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Public Capital and Economic Growth: Key Issues for Europe*

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Preliminary, please do not quote

1. Introduction

Governments can try to improve future living conditions in various ways: they can, e.g. stimulate private (foreign) investment, spend more on education and health programs in order to enhance human capital, preserve the environment, or they can add to the stock of infrastructure. According to the World Bank (1994), public capital represents the 'wheels' – if not the engine – of economic activity. Input-output tables show, for example, that telecommunications, electricity, and water are used in the production process of nearly every sector, while transport is an input for every commodity. However, the World Bank (1994, p. 19) also concludes that "infrastructure investment is not sufficient on its own to generate sustained increases in economic growth."

This note summarizes the most important conclusions from the empirical research on the impact of government capital spending on economic growth. It furthermore points to issues which still need to be addressed in future work. The next section starts with some theoretical considerations. Section 3 deals with data-related issues. Subsequently, Section 4 shortly discusses developments in public capital expenditures. Section 5 summarizes the main conclusions of this line of literature. We distinguish three waves of results. In the first wave,

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the effects were too strong to be true. Subsequently, the entire relationship between public capital and growth was questioned. In the latest wave, significant though moderate effects are reported.[1] The final section offers some concluding comments.

2. The role of public capital in economic growth

Before estimating the impact of public capital on economic growth, it would be natural to first answer the question *how* public capital affects economic growth. This more theoretical issue has received only scant attention in the literature on the relationship between public capital spending and economic growth. As Holtz-Eakin and Lovely (1996, p.106) note, "A somewhat surprising feature of this literature is the noticeable absence of formal economic models of the productivity effects of infrastructure." This has since hardly changed.

In the literature it is generally assumed that public capital forms an element in the macroeconomic production function and enters in two ways. First, its stock may enter the production function directly, as a third input. Second, its stock may influence multifactor productivity and thereby production in an indirect way. It depends on the functional form of the production function whether both effects can be identified. However, in most models both ways yield similar equations to be estimated, which implies that the direct and indirect impact of public capital can often not be disentangled in empirical work.

Either way, it is implicitly assumed that the services of public capital are a pure, non-rival public good, with services proportional to the stock of capital. Many services provided by the stock of public capital, however, are subject to congestion: more vehicles on one road lower the productivity of this road. More roads will reduce congestion, and therefore, improve productivity. Above a certain threshold, however, marginal increments will no longer affect output since they no longer cause a decline in congestion (Sanchez-Robles 1998).

A way to focus explicitly on the services provided by the assets is suggested by, for instance, Fernald (1999). He assumes that production depends on (private) transport services, which in turn depend upon the flow of services provided by the aggregated stock of government capital (roads) and the stock of vehicles in the transport sector.

Economies of scale due to network externalities are a widely recognized imperfection in infrastructure services. An important characteristic of modern infrastructure is the supply of services through a networked delivery system designed to serve a multitude of users. This interconnectedness means that the benefits from investment at one point in the network will generally depend on capacities at other points. The network character also has important consequences for the relationship between public capital and economic growth. Once the basic parts of a network are established, opportunities for highly productive investment

diminish. In line with this argument, Fernald (1999) reports that once the highway system in the US was roughly completed, after 1973, the hypothesis that the marginal productivity of roads is zero cannot be rejected. In other words, road building gave a boost to productivity growth in the years before 1973, but post-1973 investment did not yield the same benefits at the margin.

There is broad consensus among economists and politicians that public infrastructure investment is an important aspect of a competitive location policy. Often it is argued that infrastructure lowers fixed costs, attracting companies and factors of production and, thereby, raising production (see e.g. Haughwout 2002 and Egger and Falkinger 2003). This does not necessarily imply higher growth at the national level, however, since production in other regions might go down. A common result in this type of models is that, under certain assumptions, the resulting stock of capital without coordination between regions or countries is sub-optimal. Since more infrastructure in the 'home' region attracts production factors out of the 'foreign' region, there is a risk of the infrastructure being too high in both regions compared to the situation in which they coordinate their actions. That said, spill-over effects of infrastructure could lead to the opposite outcome: because the investing region only gets part of the benefits, both regions end up with too little infrastructure.

