Unsolved Asymmetries and Complex Productive Structures in the Eurozone

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Unsolved Asymmetries and Complex Productive Structures in the Eurozone

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Abstract: The severity of the crisis in the Southern Eurozone countries is frequently attributed to inflated economies and reckless spending. Thus, it isn't surprising that the main interpretation is that the crisis ought to be solved by decreasing government spending and lowering wages. This paper argues, instead, that one of the core underlying reasons for the severity of the crisis in the Southern Eurozone is grounded in large differences in productive structures. These large differences have an historical origin and have never been addressed properly. In this article, we provide clear empirical evidence for large and deeply engrained productive structure differences between the Northern Eurozone and Southern Eurozone. This paper concludes that economic divergence within the Eurozone has not, and is unlikely to be, solved by market dynamics alone. Hence, this paper argues that to create the right environment for sustainable long-term growth and convergence in the Eurozone, strategic investment in the productive structures of the Southern Eurozone is drastically needed. Lastly, this paper suggests that further research is needed to identify concrete products and a realistic plan to carry out the industrial reforms successfully.

Key words: productive asymmetries, centre-periphery, Eurozone crisis, ECI

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List of Abbreviations

RCA: Revealed Comparative Advantage
ECI: Economic Complexity Index
PSM: Product Similarity Matrix
PSSI: Productive Structure Similarity Index
ESI: Export Similarity Index

List of Abbreviations of Country Names

EU: European Union
AUT: Austria
BEL: Belgium
CHN: China
CZE: Czech Republic
DEU: Germany
ESP: Spain
FIN: Finland
FRA: France
GRC: Greece
HUN: Hungary
IRL: Ireland
ITA: Italy
LTU: Lithuania
LVA: Latvia
NLD: The Netherlands
POL: Poland
PRT: Portugal
SVK: Slovakia
SVN: Slovenia
USA: United States of America

1 Introduction

Why do some countries have a well-developed economy and others don't? More than two centuries ago, Adam Smith explained to us that the wealth of nations is intrinsically related to the division of labour. Division of labour allows a person to do their work better, be more efficient and innovate. In countries where labour is highly divided, people are highly specialized in a small number of tasks, which endows them with highly specialized capabilities. Hence, one could infer that countries with a more diverse and complex set of capabilities are able to produce more goods and have more wealth (Smith, 1776). The difference between wealthy countries and poor countries is that the people in wealthy countries possess a large diverse set of capabilities to generate a large number of products.

If the capabilities of a society are the pieces of the puzzle determining the wealth of a country, then how can we measure how much capabilities a country has? A country can make certain products only if it possesses the capabilities it takes to produce these products. Hence, the capabilities that a country possesses are embedded in the products that a country makes. Following this logic, one could say that the diversity of products a country makes is related to the amount of capabilities a country possesses. A common measure of this diversity is calculated through a country's Revealed Comparative Advantages (RCA's). Some countries are able to make a large diversity of products and therefore must possess a large amount of capabilities. Other countries make very few products and therefore do not have a large amount of capabilities. However, the problem with this measure is that some products are very complex, such as X-ray machines, and require a large amount of capabilities to be made. Other products are fairly simple, such as tomatoes, and do not require as many capabilities to be made. Measures of diversity through RCA's, regard these two products as equal and therefore can't accurately measure the amount of capabilities a country possesses(Ricardo et al., 2016).

To tackle this problem and measure accurately how much productive capabilities a country possesses C. Hidalgo, R. Hausmann and others developed the Economic Complexity Index (Hidalgo & Hausmann, 2009). The Economic Complexity Index is an indicator that corrects the RCA's for the complexity of a product. Complexity, in this case, is defined as the amount of tacit knowledge it requires to produce a product and this is defined by how many other countries can produce the same product. The idea is that if a country is highly complex, only a few countries have the capabilities it takes to produce this product. On the contrary, if a product does not require a large amount of capabilities, many countries are able to produce this product. In terms of complexity research, this phenomenon is defined as the 'ubiquity' of a product (Ricardo et al., 2016).

The analysis of the differences in productive capabilities between Eurozone countries has received increased attention in the recent years. A scholarly perspective has emerged that assigns the causes of the Eurozone crisis to the differences in productive structures and stages of development within the Eurozone. Based on the identification of large asymmetries in productive structures between Northern and Southern Eurozone countries, it is argued that the two alternatives that are currently put forward to lift the Eurozone out of its precarious situation: internal devaluation in the Southern Eurozone countries, or expansion of demand in Northern Eurozone countries, is not enough to resume long-term growth and halt the increasing divergence within the Eurozone (Botta, 2014; Celi et al., 2018; Cirillo & Guarascio, 2015; Ginzburg & Simonazzi, 2017; Simonazzi, Ginzburg & Nocella, 2013)

The literature on this perspective puts forward two important mechanisms by which the worsening of the productive structures of the Southern Eurozone countries is aggravated, whilst these mechanisms ought to improve the productive structures of Northern and Central European countries. The first mechanism is the emergence of a German 'core' of countries with similar productive structures that benefit of Germany's strong and innovative productive structures as a driver of their structural reforms. On the contrary, the Southern Eurozone countries have been increasingly left out of this beneficiary dynamic, driving the divergence. Secondly, the emergence of China is suggested to have a positive effect on the productive structure of Germany and other Northern Eurozone countries through intensified mutually beneficiary trade relations. On the other hand the emergence of China is supposedly harmful for the productive structures of Southern Eurozone countries because of their large similarities in productive structures(Ginzburg & Simonazzi, 2017).

This body of literature arrives at the conclusion that the Eurozone should implement policies for strategic industrial reforms in the Southern Eurozone countries to ameliorate their productive structures and deal with the increasing North-South divide. This strategy would be based on active strategic engagement and investment by governments through industrial policies that improve productive diversification, innovation and the strengthening of the Southern Eurozone countries (Ginzburg & Simonazzi, 2017).

The evidence provided by this body of literature is based on rather condensed measures of productive structures, such as RCA's. This paper contributes to the debate about the development of asymmetric productive structures in the Eurozone by providing more accurate measures that can clearly show the differences in productive structures. To accomplish this the Economic Complexity of a range of EU countries is calculated, both at global level and a regional level. The purpose of this thesis is to reinforce the research done by other scholars with this topic.

More concretely, this paper endeavours answering the following research question:

1. *Based on productive structures does it seem necessary for the Eurozone to reconsider its policies and focus on structural reforms in the Southern Eurozone countries?*

And based on the literature, we derived three sub-questions:

1. *Do intra-regional and global ECI support the proposed centre-periphery relationship in the Eurozone in terms of asymmetric productive structure?*
2. *Do intra-regional, global ECI and Product Similarity Matrices support the proposed 'German Core'?*
3. *Based on Product Similarity Matrices can we support the alleged negative impact of China's emergence on the Southern Eurozone countries' productive structure and positive impact on Germany's productive structure?*

This paper is structured as follows: in chapter two a theoretical background of argument on structural asymmetries in the Eurozone is provided. Consequently, this chapter will outline the research gap and provide a theoretical background for the Economic Complexity Index. In chapter 3 the data that is used will be explained and justified. Next, in chapter 4 the methodology will be explained including the mathematical framework. In chapter 5 the empirical results will be published and lastly in chapter 6 we will arrive to a conclusion, implications and suggested further research.

1.1 Sum up of paper contributions

This paper contributes to the debate on productive structure asymmetries in the Eurozone and the argumentation for strategic investment in Southern Eurozone countries' productive structure. It does so by adding three pieces to the puzzle. First it provides evidence for the existence of productive asymmetries. Secondly it provides evidence for the existence of a 'German core' versus a Southern periphery. The existence of this German core would be both a source of divergence and an argument against the interpretation that increased German internal demand would be a solution to the problem. Thirdly, this paper will provide evidence for the asymmetrical effect that the emergence of China has on the Eurozone. The emergence of China would be positive for Germany and negative for the Southern Eurozone and therefore ought to have a dividing effect on the productive structures of Eurozone countries. Being able to find evidence for this allows us to have deeper understanding of the driving forces behind the divergence.

The evidence in this paper distinguishes itself from earlier provided evidence in many aspects. Firstly, the ECI measures provided in this paper are more accurate measurements than the indicators provided in the existing literature. The existing indicators either rely on measures of diversity of Revealed Comparative Advantages or rely on a-priori arbitrarily defined concepts of a strong productive structure. The problem with the first is that it doesn't correct for the ubiquity of the products that a country produces. To give a concrete example why this is problematic: based on my own calculations with the dataset as described in chapter 3, Singapore had a diversity of 78 and Senegal a diversity of 93 in 2010. Singapore is well-known for its economic success and knowledge intense economy, while Senegal isn't. Diversity clearly doesn't capture the complexity of an economy. When looking at the Global Economic Complexity Index ranking, Singapore had the 4th most complex economy out of 124 countries, whilst Senegal can be found a place 89. For clarity about the countries that were included, and the methodology see chapter 3 & 4.

Secondly, the problem with defining the quality of an industry a-priori is that it requires an arbitrary assessment about which sector is recognized as high-skill, high-value added, and which isn't. In most indicators these sectors are defined with highly aggregated trade data, which removes many subtleties in the first place and secondarily doesn't make a clear distinction between the complexity of different products within industries. For example, manufacturing is often seen as a sign of strong productive capabilities. Historically seen industrialization stood for economic development, but in the 21st there are large differences between manufacturing. The Economic Complexity Index, on the other hand, is derived endogenously from trade data and therefore doesn't have to rely on any assumption but allows the data to speak for itself. This is further explained in the theoretical background of the ECI in chapter 2.

Another significant contribution is the calculation of the Eurozone ECI, which has never been calculated before. This indicator turns out to be a very powerful tool with high explanatory value in identifying differences in productive structure. More on this indicator will be explained in the methodology section.

Besides the ECI measures, this paper also provides evidence in the form of Product Similarity Matrices which are derived from the product-country matrix that is at the base of the ECI calculations (see methodology). Such Product Similarity Matrices in itself are not revolutionary, but the ones provided by this paper provide more detail and over a longer time period. In addition, they are also provided in relation to China. This piece of evidence has not been provided by the literature.

The data set used for the calculations was just updated before the calculations were done. Hence, the ECI measures provided are more accurate than other measures. An elaboration on the dataset is give in chapter 3. Lastly, the time period over which the measures are calculated is longer and more recent than the period provided by the existing literature, which provides statistics until 2012, whereas this paper provides statistics until 2016.

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2 Theory

2.1 Previous Research

The Eurozone crisis has often been described by economist as a balance of payments problem (De Santis & Cesaroni, 2016; Ginzburg & Simonazzi, 2017; Simonazzi, Ginzburg & Nocella, 2013). According to this traditional view, financial integration allowed capital flows to be directed into peripheral Eurozone countries fuelling their economy and resulting in a centre periphery convergence. The influx of excessive capital drove up the wages in the Southern Eurozone countries, culminating into lowered competitiveness and secondarily into the current account deficits. In addition, most of the investment ended up in non-tradable sectors such as government consumption and housing. This all came to a "sudden stop" when the financial crisis hit the Eurozone (Ginzburg & Simonazzi, 2017). The recession caused the Eurozone's economy to shake to its foundations. National governments had to bail out private banks that were too big to fail, hence a private sector problem became a public one. Having a shared currency without monetary independence induced fears of debt default of certain peripheral countries, resulting in speculative attacks and capital flights away from the indebted countries (Botta, 2014).

To deal with the current account imbalance, two leading interpretations have been provided. Firstly, the Northern European current account surpluses are a consequence of virtuous savings behaviour, to be extended to the periphery in the form of internal devaluation. Secondly, the imbalance is and expression of weak German domestic demand, hence Germany ought to raise wages and increase consumption. In fact, it is the first interpretation that has been put into practice until today(Ginzburg & Simonazzi, 2017).

However, an ever-growing body of literature argues that price competitiveness and weak German demand are only part of the explanation and don't provide a viable response to the long-term success of the Eurozone area (Botta, 2014; Celi et al., 2018; Cirillo & Guarascio, 2015; Dias, Robalo Marques & Richmond, 2016; Ginzburg & Simonazzi, 2017; Simonazzi, Ginzburg & Nocella, 2013). Instead, this body of literature lays emphasis on the asymmetries in productive structures and stages of development of member states. Some leading scholars that advocate for this argument argue that, although the financial crisis had external origins in form of the subprime crisis, the severity of the Eurozone crisis had endogenous origins in the form of long-term structural asymmetries between a peripheral and central Eurozone economies. Southern European economies had weakly diversified productive structures or were not producing high value added goods (Ginzburg & Simonazzi, 2017).

To support their claims, different scholars have investigated the prevalence of such productive asymmetries among eurozone countries. Here I will elaborate on the endeavours of different researchers to investigate those productive asymmetries. Firstly, in a seminal paper on this perspective, Simonazzi et al. (2013) have provided evidence for productive asymmetries in the form of a centre-periphery relationship between Germany and Southern Eurozone countries (Spain, Greece, Italy, Portugal). The empirical evidence provided for their argument is based on the calculation of several indicators for Southern Eurozone (periphery) countries in relation to Germany (centre). A major indicator of diverging or converging productive structures is provided through the Spearman rank correlation coefficient, calculated on revealed comparative advantage based on 2-digit SITC trade data. From this indicator Simonazzi concludes that the specialization models of Spain, Portugal and Greece have been diverging from the German specialization model between 1999 and 2008. Whereas the French and Austrian models closely resemble the specialization model of Germany and the Italian model seems to have converged. However, according to the indicator also The Netherlands has shown divergence from the German model, which is not explained. An important observation in this paper is that Germany has imported increasingly less from Southern Eurozone countries between 1999 and 2008 and the gap between imports and exports has grown.

