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Economic complexity and financial development – A multilayered analysis of the European Union

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Working Paper, No. 258/2025

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Abstract:
The economic complexity framework by César Hidalgo and Ricardo Hausmann has inspired a substantial body of literature throughout recent years. Following previous research, which explored the various drivers of economic complexity, this article contributes by exploring the interplay with financial development. For the base sample of the European Union, a positive effect of financial development on economic complexity is found, identifying the financial institutions channel as the strongest driver of the Economic Complexity Index. Critical reflection leads to the assumption that a holistic replication of the study on a global scale could retrieve non-linear characteristics of said relationship.

Keywords: Economic Complexity, Financial Development, European Economics
JEL Classification: C51, G10, G20, O16, O30

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Acknowledgements: This paper is a revised version of my Master's dissertation submitted in May 2024 to the BSEL and USPN. I would like to thank Jennifer Pédussel Wu for years of support and encouragement that have played a major part in my choice of career and my ability to pursue a doctoral education. Further, I would like to thank Prof. Gary Dymski and Prof. Arafet Farroukh for their insightful comments on my dissertation.

1 Introduction

In a world with an abundance of data, it is perplexing that certain economic phenomena remain insufficiently explained. High global wealth and income inequality are on the rise, and economic growth rates are diverging to facilitate further the drifting apart of countries (Chancel et al., 2021). A better understanding of socioeconomic dynamics necessitates a rethinking of existing frameworks and methodologies. Some approaches emphasise a fundamental restructuring of core elements in economic modelling. Others advocate for a comprehensive differentiation of the economic system and its components. Alternatively, in an interdisciplinary approach, insights, methodologies and theories are derived from different subjects such as physics, biotechnology and others. Complexity economics, a field drawing from network sciences, chaos theory and other areas of physics, acknowledges at its core the intricacy and the dynamic nature of systems (e.g., markets, financial systems, industrial networks). The resulting models, including heterogeneous agents, a bottom-up approach with micro-level data used for macro-level outcomes, and a versatile quantitative toolbox, have been employed in an increasing number of studies throughout recent years. The Hidalgo-Hausmann framework hereby represents a specific strain of complexity economics, in which they regard the varying productive structure of countries as a result of the different levels of sophistication or productive knowledge. Specialisation in certain goods cannot be explained by just factor endowment or economic development but is the outcome of a complex network structure with a multidirectional interactive nature. A variety of studies has sustained the substantial link between higher levels of complexity and higher economic development, and the complexity framework is employed to answer and shed more light on crucial issues of contemporary economic science by offering a novel perspective. While the literature is expanding, there are still fundamental gaps to fill to answer the question:

Through which socioeconomic channels is economic complexity influenced?

This article aims to contribute to answering this question by further exploring the interaction of complexity economics with another field of economics, which has received widespread attention throughout recent years: financial development. Ever since the 1990s, and even more since the outbreak of the Great Recession 2007/08, the interest in literature on topics such as financial markets, sectors and development, financial stability and crises or the financialisation of the economy has skyrocketed. Generally, one can distinguish between financial literature on a corporate or societal level (Davis and Kim, 2015). Following the latter, investigating the relevance of financial development for the phenomenon of economic complexity bears the potential to uncover critical structural relationships and provide industrial policy makers with crucial input to achieve industrial upgrading.

Given the undeniable and crucial leading role that the financial sector plays in the global economy and the only marginal exploration of its relation to economic complexity, delving deeper into the conjunction presents itself as an opportunity to add novelty to a relatively young research field by exploring the question:

To what extent and through which main channels does the financial development of countries determine their economic complexity?

To answer this question, a framework by Svirydzenka (2016) on how to measure financial development is introduced. After a theoretical elaboration, a panel regression is applied to test for causal relationships. For this purpose, a longitudinal data set has been composed from different sources to provide the necessary information to answer the research question. To begin with, a concise introduction to complexity economics is provided.

2 Economic complexity - an alternative framework for measuring economic activity?

Economic theory across most fields has been dominated by the conventional views that include hyper-rational agents, symmetric information and equilibrium-based solutions. While these assumptions may suffice in the context of clearly defined problems and modelled environments, some economists are questioning their applicability to real-world challenges. Complexity economics is one of the branches that aims at providing an alternative framework to the conventional setting of economics by characterising systems as a complex network of agents, acknowledging the heterogeneity of these agents and the multifaceted interactions between them.

Complexity was first integrated into the field of economics at the Santa Fe Research Institute in the late 1980s. Insights were derived from natural sciences, anthropology and other social sciences, including economics, focusing on stock market dynamics (Waldrop, 1993). In subsequent decades, research in complexity has vastly expanded. Not only has the concept remained highly interdisciplinary, showcasing applications amongst many different fields of academia (Holland, 2014), but it has also developed distinct strains of literature within the field of economics. For example, in more heterodox literature, agent-based modelling (Axelrod, 1997) or stock-flow consistent models (Nikiforos and Zezza, 2018) can be interpreted as such examples, as well as the more conceptual approach provided by Arthur (2021), who contrasts complexity economics as a macroeconomic framework to the conventional neoclassical narrative. Farmer (2012) stresses how the main characteristics of the complexity field are the departure from overly simplistic models. For him, *"[...] to understand where the richness of the economy comes from, we need to instead study the collective interaction of a large number of heterogeneous participants"* (p. 3). As a result, a common ground that the complexity approaches share is the refusal of two significant characteristics of economic models. Firstly,

they negate the idea that economic problems can be handled in equilibrium-based solutions. Secondly, the assumption of non-linearity within the interactive relationships of complex systems is a central idea which is incorporated into the quantitative conceptualisation.

While complexity economics can stand as a concept for itself and is not per se associated with a specific school of thought, it does not come as a surprise that it is receiving much more attention from the field of heterodox economics, which revolves frequently around the conception of complex and dynamic systems, non-equilibria and non-linearity. The literature on ABM and SFCM showcases one of the intersections. The field of structuralist economics presents another distinct, unorthodox strain of literature which has contributed to the understanding of complexity. Structuralists — both the Latin-American and Anglo-Saxon schools — attribute much of the outcome of their analyses to the structural differences and crucial changes within productive capacities that set countries apart from each other. Key concepts are the inequality in wealth that can be explained by the core-periphery framing of the global economic order, (new) dependency theory, regional divergence, or economic drifting apart (Dutt and Ros, 2003).

When working within the field of complexity economics, it is crucial to cautiously define the context and reach of the chosen approach to avoid confusing or misleading interpretations. Navigating through the intricate network of interactions and implications for different strains of literature is not an easy task. Accordingly, the focus of this article lies specifically on an approach pioneered by Hidalgo and Hausmann, which is thoroughly elaborated in the following subsections.

2.1 Theoretical foundations of economic complexity after Hidalgo/Hausmann

In orthodox literature, economic wealth, income and eventually also growth trajectories of countries have often been associated with the Smithian idea of the division of labour (Smith, 1793; Rosenberg, 1965), after which economic prosperity comes with a higher degree of specialisation of the labour force. In their framework, Hidalgo and Hausmann seek to overcome two major drawbacks of this conventional idea and tailor it towards a modern view on economic production while still focusing on specialisation as a key determining factor (Hidalgo, 2021). They do so by focusing on inputs of production, and specifically, on one distinctive element – knowledge. While all types of input are essential for production, it is knowledge, or know-how, which sets countries apart from each other. What Hidalgo (2021) and Hausmann (2016) refer to as *capabilities* describes the aggregated tacit or *productive knowledge* embedded in production processes, which cannot be acquired or replicated easily.

The novelty offered by this approach is to compare economies via production inputs on a much more detailed level than, for example, the conventional Heckscher-Ohlin model does by differentiating only between capital, labour and land (Jones, 1993). The central idea

postulates that everything produced within an economy requires a set of given capabilities, while also assuming that capabilities are not exclusive to only one type of product and can be combined at will.

Within this framework, capabilities are linked to two distinct characteristics that eventually enable the quantitative measurement of productive knowledge and the resulting productive structure. The first property is *diversity,* which proposes that countries which have a higher variety in different capabilities, hence a more diversified productive knowledge, can provide a greater variety in products, but also products which require more convoluted combinations of capabilities. Capabilities are not exclusive to unique implementations; thus, the diversity property is simultaneously also a measure of the total, aggregated productive knowledge present in an economy (Hausmann and Hidalgo, 2010). Second, the *ubiquity* of capabilities within an economy estimates how disseminated a specific capability or set of capabilities is by comparing the relative export shares for all countries of the product that corresponds to the respective set of capabilities. It measures how many countries can produce this specific product based on their available productive knowledge.

There are three general assumptions about the interplay between complexity and the above two properties:

1) The higher the diversity of a country's products, the more variation in productive knowledge, the higher the complexity of that country, ceteris paribus.
2) The lower the ubiquity of a product's required set of capabilities, the more exclusive it is relative to other products. A country that showcases a lower aggregated ubiquity in produced goods would rank higher in terms of complexity, ceteris paribus.
3) The diversity of an economy tends to be negatively correlated with the aggregate ubiquity of its export basket.

