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# The Interplay between Digitalization, Education, and Financial Development: A European Case Study

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[†] The paper was produced when the author worked at the Bank of England. However, any views expressed in this paper are solely of the author's and cannot be taken to represent those of the Bank of England or to state Bank of England policy. This paper should therefore not be reported as representing the views of the Bank of England.

**Abstract:** The paper explores the relationship between education, digitalization, and financial development between 1996 and 2019 with the aim of showcasing the differences between developed and emerging economies in Europe. We use a Bayesian VAR framework that includes variables related to education, digitalization, and financial development, as well as several endogenous variables to control for differences between countries in terms of nominal GDP growth, unemployment rate, and trade openness. Our findings clearly demonstrate the dynamic interdependence between financial development—including its two main components, financial institutions, and financial markets, digitalization, and education. Furthermore, we find that education is a leading variable in the financial development–education–digitalization nexus, whereas financial development and digitalization are laggard variables. These findings open possibilities for influencing joint policies on digitalization, education, and financial development, particularly in emerging European countries.

**Keywords:** financial development; financial institutions; financial markets; education; digitalization; dynamic interdependence; Bayesian VAR; impulse response

## 1. Introduction

Digitalization has grown rapidly over the last few decades. According to the World Bank (2021), only 4.6% of the world's population used the internet in 1999, compared to 25.5% in 2009 and 56.7% in 2019. Furthermore, there were 8.1 mobile cellular subscriptions per 100 people in 1999, compared to 67.5 per 100 people in 2009, while in 2019, on average, every person had more than one mobile cellular subscription (109.5 per 100 people).

However, digitalization emerged at different speeds across the world. Developed countries started rapidly adopting new technologies as early as the beginning of the century, while emerging economies have been rapidly catching up in recent years. For example, in Europe, according to the European Commission (2021), a clear gap has been observed between the Western, more developed, and Eastern, emerging, countries. In 2021, and in line with previous years, Denmark, Finland, and Sweden have been ranked the EU countries with the most advanced digital economies, with Romania and Bulgaria at the opposite end of the spectrum. This held true across nearly all four dimensions captured by DESI—human capital, connectivity, integration of digital technology, and digital public services.

Despite the growing number of people participating in the digital world by using new technologies, Donou-Adonsou (2019) argues that appropriate levels of education are required to achieve the full benefits of a digital economy. There is a long-standing debate in

literature on the relationship between education, digitalization, and economic growth, the latter of which is different from financial development. For example, Habibi and Zabardast (2020) provides evidence from OECD countries that improvements in technology can lead to economic growth, and that education can improve the outcome of individuals. Jepsen and Drahokoupil (2017) provide an alternative opinion, that digitalization could have a negative impact on economic growth because digitalization could first replace unskilled, repetitive, jobs, which tend to be more abundant in emerging economies. Thus, depending on countries' income levels, technological innovation could have an inconsistent impact on economic growth. Furthermore, Stiglitz and Greenwald (2015) discussed at length how technology innovation, rather than capital accumulation, leads to better standards of living. Further, improving information transparency and improving the levels of education greatly increases economic growth.

The causal relationship between financial development and economic growth is still debated in the literature. For example, McKinnon (1973), Galbis (1977), Mathieson (1980), and Balassa (1990) argue that a "liberalized" financial system will increase savings and distribute money to more productive uses, hence increasing economic growth. This liberal outlook inspired the IMF and World Bank in the early 1900s (Luintel and Khan 1999). Several writers have shown that financial intermediaries can aid economic growth by improving resource allocation and monitoring (Diamond 1984; Bose and Cothren 1996; Morales 2003; Levine 2005). However, others question the role of finance in economic growth. Financial markets develop once the economy reaches an intermediate stage of expansion, according to Kuznets (1955), while Lucas (1988) believes financial matters are over-emphasized when discussing economic growth. Thus, finance becomes the handmaiden of business, responding to increased demand for financial services as the economy expands. The relationship between financial development and economic growth is a two-way street, according to Lewis (1954) and Patrick (1966). This latter author defined the supply leading (financial development causes economic growth) and demand following (economic growth causes financial development) processes as bi-directional. It should also be mentioned that several endogenous growth models highlight the link between financial development and economic growth (Berthélemy and Varoudakis 1995; Greenwood and Smith 1997).

However, we find that the link of education and technological development to financial development, which is different, from economic growth, albeit connected, has not been adequately explored, and our paper is aiming to fill this gap in two ways. First, it adds to the scarce body of European literature on education and financial development. Second, to the best of our knowledge, there has been no comprehensive study to date exploring the link financial development has with education and digitalization. Where available, existing literature has instead focused on the impact from economic growth, financial inclusion, or human development. Our paper aims to fill this gap.

Our main research hypothesis postulates that there is a strong link between education, digitalization, and financial development in Europe. Our secondary research hypothesis proposes that there are relevant geographical differences between the Western, more developed, and Eastern, emerging, economies. While developed countries are nearing their full potential regarding digitalization levels, education, and financial development, emerging countries still have a significant growth potential. Many emerging European countries have seen high levels of digitalization in recent years, but less progress has been made regarding the levels of education and financial development. This emphasizes the relevance of our research, as our findings clearly demonstrate the dynamic interaction between financial development—including its two main components, financial institutions and financial markets, digitalization, and education, but also that education is a leading variable in the financial development–education–digitalization nexus, whereas financial development and digitalization are laggard variables. These findings provide avenues to influence policies on digitalization, education, and financial development, particularly in emerging European countries.

The next section discusses in turn the links between digitalization, financial development, and education, as they appear in existing literature. The rest of the paper is structured as follows. Section 3 discusses the data and methodology used in our analysis, including any limitations. Section 4 presents the results of our model and Section 5 discusses these results and their implication on our research hypotheses. Finally, the last section highlights the main conclusions and presents avenues for future research.

## 2. Theoretical and Empirical Background

According to Beck et al. (2007), one can expect healthy economic systems to also exhibit higher levels of financial development. Financial development, as defined by Levine (1997), is the process of increasing the quantity, quality, and efficiency of financial markets and institutions. According to Levine (2005), larger and more efficient financial markets reduce transaction and information costs by improving the availability of financial instruments and institutions. This is also the three-pronged view adopted by the International Monetary Fund that resulted in the family of financial development indexes that we will make use of in our paper (Svirydzenka 2016), which sees financial development as depending on the size and liquidity of financial markets (the depth component), the individuals' and companies' ability to access financial services (the access component), and the ability of institutions to offer low-cost financial services, with sustainable revenues, and capital market activity (the efficiency component).

Owusu-Agyei et al. (2020) argue that existing literature has largely ignored the positive impact financial development could have on economic growth, especially as it relates to emerging countries. Tsaurai (2018) explores the importance of the financial sector and finds that financial development, coupled with education expenditure, can reduce poverty and foster economic growth. According to Demirguc-Kunt et al. (2018), global financial inclusion has improved during the last decade, with more than 1.2 billion adults accessing financial services since 2011. Although the progress is encouraging, in 2017 nearly a third of all adults (1.7 billion) did not have access to financial services. In Europe, according to Meskoub (2018), some of the causes of financial exclusion include high unemployment, high cost of accessing financial services, low levels of income, as well as insufficient education.

### 2.1. Digitalization and Financial Development

The link between digitalization and economic growth has been established for at least 60 years, when Solow (1956) noted that rising incomes should largely be attributed to technological progress rather than to capital accumulations. However, the link between financial development, which is an important channel towards economic growth, and digitalization has been less widely explored, particularly in emerging economies. Nevertheless, Owusu-Agyei et al. (2020) present evidence that a positive relationship exists between the use of internet and financial development. Further, Stiglitz (2003) discusses how digitalization could reduce information asymmetries with positive implications for financial development.

Indeed, the financial sector has persistently been reshaped by innovations in technology (financial technology, or fintech). Feyen et al. (2021) argue that digitalization has not only reduced transaction costs, but also given rise to innovative business models. Furthermore, fintech has been fostering financial inclusion by maximizing economies of scale, allowing for bespoke financial services, as well as increasing the overall speed and security of individual transactions.

