Public – Private Capital Relationship in Emerging Europe

Abstract

The aim of this paper to evaluate the relationship between public and private capital formation in 16 economies from Central Eastern and South Eastern Europe, by applying panel-cointegration method to 2000-2017 data. We find positive public-private capital formation nexus both in the short and the long-run, with pro-cyclicality of private capital formation and negative relevance of the user costs of capital. The results imply that expansionary public investment policy may be effective in boosting private investment both in the short and the long-run, if fitted into the financially sustainable framework that limits negative impact of the user cost of capital.

Keywords: private investment, public investment, crowding-in hypothesis, emerging Europe

JEL classification: E22, H54, O16, O52, P33

1. Introduction

Investment is a fundamental driver of long-run growth and economic resilience. Despite this, in the years following the global financial crisis, capital investment has suffered a double blow – as austerity policies and fiscal consolidation programs constrained the capacity of national governments to expand *public* investment (Capraro and Perrotini 2013; Pianta 2016) and as uncertainty and heightened systemic risks, including the COVID-19 pandemic and more recently the war in Ukraine and the energy price hikes, have hampered significantly *private* investment (Buti and Mohl 2014; Banjeree et al 2015; Panagiotidis and Printzis 2020; IMF 2020; Cerra et al 2021; Andersson et al 2022). Reversing this trend entails a fundamental

puzzle. Should policy prioritize public investment, to compensate for the subdued rates of private investment and perhaps even to stimulate their recovery? Or should it reduce government spending (and borrowing), so as to allow the fiscal and financial space for private investment to recover? Inversely, should policy prioritize at stimulating private investment, presumably through market deregulation and favorable taxation policies; or should it rather support an expansionary public investment program, aiming at stimulating private activity through demand spillovers and improvements in infrastructure? At the heart of this dilemma lies the question concerning the link between private and public investment. If public investment crowds-out private investments, then indeed priority focus should be placed on accelerating private investment. But if public investments have the ability to crowd-in private investments, it may be more appropriate for policy efforts to focus on public investments – whether funded through borrowing, through taxation or – in the European context – through EU-sponsored financing instruments.[1]

While the challenge posed by these questions is global, the new economic environment constitutes a particular threat to emerging and developing economies, where public capital is less developed and the productivity of private investments is lower (Ram 1996); and where fiscal space is much more constrained (Ayhan 2017; Monastiriotis and Tunali 2020). In the specific context of the emerging economies from Central Eastern and South Eastern Europe (CESEE) this entails the additional challenge of keeping up with their process of real economic convergence with the pre-2004 EU member states (henceforth, old-EU). While in the pre-crisis period these countries were registering much stronger increases in both public and private capital compared to the old EU, their level of capital stock still remains today significantly lower.

[1] See Kellermann (2016) for a discussion of the effects of different types of financing public investment.

Recent evidence for the Eurozone countries (Dreger and Reimers 2016) has shown a positive long-run relationship between public and private investment as well as between public and private capital stocks, with the direction of causality running from public to private. In the CESEE countries and in the context of transitioning/convergence economies, the role of public investments may be even more important, as (public) infrastructure bottlenecks may be reducing the productivity of private capital and thus the returns to private investments – resulting potentially in a lower volume, and slower acceleration, of private investment in these countries (Nevile and Kriesler 2014). Indeed, the scant literature on the topic focusing on emerging Europe has provided empirical evidence suggesting that, in the countries of Central and Eastern Europe (CEE), government spending multipliers are significantly higher when the output gap is negative (Baranowski et al. 2016) and there are strong growth effects associated to public investment (Petrović, Arsić, and Nojković 2021). Masten and Grdović Gnip (2019) show that in the long-run public investments tend to crowd-in private investments and foster economic growth also in five countries from South Eastern Europe (SEE).

Motivated by these observations the aim of this paper is to add to the scant literature on the topic by offering a more comprehensive investigation of the interplay between public and private investment in the broader group of countries constituting what is known as 'emerging Europe' and comprising the new (post-2004) EU member states (CEE or European periphery) and a subset (due to data limitations) of the associated candidate countries (SEE or European super-periphery). In doing so, we evaluate and compare this relationship in both the short and long-run; and we differentiate and contrast the public-private investment nexus between the two groups of countries. We extend the existing literature by estimating the public-private relationship both on a stock (public and private capital) and a flow base (public and private investment), thus delving deeper into the adjustment dynamics that may be driving the

fundamental relationships. On the whole, then, our contribution is multifaceted. We provide new and original evidence on the question as to whether expansionary public investment policy in emerging Europe can be used to stimulate an increase in private investment , adding to the empirical literature on this topic by (i) providing results for a broader cohort of countries over a longer time-period (16 countries over 18 years), (ii) differentiating between short- and long-run effects, (iii) taking into account the role of adjustment dynamics (deviations from equilibrium), and (iv) differentiating and contrasting the strength of the public-private relationship for different sub-groups of countries within the CESEE region, with different degrees of economic development, association to the EU and access to international capital markets, thus providing significant insights, which are both of academic and of policy interest.

More specifically, we estimate cointegration and error correction models which allow us to consider the long-run equilibrium capital stock in our analysis (rather than concentrate exclusively on the flows of investment). To complement this, we also examine the short- and long-run dynamics of public and private investment via an investment equation which incorporates, in addition to national output and the user cost of capital (reflecting demand and price effects, respectively), the deviation of private and public capital stock from equilibrium. We find robust evidence of a positive short and long-run relationship between public and private capital formation, which applies more strongly to the less capital-endowed EU-associated countries of South Eastern Europe. Private investment appears to respond negatively to increases in the user cost of capital and to adjust only very slowly to deviations from the long-run equilibrium. These results confirm recent evidence for more advanced economies about a crowding-in mechanism for public investment in the long-run (Hatano 2010; Dreger and Reimers 2016).[2] However, opposite to the findings for developed countries, we show that

[2] As noted earlier, similar evidence for the long-run relationship has also been offered for the countries in the CEE region (Masten and Grdović Gnip 2019).

in the emerging European economies public investment may yield positive impact on private investment already in the short run. Therefore, our results may suggest that fiscal policy focused on raising public investment may be effective in promoting private capital formation and economic growth in all CESEE countries (and especially in the less developed of these economies, such as Albania, Bosnia and Herzegovina, Montenegro, North Macedonia, Serbia).