These dynamics result in two different possible indices that can be utilised. The *Economic Complexity Index* (ECI) measures the complexity of countries, while the *Product Complexity Index* (PCI) provides insight into specific products or baskets of goods, which will not be further discussed in this article. Both indices rely on conventional, bilateral trade data, which offers insights on different levels of product differentiation[1]. Complexity calculation is based on the connection of geographic locations within matrix notation and their subsequent transformation. Hidalgo and Hausmann utilise the framework of Balassa and Noland (1989), who developed the *Revealed Comparative Advantage* (RCA, 2.1). Based on this analytical framework, a specialisation matrix M_{cp} (2.2) is constructed for each country, which summarises the

[1]The ECI and PCI are computed based on the trade data provided by the Harvard University Growth Lab.

productive structure, including information on all product classes for which a country is an effective exporter.

$$RCA_{cp} = \frac{X_{cp} / \sum_c X_{cp}}{\sum_p X_{cp} / \sum_c \sum_p X_{cp}} \tag{2.1}$$

$$M_{cp} = \begin{cases} 1, & \text{if RCA} \geq 1 \\ 0, & \text{otherwise} \end{cases} \tag{2.2}$$

$$M_c = \sum_p M_{cp} \tag{2.3}$$

$$M_p = \sum_c M_{cp} \tag{2.4}$$

These specialisation matrices also represent the previously mentioned properties of diversity (2.3) and ubiquity (2.4) when reduced to one dimension, respectively. All these technical specifications are prerequisites for the construction of the ECI. The complexity K_c of a country (2.5) is equated as a function of its property-specific specialisation matrices. The second term of K_c represents a transformation utilising a dimensionality reduction method based on reciprocal averaging (Hill, 1973). The ECI (2.7) is a reshaped version, normalising K_c utilising a Laplace transformation to eliminate time-invariant, constant factors[2].

$$K_c = \frac{1}{M_p} \sum_p M_{cp} K_p = \sum_p \frac{M_{cp} M_{c'p}}{M_c M_p} K_{c'} \tag{2.5}$$

$$ECI_c = \frac{(K_c - mean(K_c))}{stdev(K_c)} \tag{2.6}$$

2.2 Complexity and comparative dynamics

The ECI is an index that consists of iterative averaged values and is used for comparative analyses exclusively, as it allows for a consistent ranking of countries. Essentially, it presents a metric for how complex an export basket is, incorporating some insightful dynamics. Firstly, if a country increases its output by creating a new product, this will only influence the ECI of that country positively if the complexity of that product is above the prevailing average. Secondly, as the ECI focuses on specialisation matrices utilising the RCA rather than on explicit product data, similar values are showcased for countries that are effective exporters to a similar extent, even if their productive structure displays substantial sectoral differences (Hidalgo, 2021:p.100). Finally, due to the location-activity-based approach of the ECI, it is possible to introduce an additional metric, which describes the interlinkages between different

[2] For a more detailed technical representation compare Hausmann et al. (2014).

products through common underlying capabilities, and is referred to as *proximity* (Hidalgo, 2021:p.98). Proximity measures the likelihood that product x_j is exported under the condition that product x_i is exported. This conditional probability is a technical representation of the instinctual consideration of how difficult the expansion of production is for a country. This is important because if a country wants to increase its ECI, it can do so via the accumulation of capabilities that allow for the production of more complex goods. The proximity property in that regard provides crucial insights as to which capabilities are easier to accumulate due to the similarity between products (Hidalgo, 2021).

Furthermore, when extended by a spatial dimension, it serves as the base for measuring the *relatedness*. This metric associates an activity with a location and is a reliable predictor for the likelihood that an activity-related specialisation in that location is increased or decreased. Because of its predictive nature, relatedness is normally presented in regressive form (2.7), where F_c and F_p represent location/activity-specific matrices containing information on RCA and R_{cp} is the resulting specialisation matrix, ω_{cp} is the relatedness coefficient and b is a positive coefficient (Hidalgo, 2021:p.98). Proximity (Φ) here plays a role in the determination of relatedness (2.8).

$$R_{cp}(t+\delta t) = R_{cp}(t) + b\omega_{cp}(t) + F_c(t) + F_p(t) + \epsilon \tag{2.7}$$

$$\omega_{cp} = \frac{\sum_p M_{cp}\Phi_p}{\sum_p \omega_p} \tag{2.8}$$

Relatedness and proximity are important properties because they add a new layer of depth to the insights that can be derived from complexity analysis. Suppose the productive structure of a country is assessed exclusively based on the diversity and ubiquity of its capabilities. In that case, this leaves out any statement on the relation between these capabilities. Relatedness enables the establishment of this lacking connection and makes a statistically sound projection on the development of similar activities. Furthermore, it suggests the possibility of comparing countries on the basis of their respective endowments in capabilities (Balland et al., 2022). This allows for the construction of a network structure incorporating all relevant metrics.

2.3 The product space as a network structure and industrial upgrading

As an addition to the ECI, Hidalgo and Hausmann thus have developed a visual representation that depicts the implications of complexity as well as proximity and relatedness: the product space (Hidalgo et al., 2007). Figure 1 shows the most recent product space of Germany. Coloured nodes represent (sector-coded) products in which Germany has an RCA; the size of the node corresponds to the product's relative share in the export basket, and the difference between nodes that are directly connected is a representation of their proximity (Hidalgo, 2021:p.97).

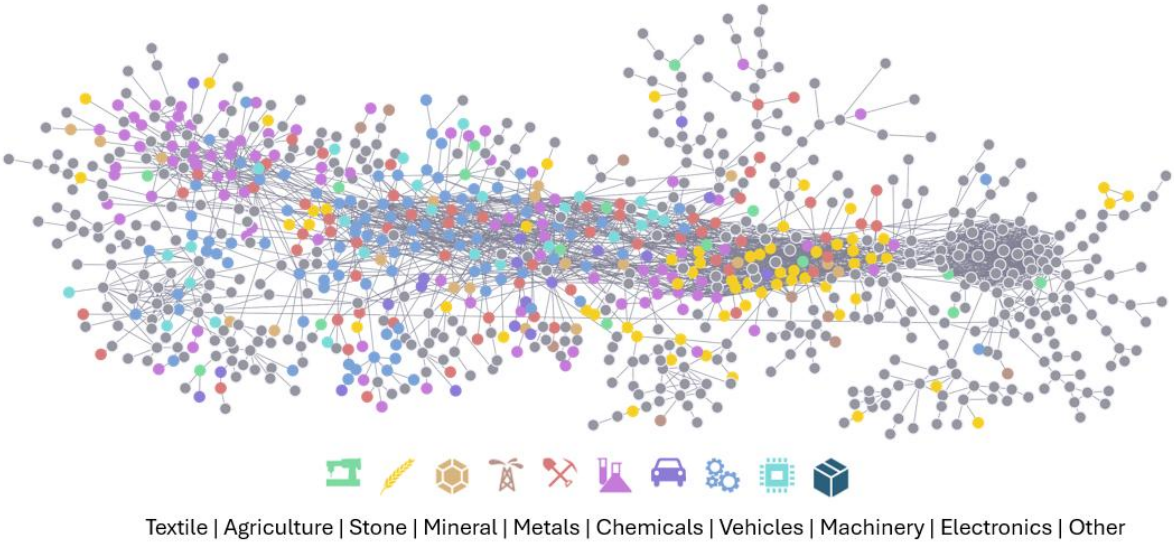

Figure 1: Product Space of Germany 2022 (Harvard Growth Lab, 2024)

The product space serves as the visualisation of a single country's network structure and allows for a more intuitive interpretation of the dynamics behind the whole complexity approach. Hausmann and Hidalgo (2010) address the problem of global divergence within economic growth trajectories by what they coin the "*trap of economic stasis"* (p. 20). They state that countries which showcase a low complexity within their production face the inability to upgrade, as they lack productive knowledge in the form of higher complexity capabilities. Thereby, the proximity needed to develop new products with high complexity is mainly reserved for countries already in possession of high complexity capabilities. This dynamic partially explains the continuing drifting apart of *loser* and *winner* countries. As analytical tools, the product space and the ECI, however, offer at least some ease, as they allow for the identification of potential new products to open up to. The importance of the product space concept in terms of economic policy decision making is stressed by Hidalgo et al. (2007), as *"[...] it is quite difficult for production to shift to products far away in the [product] space, and therefore policies to promote large jumps are more challenging. Yet it is precisely these long jumps that generate subsequent structural transformation, convergence, and growth."* (p. 487).

2.2 Economic complexity and growth trajectories

The question remains why a country may aim to increase its complexity. When observed without a specific context, the metrics introduced above do not hint towards a preferable ECI score. A country could focus on low complexity goods in which it may have an RCA. While the applications of economic complexity have become much more versatile over the recent years, early research on the ECI deals predominantly with economic performance. While constructing

the index, Hidalgo and Hausmann (2009) and, subsequently, also other scholars (Canh and Thanh, 2020; Udeogu et al., 2021), validate that the ECI is a good predictor for economic growth. Furthermore, a high economic complexity is correlated positively with the level of income and economic development of a country, as pointed out by Zhu and Li (2017) or Stojkoski and Kocarev (2017). On the nature of the relation between economic complexity and growth, Hausmann et al. (2014:p27) state that it goes beyond merely a correlation, but instead identifies complexity as a driver of economic growth. They justify this by pointing towards the statistically significant pattern of countries' growth trajectories regarding their expected income level. Actual income levels in most countries converge towards their expected values based on their economic complexity. Thus, countries have a clear incentive to expand their productive knowledge and produce more complex goods to accelerate their growth trajectories. Hidalgo and Hausmann (2009) refer to the development of new productive knowledge and the accumulation of hitherto non-existent capabilities as *industrial upgrading*. However, this upgrading process is no easy task, as it requires policies and strategies that facilitate the exploitation of new knowledge. As Hausmann et al. (2014) emphasise, *"countries with an abundance of such nearby products will find it easier to deal with the [...] problem of coordinating the acquisition of missing capabilities with the development of the industries that demand them. This should allow them to find an easier path towards capability acquisition, product diversification and development"* (p.29).

