners in Europe, have also seen a big increase in their trade potential.

Garcia-Herrero and Xu (2016) used a gravity model to determine the relationship between transportation costs and trade of the BRI countries. They found that a 10% reduction in railway, air and maritime costs increases trade by 2%, 5.5% and 1.1%, respectively. Similarly, Fardella and Prodi (2017) assessed the potential benefits for Europe of infrastructure development, including railways and ports, along the BRI. They consider new investments in railway and port infrastructure, which decrease transportation costs and increase trade volumes, to be an important stimulus for the growth of trade between the EU and China. They conclude that the development of new railway connections will benefit most of the Northern and Central European countries that export high-value products to China.

As part of the New Silk Road, Ma et al. (2019) analysed Chinese foreign direct investment (FDI) inflows to the EU to examine their impact on bilateral trade. They performed the analysis using a gravity model for the years 2003 to 2016, which was a period when not only Chinese trade but also Chinese FDI outflows grew rapidly. They found that both BRI and Chinese FDI had a positive effect on China's exports to European countries and a negative effect on exports from European countries to China in the period under study but with a small level of significance. According to the study, Chinese FDI had both complementary and substitution effects on trade with the EU, and the complementary effects were much stronger than the substitution effects. The authors expect EU exports to China will grow gradually thanks to the BRI.

Using a gravity model, Karkanis (2018) assessed the factors that influenced exports and imports between the EU and China from 2001 to 2015. Because, in the long term, the EU imported more from China than it exported to China, he wanted to identify factors that could help reduce this imbalance. His results confirmed that the distance factor had a significant negative impact on both EU exports to China and EU imports from China, but this impact was stronger with EU exports. As expected, market size and income had a positive impact on EU exports and imports, while the EU's GDP per capita had a relatively stronger impact on EU exports than on imports.

In addition, he investigated the influence of two variables that do not change over time (time-invariant proxies), namely the insularity and the landlocked nature of EU countries. For both variables, he found a positive impact on EU trade with China. He explained the positive impact of insularity, especially on EU exports to China, with the case of Ireland. It is an island country with a small market size and relatively limited expansion potential. To boost economic growth, the pro-export nature of the economy was therefore supported. With Malta and Cyprus, the island character had a more significant influence on imports from China because these countries have limited human and natural resources, as well as a limited range of domestically produced goods. The rather unexpected positive impact of the landlockedness of some EU countries (e.g., Austria, the Czech Republic, Hungary, Slovakia, and Luxembourg) on exports to China is explained by the positive externality of being at the crossroads of large markets such as Germany, France, Italy, and Poland, on the one hand, and China on the other, particularly regarding the established transport networks. Karkanis assumes that building railways will help exports to China, especially for the EU countries that are landlocked.

From the empirical studies mentioned above, it follows that building infrastructure within the BRI has a positive effect on "shortening" the distance between the EU and China, which contributes to the growth of mutual trade, even if, so far, the positive effect is manifested mainly on the side of Chinese exports to the EU.

Methodology

To assess the overall high-tech export potential of selected EU countries to China, we calculated the "export gap." For the calculation, we used disaggregated annual data on trade in goods at the HS–6 level from the International Trade Centre (ITC) database

(International Trade Center 2022a), which is based on data from UN COMTRADE and ITC statistics. At the HS–6 level, we selected 279 commodity groups identified as high-tech products by Fontagné, Freudenberg, and Ünal-Kesenci (1999). This list is a modification of the joint list of high-tech commodity groups prepared by Eurostat and the OECD (Lemoine and Ünal-Kesenci 2002).

First, we identified high-tech products in which the selected EU countries achieve comparative advantages. We calculated the Revealed Comparative Advantages (RCA) index, which is extensively used in the literature to evaluate a country's export potential (Hauk and Deb 2017). There are several methods for calculating RCA while the selection of a particular RCA index should be governed by the objective of the research (French 2017). In this study, we use one of the original formulas for calculating RCA by Balassa (1965). His index measures the relative advantage or disadvantage of a country's exports in a particular commodity group with respect to the world exports of this commodity group. It is widely used in the literature due to its clear economic interpretation and simplicity (Hadzhiev 2014). Recently, it was used by Brakman et al. (2022), who determined the comparative advantages of the Netherlands relative to the world, Falkowski (2018), to evaluate the competitiveness of the Baltic States in trade in high-technology goods, Pitoňáková (2020), who identified the comparative advantages of Slovakia on extra EU markets, Arsyad et al. (2020) to assess the competitiveness of palm oil products of Indonesia and Malaysia, and Torrecillas and Martínez (2022), who calculated the RCA for various product categories associated with the olive fruit using export data.