The remainder of the paper is structured as follows. In the next section we review the recent empirical literature on the topic and discuss the theoretical and policy questions surrounding the issue of public and private investment in transitioning economies. The third section presents some stylized facts and descriptive statistics about the distribution of public and private capital stock in the CESEE region and comparatively to the old-EU. The fourth section elaborates on our method and data; while the fifth section presents our empirical results. The last section concludes with a discussion of the implications and policy relevance of our results.

2. Literature Review

Neo-classical economic theory predicts that government expenditures have an adverse effect on private capital accumulation, via the crowding-out mechanism. This can take two forms: first, through a price effect, if government finances its investments by borrowing money from financial markets thus inducing a rise in real interest rates, which discourages private investments; second, through a quantity effect, if government finances its investments by issuing bonds, thus reducing the amount of savings in the economy (David and Scadding 1974).[3] Additionally, public investments may displace private investment by limiting the range of investment opportunities that are available for the private sector. This may be particularly relevant in a context of transitioning and emerging economies (e.g., in relation to privatization programs, or via creaming-off effects whereby the public sector absorbs a limited supply of

[3] These effects can of course be compounding. For example, Demirel, Erdem, and Eroğlu (2017) show, for the case of the Eurozone, that government debt, government expenditure, interest rates and budget deficits all affect private investment negatively.

highly-skilled individuals away from the private sector – Faggio and Overman 2014). On the other hand, the literature also identifies potential positive effects from public investments on the accumulation of private capital. The main of these, concerns the ability of public capital to crowd-in private investments by increasing the productivity of private capital, thus encouraging private investments (Aschauer 1989; Nevile and Kriesler 2014). In addition to this, Giulia (2016) has demonstrated more recently an indirect effect on private investment, emanating from the ability of public investment to stimulate industrial restructuring, thus helping direct private investment into new or more productive activities. Both of these channels may be particularly relevant for transitioning and emerging economies, where (public) infrastructure bottlenecks are likely to be more pervasive and where industrial structures need modernization. Last, a positive effect on private investment may come through the so-called 'accelerator' effect: to the extent that public investment raises incomes and consumption, it ought to stimulate private investment (Knox 1952).

On this basis, the net impact of public investments on private investments is the result of two competing effects: *i) crowding-out* effect, which is triggered by increases in the interest rate or by deviations from the long-term equilibrium in terms of the capital stock; and *ii) crowding-in* effect, which is the consequence of the positive impact of public capital on private demand, the emergence of new sectors and on the productivity of private capital.

The empirical literature has sought to address this issue by examining the relationship between public and private capital, public and private investments, or both.As mentioned already, in an early study of the issue, Aschauer (1989) specified a simultaneous equations model with a private investment function and a production function whereby the returns to private capital were dependent on the stock of public capital. Estimating this model using data for the USA, for the period 1925-1985, Aschauer (1989) found a net crowding-in effect. A similar net crowding-in effect was found by Argimon et al. (1997), based on data for 14 OECD countries

for the period 1979-1988. In contrast, using a larger set of data for 25 OECD countries (for the period 1958-1988), Bairam and Ward (1993) have found evidence that public investments crowd-out private investment. Similar results have been obtained by Kitaoka (2002) who tested the crowding-out hypothesis for Japan and Australia by means of a private investments function which included public investment as an independent variable.

The approach based on contemporaneous flow variables (investment) has been criticized from a theoretical stance, as intuitively crowding-in effects may take time to materialize. If, as theory predicts, private investments rise as a result of public investment raising the productivity of private capital, one would expect the crowding-in and crowding-out effects to have a very different time-profile and horizon. Considering this critique, a set of empirical studies has emerged that utilize vector autoregression (VAR) models – mostly using data for the USA and Japan. Some of these studies find support for the crowding-in hypothesis (Pereira 2001), while other studies arrive at opposite conclusions (e.g., Voss 2002). Afonso and Aubyn (2018) apply the VAR method to long-term panel data for 17 OECD countries and find that in some developed countries (Belgium, Ireland, Finland, Canada, Sweden, the UK) public investments crowd-out private investment, while in the rest of the countries the crowding-in effect prevailed. Such differentiation may well be related to each country's institutional context or other country-specific factors. For example, in a recent study for India, Bahal et al. (2018) found evidence of both crowding-in and crowding-out, with the former effect becoming dominant after the period of pro-market liberalization reforms since the 1980s. In turn, the empirical analysis of Bom (2017), based on a general equilibrium model with factor-biased public capital, provided evidence that the relationship between private and public investment critically depends on the labor supply elasticity and the elasticity of substitution between private inputs. In their study on China and the US, Ari and Koc (2020) found public investments to crowd-in private investment in China, while the reverse pattern of causality was identified

for the US; with the overall relationship being non-linear. A non-linear relationship (inverted U-shaped) was also found by Nguyen (2018) using data for Vietnam – which the author interprets as showing that public investment crowds-in private investment in the short-run but crowds-out private investment in the long-run. On the whole, the evidence produced in this literature, by both more traditional approaches with static models and studies adopting more dynamic specifications, remains inconclusive.

More recently, the empirical literature on the topic has utilized cointegration techniques to evaluate the relationship between private and public capital accumulation. Reflecting on the fact that crowding-out and crowding-in can be viewed as the short-run (flow) and long-run (equilibrium) components of the public-private capital relationship, this approach is developed on the assumption that a cointegration relationship may be established between public and private capital *stocks*, with the corresponding flow variables (public and private investments) being linked to each other through a deviations-adjustment mechanism (so that, for example, private investment accelerates when the ratio of public-to-private capital stock exceeds its equilibrium value). This is consistent with the view that in the long-run there is an equilibrium in terms of the private and public capital stock *ratio*, so the change in private and/or public investment dynamics is a matter of adjustment, aimed at bringing the relative capital stocks back to equilibrium. Based on this approach, Hatano (2010) using annual data for Japan for the period 1956-2004 found a positive cointegration relationship between public and private capital stock in the long run (crowding-in) and a negative relationship between public and private investments in their error correction model (crowding-out in the short run). A similar approach was applied by Dreger and Reimers (2016), who exploited annual data from 1991 to 2012 for 12 Eurozone countries, providing evidence in favor of the crowding-in hypothesis in the long-run, but no statistically significant impact of public on private investments in the short run.