3 Identifying the research gap - the dual causality of economic complexity

There are three strains of literature found in complexity economics. The first one is focusing on the foundations, conceptualisation and quantitative measuring of complexity and has been outlined in the previous section. The second and third consist of applied and empirical complexity literature, which features two diametrical thematic alignments. On the one hand, there is a substantial number of studies that use economic complexity to predict other socioeconomic phenomena, beyond the mere application to economic growth. This literature identifies what is *driven by complexity*. On the other hand, scholars have increasingly paid attention to the *drivers of complexity*. In various empirical examinations, different factors are tested to determine whether they have a causal relationship to complexity.

3.1 Economic complexity as a driver

The onset of complexity applications was undoubtedly connected to the prediction of economic growth and income levels. Building on the established causal relationship between economic wealth and complexity, research has emerged on the impact of complexity on income inequality. For instance, Hartmann et al. (2017) find that more complex economies exhibit lower income inequality. These findings are to an extent contrasted by Chu and Hoang (2020) and Lee and Vu (2019), who both conclude that the negative correlation between ECI and

GINI only persists if it is driven by high levels of educational standards and human capital. Cota et al. (2023) identify this dynamic within the EU, where only the member states with the lowest income show signs of a direct correlation.

The issue of income inequality has also been intensively addressed in studies which utilise a refined framework for the regional settings within single countries. For both high-income (Sbardella et al., 2017) and low to middle-income countries (Bandeira Morais et al., 2021; Gómez-Zaldívar, 2022), the empirical evidence shows a consistently negative correlation, meaning more complex federal regions exhibit lower income inequality. Exploring the complexity-inequality nexus further, Barza et al. (2020) and Ben Saâd and Assoumou-Ella (2019) find a negative relationship between the ECI and the gender wage gap across a diverse country sample.

Another major literature block includes research on issues of ecology and sustainability. Especially, the link between complexity and greenhouse gas (GHG) emissions is explored in different settings. Romero and Gramkow (2021) and Can and Gozgor (2017) both find a significant reducing effect of economic complexity on GHG emissions regardless of the country's income level. Neagu and Teodoru (2019) confirm this causal relationship and add that higher complexity countries also exhibit a higher share of renewable energies within the total energy consumption mix. Additionally, other ecological aspects are also investigated in the context of complexity. Ahmed et al. (2022) find that a higher ECI is causally linked to lower ecological footprints (EF) and higher energy efficiency in a regional setting in India. Similarly, in a cross-country study, Rafique et al. (2021) identify an ambiguous effect on the EF yet see a clear link to energy efficiency in terms of consumption. As the literature on the conjunction of economic complexity and environmental topics is expanding, studies like Dogan et al. (2019) suggest being cautious of the empirical specifications of analyses. Based on their findings, they identify implications for both GHG emissions, EF and other ecological factors and stress how the level of income and economic development of a country is crucial in determining the effect that economic complexity has. While GHG emissions generally show uniform trends across different countries, the EF in their sample increased alongside the ECI in high-income countries. At the same time, the interaction was reversed in low- to middle-income countries. While these are the main fields in which complexity is applied, there are also some scholars examining the connection with socio-economic and institutional issues, such as human development (Ferraz et al., 2018) or the shadow economy (Nguyen, 2022).

3.2 The drivers of economic complexity

This field of research focuses on the determinants of economic complexity. The ECI is formally defined as a measure of the productive knowledge that is present in an economy. Calculated through specialisation matrices including information on RCA, the metric alone does not give

much insight into the driving forces behind this productive knowledge. In recent years, an increasing share of the academic debate has revolved around the different factors that determine economic complexity. Much of this literature focuses on macro-institutional factors, such as Vu (2022), who finds that the ECI is positively related to the overall institutional quality of a country, measured by world development indicators. The role of governance and institutional factors is also stressed by Hausmann (2016), who identifies political stability, government effectiveness, political corruption and regulatory control as main institutional drivers that exhibit a positive (negative for corruption) correlation with economic complexity. Avom and Ndoya (2022) specifically test for different measures of stability (economic, financial, and political) and find that all are positively related to complexity, with political stability having the most significant effect.

In terms of socioeconomic drivers, several studies, such as Sanli et al. (2024) or Lee and Vu (2020), focus on the effect of human capital on the ECI through the proxy of educational quality. They confirm the intuitive notion that a higher level in terms of educational quality, accessibility and public funding is causally linked to higher complexity, as it directly boosts the accumulation process of productive knowledge. A similar approach tests for the influence of government spending behaviour. Lapatinas et al. (2019) find that a higher government expenditure is generally associated with a higher ECI.

Some literature explores more specific factors as well. For example, Nguyen et al. (2020) test for the influence of intellectual property and find a significant positive relationship between the number of patents in a country and its ECI. The effect of the internet is examined by Lapatinas (2019), who deduces a positive impact of internet access on economic complexity.

Overall, a variety of approaches have been employed, and the discipline of complexity economics is growing. Figure 2 presents a reduced overview of the current state of literature within the field.

One of the factors which has not yet been extensively studied as a driver of economic complexity is financial development. There have been a few attempts, for example by Chu (2020), who includes private credit and stock market data in a causal analysis and finds a significant, positive effect on complexity. Yet, coverage of the financial dimension remains limited. This article adds novelty to the academic discussion by including a quantitative, causal analysis of financial development and its potential role as a driver of economic complexity. **A significant positive relationship between metrics of financial development and economic complexity is hypothesised. Additionally, this positive relationship is expected to vary between transmission channels.** The next section elaborates why financial development needs to be considered an important phenomenon in the context of complexity economics and gives an outlook on the different categories in which it is measured.

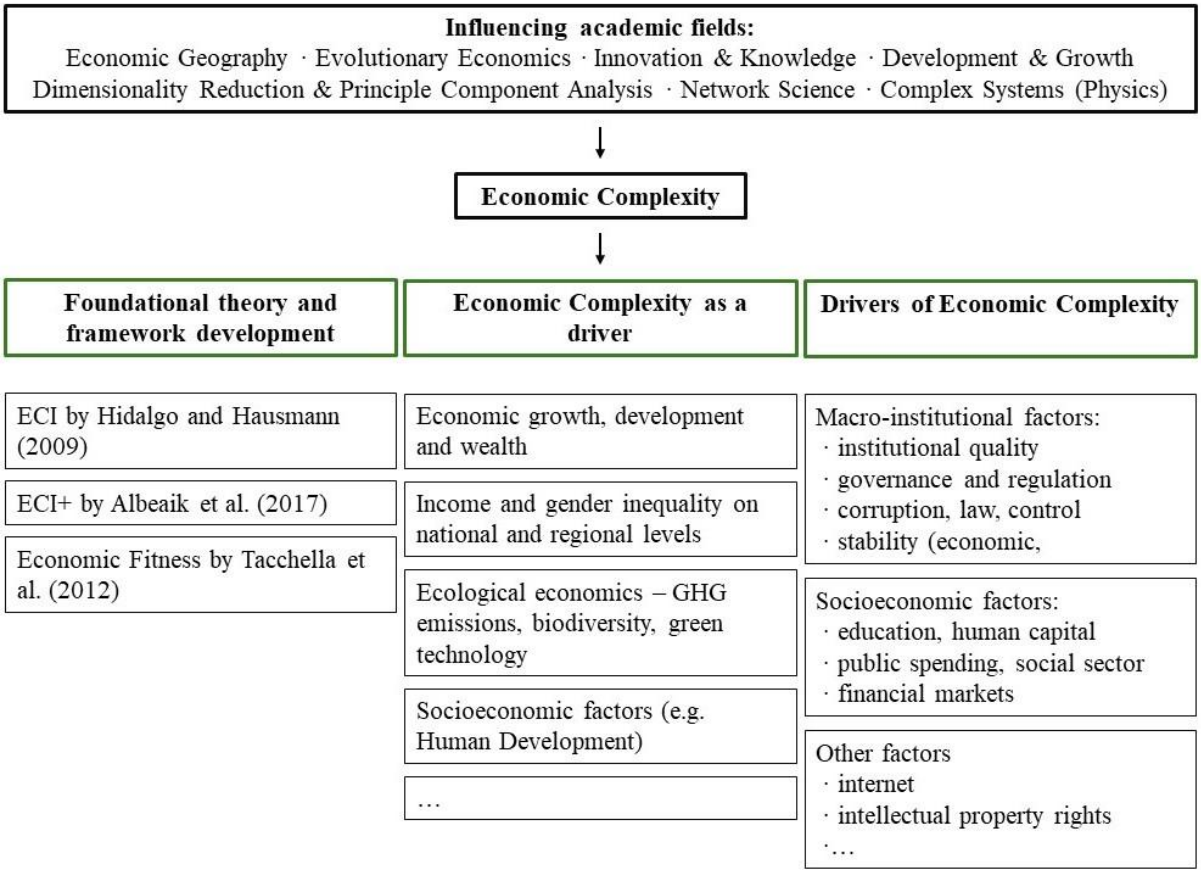

Figure 2: Literature overview on complexity economics (author's own representation)

4 Financial economics and financial development as a systemic property

The vastly expanding importance of the financial system since the 1990s has been recognised by many different fields within the economic sciences. The shift of focus of the global economy towards financial markets has been coined *financialisation* by scholars, which refers to *"the increasing role of financial motives, financial markets, financial actors and financial institutions in the operation of the domestic and international economies"* (Epstein, 2005: p.3). Taking this into account, the inclusion of financial phenomena into the field of complexity economics is crucial to work out the role it plays within the theoretical framework.