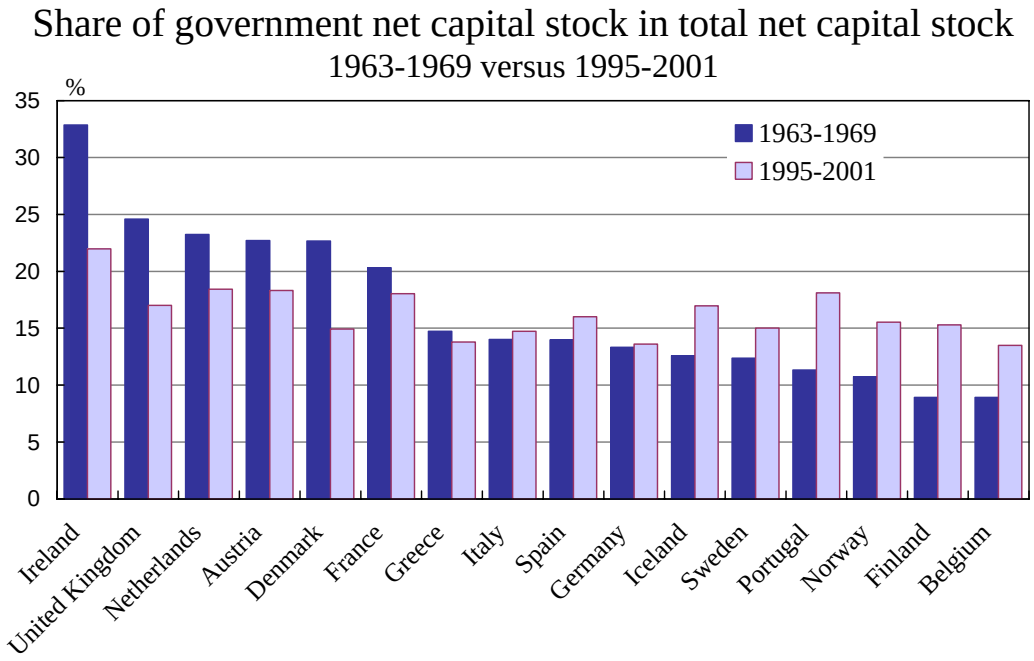
A somewhat different reason why public capital may affect economic growth is suggested by the new economic geography (e.g., Krugman 1991, Holtz-Eakin and Lovely 1996, Venables 1996, Fujita et al. 1999), which considers transport costs a central determinant of the location and scale of economic activity and of the pattern of trade. More transport infrastructure has a profound impact on the size of the market, so producers can cluster together in one central region. This clustering of activities leads to specialization and economies of scale.

3. Some measurement issues

Most of the issues raised in the scant theoretical literature concern the concept of *infrastructure*. Hence, often the existence of public good or network characteristics is decisive and ownership is of subordinate importance in classifying different types of capital. In the empirical literature, however, it is basically the other way around. Researchers are forced to use the data that is available. In the National Accounts, all capital expenditures are largely distinguished by ownership; public versus private.[2] This results in a mismatch between the theoretical and empirical work of which the consequences are rarely discussed.

Furthermore, what really matters from a theoretical perspective is the amount of services yielded by the public capital stock. In most empirical research it is implicitly assumed that these can be proxied by the stock of public capital. This may not be true, as for instance, the amount of services provided is also determined by the efficiency with which they are

Figure 1



Source: Kamps (2006).