Based on the indicators the paper also states that German trade patterns have shifted during the last decades after the expansion of the EU towards culturally similar central European countries (Austria, Czech Republic, Hungary, Poland). These countries became increasingly integrated into the German productive structure and provide mainly intermediate goods. The integration of these central European countries in Germanies' supply chain has accelerated their development, diversification and specialization. Since Germanies' demand is mainly export driven, these close trade partners benefit highly of the improved German competitive position in the world. Hence, those countries also tend to show higher growth, better fiscal position and a better balance of payments. On the contrary, the Southern Eurozone countries are more focussed on consumer goods and therefore don't benefit from these spill-over effects. The export linkages of the Southern Eurozone with Germany have even deteriorated during the past decades, whilst their import linkages remained constant. Hence, Simonazzi et al. conclude that this dynamic has contributed to the Southern trade deficits and diverging productive structures (Simonazzi, Ginzburg & Nocella, 2013).

This idea is supported by a paper of Stöllinger. The paper focusses mainly on the manufacturing sector and shows that the manufacturing is progressively dominated by this Central European core. Through econometric modelling, the paper lays claim on a relation between structural change and the emergence of global value chains between 1995 and 2011. Accordingly, the Central European manufacturing core benefits from this phenomenon, whilst in case of Southern Eurozone countries it accelerates deindustrialization (Stöllinger, 2016).

Another paper that provides empirical evidence with regards to structural asymmetries in productive structures between Eurozone (and other EU) countries is a paper by Botta (2014). This paper provides evidence for a centre-periphery relationship by comparison of the similarity of industry composition of the domestic manufacturing sector between selected European countries and Germany by calculating the Productive Structure Similarity Index (PSSI) between 1999 and 2011. Results reported show that Portugal and Ireland present majorly different productive structures with respect to the German one but are much less evident in the case of larger economies such as Italy and Spain. The paper by Botta (2014) also ascertains evidence supporting the argument of a 'German central European core'. The PSSI supports that 'German core countries' have very similar productive structures, and this has increased steadily (Botta, 2014).

A different measurement provided in the paper by Botta (2014) is Export Similarity Index (ESI) (sectorial RCA's shared between Southern periphery and Germany), which is calculated in a similar manner as the PSSI. Results of this indicator arrive to similar conclusions and can't really identify any large differences in productive structures between the larger Southern countries and Germany, but rather large one between the smaller countries and Germany. In addition, the indicator also shows that the differences between Germany, Austria, Czech Republic and Poland are lower and diminishing, which should be seen as evidence for the existence of a 'German core'. Botta points out that these two groups of countries two groups of countries have emerged as two different production poles. Due to German de-specialization into central European countries, these countries embark on a path of innovative production whereas Southern Eurozone countries are left aside (Botta, 2014).

Consequently, the paper presents Revealed Comparative Advantage measures, which really don't show a very large difference on the aggregated level between the different countries, but once disaggregated seem to hint at rather large differences between smaller countries and Germany and some differences between the larger Southern Eurozone countries and Germany. Other measures provided in the paper are an innovation measure in the form of the Theil index, R&D activities and employment in scientific and high-tech sectors. The results support the argument that the Northern Eurozone countries have more innovative, high tech, value-added productive structures than the Southern Eurozone countries(Botta, 2014).

A paper by Cirillo and Guarascio (2015) supports the claims of the former two papers by provision sectoral decomposition between the Southern periphery and Northern centre countries, with a main focus on manufacturing in contrast to non-manufacturing and the creation high-skilled jobs in contrast to low skilled jobs. The evidence provided hints at rather large differences in productive structures between centre and periphery countries. The paper emphasises especially that the austerity measures taken after the crisis are a source of a polarisation of skill sets, which has led to the emergence of a hierarchical divide between the two areas (Cirillo & Guarascio, 2015).

An often-recurring alleged contributor to the divergent productive structures is the emergence of China as a production powerhouse, which has the effect of a double-edged sword on the Eurozone. On the one side, increased trade relations with China are a large source of income and innovation for the centre countries and especially Germany. On the other side, the emergence of China and specialization in specific manufacturing sectors are supposedly a large source of competition for the Southern Eurozone countries. Hence, the Southern Eurozone countries are negatively exposed to the emergence of China as a dominant economic global player (Celi et al., 2018; Gambarotto & Solari, 2015; Ginzburg & Simonazzi, 2017; Simonazzi, Ginzburg & Nocella, 2013).

The papers that argue for the 'diverging productive structures' perspective, don't provide any solid evidence for these claims. However, three recent papers on this matter have been published within a different context. First, a paper by Silgoner et al. (2014), investigates impact of the emergence of China as a global competitor on the trade performance of Central, Eastern and South-eastern European countries as one aggregated unit group. They do so by analysing export growth, export market shares, extensive and intensive margins and the dynamics in the number of joint trade links over the period 1995–2010. The paper concludes that although the competition has increased significantly, both have grown a lot, are still highly competitive and pursuit a sustainable export strategy, hence there is no reason for worry. Another paper by Sertic et al (2017), has endeavoured to analyse the impact of China on industrial employment in the EU(27). They provide evidence in the form of econometric panel data model, based on data for the period 2003 to 2013. The results show imports from China have a statistically significant negative long term effect on industrial employment within the EU(27). More specifically, it also has a statistically negative effect per product group (Martina Basarac Sertic & Vuckovic, 2017). Lastly, a very recent paper by Giovannetti et al (2018), compares the impact of China's emergence on Germanies' and Italian exports through econometric means using data from 1999 to 2009 and arrives at the conclusion that both are impacted, but Italy more than Germany (Giovannetti, Sanfilippo & Velucchi, 2018).

All and all, proponents of the productive structure asymmetries argument arrive at the conclusion that the Eurozone region is increasingly polarised due to a specialization crisis in the South. From this perspective, the mainstream solutions to solve the worsened economic situation seem to lose much of their theoretical strength. Optimum Currency Area theory argues that if the gap in competitiveness doesn't rely on unit labour cost, structural reforms increasing labour market flexibility through cutting wages won't solve the supply side deficiencies. The risk is therefore to get stuck in the middle: less price-competitive than emerging economies because of higher labour costs, and less quality competitive than advanced economies because of a poorer innovative performance (Celi et al., 2018).

Various scholars see the polarization as an outcome of neoliberal policies intended to make the playing field more equal. Eliminating tariffs, capital controls and government planning, revealed all the industrial and institutional heterogeneity across the Eurozone countries, and gave rise to a structures-based competition (Celi et al., 2018). Southern Eurozone countries used to overcome the problem by state-led structural change, but due to the abandonment of state-led industrial policies, the Southern Eurozone countries are now facing structural asymmetries with the Northern Eurozone countries, without having the instruments available to overcome it (Simonazzi, Ginzburg & Nocella, 2013).

Theoretically, structural change implies that new sectors and products must emerge through a Smithian process of increased division of labour (Botta, 2014). Literature on innovation describes several important features of this evolutionary innovation process. First, innovation happens through the acquisition and dispersion of knowledge through intricate networks of intertwined firms and industries. This dynamic process could be envisioned as a complex puzzle, where the interactions between firm and sectoral technological and productive dynamics are the pieces of the puzzle. Hence, structural change is not just a product of a single actor, but rather the interactions and availability of diverse actors with complementary knowhow (Llerena & Lorentz, 2004). Secondly, the acquisition of specific productive structures is path dependent, related and originating from the already existing productive structures in that system (Botta, 2014).

This theoretical background makes it clear that countries with highly innovative productive structures have a good position in creation more innovative products and countries with specialization in relatively simple and not innovative products have a disadvantage. Simpler said, when allowed to evolve organically, these positive and negative feedback loops are likely to increase the centre periphery asymmetries over time (Ginzburg & Simonazzi, 2017) or at least allow them to persist (Botta, 2014**).** This implies that based on market dynamics alone, the Southern periphery won't be able to diversify in a manner that will ameliorate their productive structures to more complex productive structures(Simonazzi, Ginzburg & Nocella, 2013).

Hence, the scholars argue that the Eurozone should embark on a variety of policy measures based on strategic governmental engagement that is aimed at diversifying, innovating and strengthening the productive structures of the periphery (Ginzburg & Simonazzi, 2017). The scholars suggest that innovative clusters and networks ought to be established in a coordinated way to ensure that knowledge transfer, research, infrastructure and further training are promoted (Simonazzi, Ginzburg & Nocella, 2013). Of particular importance is that the policy aims at the development of a high level of product complexity (Cirillo & Guarascio, 2015). To achieve this, productive structures and path-dependent available opportunities for the Southern Eurozone countries have to be investigated (Ginzburg & Simonazzi, 2017).

2.2 The Research Gap

Much remains to be explored to add to the debate of structural asymmetries in the Eurozone between a Northern centre and a Southern periphery. First of all, although the different measures of diverging production structures seem to indicate that the Southern Eurozone countries are behind with regards to Germany, no indicator can decisively say how much behind. No indicator captures the productive complexity of the different countries with high precision. In addition, most indicators are provided between Southern Eurozone countries and Germany, but this leans on the assumption that a productive structure close to the German productive structure is ideal. Logically, if all countries would have the same productive structure, none would have need for trade after all. Hence, indicators that capture the complexity of a country's productive structure independently would be superior and could additionally shed light on the proposed 'German Core' phenomenon. Another considerable contribution can be made by extending the period for which the indicators are available, since the indicator provided by the other papers only provide evidence until 2012.

Secondly, the main focus of the provided evidence is on lack of high tech, high value-added manufacturers, but this relies on the pre-set arbitrary validation of what is 'high-value added' and what isn't. A deeper investigation into the productive structures of the Eurozone countries, its competitive side and less competitive sides without making strong assumptions would be a great contribution to the current literature. Which products are produced by the Southern Eurozone countries in a competitive manner? Do these products indicate little room for innovation?

Lastly, a whole range of papers talk about the benefits that Germany reaps from its trade relationship with the emerging economies, especially China (Celi et al., 2018; Gambarotto & Solari, 2015; Ginzburg & Simonazzi, 2017; Simonazzi, Ginzburg & Nocella, 2013). On the other hand, the emerging of China is supposed to be rather harmful for the competitiveness of Southern European economies. However, scant evidence of the existence of such a dynamic is provided. The current evidence doesn't involve all Eurozone countries or is an aggregation of EU countries instead. The precise similarities between China's productive structure and constituent Eurozone countries is not clear.

2.3 Theoretical Approach

In this section I will elaborate on the theory behind the Economic Complexity Index and its derivatives. This paper will largely contribute to the debate by providing this holistic indicator of economic complexity and Product Similarity Matrices which is related to the ECI indicator. The objective of these indicators is to analyse the productive structures of Eurozone countries.

More than two centuries ago, Adam Smith explained us that the wealth of nations is intrinsically related to the division of labour. Division of labour allows a person to do their work better, be more efficient and innovate. In countries where labour is highly divided, people are highly specialized in a small number of tasks, which endows them with highly specialized capabilities. Hence, one could infer that countries with a more diverse and complex set of capabilities are able to produce more goods and have more wealth (Smith, 1776). This perspective on economic development inspired C. Hidalgo, R. Hausmann and others to develop the economic complexity index (Hidalgo & Hausmann, 2009).

The theory behind the Economic Complexity Index (ECI) departs from the idea that products are made with knowledge and therefore represent a certain amount of knowledge. Embedding this knowledge into a product requires people to understand and combine knowhow, which results in a product that is build up from more knowledge than a single individual can hold. Markets, therefore, represent complex networks of interactions of specialized knowledge that scatters among many individuals and make us collectively wiser. Differences between wealth of different societies depends on the amount of tacit knowledge that a society holds. Developed economies make a large diversity of products with high knowhow intensity, whilst poor countries make few products that are relatively simple. The production of different products requires different capabilities and therefore societies that are missing parts of these capabilities can't make that product. Economic complexity is expressed in the composition of a country's productive output and reflects the structures that emerge to hold and combine productive capabalities (Ricardo et al., 2011a).

The value Economic Complexity Index has been confirmed throughout various studies. For example, the ECI is not only the expression of the prosperity of a country but is a driver of its prosperity. The fact that the ECI is highly predictive of growth supports well-established ideas in economics, such as the idea that institutions, education, knowledge, know-how, and technology, are required for economic growth and it is completely in line with the theory on innovation that an innovative productive structure bequeaths more innovation. In addition, it has been shown that this predictive ability is robust for large number of factors, from human capital factors, to measures of competitiveness and institutions (Hidalgo & Hausmann, 2009);(Hausmann & Hidalgo, 2011). In another application of the ECI it has been shown that a country's ECI is also negatively related to income inequality, providing evidence to support the argument that a country's productive structure matters in terms of income inequality. This relation is robust for controlling for more traditional explanations for income inequality such as measures of education, income, and institutions (Hartmann et al., 2017).