There is a growing body of evidence on how fintech has helped increase access to financial services, thus improving financial development. For example, Sy et al. (2019) provide evidence from Sub-Saharan African Countries, Berkmen et al. (2019) from Latin America, and Loukoianova et al. (2019) from the Pacific Island Countries. Furthermore, Khera et al. (2021) note that some of the key drivers for improving financial development are represented by the quality of financial institutions as well as the levels of financial and digital education. Finally, Bayar et al. (2021) analyze the linkages between digitalization

and financial inclusion in EU post-communist countries and conclude that mobile cellular subscriptions can positively influence economic and financial development.

### 2.2. Education and Digitalization

Although digitalization has been thoroughly researched over the years, its link to education has only just started being explored, in part due to education data limitations. Although data are available regarding years of schooling, more granular historic data sets are sporadic. According to the World Bank (2021), global digitalization has been accelerating. In Europe, according to European Commission (2021) and consistent with the European Investment Bank (2021), some countries have been leading the digital transformation (e.g., Denmark and Finland), while others have been lagging (e.g., Romania and Bulgaria). However, McKinsey argued that Central and Eastern European countries, including Romania and Bulgaria, can be considered "digital challengers", and forecasted a EUR 200 million rise in their GDP by 2025 due to their strong digital economy growth potential (Novak et al. 2018).

As of 2019, the World Bank (2021) estimated that nearly 57% of the population used the Internet, while on average everyone had more than one mobile cellular subscription (approximately 109.5 people out of every 100). According to the European Commission (2021), the COVID-19 pandemic has significantly impacted both the EU's society and economy. Further, European Investment Bank (2021) data showed that digital firms were more productive, employed more skilled workers, and had more employment growth opportunities.

To fully benefit from an increasingly digital society, existing literature argues that it is no longer enough to simply have an internet connection. Citizens must also acquire a good level of education and develop relevant digital skills. Donou-Adonsou (2019) establishes a clear link between education and digitalization, and argues that education (or lack thereof) could be one of the main reasons why many developing countries are not fully benefitting from the promise of digitalization. For example, to pay bills online, not only do buyers need to have a suitable device and a reliable internet connection, but vendors also need to develop and maintain an appropriate online billing solution. Furthermore, Jepsen and Drahokoupil (2017) present evidence that Central and Eastern European (CEE) countries are likely to be affected differently by digitalization than more developed countries. This is because more than a third of the workforce in the region tends to perform routine tasks, which are more likely to be automated, and thus replaced, in the short-term. This further highlights the need for suitable education to retrain the workforce and prepare it for an increasingly digital world. Our paper aims to further evidence the relationship between education and digitalization in Europe.

### 2.3. Financial Development and Education

The link between financial development and education has been less widely researched, with most of the existing literature focusing instead on the link between education and either economic growth or human development. Financial development occurs when financial institutions reduce the cost and improve the quality of key financial services.

Hanushek and Wößmann (2010) establish a clear link between education and economic growth, concluding that people's skills strongly influence economic growth. Adding openness to international trade, as a proxy for economic institutions, to the model has a positive impact on economic growth. Furthermore, the effect of education on growth is observed to be higher in countries more open to international trade. Whilst these findings are highly relevant for policymakers, they also provide very initial insights into the link between education and financial development, which we further develop in this paper.

A large body of evidence, including Levine (2005), Beck et al. (2010), and Čihák et al. (2012), suggests that, subject to sufficient levels of education, financial development could play a significant role in economic development and growth. This is achieved through facilitating savings, increasing the transparency and accessibility of financial products, improving the quality of information, as well as through the optimization of capital allocation.

Furthermore, Benos and Zotou (2014) argue that education increases the human capital, which could lead to an overall improvement in economic growth. For example, good levels of education can increase the availability of well-qualified professionals able to efficiently run government services and businesses alike. Although direct investments in the economy could potentially generate higher growth, education remains an important accelerator of economic growth. Even though these findings are not specifically related to financial development, but to broader economic growth, they remain relevant for our research.

Hogarth (2006) argues that consumers who benefitted from financial education tend to make better personal financial decisions that increase their economic well-being, with positive implications for broader economic development. However, Hu et al. (2020) and Popov and Rocholl (2018) present evidence that financial development might in fact hinder the educational development of children by alluring parents to pursue additional paid employment opportunities, which would result in less time spent parenting, especially in the absence of good alternatives to effective childcare.

## 3. Materials and Methods

### 3.1. Methodology

Our investigation of the dynamics and interaction shocks between financial development, education, and digitalization is implemented with the use of the Bayesian Panel VAR methodology, which is justified by our research question on the simultaneous influence of these variables on each other. The foundation of our undertaking is the Vector Autoregressive model (VAR), introduced by Sims (1972, 1980), which describes the linear interdependencies between variables over time. Although simple in formulation, these models are widely used in economics and finance, given their ability to capture the dynamic interdependencies between time series, as well as autocorrelation patterns (Canova 1995; Brandt and Williams 2006; Woźniak 2016).

The general form of VAR models is

$$Y_t = \alpha + \beta_1 Y_{t-1} + \cdots + \beta_k Y_{t-k} + \varepsilon_t \tag{1}$$

where $\alpha$ is an *N*-vector that denotes the constant of the model, the autoregressive coefficients $\beta_1$ to $\beta_k$ are in an $N \times N$ dimension matrix, and $\varepsilon_t$ is the error term, where $\varepsilon_t \sim N_N(0, \in)$—normally distributed with a mean of zero and a covariance matrix $\in$. This simple specification of the model was the core of various improvements in VAR models, such as Structural VARs (Amisano and Giannini 2012), Vector Autoregressive Moving Average Models (Lütkepohl and Poskitt 1996; Athanasopoulos and Vahid 2008), and Dynamic Stochastic General Equilibrium (DSGE) Models (Giacomini 2013; Giacomini and Rossi 2016).

Due to its informed use of the elements included in the model, such as a superior ability to consider the statistical properties of the data (Woźniak 2016; Ejemeyovwi et al. 2021), Bayesian VAR models became popular after the publication of the seminal papers of Doan et al. (1984) and Litterman (1986) and, more recently, Sims and Uhlig (1991), Uhlig (1994), and Sims and Zha (1998). These papers have shown how the Bayesian theorem can be applied to traditional VAR models to solve the limitations of unrestricted models to explore dynamic phenomena through the now established method of parameter shrinkage (restrictions imposed on parameters to reduce the parameter set), which improves the models' forecasting accuracy. Moreover, Bayesian models can be used with many variables, thus addressing the issue of over-parametrization, and the inference of the VAR parameters is not affected by the inclusion in the model of non-stationary variables. Canova and Ciccarelli (2013) have also pointed out that Bayesian VAR models can be better suited than unrestricted VARs to investigate dynamic interdependencies between variables in a panel framework, when a cross-sectional dimension is added, thus making them strong instruments for tackling policy issues. This is also the main argument behind the use of the BVAR model in our research, notwithstanding addressing the over-parametrization issue. Moreover, as shown in the Results section, the BVAR can handle non-stationary variables, unlike the unrestricted VAR.

Bayesian econometrics treat each parameter as a random variable characterized by a specific probability distribution, and for the BVAR model to be implemented, these distributions need to be defined. Hence, the probability distribution is obtained by combining a priori information with the information included in the data, which leads to a distribution that considers both types of information. We have used the Normal–Wishart distribution for our model, which is argued to offer a better performance of the model compared to other priors (Kadiyala and Karlsson 1997; Uhlig 2005). The a posteriori distribution is based on the probability density function of the data conditioned by the model parameters and a common distribution of the model parameters.