The used mathematical formula of RCA is:

$$RCA_{jk}^{n} = \frac{\frac{X_{jk}^{n}}{X_{j}^{n}}}{\frac{X_{wk}^{n}}{X_{w}^{n}}}, \qquad (1)$$

where X_{jk}^{n} represents the export of country *j* in commodity group *k* in year *n*, X_{j}^{n} represents the total export of country *j* in year *n*, X_{wk}^{n} represents the world export of commodity group *k* in year *n* and X_{w}^{n} represents the total world exports in year *n*. The basic interpretation of the result is that if $RCA_{jk}^{n} > 1$, the country achieves a comparative advantage in the given commodity group, and conversely, $RCA_{jk}^{n} < 1$ indicates a comparative disadvantage. According to Hinloopen and Van Marrewijk (2001), the results of the index, i.e. the intensity of comparative advantages, can be interpreted as follows:

$0 < RCA \leq 1$ indicates a comparative disadvantage,

$1 < RCA \leq 2$ indicates weak comparative advantage, 2 < RCA ≤ 4 indicates a moderately strong comparative advantage,

4 < RCA indicates strong comparative advantage.

Separately, for each of the selected EU countries, we calculated the RCA for all commodity groups at the HS6 level for which data was available. The RCA was calculated for five years – from 2016 to 2020. From the values of annual RCA indexes, we calculated an arithmetic average, which helped to "smooth out" potential fluctuations in exports in individual years.

Subsequently, the Import Significance (IS) index was calculated and used to identify products that China imports to a greater extent than the rest of the world (Brónček 2019). In this way, it was possible to identify commodities with increased demand from China and, thus, from the EU's point of view, commodities with a good export perspective. The formula for calculating the IS index is a changed formula for calculating RCA, using import values instead of export values. Its mathematical formula is:

$$IS_{jk}^{n} = \frac{\frac{M_{jk}^{n}}{M_{j}^{n}}}{\frac{M_{wk}^{n}}{M_{w}^{n}}}, \quad (2)$$

where M_{jk}^{n} represents the import of country *j* in commodity group *k* in year *n*, M_{j}^{n} represents the total import of country *j* in year *n*, M_{wk}^{n} represents the world import of commodity group *k* in year *n*, and M_{wk}^{n} represents the total world import in year *n*. If the value of IS > 1, the country imports the given commodity group to a greater extent than the rest of the world, and in the case of IS < 1, the country imports the given commodity group to a lesser extent than the rest of the world.

In this study, we calculated China's IS index values for 247 commodity groups at the HS6 level from 2016 to 2020, from which the average IS for the five years under study was calculated.

Next, we calculated an export gap defined by Zábojník and Borovská (2021) as:

$$EG_{jik}^{n} = \left(\frac{\sum_{n0}^{n} \frac{X_{jk}}{M_{wk}}}{(n-n0)+1} - \frac{X_{jik}^{n}}{M_{ik}^{n}} \right) M_{ik}^{n}, \quad (3)$$

where:

EG^{n}_{jik} is the export gap of country *j* for commodity *k* exported to country *i* in year *n*,

X_{jk} is the export of commodity *k* to country *j*,

M_{wk} is the world import of commodity *k*,

X^{n}_{jik} is the export of commodity *k* from country *j* to country *i* in year *n*,

M_{ik} is the import of commodity *k* to country *i* in year *n*,

n is the year for which we calculate the export gap,

*n*0 is the first year in the interval in which we calculate the average RCA_{jk}.

The condition for calculating the export gap is that the average share of the examined EU country's exports in world imports for the given time interval is greater than the share of the examined EU country's exports in Chinese imports in year *n*.

We calculated the export gap for commodity groups that meet the following condition:

$$\overline{RCA}^{t}_{j'} \geq 1 \cap \overline{IS}^{n}_{ik} \geq 1 \quad (4)$$

in which selected EU countries achieve comparative advantages, and China has comparative disadvantages with a minimum Balassa index value of 1.

The calculation of the export gap based on the intersection of exports (supply) of one country and imports (demand) of another country serves as a starting point for assessing prospective export commodities. For this aim, we supplemented the results of the export gap calculation with an assessment of several market access data, such as the average tariff imposed by China, the concentration of supplier countries, the average distance between China and its import partners, the average distance between the country and all its import markets, or the number of requirements related to China's import of the commodity.

One of the main limitations of our approach is that the calculation of the export gap is based on historical trade data and thus considers only products that one country already exports and the other imports. Another limitation concerns the measurability of export market access. The utilisation of the export gap depends on several factors that cannot be measured, like the specific needs of buyers, the administrative burdens and marketing opportunities in the importer's country, or the costs of export support activities.

Results and discussion

Exports of high-tech products accounted for up to 20% of total world exports in 2020, and their dynamics helped improve performance in other sectors (World Bank 2022). The World Intellectual Property Organization (2021) reported that the pandemic hurt international trade in 2020, but trade in high-tech goods expanded because of the boom in communication, computing, processing, and data equipment used for remote work. The EU is among the world's key producers of high-tech products. During the period under review, high-tech products accounted for approximately 16% of its total exports. In 2018, the EU had an estimated 40,358 companies in the high-tech manufacturing sector, which represents 0.2% of the total number of businesses in the EU. The countries with the most high-tech manufacturers were Germany (8,461), Italy (5,318), and Poland (4,446) (European Commission 2021).