The ECI captures the amount of productive capabilities a country contains. Hence, this type of measure is seemingly the ideal type of indicator to investigate the productive structures of the Eurozone countries. In addition, in the context of the productive structure asymmetries argument, ECI is significantly more pertinent than the RCA indicators used by the earlier mentioned papers. One large disadvantage of the indicators based on revealed comparative advantages(RCA) presented in the papers is that they don't correct for the sophistication of a product. For example, a country can have an RCA in a relatively simple product such as tomatoes, whereas another country has an RCA in jet engines, the latter is obviously a lot more sophisticated and requires a more complex productive structure and more capabilities. However, both RCA's are regarded as equally important. On the contrary, ECI does correct for the 'complexity of a product and is therefore a better indicator to assess a country's productive structures.

Another notable improvement compared to the indicators provided in the earlier mentioned papers and other indicators of productive structures or knowhow, is that the ECI avoids the need to define any factor or their importance a-priori. For example, a large portion of the indicators provided by the previously mentioned papers relied on a-priori defined definitions of the knowledge intensity of a sector. The ECI, instead, is calculated based on techniques that allow to extract the knowledge intensity of an economy endogenously from data based on linear matrix algebra techniques (more on this in the Methods section) (Hidalgo et al., 2017).

The ECI has been calculated by the Harvard Centre for International Development and the MIT Observatory for the Economic Complexity Index for a dataset covering more than 120 countries and more than 83% of world trade in 2010 (Ricardo et al., 2011a). Recently, the ECI has also been calculated for regional differences in complexity for miscellaneous countries including China (Gao & Zhou, 2018), Peru (Harvard, 2018b), Mexico (Harvard, 2018c), Colombia(Harvard, 2018d) and Argentina (Schwarz, 2017). This indicator of regional complexity can show in detail what the differences are in productive structures between different provinces within the country. Till date, such an effort has not been made for the Eurozone countries and could be of great use in analysing the alleged asymmetries in productive structures.

To conclude this section, the Economic Complexity Indicator and its derivatives seem to be the ideal indicator to further the analysis of productive structure asymmetries within the Eurozone. The expectation is that this enquiry will provide us with a significantly more profound view of the productive structures and the possibilities for convergence.

3 Data

I use a secondary international trade dataset from the Centre for International Development at Harvard University (https://intl-atlas-downloads.s3.amazonaws.com/index.html). Amongst the different datasets I preferred to use the Standard International Trade Classification (SITC) at 4-digit level aggregated dataset, because it provides the longest times series. The dataset provides trade information for 250 countries and 986 products.

The raw trade data originates from the United Nations Comtrade database, a publicly available international trade database. The raw trade data, however, has many small errors due to limited, delayed, or inaccurate reporting. To account for the inconsistencies, the research team of the Centre for International Development at Harvard University developed a data cleaning technique called the Bustos-Yildirim Method in the literature.

The dataset only contains trade information for goods and not for services, since this data is not available for every country, since service data does not go through customs. Including this data would bias the estimations towards service-reporting countries, hence they disregard this information completely(Ricardo et al., 2016).

I find the reliability and validity of the data very high. The Centre for International Development at Harvard University has published several peer-reviewed papers using previous versions of this dataset. In addition, to calculate the ECI precisely this dataset is needed, hence I don't have to work with any proxies. More information with regards to the data can be found in the FAQ section of the website of the Centre for International Development at Harvard University (http://atlas.cid.harvard.edu/learn/faq).

New Database

It's worth noting that the datasets used for this paper are the most updated versions. I contacted the Centre for International Development at Harvard University to ask about the newly published version. They confirmed that the currently available data is a newly updated which was released at the beginning of May 2018. This updated version of the data hasn't been used before for ECI calculation, hence the ECI estimates provided in this paper are unique and even more up-to-date than the estimates provided on their website.

Filters

In convention with the papers published by Hidalgo, Hausman et al. I apply some filters to reduce noise, avoid the small number bias and exclude poorly reported data. I focus on countries with a population of at least 1.25 million inhabitants in 1995 and an export of more than 1 billion USD that year. In the 'global ECI' calculations I also exclude Chad (TCD), Iraq (IRQ), and Afghanistan (AFG). In addition, products that have a global export of less than 10 million USD are rounded to zero. After these filters the 'global ECI' dataset contains 125 countries which add to more than 96% percent of global GDP and more than 83% of global trade in 2010 (Hidalgo et al., 2017).

For the 'Eurozone ECI' calculations I applied the same logic. Table 1 shows the countries that were excluded in red. The country names and country codes are the official names and codes provided by the UN Comtrade.

Countries	Code	Population 1995
Austria	AUT	7948278
Belgium	BEL	10136811
Cyprus	CYP	855384
Estonia	EST	1436634
Finland	FIN	5107790
France	FRA	59541899
Germany	DEU	81678051
Greece	GRC	10562153
Ireland	IRL	3608841
Italy	ITA	56844303
Latvia	LVA	2485056
Lithuania	LTU	3629102
Luxembourg	LUX	408625
Malta	MLT	377419
Netherlands	NLD	15459006
Portugal	PRT	10026176
Slovakia	SVK	5361999
Slovenia	SVN	1989872
Spain	ESP	39724050

Table 1; Population data from WorldBank Database (World Bank, 2018)

4 Methods

4.1 Approach

Eurozone ECI

As earlier defined, this research strongly hinges on the Economic Complexity Indicator. The theoretical background behind the ECI is explained in chapter 2. Here I will briefly elaborate on the idea behind the regional complexity indicator, since it has not been defined by other papers.

Revealed Comparative Advantages are often calculated based on global parameters of trade. This has been proven to be a powerful tool in analysing the productive structures of countries. However, by comparing a countries trade specialization to all actors in the world, it doesn't account for geographical determined advantages of certain countries. Especially when the costs of trade are high, due to transaction costs such as transportation costs, exchange rate risks or trade barriers, this globally derived RCA measure hides the large advantages that regional players have over players located far away from the receiving country(Deardorff, 2014).

This dynamic is especially relevant in case of the Eurozone since the common currency and common trade area resulted in the elimination of trade costs between those countries. Hence, these players have a large local advantage in regional trade. To attribute these differences, this paper does not only calculate the ECI based on global RCA measures, but also calculates ECI based on regional within Eurozone measures. The Eurozone ECI is calculated in the same manner as the global ECI, except that the RCA measures are based on within Eurozone trade. This turns out to be an extremely powerful measurement with high explanatory value with regards to the empirical difference in productive structures between different Eurozone countries.

4.2 Mathematical Framework

In this section I will elaborate on the mathematical framework behind the complexity indicators that I provide in the empirical analysis. The concepts used for this analysis are derived from the scientific field of network analysis. In the recent decades, network theory has emerged as the main mathematical framework to analyse complex systems. The field of network analysis is a multidisciplinary study that recently gained strong popularity as a tool to analyse miscellaneous complex systems such as social system, biological systems, systems in physics and systems in economics.

Initially, the complexity indicators were defined through a mathematical method of reflections(Ricardo et al., 2011b);(Hidalgo & Hausmann, 2009);(Hausmann & Hidalgo, 2011). Recently, however, the mathematics behind the complexity indicators have been elaborated and redefined in matrix algebra form (Caldarelli et al., 2012); (Mealy, Farmer & Teytelboym, 2018). In this paper we use sections of both, but tend to describe the latter calculations in terms of matrix algebra, for reasons of simplicity. Both are mathematically identical. An easy to access elaboration the calculation of ECI can be found here: (http://atlas.cid.harvard.edu/learn/glossary)

Revealed Comparative Advantages Matrix

The complexity indicators depart from the well-established indicator: Revealed Comparative Advantages (RCA's) as defined by Balassa (Balassa, 1977). The RCA's are calculated based on Standard International Trade Classification (SITC) trade data at 4-digit level aggregated. More information with regards to the data can be found in the 'Data' section.

The idea behind RCA's as defined by Balassa (1977) is that a country has a reveal comparative advantage when it exports more of a product than its fair share in relation to the world economy. Revealed Comparative Advantages can be mathematically expressed as:

$$RCA_{cp} = \frac{x_{cp} / \sum_p x_{cp}}{\sum_c x_{cp} / \sum c \sum_p x_{cp}}$$

In which x_{cp} stands for the total quantity in USD of a product (p) that country (c) exports. $\sum_p x_{cp}$ is the sum of exports of all products p, of country c. $\sum_c x_{cp}$ stands for the total global trade of a certain product and $\sum c \sum_p x_{cp}$ stand for the total global trade[1]. From here we define a country product matrix M_{cp}, in which country c and product p are connected by 1 if $RCA_{cp} \geq 1$ and 0 otherwise.

Economic Complexity Index Calculations

To calculate ECI we first must define a countries' diversity and a products' ubiquity. These are mathematically defined as:

$$Diversity = k_c^{(0)} = \sum_p M_{cp}$$

Which is a summation over the rows of matrix M_{cp}, hence it represents the total amount of products that country c has a Revealed Comparative Advantage in. In terms of network theory this is knows as the out-strength. The idea behin a countries' diversity is that the more products a country has a RCA in, the more knowhow it contains and the more sophisticated their productive structure is.

$$Ubiquity = k_p^{(0)} = \sum_c M_{cp}$$

And a products' ubiquity is defined as a summation over the collums of matrix M_{cp} and represents the total amount of countries that have a Revealed Comparative Advantage in product p. In terms of network theory this is knows as the in-strength. The idea behind product ubiquity is that the more countries can produce a product, the less complex it is.

The ECI corrects a countries capabilities (diversity) for the sophistications of those capabalities (ubiquity). Originally this was done through an iterative algorthim that corrected the one for the other, but more recent elaborations(Caldarelli et al., 2012) on the ECI have shown that is mathematically identical to:

$$\tilde{M}_{cc\prime} = \sum_p \frac{M_{cp} M_{c\prime p}}{k_c^{(0)} k_p^{(0)}} = \frac{1}{k_c^{(0)}} \sum_p \frac{M_{cp} M_{c\prime p}}{k_p^{(0)}}$$

[1] Note on Eurozone calculations: the RCA country-product matrix for Eurozone ECI is calculated in the same manner, but in this case only includes within Eurozone trade. Thus, instead of total global trade: total within Eurozone trade and instead of total global trade in a product, total trade of a product within the Eurozone etc.

In matrix notation this matrix $\widetilde{M}$ is expressed as:

$$\widetilde{M} = D^{-1}MU^{-1}M'$$

If we deconstruct this to its constituent parts, matrix M represents the matrix pulled from RCA_{cp}. U^{-1} is the inverse of the diagonational matrix formed by the diversity verctor given by:

$$U = I * k_p^{(0)}$$

Where I is the Identity matrix with its appropriate dimensions and $k_c^{(0)}$ is a vector of diversity, which was calculated in step 1. Consequently, the inverse of matrix U is taken and we multiply matrix M by U^{-1}. This results in a matrix of the dimensions M_{cp} in in which the constituent products are divided by its total ubiquity. Now, we multiply the resulting matrix by M', which is the transpose of matrix M, resulting in matrix S. Matrix S is a symmetric similarity matrix with the dimension $S_{cc'}$ that represent the products that country c has in common with country c', weighted by ubiquity of the products it produces.

Next, we calculate D^{-1}, which is the inverse of the diagonal matrix formed by the diversity vector given by:

$$D = I * k_c^{(0)}$$

Where I is the Identity matrix with its appropriate dimensions and $k_c^{(0)}$ is a vector of the diversity by country, which was calculated in step 1. Consequently, we calculate the dot product of $D^{-1}S$, which leaves us with matrix $\widetilde{M}$. Matrix $\widetilde{M}$ is a row stochastic weighted similarity matrix with dimensions $\widetilde{M}_{cc'}$ that reflects how similar two countries' export baskets are.

The last step is to derive the ECI, which is defined as the eigenvector associated with the second largest eigenvalue. Since matrix $\widetilde{M}$ is row stochastic, the largest eigenvalue is per definition 1 and therefore non-informative. Hence, we take the eigenvector associated with the second largest eigenvalue, which is the eigenvector that captures the most variance. The ECI is expressed in terms of standard deviations for comparability over time.

Product Similarity Matrix

Different scholars made the statement that one of the causes for the demise of Southern Eurozone productive structures the ascend of China is. Another statement is that the productive structures of Germany and Southern Eurozone countries are increasingly diverging in similarity. Hence in the empirical section this will be investigated through the provision of Product Similarity Matrices(PSM's). The PSM's are derived from the product-country matrix that is at the base of the RCA calculations. Hence, this measure is not a measure of economic complexity, but rather a side product. Even though the PSM doesn't calculate economic complexity, it is still a useful measure for comparing the similarity of productive structures and can help us in our argumentation with regards to the expose of Eurozone countries to the emergence of China. The formula in matrix notation for the calculation of the PSM is:

$$P = D^{-1}MM'$$

At the base of the calculation of the PSM's is the multiplication of the the country-product matrix M by the transpose matrix M'. This results in the symmetric similarity matrix A with the dimensions $A_{cc'}$ which describes the number of products that different countries have in common. Consequently, we obtain the dot product of matrix A and D^{-1}, which results in matrix P that shows which percentage of products a country has in common with the export basket of another country.

