Do government expenditures increase private sector productivity?

Cross-country evidence

Reino Hjerppe
Government Institute for Economic Research, Helsinki, Finland
Pellervo Hämäläinen
University of Turku, Turku, Finland
Jaakko Kiander
Labour Institute for Economic Research, Helsinki, Finland, and
Matti Viren
University of Turku, Turku, Finland and
Bank of Finland, Helsinki, Finland

Abstract

Purpose – To analyse productivity of public expenditures; especially to find out the effect of human capital investment on private sector productivity.

Design/methodology/approach – Several measures of public sector capital stock are constructed. These measures are used in testing the effects on private sector productivity. Empirical analysis makes use of cross-country panel data and utilizes various panel econometric methods.

Findings – The main finding is that public sector capital has a positive impact on private sector productivity. Some evidence is provided to the hypotheses that also human capital that is generated within the public sector increases private sector productivity.

Research limitations/implications – There are a lot of measurement problems with the cross-country data. Also the non-stationarity of data creates some estimation problems. These may have some impact on the quantitative, but perhaps not on qualitative, nature of results.

Originality/value – Relatively few analysis have made in this area; this is true in particular with comparative (cross-country) analysis.

Keywords Public sector accounting, Private sector organizations, Productivity rate, Capital growth

Paper type Research paper

1. Introduction

The size of government tended to grow almost in all countries until 1980s. This seems to have been the case whatever measure one uses to measure the size of the public sector. After 1980s, the relative size of the primary government expenditures has stabilized in many countries. Changes in the size of government raise obviously

Useful comments of participants of IIPF-2005 Congress in Jeju (Korea) and the European Public Choice Society Congress in Turku, April 2006 on the earlier version of the paper are gratefully acknowledged. The corresponding author also gratefully acknowledges financial support from the Yrjö Jahnsson Foundation.

International Journal of Social Economics
Vol. 34 No. 5, 2007
pp. 345-360

0306-8293
DOI 10.1108/03068290710741598

important questions: what is the contribution of the government expenditures on growth and productivity? Are government expenditures productive? Should they be still decreased in relative terms or would some increases be beneficial? Is there an optimal size of the government[1]?

Economists have always worried that increasing government expenditures increases the risk that part of the resources will be wasted. It is still typical to many expert bodies dominated by economists to be critical on public expenditure. Taxes are clearly harmful, and it is often believed amongst economists that nothing useful can be achieved by using tax revenues – as compared to the private use of these resources. Today, however, there are many factors which limit the growth of public sector. One is obviously the increasing tax competition, which threatens the growth of public revenues. Other one is the legacy of three decades of chronic deficit problems in many countries – the need to control deficits and public debt has helped to cap (at least primary) spending in many countries since 1980s. Within the EU there has been a constant institutional pressure to reduce public deficits due to the monetary union and its criteria for excessive public deficits and debt. These pressures led in the EU countries to relative and in some cases even absolute reductions in public sector's primary expenditures in the 1990s.

At the same time with the deficit problems and fiscal tightening the rate of economic growth has slowed down in the EU countries and Japan. The growth slow-down has but been caused by lower labour input but by declining rate of productivity growth. Disappointing growth record and the fears of the dismal consequences of the ageing of the populations have put more and more emphasis on the need to policies to enhance productivity and economic growth. The need is reflected today in political discourse. The Lisbon strategy of the EU is one example of such aspirations. Consequently, it has become more and more important to know, whether the government expenditures can have any positive role in such attempts.

Recent literature on endogenous growth theory predicts that fiscal policy changes can affect the long-term growth rate by influencing the determinants of growth (physical and human capital, technological change, employment and savings). Changes in public expenditures and taxes could boost (or depress) employment and human capital accumulation and change investment externalities that then would have effects on the growth rate of output. This contrasts with the basic neoclassical growth model, where fiscal policy is unable to affect long-term growth. However, the empirical effects of fiscal policies and especially public spending on long-term growth remain unsettled.

As to the policy front, for example, official communications from the EU Commission and the Union's ECOFIN Council note that public finances can contribute to achieve the goal of higher growth and employment via three mechanisms:

(1) by supporting a stable macroeconomic environment;

(2) making tax and benefit systems more employment friendly; and

(3) redirecting public expenditures towards productive areas (which, however, may be hard to identify).

Additionally, it is usually reminded in such contexts that fiscal policies should also be conducive to economic stability even in the short run (Lamo and Strauch, 2002).

There are, therefore, several urgent needs and reasons to know more about the growth effects of the fiscal policy. What we aim to do in this paper is to analyse

the productivity of public expenditures. Our analysis follows the branch of literature initiated by Aschauer (1989a, b) but it has also some novel features. In this paper, we try to look at the issue in broader perspective. In addition to the physical infrastructure we can think public education and health expenditures also as public investments. We explore the question, whether these expenditures also have external effects on the private sector production. We are going to focus on the effect of both public investment and public consumption on private sector productivity. For the testing purpose, we use a production function approach in which alternative definitions of public sector capital stocks are allowed to affect total factor productivity.