Despite the obvious importance of the issue to transitioning and emerging economies such as those of the CESEE region, most of the empirical literature on this topic is dealing with developed countries, while empirical literature on emerging economies is scarce. Ouédraogo et al. (2020) used data for 42 sub-Saharan countries over the period 1980–2015 and found a negative relationship between public and private investment, but only in the countries with high risks of instability – consistent with the earlier observation concerning the role of country-specific factors for the examined relationship. In the European context, most evidence concerning emerging economies concentrates on the effect of public *debt* (as opposed to public *investment*) on private investment – but, again, with inconclusive results. The study by Ganic, Hodzic, and Ridic (2021) found that public borrowing crowds-out private investment in both the long-run and the short-run in European post-transition countries, while in European transition countries the effect is pronounced only in the long run.[4] On the other hand, Avdimetaj, Marmullaku, and Haziri (2021) showed that raising public debt can have a positive effect on economic growth in European transition economies, to the extent that borrowing is directed to public investments. More specific to the topic, Masten and Grdović Gnip (2019), constructed a dataset of exogenous changes in public *investment* and, using the local projections method, found significant multiplicative effects of public investment on GDP in South Eastern Europe, delivered primarily through crowding-in of private investment. To our knowledge, there is no further literature on this issue for the countries of the European super-periphery (SEE region) and no study that has empirically examined this issue for the entire CESEE region as a whole – nor is there any empirical evidence on the interplay between public and private investment in these countries in the short and the long-run. The analysis presented in the remainder of this paper aims to fill this gap.

[4] A similar result was found for a sample of 26 EU-member states by Picarelli et al. (2019).

3. Stylized Facts

Our CESEE sample includes 16 countries all of which went more or less successfully through the process of post-communist transition, aimed to establish functioning market-based economies. In that process, these countries have posted significant economic growth and tangible convergence to developed European countries in terms of economic development (Randjelovic, 2022). Although all of these countries share the socialist heritage as the starting framework, there are pronounced discrepancies between them, in terms of institutional and political development. Thus, according to the World Bank classification, seven of them (mostly from South Eastern Europe - SEE) are considered upper middle income countries, while the remaining nine (mostly from Central and Eastern Europe – CEE) fall into the high income countries group. This categorization is largely reflected also in the status of these countries in relation to the EU: the CESEE region includes 11 countries that became EU member states in 2004, 2007 or 2013 (Bulgaria, Croatia, Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia) and five countries that are prospective EU members (four candidate countries – Albania, Montenegro, North Macedonia and Serbia – plus Bosnia and Herzegovina, which has the status of 'potential candidate'). By virtue of their membership to the EU, the countries belonging to the CEE sub-sample have higher levels of economic development, broadly speaking more stable economic and political institutions, higher rates of FDI inflows and less restricted access to financial markets; while they receive significantly larger amounts of financial transfers from the European Union. In contrast, and despite receiving significant assistance from the EU, both in financial and in technical terms, the countries belonging to the SEE group are more exposed to international business cycle fluctuations and systemic risks. This is because, while they may be less integrated with the EU economy and the international financial system, they have at the same time a much weaker

domestic capital base (including domestic savings). It is at least in this sense that the two groups are often referred to as the European periphery and European super-periphery, respectively (Bartlett and Prica 2017).

Linked to the process of EU association, all CESEE countries have received significant investments both in private and in public capital in the last few decades. As a result, public and private capital stocks in these countries increased sizably and notably faster than in the old-EU, indicating convergence in terms of capital endowments. The growth of capital stock was particularly high for private capital. As is shown in Table 1, whereas the increase in the public capital stock in the period 2000-17 was broadly speaking comparable to the cumulative GDP growth over the period (76% and 71%, respectively), private capital stock grew faster (by 87%) at an average of 61 percentage points higher than in the old EU member states – with private investments as a share of GDP exceeding those seen in the old-EU by 1.26 percentage points annually.

[Table 1 near here]

In spite of these positive trends, the CESEE countries are still lagging considerably behind the old EU member states in terms of capital *stock* – both public and private. That gap is particularly pronounced in respect of private capital. In 2017, total private capital (in per capita terms) was on average 2.4 times higher in the old EU member states than in the CESEE region; while for public capital the ratio stood at 1.7. Thus, although the capital endowment gap comparing to the old EU member states has been slightly narrowed since the year 2000, it is still pronounced. This is especially so in the countries from the so-called super-periphery. As is shown in Figure 1, total private and public capital stocks are on average higher by more than 50% in the CEE countries compared to the countries in the SEE group. And while the gap between the Central and Eastern Europe (CEE) and South Eastern Europe (SEE) countries in terms of private capital endowment has narrowed by 5.5 percentage points from 2000 to 2017,

the public capital stock gap has remained almost unchanged in the same period. At the same time, country differences in capital stock levels appear quite persistent. In the period 2000-17, correlation between public and private capital stocks across the CESEE countries was very high, standing at 0.97 (viz. a value of 0.57 in the same period for the old-EU– see Table 1).

[Figure 1 near here]

The observed heterogeneity and gaps in public and private capital stocks across the CESEE region and in relation to the old EU highlight the need for attaining strong and sustained growth in fixed capital formation in the region in the coming decades. Governments can contribute to that objective, by means of larger allocations to public investments through investment-oriented fiscal policies. However, the overall effect of such policies on the total capital stock in the economy depends also on the impact that higher public investments may have on private investments dynamics. In the next section we explain our econometric approach to examining this.