The revealed comparative advantages of selected EU countries

Chart 1 summarises the number of commodity groups in which individual EU countries achieve a comparative advantage based on the average RCA value between 2016 and 2020 in the high-tech sector. Germany had the most comparative advantages, with a total of 108 commodity groups with an RCA ≥ 1. According to the chosen approach, Germany achieved a moderate comparative advantage in 49 commodity groups and a strong comparative advantage in 10 of these. Strong comparative advantages were recorded, especially in the fields of optical, photographic, cinematographic, measuring, and control instruments and devices. For example, Germany exports up to seven times more stereoscopic microscopes and hydraulic and pneumatic automatic controls than the rest of the world, making it the world's largest exporter of these commodities.

In the high-tech industry, France has a comparative advantage in 79 commodity groups, and it is strong in 14 instances. With aeroplanes and other motor aircraft commodity groups, France reached a Balassa index of 13.7, mainly because of Airbus, which is one of the world's major manufacturers of civil transport aircraft and regularly competes only with Boeing. The Netherlands, Italy, and the Czech Republic achieve comparative advantages in the high-tech sector in approximately 60 commodity groups.

The Czech Republic exports the most commodity groups, with a Balassa index value of over ten among all countries analysed. For example, it exports up to 35 times more weapons than the rest of the world, mainly thanks to Česká zbrojovka a.s., which ranks among the world's largest manufacturers of small arms. The country also dominates the export of microscopes, proton microscopes, and diffraction instruments ($\overline{RCA}^{t}_{jk} = 25$), mainly thanks to Tescan Orsay, Delong Instruments, and Thermo Fisher Scientific.

Slovakia has a comparative advantage in high-tech exports in 25 commodity groups. The highest comparative advantage was recorded for commodity group HS 854081 – receiver or amplifier valves and tubes ($\overline{RCA}_{jk}^{t} = 19$), which were exported by companies such as LEONI Slovakia, spol. s.r.o., Klauke Slovakia s.r.o., and KE Prešov Elektrik, s.r.o. among others. In most cases, these companies have foreign capital. Greece has the fewest high-tech commodity groups (11) with a comparative advantage among the analysed EU countries.

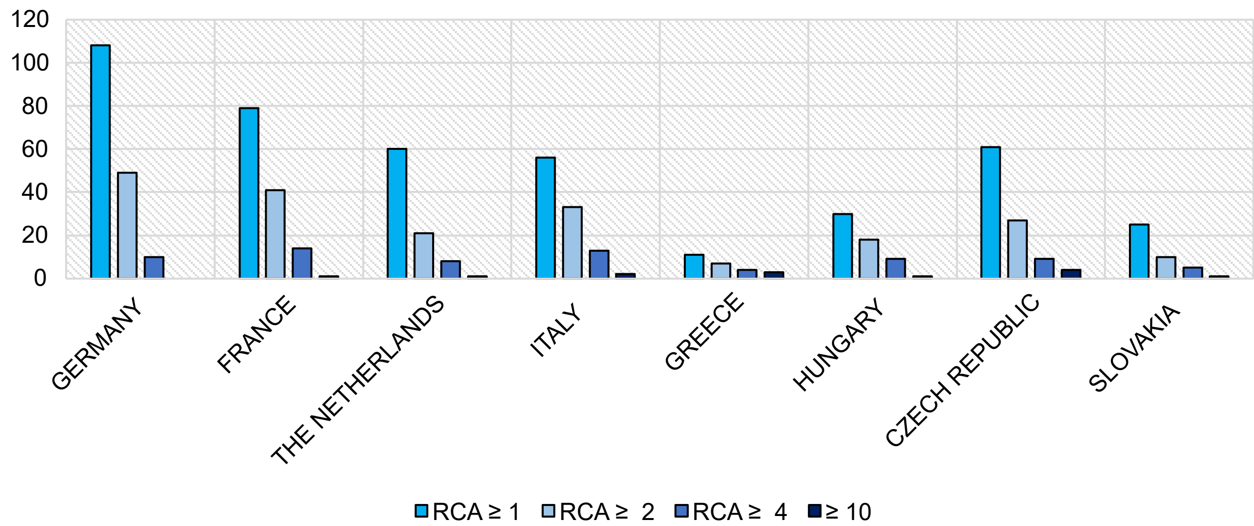

Chart 1. The number of high-tech commodity groups at the HS–6 level in individual EU countries based on the average RCA value between 2016 and 2020

Source: processed based on own calculations of data from International Trade Center 2022a.

China's import significance

According to the World Bank (2022), China's high-tech products account for up to 31% of its total exports, placing it at the forefront of technology exporters. Even in these sectors, there are commodity groups where China achieves high import signifiance index values. The list of China's most important imported high-tech commodities based on the average IS index from 2016 to 2020 is given in Table 1. On the first three rungs, optical instruments predominate. The highest index value was achieved by optical microscopes for photomicrography, cinephotomicrography, and microprojection, of which China is the largest importer in the world, with Germany, Japan, and Singapore accounting for most imports. The second highest value of the index was recorded for other liquid crystal devices assembled from products not more precisely specified, which China imports mainly from other Asian countries such as Japan, Singapore, and the Philippines. These devices are used in the production of LCD televisions and displays, for instance.