The BPVAR model used in this study is the following:

$$Y_{it} = A_{it} + B_{it}Y_{it-1} + \varepsilon_{it} \tag{2}$$

where $Y_{it}$ is a vector of endogenous variables that designate financial development, education, digitalization, and several control variables, $t = 1, \ldots , 24$, and $i = 1, \ldots , 32$, as further explained in Section 2.2. $A_{it}$ is a vector of individual countries' intercepts, $B_{it}$ is a matrix of the 1-lag polynomials, and the residual term $\varepsilon_{it}$ is a vector of error terms with a variance ($\sigma_i^2$) for each country, serially uncorrelated for each country and following a normal distribution. Based on the Schwarz Bayesian Information Criterion, we have included one lag in the estimation of the BPVAR. The a posteriori distribution is derived from Gibbs sampling with 5000 iterations and a burn-in sample of 1000 iterations.

### 3.2. Data and Data Sources

Our study covers 32 European countries, of which 27 are current members of the European Union (Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, and Sweden), 2 are European Economic Area Members (Iceland and Norway), and 3 other European countries (Switzerland, Russian Federation, and the United Kingdom—EU member during the timeframe of our research). These countries can be included in two main groups, Western and Eastern, based on their geographical location but also on their joining of the European Union and European Economic Area. Thus, all countries that joined the EU and EEA after 2004 are considered Eastern economies, jointly with Russia, while the other countries are included in the Western category, together with Switzerland and United Kingdom. We originally intended to include all European countries in our analysis, but significant data gaps prevented us from doing so.

The period of investigation is 1996 to 2019, with annual frequency of observations for each variable, selected based on data availability. Given a total number of 32 countries and 23 annual observations per country, our Bayesian VAR data panel includes 736 observations, 23 per each country. All variables have been included in the BPVAR model in the form of difference of their natural logarithms, thus ensuring the stationarity property of variables. Table 1 shows the description of the variables and the corresponding data sources.

The variables were chosen based on existing literature on financial development in relation to digitization and education, as mentioned in the Introduction, as well as economic rationale. Extant literature has used many proxies for financial development for a long time without agreeing on the ideal choice, usually considering banking system attributes and capital market characteristics, depending on the research scope and objectives (see, in this respect, King and Levine 1993; Kim and Lin 2011; Sehrawat and Giri 2015; Bist 2018; Bayar et al. 2021; Cheng et al. 2021; Mignamissi 2021, among many others). The acknowledgment by the International Monetary Fund (IMF) of the need to incorporate in the assessment of financial development the diversity of financial systems across countries, first evidenced by Čihák et al. (2012) and further by Sahay et al. (Sahay et al.) led to a comprehensive set of financial development measures in the form of indexes using the methodology proposed by Svirydzenka (2016). The primary benefit of these indices is their multi-dimensional approach to financial development, which is defined by a combination

of financial institutions and market depth, access, and efficiency. Since the IMF calculated and published them, various authors who studied financial development have resorted to them and used them in their studies—see, for example, Laktionova et al. (2021), Islam et al. (2020), Mignamissi (2021), Ejemeyovwi et al. (2021), Nguyen and Su (2021), and Baloch et al. (2021). Of these indexes, we have alternatively used in the model the broader Financial Development Index (FDI), but also its two main components—Financial Institutions Index (FII) and Financial Markets Index (FMI)—each capturing financial institutions and markets particularities. Appendix A provides a brief description of these indexes.

**Table 1.** Description of variables and data sources.

| Variable | Notation | Definition | Measurement Unit | Data Source |
|---|---|---|---|---|
| Financial Development Index | FDI | Broad measure of a country's financial development, built on financial institutions and markets development (Svirydzenka 2016) | Points | International Monetary Fund (IMF) |
| Financial Institutions Index | FII | Measure of a country's level of development of its financial institutions, built on three pillars: access, efficiency, and depth (Svirydzenka 2016) | Points | |
| Financial Markets Index | FMI | Measure of a country's level of development of its financial markets, built on three pillars: access, efficiency, and depth (Svirydzenka 2016) | Points | |
| Education Index | EDI | Calculated as the simple geometric average of two indicators: mean years of schooling and the expected years of schooling (Klugman 2011). One of the three components of the Human Development Index (HDI). | Points | United Nations Development Programme (UNDP) |
| Mobile cellular subscriptions | MOB | Mobile cellular subscriptions per 100 people | Number | World Bank (WB) |
| Unemployment rate | UNEMP | Percentage of total labor force, including all genders | % | |
| Trade openness | TRD | Ratio between trade (exports and imports) to nominal GDP | % | |
| GDP growth rate | GDP | The annual growth rate of the nominal gross domestic product. | % | |

Source: Authors' representation.

In terms of educational development, we have chosen to use the World Bank's Education Index, which is one of the components of the larger Human Development Index. It can be argued that the index incorporates other measures of education development, such as education expenditure, education personnel, vocational education development, and so on, by including the mean of years of schooling for adults aged 25 years and older and the expected years of schooling for children of school-entering age in the index. Previous studies have widely used this index to capture differences in countries' levels of education development and their subsequent evolution over time (Bryant and Javalgi 2016; Abubakar et al. 2018; Khadka 2021).

In our research, digitalization is proxied by the number of mobile cellular subscriptions per 100 persons (MOB), while we have also investigated the percentage of individuals utilizing the Internet in the entire population as a suitable proxy. Given the high correlation between them for the countries in our panel, and the widespread replacement of desktop and laptop Internet connectivity by mobile phones since the introduction of smartphones in early 2000s, particularly for individual use (Schmitz Weiss 2013), we have decided to use mobile cellular subscriptions as a proxy for digitalization.

The last three variables in Table 1, also endogenous to the model, are included to control for differences among countries in terms of nominal GDP growth—a measure

of economic advancement, countries' trade openness—as a measure of the intensity of participation in the globalization process, and unemployment rate—as a measure of how education and, lately, digitalization, impact labor markets. Other studies have also employed these variables in their approaches to the links between financial development, education, and digitalization (Çiftçioğlu and Bein 2017; Tsaurai 2018; Olowu et al. 2019; Owusu-Agyei et al. 2020; Habibi and Zabardast 2020; Ejemeyovwi et al. 2021; Mignamissi 2021). Besides these three control variables, others might have been considered in our research, based on previous empirical studies, such as inflation, public investment, and foreign aid (Asongu 2014; Asongu et al. 2020), government expenditure (Hassan et al. 2011), institutional quality (Ejemeyovwi et al. 2021), gross domestic capital formation (Habibi and Zabardast (2020), or foreign direct investments, current account balance, external debt, and savings (Owusu-Agyei et al. 2020). However, our choice of the control variables set is supported by existing scholarly contributions that evidence the links between them, and all the other variables used in the literature. Moreover, scholars are always searching for more parsimonious models, hence our choice for a lower rather than higher number of control variables in the BVAR model. Table 2 presents brief descriptive statistics of these variables at sample level and for the entire time frame of the analysis.

**Table 2.** Descriptive statistics of variables.

|  | FDI | FII | FMI | EDI | MOB | GDP | TRD | UNEMP |
|---|---|---|---|---|---|---|---|---|
| Mean | 0.559 | 0.638 | 0.464 | 0.806 | 92.542 | 2.696 | 108.502 | 8.264 |
| Median | 0.572 | 0.658 | 0.471 | 0.812 | 106.693 | 2.738 | 89.529 | 7.185 |
| Maximum | 1.000 | 1.000 | 1.000 | 0.943 | 172.122 | 25.176 | 408.362 | 27.470 |
| Minimum | 0.109 | 0.150 | 0.017 | 0.575 | 0.075 | −14.839 | 37.496 | 1.810 |
| Standard deviation | 0.205 | 0.181 | 0.265 | 0.076 | 43.615 | 3.437 | 60.659 | 4.328 |
| Skewness | −0.170 | −0.260 | −0.144 | −0.349 | −0.740 | −0.423 | 2.061 | 1.353 |
| Kurtosis | 2.156 | 2.326 | 1.978 | 2.385 | 2.496 | 9.452 | 8.319 | 5.146 |

Source: Authors' representation based on EViews output.