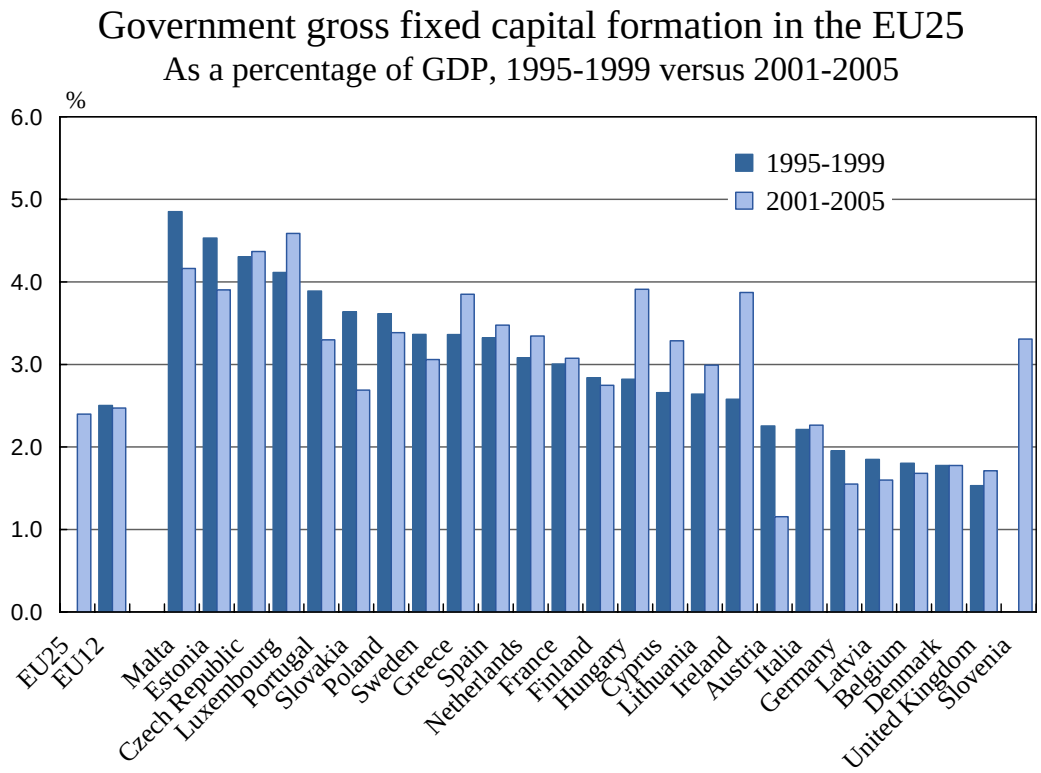
provided from the stock of public capital. Indeed, according to several author there is substantial room for improving the efficiency in many countries.[3] However, directly measuring the services provided from the stock of public capital is a difficult task.

At least as difficult, though, is calculating the stock of public capital. Researchers typically use the sum of past investment flows, adjusted for depreciation. In applying this so-called perpetual inventory method, one has to make certain assumptions about the assets' lifespan and depreciation. Furthermore, one needs an initial level for the capital stock. Especially with infrastructure these assumptions are far from trivial. There is a huge variation in the economic lifespan of different types of infrastructure; the lifespan of a railroad bridge cannot be compared with the lifespan of an electricity line.

4. The development of public capital expenditure

As illustrated in figure 1, public capital spending as a share of Gross Domestic Product (GDP) declined in most EU countries when comparing the sixties with the second half of the nineties.[4] Indeed, during the 1970s and 1980s many countries have offset increases in debt interest payments and rising social security transfers by winding back public investment. The reasons for this decline are still not well understood. The few papers which address this issue often conclude that at least one of the reasons for this decline is "the political reality that it is

Figure 2



Source: Eurostat.

easier to cut back or postpone investment spending than it is to cut current expenditures" (Oxley and Martin 1991, p. 161).[5] This has led to a growing awareness in especially the mid-nineties that the stock of public capital was neglected by many – also European – governments. Public investment shares in GDP subsequently stopped falling further. As share of total government expenditure, it even rose slightly during the last ten years.