Another important commodity group for China includes sheets and plates of polarising material, which are used in the production of optical fibres and to remove glare from windows and objects such as car dashboards, LCD screens, and television screens. Similarly, Japan, South Korea, and the United States are major Chinese suppliers of these commodities. Germany and France round out the top ten most important Chinese suppliers of this commodity group.

Even though China has a lot of natural mineral resources, silicon has a high import significance index. It is also an important commodity for the Chinese industry, as it is used in semiconductor manufacturing to produce the silicon wafers necessary to produce integrated circuits, computer chips, solar cells, and other devices. In 2020, the value of this commodity's imports into China exceeded US$1 billion, with Germany accounting for nearly 50% of the total. They are mainly followed by commodities belonging to the category of electrical machines and devices. Fourteen of the examined commodities had an IS index greater than 3, indicating that China needs these high-tech commodities three times more than the rest of the world.

Table 1. China's top 10 high-tech commodity import groups at the HS–6 level with the highest average IS value between 2016 and 2020

HS code	Product label	Average IS index 2016–2020
901120	Optical microscopes for photomicrography, cinephotomicrography or microprojection	7.126
901380	Liquid crystal devices, n.e.s. and other optical appliances and instruments not elsewhere specified	5.650
900120	Sheets and plates of polarising material	5.297
280461	Silicon containing >= 99,99% by weight of silicon	3.882
854160	Mounted piezoelectric crystals	3.871
854190	Parts of diodes, transistors, and similar semiconductor devices; photosensitive semiconductor products	3.766
853224	Fixed electrical capacitors, ceramic dielectric, multilayer (excluding power capacitors)	3.658
846031	Sharpening „tool or cutter grinding" machines, numerically controlled	3.562
284410	Natural uranium and its compounds; alloys, dispersions, incl. cermets, ceramic products	3.519
846040	Honing or lapping machines for working metals, metal carbides or cermets	3.346

Source: processed based on own calculations of data from International Trade Center 2022a.

Export gap between selected EU countries and China

Among all of the examined high-tech commodity groups, a total of 58 items for the examined EU member states were identified as having an export gap, provided that the results of the average indices of RCA of the given country and IS of China for 2016 to 2020 met or exceeded a minimum value of 1. These items have a potential export value of US$151,500,000 for the EU members under consideration.

Table 2. The export gap of high-tech products in individual countries and the number of commodity groups with an identified export gap (in 2020)

	Total EG value (in mil. USD)	Number of high-tech commodity groups with an export gap
The Czech Republic	46.74	11
Hungary	31.28	8
The Netherlands	30.84	11
France	20.24	8
Germany	13.14	5
Slovakia	4.45	6
Italy	4.18	3
Greece	0.69	6

Source: processed based on own calculations of data from International Trade Center 2022a.

Table 2 contains information on the value of the export gap for each country and the number of commodity groups for which we identified an export gap. From the perspective of individual countries, the Czech Republic had the largest total export gap, amounting to nearly US$47 million. It comprises eleven high-tech commodity groups, primarily in optical, electrical, and mechanical machines. An export gap of over US$31 million was identified for Hungary and the eight high-tech commodity groups. The Netherlands ranked 2nd, with a gap of US$30.8 million and eleven high-tech commodity groups. We can, therefore, conclude that, among the examined nations, these three have the greatest export growth potential. Germany and France, the European export giants, achieve relatively low export gaps, which we attribute to their extensive use of comparative advantages and the export of many high-tech products to China. For example, Germany accounts for nearly half of China's aircraft and silicon imports.

In contrast, France has a large share of Chinese imports, particularly combustion turbines. Additionally, thanks to large pharmaceutical companies such as Sanofi, it also has a large share of the import of many pharmaceuticals. Slovakia recorded an export gap of only US$4.45 million for six high-tech commodity groups. Greece, which has the fewest commodity groups with a comparative advantage in high technology, does not have an export gap of even one million dollars.

Considering the relatively large number of high-tech commodity groups in which an export gap was identified, we narrowed down the selection of the most significant ones to commodity groups in which the export gap reached a value of at least US$1 million, which gave us 31. The top ten of these groups of goods are listed in Appendix 1, along with factors that we will take into account when assessing the possibilities for using the existing export potential:

- **Average tariff imposed by China on imports of a commodity** (International Trade Center 2022b).
- **Tariff imposed by China on imports of a commodity from a specific EU country** (International Trade Center 2022b).
- **Concentration of supplier countries** based on the Herfindahl index. It is calculated as the sum of the square root of each supplier country's import share in the selected country. According to the ITC (2022b), a country's imports are moderately concentrated if the Herfindahl index value is between 0.1000 and 0.1800. A value higher than 0.1800 suggests that imports are concentrated.
- **Average distance between China and its supplier countries,** which corresponds to the average distance between China as a target market and all its supplier countries weighted by the trade value. This indicator helps in determining if the target market is mostly supplied by regional partners. The ITC (2022b) derives its data on the geographical distance between countries from the CEPII database using Mayer and Zignago's (2006) methodology.
- **Average distance between the given EU country and its export markets,** which is determined on the same basis as the average distance between China and its suppliers (International Trade Center 2022b).
- **The number of import requirements related to the import of a commodity from the supplier country to China** (International Trade Center 2022b).

