Eastern European Economics

ISSN: 0012-8775 (Print) 1557-9298 (Online) Journal homepage: https://www.tandfonline.com/loi/meee20

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Eastern European Economics, 54: 93–108, 2016

ISSN: 0012-8775 print / 1557-9298 online
DOI: 10.1080/00128775.2015.1126787

Economic Convergence in the EU: A Complexity Approach

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This paper examines the effect of economic complexity on economic growth in the context of the EU countries. Our results suggest that a group of countries in the EU whose economic complexity exceeds a certain threshold tend to converge to levels of income corresponding to their measured complexity. On the other hand, the interaction of the current account deficit with economic complexity has important effects on growth for a second group of countries with lower levels of complexity. Since we also find that income convergence is faster within the first group, we argue that convergence is much faster for countries whose economic complexity exceeds a certain threshold.

Keywords: economic complexity, European Union, growth, heterogeneity, income convergence

JEL Classification: O11, O52, F43

Economic complexity, the ability of a country to transform its economic structure toward the production and export of more sophisticated products, has emerged as a key factor in explaining economic growth and development (Hausmann, Hwang, and Rodrik 2007; Hidalgo and Hausmann 2009). The relatedness of products in global trade to product space (Hausmann, Hwang, and Rodrik 2007; Hidalgo et al. 2007) portrays the productive structure of each country, and provides paths through which countries can spread to nearby products and increase their productive capacities. The higher the proximity between a pair of products, the closer the requisite capabilities to produce these two products. Therefore, a country exporting one product can easily transfer to the other product and thereby increase its productive structure (Hausmann and Klinger 2006; Hidalgo et al. 2007). A variant of this idea, introduced by Hidalgo and Hausmann (2009), is the method of reflections, which evaluates the sophistication of products and the complexity of countries through joint and iterative calculations of ubiquity and diversity indicators. Hidalgo and Hausmann claim that the concept of economic complexity is closely related to the capabilities of countries. A country with more diverse capabilities can produce more complex products, thereby requiring a varying set of capabilities in its production process,

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as can be inferred from the product's ubiquity, and from the diversity of the countries that export it. Their main argument is that the growth path of an economy is determined by the overall complexity of a country's productive structure, and, in turn, its ability to produce and export sophisticated products requiring diverse capabilities. They validate the theory by presenting cross-country evidence that economic complexity is strongly correlated with income per capita, and that deviations from this correlation are predictive of subsequent economic growth and development (Hausmann et al. 2011; Hidalgo and Hausmann 2009). This cross-country regression result revives the question of whether the relationship between complexity and growth is confirmed in the context of the European Union (EU), whose new lower-income members tend to grow faster, implying absolute beta-convergence across the Union (See Figure 1).[1]

Trade relations within the EU are undoubtedly an integral part of the Union. Moreover, the FDI received by new entrants has served to designate them as the producers of specific goods, primarily for the European market. These dynamics are closely linked to the economic complexity of the countries. Thus, investigating the effect of economic complexity on growth in this part of the world, with its particular and distinctive economic and trade relations, could shed light on the significance of economic complexity for economic growth and convergence in the EU.

The accession of lower-income countries from Central and Eastern Europe to the EU during the last decade has brought renewed interest in the issue of the narrowing the gap between old and new members, and a number of studies have examined beta-convergence within the enlarged EU, utilizing different sample periods and methods.[2] Matkowski and Próchniak (2007) confirm the existence of beta-convergence in per capita real GDP between eight new

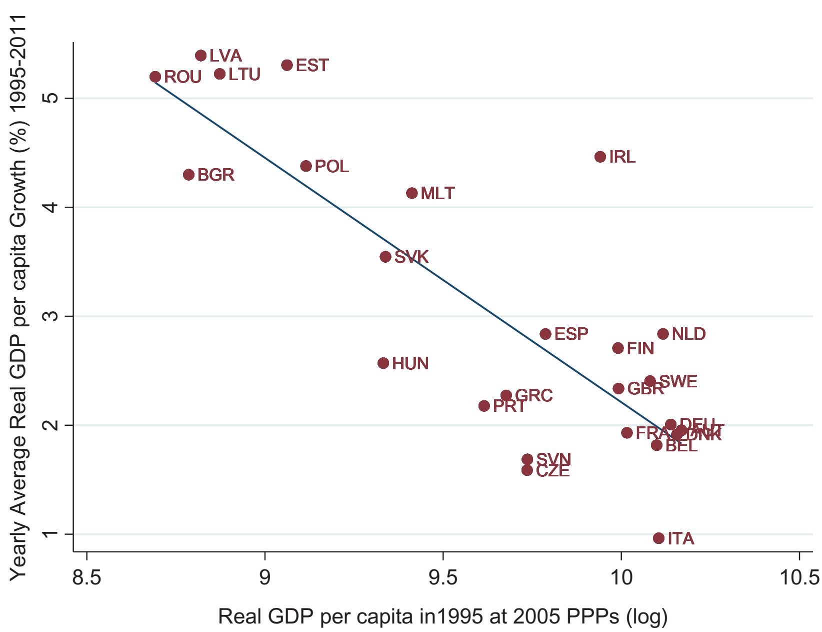

FIGURE 1 Beta-Convergence in the EU, 1995–2011.