The field of financial economics has not been developed only at the end of the 20th century, but instead goes back to the very beginning of the financial system itself. Nevertheless, with the increasing scale of the financial sector, the attention of scholars has equally expanded. The term *financial* here refers to the carrying out, the corresponding regulations and institutions and the analysis of trade, in which money is to be found exclusively as the traded good. Two general fields of literature can be identified. Firstly, the field of *finance and financial corporations* primarily deals with microeconomic dynamics within markets and firms and covers areas such as risk measurement and valuation, debt and financing, decision-making processes and ownership structures of firms (Eichberger and Harper, 1997).

Secondly, *macroeconomic financial economics* looks at the broader picture, including financial institutions, governance and regulatory settings, financial development, stability, crises or market/sector interdependencies. The previously mentioned focus on the phenomenon of financialisation can be attributed to both firm-level or microeconomic research (Lazonick and O'Suvillan, 2010; Davis, 2016) and macroeconomic perspectives (van Treeck 2009; Stockhammer, 2004; Krippner, 2005). While financialisation is not the primary focus of this article, it yet hints towards an important aspect. The continuous growth of the financial system has made it exceedingly more complex. This can be seen on all levels, from the much more complex and versatile financial instruments to the increasing amount and diversity of financial intermediaries to the increased effort that has to be put into more adequate governance frameworks and financial regulations.

4.1 Financial development

It is important not to confound financial development with the concept of *financial sector development*, which refers explicitly to development assistance for developing and emerging economies' financial sectors (Zhuang et al., 2010). Instead, it relates to the measurement of an economy's financial system quality. The term itself comes with a degree of ambiguity. While there are different ways of outlining this system, here the approach provided by Levine (2005) is followed. Based on Merton (1992), who identifies the primary reason for the existence of a financial system to be the overcoming of market frictions/imperfections to achieve the goal of reallocating resources, Levine specifies five key functions. These entail the "*(i) production of ex ante information about possible investments, (ii) monitoring of investments and implementation of corporate governance, (iii) trading, diversification, and management of risk, (iv) mobilization and pooling of savings, and (v) exchange of goods and services"* (Levine, 2005:p870). Consequently, financial development refers to these five functions within a single economy and assesses its level of functionality. These functions are all relevant for decisions on investment and saving and thus play a significant role in the determination of capital accumulation and also resource allocation, which ultimately suggests a direct effect of financial development on economic development, growth and stability (Dabla-Norris and Srivisal, 2013).

Within the presented literature, the financial system typically consists of two main components: financial institutions and markets. The term *financial institutions* can be understood in two different ways. On the one hand, it encompasses a wide range of firms and actors that are active in the financial sector. Commercial banks, insurance, funds and financial (service) companies represent the most significant share of these. On the other hand, it also refers to the understanding of the financial system from an institutionalist perspective. In economics, North (1990) was among the first to provide a comprehensive analysis. His

definition describes institutions as *"the rules of the game in a society or, more formally, [...] the humanly devised constraints that shape human interaction"* (p.2). These rules within the financial market are expressed by the legal framework and jurisdiction, which alter the playground of financial actors. Additionally, it includes national and supra-national authorities and organisations that develop and enforce these regulations, such as central banks or financial supervision agencies.

One of the major challenges that accompanies research which merges financial development with another subject comes from the field itself. The literature on financial development lacks a clear consensus. While general scholars agree that it refers to the overall quality of the financial sector, the particularities and the scope of matters covered by the term can differ widely based on the specific research question, the application or the school of thought from which it arises. Especially when it comes to measuring the level of financial development, this variety in approaches and the multilayered complexity of the topic emphasise how important it is to define the basic conditions of an analysis. Therefore, the following two clarifications are made. Firstly, financial institutional development refers to the understanding of institutions as firms, banks, etc., as outlined above. This does not imply that the regulatory and legal setting of the financial sector does not matter. Instead, it stems from the fact that the institutional setting in question is difficult to measure quantitatively, and therefore, including it in the analysis would prove problematic. Secondly, to avoid contradiction or ambiguity, the subsequent section will introduce a specific approach to measure the degree of financial development that will be referred to for the remainder of the article.

4.2 How to measure financial development?

This article assumes the approach by Svirydzenka (2016), which draws from Cihak et al. (2012), to provide a quantitative measurement of financial development. Within their framework, they present three dimensions in which both financial institutions and markets are assessed. **Depth** refers to the size/scope which financial markets and institutions showcase relative to overall economic activity. In previous research, the depth of the financial sector has been an important metric, which was calculated through a variety of ratios that express the relative amount of liquid liabilities to the GDP. Here, different measures related to money supply have been used that include *narrower* definitions of liabilities (Anwar and Cooray, 2012) or *broader* definitions (Hassan et al., 2011). Capitalising on these findings, the framework by Svirydzenka (2016) includes several indicators on depth, which account for the most complete measurement of the financial sector. **Access** refers to the ability of individuals to make use of institutions and partake in financial market transactions, and **efficiency** refers to the profitability of the financial sector's respective components. Each of these dimensions consists of the aggregated value of several respective indicators, as outlined in Table 1. Thus, this

framework is three-dimensional, hierarchically measuring financial development and resulting in a total of nine indicators which assess overall financial development, institutions and markets separately and each of the three dimensions, respectively. While Svirydzenka (2016) acknowledges that this measure does not include the entirety of facets characterising a financial system, they hint at the general lack of frameworks that offer alternatives for a quantitative assessment. They identify a general gap between the theoretical models within the field and the empirical results, which they intend to close with their contribution. Much of the financial development research relies on measures that solely refer to the size of the banking or financial sector (e.g. Beck et al., 2010). Including the dimensions of efficiency and access, therefore, provides additional insight and renders this framework the most suitable for a thorough cross-country comparison, as it includes an additional structural perspective through the dimensions of *access* and *efficiency*.

There are three main arguments in favour of this framework. The first one is straightforward: data availability. Adopted by the IMF, the metrics summarised above are annually updated. Secondly, the three different sub-categories for both markets and institutions allow for a precise analysis based on channels of impact.

This is especially beneficial when addressing the issue of policy implications. And lastly, the index, as developed by Svirydzenka (2016), has proven itself to be versatile and reliable, as demonstrated by the amount of research which applied the metric to generate robust findings. Some examples for this are the implementation in studies on energy consumption (Cao et al., 2022), carbon emissions and efficiency (Acheampong et al., 2020) or income inequality (Demir et al., 2022).

Financial Institutions Development	Financial Institutions Depth	Private sector credit / GDP
		Pension funds assets / GDP
		Mutual funds assets / GDP
		Insurance Premiums / GDP
	Financial Institutions Access	Bank branches per capita
		ATMs per capita
		Percentage of firms with line of credit
		Bank accounts per capita

	Financial Institutions Efficiency	Net interest margin
		Lending-deposits spread
		Non-interest income / total income
		Overhead costs / total assets
		Return on assets
		Return on equity
Financial Markets Development	Financial Markets Depth	Stock market capitalisation
		Stocks traded / GDP
		Government international debt securities / GDP
		Debt securities of fin. corporations / GDP
		Debt securities of non-fin. corporations / GDP
	Financial Markets Access	Market capitalisation outside of top 10 companies
		Total number of issuers of debt
	Financial Markets Efficiency	Stock market turnover ratio (composed of seven different capitalisation metrics)

Table 1 - Composition of Financial Development Indicators after Svirydzenka (2016, p.8; author's own representation)

4.3 Building the bridge between financial development and economic complexity

Economic complexity and financial development share an important area of application: economic growth theory. However, even though the relationship between financial development and growth has been researched intensively, unlike economic complexity, financial development is not associated with such a clear relationship towards growth rates. Valickova et al. (2014) conduct a meta-regression analysis on a total of 67 studies with a global country sample and find that a positive relationship between the level of financial development and economic growth is consistently found within high-income countries and

mostly found in middle-income countries. For low-income countries, however, most studies find a weaker direct effect of financial development on growth. The authors further remark that the methodological approach is of high importance, as the studies which focus solely on sector size exhibit weaker causal evidence. In a similar cross-country study, Ang (2008) reinforces the differences that occur between high and low-income countries, but also finds an overall positive relationship between financial development and economic growth. He further hints towards the substantial institutional differences between countries based on income, stating that the higher development most likely accounts for much of the higher effect in high-income countries. He stresses the role of financial intermediaries in that regard specifically. Other studies come to similar conclusions (Arestis et al., 2015; Levine and Zervos, 1998), yet there are also studies with a specific regional focus which find strictly positive relationships even for low-income countries (Al-Makawi and Abdullah, 2011).

The notion of non-linearity is also examined in the financial development-growth literature. Beck (2014) addresses the crucial issues of a *threshold* level of financial development, after which the stimulating effect increasingly weakens. Similarly, Aghion et al. (2005) indicate that countries with an exceedingly high level of financial development often show statistically less significant links to growth. More drastically, some studies even suggest an adverse direct effect of financial development once it surpasses a very high level (Arcand et al., 2015; Cecchetti and Kharroubi, 2012). Arcand et al. (2015) try to define this threshold, after which the effect turns, and conclude that private sector debt to GDP must equal 100 per cent. However, this is a rather rudimentary measure which also neglects other aspects of financial development as it focuses solely on financial depth. The main takeaway of this literature is the assumption that financial development's stimulating effect is diminishing or even reversing after a certain high level it achieves. This assumption is important for the interplay of economic complexity and financial development because such a threshold could also exist for the effect of the latter on the ECI.