Table 3 presents the ten highest export gaps that were calculated, while the next section elaborates on the first five commodity groups in more detail. Most of the ten largest export gaps were recorded for commodities belonging to the commodity group of electrical machinery and equipment and parts thereof; sound recorders and reproducers, television image and sound recorders and reproducers, and parts and accessories of such articles (HS 85).

Table 3. The highest export gaps in high-tech products of selected EU countries in trade with China (in 2020)

Country	HS Code	Product label	Average share in world imports in 2016–2020 (%)	Share in China's imports in 2020 (%)	Exports to China in 2020 (million USD)	Export gap in 2020 (million USD)
Czech Republic	853224	Fixed electrical capacitors, ceramic dielectric, multilayer (excluding power capacitors)	1.35	0.00	0.33	21.69
Hungary	853400	Printed circuits	0.64	0.02	2.30	11.54
The Neth-erlands	853222	Fixed electrical capacitors, aluminium electrolytic (excluding power capacitors)	3.33	0.05	0.82	9.77
Czech Republic	853221	Fixed electrical capacitors, tantalum (excluding power capacitors)	7.44	0.26	1.86	8.91
The Neth-erlands	902750	Instruments and apparatus for physical or chemical analysis, using UV, visible or IR optical ...	4.38	0.54	12.62	7.90
Germany	840130	Fuel elements „cartridges", non-irradiated, in casing with handling fixtures, for nuclear reactors...	10.21	0.00	0.00	7.37
Czech Republic	851830	Headphones and ear-phones, whether or not combined with a microphone, and sets...	2.14	0.00	0.00	5.99
Czech Republic	902710	Gas or smoke analysis apparatus	3.50	0.06	0.51	5.85
France	284420	Uranium enriched in U 235 and its compounds: pluto-nium and its compounds; alloys, dispersions	12.59	0.00	0.00	4.93
Hungary	300432	Medicaments containing corticosteroid hormones, their derivatives or structural analogues	1.45	0.00	0.00	4.69

Source: processed based on own calculations of data from International Trade Center 2022a.

The largest export gap was found in the Czech Republic and the commodity group electric capacitors, solid, ceramic, and multilayer (HS 853224), which store energy in an electric field and are used in the automotive industry, the IT industry, and the camera manufacturing industry. It reached US$21.7 million. The main manufacturers of these goods in the Czech Republic are VISHAY ELECTRONIC spol. s r.o. and KYOCERA AVX Components s.r.o. China imports these products mostly from Japan (40.6% of Chinese imports), the Philippines (9.5%), and Taiwan (8.5%), followed by other (geographically close) Asian countries, as indicated by the relatively small average distance of supplier countries (2199 km) and high import concentration (0.24). This raises obstacles for European "players" to enter the Chinese market. As China imposes no tariffs on imports of these items from the majority of countries, a trade agreement between the EU and China could help boost EU exports only if it includes the elimination of non-tariff barriers. Exports of these goods from the Czech Republic flow to neighbouring European nations located an average of 906 kilometres away. During the monitored period, the Czech Republic exported also to China, but at a modest amount (in 2020, it was US$0.3 million). In line with the findings of Karkanis (2018), which suggest that building railways helps landlocked EU countries export to China, accelerating and improving the efficiency of land transport routes could help the Czech Republic utilise the export gap identified for this commodity group.

We recorded the second-largest export gap for Hungary, at US$11.5 million for HS 853400, which contains electronic printed circuits or printed circuit boards used in the building of a variety of electrical appliances and electronic equipment. Several Continental Automotive Hungary facilities, IBM Data Storage Systems Kft, and Nokia Solutions and Networks Kft are among the main producers and exporters of this commodity. In 2020, China accounted for 21.8% of worldwide imports of this product, making it the world's top importer. Interestingly, according to the ITC (2022a), China was its own top supplier (30% share), which can be partially explained by re-imports. Over 90% of Chinese imports are manufactured in China, shipped to Hong Kong, and then re-imported. Up to 73% of re-imported items are used as raw materials for inward processing, with Guangdong Province importing 70%. The geographical and logistical advantages of Guangdong Province and Hong Kong are the primary factors that explain this trade. China-origin goods entering Hong Kong for processing are exempt from import duties, and business management and distribution centres of global corporations are frequently based in Hong Kong. We can, therefore, assume that around one-third of the reported imports are generated in China. Next, the imports originate in Asian countries such as Taiwan (with a 28.8% share of Chinese imports), Japan, South Korea (both with a roughly 13% share), and Hong Kong (with a 7.8% share). The import concentration of China is high (0.24). Hungary mostly exports to EU countries such as Germany (5% of Hungarian exports of the commodity) and Belgium (7.3%), as well as to the geographically close Ukraine (7.1%). China imposes no tariffs on imports from the EU, but numerous import requirements apply to these products. Improved access to trade routes and the establishment of stable rail connections to the centre of Europe could have a positive impact on Hungarian exports to China.