member states and the EU-15 during the period 1993–2004. Kočenda, Kutan, and Yigit (2006) find evidence for real income per capita convergence of ten new member countries toward EU standards between 1995 and 2005, but highlight significant growth disparities among these countries. Ingianni and Zdarek (2009) support the process of beta-convergence in real income per capita within both the group of new entrants and the whole Union over the 1995–2006 period, but argue that the convergence rate is higher in the former countries. Cavenaile and Dubois (2011) provide evidence for the beta-convergence of real income per capita for the EU-27 over the 1990–2007 period. However, they point to the existence of significant differences in convergence processes between new entrants and the EU-15. More recently, Dobrinsky and Havlik (2014) find uneven real economic convergence within the EU-27 over the period 2000–2011, highlighting the differences in growth patterns between new members and the other countries. In summary, the reviewed empirical literature supports the beta-convergence hypothesis of the neoclassical growth theory within the EU, despite the different convergence patterns of new and older members.[3]

This article contributes to the literature relating beta-convergence within the EU to the economic complexity index developed by Hidalgo and Hausmann (2009). The objective is twofold. First, we check whether there has been beta-convergence within the EU in the period 1995–2010, controlling for economic complexity apart from the other traditional determinants of economic growth. After confirming the catching-up process, we further scrutinize whether there has been uniform convergence within different subsets of countries. Second, we take the opportunity to test, in the context of the EU countries, Hidalgo and Hausmann's (2009) finding of a positive and significant association between economic complexity and subsequent real GDP growth per capita.

We first compute the economic complexity for twenty-five EU counties, and run a regression equation establishing the link between economic complexity and GDP per capita growth.[4] The baseline model builds on a fixed-effect estimation employing panel data. The regression includes country and time dummies. We also conduct robustness checks to take account of potential endogeneity and estimation issues.

Our findings support the evidence presented by Hidalgo and Hausmann (2009) for a group of EU countries that exceed a certain threshold of economic complexity. The five new entrants from Eastern and Central Europe, namely Slovenia, Slovakia, Czech Republic, Poland, and Hungary, and the EU-15 countries, excluding Greece, Spain, and Portugal, constitute a distinct group (first group) in the EU for which a high economic complexity index has led to faster subsequent economic growth. The inclusion of Slovakia, Czech Republic, Poland, and Hungary in the first group is in line with the IMF (2013) report which posits that the integration of these four new members in a German–Central European supply chain, specifically in the knowledge-intensive and high-technology sectors, has enabled them to grow faster. Slovenia, too, has integrated into European and global supply chains of production and trade in roles similar to those of the core EU countries (Bohle and Greskovits 2012).

There is a negative correlation between economic complexity and future economic growth for the second group, which consists of all other EU countries. Therefore, in the European context, in order for the effect of complexity on subsequent economic growth to materialize, a country's complexity index should exceed a certain level. Moreover, the first group displays a higher convergence rate, thus implying heterogeneity across the Union. We argue, therefore, that convergence is much faster for countries whose economic complexity exceeds a certain threshold.

In order to confirm our results, we rely on the argument of Gill et al. (2012) and Stojkov and Zalduendo (2011) that capital inflows have supported growth in many emerging European countries, and therefore we add the current account balance to our estimation equation as a proxy for these flows. The aim here is to understand the effect of capital flows on the contribution of economic complexity to future economic growth. Our empirical results suggest that the impact of economic complexity on growth decreases with the current account deficit (i.e., capital inflows) across the second group of countries. This finding clearly explains why there is a negative association between economic complexity and GDP per capita growth for the second group of countries. In fact, capital inflows have triggered rapid growth in these countries without high economic complexity.

The structure of the article is as follows. The second section describes the construction of economic complexity index. The third section explains data and methodology. The fourth section presents empirical results and robustness checks, followed by the conclusion.

ECONOMIC COMPLEXITY INDEX

In this article, we use the method of reflections developed by Hidalgo and Hausmann (2009), which evaluates the sophistication of products and the complexity of countries through joint and iterative calculations of ubiquity and diversity indicators. They argue that a country whose production process has diverse capabilities will have a diversified export basket and a high level of economic complexity. Likewise, a product whose production process requires diverse capabilities is likely to be exported by fewer countries and is expected to be more sophisticated or less ubiquitous. Hidalgo and Hausmann use the global trade networks of countries and products in their method of reflections to jointly and iteratively calculate the ubiquity and diversity indicators. The method of reflections indicators considers only those products whose revealed comparative advantage index (RCA) (Balassa 1964), that is, the ratio of the share of a given product in the country's export basket to the share of the product in the total world export basket, is greater than 1. RCA is computed as in Equation (1):

$$RCA_{jk} = \frac{X_{jk}}{\Sigma_k X_{jk}} / \frac{\Sigma_j X_{jk}}{\Sigma_{j,k} X_{jk}} \tag{1}$$

where X_{jk} represents the dollar exports of country j in product k. We define the adjacency matrix M_{jk} to study the structure of the bipartite network of countries and products; M_{jk} is equal to 1 if country j exports product k with revealed comparative advantage, and 0 otherwise.