Weaknesses of methodology

A research wouldn't be complete without acknowledging the weaknesses of the methodology used. Here a sum up of the weaknesses that we recognize:

- The RCA measures are based on a contradiction, the more heterogenous a countries' export base is, the larger the denominator is, which lowers the relative RCA's (Botta, 2014).
- The Method captures the complexity of an economy as a closed system based on geography and hereby rules out any kind of transcendence of knowhow between countries
- Trade in services isn't captured by the ECI
- Does not distinguish between different subtleties of product sophistication (a German car versus a Chinese car), although this should be somewhat expressed in terms of trade value.

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5 Empirical Analysis

5.1 Results

To analyse the productive structure complexity of the constituent Eurozone countries I first calculated the Economic Complexity Indicator based on trade data of 124 countries around the globe, from 1993 to 2016. More on the data can be found in the data section. Here I will elaborate on the results.

5.1.1 Global Economic Complexity Index

The Global Economic Complexity Index Ranking

In table 2 the development of the global ECI ranking of the Eurozone countries and the Central European countries that are allegedly part of the 'German core' are displayed for 5 years. In the appendix the full ranking for these years for all countries is provided.

	1993	1999	2005	2010	2016
DEU	**2**	**2**	**2**	**3**	**4**
AUT	**5**	**6**	**5**	**5**	**6**
CZE	**16**	**12**	**10**	**7**	**7**
HUN	**20**	**26**	**17**	**11**	**9**
FIN	7	5	6	9	10
SVK	19	19	18	13	12
IRL	13	11	11	16	14
SVN	18	14	12	12	15
ITA	*8*	*10*	*15*	*17*	*16*
FRA	10	9	13	15	17
POL	**30**	**24**	**24**	**21**	**20**
BEL	12	16	20	20	23
NLD	14	18	22	25	28
LTU	58	43	41	34	32
ESP	*17*	*21*	*23*	*24*	*33*
PRT	*33*	*31*	*33*	*36*	*38*
LVA	70	44	35	35	40
GRC	*55*	*52*	*51*	*52*	*56*

Table 2; Global ECI Ranking Eurozone & Central European Countries, source: own calculations, data from (Harvard, 2018a)

As we can observe, most Eurozone countries dropped in their ranking between 1993 and 2016. This is mainly due to the rise of East-Asia and especially South-Korea (from 24 to 3), China (from 45 to 18) and Singapore (from 21 to 5), but also the ascend of Central European countries (in blue). The Central European countries, except for Poland, joined Germany in the top 10 most complex productive structures during the last decades. This provides some evidence with regards to the positive spill-over effects of the German productive structures on these countries, although from ranking alone we are not able to conclude that this ascend is due to these positive spill-over effects. Later in this chapter we will provide more evidence for this relationship.

Ranking wise, we can't find evidence for a weak productive structure of Italy. Although Italy's rank dropped significantly, it still had the 16th most complex productive structure in the world in 2016. However, ranking wise, we do see that there is a large gap between the complexity of the Latin Italian and French productive structures versus the German and Austrian productive structures. This gap widened significantly from 1993 to 2016, providing evidence that the Germanic productive structures are more resilient to the global developments of the past two decades.

Interestingly, both The Netherlands and Belgium are scoring remarkably low and have been falling significantly from 1993 onwards. This could possibly be explained by the type of economies that these two countries have, which are specifically geared towards trade, as suppliers of goods for the European hinterlands. This will become clearer when analysing the Eurozone specific ECI later in this chapter.

What does become very evident from the results in table 2, is that the other three Southern Eurozone countries Spain, Portugal and Greece are significantly lacking behind the rest and have deteriorated in terms of ranking. Even though Greece didn't have a very complex productive structure to begin with and therefore had much room for growth, Greece actually ranked lower in 2016 than in 1993. This in stark contrast with Latvia and Lithuania, which started with a lower ranking than Greece in 1993 (70 & 58) but ended with a significantly higher ranking than Greece in 2016 (40 & 32). This should be regarded as evidence for weak structural reform in Greece.

The Global Economic Complexity Index

In figure 1 the development of Global Economic Complexity Index for the Southern Eurozone countries and Germany are displayed. The ECI is a relative indicator expressed in terms of standard deviations. If a country has decreased in ECI, this doesn't mean that they somehow declined in productive capabilities. It rather means that the productive capabilities that a country possesses became less unique (more ubiquitous). Hence, a countries' ECI can have declined significantly in terms of standard deviations whilst its ranking hasn't. We can see, for example, that Germany's ECI has declined whilst its ranking has hardly changed. Reason for this is that Germany's productive knowledge was relatively more sophisticated in 1993, because the divide between productive knowledge of developing countries and Germany was still very large. More concretely, at the beginning of the 90's producing cars was still a relatively complex process, whilst in 2016 many countries possess the capabilities to make cars such as China, South-Korea and Thailand. Hence, the capability to produce cars became relatively less unique and therefore less complex.

Figure 1 provides us with a more accurate understanding of the relative differences in complexity of the productive structures of different countries. In addition to the time series lines, I added several value labels to provide some orientation to the reader. The data labels for Germany are places above the time series line (1.72 & 1.39), whilst the data labels for Italy, Portugal and Greece were places below the line. In favour of spatial and clarity consideration, not all countries have data labels.

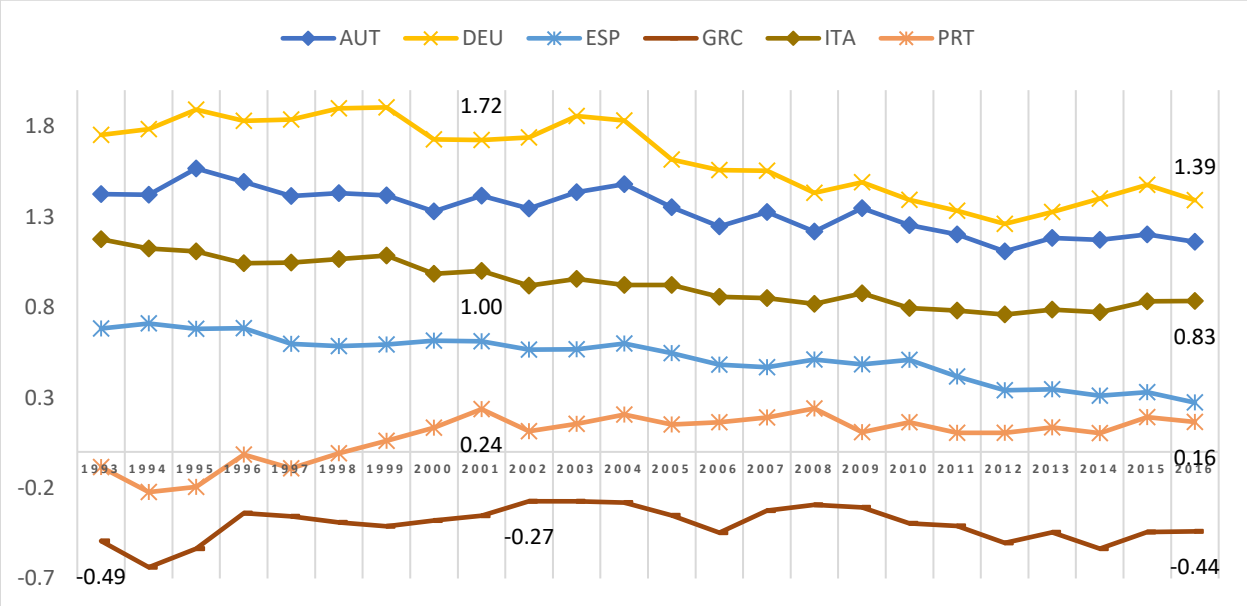

Figure 1; Global ECI Selected Eurozone Countries , source: own calculations, data from (Harvard, 2018a)

Looking at the graph we can draw several interesting conclusions. First the results support the idea that the development of productive structures is path dependent because it is low in volatility and seems to be based on past values. This is in line with the innovation theory presented in chapter 2.

Secondly, although the Italian productive structure has declined, it is still relatively strong compared to other Southern European countries and seems to stable out around an ECI score of 0.8. France and Ireland (included in figure 2), had a similar level of global complexity in 2016. In addition, The Netherlands and Belgium had a lower level of global complexity in 2016 (see figure 2). Hence, regarding the global complexity of the Italian productive structures it seems not appropriate to talk about an asymmetric situation. The graph does support a significant gap between Germany-Austria and Italy, but this gap has historically always been there (or at least since 1993) and has remained relatively similar.

The same historical differences can be found between the productive structures of Spain and Italy, but the gap is significantly larger and seems to have widened since 2010. In addition, when comparing Spain to Germany and Austria, we can conclude that there is a very large structural gap between the complexity of their productive structures, which clearly provides support for structural asymmetries.

The Portuguese ECI score shows an interesting pattern. It seems to have improved markedly from 1993 till 2001, around the introduction of the Euro, but after 2001 the productive structure of Portugal seems to have declined slightly and a very large structural gap with the Northern Eurozone countries remains.

Greece is really the epitome of the centre periphery argument. The gap between Greece and every other country depicted in figure 1 (and figure 2) is very large. Based on this data it seems fair to say that in terms of productive structure Greece and Germany are two worlds apart. Greece's productive structure has witnessed growth until their adoption of the Euro in 2001/2002, but ever since the complexity of Greece's productive structure has fallen steadily.

Looking both at the sharp decline in global rank and global ECI, there is no doubt that there is a very large and growing gap between Spain, Portugal, Greece in relation to Germany-Austria. Italy seems to have remained a relatively strong global productive structure, although there is clearly a gap with Germany-Austria. However, Italy has fallen steeply in terms of global ECI ranking, indicating that it has been overtaken by many global players. This could imply that the global developments of the last two decades have had a significantly larger impact on the productive complexity of Italy than of Germany. In figure 2 we continue our analysis by comparing the productive structures of some other Eurozone countries.

Figure 2 shows the development of the Global ECI's for some of the Northern Eurozone countries and in addition Greece's development is added.

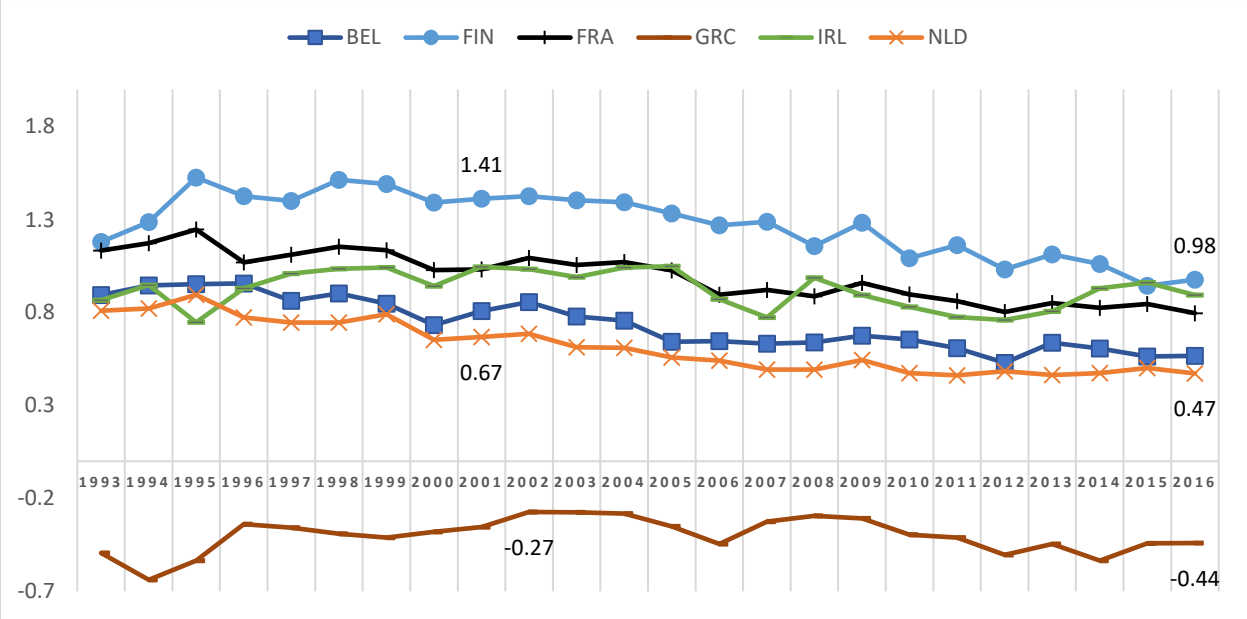

Figure 2; Global ECI Selected Eurozone Countries, source: own calculations, data from (Harvard, 2018a)

The figure shows clearly how strikingly large the gap is in global productive structure complexity between Greece and the Northern Eurozone countries. Greece's Global ECI was -0.44 in 2016 whereas the country with the lowest Global ECI of the countries depicted above, The Netherlands, had a Global ECI score of 0.47 in 2016.

The Netherlands and Belgium have a lower global ECI than the other Northern Eurozone countries, but still relatively close to the other Northern Eurozone countries and higher than Spain and Portugal (0.27 & 0.16 in 2016). Yet, this is not completely in line with the expectations, since both The Netherlands and Belgium are current account surplus countries and have a relatively strong economy. The Eurozone Complexity Index in the following section will shed more light on this phenomenon.

