Economic Complexity and Product Space of Visegrad Countries: A New Perspective on Czech Republic, Hungary, Poland and Slovakia

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ABSTRACT

In 1991, four Central European countries (the Czech Republic, Hungary, Poland and Slovakia) decided to form a political alliance called the Visegrad Group to explore paths of cooperation in various domains. Since the fall of communism, these countries have followed a formidable development trajectory that culminated with their integration in the European Union in 2004.

In this thesis, we approach this region using a new macroeconomic theory that provides a framework to evaluate the complexity of economies and their productive structures. After analyzing trade data at a world level we find that V4 countries have complex economic structures. They also demonstrate a high level of robustness as they maintain consistent Economic Complexity Rankings when we vary the theory’s underlying assumptions. We show that V4 countries have acquired capabilities relevant to many sectors, which provides them with numerous development opportunities. Based on those findings, we suggest policy recommendations leading both to stronger regional integration and to the creation of a more attractive business environment.

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**Introduction**

**Personal motivations**

Having strong personal ties to Hungary and Poland, we have decided to co-write our master thesis on the economic state of four countries located in Central Europe. These countries include the Czech Republic, Hungary, Poland and Slovakia and are commonly referred to as the Visegrad Group, or V4 countries, in reference to a meeting that occurred in 1335 between the kings of the then nations in the city of Visegrad, Hungary.

Since the fall of communism, V4 countries have undergone significant economic, political and societal transformations. In this thesis, our focus is on the economic aspect of these changes. Several macroeconomic studies have been conducted about V4 countries that use aggregate indicators of economic wealth and performance. These include, but are not restricted to, country reports done by major international organizations such as the World Bank, the OECD and the IMF as well as papers published by academia.

Our aim here is neither to write an additional paper focusing on these aggregate indicators nor to conduct a literature review of existing studies. Instead, we would like to offer a different understanding of these countries’ current economic state and development perspectives using a novel empirical approach which relies on trade data and on connections between products and the capabilities they require. We use data available on the *Observatory of Economic Complexity* website run by the Macro Connections research team of the MIT Media Lab.

This theory we refer to in this paper has been developed ten years ago by four academics: C. Hidalgo, B. Klinger, A.-L. Barabási and R. Hausmann. It was first outlined in an article published in *Science* magazine entitled *The Product Space Conditions the Development of Nations*. We will make further reference to this article in the theory explanation part of the thesis.

Throughout this paper, we analyze the countries in the following alphabetical order: the Czech Republic, Hungary, Poland and Slovakia, except when there is a rationale for doing otherwise.

**Structure of the thesis**

We have divided the thesis in three main parts in order to illustrate the past of V4 countries (where they come from), their current economic state (where they are now) and their future potential paths of development (where they could be heading to).
In the first part, we give an overview of V4 countries by describing the economic transformations they have experienced over the past 25 to 30 years after the fall of communism, notably the strong economic growth that happened subsequently. We then introduce the notion of the Visegrad Group, an alliance that is mostly political but that also puts forward elements of economic integration. Finally, we examine the exports of V4 countries and highlight similarities both in terms of top economic sectors and trade partners.

In the second part, we assess the level of economic complexity V4 countries have reached. We then test the robustness of such a ranking to further strengthen our analysis by varying the key parameter of the economic framework: the threshold above which a country exports a product with Revealed Comparative Advantage. Finally, we introduce a new view of trade relations, not only looking at trade balance from a quantitative point of view (i.e. in surplus or in deficit) but also from a qualitative standpoint (i.e. how does the complexity of a country’s export basket to a given trade partner compare to the complexity of its import basket from that given partner).

In the third part, we apply the Product Space Theory to identify potential development opportunities and paths in the “near” future. We first look at proximities between products (i.e. the amount of capabilities two products share). We compute density values for our four countries (i.e. we estimate what fraction of required capabilities a country has developed around a new potential product). We compare the paths of development between V4 countries in terms of likeliness of developing products (depending on sectors, complexity of products...). We then examine a consolidated view of the region and try to identify where the opportunities would lie should there be more economic integration going forward.

Based on this three-part study, we finally formulate a set of national as well as regional policy recommendations that we believe are relevant given the results of our analysis.
Preliminary view on V4 Countries

From the Eastern Bloc to the European Union

Countries from the former Eastern Bloc have undergone an impressive transformation since the collapse of the Berlin Wall. In particular, Poland and Hungary as well as the Czech Republic and Slovakia (the former Czechoslovakia) were among the first and the most successful to realize a radical regime change, both politically and economically.

From a political perspective, Hungary was the first country to open its borders with Austria in the course of summer 1989, unleashing a wave of reforms and regime changes throughout the Central and Eastern European satellite communist countries. This would eventually lead to the collapse of the Soviet Union in 1991 and the separation of the Czech Republic and Slovakia in December 1992. These institutional reforms have been strengthened by the integration of V4 countries in the European Union in 2004. While Slovakia adopted the Euro in 2009, none of its above mentioned neighbors has yet followed on.

Post-communist governments in Central and Eastern Europe were eager to show the world that they had turned the page of Soviet rule over their countries. That is the reason why Hungary, Poland and the Czech Republic demanded their inclusion into the North Atlantic Treaty Organization (NATO) soon after the regime change and were given full membership in 1999, followed by Slovakia in 2004. Similarly, membership into the Organization for Economic Cooperation and Development (OECD) was granted to these countries in the 1990s and early 2000s, after a dedicated period during which OECD had set up a special program called “Partners in Transition” to help the governments of Hungary, Poland and Czechoslovakia successfully engage their countries on the path of liberal capitalism after forty years of communist rule.

Geographically speaking, the Central and Eastern European countries are strategically located, at the crossroads between Western Europe and Russia. They are on the trajectory of several transport corridors, both in terms of goods, energy and people. The latter category has been particularly topical recently, as the public opinion saw the flow of refugees and migrants, coming from Africa and the Middle East, transit through Hungary.

Central European countries had another major comparative advantage in the early 1990s: their educated yet affordable labor force. Compared to other low-cost countries across the world, the
Czech Republic, Hungary, Poland and Slovakia had a relatively well-educated population, which, once trained to modern management techniques, would prove of great value to Western European companies looking for new places to relocate their manufacturing activities. This produced a shift of focus in the Western hemisphere from regions like Sub-Saharan Africa towards Central Europe. A famous African quote deplored and summarized this sudden pivot: “Adieu Bangui, bonjour Varsovie”.

From an economic perspective and despite variations in terms of timing, scope and political agenda, these Central European countries have overall quickly abandoned their former socialist models to transit towards a more liberal form of capitalism, through privatization of state-run companies and efficient labor reforms, allowing them to unlock their underlying strengths (educated yet affordable labor force, geographical position between Western Europe and Russia, cultural homogeneity with European partners...).

These successful reforms attracted Western European companies and brought them to invest in the region in the form of Foreign Direct Investment and other capital vehicles. In particular, sectors such as the automotive industry as well as back-office activities for banks and multinational companies have greatly benefited from foreign investments, building upon existing capabilities to create new ones and raising productivity across the region. As mentioned in a special report on the Central and Eastern European region published by the McKinsey Global Institute in 2013, “Foreign companies brought not only money to capital-starved industries, but also technology, managerial expertise, and the ability to exploit economies of scale” 2. These changes had several positive spillover effects across a wide range of industries.

A special point is worth to be made here about the privatizations of state-run companies in Central and Eastern Europe and the political agendas that have determined their schedule, form and extent. Transforming former socialist countries into market-oriented economies was not a small challenge. Across the region, long-term objectives had been determined for decades by state planned economic policies (five-year plans) often dictated directly by Moscow in the context of

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1 “Good bye Bangui, hello Warsaw”. Bangui being the capital of the state of Central Africa and Warsaw the capital of Poland, this sentence mostly emphasized the understanding that the fall of communism had given birth to a new area in which economic development and foreign investments would be increasingly going towards Central and Eastern Europe rather than Africa. From Sylvie Brunel, L’Afrique: un continent en reserve de développement, 2004

COMECON\(^3\). After the fall of communism, the inefficient and bureaucratic nature of state-run companies appeared to be a significant threat to the ability of these countries to engage on the path of market-based development and growth. Although privatizations occurred all across the 1990s in most Central and Eastern European countries, some like Hungary have experienced a more consequential earlier wave due to their willingness to experiment reforms in that field in the 1980s before the fall of communism. Others countries like Poland have known multiple, but slower, phases across the last 25 years with still a large number of state-run companies in place as of today.

As a result of these efforts, which included several layers of institutional and market reforms, countries in Central Europe have been able to unlock their potential. Between 1995 and 2014, in a time frame of 20 years and according to IMF World Economic Outlook data, GDP per capita more than tripled in the Czech Republic ($19.8k) and Hungary ($14.0k), nearly quadrupled in Poland ($14.3k) and was multiplied by five in Slovakia ($18.5k)\(^4\).

Between 1993 and 2015, GDP annual growth rates averaged 2.5% in the Czech Republic, 2.1% in Hungary, 4.2% in Poland and 4.1% in Slovakia, compared to an average 1.7% in the European Union as a whole\(^5\).

On average over the 1993 to 2015 period, annual Foreign Direct Investment (as a percentage of GDP) culminated in Hungary (8.7%), followed by the Czech Republic (4.5%), Slovakia (3.5%) and Poland (3.3%)\(^6\). These figures appear particularly high when compared to FDI rates going into BRIC economies over the same period: on average, annual FDI reached 2.8% of GDP in Brazil, 1.9% in Russia, 1.3% in India and 3.9% in China.

Key infrastructure capabilities have been established in the region over the last quarter of a century, such as Hungary’s highway system covering 1,100 kilometers within the country and connecting Budapest to all major borders with neighboring countries. Dense industrial clusters have been created around competitive and high-tech sectors, such as the automotive industry in all four countries but also the aerospace industry in the Czech Republic and Poland. Other business areas are gaining importance too, such as electronics and back-office activities.