## 4. Results

The descriptive statistics in Table 2 contain several patterns of the financial development–education–digitalization nexus in Europe that are useful to explore before revealing the results of the BPVAR model. In terms of financial development, our sample of countries shows higher medians for FDI, FII, and FMI compared to the values for all countries both at the beginning and ending of the time frame: in 1996, 0.43 against 0.24 (FDI), 0.54 against 0.32 (FII), and 0.31 against 0.15 (FMI); in 2019, 0.57 against 0.32 (FDI), 0.65 against 0.42 (FII), and 0.51 against 0.21 (FMI). Moreover, most European countries in our sample have seen their overall level of financial development (measured by FDI) increase between 1996 and 2019, ranging between 0.6% (Netherlands) and 106.2% (Croatia)—see Figure 1. The exceptions are Bulgaria and Ireland, with drops of 14.2% and 0.1%, respectively. Furthermore, the median growth in FDI between 1996 and 2019 for the Eastern European countries was higher than the median for the developed countries—39.5% versus 28%—suggesting a faster financial development process in the former. However, this is unsurprising, given the significantly lower FDI level in 1996 for Eastern countries compared to Western—0.26 versus 0.51. Still, five countries have shown FDI levels below the all-countries levels both in 1996 and 2019 (Estonia, Latvia, Lithuania, Romania, and Slovakia), indicating that their progress in terms of financial development is lingering.
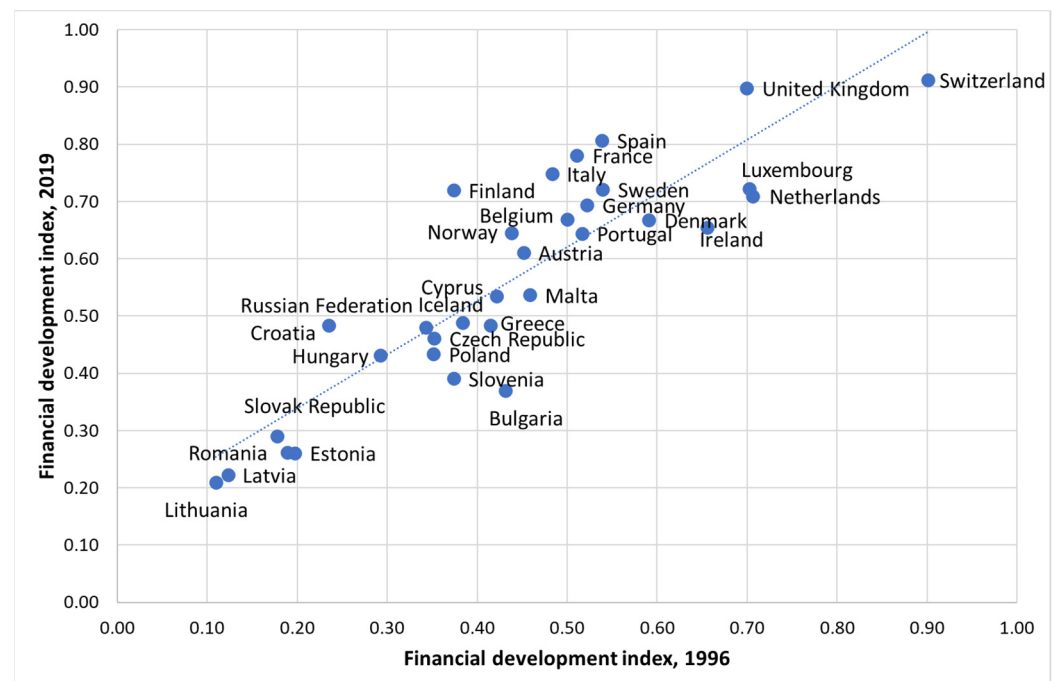
**Figure 1.** Financial development index in Europe, 1996 versus 2019. Source: Authors' representation based on IMF data.

The results for our sample are intriguing when financial development is divided into institutional improvement and financial market progress. Both financial institutions and markets, such as the FDI, have shown clear progress over time at the sample level, with medians of 21.7 percent and 63.4 percent, respectively. However, this is a progress in diversity, as seven Western countries saw their financial institutions' level decline between 1996 and 2019 (Cyprus, Denmark, Germany, Greece, Ireland, Netherlands, and Portugal), while several Eastern countries (Bulgaria, Poland, Romania, Russia, Slovenia, and Switzerland) saw significant falls in their financial market development. Figure 2 depicts the common evolution of financial institutions and markets for all the countries in our sample from 1996 to 2019, and evidences a negative correlation between the two variables. Moreover, countries in Eastern Europe were characterized by significant increases in financial institution development but slower, or even negative, progress in financial markets. Between 1996 and 2019, the median rise in FII for Eastern countries was 75.8% versus 5.7% for Western countries, while the median increase in FMI for the former was 33.3% compared to 70.3% for the latter.

Turning to education, all countries in the sample have experienced increases in the Education Index (EDI), with an overall median growth between 1996 and 2019 at a sample level of 21.6% and no significant difference between Eastern countries (22.5%) and Western economies (21.0%), but slightly higher for Eastern countries. However, five Eastern economies recorded EDI values below the sample median both in 1996 (0.71) and 2019 (0.88)—Bulgaria, Croatia, Hungary, Romania, and Russia, while others (Czechia, Latvia, and Lithuania) raised their EDI level above the sample median in 2019 after being below the median in 1996. Slovakia is the only Eastern country with an EDI value above the median in 1996 but below the median in 2019, albeit with an increase in EDI of 15% over the period. Interestingly, a few developed economies also had EDI levels below the sample median in 1996 and 2019 (Austria, Cyprus, Greece, Italy, Luxembourg, Malta, Portugal, and Spain), joined by France in 2019.
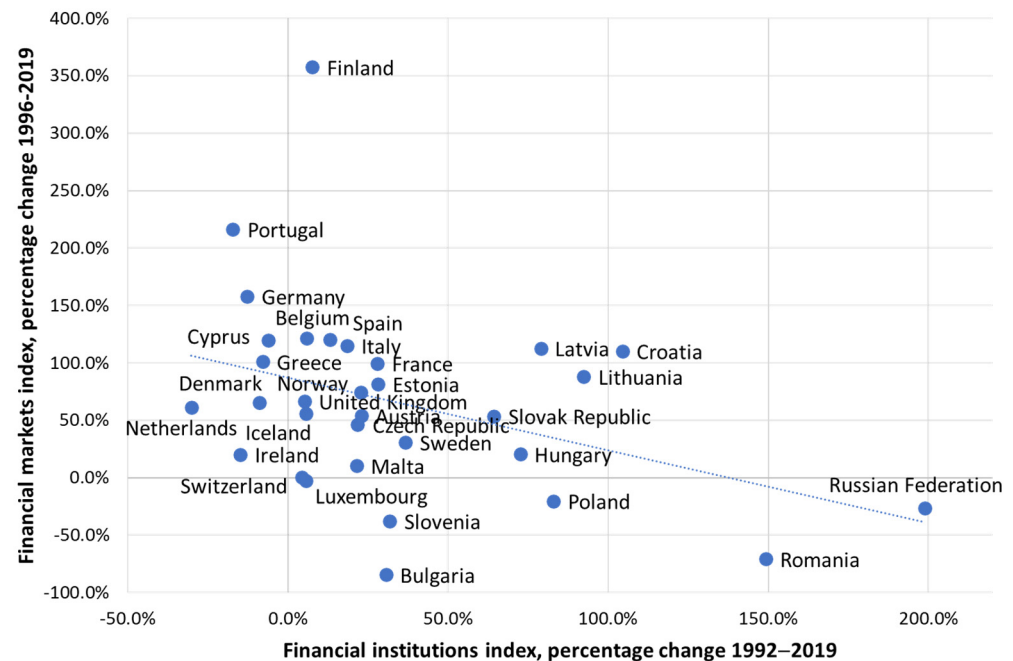
**Figure 2.** Financial institutions' versus financial markets' evolution in Europe, 1996–2019. Source: Authors' calculations and representation based on IMF data.