5.1.2 Eurozone Complexity Index

Now we will analyse the within Eurozone ECI, which is simply an indicator of how ubiquitous a countries' capabilities are within a closed Eurozone system. More elaboration on this indicator in the methodology. In figure 3, the countries that have relatively low levels of within Eurozone Economic complexity are shown. For purpose of clarity Finland, Slovakia, Slovenia, Lithuania and Latvia are excluded but also these countries belong to the countries with lower levels of within Eurozone complexity. The full figure is provided in the appendix.

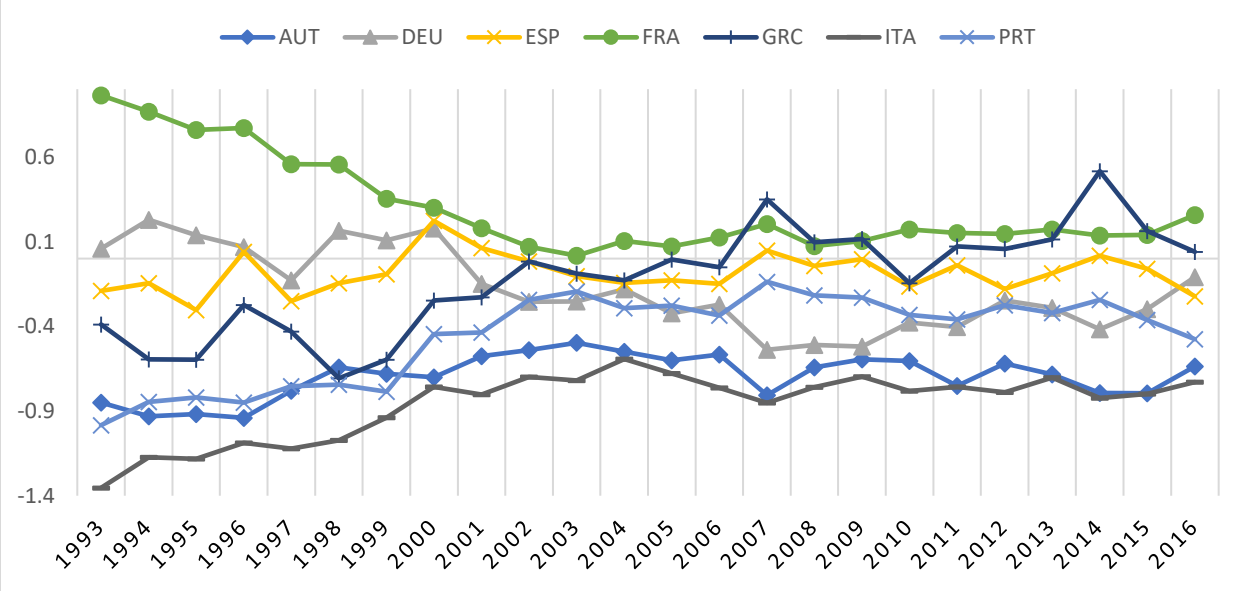

Figure 3; Within Eurozone ECI Selected Eurozone Countries, source: own calculations, data from (Harvard, 2018a)

In figure 3 we can observe the within Eurozone ECI for several Eurozone countries. For these countries, the general pattern is a pattern of convergence. Especially towards the instigation of the Euro and the first few years of the Euro are recognized by strong convergence of within Eurozone ECI. In the years after, marginal divergence between these countries took place. This could be interpreted in a way that the products that are traded between these countries have relatively similar levels of ubiquity within the Eurozone.

Spain and Greece have developed as countries with a better within Eurozone ECI than Germany. At first sight this seem a better position than their global ECI. However, this could also be a sign path dependency with regards to relatively uncomplex products globally that are somewhat more ubiquitous in the Eurozone. Being the local supplier of a specific product that is relatively uncommon within the region but rather abundant globally could be profitable based on proximity, relatively lower wages and open market advantages compared to global competitors. Profit is an incentive to continue in the business, even though the products are uncomplex and non-innovative. These countries would function as the peripheral suppliers of cheaper uncomplex goods for the local centre.

Italy has the lowest within Eurozone complexity of all Eurozone countries, whilst its global ECI is well above average. This could be interpreted as high dependency on its global complexity and productive structure poorly geared towards the Eurozone. Germany seems to show a rather balanced view since its Global complexity is very high, but also its local complexity average.

However, the within Eurozone complexity of the above-mentioned countries is very low compared to Ireland, The Netherlands and Belgium, see figure 4.

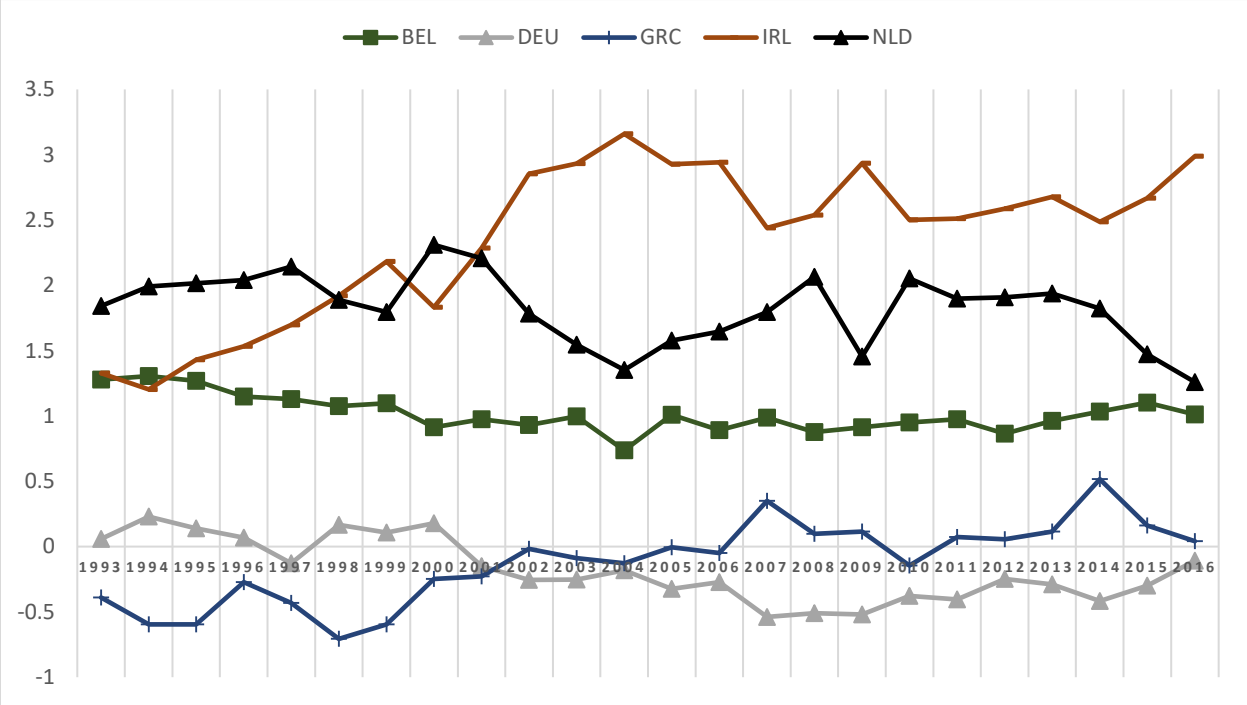

Figure 4; Within Eurozone ECI Selected Eurozone Countries, source: own calculations, data from (Harvard, 2018a)

This result reveals, markedly, what is behind the lower Global ECI levels of these countries. Although these countries have globally seen a productive structure that is not as complex as some of their neighbouring countries (but yet top 30), locally they stand out as procurers of products with a very low ubiquity. Hence, these countries have an exceptionally complex productive structure to serve local needs.

This pattern seems to hint at two different, but both successful diversification strategies. One that is mainly aimed at competitivity in the global markets and one that is rather aimed at competitivity in the regional markets. We will analyse this further later in this chapter.

5.1.3 The German Core

Now, we will analyse the claims that during the past decades a central European 'German core' emerged of culturally similar countries that have close ties with Germany. According to the literature in a large portion of the semi-finished goods are outsourced by Germany to these countries. The countries that allegedly consist of the 'German core' are Germany, Austria, Czech Republic, Hungary and Poland. On the other side, the Southern periphery has allegedly developed completely distinctively from this German Core that doesn't benefit from improved German competitiveness. For an elaborate explanation of the theoretical background see chapter 2. In figure 5 the global ECI of these Countries is depicted. The German core countries are the black lines and the Southern periphery the blue lines.

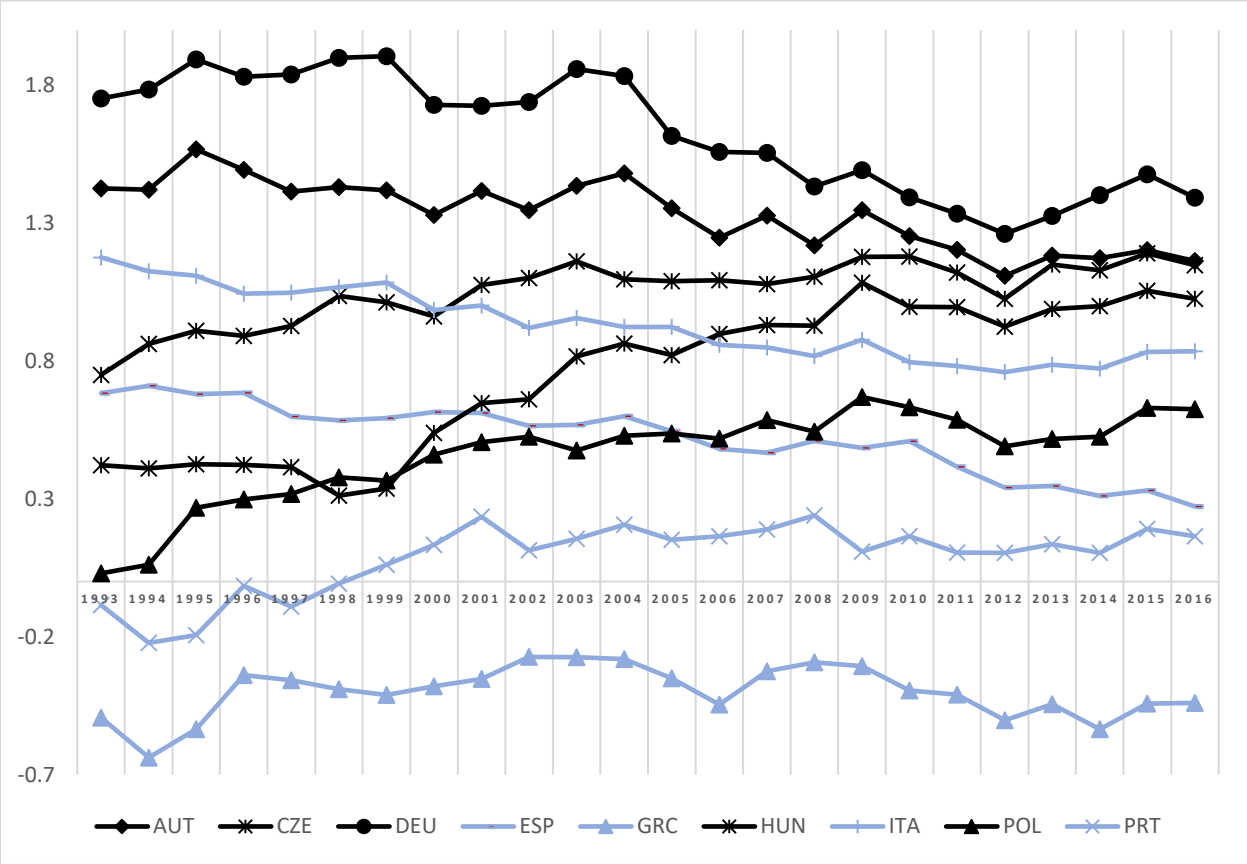

Figure 5; The German Core versus The Southern Periphery, source: own calculations, data from (Harvard, 2018a)

Although the evidence isn't conclusive, the graph above clearly shows notable converging patterns of the German core countries, whereas the Southern periphery seems to be diverging from the German core. The tendency of this pattern becomes even clearer when looking at the overall situation in 1993, which is very mixed, and the situation in 2016, which seems to be rather ordered in such a German core versus Southern periphery situation. This pattern clearly supports the idea that the core countries benefit greatly in terms of structural reform from the strong German productive structure, whereas the Southern peripheral countries are left out of these spill-over effects. In table 3 on the next page we provide additional evidence for such a dynamic.

Germany Product Similarity

Table 3 depicts, percentage wise, the share of Global Revealed Comparative Advantage basket that constituent Eurozone and central European countries have in common with Germany. Similar tables have been provided in previous research (see chapter 2), but this table provides more detail and over a longer period including more recent data. To get the focus on what I want to discuss I excluded several Eurozone countries, but a more complete table is provided in the appendix.