The common statistical relationship on growth, which has been established for both economic complexity and financial development, serves as a first reason for the intuitive notion of a causal relationship between the two phenomena. Can (some of) the effect of complexity on growth be explained by financial development?

Further, the connection between financial development and innovation, research and development and technological change, all concepts closely related to the field of complexity economics, is researched increasingly. Hsu et al. (2014) and Ang (2010) both find a positive effect of financial development on technological progress and the intensity of research and development. Hall and Lerner (2010) argue that what they identify as the "funding gap" (p. 611) is lower for countries with deeper financial systems, reducing the financing constraints firms face for the implementation of innovative endeavours. Moreover, Aghion et al. (2005)

include the aspect of financial development in a Schumpeterian growth framework, arguing it promotes innovative processes that resemble *creative destruction*. Additional empirical evidence is provided by Law et al. (2018) or Ho et al. (2018). Innovation, knowledge accumulation and technological progress are three concepts closely related to the process of industrial upgrading. The relevance of these not only points out another common area of application but also presents the possibility for a causal interaction. Could the potential effect of financial development on economic complexity be partially explained by the innovative impact of the former?

5 Economic complexity and financial development in the European Union

Figure 3 shows the ECI for the EU countries in 2020. Here, a first important particularity can be derived — each of the EU countries showcases a positive ECI value. This does not come as a surprise, as the EU resembles one of the economically most developed regions in the world. However, while the most complex countries like Germany (1.94), Austria (1.68) or Sweden (1.54) have ECI values that continuously place them in the top decile of the ECI ranking, the countries with lower ECI rankings like Greece (0.25) or Bulgaria (0.62) are closer to the fifth decile.

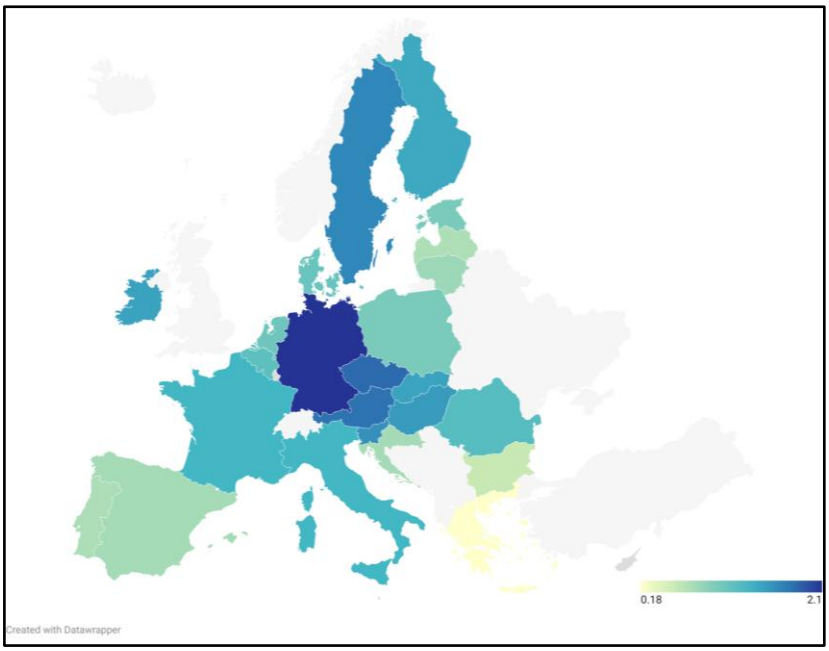

Figure 3 - ECI of EU countries in 2020 (Atlas of Economic Complexity, 2024; author's own representation)

The positive relationship between economic development (Figure 4), here depicted by per capita income levels, and economic complexity, which is suggested by the literature, also holds for this sample.

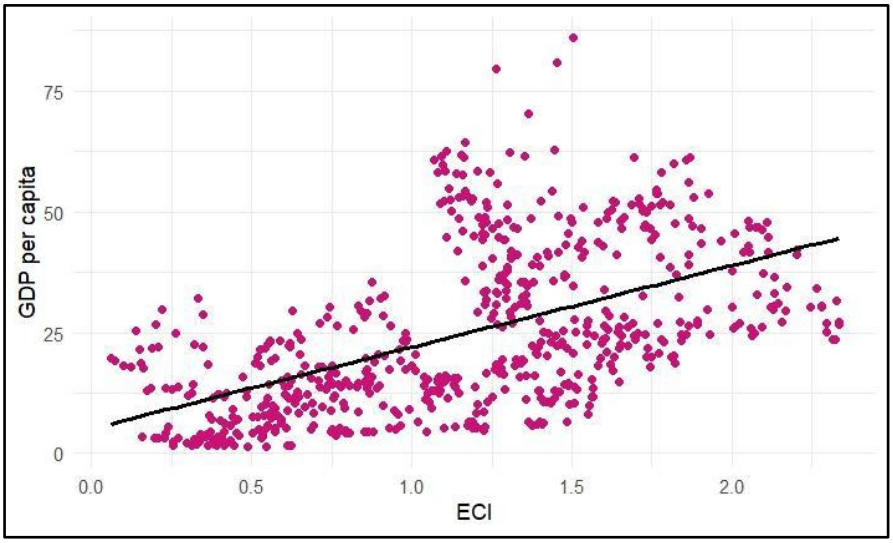

Figure 4 - GDP per capita and ECI of EU countries 1995 - 2020 (World Bank; Atlas of Economic Complexity; Author's own representation)

Similarly, in Figure 5, a positive correlation between the level of financial development and the ECI can be observed. This correlation already hints towards a positive relationship following the hypothesis.

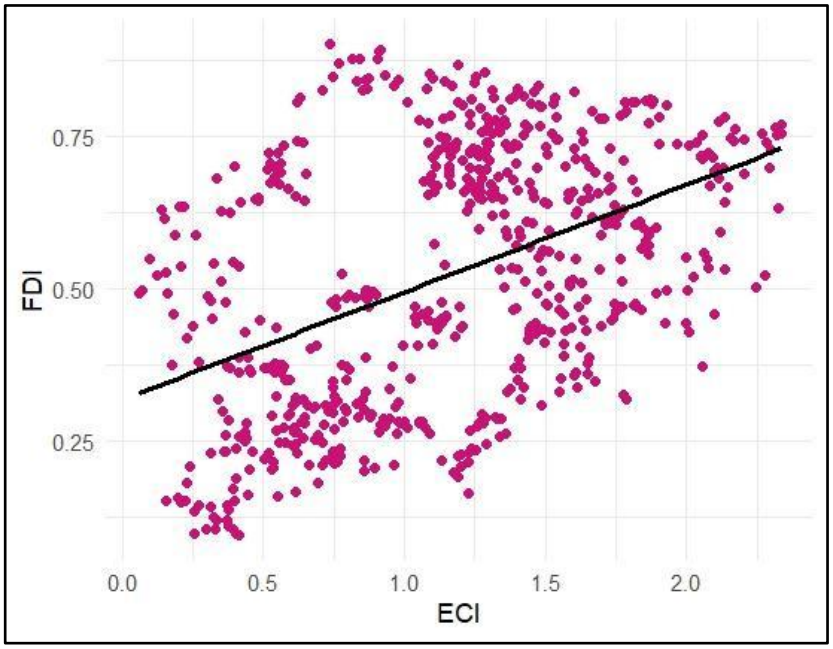

Figure 5 - Financial Development Index and ECI of EU countries 1995 - 2020 (IMF, Atlas of Economic Complexity; author's own representation)

Figure 6 represents the averages of indices within the EU over the years. The financial development indicators show a continuous increase until the late 2000s, then decrease slightly until 2020. This fall-off is most likely attributed to the aftermath of the global financial crisis of 2007/08, which induced a slight de-intensification of the European financial sector and a decline in banking sector profits (Schaefer et al., 2016).

The ECI remains relatively stable over time. This can be explained by the comparative nature of the index. As it places countries within a relative position, the metric, to an extent, is resistant to global recessionary trends, given these do not reshape the overall patterns of international trade. The average ECI of the EU is above 1.2 throughout the whole period, indicating that the 24 countries continuously resemble a very complex region in global comparison.

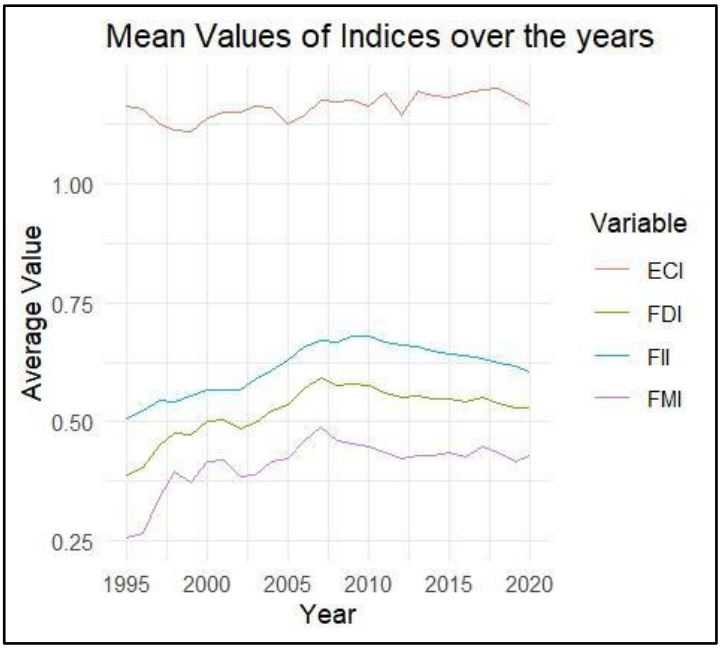

Figure 6 - Different averaged indices, 1995 - 2020 (IMF, Atlas of Economic Complexity; author's own representation)

6 Methodology and data

The influence that financial development has on economic complexity is estimated statistically. Taking inspiration from the studies of Lapatinas (2019) and Avom and Ndoya (2022), the model is formally defined as:

$$ECI_{t,c} = \beta_0 + \beta_1 ECI_{t-1,c} + \beta_2 DEV_{t,c} + X_{t,c} + \gamma_{t,c} + \mu_{t,c} + \epsilon_{t,c}$$

The *ECI* for country *c* in period *t* is the dependent variable, the lagged *ECI* is included as an auto-regressor to test for persistence within the index. *DEV* describes the vector including the nine different financial development indicators, resulting in nine iterative estimations in total. *X* is a vector of controls which were selected based on literature screening. Unobserved effects are captured in γ (country-specific) and μ (year-specific), ϵ is the idiosyncratic error term.