By far, the most impressive evolution between 1996 and 2019 was recorded by digitalization, proxied by the number of mobile cellular subscriptions per 100 people (MOB). At sample level, MOB increased from a median of 5.72 in 1996 to 122.26 in 2019 (a 1939% increase over the period), but the process was almost ten times more pronounced in Eastern countries than in Western countries, as the former reached a median in 2019 almost equal to the one for Western countries (121.71 over 123.72) while starting at a much lower level in 1996 (a median of 1.28 versus 8.69). Hence, Eastern countries' growth in mobile subscriptions was 10,593.6% between 1996 and 2019 against only 1235.7% for Western economies. This suggests that digitalization may be used as a highly powered channel for economic development in these countries, given its ubiquitous presence in individuals' everyday lives.

When we assemble the evolution of all three components of the financial development–education–digitalization nexus over the time frame of our analysis, interesting observations emerge. Figure 3 shows their interaction in 1996 and 2019—the two axes indicate the EDI and MOB levels, while the size of the bubble shows the FDI dimension in each year. Eastern countries form a rather well-established cluster in 1996, which has as its main attributes the low level of digitalization compared to Western economies but an overall lower level of education that matched the one in many Western countries (except for Belgium, Netherlands, United Kingdom, and Germany). The leading position of Iceland and United Kingdom on the digitalization axis is also observable. Eastern countries display lower levels of financial development when compared to their Western peers, as indicated by the smaller size of the bubbles. However, the landscape changes in 2019, particularly when digitalization is considered: three Eastern countries (Lithuania, Russia, and Estonia) had mobile cellular subscriptions not matched by other European countries—168.8, 164.4, and 147.2, respectively—while in others, the number of mobile cellular subscriptions overcomes the one in many Western countries. There has also been noticeable progress in terms of education for all European countries, as outlined above, but what the right panel in Figure 3 reveals is that the level of financial development in Eastern countries remains low compared to Western ones in 2019.
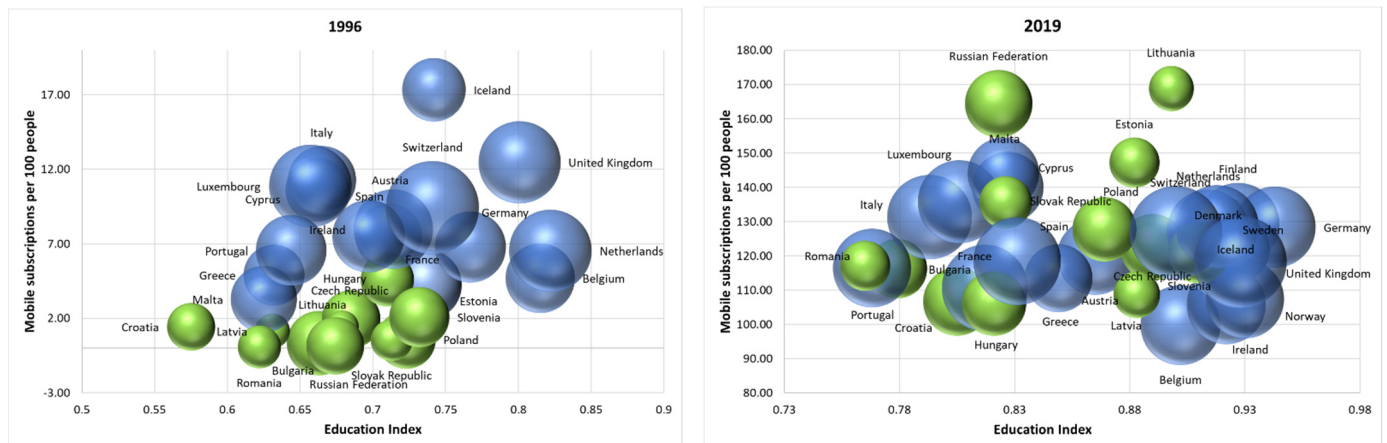
**Figure 3.** The financial development–education–digitalization nexus in Europe, 1996 (**left** panel) and 2019 (**right** panel). The size of the bubbles is given by the values of the Financial Development Index (FDI) in each year. Eastern countries are colored in green and Western countries in blue. Source: Authors' representation.

We now turn to the results of the BPVAR model. Table 3 shows the results of panel unit root tests, which show that that our variables are I(1), except for GDP that is I(0). The null hypothesis for all tests is that series have a unit root. Therefore, we have decided to implement the BPVAR with the first difference of all variables and the level for GDP growth rate.

**Table 3.** Panel unit root tests results.

| Variables and Testing Levels | | Levin, Lin, and Chu t * | Breitung t-Stat | Im, Pesaran, and Shin W-Stat | ADF—Fisher Chi-Square | PP—Fisher Chi-Square |
|---|---|---|---|---|---|---|
| FDI | Level | −0.950 | 2.257 | −1.101 | 88.847 ** | 192.908 |
| | First difference | −5.586 * | −6.430 * | −9.780 * | 214.534 * | 919.438 * |
| FII | Level | 0.230 | 2.836 | 1.356 | 68.004 | 91.372 ** |
| | First difference | −5.809 * | −8.439 * | −8.369 * | 187.723 * | 860.064 * |
| FMI | Level | −2.341 * | −0.329 | −3.476 | 111.853 | 265.717 |
| | First difference | −7.531 * | −5.513 * | −11.261 * | 241.574 * | 788.285 * |
| EDI | Level | −3.479 * | 4.353 | −0.662 | 87.546 ** | 98.1608 * |
| | First difference | −7.214 * | −7.152 * | −6.848 * | 161.738 * | 328.763 * |
| MOB | Level | −6.198 * | 4.262 | 0.718 | 60.128 | 15.935 |
| | First difference | −7.326 * | −9.622 * | −8.070 * | 177.381 * | 188.142 * |
| GDP | Level | −8.109 * | −9.910 * | −6.035 * | 143.820 * | 194.639 * |
| | First difference | −15.809 * | −18.535 * | −16.696 * | 346.831 * | 1979.91 * |
| TRD | Level | −3.124 * | −3.108 | −4.027 | 118.732 | 86.397 ** |
| | First difference | −12.980 * | −11.163 * | −10.274 * | 217.018 * | 769.114 * |
| UNEMP | Level | −3.239 * | −4.224 | −4.265 | 122.789 | 36.958 |
| | First difference | −4.947 * | −8.518 * | −5.373 * | 132.23 * | 153.858 * |

Note: * and ** denote statistical significance at 1% and 5% level, respectively. Unit root tests have been tested with individual intercept and trend. Source: Authors' calculations.

The Bayesian Schwartz Information Criterion (SIC) was used to determine the optimal number of lags and the test indicated 1 lag for all six panels. Further, the Dumitrescu-Hurlin panel causality test has been applied using 1 lag—results are reported in Table 4. The test shows that bi- or uni-directional causality exists between financial development, education, and digitalization variables, which supports their inclusion in a VAR type of model. We have not tested the causality between financial development variables, given that FDI is constructed using FII and FMI, and such a test would have been irrelevant. The results evidence the bi-directional causality between FDI, FII, and FMI, and digitalization, as well as between education and digitalization. Moreover, we find uni-directional causality from education to FDI and FII, as well as from all financial development variables to GDP growth. Furthermore, TRD received the uni-directional influence (in Granger sense) of FII, and uni-directionally causes EDI.

**Table 4.** Granger causality tests results.

| | FDI | FII | FMI | EDI | MOB | GDP | TRD | UNEMP |
|---|---|---|---|---|---|---|---|---|
| | **Null Hypothesis: Variable on the Line Does Not Homogeneously Cause Variable on the Column** | | | | | | | |
| FDI | – | – | – | −0.097 | 2.355 ** | 9.444 * | 0.720 | 1.893 |
| FII | – | – | – | −0.729 | 2.227 ** | 7.013 * | 2.179 ** | 1.503 |
| FMI | – | – | – | −0.263 | 7.260 * | 4.943 * | 0.576 | 1.263 |
| EDI | 2.915 * | 2.051 ** | 1.473 | – | 2.616 * | 8.302 | −0.020 | −0.895 |
| MOB | 4.080 * | 6.536 * | 2.596 * | 2.674 * | – | 2.214 ** | 0.768 | 0.036 |
| GDP | 0.808 | 0.513 | −0.16 | 1.667 | 0.089 | – | 1.214 | −0.293 |
| TRD | 0.136 | −0.877 | 0.557 | 2.069 ** | 0.959 | 21.009 * | – | 1.379 |
| UNEMP | 0.369 | −0.441 | −0.837 | 0.555 | 0.809 | 26.973 * | 4.800 * | – |

Note: The table reports the values of the Z-bar statistic for the Dumitrescu–Hurlin causality panel test, calculated as the standardized value of average test statistic calculated by applying Granger causality regressions on each cross-section. * and ** denote statistical significance at 1% and 5%, respectively, and indicate the presence of Granger causality between the variables on the line and the variables on the column. Source: Authors' calculations.