An almost US$9.8 million export gap was calculated for the Netherlands and solid, aluminium, and electrolytic electrical capacitors (HS 853222), which are frequently employed in smaller electronic circuits and consequently have a wide range of applications. China, a global exporter and importer of electrical machinery and equipment, was, the world's largest importer of these products in 2020, with a 29.3% share. Even in this case, China's major suppliers included Asian countries such as Japan, Indonesia, and Malaysia, and the import concentration was high (0.22). In 2020, the Netherlands was the tenth greatest exporter of these commodities worldwide. The average distance between the Netherlands and importing countries is a little over a thousand kilometres, which implies that exports are concentrated in Europe, particularly in the EU despite the direct access of Dutch exporters to the Port of Rotterdam that is the largest seaport in Europe and an important logistics hub for exporting to the whole world. While the Netherlands' exports over the past five years have averaged approximately only US$180 million, China's imports have averaged US$1.5 billion. We can assume that the Dutch exporters, most of which are medium-sized businesses, would have difficulties supplying the quantities requested by China and competing with large Japanese industry leaders such as Toshiba or Murata Manufacturing, as well as the lower labour costs in Indonesia. The prospects for exploiting the export gap identified for the Netherlands are, therefore, not optimistic.

Electric capacitors, specifically tantalum (HS 853221), represent a commodity group for which the Czech Republic has a nearly $9 million export gap. Tantalum capacitors are used in computer electronics, audio amplifiers, automotive circuits, medical devices, and mobile phones. As in the first examined group, VISHAY ELECTRONIC spol. Ltd. and AVX Czech Republic s.r.o. are among the largest manufacturers. They are divisions of companies that are leaders in their respective industries. As a result, the Czech Republic was the eighth-largest exporter in the world in 2020. As for Chinese imports, almost 27% came from Thailand, 20% from Indonesia, and 11% from Japan. Despite this, we observe lower market concentration (0.16) compared to the commodity groups analysed so far. The average distance of China from its import partners is up to 5414 km. In addition, the average distance between the Czech Republic and importing countries was 4521 kilometres, and the export concentration was only 0.14. It is noteworthy that, for the Czech Republic, the seventh-largest supplier to China, the customs rate is 0%, as it is for most other suppliers. By comparison, as China's fifth largest supplier on the Pacific coast, El Salvador's exports are subject to tariffs of up to 35%. Even in this instance, we can assume that a more efficient logistical connection between the Czech Republic (or the EU) and China would boost this export.

The Netherlands reported an export gap of over US$8 million for the HS 902750 commodity group, which contains other instruments, apparatus, and equipment using optical radiation (ultraviolet, visible, and infrared) mostly used in medicine (e.g. x-rays or ultrasounds). As the world's largest importer of this group of commodities, China imported over a third from the United States in 2020. Singapore and Japan accounted for almost 20% of China's imports, followed by Germany with a much smaller 8.4% share. According to the methodology, this market can be regarded as moderately concentrated. The Netherlands, the sixth largest exporter of this commodity group in the world, has even fewer concentrated exports than Germany (the Herfindahl index was only 0.06), meaning its exports are "scattered" among many partners. Philips Healthcare, whose parent business is the Dutch Koninklijke Philips Electronics, is one of the top producers of these goods. China also applies a 0% tariff. From the perspective of export growth or the exploitation of the export gap by the Netherlands, ratification of the Comprehensive Agreement on Investment (CAI), which would allow EU investments to be implemented in China, might have a positive effect on the EU. China's commitments under the CAI include the establishment of privately funded hospitals and foreign-owned clinics in Beijing, Tianjin, Shanghai, Nanjing, Suzhou, Fuzhou, Guangzhou, Shenzhen, and throughout Hainan Island, as noted by Gigler (2021). The agreement would also be a big step toward better relations between the EU and China, which could help China switch from buying American goods to buying Dutch ones.

The commodity group with the smallest export gap, according to Table 3, is also interesting when considering events from 2020. HS 300432 includes medications, specifically corticoids or hormones of the adrenal cortex. Hungary was found to have here an export gap of nearly US$4.7 million. Unlike the other commodity groups listed, they are pharmaceutical industry products. Corticosteroids may be used to treat anaemia, osteoporosis, and hypertension. They are typically prescribed to patients with adrenal gland health problems. According to Research and Markets (2021), various well-known brands such as Pfizer, Novartis, Merck, Sanofi, Johnson & Johnson, GSK, AstraZeneca, Cipla, and LEO Pharma dominate the market for these pharmaceuticals. In terms of exporters, Australia was the leading supplier in 2020, accounting for 33.2% of Chinese imports.

Several of the aforementioned enterprises are based in Australia. 2020 and 2021 brought dramatic changes to trade relationships between Australia and China, which culminated in a trade war. Australia demanded an independent investigation into the origins of COVID–19 in 2020, which outraged Chinese officials. They responded with an unprecedented wave of trade restrictions, which halted the import of several Australian commodities and led to the severing of economic ties (Wilson 2021). Although the Chinese measures did not have a direct impact on the pharmaceutical business, strained relations may manifest themselves in these industries soon.

The second greatest percentage of Chinese imports of this commodity group (17.2%) was recorded by France, which is home to one of the top EU pharmaceutical companies, Sanofi. In Hungary, the pharmaceutical companies mentioned above have multiple branches.