We define the ubiquity of product k as the sum of the adjacency matrix M_{jk} over all countries, and the diversity of country j as the sum of M_{jk} over all products found in Equations (2) and (3):

$$Ubiquity_k = K_{k,0} = \sum_j M_{jk}, \tag{2}$$

$$Diversity_j = K_{j,0} = \sum_k M_{jk}. \tag{3}$$

The ubiquity and diversity indicators show, respectively, the ubiquity of the product ($K_{k,0}$), that is, the number of countries exporting the product, and the diversification of a country ($K_{j,0}$), namely, the number of products the country exports. Iteratively calculating the ubiquity and diversity indicators gives the weighted-average Equations (4) and (5):

$$K_{k,n} = \frac{1}{K_{k,0}} \sum_{j} M_{jk} K_{j,n-1} \tag{4}$$

$$K_{j,n-1} = \frac{1}{K_{j,0}} \sum_{k} M_{jk} K_{k,n-2} \tag{5}$$

where n is the number of iterations.

Equations (4) and (5) are iterated until the relative rankings of the values estimated using the (n + *1*)th and nth iterations are the same. These iterations yield two vectors: a vector characterizing each country, and a vector characterizing each product. In this article, Equations (4) and (5) are iterated sixteen times and seventeen times, respectively.

To understand how higher iterations of indicators yield more information regarding the complexity of countries and products, let us look at the additional benefit derived from moving from $K_{k,0}$ with $K_{k,1}$ and from $K_{j,0}$ with $K_{j,1}$. Note that $K_{k,0}$ represents the number of countries exporting a product (ubiquity). However, this measure does not give any information about the complexity of the countries exporting that particular product. Plugging $K_{jk,0}$ into Equation (4) yields $K_{k,1}$, which represents the average diversification of the exporting countries. Therefore, $K_{k,1}$ includes information regarding both the ubiquity of the product and the diversification of the countries exporting the product. $K_{j,0}$ reflects only the number of products exported by a country (diversification), which provides no information regarding the complexity of the exported products. Plugging $K_{k,0}$ into Equation (5) gives $K_{j,1}$, which denotes the average ubiquity of the products exported by that country. Additional information can be gathered about the country's diversification by plugging $K_{j,1}$ into Equation (4). This leads us to $K_{k,2}$, the average ubiquity of the products exported by countries that export product k. Likewise, $K_{k,1}$ leads us to $K_{j,2}$, the average diversification of countries exporting products similar to those exported by country j. In brief, higher-order iterations extract more relevant information about the complexity of the countries as well as the sophistication of the products.

Following Hausmann et al. (2011), we use Equation (6) for the economic complexity index:

$$\text{Economic Complexity}_j^t = \frac{K_j^t - \Sigma_c K_j^t / n}{\sigma_{K_j^t}} \tag{6}$$

where $\Sigma_c K_j^t / n$ is the yearly average across the European countries in the sample, and $\sigma_{K_j^t}$ is the yearly standard deviation. Our economic complexity index corresponds to the sixteenth iteration, K_j^{16}, for 1995, which is the first year of our period.

Hidalgo and Hausmann (2009) suggest that higher iterations of their method give information regarding the complexity of products in the export basket of countries, as well as the diversification of the countries connected to them, and thereby capture the set of capabilities available in a particular country. They empirically find that their measures of economic complexity are strongly correlated with income per capita, and that a country's future economic growth and, accordingly, its economic development rely heavily on the country's complexity. They confirm that their findings are valid for the 20-year period, two 10-year periods, or four 5-year periods between 1985 and 2005. Hausmann et al. (2011) also find that economic complexity has a significant impact on the future economic growth of countries for four 10-year periods between 1978 and 2008, controlling for initial income and natural resource exports. This indicator is widely used; for instance, Felipe et al. (2012) used it to rank 5,107 products and 124 countries. Using the economic complexity indicator of Hidalgo and Hausmann (2009) as a proxy for upgrading, Poncet and Starosta de Waldemar (2013) find a relationship between upgrading and economic growth in 200 Chinese cities.

DATA AND METHODOLOGY

We analyze the effect of initial economic complexity on economic growth in the EU countries, controlling for initial income per capita and the other determinants of growth à la Barro and Sala-i-Martin (1992). We use the beta-convergence regression specification with fixed effects found in Equation (7):

$$\begin{aligned}(\log y_{j,t+4} - \log y_{j,t})/4 = {} & a_0 + a_1 \log y_{j,t} + bComplexj, t + c_1 Inv_{j,t} \\ & + c_2 Open_{j,t} + c_3 FDI_{j,t} + c_4 Hum_{j,t} + \\ & + \gamma_j + \mu_t + \varepsilon_j \end{aligned} \tag{7}$$

where y denotes GDP per capita in PPP terms, j is the index of countries, and t is the index of years. Data on GDP per capita are taken from the latest update of the Penn World Tables. We test the model with 4-year subperiods starting from 1995 (1995–1998, 1999–2002, 2003–2006, 2007–2010).