Multicollinearity is to be avoided between the variables that enter a VAR model, as it may lead to biased estimators (Joutz et al. 1995; Gujarati and Porter 2009), but there is no consensus in the literature regarding the level of correlation between variables that should be avoided. Table 5 shows the Pearson correlation coefficients for the variables included in our analysis and the only figures above 0.6 are for FDI-FII. Because the two financial development variables will not be included simultaneously in our BPVAR models, multicollinearity is not an issue of concern for our estimations.

**Table 5.** Correlations between variables.

| | FDI | FII | FMI | EDI | MOB | GDP | TRD | UNEMP |
|---|---|---|---|---|---|---|---|---|
| FDI | 1.000 | | | | | | | |
| FII | 0.546 * | 1.000 | | | | | | |
| FMI | 0.747 * | 0.028 | 1.000 | | | | | |
| EDI | 0.186 * | 0.161 * | 0.085 * | 1.000 | | | | |
| MOB | 0.196 * | 0.176 * | 0.111 | 0.270 * | 1.000 | | | |
| GDP | 0.143 * | 0.145 * | 0.057 | 0.120 * | 0.189 * | 1.000 | | |
| TRD | 0.091 * | −0.024 | 0.069 | 0.019 | 0.103 * | −0.145 * | 1.000 | |
| UNEMP | −0.087 * | −0.052 | −0.030 | −0.030 | −0.060 | −0.350 * | −0.152 * | 1.000 |

Note: The table reports the values of the Pearson correlation coefficient for all pairs of variables. * designates statistical significance at 5% level. Source: Authors' calculations.

Table 6 shows the autoregressive root results for the three panels and reveals that all estimations meet the BVAR stability (stationarity) criterion, because the AR roots have modulus lower than one and lie within the unit circle. Hence, the results of the BPVAR estimates are valid and we proceed to the analysis of impulse responses and variance decomposition results.

**Table 6.** BPVAR stability results.

| Root | Modulus | Root | Modulus | Root | Modulus |
|---|---|---|---|---|---|
| Panel 1: FDI-EDI-MOB | | Panel 2: FII-EDI-MOB | | Panel 3: FMI-EDI-MOB | |
| 0.690289 | 0.690289 | 0.692009 | 0.692009 | 0.691215 | 0.691215 |
| 0.278061 − 0.231077i | 0.361545 | 0.261162 − 0.232734i | 0.349815 | 0.299314 − 0.255403i | 0.393471 |
| 0.278061 + 0.231077i | 0.361545 | 0.261162 + 0.232734i | 0.349815 | 0.299314 + 0.255403i | 0.393471 |
| 0.160820 | 0.160820 | 0.171515 − 0.050995i | 0.178936 | −0.144354 | 0.144354 |
| 0.090574 | 0.090574 | 0.171515 + 0.050995i | 0.178936 | 0.132559 | 0.132559 |
| −0.034033 | 0.034033 | −0.000609 | 0.000609 | 0.071673 | 0.071673 |
| No root lies outside the unit circle. | | No root lies outside the unit circle. | | No root lies outside the unit circle. | |
| VAR satisfies the stability condition. | | VAR satisfies the stability condition. | | VAR satisfies the stability condition. | |

Source: EViews output and author's representation.

In addition, we present the estimated BPVAR models' Impulse Response Functions (IRF) for financial development, education, and digitalization. Individually, these functions represent the impact of shocks originating in one variable on each of the other variables, describing the VAR system's response to shocks through time and proving its dynamic nature given the endogeneity of variables included in the model. Figure 4 depicts the first period's lack of response by FDI, FII, and FMI to a one standard deviation shock (or innovation) in education, followed by a positive response in the second period (between 0.0043 for FII and 0.0050 for FMI), and a declining influence up to the eighth period. The same pattern can be seen in the responses of all financial development variables to shocks in digitalization (MOB), but the positive reaction in the second period is lower than in the first, varying between 0.0028 for FDI and 0.0037 for FMI. However, even after ten periods, the response of financial development to digitalization shocks is positive, albeit small, implying a longer-term impact of digitalization on financial development for the countries in the sample.

In the case of education (EDI), regardless of the variable chosen, all three panels show a positive first 2-period impact of one standard deviation innovations in financial development, which falls to zero after six periods. The response of education to digitalization is observable only from the second period (it is zero in the first period) and, as with financial development, there is no impact after six periods, implying that education is a type of leading variable in the financial development–education–digitalization nexus, whereas financial development and digitalization are laggard variables. This finding is supported by the response of digitalization (MOB) to one standard deviation shocks in education: positive in the first period (between 0.0076 for FDI and 0.0089 for FMI) but increasing in the second period (between 0.0123 (FDI) and 0.0140 (FMI)), followed by declines and then remaining positive after ten periods. In terms of financial development, a one standard deviation shock has a considerable impact in the first period (between 0.0064 for FMI and 0.0107 for FDI), which reduces over time but remains positive and significant after ten periods. This conclusion suggests that both financial development and education have a stimulating influence on digitalization, which is fueled by the desire for more educated people to access sophisticated financial products, platforms (therefore markets), and financial institutions.
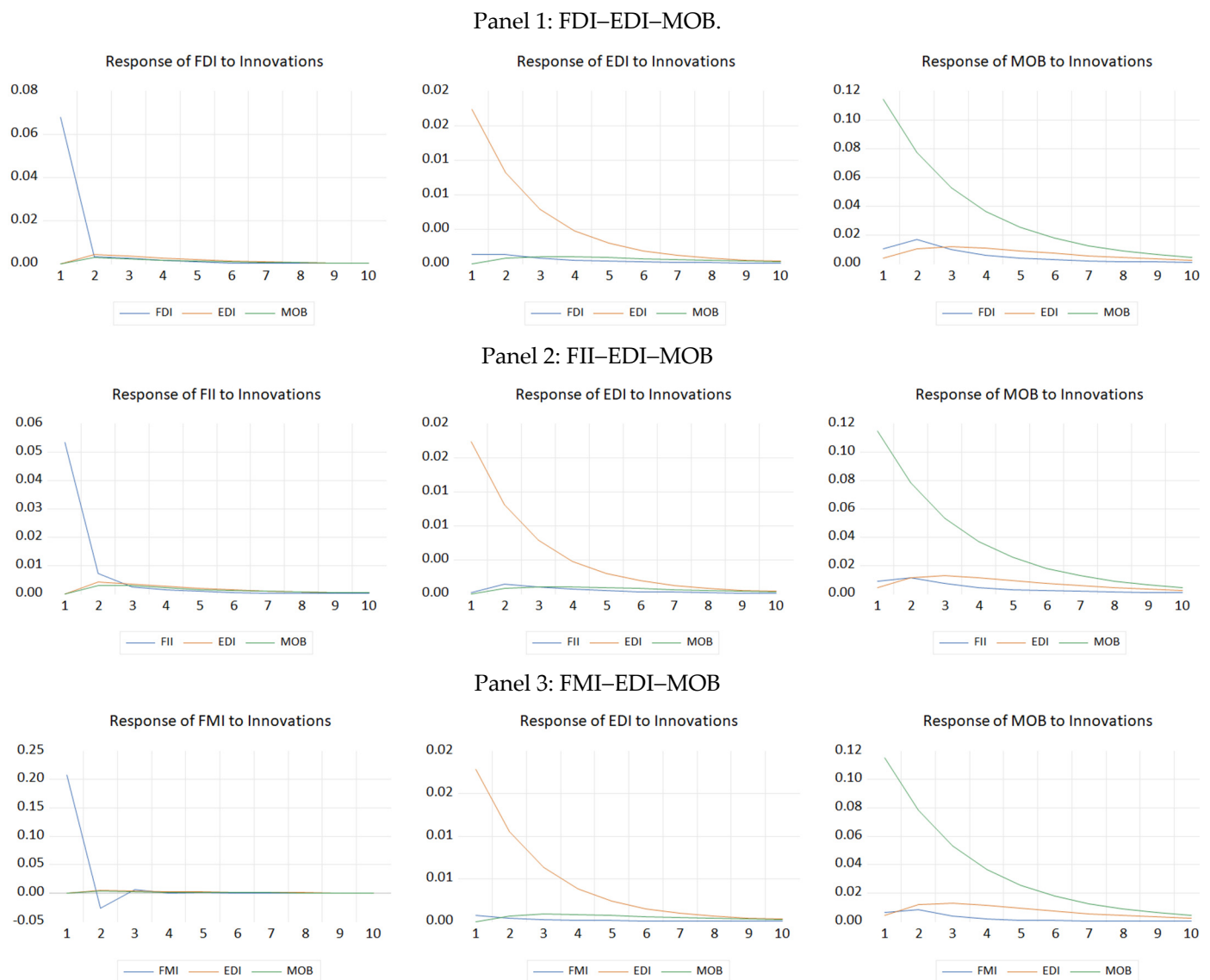
Panel 1: FDI–EDI–MOB.