\(^3\) COMECON, or Council for Mutual Economic Assistance, was the economic organization that the Soviet Union used from 1949 to 1991 to impose its views on the economic development and activities of its allies within the Eastern Bloc.
\(^4\) The World Bank data.
\(^5\) Idem.
\(^6\) Idem.
Overall, the Central and Eastern European region has undergone what the McKinsey report calls “a remarkable journey” since the fall of communism. This conclusion must however be mitigated by some important factors that might seriously affect the region on the long run. The first one is economic and refers to the significant brain drain that the West has been exercising on the young and skilled population of these countries. The second drawback is about the new political landscape arising in Central Europe. Without expressing any political opinion, it can be stated that populist far-right parties have gained more importance in the region. This can be explained by both the aftermaths of the world financial crisis, which has heavily hit some of these economies, and by the more recent refugee and migration crisis which was used by these parties to support their nationalist, anti-European rhetoric. Whether this change in the political spectrum will affect the economies of these countries still remains to be seen.

The Visegrad Group: a centenarian idea

In addition to the geographic and historical rationale for studying the Czech Republic, Hungary, Poland and Slovakia jointly also lies a geopolitical argument, as evidenced by the so-called Visegrad Group that these countries form together. We will briefly present this group in the subsequent paragraphs. One of our objectives through this thesis is to see whether there is also an economic and capability justification for offering a joint vision of these countries, beyond the geopolitical perspective.

The origin of the Visegrad appellation goes back to the Middle Age. In 1335, the kings of three important Central European countries (i.e. Bohemia, Poland and Hungary) met in the castle of Visegrad on top of a hill in the famous Danube bend that lies north of Budapest. This meeting had been initiated by Hungarian king Charles I of Anjou and aimed at resolving tensions that had been mounting up between the kingdoms of Bohemia and Poland. Several peace treaties and other official documents attesting of an agreement of mutual assistance in case of conflict with a third country were signed in Visegrad during the month-long meeting and celebrations. As such, this can be considered as one of the earliest international peace conferences in Central Europe.

It is to this historical origin and source of pride regarding the past diplomatic achievements of their respective countries that the leaders of Czechoslovakia, Hungary and Poland decided to refer to in 1991 when the fall of communism provided a new avenue for exploring paths of cooperation in multiple fields, such as diplomacy and economic development. “Convergent basic objectives”
were identified to be the main rationale for closer cooperation in the future. The 1991 Visegrad Declaration sets as a priority the “elimination of all existing social, economic and spiritual aspects of the totalitarian [communist] system” and the “creation of a modern free market economy”. The same declaration lists a set of tasks to be undertaken by the signatories, which includes the following:

“in order to support free flow of labor force and capital, they shall develop economic cooperation, based on the principles of the free market, and mutually beneficial trade in goods and services, moreover they shall strive to create favorable conditions for direct cooperation of enterprises and foreign capital investments, aimed at improving economic effectiveness.”

Economic cooperation was therefore part of the joint endeavor from the very beginning and lies at the heart of what has since then become known as the Visegrad Group. The 1991 Declaration also emphasizes the fact that this framework for cooperation shall not be in any way an obstacle to cooperation with other countries. On the contrary, it is considered as a catalyst for wider regional cooperation as well as a vehicle for facilitating the long term integration of the signatories and their neighbors in the European Union.

After the separation of the Czech Republic and Slovakia in January 1993, the Cooperation Agreement was enlarged to four partners, which led the Visegrad Group to be commonly referred to as “Visegrad Four” or V4. Today these countries collectively amount to c. 64 million inhabitants\(^8\) and their aggregated Gross Domestic Products add up to c. $870bn\(^9\).

Despite these initiatives and economic developments that support the political willingness for unifying these four countries, some drawbacks need to be highlighted. The Visegrad countries still remain fragmented markets where “rolling out a cross-border business, even through consolidation, often remains a slow and challenging process”\(^10\), as explained in a 2014 report published by the KKR Global Institute. Each partner country has its own national language and currency (except for Slovakia which has adopted the Euro as indicated earlier) as well as its own

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\(^7\) Visegrad Declaration, February 15, 1991
\(^8\) Population in number of inhabitants according to 2015 World Bank data: 10.6 million in the Czech Republic, 9.8 million in Hungary, 38 million in Poland and 5.4 million in Slovakia.
\(^9\) GDP in current USS according to 2015 World Bank data: $185bn in the Czech Republic, $122bn in Hungary, $477bn in Poland and $87bn in Slovakia.
\(^10\) KKR Global Institute, *Unlocking the World for Central and Eastern European Champions*, 2014
in institutional framework, which might hinder further economic integration and ease of doing business across borders.

V4 economies are heavily reliant on exports

In addition to the political mandate clearly stated above by the signatories of the Visegrad Declaration with regards to cooperation in framing economic policy, we find that empirical data provides additional economic rationale for considering these countries collectively in the frame of this study. In this section, we analyze the exports of the Visegrad countries and outline that their economies are (1) heavily reliant on exports and (2) strongly interdependent in terms of foreign trade. We describe the composition of their respective export baskets and then analyze the destination of these exports. We use export data from the *Observatory of Economic Complexity* website.

**The composition of export baskets – main product categories**

We first consider the composition of the basket of products that V4 countries export. Figures 1 to 4 offer a summary view of the key product sectors being exported using a low level of granularity.

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**Czech Republic**

- 1.90% Machines
- 2.06% Transportation
- 2.19% Metals
- 2.41% Plastics and Rubber
- 2.31% Chemical Products
- 3.12% Foodstuffs
- 3.66% Textiles
- 4.61% Mineral Products
- 5.23% Paper Goods
- 5.24% Stone and Glass
- 9.03% Other

**Hungary**

- 2.18% Machines
- 2.59% Transportation
- 2.79% Chemical Products
- 3.09% Plastics and Rubber
- 3.23% Metals
- 3.58% Instruments
- 4.13% Foodstuffs
- 5.14% Mineral Products
- 6.22% Vegetable Products
- 8.25% Animal Products
- 10.01% Other

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*Figure 1: Basket of exports – Czech Republic*  
*Figure 2: Basket of exports – Hungary*
Overall in 2014, the Czech Republic exported $162bn (and ranked 30\textsuperscript{th} among 220 countries in terms of dollar size of exports), Hungary $106bn (37\textsuperscript{th}), Poland $206bn (24\textsuperscript{th}) and Slovakia $78bn (42\textsuperscript{nd}).

Machines and Transportation were the main product sectors being exported by V4 countries, ranging between 25 to 40% and 14 to 28% of exports respectively. A more detailed study of any individual sector would be required to understand the precise patterns of imports, local manufacturing and exports as well as origins and destinations of these trade flows. This is not our aim here. However, the fact that these low-level granularity product categories are identical for these countries may hide significant local specificities worth highlighting.

For example, in the case of Machines, at a medium level of granularity, key export products for Hungary include Spark-Ignition Engines and Combustion Engines, unlike for the Czech Republic, Poland and Slovakia where Computers, Insulated Wire, Video Displays and Telephones are more significant.

In the case of Transportation, Cars and Vehicle Parts make up a significant portion of V4 exports. However, Poland also exports Passenger and Cargo Ships, which accounted for 1.7% of its total exports in 2014 and for which it ranks as the fourth largest exporter in the world after South Korea, China and Germany.

Nonetheless, at a low level of granularity, the export baskets of V4 countries have a relatively comparable composition, despite significant variations in total value of exports due partially to country sizes. It is our objective in this paper to strengthen our understanding of these patterns by characterizing the economic complexity of these countries.
The composition of export baskets – main export destinations

We now consider the countries towards which V4 countries export their products. Figures 5 to 8 exhibit, in terms of foreign trade, the exposure of V4 countries to Europe in general and to Germany in particular.

Germany holds a primary role for all Visegrad countries as the dominant destination of their exports (i.e. between 22% and 31% of total exports). Similarly, the European continent as a whole absorbs between 83% and 88% of their exports, showing a strong local exposure and a low level of geographic diversification.

It is also worth mentioning the strong inter-connections between the Visegrad countries themselves in terms of exports. The most striking dependency towards neighbors occurs in the case of Slovakia (as displayed by Figure 8) which shows how its three V4 partners are second to Germany as main export destinations and collectively account for a higher share of exports than Germany itself (23.2% versus 22.0%): 11.0% for the Czech Republic, 6.2% for Poland and 6.0% for Hungary.
Similarly, V4 partners' collective share of export destinations stands at 15.3% for the Czech Republic, 11.0% for Hungary and 10.6% for Poland.

In order to get a more granular view of the outbound foreign trade landscape of V4 countries, we have chosen to present in the below graphs the top ten export destinations for each country (Figures 9 to 12).

**Figure 9: Top 10 export destinations – Czech Republic**

**Figure 10: Top 10 export destinations – Hungary**

**Figure 11: Top 10 export destinations – Poland**

**Figure 12: Top 10 export destinations – Slovakia**
Once again we notice the heavy reliance on European partners as main export destinations. For the Czech Republic and Poland, there are only European countries among their Top 10 trade destinations. Germany, as we have already seen earlier, is the top export destination for all V4 countries. Beyond that however, rankings vary but the main export destinations remain the same: France, the United Kingdom, Italy and Austria are always among the Top 10. Most of the time, V4 partners also rank among the main export destinations of each other (except for Poland, where Slovakia is not among the Top 10 but does not stands far behind, ranking no12).

We are not discussing here the general composition of the import baskets of these countries. Neither are we discussing the origins of their imports. However, we will later in this paper compare the baskets of exports and imports between selected countries in terms of their economic complexity, which we believe is relevant in understanding the nature of the trade relations that characterize V4 countries and their trade partners.

**Case Analysis: The Hungarian - German trade relations in the automotive industry**

We briefly analyze the trade relations between Hungary and Germany in the automotive sector. This particular case offers the advantage of exploring some potential patterns of bilateral partnership and industrial specialization, while highlighting the important exposure of Hungary towards Germany in terms of foreign trade. It is also representative of the set of bilateral trade relations that other V4 countries have with Germany, thus being an adequate characterization of the region’s import-export landscape with regards to the automotive industry.