Complex captures the economic complexity index explained in the previous section. We retrieve the export data to compute this index for each country in our sample from the Base pour l'Analyse du Commerce International (International Trade Database at the Product Level, BACI), as reported by Gaulier and Zignago (2010) from CEPII (http://www.cepii.fr/CEPII/en/welcome.asp). We first compute the product complexity for 5,017 products, covering trade at the 6-digit product level for 230 countries.[5] We then compute economic complexity for the twenty-five EU counties, including initial GDP per capita as a control variable. The ratio of gross capital formation to GDP (Inv) is a proxy for the rate of physical capital accumulation, and the share of labor force completed tertiary education is a proxy to control for human capital (Hum). Also included are imports plus exports over GDP, the openness rate, (Open), and FDI inflows over GDP (FDI) in the country. We use the average rates for investment, openness, FDI, and human capital for each 4-year subperiod. The control variables other than economic complexity and initial GDP per capita are taken from the World Development Indicators (WDI) database. Finally, the regression equations contain country dummies, time dummies, and error terms denoted γ_j, μ_t, and ε_j, respectively.

ESTIMATION RESULTS

Hidalgo and Hausmann (2009) find that economic complexity explains growth differentials across the world. We revisit the impact of economic complexity on growth in the context of the EU and EU expansion. A consensus is emerging in the literature about three aspects of growth within the EU. First, an increasing number of scholars find that there is income convergence in the EU. Second, they agree that convergence rates differ for old and new members. Third, there is a consensus that capital flows have been an important growth factor growth for new member countries. These three issues, on which there is broad consensus, are reconsidered from the standpoint of economic complexity in the current study.

In Table 1 we report the regression results for the twenty-five EU members for which the effect of economic complexity, capital flows, and their interaction is investigated. Regression (1) is our baseline regression, with complexity and other conventional variables in the growth regressions. Results show no significant relationship between complexity and growth. Initial GDP per capita has a significant and negative coefficient, indicating beta-convergence across EU countries. Investment rate enters with a significant and positive sign; however, our human capital measure unexpectedly enters negatively and significantly. This counterintuitive result is specific to EU countries, possibly because of the effect of some unique country characteristics during the sample period. In considering the reason, it is important to note that the formerly communist EU members have very high rates of tertiary education. Tertiary education has become more widespread everywhere, but especially in the more developed regions of the world, and thus this phenomenon is very strong in Europe.

Since our period coincides with a great European recession, we may be seeing rising rates of tertiary education coupled with low rates of growth. Openness rate and FDI enter positively, as expected, but with insignificant signs.

TABLE 1
Fixed-Effects Regression Results for Economic Complexity and Growth (EU total)

	GDP per capita growth, 1995–2010 (4-year sub-periods)		
	Benchmark		
	(1)	*(2)*	*(3)*
Complexity	−0.003	−0.003	0.008
	(0.01)	(0.01)	(0.01)
Initial GDP per capita	−0.110***	−0.110***	−0.104***
	(0.02)	(0.02)	(0.02)
Investment	0.267***	0.267**	0.212*
	(0.09)	(0.11)	(0.11)
Openness	0.010	0.010	0.004
	(0.02)	(0.02)	(0.02)
FDI	0.0001	0.0001	0.0001
	(0.0006)	(0.0006)	(0.0006)
Human capital	−0.162***	−0.162***	−0.148***
	(0.06)	(0.06)	(0.06)
CAB		−0.004	0.014
		(0.10)	(0.10)
CAB*complexity			0.104
			(0.06)
Observations	98	98	98
Groups	25	25	25
R^2	0.19	0.19	0.21

Notes: *, **, and *** indicate statistical significance at 10%, 5%, and 1% levels, respectively. Standard errors are in parentheses. Year effects are included.

If economic complexity cannot explain economic growth within the EU, the high growth performance of countries such as Latvia and Estonia must be due to different factors. Gill et al. (2012) claim that capital inflows to the emerging countries of Europe, in contrast to inflows to other parts of the world, have helped poorer countries grow faster, enabling convergence across Europe. Moreover, as Stojkov and Zalduendo (2011) show, foreign savings support growth in many emerging European countries. Figure 2 plots the average current account balance to GDP ratio of EU countries against their real GDP per capita growth in the period 1995–2010. A positive association between the current account deficit to GDP ratio and income growth is observed for a group of countries that includes Latvia, Romania, and Estonia, and this may explain their fast growth in the absence of high economic complexity. Therefore, in order to see the effect of capital inflows on the contribution of economic complexity to future economic growth, we add an interaction term to our regression equation. We use the current account balance to capture capital flows, so that our interaction term denotes the interaction between economic complexity and the current account balance to GDP ratio. In regression (2) the current account balance to GDP ratio is added to our baseline regression, and in regression (3), an interaction term is added between the current account balance to GDP ratio and complexity.