Panel 2: FII–EDI–MOB



Panel 3: FMI–EDI–MOB



**Figure 4.** Responses of variables to shocks in other variables. The figure shows the response of VAR system variables to Choleski one standard deviation innovations in the other variables. Source: EViews output and authors' representations.

## 5. Discussion

The relationship between education, digitalization, and economic growth has been thoroughly explored by existing literature, including with regards to financial inclusion and human development. However, the link with financial development has been less established, and our paper aims to fill this gap. Our empirical analysis focuses on 32 European countries during the 1996 to 2019 period, of which 27 are current European Union members. The findings highlight an overall positive association between financial development, education, and digitalization, where education is a leading variable in this triad, whereas financial development and digitalization are laggards.

Collectively, European countries have improved their levels of financial development, considering both dimensions—institutions and markets. However, the growth in financial development between 1996 and 2019 for the Eastern European countries was higher than the one for Western countries, thus suggesting a faster financial development process in the former. Certainly, this catching up was expected given the significantly lower levels of financial development in the former countries in 1996. This may be due to the private capital

flows, in the form of direct and portfolio investments, attracted over time, and largely fueled by the prospective of EU accession, which often meant political and economic transition, privatization, increased opening of the economies, and financing opportunities. Thus, between 2002 and 2007 (the EU pre-accession period), CEE countries attracted one-third of all private capital inflows to emerging markets (Kattel 2010), which contributed to their building of capital stock and fast growth. The presence of foreign capital providers also fueled a learning process within domestic financial markets participants, which further incentivized financial institutions and markets to develop (Henry 2000; Bekaert et al. 2007; Otchere et al. 2016). Moreover, Bayar and Gavriletea (2018), Henri et al. (2019), and Majeed et al. (2021) support the view that higher levels of financial development attract foreign investments, which leads to the existence of a virtuous foreign capital–financial development cycle.

However, some of these countries have shown financial development levels below the all-countries levels both in 1996 and 2019, which may be the effect of their lower ability to attract foreign capital flows. This negatively impacted their progress in terms of financial development. An interesting explanation of these countries' lower progress in financial development may rely on their bank-centric financial systems, which Ivanisevic Hernaus and Stojanovic (2015) argue are typical of CEE countries. Furthermore, Bats and Houben (2020) show that financial systems that rely more on financial markets are more efficient, provide investors with more diversified opportunities, and can sustain a lower exposure to systemic risk. However, these countries' financial development evolution has different roots; Estonia and Latvia's financial institutions development was less rapid than their financial market development, while the reverse is true for Lithuania, Romania, and Slovakia, with Romania showing a decline in financial market development.

Hence, for completeness, it is necessary to consider both components of financial development. We observe differences when financial development is divided into institutional improvement and financial market progress. Some Western countries saw their financial institutions' level decline between 1996 and 2019, while several Eastern countries saw significant falls in their financial market development. These results are in line with Chinn and Ito (2006) and Khera et al. (2021) stating that the quality of financial institutions is one of the key drivers for improving financial development.

Furthermore, according to (Fratzscher 2012; Różański and Sekuła 2016; Kurul and Yalta 2017), institutions and their quality are major factors of capital inflows, including the link between foreign capital and financial market development. Referring to the latter, recent financial markets' deregulation strongly encouraged the development of financial markets and their integration at regional and global levels (Rajan and Zingales 2003). In the European Union in particular, the introduction of the euro (EUR) in 1999 led to increased financial markets integration, as evidenced by Bartram et al. (2007), Horobet and Lupu (2009), Mylonidis and Kollias (2010), Grossman and Leblond (2011), and Vukovic et al. (2017), although on a slower pace after the 2007 global financial crisis (Pungulescu 2013).

According to Savva and Aslanidis (2010), the former communist countries that are currently European Union members have been part of the financial integration process, with beneficial effects for their financial markets' development. However, two of the CEE countries, Bulgaria and Romania, have seen their financial market development level significantly drop between 1996 and 2019, which may be explained by their joining of the EU just before the 2007 global financial crisis and the European sovereign debt crisis in 2011–2012 (Moagăr-Poladian et al. 2019).

However, we observe that Bulgaria and Romania are the European laggards in almost all measures of financial market development. For example, the ratio of bank deposits to GDP for these two countries was 67.72% and 31.61%, respectively, in 2017 (the latest year with available data from IMF), substantially lower than 82.14% for Germany (in 2017) or 171.25% for Switzerland (in 2016), according to the Federal Reserve Bank of St. Louis (FRED). When analyzing capital markets, the other main component of financial markets, Bulgaria had a ratio of market capitalization to GDP of 23.19% in 2020 and Romania a

ratio of 14.6%, according to IMF and CEIC data, compared to an overall 54.6% ratio for the European Union in 2018.

Another possible explanation for the declines observed in financial markets' development is IMF's calculation of the index values, which are not absolute values, but the result of a normalization procedure applied to the raw set of indicators used to build these indexes (Svirydzenka 2016). Hence their lower values in 2019 compared to 1996 may indicate that these countries' markets have not been able to keep up with the rest of the world. Nevertheless, this is a warning sign for policy makers in these countries, as they need to identify and implement strategies meant at increasing the relevance and usefulness of financial markets for the real economy.

With regards to education development, our results suggest that all countries in our sample experienced increases over our time frame. Although there were no significant differences between Eastern and Western economies, we found that education plays a leading role in both financial development and digitalization. This supports Donou-Adonsou's (2019) conclusion that a lack of education is one of the main reasons why developing countries may not be fully reaping the benefits of digitalization. Given that many Eastern countries underwent several social and political changes during this period and a transition from centralized to market-based economies, they require a highly skilled and knowledgeable population to increase overall prosperity. Our results also support education as the intermediary between financial development and economic growth (Levine 2005; Beck et al. 2010; Čihák et al. 2012; Benos and Zotou 2014).

Between 1996 and 2019, digitalization demonstrated the most impressive evolution, with the process being more pronounced in Eastern countries than in Western ones. Thus, digitalization may be used as a highly powered channel for financial and economic development in these countries, given its pervasive presence in individuals' everyday lives. In 1996, Eastern countries evidenced much lower levels of digitalization compared to Western economies, but the gap had shrunk substantially by 2019. To this end, Jepsen and Drahokoupil (2017) present evidence that CEE countries are likely to be affected differently by digitalization than more developed countries. Whilst education levels across Europe also improved by 2019, the discrepancies in 1996 were much less significant. This highlights the importance of education in retraining the workforce in preparation for an increasingly digital world.