In 2015, Cars, Vehicles Parts, Spark-Ignition Engines, Combustion Engines and Engine Parts collectively accounted for 24% of Hungary’s exports\(^\text{13}\) and 12% of its imports\(^\text{14}\). This subset of product categories therefore constitutes a large enough share of Hungary’s industrial and trade activities while being a good approximation for the automotive industry as a whole.

To illustrate the relations between Hungary and Germany with regards to the automotive industry, we first study the trade flows for the following two product categories: Cars and Vehicle Parts. These are heavily inter-related product categories since they are sequential in the value chain of automobiles (i.e. Vehicle Parts are necessary to manufacture Cars). In 2015, Hungary exported

\(^{13}\) 2015 exports for Hungary included: Cars (12%), Vehicle Parts (5.2%), Spark-Ignition Engines (3.3%), Combustion Engines (2.8%) and Engine Parts (0.85%). Source: *Observatory of Economic Complexity* website.

\(^{14}\) 2015 imports for Hungary included: Cars (2.6%), Vehicle Parts (5.8%), Spark-Ignition Engines (0.6%), Combustion Engines (0.5%) and Engine Parts (2.6%). Source: *Observatory of Economic Complexity* website.
Cars for a total value of $11.5bn, making it the 14th largest automobile exporter in the world with 1.7% of global exports. Significantly enough, 33% of Hungary’s automobile exports went to its major trade partner Germany. In terms of Vehicle Parts, which are a product category encompassing several sub-categories necessary to manufacture and assemble Cars, Hungary was the world’s 16th largest importer (i.e. 1.5% of global imports reaching $5.2bn in 2015). Germany is by far the main country of origin, representing 48% of Hungary’s Vehicle Parts imports. When we look at the Product Complexity Index (PCI), we observe that Vehicle Parts are more complex than Cars (PCI of 1.09 versus 0.806).

These two data facts are most insightful when accompanied by a deeper industry-specific understanding of the two countries’ economic relations. In its 2014 list of the Top 500 Hungarian companies, the Hungarian economic newspaper HVG ranked the local subsidiaries of Audi and Mercedes Benz among the five largest Hungarian companies in terms of 2014 revenue (respectively n°2 and n°5). Audi is the main employer in the North-Western part of the country, with several manufacturing sites in the city of Győr, where it has been present since the early 1990s. Mercedes Benz decided in 2008 to establish manufacturing and assembly lines in the central part of the country near the city of Kecskemét and currently employs over 4,000 people on site. Even more striking is the fact that 99.96% and 99.68% of 2014 revenues for the two local subsidiaries of Audi and Mercedes Benz came from international sales, as stated by HVG.

Together with the export data between Hungary and Germany exposed above, this suggests that Hungary serves as a “backyard” manufacturing country for large German automobile companies, which import complex Vehicle Parts from Germany, manufacture and assemble them locally before re-exporting finished Cars towards Western European markets. This also confirms the common understanding of how the German automobile industry was able to climb the value chain by focusing more on Research and Development and design activities while relocating manufacturing and assembly tasks to Central and Eastern Europe, notably the Visegrad countries.

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15 For comparison purposes, other V4 countries ranked 11th (Czech Republic with 2.4% of global exports), 13th (Slovakia with 1.9%) and 17th (Poland with 0.9%). Germany is the world’s largest exporter of automobiles with 27% of global exports.

16 The Product Complexity Index (PCI) is an iterative measure incorporating a product’s ubiquity and the diversity of its exporters, obtained using the Method of Reflections as described in Hidalgo and Hausmann (2009). Source: Observatory of Economic Complexity website

We now focus on three additional sub-categories of products (Spark-Ignition Engines, Combustion Engines and Engine Parts), which are essential components in the automotive value chain. Engine Parts are used to assemble Spark-Ignition Engines and Combustion Engines, which are both required to manufacture Cars\textsuperscript{18}.

Hungary is the world’s 7\textsuperscript{th} largest importer of Engines Parts (3.6% of global imports amounting to $2.27bn in 2015)\textsuperscript{19}. It imports Engine Parts from Germany (62%) and from its V4 partners (collectively 10%). These products are then used to manufacture Engines mostly for exportation purposes or local assembly of Cars. Indeed, Hungary is the world’s 5\textsuperscript{th} largest exporter of Spark-Ignition Engines (7.9% of global exports\textsuperscript{20}) and the world’s 6\textsuperscript{th} largest exporter of Combustion Engines (5.8% of global exports\textsuperscript{21}). The most compelling fact is once again the destination of these exports: 52% of Spark-Ignition Engines and 61% of Combustion Engines produced in Hungary are exported towards Germany. A respective additional 11.6% and 17.3% per product category are exported towards V4 partners.

These figures not only show the important exposure of Hungary’s Engine exports towards its regional trade partners and especially Germany, they also bring additional evidence of how German automobile companies have decided to relocate their manufacturing activities to Central and Eastern European neighbors that serve as industrial “backyards”. In 20 years, Audi, for example, has manufactured over 25 million engines in its Hungarian plant in Győr.

Hungary benefited from this industrial “offshoring”. German car manufacturers drained into the country all their major suppliers, contributing to the creation over time of a competitive industrial ecosystem within the automotive landscape, with technical know-how and skilled labor. A similar case can be made for other V4 countries. The Czech Republic, for example, has largely benefited from the Volkswagen takeover and turnaround of local car manufacturer Skoda in the early 1990s.

\textsuperscript{18} In this classification, Spark-Ignition Engines refer to petrol engines, whereas Combustion Engines might include other compression-ignition based engines such as diesel engines.

\textsuperscript{19} For the sake of comparison, Germany is the largest importer of Engine Parts with 9.7% of global imports. Poland is n\textsuperscript{12} with 2.4% and the Czech Republic is n\textsuperscript{22} with 1.3%.

\textsuperscript{20} The United States ranked n\textsuperscript{1} with 14%, followed closely by Germany and Japan (12% each of them) as well as Mexico (9%). V4 partners’ share of global exports of Spark-Ignition Engines: 1.4% for Poland (n\textsuperscript{13}), 0.68% for the Czech Republic (n\textsuperscript{19}) and 0.68% for Slovakia (n\textsuperscript{20}).

\textsuperscript{21} Behind the United States (15%), Germany, Japan, the United Kingdom and France. V4 partners’ share of global exports of Combustion Engines: 5% for Poland (n\textsuperscript{8}), 1.1% for Slovakia (n\textsuperscript{16}) and 0.43% for the Czech Republic (n\textsuperscript{20}).
Nonetheless, from a macroeconomic perspective, this trend illustrates the state of bilateral economic and trade relations in the region as well as the specialization of “backyard” countries in sectors where their relative comparative advantage is higher, allowing Germany to focus on higher value-added activities such as Research and Development.
V4 Countries through the prism of Economic Complexity

Introduction to the Product Space and the Theory of Economic Complexity

In this part we describe the theory that underlines our analyses by introducing the key concepts defined by C. Hidalgo, B. Klinger, A.-L. Barabási and R. Hausmann in their article entitled *The Product Space Conditions the Development of Nations* and published in *Science* magazine in 2007.

**The concept of Revealed Comparative Advantage**

Country \( c \) is said to export product \( p \) with Revealed Comparative Advantage\(^{22} \) when the ratio of the relative weight of product \( p \) among its own exports to the relative weight of product \( p \) in the world economy (i.e. total global exports) is above a certain threshold \( T \) (in our base case \( T = 1 \)). This ratio is given by the equation stated below in which \( x(c,p) \) represents the export value of product \( p \) by country \( c \).

\[
RCA(c, p) = \frac{x(c,p)}{\frac{\sum_p x(c,p)}{\sum_c x(c,p)}}
\]

We make the difference between the ratio itself, which we refer to by the acronym RCA, and the situation when this ratio is higher than the pre-determined threshold for a given country-product pair (\( RCA > T \)), in which case we say that “country \( c \) has a Revealed Comparative Advantage in product \( p \)

**The country-product matrix**

The *Theory of Economic Complexity* is based on the assumption that countries develop capabilities, which will then allow them to produce and export certain products. There are two sets of connections that can both be represented in matrices filled with binary elements. The first matrix connects products and the capabilities they require. The second matrix connects countries and the capabilities they have developed. Since capabilities are difficult to list and perceive, these two matrices are purely theoretical. However, they can be combined to form a third matrix that

\(^{22} \text{The Product Space Conditions the Development of Nations, C. Hidalgo, B. Klinger, A.-L. Barabási and R. Hausmann, Science, 2007} \)
connects countries with the products they export. Such a matrix can be empirically constructed using appropriate trade data.

We call $M$ the matrix connecting countries to the products they export. For any given pair of country $c$ and product $p$, $M_{c,p} = 1$ if country $c$ exports product $p$ with Revealed Comparative Advantage and $M_{c,p} = 0$ otherwise.

**How diversified is country $c$?**

The level of diversification of a country is the number of products that it exports with Revealed Comparative Advantage. Illustratively, for a country $c$ this is the number of elements that take 1 as a value on the $c^{th}$ line of the $M$ matrix.

$$k(c, 0) = \sum_p M(c, p)$$

A preliminary hypothesis would be that the higher the level of diversification of a country, the more complex its economy. However, this metric alone does not account for the qualitative differences that may arise between the baskets of products exported by two countries having similar levels of diversification. This leads us to introduce the concept of ubiquity.

**How ubiquitous is product $p$?**

The ubiquity of a product is the number of countries that export it with Revealed Comparative Advantage. Illustratively, for a product $p$ this is the number of elements that take 1 as a value on the $p^{th}$ column of the $M$ matrix.

$$k(p, 0) = \sum_c M(c, p)$$

Arguably, ubiquity is a good measure for the sophistication of a product, since products exported by many countries probably require a set of less sophisticated capabilities, whereas products exported by a few countries may require a set of capabilities that only some have managed to develop.
Iterative measures of diversity and ubiquity: the Method of Reflections

In order to reach a more accurate measure of the complexity of a country’s economy, Hidalgo and Hausmann introduce the Method of Reflections\(^{23}\) which consists of combining the concepts of diversity and ubiquity in an iterative way. This is due to the fact that the iteration allows to take into account the ubiquity of the products exported by a given country and the level of diversification of the countries exporting these products.