6.1 Data

This article draws from observations over the continuous period from 1996 to 2020, including 24 countries out of the EU27, with the three smallest countries by population omitted. To avoid obtaining skewed results due to the economic crises resulting from the COVID-19 pandemic and the geopolitical tensions from 2022 onwards, 2020 is chosen as the cut-off year. In addition to the auto-regressor and the financial development indicators, there are a total of seven control variables used, which are tested for having a significant influence on economic complexity. Derived from Hausmann et al. (2007), three variables are assumed. Firstly, the population density serves as a measurement for the labour force size and the demographic structure of a country. Secondly, the level of economic development is measured by GDP per capita. Thirdly, to measure the labour force's competence, the average years spent in education are used.

Additional controls are taken from Nguyen et al. (2020), who look at trade openness and the foreign direct investment (FDI) net inflows to test for the influence of cross-border investment activities. Furthermore, the government expenditure (final consumption expenditure) is also included to control for public investments and institutional infrastructure, with a positive effect expected. Thus, the model results in:

$$ECI_{t,c} = \beta_0 + \beta_1 ECI_{t-1,c} + \beta_2 DEV_{t,c} + \beta_3 GDPpc_{t,c} + \beta_4 POP_{t,c} + \beta_5 TOP_{t,c} + \beta_6 EDUC_{t,c} + \beta_7 GVEXP_{t,c} \beta_8 FDI_{t,c} + \gamma_{t,c} + \mu_{t,c} + \epsilon_{t,c}$$

6.2 Estimation method

The longitudinal structure of the data suggests several estimation methodologies. Many studies with similar settings employ the *System General Methods of Moments* (SGMM) after Arellano and Bover (1998). The benefit of the SGMM estimator lies in its ability to better handle potential endogeneity problems arising within independent variables and, therefore, constitutes a promising approach for populations in macroeconomic settings. However, it usually assumes a wider spread between the dimensions of longitudinal data sets. With the temporal dimension and the number of groupings being close together, this could limit the explanatory power through an overfitting of instruments, a common problem identified by Mehrhoff (2009). Therefore, a *Fixed Effects Panel Regression* estimation will alternatively be employed. The implementation of an Instrumental Variables estimator as used by, for example, Lapatinas (2019) proves problematic due to the multifaceted nature of the different financial development indicators and is therefore neglected.

To ensure the robustness of results several measures are undertaken, one of them being the already mentioned use of different estimation models. In addition, the analysis is also done in two sub-samples based on income classification. The income per capita for every EU country is averaged over the relevant period. The same is done with the threshold defined by

the World Bank annually that separates high-income and middle-income countries. This results in 7 countries classified as middle-income countries, as they are on average below this threshold and 17 countries classified as high-income countries[3]. Finally, two time periods will be tested, pre- and post-crisis of 2007/08.

7 Results

Table 2 shows the results for the fixed effects panel regression. Comparing the outcomes of all estimations, the most robust and significant results have been generated by this estimation method. The Arellano-Bover SGMM estimation reveals the suspected problem of overfitted instruments, which leads to reduced significance.

According to the estimations, the effect of **financial development on economic complexity is positive and statistically significant** (1), as suggested in the hypothesis. The coefficient states that a 1 per cent increase in financial development causes a 0.143 unit increase in the ECI. This positive effect is robust when including the control variables. The positive and significant effect of the lagged ECI suggests a strong persistence of the variable and the characteristic of state dependence. The expected positive effects of economic development and trade openness, as well as the expected adverse effects of FDI, are statistically significant. The effects of population density, education and government spending show the expected positive tendencies, but no statistical significance.

This could partially be a result of somewhat similar values of the respective controls within the sample, a notion supported by the inflated standard errors. The coefficients of all control variables remain consistent throughout the iterations of the regression in both values and significance, adding justification to their choice. While the positive effect of overall financial development is one of the main takeaways of the analysis, the different channels show mixed results. Overall financial institutions development (5), access (2) and efficiency (4), as well as financial markets depth (7) show significant positive effects on the ECI, while the remaining coefficients (3,6,8,9) lack statistical significance, yet are directional. In regard to transmission channels, the development of financial institutions seems to play a much more significant role in promoting economic complexity.

The regression analyses[4] for the middle-income (table A2) and high-income countries (table A3) are in line with the previously outlined dynamic. Middle-income countries show a more significant and stronger positive effect of financial development on economic complexity than high-income countries. This divergence in results suggests that a threshold exists, after which the causal effect of financial development diminishes and the relationship with economic complexity shows signs of non-linearity. This conclusion needs to be handled with care, given

[3] Compare the appendix A1 for a full representation of countries ranked by income per capita.

[4] For enhanced readability, the subset output tables are found in the appendix.

	Dependent variable:								
	Economic Complexity								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Lagged ECI	0.743***	0.737***	0.752***	0.753***	0.745***	0.749***	0.751***	0.767***	0.748***
	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)	(0.027)	(0.026)
FDI	0.143***								
	(0.053)								
FIAI		0.094***							
		(0.028)							
FIDI			0.052						
			(0.032)						
FIEI				0.123**					
				(0.059)					
FII					0.149***				
					(0.049)				
FMAI						-0.019			
						(0.018)			
FMDI							0.042*		
							(0.026)		
FMEI								0.002	
								(0.013)	
FMI									0.021
									(0.022)
GDPpc	0.300***	0.264***	0.303***	0.275***	0.258***	0.327***	0.302***	0.301***	0.332***
	(0.045)	(0.047)	(0.046)	(0.049)	(0.049)	(0.045)	(0.046)	(0.048)	(0.046)
Population	0.035	0.037	0.035	0.037	0.036	0.035	0.035	0.031	0.034
	(0.032)	(0.032)	(0.032)	(0.032)	(0.032)	(0.032)	(0.032)	(0.031)	(0.032)
Trade Openness	0.084***	0.081***	0.066**	0.069**	0.081***	0.055*	0.072**	0.064*	0.070**
	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)	(0.033)	(0.030)
Education	0.189	0.060	0.213	0.178	0.141	0.174	0.226	0.180	0.225
	(0.197)	(0.200)	(0.198)	(0.198)	(0.197)	(0.199)	(0.199)	(0.206)	(0.200)
Government Spending	0.230	0.073	0.111	0.094	0.106	0.065	0.095	0.212	0.149
	(0.236)	(0.228)	(0.231)	(0.230)	(0.229)	(0.230)	(0.230)	(0.269)	(0.243)
FDInvestment	-0.060**	-0.067**	-0.061**	-0.062**	-0.062**	-0.063**	-0.062**	-0.071**	-0.063**
	(0.028)	(0.028)	(0.028)	(0.028)	(0.028)	(0.028)	(0.028)	(0.028)	(0.028)
Observations	600	600	600	600	600	600	600	525	600
R^2	0.835	0.836	0.833	0.834	0.835	0.833	0.833	0.818	0.833
Adjusted R^2	0.818	0.819	0.816	0.817	0.819	0.816	0.816	0.798	0.816
Note:									*p<0.1; **p<0.05; ***p<0.01

Table 2 - Fixed effects regression analysis results for all nine financial development indices (author's representation)

the rather small set of countries. The second set of subsets distinguishes between pre-crisis (table A4) and post-crisis (table A5), with the immediate years following the crisis' outbreak omitted. Here, the pre-crisis analysis shows higher statistical significance and a more substantial effect of the different financial development indicators on economic complexity. This suggests a diminishing effect of financial development due to the restructuring of EU financial markets, which includes new and stricter regulations and overall economic turbulence.

8 Discussion

This section assesses the outcome of this article regarding three different aspects. Firstly, based on the empirical estimations and the identified dynamics, policy implications are discussed. Secondly, the limitations of the methodological approach are addressed in conjunction with a critical view of the financial development literature. Finally, the analysis is evaluated in terms of replicability and potential application and integration into further research.

8.1 Policy implications

From the perspective of policymakers, to coherently understand the implications of a causal relationship from financial development to economic complexity, two important questions need to be answered.

What are the incentives/benefits to increase one's ECI through a boost of financial development?

As previously outlined, the level of economic complexity is positively associated with a higher level of economic growth and wealth. In addition, positive effects on ecological factors such as GHG emissions have also been found. All these findings are robust and have been proven to apply to a heterogeneous variety of country samples. Thus, increasing economic complexity is generally in the interest of most countries. How to industrially upgrade is one of the major issues which research on economic complexity revolves around. Having identified financial development as one of these drivers thus proposes one specific pathway through which this goal can be achieved. On the most general level, the policy implication derived from this analysis is that EU countries should aim to promote the development of their financial sector, as it leads to an increase in economic complexity, which then boosts economic performance. This also holds true when taking into account potential macroeconomic externalities. Empirical literature does not suggest a rebound effect or deterioration of macroeconomic variables resulting from higher financial development — that is, for middle- and most high-income countries, which corresponds to this specific data set. Accordingly,

there are no conflicting incentives which put an increase in economic complexity and in financial development against one another.