Our research found that financial development responds positively to digitalization shocks, meaning that digitalization will have a longer-term impact on financial development. Our findings are consistent with Feyen et al. (2021), in that digitization has not only lowered transaction costs but also fostered the emergence of new fintech business models.

Overall, we suggest several areas that require development policies concerning the acquiring of a better level of education to fully benefit from an increasingly digital society. The global financial crisis has demonstrated the extent and speed of contagion to the real economy, highlighting the need for prudential oversight of financial institutions. The development of macro-prudential policies that safeguard the integrity and transparency of financial markets remains critical. Alignment of countries outside the Eurozone with EU's financial markets could improve economic stability and prosperity. Our findings reveal that some European countries' financial development levels fell below the global median both in 1996 and 2019. For this reason, it is critical for policymakers to design safe and sound financial institutions and not just simply increase the number of individual banks in less developed Eastern European countries. This is because low overall banking assets result in non-performing loans and inefficient resource allocation (Jaffee and Levonian 2001). Instead, central banks could consider improving interest margins or domestic credit provision to the private sector. In turn, these measures could attract foreign capital flows.

Furthermore, it is vital that Eastern European countries continue to accelerate their digitalization by embarking on initiatives supporting the EU's goal of creating a digital single market and strengthening its global digital leadership (Mnohoghitnei et al. 2021). Governments and the private sector should collaborate to create the appropriate structures

for the transposition of European laws into national law. Moreover, emerging countries should take advantage of the infrastructure and technological support offered by the fact that their market players, notably in finance, are already connected to the most developed countries via European electronic networks.

To ensure a robust educational framework, research and development should be prioritized to support the development of a qualified and specialized workforce. Our findings demonstrate that education should be used to guide future policies in order to accelerate economic progress.

## 6. Conclusions

This paper empirically examines the link between financial development, education, and digitalization, by analyzing a group of 32 European countries during 1996 and 2019, of which 27 are current European Union members. We used a Bayesian panel VAR (BPVAR) model, which suits our sample and research objectives. Aside from the expected finding that there is a dynamic interdependence between financial development, digitalization, and education, a highly interesting result is that education is the leading variable in the nexus, while financial development and digitalization are laggard variables. These findings pave the way for the development of concurrent policies and strategies on digitalization, education, and financial development, particularly in emerging European countries where financial development is significantly lower than in more developed peers. Thus, our findings point to direct support for financial markets and institutions, owing to increased diversity of financial products and greater access to them by individuals and businesses, which will eventually lead to deeper markets and more efficient institutions. These will eventually increase the integration of emerging European financial markets into developed European markets, benefiting both consumers and businesses. Furthermore, financial development can be aided by investment in education, which can target various segments of the population, including lower income or elder populations.

Finally, digitalization may be a critical component of a successful education strategy, as its ubiquitous role in our lives has been clearly revealed by the current pandemic. The ongoing pandemic is causing significant changes in society, with ramifications for the economy, the environment, and the population, but especially for the role of innovation and technology. The pandemic provides opportunities for significant reforms and investments in digital infrastructure and technology. To build a more sustainable Europe for future generations, the EU adopted the Next Generation EU European Recovery Plan in December 2020, which aims to assist Member States in dealing with the consequences of the pandemic while also assisting the EU economy in recovering in a greener, digital, and resilient direction. However, this will not be an easy path, particularly in emerging European countries, because digital development necessitates both the modernization of teaching methods and educational systems, as well as significant streamlining of administrative processes. Thus, given the EU's goal of building a single digital market, it is important to study the potential risks to the competitiveness and development of the digital economy in the context of economies that have not reached the digital maturity stage. Moreover, by identifying gaps, opportunities, and challenges from the perspective of integration into the digitalized single market, one good question is whether the attractiveness of emerging markets as a model of consumer and outsourcing markets will increase.

Certainly, our research has limitations that are inherent to the model, variables used, and time frame of the analysis, all of which are highly dependent on data availability. Based on our findings, several future research directions may be explored, including an investigation of the relationship between financial market development and institutional development (not just financial institutions), an examination of how businesses' level of digitalization relates to financial development, and a more in-depth analysis of the level of education and its impact on financial and economic development. Moreover, studies on the joint reinforcement of education, digitalization, and financial development through targeted policies are highly relevant.

## Appendix A

The Financial Development Index (FDI) proposed by Čihák et al. (2012), further refined by Svirydzenka (2016), and adopted by the International Monetary Fund to measure the level of financial development across the world is methodologically built on a pyramidal structure—see Figure A1 below. Thus, the FDI is composed of two other indexes, the Financial Markets Index (FMI) and the Financial Institutions Index (FII); each include three other dimensions: access, depth, and efficiency. It is important to mention that the index aims at showing which are the features of financial systems in terms of depth, accessibility, and efficiency, and not at capturing the drivers behind these features, i.e., the indexes are not meant to provide explanations on how various institutional or regulatory frameworks are leading to growing or becoming more or less stable financial systems. For more details, the readers are advised to refer to the comprehensive IMF paper of Svirydzenka (2016).
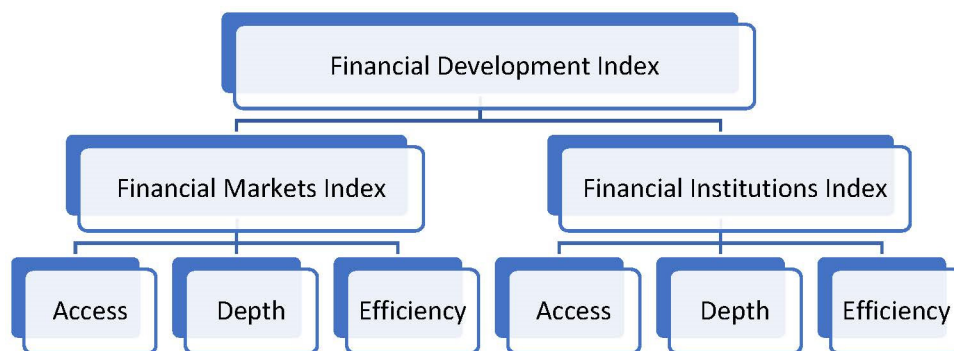


**Figure A1.** Financial Development Index decomposition.

The model behind the *FDI* is a linear combination of the following:

$$FDI = w_1 FMI + w_2 FII \tag{A1}$$

where $w_1$ and $w_2$ are the *FMI* and *FII* weights in *FDI*, respectively. Further, *FMI* and *FII* are constructed as linear combinations:

$$FMI = w_1^A FMIA + w_1^D FMID + w_1^E FMIE \tag{A2}$$

and

$$FII = w_2^A FIIA + w_2^D FIID + w_2^E FIIE \tag{A3}$$

where *FMIA*, *FMID*, and *FMIE* are the access, depth and efficiency components of *FMI*, while *FIIA*, *FIID*, and *FIIE* are the access, depth and efficiency components of *FII*. $w_1^A$ and $w_2^A$ are the weights of the access components in *FMI* and *FII*, $w_1^D$ and $w_2^D$ are the weights

of the depth components in *FMI* and *FII*, and $w_1^E$ and $w_2^E$ are the weights of the efficiency components in *FMI* and *FII*, respectively. The weights in each of the Equations (A1)–(A3) sum up to 1.

At all construction stages, the indices are normalized on the [0,1] range, following a winsorization procedure to treat extreme values and then normalization between 0 and 1 of the winsorized indicators using a min-max approach. Hence, the resulting values should not be treated as absolute, but relative, as they show a country's performance depending on a minimum and maximum value across all years and countries.

The data used to construct the indexes originate from the WorldBank FinStats, an updated version of the Global Financial Development Database (GFDD), the Bank of International Settlements, Dealogic, and IMF Financial Access Survey. The specific data source for each component is presented in Svirydzenka (2016), Table 1.

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