4. Methodology and Data

As noted earlier, the traditional approach to assessing the relationship between private and public investments, by considering their contemporaneous reaction, has been criticized for not considering the long-run equilibrium connecting the two aggregates. As demonstrated by Aschauer (1989), the long-run equilibrium between these two flow variables (public and private investments) is established on the stock phase, i.e., it concerns the balance between public and private capital stocks. To see this, start from the standard Cobb-Douglas production function, in which physical capital is disaggregated into private capital stock (PCS) and public (government) capital stock (GCS):

$$Y_t = A_t L_t^{\alpha} PCS_{t-1}^{\beta} GCS_{t-1}^{\gamma} \quad (1)$$

where Y_t is real output in period *t*, A reflects total factor productivity and L stands for labor. If capital is accumulated optimally, private capital productivity $\beta Y_t/PCS_{t-1}$ and public capital productivity $\gamma Y_t/GCS_{t-1}$ are equal to private and public interest rates (*m* and *n*) respectively. Although the interest rates for the public and private sectors can differ, under the arbitrage condition they are expected to move in parallel so that the ratio between the two (π) is constant. If $m_t = \pi n_t$, then there is a functional relationship between public and private capital, which can be specified as follows:

$$PCS_t = (\frac{\beta}{\pi\gamma})GCS_t \quad (2)$$

or, in log-linear form:

$$lnPCS_t = \alpha_0 + \alpha_1 lnGCS_t + e_t \quad (3)$$

Equation (3) suggests that there is a stable long-run relationship between private and public capital stock, which then also implies a relationship between the growth of private and public capital (i.e. private and public investments). As has been shown (Kalyvitis 2003), the relationship applies also when the production function exhibits increasing returns (endogenous growth models).

In our empirical analysis we follow this approach, as has also been applied by Hatano (2010) and Dreger and Reimers (2016). We start by testing the stationarity of the respective panel data, using the Pesaran (2007) and Im-Shin-Pesaran (2003) unit root tests. Subsequently we examine the presence of a cointegration relationship in equation 3, evaluated using the Westerlund (2007) and Pedroni (1999) cointegration tests. To further distinguish between the short and long run effects, we estimate the error correction model of the capital stock equation:

$$\Delta lnPCS_{it} = \beta_0 + \beta_1 \Delta lnGCS_{it} + \beta_3 e_{it-1} + \mu_{it} \qquad (4)$$

The estimated coefficients α_1 in equation 3 and β_1 in equation 4 capture, respectively, the long-run and short-run elasticities of public capital to private capital stock. Positive values of these coefficients suggest that public and private capital are complementary, which in turn can be taken as suggesting that the crowding-in hypothesis holds.

An alternative approach to examining the relationship between public and private investments, while taking into account the long-run equilibrium of the stock aggregates, is through an investment function approach, as suggested by Hatano (2010). This approach may also serve as the way to check the robustness of the findings based on the capital stock model. In this approach, (log) private investment (PIN) is determined in the long-run under the following relationship:

$$lnPIN_{it} = \gamma_0 + \gamma_1 lnY_{it} + \gamma_2 ln\ddot{I}_{it} + \gamma_3 \ln DEV_{it-1} + \varepsilon_{it} \qquad (5)$$

Equation (5) includes the standard drivers of investment – namely output, usually measured with real GDP (Y_{it}), and the user cost of capital ($\ddot{I}_{it}$), which is measured using real interest rates (Eklund 2013; Dreger and Reimers 2016). Additionally, the investment function includes a deviation variable (DEV), derived as a residual from the long-run relationship between private and public capital stock (equation 3). Introduction of this variable allows us to examine whether private investments respond to temporary deviations of the private capital stock from its long-run equilibrium path. More specifically, the rationale underpinning this variable is that, as long as a cointegration relationship exists between private and public capital stock, indicating that there is a long-run equilibrium between the two, whenever the system deviates from equilibrium, private and public investment dynamics are expected to enter into motion to correct for this deviation.

As suggested by Dreger and Reimers (2016), it is possible to extend this analysis to capture the relevance of flow-variables adjustment dynamics (in terms of private and public investment), through a deviations-adjustment mechanism. This can be done by means of the following investment function:

$$\Delta lnPIN_{it} = \varphi_0 + \varphi_1 \Delta lnGIN_{it} + \varphi_2 \Delta lnY_{it} + \varphi_3 \Delta ln\ddot{I}_{it} + \varphi_4 \varepsilon_{it-1} + \omega_{it} \quad (6)$$

where ε_{it-1} is (the lag of) the error term from equation (5). Negative values for the φ_4 coefficient would suggest that declines in the private-to-public capital ratio, caused by increases in public capital, would trigger rises in private investments in order to restore long-run equilibrium. This would be equivalent to a crowding-in process.

We apply these two sets of tests on a sample comprising a panel of annual data covering 16 CESEE countries from 2000 to 2017.. To test for possible heterogeneity in the relationships under investigation across the two groups, we repeat our analysis separately and compare the results for the two sub-samples as discussed above (11 new EU-member states mostly from CEE and five non-member states from SEE). For all countries, data on private and public investments, private and public capital stock, real GDP and real interest rates, are taken from the IMF Capital Stock Database and the IMF International Financial Statistics Database. All monetary variables (PCS, GCS, PIN, GIN and Y) are stated in log real terms (international dollars, using 2011 prices).

Results of the unit root tests (Table A1, Appendix) strongly suggest that both private and public capital stock are I(2), which is in line with the findings of Dreger and Reimers (2016) for the Eurozone countries, while all variables included in the investment function are I(1). Given this, the relationship between the private and public capital is evaluated by means of panel cointegration, using the augmented Mean Group (MG) estimator (Tables 3, 5, 7 and 8) that allows for heterogeneous slope coefficients across panel members and cross-sectional

dependence. Robustness of the results is checked using the Pooled Mean Group (PMG) estimator and Generalized Least Squares (GLS) (Tables A3 and A4) in order to take into account potential heteroscedasticity and cross-sectional dependence correction issues.