However, Hungary has not yet exported pharmaceutical products to China, instead prioritising exports to countries that are physically closer (the average distance between Hungary and all its import markets is 933 km). China imposes an average import duty of 0% on this category of goods, creating favourable conditions for Hungarian export growth. The trade war with Australia, from which Hungary could gain due to its ever-improving relations with China, and the emerging train connections between the EU and China within the framework of the BRI, can contribute to the faster and more secure transportation of pharmaceutical products.

During the COVID–19 crisis of 2020, train lines were used for the rapid transport of a variety of medical necessities. Between January and May 2020, 12,524 tons of anti-pandemic materials were transported by train from China to Europe. In less than ten days, COSCO moved 35 containers from the central Chinese province of Hubei to Duisburg (Xinhua 2020). However, it is advantageous for the EU to also employ these routes for exports to China. Corticoids may be one of the most significant export products using the emerging rail connections. However, the problem with the commodity group is that, compared to the other commodities with an export gap, it has the most import requirements in China (177).

To summarise, five commodity groups with the largest export gap benefit from zero tariffs when imported from the EU to China. Therefore, reducing customs barriers will not increase EU exports. The number of import requirements representing non-tariff barriers for the export of these products to China shows the possibility of exploiting the identified export gaps by negotiating a trade agreement between the EU and China that would eliminate these barriers. However, the cautious attitude of EU institutions, as well as Germany and France, towards China in the current geopolitical situation does not indicate the prospect of concluding such an agreement in the foreseeable future. A relatively high import concentration of Chinese imports in geographically close countries was observed mainly for the top three commodity groups, including specific electrical capacitors and printed circuits. EU exports of the commodities concerned flow to closely located countries. This trade pattern reflects that transportation costs arising because of the geographical distance between the EU and China represent an important barrier to export growth, which is in line with the findings of Garcia-Herrero and Xu (2016), Fardella and Prodi (2017) and Karkanis (2018). The Czech Republic and Hungary recorded the highest export gaps for three out of the top five commodities. For these landlocked countries, new railway connections within the BRI represent an important stimulus for the growth of exports to China (Fardella and Prodi 2017; Karkanis 2018; Li, Bolton, and Westphal 2018).

Conclusions

Currently, the high-tech industry plays a crucial role in international business, particularly for economic powers striving to be leaders in the global economy while maintaining their own competitiveness. In this sector, the EU and its member countries achieve comparative advantages, with Germany and France being the most competitive, as the article showed. Despite steadily increasing the production and exports of high-tech products, China remains a significant importer of a variety of high-tech products, particularly in the fields of electrical and optical devices. This study identified the untapped potential for high-tech exports of selected EU countries in trade with China and evaluated the benefits of the BRI in utilising this potential.

We revealed export potential in the high-tech industry, amounting to US$151,500,000 for all EU countries analysed. Companies from countries such as Germany and France, which have a dominant position in the high-tech sector within the EU and are also its largest economies, fully use their comparative advantages, particularly in the fields of aviation, pharmaceuticals, and optical devices. They can meet the demand of the world's most populous country because of sufficient production capacities. This was confirmed by the existence of a relatively small export gap (especially when considering the size of the economies). Nonetheless, these nations have long been sceptical of strengthening ties with China under the framework of the BRI initiative.

By contrast, we showed that Greece and Italy, which have the most extensive collaboration with China under the BRI, both the value of the export gap and their competitiveness in the export of high-tech products is relatively minor. We conclude that BRI does not have the potential to facilitate the export of high-tech products to China for these countries. Therefore, a "win-win" cooperation cannot be achieved in this sector.

Electrical machinery and equipment had the largest export gaps (e.g., HS 853224 for the Czech Republic, HS 853400 for Hungary, and HS 853222 for the Netherlands). For most commodities with an export gap, China prefers geographically closer suppliers. Emerging rail connections and modernised transport within the BRI could help mainly the CEE countries with the highest untapped export potential to accelerate the delivery of high-tech products to Chinese customers. However, this is challenged by the current situation surrounding the Russian invasion of Ukraine, as many trains moving from Europe to China pass through Russia, and transport on these lines was suspended in February and March 2022. China is attempting to use routes along the southern branch of the BRI, which passes via Kazakhstan, Azerbaijan, Georgia, Romania, Hungary, Slovakia, and the Czech Republic before reaching Mannheim, Germany.

Even though most investigated commodities with an export gap are not subject to Chinese customs duties, the conclusion of a modern trade agreement between the EU and China would help the EU exploit its untapped export potential. It would be a significant milestone in improving the long-term strained relations between the EU and China, which may help shift China's attention away from importing American or Australian goods, for instance, towards European ones.

The findings of this study, particularly the identification of specific high-tech goods with export potential to China, can be used by European businesses in their decision-making. They can also help institutions in the studied countries adjust their economic and trade policies, particularly vis-à-vis China and the BRI initiative, within the field of supporting infrastructure projects, as well as high-tech industries. From an academic point of view, the study contributes to the existing literature on the potential of EU export growth to China, which has not been sufficiently explored yet. Considering the limitations of the methodology used, we recommend verifying the results by implementing an alternative methodological approach. We also recommend including more EU countries in the research.