	AUT	CZE	HUN	POL	BEL	ESP	FIN	FRA	GRC	IRL	ITA	NLD	PRT
1993	63%	57%	46%	38%	54%	49%	60%	58%	29%	47%	59%	52%	31%
1994	62%	55%	44%	38%	54%	50%	59%	59%	28%	47%	58%	51%	31%
1995	61%	55%	44%	42%	54%	47%	59%	58%	29%	43%	56%	52%	34%
1996	60%	53%	43%	42%	53%	47%	58%	56%	31%	44%	54%	50%	34%
1997	60%	56%	44%	44%	52%	45%	62%	58%	31%	43%	55%	47%	34%
1998	57%	55%	38%	42%	52%	44%	61%	55%	29%	37%	53%	46%	35%
1999	60%	52%	37%	43%	51%	45%	59%	57%	29%	38%	54%	47%	34%
2000	59%	54%	43%	46%	52%	48%	62%	57%	31%	40%	55%	48%	34%
2001	62%	57%	44%	45%	54%	48%	66%	57%	31%	40%	55%	47%	40%
2002	65%	60%	44%	50%	56%	49%	67%	61%	36%	41%	55%	50%	38%
2003	60%	57%	43%	43%	51%	43%	60%	56%	32%	43%	53%	46%	34%
2004	61%	54%	42%	45%	48%	45%	60%	54%	33%	40%	51%	45%	38%
2005	64%	62%	50%	51%	54%	48%	63%	60%	38%	50%	54%	50%	42%
2006	65%	61%	52%	52%	54%	49%	62%	58%	35%	47%	54%	51%	41%
2007	66%	60%	52%	51%	51%	47%	59%	56%	35%	47%	52%	47%	39%
2008	67%	64%	58%	54%	55%	50%	59%	58%	37%	52%	55%	48%	44%
2009	68%	63%	59%	57%	55%	51%	65%	59%	39%	52%	56%	49%	41%
2010	67%	65%	59%	60%	54%	52%	63%	60%	38%	54%	54%	50%	44%
2011	70%	68%	65%	62%	60%	56%	66%	65%	42%	56%	59%	54%	47%
2012	69%	68%	65%	59%	62%	54%	65%	64%	40%	57%	57%	56%	47%
2013	68%	67%	64%	59%	61%	54%	65%	65%	43%	60%	56%	55%	46%
2014	66%	64%	63%	56%	59%	49%	61%	61%	36%	58%	54%	53%	42%
2015	62%	60%	60%	54%	52%	46%	55%	57%	35%	58%	51%	48%	41%
2016	62%	62%	60%	54%	52%	45%	58%	59%	34%	53%	52%	50%	39%

Table 3; Product Similarity with Germany , source: own calculations, data from (Harvard, 2018a)

Assuming that Germany's productive structure is exemplary for any country, having a more similar global export basket would be an indicator of a strong productive structure. This assumption provided, it is interesting to see that Spain, Portugal and Greece show clearly the worst performance. Spain had 49% of its export basket in common with Germany in 1993, but in 2016 only 45%. Greece had 29% in common with Germany in 1993 and increased this to 34% in 2016, this is far lower than the other countries which are (except for Spain) all over 50% similarity in 2016. Portugal had 31% in common with Germany in 1993 and increased this to 39%.

Italy's situation is different, as shown many times in the previous statistics. The story about Italy in this case is that it can't be called in one breath with the other three Southern countries, because it has an export similarity with Germany significantly higher than the other countries. However, it is clearly in a downtrend and its similarity has declined from 59% in 1993 to 52% in 2016. When comparing this with France we can't find the same trend. France had a similarity of 58% in 1993 and increased this marginally to 59% in 2016.

The findings in table 3 clearly support for the 'German core' argument. Austria, Czech Republic and Hungary were the three countries with the highest productive structure similarity with Germany. In addition, Poland increased its similarity with Germany markedly from 38% in 1993 to 54% in 2016. This makes it likely that these countries benefit from spill-over effects from the German economy. On the contrary, the decreased or low similarity of the Southern Eurozone countries suggests that these countries are indeed not benefitting as much or decreasingly of these spill-over effects.

5.1.4 Productive Structure Exposure to China

Next, we contribute to the debate about the alleged influence of the emergence of China as a global player on the productive structures of Eurozone countries. According to the literature, this influence ought to be asymmetric where Germany would mainly benefit from the relationship whilst the Southern European countries would be damaged because of larger exposure due to more similar productive structures. In table 4 the Product Similarity Matrix between China and the constituent Eurozone countries is provided.

	AUT	BEL	DEU	ESP	FIN	FRA	GRC	IRL	ITA	NLD	PRT	USA
1993	23%	20%	16%	25%	18%	19%	35%	27%	29%	19%	45%	14%
1994	25%	20%	17%	28%	20%	20%	39%	27%	32%	22%	47%	16%
1995	24%	21%	18%	32%	21%	22%	36%	27%	33%	21%	45%	16%
1996	24%	22%	18%	29%	18%	23%	35%	29%	32%	23%	43%	16%
1997	26%	23%	16%	29%	16%	22%	37%	30%	32%	24%	46%	18%
1998	26%	20%	16%	26%	14%	20%	35%	29%	33%	21%	44%	16%
1999	25%	22%	16%	25%	15%	19%	32%	24%	32%	21%	43%	15%
2000	27%	23%	17%	29%	15%	22%	32%	22%	34%	20%	42%	17%
2001	29%	23%	18%	29%	18%	21%	32%	22%	36%	21%	42%	18%
2002	27%	19%	18%	29%	17%	20%	33%	21%	36%	19%	43%	18%
2003	27%	19%	17%	29%	16%	20%	32%	24%	35%	19%	44%	18%
2004	29%	20%	20%	31%	18%	21%	32%	25%	37%	21%	43%	20%
2005	31%	23%	22%	34%	20%	24%	33%	29%	38%	23%	43%	23%
2006	30%	25%	24%	36%	24%	24%	34%	29%	39%	23%	44%	23%
2007	34%	26%	27%	37%	28%	26%	37%	29%	44%	25%	50%	23%
2008	37%	29%	31%	38%	30%	28%	39%	31%	47%	23%	48%	27%
2009	33%	25%	28%	34%	26%	23%	30%	26%	43%	23%	46%	22%
2010	37%	27%	31%	37%	29%	27%	32%	25%	46%	23%	46%	25%
2011	40%	29%	36%	39%	31%	30%	35%	26%	48%	28%	49%	28%
2012	40%	29%	38%	38%	33%	30%	33%	26%	49%	25%	48%	28%
2013	41%	26%	38%	39%	33%	32%	33%	27%	51%	25%	48%	30%
2014	41%	29%	39%	40%	33%	31%	30%	27%	51%	25%	49%	29%
2015	38%	26%	35%	38%	32%	28%	33%	24%	50%	26%	47%	25%
2016	38%	24%	35%	36%	33%	28%	31%	27%	48%	25%	44%	25%

Table 4; Product Similarity with China , source: own calculations, data from (Harvard, 2018a)

In 1993, Portugal had the highest similarity with China and with 45% far higher than all other countries. This high degree of similarity persisted and stayed roughly the same until 2016. Hence, in case of Portugal its plausible that the emergence of China has had significant influence on the relative complexity of the Portuguese productive structure. Italy is another country that seems to qualify itself for this phenomenon. Although in 1993 Italy only had 29% similarity with China, this increased steadily and even surpassed Portugal to almost 50% in 2016. Portugal and Italy show by far the highest similarity with China in 2016 of all Eurozone countries.

In case of Spain, this alleged asymmetry is not so evident. Although its similarity with China did increase steadily from 25% in 1993 to 36% in 2016, this is not very different from Germany which is alleged to reap the benefits of the emergence of China. In case of Greece, the argumentation is not so straight forward. On the one hand, Greece's similarity decreased slightly over this period. On the other hand, Greece had a relatively high similarity to start with, a level that most countries only reached in recent years. This could be indicative for a lack of specialization possibilities, because China has outcompeted them on price on the industries that they were specialized in.

A more general view of the development of productive similarities between China and the Eurozone countries is that it has increased largely since 1993. When compared to the USA, for example, the percentage of similarity of Eurozone countries with China was a lot higher in 2016. Given Germany's high dependency on its global exports this development could form a threat to its current advantageous position and should be of concern to the entire Eurozone.

5.1.5 Economic Complexity Index and GDP per Capita

To reach a sum up of our finding with regards to differences in productive structures figure 6, 7 and 8 depict Eurozone ECI on the y-axis, Global ECI on the x-axis and the size of the bubble represents GDP per capita of the constituent Eurozone countries in 1995, 2008 and 2016. For reasons of comparability the dimensions of the x and y-axis are left the same in the three figures.

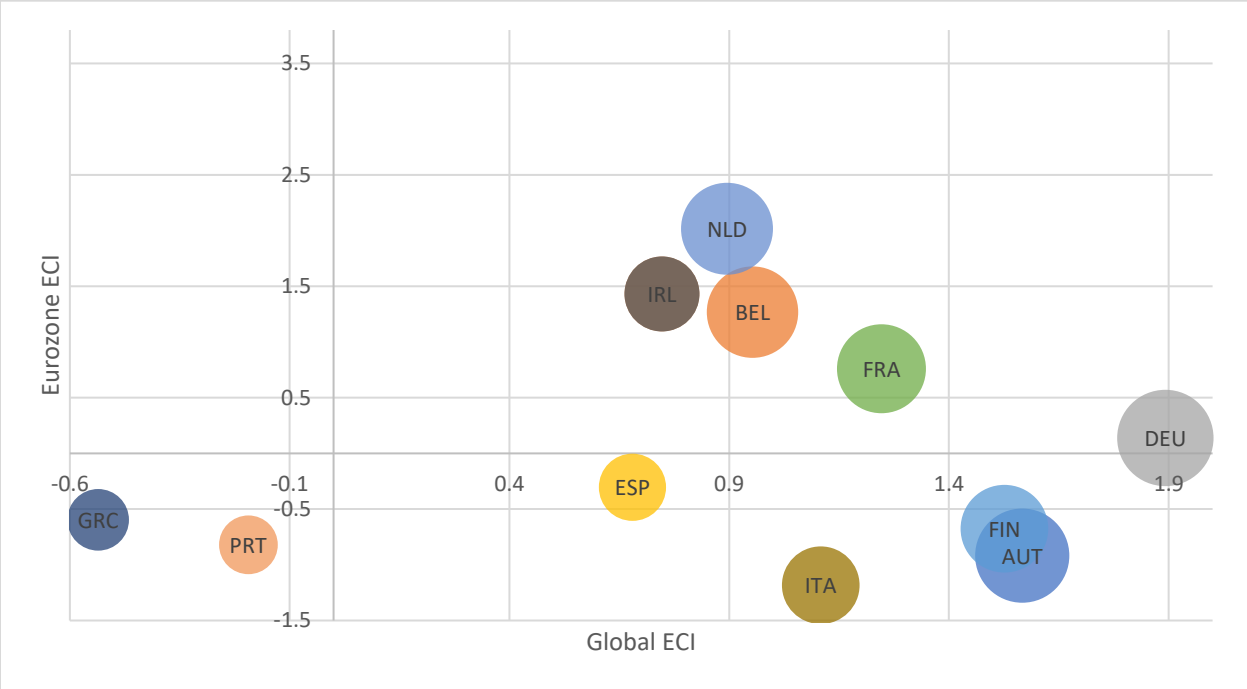

Figure 6; , ECI & GDP per Capita 1995, source: own calculations, data from (Harvard, 2018a)

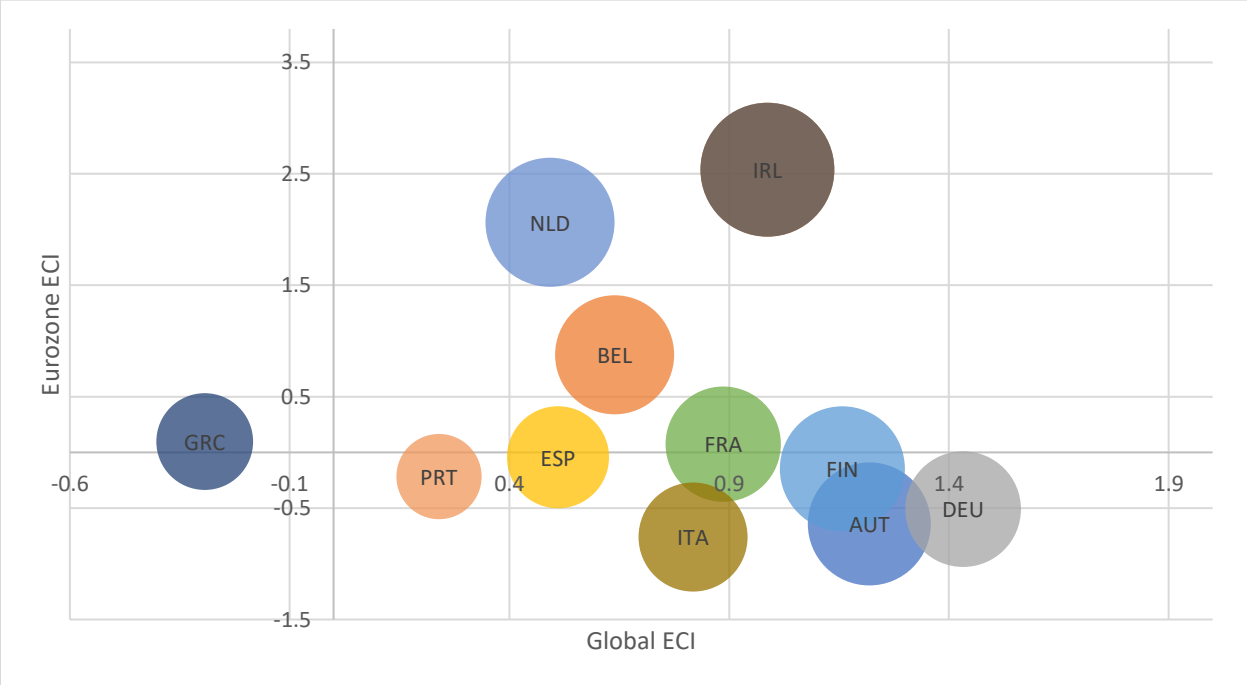

Figure 7; ECI & GDP per Capita 2008, source: own calculations, data from (Harvard, 2018a)