<table>
<thead>
<tr>
<th>Measures</th>
<th>Explanation</th>
</tr>
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</table>
| \(k(c, 0) = \sum_p M(c, p)\) | Diversity of a country
| \(k(p, 0) = \sum_c M(c, p)\) | Ubiquity of a product
| \(k(c, 1) = \frac{1}{k(c, 0)} \sum_p M(c, p)k(p, 0)\) | Ubiquity of a country’s export basket
| \(k(p, 1) = \frac{1}{k(p, 0)} \sum_c M(c, p)k(c, 0)\) | Diversity of the set of exporters of a product
| \(k(c, 2) = \frac{1}{k(c, 0)} \sum_p M(c, p)k(p, 1)\) | Diversity of exporters of a country’s export basket
| \(k(p, 2) = \frac{1}{k(p, 0)} \sum_c M(c, p)k(c, 1)\) | Ubiquity of export baskets of a product’s exporters
| \(k(c, n) = \frac{1}{k(c, 0)} \sum_p M(c, p)k(p, n - 1)\) | Country information
| \(k(p, n) = \frac{1}{k(p, 0)} \sum_c M(c, p)k(c, n - 1)\) | Product information

\(^{23}\) The building blocks of economic complexity, C. Hidalgo and R. Hausmann, Proceedings of the National Academy of Science, 2009

\(^{24}\) Idem.
Methods and data

We use cleaned data available on the Observatory of Economic Complexity website at a medium level of granularity\textsuperscript{25}. The data is generated by the United Nations Statistical Division (COMTRADE), and subsequently cleaned by BACI International Trade. It is harmonized to reconcile the declarations of exporters and importers and therefore to reach a more complete dataset\textsuperscript{26}.

Although this data is from 2014, the fact that it has been cleaned and used by the Observatory of Economic Complexity means that it is simpler for us to use in the context of this one-year master thesis.

For analyses purposes, we consider two different datasets. The first dataset contains export data for 219 countries\textsuperscript{27} and over 1,200 products. We use it for the main part of our analysis (i.e. for the computation of the Economic Complexity Index, for sensitivities around RCA thresholds and for prospective analyses around the concepts of density and proximity). The second dataset contains bilateral export information and is therefore “heavier” due to its higher level of granularity. Practically, this means that we look at 219 countries exporting over 1,200 products towards one another. We use this dataset for our qualitative trade balance analysis and restrain it to European countries for clarity purposes.

We conducted our analysis on a free statistical software called R using the two datasets mentioned above combined with two additional datasets containing product and country name information. Additionally, we use the Product Complexity Ranking available on the Observatory of Economic Complexity. Such a ranking is generated for the HS07 dataset at a 4-digit product level specification for 2014. We also use an openly available dataset from the World Bank containing 2014 GDP per capita information.

The data analysis part constituted the major part of our research for this thesis, alongside familiarizing ourselves with the Theory of Economic Complexity.

\textsuperscript{25} 4-digit depth data from the HS6 REV. 2007 (2008 - 2014) dataset
\textsuperscript{26} http://www.cepii.fr/CEPII/fr/publications/wp/abstract.asp?NoDoc=2726
\textsuperscript{27} We then limit our rankings to the 145 countries for which the Observatory of Economic Complexity restrains itself.
Relevance of the Theory of Economic Complexity for V4 countries

We have seen in the first part of this paper that V4 countries are heavily reliant on foreign trade. Indeed, exports of goods and services, as expressed in percentage of GDP, accounted for 83% of GDP in the Czech Republic, 90% in Hungary, 50% in Poland and 93% in Slovakia in 2015.\(^{28}\)

V4 countries being large exporters, there is a strong rationale for introducing an export-based empirical study of the structure of their respective economies. The Theory of Economic Complexity offers this possibility by pairing countries with the products they export and by using the Method of Reflections explained above to produce measures of their economic complexity. This theory has not yet been applied in the frame of a study dedicated to these four countries, allowing us to bring a novel, enriching approach to better understand them.

Furthermore, it is our objective in this paper to offer a joint view of what the economic complexity of V4 countries could be if considered in a combined way, as their common regional appellation and political agenda would suggest. This idea was driven by the example of a regional study made by C. Hidalgo in 2011 in which he used the Theory of Economic Complexity to analyze five countries (Kenya, Mozambique, Rwanda, Tanzania and Zambia) both individually and in a joint regional approach:

"We study the collective regional position of these countries in the product space in an attempt to identify the opportunities that would be unveiled if the productive structures of these countries were to be combined. Since the capacity of a country to discover a good depends on the goods that it is already exporting, the industrial opportunities that appear as natural next steps for these countries will be different depending on whether we examine them as independent units or as a single integrated economy."\(^{29}\)

In this thesis, we conduct a similar combined analysis of the productive structure of the V4 region as a whole in an attempt to unveil potential new industrial opportunities that could lie ahead of the member states if their economies were to be more integrated with those of their neighbors.

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\(^{28}\) The World Bank data (2015)

\(^{29}\) Discovering Southern and East Africa’s Industrial Opportunities. C. Hidalgo, GMF Economic Policy Paper Series, 2011
Diversified countries producing complex products

Figure 13 shows the position of countries in the “\(k_{c,0} \text{ versus } k_{c,1}\)” space. This space is defined by the level of diversification (\(k_{c,0}\)) of a country and the average ubiquity of the products that it exports with Revealed Comparative Advantage (\(k_{c,1}\)).

Figure 13: Diversity \(k_{c,0}\) and average ubiquity of exported products \(k_{c,1}\)

Figure 13 shows that highly diversified countries tend to be so in products that are exported with Revealed Comparative Advantage by a relatively low number of countries (i.e. low \(k_{c,1}\)), whereas poorly diversified countries export products that are produced and exported by many other
countries as well (i.e. high $k_{c,1}$). Based on the results exemplified in this figure and similarly to what has been described in Hidalgo and Hausmann (2009)\textsuperscript{30}, there appears to be a negative correlation between a country’s level of diversification and the average ubiquity of the products it exports: average ubiquity tends to decrease as the level of diversification increases. An interpretation of this can be that “diversified countries will be able to make less ubiquitous products”\textsuperscript{31}. This justifies introducing the categorization shown in Table 2 below.

<table>
<thead>
<tr>
<th>Non-Diversified Countries Producing Standard Products</th>
<th>Diversified Countries Producing Standard Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Diversified Countries Producing Exclusive Products</td>
<td>Diversified Countries Producing Exclusive Products</td>
</tr>
</tbody>
</table>

Table 2: Categorization of countries introduced by Hidalgo and Hausmann (2009)\textsuperscript{32}

On average, countries tend to be positioned in the upper-left or lower-right corners of the categorization table introduced above.

In Figure 13, we have highlighted with color dots the position of the Visegrad countries, showing how they tend on average to be on the lower right corner of the “$k_{c,0}$ versus $k_{c,1}$” space. This confirms that they are highly complex economies, that is, “diversified countries producing exclusive products”\textsuperscript{33}. While they export a relatively high number of products with Revealed Comparative Advantage (between 240 and 420 products), the average ubiquity of these export products is low (between 25 and 30 countries). However, at a higher-level analysis, the four countries tend to show somewhat different characteristics. Slovakia and Hungary are both less diverse and exporting less exclusive products than the Czech Republic. Poland has the highest level of diversification, but further analysis will show that its economic complexity is lower than that of its V4 partners after correcting for the size of its economy and taking into account the qualitative aspect of its exports using the Method of Reflections.

\textsuperscript{30} The building blocks of economic complexity, C. Hidalgo and R. Hausmann, Proceedings of the National Academy of Science, 2009
\textsuperscript{31} Idem.
\textsuperscript{32} Idem.
\textsuperscript{33} Idem.
Economic Complexity Index and Ranking

In our analysis, we use $k_{c,18}$ as the measure of a country’s economic complexity (i.e. Economic Complexity Index or ECI). Instead of showing the values themselves, we have ranked them and show the countries from last to first. Figure 14 shows the evolution of country rankings through several rounds of iterations for level of diversification measures $k_{c,0}$, $k_{c,2}$, ..., $k_{c,18}$. The higher a country’s Economic Complexity Ranking, the lower that country appears on the list. We notice that China ranks 1st for the level of diversification (i.e. $k_{c,0}$). Yet, once we account for the size of the country and for the complexity of the products it exports, China falls to the 22nd rank (i.e. for $k_{c,18}$). On the opposite, Japan starts at the 16th position for the level of diversification but ends up being 1st in terms of Economic Complexity Ranking.
Figure 14: Evolution of country rankings for $k_{c,0}$, $k_{c,2}$ ... $k_{c,18}$
Despite early volatility due mostly to country size (economy, population, territory…) and after a few iterations using the Method of Reflections, Visegrad countries tend to have a very stable ranking for subsequent levels of diversification. However, their patterns of stabilization vary significantly. Analyzing these patterns is a valuable source of information for understanding these countries.

The Czech Republic is initially ranked n°14 for $k_{c,0}$, which is the measure of a country’s level of diversification (i.e. the number of products that a country exports with Revealed Comparative Advantage). This is already insightful if we consider the small size of that country’s economy and population compared to countries that are ahead in the rankings, which are either larger economies (such as China, India, Turkey but also Poland) or part of the more developed Western European region (such as The Netherlands and Austria).

After taking into account the average level of diversification of the countries exporting with Revealed Comparative Advantage the products that the Czech Republic itself exports with Revealed Comparative Advantage (i.e. after obtaining $k_{c,2}$ from two iterations using the Method of Reflections), we see that the Czech Republic climbs to the 3rd position. This is most certainly due to the fact that its “peer exporters” described above are on average even more diversified than the Czech Republic itself. Additional rounds of iterations result in the Czech Republic quickly stabilizing as n°6 in successive measures of diversity.

Hungary follows a pattern of upward stabilization in the rankings, from n°27 to a stabilized n°13. Slovakia follows a similar pattern, from n°38 to n°15. This increase in comparative performance as measured by the rankings shows how these two economies are fairly complex despite their small size.