In regression (2), we see that when we add the current account balance to our growth regression as our measure of capital flows, nothing is affected. The coefficient of this variable is insignificant, and its inclusion in the regression does not change any of the significant or insignificant coefficients. When we add the interaction term in regression (3), complexity, current account balance, and the interaction terms remain insignificant, but now we observe some changes in the other coefficients. The changes are statistically significant but not large. However, the fact that the interaction term resulted in this change is an indication that there is

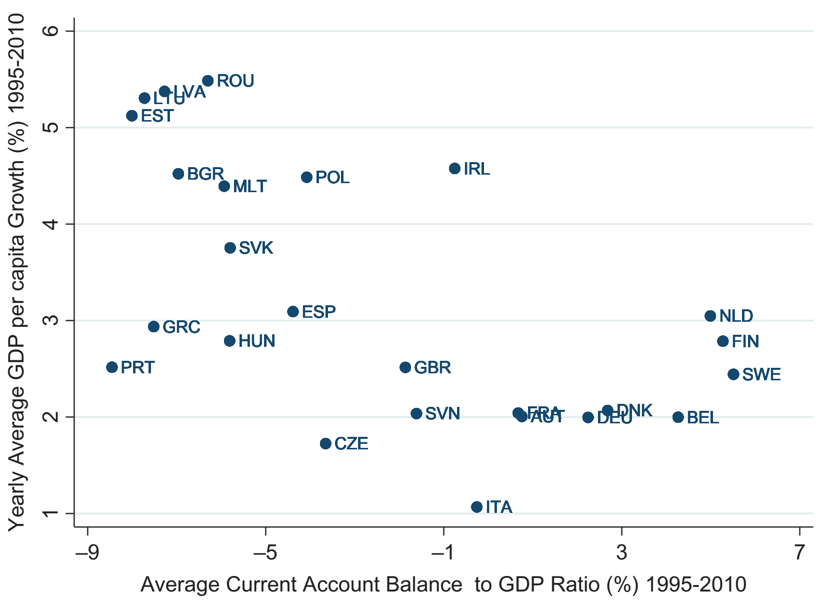

FIGURE 2 Economic Growth and Current Account Balance.

something there, but not strong enough to be identified in a statistically significant way in this sample. The probability value of the interaction term is slightly above 10 percent.

Our results suggest that initial complexity cannot explain the growth differentials in the EU, where the variation is much smaller than in a larger set of developed and underdeveloped countries. Although variations in GDP per capita and in economic complexity are not very high across EU countries, as compared to countries elsewhere in the world, levels of GDP per capita and economic complexity are far from uniform across the Union. In this context, it would be interesting to investigate whether there are any countries in the EU where economic complexity is associated with income growth, boosting beta-convergence among them. Therefore, we compute a yearly average complexity measure for each country. We categorize countries into two groups based on the complexity index. The first group includes Austria, Belgium, Czech Republic, Germany, Denmark, United Kingdom, Finland, France, Italy, Slovenia, Slovak Republic, Ireland, Netherlands, Poland, Hungary, and Sweden. These countries have an average complexity index higher than −0.22. The second group includes countries with an average complexity index smaller than −0.68, namely Bulgaria, Estonia, Spain, Lithuania, Latvia, Romania, Portugal, Malta, and Greece.[6] Figure 3 plots yearly average real GDP per capita growth against average economic complexity for the period 1995–2010. The figure shows that, among all adjacent countries in the EU, the largest gap between two adjacent countries is between Poland and Malta. Furthermore, most countries in both groups exhibit increasing economic complexity over the sample period. Poland and Hungary, but no other countries, reach positive levels of economic complexity toward the end of the sample period. Hence, if we had set the final (not average) complexity threshold at zero, we would end up with the same

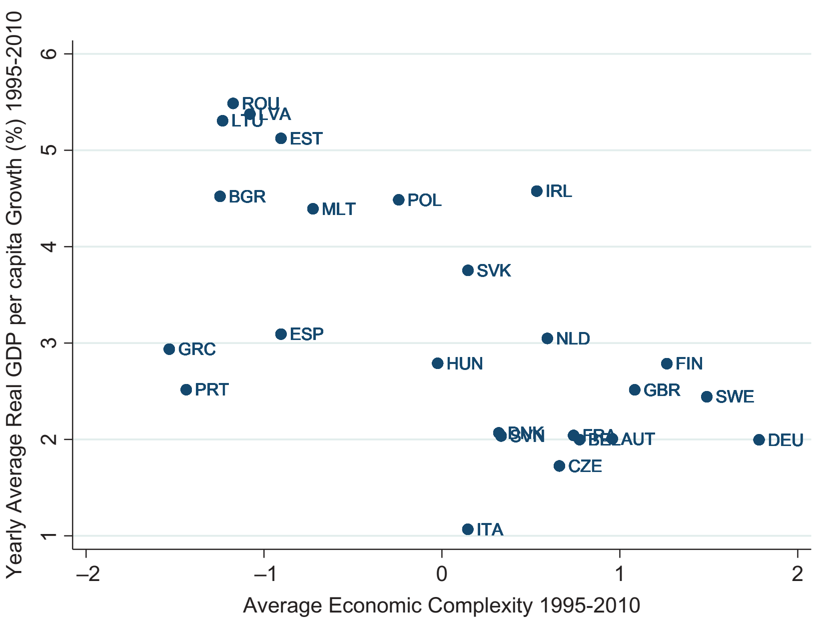

FIGURE 3 Average Growth and Average Complexity.