However, when talking about country-specific recommendations, one needs to take into account the notion of non-linearity in the relationship between financial development and economic complexity. This relationship is explored in this first rudimentary additional analysis. This potential non-linearity is expressed as follows: the causal effect is relatively lower for low-income countries, becomes much stronger for middle- and high-income countries, but diminishes after reaching a certain threshold of financial and economic development. Some of the EU countries represent countries at the top of the global ranking in terms of financial and/or economic development. If the assumption of a threshold, after which the effect of an increase in financial development diminishes, holds, then this has important implications for the decision-making process around financial policies for the highest developed countries. Identifying an indicator for this threshold would be necessary to determine the extent to which countries should focus on increasing their level of financial development. For this, more research is necessary to confirm the validity of this assumption in general and find out more specific approaches to measuring it.

What are the practical approaches and concepts of policy strategies in that regard?

It is important to go beyond a general policy recommendation and instead focus on concrete proposals and strategies. It is difficult to draft a *one-size-fits-all* policy proposition in that regard, since the particularities and legal prerequisites of each country make for an uncommon ground. Fostering the specific transmission channels will also have a positive impact on overall financial development and thus stimulate economic complexity. The results suggest placing a stronger focus on the financial institution channels, as they exhibited more substantial causation, particularly in terms of access and efficiency. By facilitating the accessibility of financial institutions, the financial sector becomes more inclusive. A relatively recent subfield of financial development literature deals with the phenomenon of financial inclusion. It positively links it to financial development and economic performance, defining *"[...] financial inclusion [...] as a process that ensures the ease of access, availability, and usage of the formal financial system for all members of an economy"* (Sarma, 2016:p.4). Diving deeper into this literature could yield concrete suggestions on regulative strategies. Ozili (2021) identifies three main approaches that make financial sectors more accessible: increasing financial literacy, focusing on financial innovation and technological change and interventive policies that allocate and redistribute capital towards firms, promoting the first two channels. Further research within this field, tailored to the specific financial sector landscape of the respective legislature, is recommended to develop specific policy strategies that would prove adequate.

Increasing the efficiency of the financial sector is an intricate endeavour. It is not advisable to express concrete measures, but rather to be vigilant about including the goal of efficiency increases in the design process of policy instruments. Additionally, much of the financial institutions' profitability comes from market dynamics, and therefore targeting it through regulatory strategies may entail multilayered and complex hurdles. Exemplary studies find that strategic market consolidation and targeted mergers and acquisitions of financial institutions can have a positive impact on the efficiency of the financial sector (Amel et al., 2004). Other literature suggests the importance of addressing cost efficiency (Esho, 2001) or monetary and price policy (Chodorow-Reich, 2014).

To summarise, while policies, strategies and regulations in that regard can look widely different, European decision makers are generally well advised to accelerate financial development in order to capitalise on the increase of economic complexity. Also, country-specific analysis on the interplay between the two phenomena would prove helpful to identify every economy's perspective.

8.2 A critical assessment of the financial development framework

The academic field of financial development, primarily represented by Svirydzenka (2016), needs to be addressed from a critical perspective. Including a macroeconomic systemic property into a quantitative analysis by nature will involve some challenges. It encompasses a multitude of actors, institutions, rules, and structural differences among different economies, which alone already account for an intricate system of information to consider. Further, given the discrepancy in findings, the conclusion becomes more delicate, as one needs to manoeuvre through these impasses. With the most significant share of the financial development literature revolving around the interconnection with economic growth, there are several contesting views. This goes beyond the already described difference between low and high-income countries. While within this article, financial development is regarded as a preceding factor, both to economic growth and economic complexity, some scholars see financial development less of a driving force and more of a multicausal phenomenon which is subject to continuous interaction and interlinkages with other macroeconomic and systemic factors (Reid, 2010). The field of financial development also exhibits a variety of quantitative approaches in measuring certain aspects, exposures and characteristics within the sector. Navigating through this multitude of concepts proves challenging, and selecting the most adequate theoretical framework depends on several factors. Finally, one may also argue that financial development as a field of research should focus less on the creation of indices and metrics, due to the heterogeneity of economic systems, the ambiguity of approaches and the discrepancy in outcomes. Instead, it could focus more on the structural and institutional factors surrounding this phenomenon and provide a rather qualitative or descriptive characterisation.

All these different lines of thought need to be incorporated into further research on financial development. The application of the issue in the context of, e.g., economic complexity, can only benefit from a deeper understanding of the field.

Finally, the model itself, which has been employed, needs to be addressed. The statistical analysis provides a first glimpse at the causal relationship between financial development and economic complexity, yet to strengthen these arguments, several adjustments are proposed.

Firstly, the sample base should be expanded to include as many countries as possible. Not only would this increase insight and validity in general, but it would also provide more valuable findings for generalised conclusions. Furthermore, it would make the implementation of an SGMM estimation more feasible. Alternatively, extensive work on the quantitative financial development framework could allow for the employment of instrumental variables, which would also address potential endogeneity beyond the standardised tests. Secondly, with a bigger sample size, the expected non-linearity could manifest itself more clearly, arguably suggesting a methodological rethinking overall.

9 Conclusion

This article aims to add to the growing field of literature around the economic complexity framework by Hidalgo and Hausmann (2009) and the question of what determines the ECI of a country. In order to create novelty and cater to another highly relevant field in research, the interplay between financial development and economic complexity has been explored. To answer the question of how a country's economic complexity is influenced by its level of financial development, the conceptual foundations of the economic complexity framework are presented. Here, the focus lies on the role of productive knowledge as the determinant of a country's productive structure and how the diversity and ubiquity of products are used to derive the important metric of the ECI. In a comprehensive literature review, the different fields in which complexity is applied are listed. The core of research deals either with the predictive nature of economic complexity as a driver for other socioeconomic phenomena or investigates factors through which economic complexity is driven. The latter area of application exhibits a research gap that revolves around financial economics, which leads to the implementation of financial development as a macroeconomic property into the analysis. Section 4 first introduces the concept of financial development on a theoretical level and then illustrates the framework by Svirydzenka (2016) to measure a country's level of financial development in a multidimensional model. Several stylised facts provide more context and elaborate on the choice of the EU as a country sample for the analysis.

By integrating these frameworks, a statistical model is carefully constructed to examine the causal link between financial development and the ECI. To ensure robust results,

adequate controls and model specifications are chosen, including the splitting of the EU countries into two sub-groups based on income and accounting for the financial crisis of 2007/08.

In conclusion, this article finds a significant and direct impact of financial development on economic complexity within the EU. This effect is stronger for the financial institutions channels compared to the financial markets channels, and weaker for high-income countries compared to middle-income countries. With these outcomes, this article makes several important contributions to the academic debate. Firstly, by identifying the causality from financial development to economic complexity, a foundation for policy decision-making is established. Secondly, by successfully integrating the financial development framework by Svirydzenka (2016) into the analysis, a methodological approach is presented which, supplemented with additional quantitative research, could develop into a more extensive complexity-financial development nexus. Thirdly, by hinting towards first signs of non-linearity in the causal relationship, a cautious approach to future quantitative work and the consideration of this phenomenon when discussing the implications of financial development and economic complexity is stressed.

These different contributions all emphasise what is most important: further research. Economic complexity represents a versatile field which continuously grows and presents new findings in conjunction with many different subjects. By further exploring the intersection between economic complexity and financial development, through refined methodology, expanded data populations or alternative frameworks, not only will this specific sub-field grow, but there will most likely be spillover effects to other research focused on applied economic complexity.

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10 Appendix

10.1 Countries by income per capita

Rank	Country	GDP per capita in EUR
1	Ireland	49956
2	Denmark	49935
3	Sweden	45923
4	Netherlands	43112
5	Austria	40749
6	Finland	40243
7	Belgium	38032
8	Germany	37761
9	France	35127
10	Italy	30696
11	Spain	25089
12	Greece	20002
13	Slovenia	19411
14	Portugal	18718
15	Czech Republic	15455
16	Slovakia	13354
17	Estonia	13330
μ	**Average threshold**	**11181**
18	Hungary	11107
19	Croatia	10983
20	Lithuania	10764
21	Latvia	10443
22	Poland	10036
23	Romania	6808
24	Bulgaria	5649