Poland’s initial level of diversification ranks high (n°10). However, its position in rankings worsens as subsequent layers of product ubiquity and diversity of “peer exporters” are taken into account. This exemplifies how Poland, despite being a large economy compared to its V4 partners, exports products that are themselves exported by on average less diversified “peer exporters”. On top of that, the ubiquity of its exports is also higher than that of its V4 partners. These are the primary factors that explain why its rankings for subsequent measures of diversity stabilize at a lower n°21.
Ranking sensitivity to Revealed Comparative Advantage threshold variations

The *Economic Complexity Index* is partly based on a certain RCA threshold $T$ above which we consider that countries have developed a Revealed Comparative Advantage in a given product. In previous studies\(^{34}\), this threshold has been fixed at $T=1$. This level makes intuitive sense as it represents the limit above which the weight of a product in a country’s export basket is higher than the weight of this product in the total exports of the world economy.

Yet, what would be the impact of changing the RCA threshold on the *Economic Complexity Ranking* of the four countries we consider in this study? Indeed, setting a given RCA threshold implies that, should a country exceed this threshold for a given product, we assume that it has developed all the required capabilities for that particular product. Yet, we could imagine a country having a high *Economic Complexity Ranking* as a consequence of exporting a vast number of relatively complex products with RCA slightly above the $T=1$ threshold. In this case, the ranking of that country would prove to be very sensitive to small variations in the threshold level.

In order to avoid such a fallacy, it is important to evaluate the robustness of these results. We therefore conduct a sensitivity analysis of the *Economic Complexity Ranking* to variations in the RCA threshold, varying from $T=0.5$ to $T=2.0$ with 0.1 increments. We run our model 16 times for the 16 RCA threshold values and report each of the rankings on a graph similar to the one we used to show the results of the Method of Reflections. The lower a country is on the graph, the higher its *Economic Complexity Ranking*. At a 0.5 RCA threshold, Japan ranks first while South Sudan ranks last.

\(^{34}\) Hidalgo et al. (2007), Hidalgo and Hausmann (2009)
Figure 15: Evolution of Economic Complexity Ranking depending on RCA threshold
As shown in Figure 15, the Economic Complexity Rankings of V4 countries remain relatively stable despite significant variations in the RCA threshold. This suggests that empirical RCA levels, resulting from the mathematical concept we use, are not all concentrated around one particular figure (or at least this figure is not included in the [0.5,2] range), but rather experience a distribution that testifies of the overall robustness of the economic complexity of V4 countries. This result is even more compelling as we see that other countries fall significantly in rankings as the RCA threshold becomes higher.

We quantify the level of robustness of V4 countries by introducing a metric of dispersion. We define the level of dispersion as the difference between the minimum and the maximum ranking a country experiences while we make the RCA threshold vary from 0.5 to 2. For example, we see in Figure 15 that the Czech Republic’s highest ranking is n°5, while its lowest ranking is n°6. Its level of dispersion is therefore of 1. The levels of dispersion are represented in Figure 16.
<table>
<thead>
<tr>
<th>Country</th>
<th>Level</th>
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<tbody>
<tr>
<td>Burundi</td>
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<td>Jamaica</td>
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<td>Malaysia</td>
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<tr>
<td>Papua New Guinea</td>
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<tr>
<td>Sao Tome and Principe</td>
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<tr>
<td>Afghanistan</td>
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<td>Benin</td>
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<td>Bolivia</td>
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<td>Madagascar</td>
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<td>Moldova</td>
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<td>Oman</td>
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<td>Laos</td>
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<td>Galapagos</td>
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<td>Sierra Leone</td>
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<td>Canada</td>
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<td>Iran</td>
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<td>Trinidad and Tobago</td>
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<td>Qatar</td>
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<td>South Sudan</td>
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**Figure 16: Levels of dispersion from ECI sensitivity analysis**
The Czech Republic’s *Economic Complexity Ranking* is the most robust to changes in the RCA threshold among V4 countries. In fact, its robustness is the highest among all countries, identical to that of other complex economies such as Japan. Poland’s *Economic Complexity Ranking* is very robust to variations in the RCA threshold, experiencing a level of dispersion similar to that of countries such as France or Germany. Hungary and Slovakia rank slightly worse with dispersion levels of 6 and 7 respectively. Overall, these levels of dispersion qualify V4 countries in the top quartile compared to the list of other countries.

In order to understand why V4 countries are robust to variations in the RCA threshold, we look at the dispersion of products depending on their RCA levels and on *Product Complexity Indices* (PCI). In Figure 17, each dot represents a product that the relevant country exports with RCA levels higher than 0.5 and lower than 4. Other products are ignored for this analysis for clarity purposes.

The intuition behind this analysis is that, if a country tends to export less complex products as RCA levels increase, then its *Economic Complexity Ranking* is likely to fall when exposed to variations in the RCA threshold. On the opposite, if a country tends to export more complex products as RCA levels increase, then its *Economic Complexity Ranking* is likely to climb when exposed to variations in the RCA threshold.

The robustness of V4 economies seems to be explained by the relatively even distribution based on the *Product Complexity Indices*. As the RCA threshold increases, they continue exporting a complex product basket. To their benefit, if we set the RCA threshold at 3, V4 countries tend to export an even more complex basket of products than at lower threshold levels. This is notably the case for the Czech Republic. To a lesser extent, this is also the case for Poland, Hungary and Slovakia at high RCA values, which helps explaining why they experience increasing *Economic Complexity Rankings* at higher threshold levels.
Figure 17: Dispersion of Export RCA by Product Complexity Index
Qualitative trade balance: economic complexity of bilateral export baskets

Countries export and import products from one another. The net trade balance of country \( c \) with regards to country \( d \) is the difference between the dollar value of its exports to country \( d \) and that of its imports from that country.\(^5\)

We believe that this aggregate quantitative approach, although necessary and useful, fails to give a sense of the qualitative aspect of this trade relation. Building on the concept of economic complexity introduced earlier, we propose a qualitative measure of trade balance by analyzing the composition of bilateral export baskets between two countries.

We do so for every pair of countries and in both directions of foreign trade, ranking the results in a similar way as we ranked the Economic Complexity Indices of countries. The main difference, in this case, is that every bilateral oriented export basket is considered as if it were a country of its own. For example, we call the export baskets of Poland towards Germany and Germany towards Poland matching bilateral oriented export baskets. These export baskets \([\text{POL} \rightarrow \text{DEU}]^6\) and \([\text{DEU} \rightarrow \text{POL}]\) have their own levels of diversification, similarly to any individual country. We name these levels of diversification \( k_{\text{POL} \rightarrow \text{DEU}},0 \) and \( k_{\text{DEU} \rightarrow \text{POL}},0 \) respectively.

These results for bilateral oriented export baskets are iterated using the same Method of Reflections as in Hidalgo and Hausmann (2009)\(^7\) to obtain their respective Economic Complexity Indices: \( k_{\text{POL} \rightarrow \text{DEU}},1 \) and \( k_{\text{DEU} \rightarrow \text{POL}},1 \). We then rank all bilateral oriented export baskets from first to last.

Once we have this set of rankings, we plot the qualitative trade relations between a country and its trade partners on a graph where the x-axis represents the Economic Complexity Ranking of the country’s export basket towards a trade partner and the y-axis represents the Economic Complexity Ranking of the trade partner’s basket towards the original country. For example, in the case of Poland and Germany and if we consider Poland being the country analyzed, the qualitative trade relation would be identified on the graph by a point titled DEU, where the x-axis coordinate of that point would be the Economic Complexity Ranking of the \([\text{POL} \rightarrow \text{DEU}]\) export basket and the y-

\(^5\) In our case, we restrain ourselves to the export/import of goods.
\(^6\) DEU stands for Deutschland (Germany).
\(^7\) The building blocks of economic complexity, C. Hidalgo and R. Hausmann, Proceedings of the National Academy of Science, 2009
axis coordinate would be the *Economic Complexity Ranking* of the matching [DEU→POL] export basket.

We find this visualization compelling once we plot the qualitative trade relations against the $y = x$ linear function. Indeed, if the qualitative trade relation of any two countries figured on that line, the *Economic Complexity Rankings* of the *matching bilateral export baskets* would be absolutely identical (which would not mean that these export baskets have the same composition). For any trade partner represented above this line, the original country exports a more complex product basket towards its partner than vice versa. In this case, we talk of a qualitative trade surplus. For any trade partner lying below this line, the original country exports a less complex product basket towards its partner than vice versa. In this case, we talk of a qualitative trade deficit. Hence, this visualization provides a straightforward characterization of the nature of the qualitative trade relations between a country and its export partners.

To qualify even more accurately the bilateral trade relations, we have added two additional layers of information on the graphs presented in Figures 18 to 21. On the first type of graphs, the size and color intensity of any data point are determined by the weight of the exports toward the trade partner as a percentage of the original country’s total exports. On the second type of graphs, the size and color intensity of any data point are determined by the ratio of GDP per capita of the trade partner to the GDP per capita of the original country. These two additional layers of information, which we call “*Relative weight of exports*” and “*Relative wealth of countries*”, are useful to better describe the trade relations.

For the sake of clarity and because we find it to be more relevant given the weight of European trade partners in the total exports of V4 countries (between 83% and 88% of their total exports), we decided to plot only the qualitative relations with European trade partners (including Russia).
Figure 18: Matching bilateral oriented export baskets – Czech Republic
Figure 18 shows how the Czech Republic has an overall positive qualitative trade relation with its European trade partners. The complexity of its export baskets towards them is higher than that of its import baskets from them. There is a clear difference however between its Western European trade partners such as Germany, France, Spain or Austria, which lie mostly below the $y = x$ function, and its Eastern European trade partners which stand above this line, such as its V4 partners but also Croatia, Serbia or Russia.

The first graph of Figure 18, titled *Relative Weight of Exports*, shows the Czech Republic's largest export destinations. The main trade destination of the Czech Republic is Germany, which is consistent with the size and color intensity of the point representing the qualitative aspect of that trade relation. V4 partners are also marked by slightly larger points than the average, showing the importance of these trade relations as well. However, the Czech Republic runs a qualitative trade deficit with Germany, whereas it benefits from a qualitative trade surplus with Hungary, Poland and Slovakia. This is consistent with the fact that the Czech Republic has a higher *Economic Complexity Ranking* than its V4 partners, although there is no immediate causality that can be drawn here.