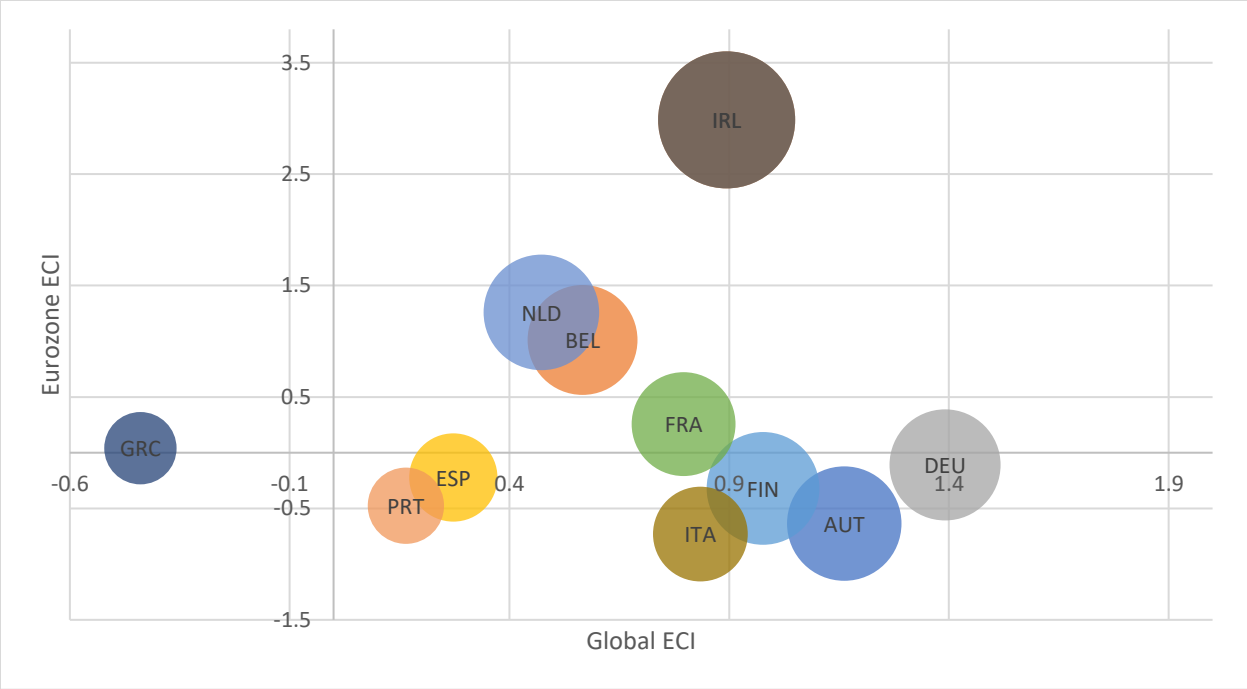

Figure 8; ECI & GDP per Capita 2016, source: own calculations, data from (Harvard, 2018a)

Several conclusions can be drawn from these graphs. First, the graph suggests a relation between GDP, Eurozone ECI and Global ECI. Countries with a higher global ECI have a larger GDP in the graphs above. Exceptions to this rule area Ireland, The Netherland and Belgium, which have a higher GDP per capita than their Global ECI score suggests. The reason for this is that their Eurozone ECI is exceptionally high, which is another way of obtaining a competitive productive structure.

Secondly, we can observe that the productive structure asymmetries are mainly present between Greece, Portugal, Spain and the other Eurozone countries. Although Italy performs especially bad in terms of Eurozone ECI, Italy's global ECI is still relatively good and therefore the situation is not exactly comparable with the other Southern Eurozone countries.

Thirdly, we observe that from 1995 to 2008, the productive structures of Portugal and Greece had improved slightly, and Spain's had remained relatively similar. From 2008 to 2016 we see that Spain's and Greece's productive structures worsened and Portugal's productive structure remained roughly the same. This becomes even more interesting when looking at the size of the bubbles. We can clearly see that the GDP per capita of these countries declined, likely due to austerity and wage deflation, but their productive competitiveness worsened. In addition, we observe that Greece's GDP per capita was too large for its ECI scores. In line with the literature that ECI predicts GDP growth or decline, Greece's GDP per capita declined significantly.

The graphs seem to suggest that, although necessary, the deflation of GDP per capita does not seem to improve the productive structure of Greece. This could be seen as support for the argument that merely austerity and deflationary policies are not enough to obtain structural reform in the Southern Eurozone countries.

Lastly, the graph suggests an additional factor of importance, namely geography. It is clear that countries with similar ECI scores are also geographically closely located. This dimension could be, however permanent, an important contributor to the differences in productive structure especially in terms of spill-over effects.

6 Conclusion

This paper concludes that it is necessary for the Eurozone to reconsider its policies and encourage structural reforms in the Southern Eurozone countries. To arrive at this conclusion, we calculated the complexity and product similarity of productive structures of different countries and in particular Eurozone countries.

This paper has identified two successful diversification strategies for Eurozone countries. The first is based on developing capabilities that are highly competitive in global markets. Germany and Austria are examples of Eurozone countries that excel in this form of diversification. Their productive capabilities are highly competitive in a global market environment. The second diversification strategy is based on regional competitive capabilities. The Netherlands, Ireland and Belgium are the Eurozone countries that excel in this strategy. Their capabilities are highly complementary to the regional needs and these countries can produce products that no other countries can provide in the region.

The analysis of the complexity of productive structures of Eurozone countries provides ample evidence for a large divide between Greece, Spain, Portugal and other Eurozone countries. Spain and Portugal show about average Eurozone ECI scores and relatively low Global ECI scores. The productive complexity of these countries suggests a large gap in complex capabilities with the Northern Eurozone countries. Greece, however, is clearly the epitome of the polarization of productive structures. As shown by our calculations, Greece's productive structure has always been largely less complex than that of other Eurozone countries and especially Northern Eurozone countries. This situation improved somewhat before the introduction of the Euro but has worsened ever since. This supports the literature on the argument that a structures-based competition contributes to the deterioration of Southern Eurozone's productive structure and gives us reason to strongly question if it was a good idea for Greece to enter the Euro in the first place.

The case of Italy is somewhat different than the other Southern Eurozone countries. The Global ECI scores clearly suggest that Italy's global productive structure is still among the best 16 in the world. However, the Global ECI does show a decline in the past decades and this should be reason for alertness. With regards to Eurozone ECI, Italy has the lowest score of all Eurozone countries, clearly suggesting that Italy's productive structure is not successfully geared towards its own region. Italy would clearly benefit from improving their Eurozone complexity.

Another conclusion that we can draw is that the evidence provided by this paper suggests that there is indeed a 'German core' of central European countries that benefit mutually from the strong position of the German economy. On the contrary, the Southern Eurozone countries, and especially Spain, Portugal and Greece, seem to be increasingly left out and therefore don't benefit as much. This evidence supports the argument that increasing German internal demand won't have a strong effect on the Southern Eurozone countries and therefore does not seem the solution to the divergence between North and South.

We also found evidence with regards to asymmetrical benefits and burdens of the emergence of China on productive structures of Eurozone countries. The literature suggests that especially Germany tends to benefit from the emergence of China through good trade relations, whilst Southern Eurozone countries are exposed to high competition due to similar productive structures. We found that especially Italy and Portugal are likely to have been highly affected by the emergence of China during the past two decades, since their productive structure was almost for 50% the same in recent years. This is far higher than the other Eurozone countries. Greece could possibly be strongly affected as well, but this the evidence provided couldn't decisively confirm this. The asymmetries in exposure to the emergence of China are difficult to ameliorate based on market forces alone, since innovation is a path dependent process and the specializations that these countries have are competing with the Chinese productive specialization.

Since the crisis of 2008, deflationary policies have been implemented in the Southern Eurozone countries. This seems a reasonable thing to do given the over-extension of the GDP per capita in relation to their ECI. However, cutting wages is one thing, but this has seemingly not contributed to the improvement of the productive structures of these countries. In addition, Southern Eurozone countries are also not likely to benefit majorly of an increase in German internal demand and therefore this also doesn't seem a solution for the polarization within the Eurozone. More than 20 years data showed clearly deep productive asymmetries in the Eurozone. Given the lack of an endogenous process of convergence and the path dependency of the development of productive structures, it seems highly unlikely that market dynamics alone are going to correct these asymmetries. Thus, this paper joins the argument that new state policies based on state-led industrial reform are necessary for Greece, Portugal and Spain to catch up with the other Eurozone countries. With regards to Italy, we expect that if the industrial reform is carried out in the other Southern Eurozone countries and growth will catch up, Italy is likely to benefit majorly due to positive spill-over effects because of its geographic proximity to these countries. The Eurozone as a whole should support the need for structural reforms, especially in these times in which new global competitors are emerging and developing quickly. Strong stakeholders make the Eurozone area stronger as a whole and the Euro project more likely to succeed.

Where should the research go from here? Here we argue that the research should be furthered by analysing productive structures of Greece, Portugal and Spain more closely with the objective of identifying a clear concrete industrial reform strategy. The specific products that are recommended should be based on existing productive structures. In addition, the products should be products with high complexity and innovation perspective, so they improve their productive structures sustainably.

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Appendix

Appendix A: Global ECI Ranking and ECI score for EU countries, USA and China

	1993	1993 ECI	1999	1999 ECI	2005	2005 ECI	2010	2010 ECI	2016	2016 ECI
CHE	3	1.675005	3	1.747452	3	1.556129	2	1.468302	2	1.574009
DEU	2	1.752012	2	1.904767	2	1.615945	3	1.393512	4	1.391291
AUT	5	1.425139	6	1.418479	5	1.353086	5	1.252677	6	1.161942
CZE	16	0.749558	12	1.012904	10	1.088537	7	1.177932	7	1.146971
SWE	4	1.465178	4	1.611056	4	1.435761	6	1.232521	8	1.062357
HUN	20	0.421414	26	0.337529	17	0.820813	11	0.996063	9	1.024936
FIN	7	1.180069	5	1.4913	6	1.333322	9	1.092413	10	0.977137
USA	9	1.174668	8	1.37152	9	1.134045	14	0.900544	11	0.951574
SVK	19	0.56107	19	0.771916	18	0.78016	13	0.939924	12	0.914427
GBR	6	1.265332	7	1.379255	8	1.206179	10	1.008641	13	0.908409
IRL	13	0.867079	11	1.041832	11	1.048843	16	0.829422	14	0.894318
SVN	18	0.66743	14	0.972256	12	1.036354	12	0.945258	15	0.889695
ITA	8	1.175383	10	1.084632	15	0.923474	17	0.795623	16	0.834599
FRA	10	1.133734	9	1.135341	13	1.026197	15	0.897274	17	0.796365
CHN	45	-0.31897	36	-0.08661	32	0.159334	26	0.434175	18	0.653251
POL	30	0.029843	24	0.366727	24	0.536236	21	0.631938	20	0.624566
DNK	11	1.0028	13	1.004456	16	0.853727	19	0.755153	21	0.612932
BEL	12	0.893491	16	0.84823	20	0.642196	20	0.654822	23	0.566471
ROU	31	-0.00332	33	0.011133	39	0.031653	30	0.31165	25	0.519708
NLD	14	0.810251	18	0.790833	22	0.558481	25	0.473109	28	0.472812
HRV	27	0.212374	27	0.239282	27	0.345498	28	0.359857	30	0.345673
LTU	58	-0.52127	43	-0.21235	41	-0.0395	34	0.237289	32	0.274881
ESP	17	0.682818	21	0.592988	23	0.545322	24	0.509491	33	0.272472
PRT	33	-0.08465	31	0.060708	33	0.152021	36	0.164068	38	0.164531
NOR	32	-0.01805	30	0.130558	31	0.19413	38	0.126981	39	0.094805
LVA	70	-0.74819	44	-0.2654	35	0.083154	35	0.170901	40	0.085838
BGR	39	-0.17607	39	-0.11979	44	-0.16812	41	-0.00701	41	0.017913
GRC	55	-0.49306	52	-0.41144	51	-0.35121	52	-0.39478	56	-0.43953

Table 5 Global ECI Ranking and ECI score EU countries, source: own calculations, data from (Harvard, 2018a)