groups of countries. We therefore argue that several measures confirm that Poland and Hungary belong in the first group, but our results are robust regardless of which group Poland and Hungary are assigned to.

In Table 2 we present our regression results for the two different groups of countries. The regression results show that the economic complexity index is strongly associated with economic growth for the first group of countries. Moreover, the significant and negative coefficient of initial GDP per capita indicates a process of beta-convergence across this group of countries. Therefore, our results support the findings of Hidalgo and Hausmann (2009) that a group of countries in the EU with higher economic complexity tend to converge to levels of income corresponding to their measured complexity. Excluding Hungary and Poland from this first group produces no change in results.

For the second group, economic complexity has a significant but negative effect. Countries with lower levels of economic complexity have higher growth. This is undoubtedly possible only because of the trade patterns within the EU. Having the advantage of access either to the EU market or to other markets thanks to EU trade agreements, the new member countries have become producers of goods that do not require high economic complexity. Note that all the countries in this group have a negative economic complexity index.

TABLE 2
Fixed-Effects Regression Results for Economic Complexity and Growth (Group 1 & 2)

	GDP per capita growth, 1995–2010 (4-year sub-periods)					
	Group 1			*Group 2*		
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Complexity	0.043***	0.043***	0.043***	−0.042**	−0.050**	−0.168***
	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.03)
Initial GDP per capita	−0.144***	−0.144***	−0.144***	−0.078***	−0.083***	−0.058***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Investment	−0.041	−0.042	−0.023	0.22	0.32*	0.037
	(0.12)	(0.12)	(0.13)	(0.15)	(0.18)	(0.16)
Openness	−0.036	−0.036	−0.033	0.048	0.057	0.058
	(0.02)	(0.02)	(0.02)	(0.04)	(0.05)	(0.03)
FDI	−0.0006	−0.0006	−0.0007	0.0019	0.0026	0.0014
	(0.0005)	(0.0005)	(0.0005)	(0.0015)	(0.0016)	(0.0013)
Human capital	−0.083	−0.084	−0.089	− 0.085	−0.046	−0.033
	(0.06)	(0.06)	(0.06)	(0.11)	(0.11)	(0.09)
CAB		−0.015	0.064		0.205	−1.647***
		(0.09)	(0.15)		(0.20)	(0.50)
CAB*complexity			−0.085			−1.418***
			(0.12)			(0.37)
Observations	63	63	63	35	35	35
Countries	16	16	16	9	9	9
R^2	0.15	0.15	0.15	0.19	0.20	0.23

Notes: *, **, and *** indicate statistical significance at 10%, 5%, and 1% levels, respectively. Standard errors are in parentheses. Year effects are included only for group 1.

We find that neither the current account balance nor its interaction with complexity has any effect on growth for countries in the first group. In contrast, for the second group, comprising countries with low levels of economic complexity, we find that both capital flow and its interaction with complexity are significantly important. The coefficient of current account balance is negative and significant, indicating that higher deficits lead to high growth. However, this effect is stronger for countries with higher complexity. Our empirical results suggest that the impact of economic complexity on growth increases with current account surplus, consistent with our previous result.

By dividing the countries based on the complexity threshold, we are able to uncover the effect of complexity on growth, but the investment and human capital variables lose significance. We observe different rates of convergence for the two groups of countries. The speed of convergence for the first group is double that of the second; therefore we argue that catching-up is much faster for countries whose economic complexity reaches a certain threshold.

In Tables 3 and 4, we report the first difference and GMM (generalized method of moments) estimates to check for the robustness of our results. Fixed effects perform better when the errors are serially correlated. Both first differences and fixed effects are biased when there is endogeneity; hence comparing the estimates from fixed effects and first differences can help detect endogeneity. The estimated coefficients of statistically significant variables are similar for group 2 countries. The complexity variable is found to be negative and significant at the 10 percent level of significance for the whole sample, but insignificant for group 1 countries. Both of these results are consistent with previous findings.

Owing to concerns about the endogeneity of complexity with variables like investment and openness, we also investigate the use of first difference and GMM estimators à la Arellano and Bond (1991), Arellano and Bover (1995), and Blundell and Bond (1998). The sample of group 2 countries is too small for GMM estimation to be viable, so we report these results only for the EU total and group 1 countries. Moreover, the similarity of first-difference and fixed-effects estimators for group 2 suggests the validity of the strict exogeneity assumption.