5. Results

5.1 Public-Private Capital Nexus

The Westerlund (2007) panel cointegration test and the three versions of the Pedroni (1999) panel cointegration test signal robust evidence of a cointegration relationship between the private and public capital stocks (Table 2), thus enabling estimation of a panel regression model.

[Table 2 near here]

The results (Table 3, left panel) show that the long-run relationship between public and private capital stock is significant and positive, indicating crowding-in dynamics. This result is in line with findings in other studies, which employ similar techniques to evaluate the relationship between private and public capital stock – e.g. Masten and Grdović Gnip (2019) for South Eastern Europe, Hatano (2010) for Japan, Dreger and Reimers (2016) for the Eurozone – as well as with studies applying different methodologies (e.g., Bairam and Ward (1993), who investigate panel data for 25 OECD countries; or Otto and Voss (1996) and Pereira (2001), who apply the VAR approach to data from Australia and the USA).

To evaluate the short-run relationship and the relevance of the flow-variables adjustment process, we estimate further the error-correction specification of the capital stock model (equation 4). The results (Table 3, right panel) show that there is a positive relationship between private and public capital stock also in the short-run. In this case, the coefficient is much smaller in magnitude than the one estimated from equation 3 (0.290 versus 1.292), but the coefficient

remains statistically different from zero at the 5% level. Robustness of the results has been confirmed using the GLS estimator with heteroscedasticity and cross-sectional dependence correction and the PMG estimator – the estimated coefficients being stable both in terms of size and statistical significance (Tables A3 and A4, Appendix). This result seems to be in line with the "capital productivity" hypothesis, in the sense that synergies between public and private capital take time to materialize. The error correction term is also statistically significant and negative, confirming the presence of a long-run equilibrium, even if the speed of adjustment appears relatively low and much smaller than that found in the literature for other countries.

[Table 3 near here]

It is of course possible that the estimated positive link between the public and private capital stocks may be driven not only by a crowding-in mechanism, but rather by an inversely causal mechanism, if for example accumulation of private capital causes increase in the demand for public capital. To check for the direction of causality between the two aggregates, we perform a Granger causality Wald test. The results (Table 4) show that public capital does indeed drive private capital stock dynamics: specifically, we find that at the 5% significance level public capital stock Granger-causes private capital stock, while in the opposite direction causality is significant at 10% only. This seems to provide further evidence in support of the crowding-in hypothesis.

[Table 4 near here]

We have noted earlier the sizeable heterogeneity that exists between the CEE and SEE countries with regard to their capital stock endowments and investment dynamics (see Section 3). The two groups are also known to differ in other important parameters, such as their trade openness, export performance and integration to global financial markets (Botrić et al. 2020). Therefore, we extend the analysis to explore how this heterogeneity may influence the results

we obtain in the full-sample analysis. We start with a series of unit root and cointegration tests which all confirm the presence of a cointegration relationship between private and public capital stocks, in both groups of countries (Tables A2 and A5, Appendix). Following, we apply the panel regression and error correction models on a stock base, analogous to Table 3.

[Table 5 near here]

Table 5 reports the results obtained for the capital stock function (equations 3 and 4) by sub-groups of countries. Results for the cointegration model (left panel) suggest that in both groups of countries there is a positive long-run relationship between public and private capital stock, which is an additional evidence of robustness of the results. The estimated coefficient for public capital stock in SEE is significantly higher than in the CEE group. This may be taken to indicate that the long-run crowding-in effect is stronger in countries with lower capital endowments, which further suggests a decreasing marginal impact of public capital on private capital productivity. This is consistent with the scant evidence in the literature showing that the size of the public investment multiplier is inversely related to the initial stock of public capital (Izquierdo et al. 2019). Although the coefficients are higher in SEE countries, the Granger causality Wald test indicate strong causality (from GCS to PCS) in the CEE countries, suggesting significant crowding-in dynamics also in the countries with stronger capital endowment (results available upon request).

The results from the error correction model show statistically significant positive association between public and private capital stock also in the short-run, albeit only in the CEE countries (the coefficient is significant only in the CEE sample and much larger in magnitude than in the SEE group). This shows that the overall positive short-run effect of public capital found earlier for the full sample is driven almost exclusively by the CEE countries. A possible interpretation for this result may have to do with the existing differences between the two groups with regard to their access to international financial markets (Botrić et al. 2020): as the SEE countries are

less integrated with the global financial system, it is possible that in the short-run crowding-out tendencies will be stronger there, compared to the CEE group which enjoys much less constrained access to international markets, not least by virtue of its EU membership (Monastiriotis 2016; Bartlett and Prica 2017). Last, the ECM term is negative in both groups, but the speed of adjustment is again very low and the effect is statistically significant only in the CEE group.

5.2 Public-Private Investment Nexus

To check the robustness of these findings we turn to the examination of the public-private relationship using the investment model with flow variables. The Westerlund cointegration test indicates the presence of a cointegration relationship between private investment, GDP, interest rates and the deviation term, which is also confirmed by the Pedroni tests (Table 6).

[Table 6 near here]

Based on this, we evaluate the long-run private investment dynamics using the investment model presented in equation 5 (Table 7, left panel). All coefficients are statistically significant (at 1% or 5%) and correctly signed. Hence, private investments are positively associated with GDP in the long run, while a rise in the user cost of capital impedes private investments. The estimated coefficient for the DEV variable is negative, showing that private investments adjust downwards to any unexpected increases in the private-to-public capital stock ratio. In other words, when relative private capital stock deviates upwards from its long-run equilibrium path, private investment declines, in order to restore the long-run equilibrium, which again supports the crowding-in hypothesis.