Appendix B: Global ECI score for Eurozone and German Core countries

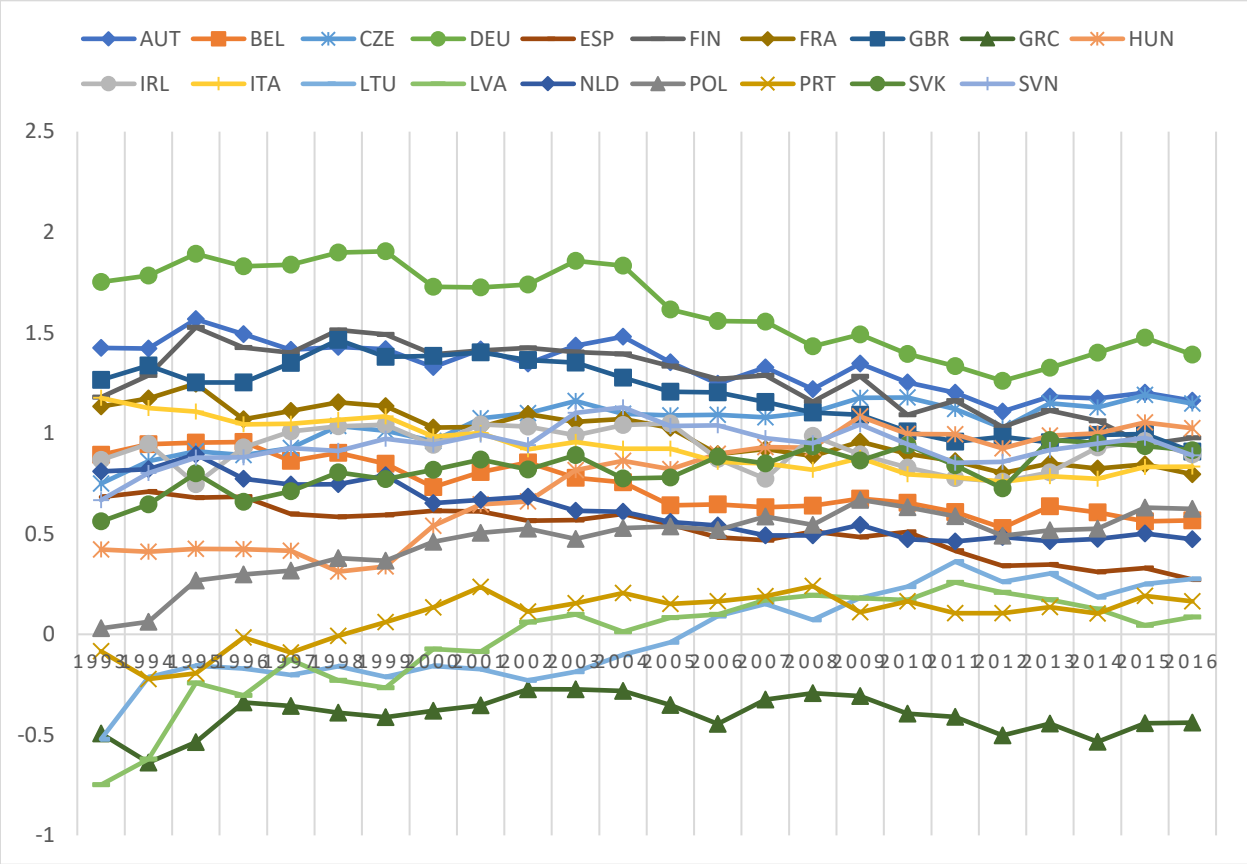

Figure 9; Global ECI score All Eurozone and German Core countries, source: own calculations, data from (Harvard, 2018a)

Appendix C: Eurozone ECI ALL countries

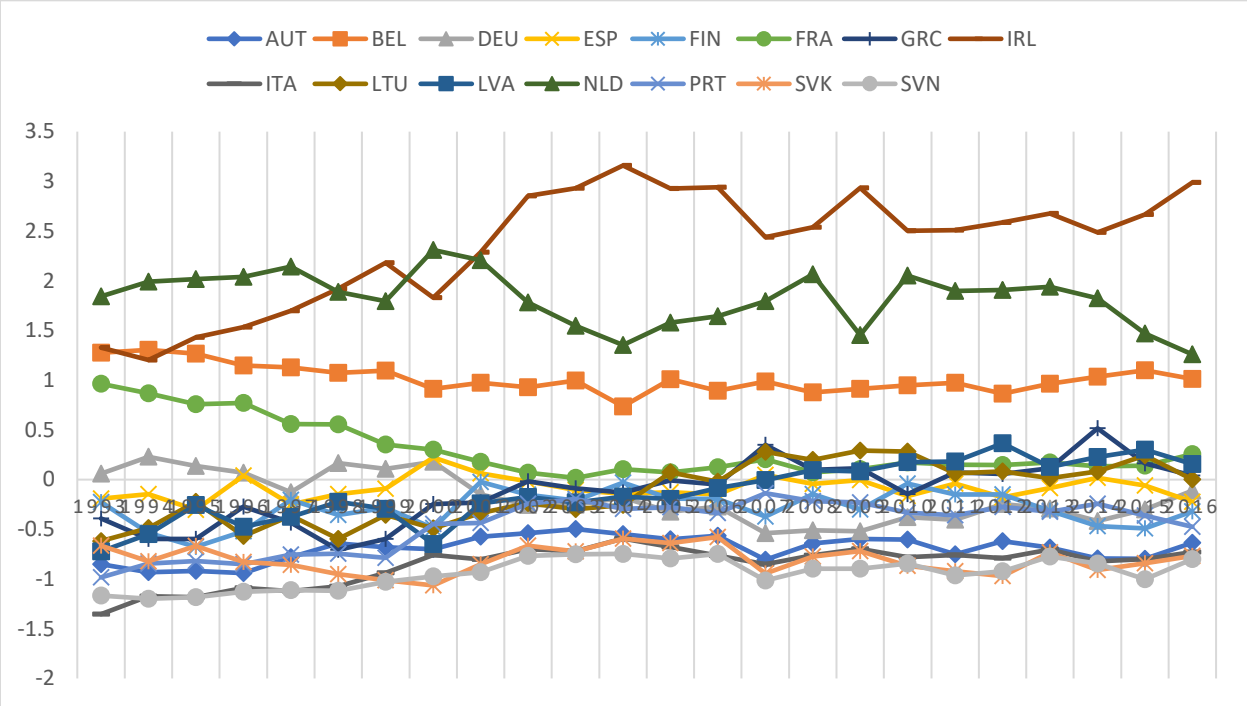

Figure 10; Within Eurozone ECI All Countries, source: own calculations, data from (Harvard, 2018a)

Appendix D: Product Similarity Matrix Germany

	AUT	BEL	ESP	EST	FIN	FRA	GRC	IRL	ITA	LTU	LVA	NLD	PRT	SVK	SVN
1993	63%	54%	49%	27%	60%	58%	29%	47%	59%	26%	21%	52%	31%	51%	54%
1994	62%	54%	50%	29%	59%	59%	28%	47%	58%	34%	28%	51%	31%	52%	55%
1995	61%	54%	47%	34%	59%	58%	29%	43%	56%	34%	38%	52%	34%	52%	56%
1996	60%	53%	47%	34%	58%	56%	31%	44%	54%	36%	33%	50%	34%	48%	52%
1997	60%	52%	45%	32%	62%	58%	31%	43%	55%	34%	38%	47%	34%	52%	55%
1998	57%	52%	44%	34%	61%	55%	29%	37%	53%	33%	31%	46%	35%	50%	52%
1999	60%	51%	45%	33%	59%	57%	29%	38%	54%	30%	31%	47%	34%	50%	53%
2000	59%	52%	48%	30%	62%	57%	31%	40%	55%	29%	36%	48%	34%	52%	54%
2001	62%	54%	48%	36%	66%	57%	31%	40%	55%	32%	35%	47%	40%	53%	55%
2002	65%	56%	49%	37%	67%	61%	36%	41%	55%	34%	40%	50%	38%	53%	57%
2003	60%	51%	43%	34%	60%	56%	32%	43%	53%	29%	37%	46%	34%	51%	56%
2004	61%	48%	45%	37%	60%	54%	33%	40%	51%	29%	37%	45%	38%	47%	56%
2005	64%	54%	48%	40%	63%	60%	38%	50%	54%	36%	44%	50%	42%	56%	62%
2006	65%	54%	49%	39%	62%	58%	35%	47%	54%	39%	45%	51%	41%	58%	62%
2007	66%	51%	47%	40%	59%	56%	35%	47%	52%	39%	46%	47%	39%	56%	60%
2008	67%	55%	50%	43%	59%	58%	37%	52%	55%	39%	45%	48%	44%	59%	60%
2009	68%	55%	51%	46%	65%	59%	39%	52%	56%	41%	47%	49%	41%	57%	62%
2010	67%	54%	52%	46%	63%	60%	38%	54%	54%	46%	50%	50%	44%	59%	63%
2011	70%	60%	56%	49%	66%	65%	42%	56%	59%	54%	54%	54%	47%	62%	64%
2012	69%	62%	54%	47%	65%	64%	40%	57%	57%	53%	54%	56%	47%	60%	64%
2013	68%	61%	54%	47%	65%	65%	43%	60%	56%	53%	52%	55%	46%	62%	63%
2014	66%	59%	49%	49%	61%	61%	36%	58%	54%	48%	48%	53%	42%	58%	64%
2015	62%	52%	46%	47%	55%	57%	35%	58%	51%	45%	41%	48%	41%	55%	60%
2016	62%	52%	45%	47%	58%	59%	34%	53%	52%	45%	43%	50%	39%	57%	57%

Table 6; Product Similarity Matrix with Germany All Countries, source: own calculations, data from (Harvard, 2018a)

Appendix E: Product Similarity Matrix China

Year	AUT	BEL	CHN	DEU	ESP	EST	FIN	FRA	GRC	IRL	ITA	LTU	LVA	NLD	PRT	SVK	SVN	USA
1993	23%	20%	100%	16%	25%	39%	18%	19%	35%	27%	29%	35%	26%	19%	45%	22%	35%	14%
1994	25%	20%	100%	17%	28%	43%	20%	20%	39%	27%	32%	33%	35%	22%	47%	25%	37%	16%
1995	24%	21%	100%	18%	32%	42%	21%	22%	36%	27%	33%	32%	38%	21%	45%	27%	37%	16%
1996	24%	22%	100%	18%	29%	44%	18%	23%	35%	29%	32%	37%	33%	23%	43%	27%	39%	16%
1997	26%	23%	100%	16%	29%	42%	16%	22%	37%	30%	32%	32%	34%	24%	46%	28%	37%	18%
1998	26%	20%	100%	16%	26%	39%	14%	20%	35%	29%	33%	33%	35%	21%	44%	26%	38%	16%
1999	25%	22%	100%	16%	25%	43%	15%	19%	32%	24%	32%	37%	37%	21%	43%	26%	38%	15%
2000	27%	23%	100%	17%	29%	46%	15%	22%	32%	22%	34%	40%	39%	20%	42%	28%	38%	17%
2001	29%	23%	100%	18%	29%	41%	18%	21%	32%	22%	36%	39%	39%	21%	42%	28%	38%	18%
2002	27%	19%	100%	18%	29%	45%	17%	20%	33%	21%	36%	42%	39%	19%	43%	31%	37%	18%
2003	27%	19%	100%	17%	29%	45%	16%	20%	32%	24%	35%	41%	39%	19%	44%	30%	36%	18%
2004	29%	20%	100%	20%	31%	42%	18%	21%	32%	25%	37%	39%	38%	21%	43%	33%	37%	20%
2005	31%	23%	100%	22%	34%	40%	20%	24%	33%	29%	38%	39%	36%	23%	43%	35%	37%	23%
2006	30%	25%	100%	24%	36%	40%	24%	24%	34%	29%	39%	40%	36%	23%	44%	34%	38%	23%
2007	34%	26%	100%	27%	37%	44%	28%	26%	37%	29%	44%	38%	38%	25%	50%	40%	40%	23%
2008	37%	29%	100%	31%	38%	45%	30%	28%	39%	31%	47%	37%	39%	23%	48%	41%	42%	27%
2009	33%	25%	100%	28%	34%	44%	26%	23%	30%	26%	43%	38%	33%	23%	46%	38%	38%	22%
2010	37%	27%	100%	31%	37%	47%	29%	27%	32%	25%	46%	38%	33%	23%	46%	40%	40%	25%
2011	40%	29%	100%	36%	39%	50%	31%	30%	35%	26%	48%	39%	35%	28%	49%	45%	45%	28%
2012	40%	29%	100%	38%	38%	52%	33%	30%	33%	26%	49%	38%	35%	25%	48%	44%	44%	28%
2013	41%	26%	100%	38%	39%	53%	33%	32%	33%	27%	51%	39%	33%	25%	48%	46%	44%	30%
2014	41%	29%	100%	39%	40%	46%	33%	31%	30%	27%	51%	38%	34%	25%	49%	44%	44%	29%
2015	38%	26%	100%	35%	38%	42%	32%	28%	33%	24%	50%	34%	30%	26%	47%	42%	40%	25%
2016	38%	24%	100%	35%	36%	44%	33%	28%	31%	27%	48%	34%	30%	25%	44%	40%	43%	25%

Table 7; Product Similarity Matrix with China All Countries, source: own calculations, data from (Harvard, 2018a)