The second graph of Figure 18, titled *Relative Wealth of Countries*, highlights the differences between the Czech Republic and its European trade partners in terms of GDP per capita. The larger the points, the wealthier the trade partner is compared to the Czech Republic. Interestingly, most of the countries with whom the Czech Republic runs a qualitative trade deficit have a higher standard of living (as measured by GDP per capita). We will see later that this apparent pattern between the qualitative trade relation and the *Relative Wealth of Countries* occurs for most of V4 countries.

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38 The higher a country’s *Economic Complexity Index*, the lower its *Economic Complexity Ranking*. 
Figure 19: Matching bilateral oriented export baskets – Hungary
Hungary’s qualitative trade relation with its European trade partners is more balanced than that of the Czech Republic as the numbers of partners with which it runs a qualitative trade surplus (17 countries) and a qualitative trade deficit (19 countries) are similar.

When considering the Relative Weight of Exports, Hungary exports on average more towards partners with which it runs a qualitative trade deficit. Unsurprisingly, these countries include Germany, which we know represents a very large share in Hungary’s total exports (27%), but also other key Western European partners such as France and Great Britain as well as Scandinavian countries (Sweden, Norway, Finland and Denmark). As for its Visegrad partners, while Hungary runs a qualitative trade deficit with the Czech Republic, it benefits from a qualitative trade surplus with its two other partners, Slovakia and Poland. This is consistent with Hungary having a higher Economic Complexity Ranking than Slovakia and Poland but lower than the Czech Republic.

In terms of Relative Wealth of Countries, Hungary runs a qualitative trade deficit mostly with countries that are on average wealthier in terms of GDP per capita, such as the countries already mentioned earlier in the previous paragraph but also Switzerland and Austria. However, there are a few wealthier countries with which it runs a qualitative trade surplus, such as Spain and Greece.

Poland exhibits a similar pattern of trade relations as Hungary, both in terms of Relative Weight of Exports and Relative Wealth of Countries. A very large part of its exports go to Germany, towards which it experiences a qualitative trade deficit. Other partners with which it runs a qualitative trade deficit include France, Great Britain and Switzerland but also the Czech Republic and Hungary.
Figure 20: Matching bilateral oriented export baskets – Poland
Figure 21: Matching bilateral oriented export baskets – Slovakia
Slovakia has a somewhat different bilateral trade landscape in Europe, being more heterogeneous and therefore more complicated to qualify. It runs a qualitative trade deficit with all of its V4 partners (which together represent 23.2% of its exports), but unlike them it experiences a unique qualitative trade surplus towards Germany as well as other Western European countries such as Great Britain. In terms of Relative Wealth of Countries however, Slovakia follows the same general pattern as its Visegrad partners: most of the countries with which it has a qualitative trade deficit are also wealthier in terms of GDP per capita.

Synthesis on Economic Complexity and current state of V4 countries

In this part, we have first introduced the concepts of diversity and ubiquity in the broader context provided for by the Theory of Economic Complexity. We have offered an overview of the Visegrad countries based on where they lie in the “diversity versus average ubiquity” space. This overview has shown that they all rank among “Diversified Countries Producing Exclusive Products”, with Poland being the most diversified and the Czech Republic exporting on average the less ubiquitous products.

With the Method of Reflections, we have then iterated the diversity and ubiquity measures to compute the Economic Complexity Index of V4 countries. Based on this index, we rank them from first to last among other countries. The Visegrad countries prove to be complex economies, the Czech Republic ranking above the others and Poland slightly lagging behind.

This result however has to be mitigated by the fact that our study focuses exclusively on export data and does not take into account the relative importance of the national market and the products that are being produced for local consumption. Indeed, when we look at exports over GDP for V4 countries (a measure of how much of its economic output a country exports), we observe different patterns. For both Hungary and Slovakia, exports represent more than 90% of GDP, suggesting that these countries export a very significant part of their economic output. The ratio is slightly lower for the Czech Republic but still very high at 83% of GDP. Poland, however, only exports 50% of its economic output. This suggests a more important domestic market for the latter than for the formers. Indeed, when we look at household expenditures, we notice that Poland surpasses all other V4 members, notably due to its population size. According to the OECD, in 2015
household spending reached $588.7bn in Poland compared to $164.8 for the Czech Republic, $124.0bn for Hungary and $87.5bn for Slovakia.\textsuperscript{39}

Therefore, while for Slovakia, Hungary and the Czech Republic exports seem to provide a good approximation for their productive structure, this is less straightforward for Poland. Indeed, the latter could be producing complex products for its domestic market without exporting them to the rest of the world with Revealed Comparative Advantage. This could explain its lower Economic Complexity Ranking compared to other V4 countries.

To certify that the results of economic complexity we have obtained for the Visegrad countries are robust, we have performed a sensitivity analysis to understand how the rankings would be impacted by variations in the RCA threshold used to determine whether a product is exported with Revealed Comparative Advantage. Unlike some countries that have a volatile economic complexity profile (i.e. Saudi Arabia, Brazil, Russia or South Africa), the sensitivity test has shown that the economic complexity measures of V4 countries are robust.

Finally, we have analyzed the bilateral trade relations between the Visegrad countries and their European trade partners. We did so using what we call the “qualitative trade balance” approach that consists in comparing the export basket of a country towards its neighbor with the export basket of that neighbor towards the original country. We have seen that although V4 countries have a somewhat different qualitative trade profile, some important patterns remain consistent across the region, notably the fact that the Visegrad countries have a qualitative trade deficit mostly with more developed, wealthier trade partners that account for a large part of their exports.

\textsuperscript{39} OECD 2015 Data. Household spending is defined as « the amount of final consumption expenditure made by resident households to meet their everyday needs ». 
V4 Countries in the Product Space

In the third part of this paper, we introduce the concepts of proximity and density to identify new product categories around which V4 countries have developed a strong ecosystem of required capabilities. This could allow them to expand their industrial base by producing and exporting these new products. This prospective analysis aims at exploring whether there are opportunities for the Visegrad countries to voluntarily expand their product space and engage on new industry-specific development trajectories or if they should rather focus on building cross-industry capabilities.

The concepts of proximity and density

Country, Capability, Product: a tri-partite network

In their 2009 paper on “The building blocks of economic complexity”, Hidalgo and Hausmann develop the view that:

“The productivity of a country resides in the diversity of its available non-tradable “capabilities,” and therefore, cross-country differences in income can be explained by differences in economic complexity, as measured by the diversity of capabilities present in a country and their interactions.\(^{40}\)"

It is possible to map the following theoretical links: (1) products to the capabilities they require and (2) countries to the capabilities they have developed. Countries and products can then be indirectly linked through the capabilities that they have or require, which can be visualized as a tri-partite network: Country – Capability – Product.

In a mathematical approach, this can be modeled using two matrices. The Country – Capability Matrix (for the sake of convenience, we call it $M_{\text{Country, Capability}}$) links the countries to the capabilities that they have developed over the years. The Product – Capability Matrix (called $M_{\text{Product, Capability}}$) links the products to the capabilities that they require in order to be produced. These matrices however cannot be visualized because capabilities are not easy to list or identify explicitly. Hidalgo and Hausmann have shown that it is possible to consider the trade data linking a country to the products it exports as a third matrix (called $M_{\text{Country, Product}}$), which can also be

\(^{40}\) The building blocks of economic complexity, C. Hidalgo and R. Hausmann, Proceedings of the National Academy of Science, 2009
understood as the mathematical product of the two above mentioned matrices. “Hence”, they say, “connections between countries and products signal the availability of capabilities in a country.”

It is therefore worth to analyze more in depth the bi-partite network composed of countries and the products they export and to understand the various qualitative characteristics of its structure.

**The concept of proximity**

The proximity $\phi$ between products $i$ and $j$ is the minimum of the pairwise conditional probability of a country $c$ exporting product $i$ (respectively $j$) with Revealed Comparative Advantage given that it exports product $j$ (respectively $i$) with Revealed Comparative Advantage:

$$
\phi(i, j) = \min \left( P_{\text{RCA}(c,i)} \text{RCA}(c,i), P_{\text{RCA}(c,j)} \text{RCA}(c,j) \right)
$$

Here we simplify by calling $\text{RCA}(c,i)$ the event when $\text{RCA}(c,i) \geq T$.

For the sake of clarity, let us consider that $T=1$ and that there are $n$ countries exporting product $i$ with $\text{RCA} \geq 1$, $m$ countries exporting product $j$ with $\text{RCA} \geq 1$ and $t$ countries co-exporting products $i$ and $j$ with $\text{RCA} \geq 1$. In this case, the proximity $\phi$ between products $i$ and $j$ is:

$$
\phi(i, j) = \min \left( \frac{t}{n}, \frac{t}{m} \right)
$$

**The concept of density**

In order to detect the entry of potential products, Hidalgo et al. (2007) introduce the concept of density. The idea is to quantify the number of capabilities a given country has built around a new potential product (i.e. a product that a particular country does not export yet with Revealed Comparative Advantage). Mathematically, density of country $k$ around product $j$ is defined as:

$$
\omega(c, j) = \frac{\sum_i x(i) \phi(i, j)}{\sum_i \phi(i, j)}
$$

where $x(i)=1$ if $\text{RCA}(c, i) \geq 1$ and 0 otherwise.

---


43 Idem.
This equation maps the proximity landscape of a country’s RCA export basket (i.e. the basket of all products it exports with Revealed Comparative Advantage) around a potential new product. This proximity landscape is aggregately referred to as density.

Why do density values matter for potential product expansion?

In this section, we use the notions of transition and undeveloped products introduced by Hidalgo et al. in *The Product Space Conditions the Development of Nations* (2007). We further define a transition product as a product that a given country did not export with Revealed Comparative Advantage in 2008 but that did export it with such an advantage in 2014. Similarly, we characterize an undeveloped product as a product that was neither exported with Revealed Comparative Advantage in 2008 nor in 2014. In the matrix connecting products to countries, product $p$ is called a transition product for country $c$ if $M_{c,p}$ equals 0 in 2008 and 1 in 2014. A product $p$ is called undeveloped for country $c$ if $M_{c,p}$ equals 0 both in 2008 and 2014.