[Table 7 near here]

The right panel of Table 7 reports our estimates from the deviations-adjustment model (equation 6), which examines the short-run fluctuations in public investments in line with the

approach proposed by Hatano (2010) and Dreger and Reimers (2016). The estimated coefficient for public investment is positive and statistically significant, signaling stark crowding-in dynamics also in the short-run, which is different from the finding of Dreger and Reimers (2016), who report no statistically significant short-run relationship between public and private investments in the Eurozone countries. These results indicate that in European emerging economies, crowding-in dynamics enter into play not only in the long-run but also in the short-run, while in the developed countries with large capital stocks the crowding-in effects kicks-in only in the long-run. Therefore, from a policy point of view, it may be concluded that increasing public investment may be an effective tool in promoting private capital formation in European emerging economies not only in the long-run, but rather in the short-run too. At the same time, our results indicate that the user cost of capital plays no significant role in terms of private investment dynamics in the short-run.

[Table 8 near here]

We next replicate this analysis separately for the two sub-groups of countries. The Westerlund and Pedroni tests show strong cointegration between private investment, GDP and the user cost of capital in both groups (Table A6, Appendix), thus allowing us to proceed with the panel estimation for the investment/flow phase for each of the two sub-samples. The results (Table 8) indicate similar patterns across the two sub-groups, but with significant differences in the intensity of the estimated relationships. Starting with the first row of Table 8, private investments are found to be strongly pro-cyclical both in CEE and SEE countries, in the short as well as in the long-run. But while the short-run responsiveness of private investment to GDP does not differ significantly across the two sub-groups (right panel), the long-run responsiveness in the SEE group is almost twice as high as that estimated for the CEE countries. Moving to the influence of the user cost of capital (second row), our findings show that its long-run relationship with private investment is significant and negative in both sub-groups,

while in the short-run the user cost of capital plays no significant role: neither in the CEE nor in the SEE countries. The long-run elasticity to the user cost of capital is found to be slightly lower in the SEE group. Finally, the deviations-adjustment specification for the investment function (equation 6) indicates that in CEE countries there is a statistically significant relationship between public and private investments both in the short and the long-run, while no such relationship is established in the SEE countries. On the whole, the cross-group heterogeneity of the obtained elasticities suggests that in the SEE economies, where capital endowments are lower and where access to financial markets is more limited, private investment is more responsive to fluctuations in domestic demand (as captured by the GDP variable) than to variations in prices or to expansions/contractions in public investment.

6. Conclusion

The 2008 crisis in Europe has left a legacy of subdued capital investment and decelerating productivity growth. The continuing uncertainty under intensifying European and global risks raises questions about how to stimulate productive investments and capital accumulation in order to foster economic growth and, in the case of emerging economies, close their productivity and development gaps. In the countries of the European periphery and super-periphery, this question attains higher importance, as it interacts with pre-existing pressures and challenges of economic transition and EU integration. Soaring public debt, caused by the COVID-19 pandemic will put an additional pressure on tightening fiscal policy in the coming period in order to restore public finance sustainability. In that respect, due to political economy reasons, there is a risk of public investment cuts (Randjelovic 2020), with potential impact on private capital formation and, by implication, long-run growth. Recent interest in the issue of the complementarity or substitutability between public and private investment has led to new

studies and approaches that have examined this relationship not only contemporaneously but also in terms of separating between short- and long-run dynamics. The underlying hypothesis is that, whereas crowding-out forces may dominate in the short-run, in the long-run public capital may well crowd-in private investment as the quality and volume of public capital is understood to contribute to raising the productivity of private capital and thus also the profitability of private investments.

In this paper we examined this issue for the group of 16 CESEE countries comprising of recent (2004-13 enlargements) and prospective EU member states. Covering the period since the turn of the century, our analysis followed recent contributions in the literature which apply standard (cointegration-based) panel/time-series econometric techniques, modified to account for the movement of investments in response to deviations from the long-run capital stock equilibrium. Consistent with findings elsewhere in the literature for other sets of countries, both in Europe (Eurozone countries – Dreger and Reimers 2016) and beyond (Japan – Hatano 2010; India – Bahal et al. 2018), our results find evidence in favor of the crowding-in hypothesis, indicating that public capital and investments contribute positively to the rate of accumulation of private capital both in the short and in the long-run.

More specifically, for the full sample of CESEE countries we find strong evidence of complementarity between public and private capital (crowding-in), with a long-run elasticity of 1.292 and a much weaker – but still positive – short-run elasticity of 0.290, which indicates that in the short-run some degree of crowding-out forces is also present. Evidence for this relationship from the modified investment function, which allows for private investment adjustments to temporary deviations from the long-run capital stock equilibrium, is generally very consistent. The relationship between public and private investments points again to strong crowding-in, as private investment is found to respond very strongly and positively to temporary expansions of the public capital stock beyond the long-run equilibrium. Opposite of

the finding for developed European economies (Dreger and Reimers 2016), we find evidence on the crowd-in effect also in the short-run, both on the stock and the flow/investment phase. Consistent with that, reducing public investment in a course of fiscal consolidation may yield negative effects in terms of private investment already in the short-run, while in developed European countries the negative impact is expected to materialize only in the long-run.

Analyzing these relationships separately for the two sub-groups of countries unveils some important differences, in line with the observed heterogeneity across groups in their capital endowments/mix and investment rates. In the long-run, we find evidence of crowding-in on the stock variables (public and private capital) for both groups of countries, but for the CEE countries (which are more capital endowed, more advanced economically and more integrated with the EU economy and with international capital markets) the effect is much weaker than in the SEE group. In the short-run, however, evidence of crowding-in is only captured for the more advanced CEE group – a result which is also confirmed by the evidence provided from the investment function analysis. We can interpret these patterns as indicating, on one hand, the short-run tension between public and private investments in economies with less developed capital markets (no evidence of crowding-in in the SEE in the short-run) but, on the other hand, the heightened importance of public capital, especially in such economies, for stimulating private capital expansion in the long-run.