In Table 4, we report two-step coefficient estimates with robust standard errors. We also report the Sargan test from the two-step estimation without robust standard errors and AR(1) tests from the two-step robust estimation. The difference GMM is valid under the null hypothesis of no autocorrelation. This hypothesis needs to be tested for second-order serial correlation, which was impossible with so few time periods. The AR(1) test results show no first-order serial correlation. However, note that this finding alone is not sufficient to conclude that this method of estimation is valid for this model and this sample. Similarly, we report the Sargan test, in spite of selecting robust standard errors. The Sargan test is only valid under the null hypothesis of homoscedastic errors; it overrejects in the presence of heteroscedasticity in one-step estimation and underrejects in two-step estimation (Arellano and Bond 1991). Finally, Roodman (2009) warns against using too many instruments, and presents the sensitivity of the bias to the number of instruments. Even though the number of cross-sections is suggested as the upper limit for the number of instruments, he recommends using significantly fewer. The number of instruments for the regressions estimated for the whole sample is reasonable, given its size. The number of instruments for group 1 countries is close or equal to the number of countries; hence it is borderline regarding this requirement. The shortcomings of the regressions in Table 4 notwithstanding, we find that complexity increases growth for group 1 countries, confirming our previous results. We also find that the interaction of the current account balance with complexity is positively associated with growth both for group 1

TABLE 3
First Difference Regression Results for Economic Complexity and Growth

	GDP per capita growth, 1995–2010 (4-year sub-periods)								
	All countries			*Group 1*			*Group 2*		
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
Complexity	−0.021*	−0.022*	−0.016	0.231	0.218	0.024	−0.054***	−0.058**	−0.185***
	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)
Initial GDP per capita	−0.084***	−0.084***	−0.085***	−0.089***	−0.088***	−0.090***	−0.093***	−0.097***	−0.059***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.02)
Investment	0.283***	0.297**	0.264**	0.165	0.196	0.156	0.270*	0.354	0.004
	(0.09)	(0.12)	(0.13)	(0.15)	(0.16)	(0.16)	(0.15)	(0.22)	(0.17)
Openness	0.039	0.039	0.036	0.031	0.031	0.029	0.037	0.039	0.081
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.05)	(0.03)
FDI	0.0003	0.0003	0.0003	0.0000	0.0001	0.0001	0.0012	0.0016	0.0005
	(0.0005)	(0.0006)	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0016)	(0.0018)	(0.0013)
Human capital	−0.118*	−0.117*	−0.117*	−0.121*	−0.124*	−0.117*	−0.060	−0.044	−0.115
	(0.06)	(0.06)	(0.06)	(0.07)	(0.07)	(0.07)	(0.13)	(0.14)	(0.10)
CAB		0.021	0.046		0.066	−0.107		0.12	−2.075***
		(0.12)	(0.12)		(0.14)	(0.22)		(0.23)	(0.50)
CAB*complexity			0.091			0.202			−1.667***
			(0.08)			(0.19)			(0.036)
Observations	73	73	73	47	47	47	26	26	26
Countries	25	25	25	16	16	16	9	9	9
R^2	0.43	0.43	0.44	0.46	0.46	0.48	0.57	0.57	0.81

Notes: *, **, and *** indicate statistical significance at 10%, 5%, and 1% levels, respectively. Standard errors are in parentheses.

TABLE 4
GMM Regression Results for Economic Complexity and Growth

	GDP per capita growth, 1995–2010 (4-year sub-periods)											
	Difference GMM						*System GMM*					
	All countries			*Group 1*			*All countries*			*Group 1*		
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*
Complexity	−0.005	−0.008	−0.001	0.029***	0.023**	0.022**	−0.011	−0.010	−0.005	0.022*	0.016	0.018
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.03)	(0.03)	(0.01)	(0.02)	(0.02)
Initial GDP per capita	−0.145***	−0.145***	−0.142***	−0.170***	−0.170***	−0.172***	−0.032	−0.032	−0.052*	−0.069***	−0.063**	−0.060*
	(0.03)	(0.03)	(0.03)	(0.04)	(0.03)	(0.04)	(0.01)	(0.03)	(0.03)	(0.02)	(0.03)	(0.03)
Investment	0.230***	0.264**	0.234**	0.146	0.213	0.214	0.008	−0.017	0.008	0.018	0.094	0.112
	(0.08)	(0.11)	(0.11)	(0.12)	(0.16)	(0.14)	(0.10)	(0.15)	(0.15)	(0.09)	(0.12)	(0.13)
Openness	0.019	0.020	0.020	−0.026	−0.020	−0.018	0.026	0.025	0.021	−0.011	−0.002	−0.002
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.02)	(0.12)	(0.03)
FDI	−0.0001	0.0000	0.0001	−0.0004	−0.0002	−0.0002	−0.0003	−0.0004	−0.0002	−0.0006	−0.0005	−0.0005
	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0005)	(0.0005)	(0.0004)	(0.0005)	(0.0005)
Human capital	0.003	0.0002	0.006	0.027	0.066	0.061	−0.047	−0.048	−0.115	−0.049	0.024	0.027
	(0.08)	(0.08)	(0.09)	(0.09)	(0.08)	(0.08)	(0.05)	(0.09)	(0.10)	(0.10)	(0.11)	(0.11)
CAB		0.52	0.070		0.114	0.153		−0.031	0.029		0.066	−0.0002
		(0.08)	(0.08)		(0.10)	(0.25)		(0.18)	(0.14)		(0.15)	(0.28)
CAB*complexity			0.090***			−0.043			0.142**			0.091
			(0.03)			(0.09)			(0.07)			(0.14)
Observations	50	50	50	32	32	32	75	75	75	48	48	48
Countries	25	25	25	16	16	16	25	25	25	16	16	16
Instruments	12	13	14	12	13	14	14	15	16	14	15	16
Sargan test	0.21	0.22	0.48	0.06	0.011	0.0006	8.32	8.05	9.69	2.86	3.38	3.24
p-value	0.90	0.89	0.79	0.97	0.99	0.99	0.08	0.09	0.05	0.58	0.50	0.52
AR(1)	0.27	0.41	0.33	0.45	0.42	0.47	−0.21	−0.14	−0.30	0.65	0.69	0.66
p-value	0.78	0.68	0.74	0.66	0.67	0.63	0.83	0.89	0.76	0.52	0.49	0.51