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Potencjał eksportu produktów zaawansowanych technologicznie z wybranych państw członkowskich UE do Chin i związane z nim możliwości wynikające z inicjatywy Pasa i Szlaku

Stosunki gospodarcze UE z Chinami charakteryzują się znacznym deficytem handlowym. Zwiększenie unijnego eksportu produktów zaawansowanych technologicznie, w szczególności do Chin, jest najlepszym sposobem wyjścia z tej nierównowagi. W ten sposób kraje UE mogą skorzystać z możliwości oferowanych przez Inicjatywę Pasa i Szlaku (BRI), która ma na celu poprawę łączności między Europą a Azją.

Cel: Niniejsze opracowanie ma na celu identyfikację niewykorzystanego potencjału eksportowego produktów zaawansowanych technologicznie wybranych krajów UE w handlu z Chinami oraz ocenę możliwości wynikających z BRI w zakresie wykorzystania tego potencjału.

Metody badawcze: Aby ocenić ogólny potencjał w zakresie eksportu produktów zaawansowanych technologii wybranych krajów UE do Chin, dokonano kalkulacji luki eksportowej przy użyciu koncepcji ujawnionych przewag komparatywnych.

Ustalenia: Spośród badanych krajów UE największy potencjał wzrostu eksportu produktów zaawansowanych technologicznie do Chin mają Węgry i Czechy. Największe luki eksportowe odnotowano w przypadku maszyn i urządzeń elektrycznych.

Implikacje i zalecenia: Wyniki badań mogą być wykorzystane przez europejskie przedsiębiorstwa do dostosowania swoich strategii eksportowych. Mogą być również wykorzystywane przez instytucje rządowe badanych państw przy projektowaniu ich polityki gospodarczej i handlowej, szczególnie wobec Chin i inicjatywy BRI, w zakresie wspierania projektów infrastrukturalnych, a także branż high-tech.
Wkład i wartość dodana: Opracowanie wnosi wkład do literatury na temat potencjału wzrostu eksportu UE do Chin, który nie został jeszcze wystarczająco zbadany. Nowością przeprowadzonych badań jest identyfikacja konkretnych produktów zaawansowanych technologicznie o najwyższym potencjale eksportowym do Chin.

Słowa kluczowe: Unia Europejska, Chiny, potencjał eksportowy, produkty high-tech

Appendix 1. Top 10 export gaps of high-tech products of selected EU countries in trade with China (in 2020) with additional data

Country	HS Code	Commodity Group	The country's average share of world imports in 2016–2020 (%)	The country's share of China's imports in 2020 (%)	The country's exports to China in 2020 (million US$)	The country's export gap in 2020 (million US$)	Average tariff (estimated) applied by China	Tariffs on products from the EU	The average RCA index of a country between 2016 and 2020	The average IS index of China between 2016 and 2020	Concentration of supplying countries	The average distance between China and its import partners (km)	Average distance between a country and all its import markets (km)	The number of requirements related to the import of the commodity
The Czech Republic	853224	Fixed electrical capacitors, ceramic dielectric, multilayer (excluding power capacitors)	1.35	0.00	0.33	21.69	0%	0%	1.45	3.66	0.24	2199	906	38
Hungary	853400	Printed circuits	0.64	0.02	2.30	11.54	2.69%	0%	1.00	2.16	0.24	1740	1227	41
The Netherlands	853222	Fixed electrical capacitors, aluminium electrolytic (excluding power capacitors)	3.33	0.05	0.82	9.77	0.28%	0%	1.180	2.677	0.22	3143	1020	38
The Czech Republic	853221	Fixed electrical capacitors, tantalum (excluding power capacitors)	7.44	0.26	1.86	8.91	1.29%	0%	7.44	2.93	0.16	5414	4521	38
The Netherlands	902750	Instruments and apparatus for physical or chemical analysis, using UV ...	4.38	0.54	12.62	7.90	0.95%	0%	1.44	1.93	0.17	6554	3154	N/A
Germany	840130	Fuel elements "cartridges", non-irradiated, in casing with handling fixtures ...	10.21	0.00	0.00	7.37	1.50%	2%	1.17	1.27	0.72	8371	584	35
The Czech Republic	851830	Headphones and earphones, whether or not combined with microphone, and sets ...	2.14	0.00	0.00	5.99	2.80%	0%	2.34	1.24	0.68	2517	995	40
The Czech Republic	902710	Gas or smoke analysis apparatus	3.50	0.06	0.51	5.85	3.75%	4%	3.20	1.33	0.17	6296	2370	40
France	284420	Uranium enriched in U 235 and its compounds: plutonium and its compounds; alloys, dispersions, ...	12.59	0.00	0.00	4.93	4.70%	5%	9.41	1.23	0.38	5466	5232	17
Hungary	300432	Medicaments containing corticosteroid hormones, heir derivatives ...	1.45	0.00	0.00	4.69	0%	0%	2.27	1.43	0.18	8127	933	117

Source: processed based on own calculations of data from International Trade Center 2022a.