There are important policy lessons that emanate from these findings. Faced with the double challenge of ensuring fiscal stability and stimulating economic growth, the countries of Central Eastern and – especially – South Eastern Europe are subject to pressures to reduce their government expenditures, hoping that this will improve the perceived business climate and thus stimulate private investment, especially from abroad (foreign direct investment). Our results show that pursuing such a policy approach has its limits: as much of public consumption is inelastic (e.g., for pensions, social services, etc. – especially in the current climate of

pandemic risk and fast rising energy prices), fiscal stabilization often works disproportionately at the expense of public investments (Randjelovic 2020), thus contributing to the observed deficits in public capital in these countries, including with regard to key public infrastructures. Given the strong evidence indicating that public capital crowds-in private capital, both in the long and in the short-run (especially in the CEE countries), the persistence of public capital deficits in these countries effectively hinders private capital accumulation – and, in this sense, also the convergence of their economies to the EU levels of capital stocks and economic development. Our evidence points to the productivity hypothesis as the mechanism that drives this. Public capital appears to raise the productivity of private capital, thus making private investments more profitable and thus potentially more plentiful. To the extent that this is true, the policy implication is that the CESEE countries ought to be afforded the opportunity to expand their public investment programs as a means for stimulating private capital accumulation and economic growth. However, since private investment in CESEE is sensitive to interest rates, which are at least partly driven by country risks, for these countries it is also important to maintain public finance sustainability while expanding public investment programs, in order to attain a strong positive impetus for capital formation. Providing enhanced support to public investment through EU-sponsored schemes may be a viable option for compromising these two needs.

Finally, our results also have implications for the wider literature on the relationship between public and private investments. They show that the recent evidence of crowding-in in the long-run obtained in studies examining data from advanced economies (such as the Eurozone and Japan), broadly generalize – and in some respects are stronger – also to less advanced transitioning economies. Our results also show that in emerging European economies, public investment programs may trigger private capital formation already in the short-run. Capital financing constraints are of course more important in the case of emerging economies, as less

advanced economies have to work in settings with weaker domestic savings bases and more limited access to international capital markets. However, the complementarity between public and private capital appears to be stronger there, as the quality and extent of productivity-enhancing public infrastructures is also more limited.

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Appendix

Table A1: Unit root tests (CESEE)

Test	Variable	Levels	1st diff.	2nd diff.	Decision
Pesaran	PCS	1.0000	0.7080	0.0000	I(2)
	GCS	1.0000	0.0540	0.0000	I(2)
	PIN	0.1850	0.0000	0.0000	I(1)

	GDP	0.6660	0.0000	0.0000	I(1)
	RIR	0.1900	0.0000	0.0000	I(1)
Im-Pesaran-Shin	PCS	0.9407	0.0661	0.0000	I(2)
	GCS	0.8297	0.2070	0.0000	I(2)
	PIN	0.0867	0.0000	0.0000	I(1)
	GDP	0.2930	0.0000	0.0000	I(1)
	RIR	0.1010	0.0000	0.0000	I(1)

Table A2: Unit root tests (CEE and SEE)

Test	Variable	Levels	1st diff.	2nd diff.	Decision
Pesaran	*CEE*				
	PCS	1.0000	0.4710	0.0010	I(2)
	GCS	1.0000	0.1060	0.0000	I(2)
	SEE				
	PCS	1.0000	0.6860	0.0000	I(2)
	GCS	0.9950	0.0630	0.0000	I(2)
Im-Pesaran-Shin	*CEE*				
	PCS	0.8585	0.1232	0.0004	I(2)
	GCS	0.8810	0.5437	0.0000	I(1)
	SEE				
	PCS	0.8476	0.1742	0.0001	I(2)
	GCS	0.4330	0.1246	0.0009	I(2)

Table A3: Capital stock function (CESEE),
GLS estimator with heteroscedasticity and cross-sectional dependence correction

Long-run model		*Short-run model*	
lnPCS	Coef.	Δ^2lnPCS	Coef.
lnGCS	1.218***	Δ^2lnGCS	0.224***
	(0.000)		(0.000)
		ECM(-1)	-0.0003***
			(0.001)
No. obs.	288		256
Wald chi2 (1)	2.26E+08		268.4
Prob>chi2	(0.000)		(0.0006)

*p values presented in parentheses

Table A4: Capital stock function (CESEE), PMG estimator

Long-run model		*Short-run model*	
lnPCS	Coef.	Δ²lnPCS	Coef.
lnGCS	1.354***	Δ²lnGCS	0.663***
	(0.000)		(0.000)
		ECM	-0.028*
			(0.090)
No. obs.	272		288

*p values presented in parentheses

Table A5: Cointegration tests – capital stock PCS, GCS (CEE vs. SEE)

H_0: No cointegration

	CEE		*SEE*	
Test	*Statistic*	*p-value*	*Statistic*	*p-value*
Westerlund	3.9026	0.0000	2.0941	0.0181
Pedroni				
- Modified Phillips-Perron	3.2619	0.0006	2.0708	0.0192
- Philips-Perron	2.4567	0.0070	1.3809	0.0837
- Augmented Dickey-Fuller	3.4111	0.0003	0.8106	0.2088

Table A6: Cointegration tests – PIN, GDP, Ï, DEV (CEE vs SEE)

H_0: No cointegration

	CEE-EU		*CEE non-EU*	
Test	*Statistic*	*p-value*	*Statistic*	*p-value*
Westerlund	-2.6488	0.0040	-1.9777	0.0240
Pedroni				
- Modified Phillips-Perron	0.9484	0.1715	1.091	0.1376
- Philips-Perron	-6.5329	0.0000	-1.8097	0.0352
- Augmented Dickey-Fuller	-4.8169	0.0000	-4.4202	0.0000

Tables

Table 1: Descriptive statistics

		EU-old	CESEE-16	CEE (EU)	SEE (non-EU)
Public capital stock	2000 (% GDP)	0.67	0.61	0.59	0.65
	2017 (% GDP)	0.67	0.60	0.57	0.67
Private capital stock	2000 (% GDP)	2.23	1.53	1.65	1.28
	2017 (% GDP)	2.40	1.78	1.87	1.58
Public capital stock	2017/2000 (% GDP)	0.99	0.98	0.96	1.03
Private capital stock		1.08	1.16	1.13	1.24
Public capital stock	2017/2000 (intl. USD per 1,000 inhabitants)	1.16	1.76	1.76	1.78
Private capital stock		1.26	1.87	1.83	2.08
Correlation:		0.571	0.972	0.971	0.974

public and private capital stock					
Public investments	annual average, % GDP (2000-17)	3.37	4.30	4.27	4.33
Private investments		18.40	19.66	19.96	18.79
GDP (int. USD, prices 2011)	2017/2000	1.32	1.71	1.72	1.69