We look at density distributions for both transition products and undeveloped products in order to put forward the empirical link between density and the probability of developing a given product in a “near” future. We use the same dataset of 1,220 products and 219 countries and split it into two subsets for our subsequent analysis. The first dataset contains density information for transition products with over 1,900 observations and the second dataset contains density information for undeveloped products with over 38,500 observations. Figure 22 displays histograms showing the distribution of density values for both subsets.
Figure 22: Density Distribution Transition vs. Undeveloped Products

We observe very different distributions between transition and undeveloped products. For undeveloped products, density values concentrate to the left of the histogram, suggesting that
products that are undeveloped tend to have low density values. For transition products, density distribution shows a distinct shape with density values displaying a more even staircase pattern. Looking at the empirical cumulative distribution function, we notice that the curve is steeper in the case of undeveloped products. In the table below, we report the empirical cumulative distribution results we observe for density values comprised between 0.1 and 0.5 with 0.1 increments in both the transition and undeveloped products cases.

<table>
<thead>
<tr>
<th>Density value in 2008</th>
<th>0.1</th>
<th>0.2</th>
<th>0.3</th>
<th>0.4</th>
<th>0.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transition products</td>
<td>0.395</td>
<td>0.687</td>
<td>0.889</td>
<td>0.964</td>
<td>0.997</td>
</tr>
<tr>
<td>Undeveloped products</td>
<td>0.640</td>
<td>0.835</td>
<td>0.942</td>
<td>0.985</td>
<td>0.999</td>
</tr>
</tbody>
</table>

The table should be read in the following way: 88.9% of transition products had a density lower or equal to 0.3 in 2008 while 94.2% of undeveloped products had a density lower or equal to 0.3 in 2008.

This empirical analysis makes intuitive sense as it shows that countries that have developed a strong network of products (i.e. a strong network of capabilities) around potential new products (as reflected by the concept of a high density) tend to develop these potential products in a “near” future.

A high density value does not, however, automatically mean that a country will develop a given product in a “near” future. The development of a given product can be seen as the presence of all the necessary capabilities in a particular country. Density gives a notion of how many of these capabilities a country has developed around a potential new product. Yet, as a purely mathematical tool, it does not take into account the fact that some products may require capabilities that do not exist in a particular country: access to the sea for fishing products or to a particular commodity. This is where a more qualitative and granular analysis is needed to identify which of the high density products have a true potential within an economy.
Analysis of V4 countries via proximity and density

In this section, we apply the density framework to each individual V4 country to discover if there are potential industry-specific development trajectories that these countries may follow in a “near” future. We first look at disparities of density values across the region. We then assess the main sectors where high density values are concentrated. Finally, we put density values in perspective using the Product Complexity Index in order to determine how sophisticated development opportunities are and verify our assumption that the more complex an economy is, the higher its density values for complex products.

When it comes to density, size matters

In Figure 23 we plot histograms showing the density value distribution for each V4 member.

---

44 At a low level granularity.
We notice that Poland has the highest density values among V4 countries, followed respectively by the Czech Republic, Hungary and Slovakia. By comparing the cumulative distribution function results for V4 countries, we see that almost all products in Slovakia and Hungary have density values below or equal to 0.3 while for Poland and the Czech Republic less than 20% of products fall in that range.
<table>
<thead>
<tr>
<th></th>
<th>0.15</th>
<th>0.20</th>
<th>0.25</th>
<th>0.30</th>
<th>0.35</th>
<th>0.40</th>
<th>0.45</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Poland</strong></td>
<td>0</td>
<td>0</td>
<td>0.009</td>
<td>0.116</td>
<td>0.461</td>
<td>0.873</td>
<td>0.998</td>
</tr>
<tr>
<td><strong>Czech Republic</strong></td>
<td>0</td>
<td>0</td>
<td>0.018</td>
<td>0.169</td>
<td>0.701</td>
<td>0.993</td>
<td>1</td>
</tr>
<tr>
<td><strong>Hungary</strong></td>
<td>0.002</td>
<td>0.022</td>
<td>0.402</td>
<td>0.961</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Slovakia</strong></td>
<td>0.010</td>
<td>0.324</td>
<td>0.953</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

While Poland clearly benefits from the best density distribution among V4 countries, it ranks below its neighbors in terms of Economic Complexity Index. We explain this by the fact that density values are highly reliant on levels of diversification. In 2014, V4 countries had respective levels of diversification of 411 for Poland, 384 for the Czech Republic, 292 for Hungary and 241 for Slovakia. As mentioned earlier in this paper, these levels largely reflect the size of the economy. Some products may require a set of capabilities that cannot be developed unless a certain scale is reached, be it in terms of population or productive structure. It may not be economically efficient, for example, for a given firm in a given country to build the capabilities required to address a market if the latter is not large enough. While the Economic Complexity Index accounts for several factors through the Method of Reflections, such as the complexity of products, the size of the economy and of the population, the concept of density does not. All else being held constant, the higher a country’s the level of diversification is, the more right-shifted its density distribution profile.

**The Visegrad Group: a sector-agnostic region?**

In this section, we conduct an analysis of the density levels V4 countries have developed around selected product categories. As shown in the first part of the thesis, these countries are highly reliant on exports from 8 main sectors: Machines, Transportation, Metals, Plastics and Rubber, Chemical Products, Foodstuffs, Textiles and Mineral Products. We therefore limit the density per sector analysis to these product categories for the sake of clarity and interpretability of results. Figure 24 shows the density profile of V4 countries for the above mentioned product sectors.
Figure 24: Density Distribution by Top Product Sectors
We note a rather homogeneous distribution of density values as no particular sector stands out. Although some discrepancies occur, the majority of density values is located within a 0.05 range from the mean. In some way this confirms the high level of diversification these countries have achieved. They are not exclusively reliant on one particular industry (as some less developed countries would be) and have therefore built capabilities that will enable the development of products in diverse sets of industries.

Transportation as well as Machinery and Electrical products qualify as common axes of future development for these 4 countries as they experience high density levels. In the table below, we summarize the top 4 sectors with the highest density values (estimations by the mean).

<table>
<thead>
<tr>
<th>Place</th>
<th>Sector</th>
<th>Poland</th>
<th>Czech Republic</th>
<th>Hungary</th>
<th>Slovakia</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Foodstuffs</td>
<td>Machinery / Electrical</td>
<td>Foodstuffs</td>
<td>Machinery / Electrical</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Transportation</td>
<td>Transportation</td>
<td>Transportation</td>
<td>Machinery / Electrical</td>
<td>Foodstuffs</td>
</tr>
<tr>
<td>3</td>
<td>Mineral Products</td>
<td>Plastics / Rubbers</td>
<td>Transportation</td>
<td>Plastics / Rubbers</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Machinery / Electrical</td>
<td>Metals</td>
<td>Plastics / Rubbers</td>
<td>Transportation</td>
<td></td>
</tr>
</tbody>
</table>

Most importantly, V4 countries seem to be sector-agnostic in terms of future development path. Not a single sector stands out from the others. Instead, capabilities have been built so that development opportunities may arise in a wide range of sectors.

**Going forward, everything remains possible**

We look at how density values for specific products are distributed in V4 countries depending on their Product Complexity Indices (PCI). We use the ranking available on the Observatory of Economic Complexity website containing PCI values for the 1,220 products classified in the HS07 dataset available for 2014\(^{45}\). In Figure 25 we plot density values versus PCI\(^{46}\) for relevant products for each V4 country.

\(^{45}\) Source: Observatory of Economic Complexity website.

\(^{46}\) The most complex product is *Chemical preparations for photographic uses* with a PCI of 2.32. The less complex product is *Tin ores and concentrates* with a PCI of -3.295.
We observe that distributions are overall heterogeneous. V4 countries have developed high density values for both complex and less complex products. The Czech Republic seems to have a small advantage as it has developed higher density values for complex products than for less complex ones. On a regional scale this seems to confirm that V4 countries have developed capabilities that will enable the development of diversified products.

Figure 25: Density Distribution by PCI
Unlocking opportunities through regional integration

We assess what type of opportunities could be created should more economic integration within the V4 region occur. We consider a joint picture obtained by merging V4 countries into one consolidated entity called “V4 combined”. We aggregate export values for each of the 1,220 products exported by our newly created entity. We then follow the same methodology already used in the previous sections. First, we calculate the Revealed Comparative Advantage for each of the 1,220 products. We introduce a vector $M_{V4,p}$ with elements that take values of 1 if product $p$ is exported with Revealed Comparative Advantage at the V4 level and 0 otherwise. We use proximity measures to calculate the density for each potential new product (i.e. products not yet exported with Revealed Comparative Advantage) given the export structure of “V4 combined”.

**Together V4 countries stand stronger**

In Figure 26 we display the distribution of density values for our newly created entity. Overall, we achieve a superior density distribution profile for “V4 Combined” than for any V4 country taken individually. Indeed, 96% of products would, in this hypothetical case, have a density value in 2014 that is higher or equal to 0.3. The key beneficiaries of such an increase would be Slovakia and Hungary whose density distribution profiles are on average much weaker (i.e. left-shifted) when considered individually. The Czech Republic and Poland also slightly benefit from the increase in density values, though more marginally.

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47 As a reminder, the share of products with a density value higher or equal to 0.3 is 88% for Poland, 83% for the Czech Republic, 4% for Hungary and 0% for Slovakia.
Although some capabilities might be redundant, the shift to the right of density values suggests that V4 countries have developed complementary capabilities. This would strengthen the potential for future development of particular products, were these countries to achieve a higher level of economic integration and sharing of capabilities. Hungary, Slovakia and the Czech Republic would benefit from the size of Poland’s economy and its level of diversification. Poland would benefit from the fact that those countries have more complex productive structures.