5. Empirical findings in the literature

The simple fact that public investment has declined in most EU countries in itself is no evidence that public capital is currently undersupplied. However, at approximately the same time that government investment spending declined, productivity growth plummeted almost everywhere. Aschauer (1989) was the first to hypothesize that the decrease in productive government services in the US may be crucial in explaining the general decline in productivity growth in that country. Based on his results, a 1 per cent increase in the public capital stock might raise total factor productivity by 0.4 per cent. The implications of these results for policymakers seem to be clear: public investment should go up to give a boost to the economy. Because of these well-received policy implications the findings of Aschauer

have sparked research into the impact of public sector capital spending on private sector output and stopped public investment shares in GDP from falling further.

In the literature one can roughly distinguish four approaches to measure the impact of public capital on economic growth. The most common approach is what is often labeled the production function approach. Here, a functional form – like the Cobb-Douglas one – is chosen for the production function and this production function is subsequently estimated. In the so-called behavioral approach, a cost or profit function in which the public capital stock is included is estimated. It allows the use of more flexible functional forms and takes somewhat better account of the different characteristics of public versus private capital. By imposing as few economic restrictions as possible, Vector Auto Regressions (VAR) models try to solve some of the causality and endogeneity problems related to the first two approaches. A final alternative way to model the growth effects of public capital spending is to include government investment spending in cross-section growth regressions. Each approach has its merits and own set of problems. However, the overall conclusions derived from these different approaches are surprisingly similar. Or, at least, the differences in estimated output effects can rarely be attributed to the use of different approaches.

In the first wave of papers on this topic, mostly following the set-up chosen by Aschauer (1989), the reported elasticities were substantial and suggested large effects of public capital on growth. At a time when the slowdown in productivity growth was a widespread concern, these findings suggested that a decline in the rate of public-capital accumulation was "a potential new culprit" (Munnell 1990a, p. 3).

However, over time several economists questioned the estimates of this first wave on the grounds that they are implausibly high (see, for instance, Gramlich 1994). Furthermore, the early studies were fraught with methodological and econometric difficulties. Issues ranking high on the list of potential problems include reverse causation from productivity to public capital and a spurious correlation due to non-stationarity of the data.[6]

In their survey of the earlier literature summarizing these first two waves, Sturm et al. (1998) shows that the literature contained a relatively wide range of estimates, with a marginal product of public capital that is much higher than that of private capital (e.g., Aschauer 1989), roughly equal to that of private capital (e.g., Munnell 1990b), well below that of private capital (e.g., Eberts 1986) and, in some cases, even negative (e.g., Hulten and Schwab 1991). The wide range of estimates makes the results of these older studies almost useless from a policy perspective.

However, more recent studies – as summarized by Romp and De Haan (2007) – generally suggest that public capital may, under specific circumstances, raise income per capita.

Although not all studies find a growth-enhancing impact of public capital, it is worth noting that – compared to the results surveyed by Sturm et al. (1998) – there is more consensus that public capital furthers economic growth. Another interesting result is that the impact as reported in recent studies is substantially less than suggested in earlier studies.

Empirical research on the relationship between public capital and growth should provide answers to two important questions. First, does an increase in the public capital stock foster economic growth? Second, the 'policy relevant' question for infrastructure investment is not 'what is the effect of extra infrastructure, holding everything else constant?' but 'what is the net effect of more infrastructure given that infrastructure construction diverts resources from other uses?' (Canning and Pedroni 1999). In other words, is the existing stock of capital optimal? There are only a few studies that estimated the optimal amount of public capital and compared it with the actual stock of public capital.

Aschauer (2000) estimates the growth-maximizing ratio of public to private capital using data for 48 US states over the period 1970-90. He finds that for most of the United States the actual levels of public capital were below the growth maximizing level. Kamps (2005) applies the methodology of Aschauer (2000) in the European context to assess the gap between actual and optimal public capital stocks. His results, however, suggest that there is currently no lack of public capital in most of the 'old' EU member states.