Table A1: Average GDP per capita in EUR from 1996 - 2020

Source: World Bank, author's own representation

10.2 Regression Output for subsets

	Dependent variable:								
	Economic Complexity								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Lagged ECI	0.750***	0.760***	0.808***	0.801***	0.771***	0.793***	0.781***	0.840***	0.791***
	(0.053)	(0.053)	(0.051)	(0.050)	(0.050)	(0.051)	(0.052)	(0.060)	(0.053)
FDI	0.220**								
	(0.087)								
FIAI		0.110**							
		(0.048)							
FIDI			0.109*						
			(0.060)						
FIEI				0.225**					
				(0.104)					
FII					0.245***				
					(0.086)				
FMAI						-0.038			
						(0.037)			
FMDI							-0.076		
							(0.054)		
FMEI								-0.012	
								(0.035)	
FMI									0.021
									(0.037)
GDPpc	0.129	0.063	0.222*	0.103	0.037	0.257**	0.261**	0.135	0.263**
	(0.126)	(0.141)	(0.119)	(0.134)	(0.137)	(0.120)	(0.120)	(0.169)	(0.126)
Population	-0.269	-0.527	0.088	0.108	-0.574	0.262	0.116	-0.365	0.290
	(0.639)	(0.695)	(0.618)	(0.612)	(0.667)	(0.616)	(0.622)	(1.315)	(0.622)
Trade Openness	0.124*	0.107	0.090	0.099	0.133*	0.054	0.059	-0.011	0.075
	(0.072)	(0.070)	(0.070)	(0.070)	(0.071)	(0.069)	(0.068)	(0.094)	(0.072)
Education	0.036	0.099	0.805	0.120	0.116	0.396	0.402	-0.554	0.550
	(0.757)	(0.757)	(0.761)	(0.759)	(0.742)	(0.755)	(0.749)	(1.101)	(0.755)
Government Spending	0.581	0.130	0.249	0.255	0.272	0.110	0.138	-0.057	0.206
	(0.453)	(0.411)	(0.423)	(0.419)	(0.412)	(0.418)	(0.417)	(0.611)	(0.464)
FDInvestment	-0.094*	-0.108**	-0.092*	-0.099**	-0.102**	-0.100**	-0.103**	-0.126**	-0.099*
	(0.049)	(0.049)	(0.049)	(0.049)	(0.048)	(0.050)	(0.050)	(0.053)	(0.050)
Observations	175	175	175	175	175	175	175	125	175
R^2	0.713	0.710	0.706	0.709	0.716	0.701	0.703	0.746	0.700
Adjusted R^2	0.632	0.630	0.624	0.628	0.637	0.618	0.621	0.642	0.616
Note:									*p<0.1; **p<0.05; ***p<0.01

Table A2: Fixed Effects regression results for middle income EU countries(author's own representation)

	Dependent variable:								
	Economic Complexity								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Lagged ECI	0.721***	0.718***	0.716***	0.719***	0.723***	0.717***	0.711***	0.709***	0.723***
	(0.034)	(0.034)	(0.034)	(0.034)	(0.034)	(0.034)	(0.034)	(0.035)	(0.034)
FDI	-0.034								
	(0.087)								
FIAI		0.096*							
		(0.053)							
FIDI			-0.091*						
			(0.051)						
FIEI				0.062					
				(0.075)					
FII					0.005				
					(0.082)				
FMAI						-0.031			
						(0.021)			
FMDI							0.067**		
							(0.032)		
FMEI								-0.004	
								(0.014)	
FMI									0.002
									(0.031)
GDPpc	0.335***	0.314***	0.338***	0.317***	0.330***	0.331***	0.332***	0.183**	0.331***
	(0.067)	(0.067)	(0.066)	(0.069)	(0.068)	(0.066)	(0.066)	(0.079)	(0.067)
Population	0.020	0.022	0.021	0.021	0.020	0.022	0.019	0.027	0.020
	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)
Trade Openness	0.062**	0.075**	0.067**	0.065**	0.065**	0.051	0.082***	0.126***	0.065**
	(0.031)	(0.031)	(0.030)	(0.030)	(0.031)	(0.032)	(0.031)	(0.038)	(0.032)
Education	0.248	0.101	0.253	0.243	0.239	0.215	0.297	0.422**	0.242
	(0.204)	(0.216)	(0.202)	(0.203)	(0.206)	(0.203)	(0.204)	(0.212)	(0.204)
Government Spending	0.237	0.344	0.275	0.258	0.251	0.219	0.301	0.456	0.252
	(0.312)	(0.313)	(0.309)	(0.310)	(0.311)	(0.310)	(0.309)	(0.332)	(0.312)
FDInvestment	-0.051	-0.050	-0.056	-0.048	-0.049	-0.052	-0.045	-0.065*	-0.050
	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)
Observations	425	425	425	425	425	425	425	400	425
R^2	0.776	0.778	0.778	0.776	0.776	0.777	0.779	0.727	0.776
Adjusted R^2	0.747	0.750	0.749	0.748	0.747	0.749	0.750	0.691	0.747
Note:									*p<0.1; **p<0.05; ***p<0.01

Table A3: Fixed Effects regression results for high income EU countries(author's own representation)

	Dependent variable:								
	Economic Complexity								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Lagged ECI	0.649***	0.670***	0.677***	0.695***	0.689***	0.676***	0.674***	0.709***	0.655***
	(0.045)	(0.045)	(0.045)	(0.047)	(0.045)	(0.045)	(0.045)	(0.046)	(0.047)
FDI	0.240***								
	(0.085)								
FIAI		0.180**							
		(0.078)							
FIDI			0.101**						
			(0.045)						
FIEI				0.122					
				(0.082)					
FII					0.259***				
					(0.098)				
FMAI						0.008			
						(0.030)			
FMDI							0.025		
							(0.031)		
FMEI								-0.007	
								(0.017)	
FMI									0.043
									(0.032)
GDPpc	0.472***	0.375***	0.433***	0.405***	0.350***	0.474***	0.456***	0.476***	0.511***
	(0.071)	(0.083)	(0.074)	(0.085)	(0.085)	(0.072)	(0.075)	(0.085)	(0.077)
Population	0.047	0.047	0.047	0.049	0.046	0.049	0.049	0.045	0.049
	(0.031)	(0.031)	(0.031)	(0.032)	(0.031)	(0.032)	(0.032)	(0.030)	(0.032)
Trade Openness	0.190***	0.180***	0.162***	0.175***	0.169***	0.180***	0.181***	0.159***	0.195***
	(0.047)	(0.047)	(0.048)	(0.048)	(0.047)	(0.049)	(0.048)	(0.059)	(0.049)
Education	-0.289	-0.336	-0.301	-0.399	-0.282	-0.440	-0.405	-0.610	-0.370
	(0.363)	(0.363)	(0.366)	(0.364)	(0.364)	(0.365)	(0.367)	(0.388)	(0.367)
Government Spending	0.544	0.203	0.179	0.034	0.247	-0.014	-0.017	0.045	0.208
	(0.360)	(0.315)	(0.313)	(0.304)	(0.315)	(0.307)	(0.302)	(0.387)	(0.347)
FDInvestment	-0.010	0.002	-0.009	-0.009	0.009	-0.020	-0.020	-0.038	-0.022
	(0.053)	(0.054)	(0.053)	(0.054)	(0.054)	(0.054)	(0.054)	(0.053)	(0.054)
Observations	288	288	288	288	288	288	288	252	288
R^2	0.706	0.703	0.702	0.699	0.705	0.696	0.697	0.720	0.698
Adjusted R^2	0.655	0.652	0.651	0.647	0.654	0.644	0.645	0.668	0.647
Note:									*p<0.1; **p<0.05; ***p<0.01

Table A4: Fixed effects regression results for the time period 1996 - 2007 (Author's own representation)

	Dependent variable:								
	Economic Complexity								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Lagged ECI	0.721***	0.718***	0.716***	0.719***	0.723***	0.717***	0.711***	0.709***	0.723***
	(0.034)	(0.034)	(0.034)	(0.034)	(0.034)	(0.034)	(0.034)	(0.035)	(0.034)
FDI	-0.034								
	(0.087)								
FIAI		0.096*							
		(0.053)							
FIDI			-0.091*						
			(0.051)						
FIEI				0.062					
				(0.075)					
FII					0.005				
					(0.082)				
FMAI						-0.031			
						(0.021)			
FMDI							0.067**		
							(0.032)		
FMEI								-0.004	
								(0.014)	
FMI									0.002
									(0.031)
GDPpc	0.335***	0.314***	0.338***	0.317***	0.330***	0.331***	0.332***	0.183**	0.331***
	(0.067)	(0.067)	(0.066)	(0.069)	(0.068)	(0.066)	(0.066)	(0.079)	(0.067)
Population	0.020	0.022	0.021	0.021	0.020	0.022	0.019	0.027	0.020
	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)
Trade Openness	0.062**	0.075**	0.067**	0.065**	0.065**	0.051	0.082***	0.126***	0.065**
	(0.031)	(0.031)	(0.030)	(0.030)	(0.031)	(0.032)	(0.031)	(0.038)	(0.032)
Education	0.248	0.101	0.253	0.243	0.239	0.215	0.297	0.422**	0.242
	(0.204)	(0.216)	(0.202)	(0.203)	(0.206)	(0.203)	(0.204)	(0.212)	(0.204)
Government Spending	0.237	0.344	0.275	0.258	0.251	0.219	0.301	0.456	0.252
	(0.312)	(0.313)	(0.309)	(0.310)	(0.311)	(0.310)	(0.309)	(0.332)	(0.312)
FDInvestment	-0.051	-0.050	-0.056	-0.048	-0.049	-0.052	-0.045	-0.065*	-0.050
	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)
Observations	425	425	425	425	425	425	425	400	425
R^2	0.776	0.778	0.778	0.776	0.776	0.777	0.779	0.727	0.776
Adjusted R^2	0.747	0.750	0.749	0.748	0.747	0.749	0.750	0.691	0.747
Note:									*p<0.1; **p<0.05; ***p<0.01

Table A5: Fixed effects regression results for the time period 2010 - 2020 (Author's own representation)

Imprint

Editors:
Sigrid Betzelt, Eckhard Hein, Martina Metzger, Martina Sproll, Christina Teipen, Markus Wissen, Jennifer Pédussel Wu (lead editor), Reingard Zimmer

ISSN 1869-6406

Printed by
HWR Berlin

Berlin, August 2025