Our findings prove even more compelling when we compare the density distribution profile of “V4 Combined” to that of more complex and developed economies. Indeed, when we look at how density values are distributed for Germany, in Figure 27, we notice a strong concentration of density values in higher ranges. This clearly shows that more developed and complex economies have, over time, built a much more complete set of capabilities. Regional integration would enable V4 countries to export more complex products and would help bridge the qualitative trade balance gap that we have put in evidence in an earlier part of this thesis.

![Figure 27: Density Distribution for Germany](image)

48 Please note that x-axis limits were modified for visualization purposes.
Separated or combined, sector-agnosticism remains

Figure 28: Density Distribution by Top Sectors for "V4 Combined"

Figure 28 exhibits the density profile of the combined entity for the main product sectors. The density distribution for “V4 Combined” is quite homogeneous with all product sectors showing density values comprised between 0.35 and 0.45. The combined entity remains sector-agnostic.

Density distribution by product complexity

Figure 29: Density Distribution by PCI for "V4 Combined"

We plot, in Figure 29, density values versus PCI for relevant products. The “V4 Combined” entity exhibits a non-linear distribution when looked through the prism of Product Complexity Index (PCI): the region as a whole reaches high density values for complex and less complex products. Poland, Hungary and Slovakia clearly benefit from such a distribution, since density around specific products increases compared to previously experienced levels. This is also the case for the Czech Republic, although it may not be straightforward at first sight: while losing the apparent
positive correlation exhibited in Figure 25, the density values increase quite substantially for products of similar above-average complexity.
**Recommendations**

Based on the understanding of the Visegrad countries that we have gained through this study, we make the following two main policy recommendations regarding their future development paths and the expansion of their export-oriented productive landscape.

**Develop cross-industry capabilities to enhance an attractive business environment**

V4 countries have on average high density levels around a wide range of product categories, making them sector-agnostic. These economies are sophisticated and have developed complex productive landscapes. Choosing to support a specific industry would therefore not be an optimal use of government or other funds. We would rather recommend developing capabilities which will be of benefit to a broad array of industries. On the national scale our first recommendation is therefore to focus on developing cross-industry capabilities rather than designing industry-specific strategies. This general capability development approach might include some of the following measures.

**Invest in infrastructure and urban networks**

Roads and highways, modern railroads for targeted trajectories, state-of-the-art ports (for Poland) are all items of infrastructure that constitute key capabilities for any country and strengthen its competitiveness. Although some of these countries have already built functional transport infrastructure, there is still a lot to be done to match Western European standards. For example, Poland currently has around 3,300 kilometers of highways, compared to nearly 13,000 kilometers in neighboring Germany, despite the fact that the two countries have relatively similar sizes\(^{49}\).

The World Bank has indicated that Central and Eastern European countries have been lagging behind their European partners in terms of urbanization. When considering the share of urban population in the country, the Czech Republic (73.4%) is slightly behind the EU-15 average (77.3%), however Hungary (69.4%), Poland (60.9%) and especially Slovakia (54.8%) are far behind Western European standards of urbanization\(^{50}\). Since most of the high value-added jobs are increasingly concentrated in big cities and urban areas, this pattern of under-urbanized population highlights the fact that there is still room for V4 countries and their population to climb up the

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\(^{49}\) Poland’s geographical area covers 312,679 square kilometers, Germany’s area is 357,021 square kilometers.

\(^{50}\) Source: The World Bank, as quoted in a McKinsey Global Institute Report on the CEE region
value chain. Infrastructure projects for facilitating commuters’ access to city centers are critical in allowing a bigger part of the population to participate in the development of a value-added economy.

**Improve healthcare services**

Several issues with the healthcare systems of V4 countries exist, leading us to believe that healthcare is to be considered a crucial capability for the development of these economies. Public hospitals are decades behind their Western European counterparts in terms of infrastructure while a significant part of the population cannot afford the services provided by state-of-the-art private clinics. Paradoxically enough, there is an increasing lack of skilled doctors in these countries. Although they host some of the most prestigious medical schools of Central Europe, V4 countries are subject to one of the strongest brain drain ever experienced with regards to doctors and other trained medical professionals seeking more rewarding employment opportunities in Germany, England and the Scandinavian countries. According to World Bank data\(^5\) available for the year 2011, Euro Area countries had 3.9 physicians per 1,000 inhabitants, above levels experienced by V4 countries, respectively at 3.6 for the Czech Republic, 3.0 for Hungary, 3.0 for Poland and 3.6 for Slovakia. These countries must find a way to improve healthcare services by investing in hospitals and developing an efficient strategy to retain skilled medical labor from systematic expatriation.

**Develop a complementary education offering to STEM\(^52\)**

Education is another capability in which we believe that V4 countries should invest more. In terms of primary education, students in these countries had continuously declining results in Science, Mathematics and Reading skills between 2006 and 2015, as measured by successive PISA tests (except for Poland which has seen some improvement in these fields over the same period)\(^53\). Regarding higher education, Central European universities excel in hard skills (STEM majors) but “lag behind international best practices” in the fields of soft skills and entrepreneurship education, as outlined by a KKR Institute report on the region\(^54\). Similarly to the field of healthcare, creating the conditions for retaining and attracting the best professors and faculty members is absolutely

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\(^5\) Source: World Bank Data
\(^52\) STEM: Science, Technology, Engineering and Mathematics
\(^53\) Source: OECD website for PISA (http://www.oecd.org/pisa/)
\(^54\) KKR Global Institute, *Unlocking the World for Central and Eastern European Champions*, 2014
essential for V4 countries to offer higher education services that are competitive on the world stage.

Enhance business attractiveness

Although V4 countries have complex productive structures, they can still further improve the business environment to foster entrepreneurship and innovation. Indeed, the World Bank ranks these countries at the following respective positions for the ease of doing business: 27th for the Czech Republic, 41st for Hungary, 24th for Poland and 33rd for Slovakia. These rankings could be improved if V4 countries were to strengthen the skilled labor market (especially in the field of engineering, where there is a clear need for competent professionals trained in western managerial techniques), create a robust and tailored financing environment to support entrepreneurship, provide adequate corporate governance guidelines and streamline institutional and regulatory frameworks. On top of those, we have already mentioned the problems created by a massive talent exodus to the West. We believe it is crucial for these countries to reverse the brain drain and attract back local talent that has moved abroad for economic purposes.

Accelerate economic and institutional integration with V4 partners

Our second recommendation for V4 countries is to continue on the path of regional economic integration initiated at the signature of the Visegrad Declaration in 1991. This is strongly suggested by the analysis that we have led around the combined regional density distribution. Indeed, we have shown that V4 countries have developed complementary capabilities that could open potential development opportunities in the future.

Harmonize tax regimes

V4 countries have themselves set out objectives of cooperation for their respective tax administrations. These objectives, stated in the program of the Polish Presidency of the Visegrad Group for 2016-2017, include “closer cooperation in the area of fight against VAT tax fraud”55. Our opinion is that there is room for far more harmonization of tax regimes than what is currently being done.

While the mutual benefits of fiscal harmonization as part of regional integration endeavors are increasingly more acknowledged within academic circles, fiscal policy has nonetheless always

55 Source: Visegrad Group website: Program of the Polish Presidency, July 1, 2016 – June 30, 2017
been and remains a key element of sovereignty for national states and their governments. This explains why there has been scarce progress on the pragmatic side of its realization, whether in Europe or in other parts of the world.

We believe that V4 countries could do an important leap forward on their path towards more fruitful economic integration if they were to set aside national differences and collectively establish a harmonized tax regime across the region. Trans-border businesses would flourish and companies would be even more encouraged to make use of other countries’ capabilities and share their own.

*Initiate mutual efforts to support Research and Development activities*

We have seen that V4 countries have developed knowledge and expertise in some specific industries such as automobile manufacturing but also aerospace (in the case of the Czech Republic and Poland). As the KKR report cited above says however, “low-cost manufacturing is not an attractive and sustainable business niche”\(^{56}\). We have seen how some Western European companies relocate their manufacturing activities to Eastern neighbors while keeping all the Research and Development efforts at home. We recommend V4 countries to support Research and Development initiatives across all industrial sectors. Focusing on cross-border initiatives will allow them to benefit from one another’s capabilities and create new frameworks of collaboration in the fields of science and technology.

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\(^{56}\) KKR Global Institute, *Unlocking the World for Central and Eastern European Champions*, 2014
Conclusion

Using a novel macroeconomic approach, our intent in this thesis was to shed a new light on a region that may sometimes be overlooked because considered as too small to be interesting or as too stable to be worried about.

We first attempted to give an overlook of the Visegrad countries from a historical, geopolitical and macroeconomic perspective. We highlighted the importance of Germany as the main export partner as well as the strong interdependency among V4 countries in terms of foreign trade.

We then analyzed specific trade data of V4 countries using the Theory of Economic Complexity and we iterated successive measures of diversity and ubiquity using the Method of Reflections. Beyond what mainstream macroeconomic indicators tend to show, this region possesses attractive and compelling characteristics. We found that V4 countries have high Economic Complexity Rankings and that these results are particularly robust to variations in the threshold applied to define Revealed Comparative Advantage. However, when we look at them from a qualitative trade balance perspective, V4 countries tend to export a basket of products that is less complex than the basket of products they typically import from wealthier Western European countries.

In the third part of this paper, we studied the product space of the Visegrad countries, looking at density distributions around potential products. The results show that the Czech Republic, Hungary, Poland and Slovakia are complex and resilient economies which have developed capabilities around a wide range of product categories. Moreover, the density distribution of the combined economies proves to be higher than that of any V4 member state taken individually, which suggests that V4 countries have complementary capabilities from which they could benefit if economic and institutional integration was to be accentuated.

Finally, based on the understanding we gained through this study, we made two policy recommendations for V4 countries. On the national scale, we recommend focusing on developing cross-industry capabilities that will be of benefit to a large array of productive sectors, rather than designing an industry-specific strategy. On the regional scale, we believe that the Czech Republic, Hungary, Poland and Slovakia need to continue on the path of economic and institutional integration to combine capabilities in a way that might favor the development of new productive sectors or strengthen existing industries across the region.
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