Most of the literature has focused on the importance of additional public investment spending, while maintenance of the existing stock is as important, if not more important, as additions to the stock. Unfortunately, policymakers have a perverse incentive: new public investment projects are politically more attractive than spending on infrastructure maintenance. Consequently, there may be a tendency to neglect maintenance of existing public infrastructure in favor of starting new, highly visible projects. However, maintenance disregard leads to road deterioration, irrigation canal blockage, leaks, and power line breakdowns reducing the economy's productive capacity.

As pointed out by Kalaitzidakis and Kalyvitis (2005), in most theoretical studies public capital deterioration is considered as an exogenously given technical relationship, thereby neglecting a crucial choice concerning the implementation of public investment decisions, namely the choice between investing in 'new' public capital and extending the durability of the existing public capital stock via maintenance. It might be that reallocating some of the public investment away from new investments and towards maintenance can have positive effects on GDP.

6. Concluding remarks

The literature on the relationship between public capital and economic growth suggests the following main results. First, although not all studies find a growth-enhancing effect of public capital, there is more consensus in the recent literature than in the older literature. Second, according to most studies, the impact is much lower than found by Aschauer (1989), which is generally considered to be the starting point of this line of research. Third, there is evidence for reverse causality. Hence, not only might public investment stimulate growth, higher growth also often leads to higher demand for infrastructure. Fourth, many studies report that there is heterogeneity: the effect of public investment differs across countries, regions, and sectors. This is perhaps not a surprising result. After all, the effects of new investment spending will depend on the quantity and quality of the capital stock in place. In general, the larger the stock and the better its quality, the lower will be the impact of additions to this stock. Fifth, the network character of public capital, notably infrastructure, causes non-linearities. Sixth, the effect of new capital will crucially depend on the extent to which investment spending aims at alleviating bottlenecks in the existing network. Finally, maintenance and efficient use of existing infrastructure might be more important than building new infrastructure but often is assigned less priority for political reasons.

In concluding, we would like to mention a few issues we believe have not been well researched. First, attempts at explaining existing differences in capital stocks are only in their infancy. Second, only a few of the enormous bulk of studies on the output effects of infrastructure base their estimates on solid theoretical models. But to understand non linearities and heterogeneity, we must understand the channels through which infrastructure affects economic growth. After all, government roads as such do not produce anything, and to include infrastructure or public capital as a separate input in a production function neglects the usually complex links.

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[1] Note that, we only review the impact of public capital on the supply side; demand raising effects of government investment spending are not taken into account.

[2] Because of this definition, capital outlays of publicly-owned firms like, the railway companies and public utility firms are often not counted as part of public capital spending. Although 'land' is often considered to be an indispensable factor of production and therefore regularly counted as part of the capital stock, public purchases of land are excluded by definition. On the other hand, swimming pools are part of public capital.

[3] See, for instance Munnell (1993) and Boarnet (1997).

[4] Spain and Portugal are exceptions. In order to become more competitive within the European Union, these countries undertook extensive programmes of upgrading their stock of public capital. A small rise occurred also in Greece.

[5] De Haan et al. (1996) report evidence that during fiscal contractions government capital spending is indeed reduced more than other categories of government spending.

[6] Perhaps the most important concern is the direction of causality between public capital and aggregate output: while public capital may affect productivity and output, economic growth can also shape the

demand and supply of public capital services, which is likely to cause an upward bias in the estimated returns to public capital if endogeneity is not addressed.

Some of the earlier studies have also been criticised for not taking the stationarity of the data properly into account (see, for instance, Sturm and De Haan 1995). Unit root tests often suggest that output and public capital contain a unit root. However, it is well known that unit root tests have low power to discriminate between unit root and near unit root processes. This problem is especially pronounced for small samples.