Table 2: Cointegration tests – PCS, GCS (CESEE)

H_0: No cointegration		
Test	*Statistic*	*p-value*
Westerlund	4.2573	0.0000
Pedroni		
- Modified Phillips-Perron	3.6582	0.0001
- Philips-Perron	2.5385	0.0056
- Augmented Dickey-Fuller	2.9463	0.0016

Table 3: Capital stock function (CESEE)

Long-run model		*Error correction model*	
lnPCS	Coef.	Δ^2lnPCS	Coef.
lnGCS	1.292***	Δ^2lnGCS	0.290**
	(0.000)		(0.024)
		ECM(-1)	-0.0068***
			(0.002)
No. obs.	288		256
Wald chi2 (1)	25.47		14.86
Prob>chi2	(0.000)		(0.0006)

*p values presented in parentheses

Table 4: Granger causality Wald test – capital stock (CESEE)

H_0: No Granger causality		
Causal relationship	chi2	p-value
Δ^2lnGCS→ Δ^2lnPCS	9.618	0.019
Δ^2lnPCS→ Δ^2lnGCS	5.174	0.075

*Lag orders are all 2 (selected to minimize p-value)

Table 5: Capital stock function (CEE vs. SEE)

Long-run model			*Short-run model*		
lnPCS	CEE	SEE	Δ^2lnPCS	CEE	SEE
lnGCS	0.887***	1.393***	Δ^2lnGCS	0.442***	0.183
	(0.000)	(0.000)		(0.000)	(0.466)
			ECM(-1)	-0.0001*	-0.0024

				(0.091)	(0.570)
const.	0.722*	-0.207			
	(0.052)	(0.5570)			
No. obs.	198	96		176	96
Wald chi2 (1)	30.42	31.53		18.74	0.66
Prob>chi2	(0.000)	(0.000)		(0.0001)	0.7186

*p values presented in parentheses

Table 6: Cointegration tests – PIN, GDP, Ï, DEV (CESEE)

H_0: No cointegration		
Test	*Statistic*	*p-value*
Westerlund	-2.9072	0.0018
Pedroni		
- Modified Phillips-Perron	1.3732	0.0848
- Philips-Perron	-5.3260	0.0000
- Augmented Dickey-Fuller	-5.5346	0.0000

Table 7: Investment function (CESEE)

Long-run model		*Short-run model*	
lnPIN	Coef.	ΔlnPIN	Coef.
lnGDP	1.067***	ΔlnGDP	-0.035
	(0.000)		(0.490)
		ΔlnGIN	2.502***
			(0.000)
lnÏ	-0.049*	ΔlnÏ	-0.001
	(0.074)		(0.973)
lnDEV	-0.504**	ε(-1)	-0.236***
	(0.011)		(0.000)
No. obs.	232		204
Wald chi2 (1)	200.62		94.86
Prob>chi2	(0.000)		(0.000)

*p values presented in parentheses

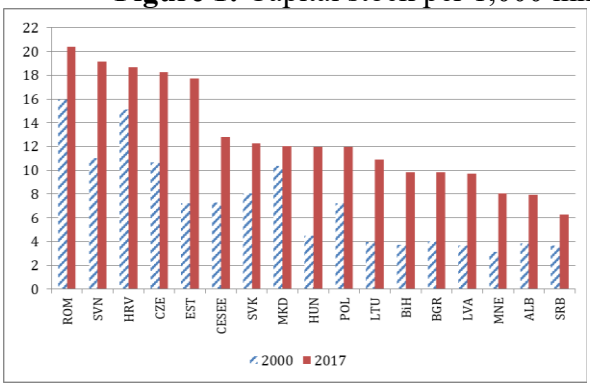
Table 8: Investment function (CEE vs. SEE)

Long-run model			*Short-run model*		
lnPIN	CEE	SEE	ΔlnPIN	CEE	SEE
lnGDP	1.061***	1.906***	ΔlnGDP	2.618***	2.313***
	(0.000)	(0.010)		(0.000)	(0.000)
			ΔlnGIN	-0.006	-0.063
				(0.863)	(0.684)
lnÏ	-0.064**	-0.047**	ΔlnÏ	0.0002	0.002
	(0.030)	(0.029)		(0.985)	(0.953)
lnDEV	-1.639***	-0.783	ECM(-1)	-0.020***	-0.013
	(0.000)	(0.508)		(0.000)	(0.761)
No. obs.	165	84	No. obs.	147	73
Wald chi2 (1)	254.95	11.8	Wald chi2 (1)	258.64	31.86
Prob>chi2	(0.000)	(0.008)	Prob>chi2	(0.000)	(0.000)

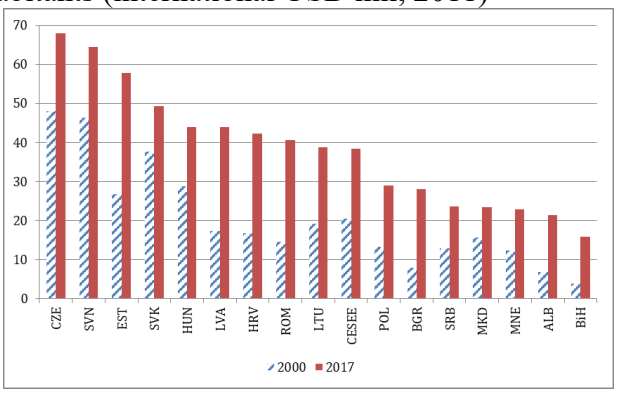
*p values presented in parentheses

Figures

Figure 1: Capital stock per 1,000 inhabitants (international USD mil, 2011)



Public



Private

Source: Authors' calculations