Notes: *, **, and *** indicate statistical significance at 10%, 5%, and 1% levels, respectively. Standard errors are in parentheses.

countries and the whole sample, although the size of the effect is much smaller than the effect of the interaction variable for group 2 countries.

Finally, considering the possible effect on the results of the global financial crisis of 2008, we run our regressions omitting the last subperiod, which starts in 2008. Our results are not affected. These results are not reported but are available from the authors upon request.

All in all, our article argues that there are two groups of countries in the EU. The first group consists of countries with higher economic complexity indices tending to converge to levels of income corresponding to their measured complexity, as evidenced by Hidalgo and Hausmann (2009). The second group mostly consists of countries with lower economic complexity and higher GDP per capita growth; for this group, lower economic complexity is associated with higher growth. We also provide evidence for income convergence within the EU, but at differing rates for the two groups of member countries. In addition, we show that the interaction of capital flows with economic complexity is important for growth for a group of countries in the EU. Rather than subscribing to the traditional division of EU members as old and new, we offer an alternative based on economic complexity.

CONCLUSION

Our results indicate that there is a strong association between economic complexity and growth over the 1995–2010 period in a group of EU countries with higher economic complexity, supporting the evidence presented by Hidalgo and Hausmann (2009). Countries with an initial complexity index exceeding a certain threshold are found to grow faster. Convergence is twice as fast within this high-complexity group. Thus, we argue that convergence is much faster across countries whose economic complexity exceeds a certain threshold.

In contrast, there is a negative correlation between economic complexity and future economic growth for the second group of countries, where economic complexity is lower. We also find that the impact of economic complexity on growth decreases with the current account deficit across the second group. This is a strong indication of the reason why this group of countries can achieve high growth rates without high levels of economic complexity.

Subsequent research should focus on the explicit mechanisms by which some European countries develop the capability of producing more complex products that are conducive for future growth.

ACKNOWLEDGMENTS

The authors would like to thank Alper Duman and participants of the Seventh Conference on Economic Challenges in Enlarged Europe, held on June 14–16, 2015, in Tallinn, Estonia, for their comments and discussions.

NOTES

1. Lower-income new members grew faster than the core members of the EU between 1995 and 2011, except for the years of global crisis starting in 2008, and there were growth disparities among them.

2. Beta-convergence can be unconditional (absolute) or conditional, the latter meaning controlling for other country-specific variables than initial income per capita. Empirical applications of the hypothesis originate with Barro and Sala-i-Martin (1992), Baumol (1986), and Mankiw, Romer, and Weil (1992). We focus on articles that examine real income per capita convergence in the enlarged EU.
3. Employing an econometric analysis adapted from a neoclassical growth model augmented with endogenous technological progress, which varies across countries and over time, Borsi and Metiu (2015) find no evidence of real income convergence within the EU for either 1995–2010 or 1970–2010. Yet they identify a separation between new EU members and the old member countries in the long run. Our article is mostly related to previous literature as we follow the neoclassical growth theory with exogenous technological process.
4. We exclude Luxembourg, Cyprus, and Croatia from our analysis due to data limitations.
5. Hidalgo and Hausmann (2009) worked with the SITC rev. 4 (772 products, 129 countries), the HS at the 4-digit level (1,241 products, 103 countries), and the NAICS at the 6-digit level (318 products, 150 countries). The trade data are from the UN Commodity Trade Statistics.
6. We opted to divide the countries into two groups based on the complexity threshold of −0.25. Separating the two groups at the 0 threshold puts Hungary and Poland in group 2. Our main findings are robust to this particular choice of threshold. The results for this alternative grouping are available from the authors upon request.

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