The production relationships are estimated by using large cross-country data that cover more than three decades. Our panel data are derived from the data banks of OECD and the World Bank. We use two data sets: one from 21 OECD countries and the other 93 countries from the World Bank data set. In the case of OECD countries we specify a model of private production whereas in the case of World Bank data the dependent variable is total GDP, even though the preferable data would be also here the private production.

The main obstacle in empirical analysis is lack of data for relevant capital stocks. We have solved the problem by computing the corresponding time series by using the perpetual inventory method (accumulate investments) in the same way as Kamps (2006). The capital stock data have been in assessing the impact of competing capital stock measures on production.

Our findings suggest that, to some extent, the significant deceleration of economic growth in many OECD countries during the last two decades can, in the same way as in the original Aschauer analysis with the US data, be explained by a secular decrease in public sector investment. In this respect the results are similar to those of Kamps (2006). More specifically, our results suggest that, in addition to public investment also public health and education expenditures (i.e. public investments in human capital) have contributed to private sector productivity growth. This is the main result of the paper.

The production function approach suffers from several problems (most notably from nonstionarity of the key variables); see, e.g. Sturm and De Haan (1995) for a critical review. Therefore, alternative approaches have been used. In particular, a reference should be made to VAR studies which have analyzed the impact of public expenditures on output. The analyses, like Perotti (2004, 2005) have not only analyzed the role of total expenditures but also the structure of expenditures. The findings of these analyses have generally been quite negative in terms of the supposed positive impact of public expenditures. This is true especially for public investment. The results do not seem to support the notion that government investment would be a better countercyclical tool than government consumption. Here, we do not intend to challenge these results – mainly because our data and analytical framework are quite different.

This paper proceeds as follows. In the next section we discuss the relationship between (the structure of) public expenditures and business sector productivity. In Section 3, we outline the empirical analysis and in Section 4 we summarize the data. Estimation results are presented in Section 5 and some concluding remarks are presented in Section 6.

2. Public expenditure and private sector productivity

Productivity of the public sector can be approached both from the macro and micro perspectives. It is obvious that studies using aggregate time series evidence are not as

good as a detailed and informed cost benefit assessment of the likely returns on each individual project would be. However, using large cross-country data sets makes macro approach unavoidable. Furthermore, it is very likely that at the macro level public expenditures have nontrivial effects on GDP. These effects can be either positive or negative. Public infrastructure, education and health expenditures can in principle be complementary to private activities and therefore have positive effects on GDP. For example, the new transport infrastructure save travel time and therefore bring positive effects on private agents. Alternatively public expenditures can be substitutes for private expenditures and therefore crowd out private activities.

Public consumption and investment can also be wasteful if the investment is not needed and if the productivity of public sector is clearly lower than in the private sector. Furthermore, taxes, subsidies and transfers have dead-weight costs, and they can therefore reduce the efficiency in the economy, and consequently have negative effects on the growth of the GDP.

Many studies in both developing and developed countries have tried to establish statistical link between aggregate infrastructure investment and growth in GDP. There is a quite strong positive correlation between infrastructure and growth (Banister and Berechman, 2003). However, the question of causality is usually left open in the simple correlation studies and there is an issue, whether other factors also are affecting the correlation.

The paper by Aschauer (1989a, b) started an important debate about the possible complementarities between public and private investments. According to Aschauer public infrastructure investments are complementary with the private sector activity (have an external effect) and increase both the productivity of private investments and production. Since, then there have been several studies on this issue. Some of the studies have rejected Aschauer's findings. For instance, production function estimations with aggregate US data have in some cases yielded zero or even negative marginal products of public capital (Tatom, 1991; Hulten and Schwab, 1991; Garcia-Milà *et al.*, 1996).

At the micro level one can imagine two types of productivity effects of the public sector activities. First, public expenditures on education and health can contribute positively to the stock of human capital. Since, human capital is one important factor in the growth of the GDP public expenditures can have a positive effect on GDP.

Another micro-level productivity aspect in the public sector comes from the internal efficiency of the public sector activities. However, we are note dealing with this aspect of productivity in this paper.

In a standard neoclassical growth model, economic growth depends on the increase in the capital and labour input and the pace of technological progress. Public policies in general and public expenditures specifically, do not affect growth. In the extended Solow model, however, human capital is an important input to growth (Mankiw *et al.*, 1992). In the endogenous growth models, public policies can affect both human capital formation and technological progress and therefore public policies can also have an effect on economic growth. As to the government expenditures, public educational and health expenditures are two of the most important public expenditure items which can contribute to the formation of the human capital, and consequently there is, in principle, a channel from government expenditures to economic growth.

Usually in growth studies economic growth is determined by labour (human capital), man-made capital, nature (natural capital), institutions (social capital and institutions) and technological progress. Possible growth and productivity effects of public expenditures come indirectly via measures of education and health, which affect human capital, and physical infrastructure expenditures. Of course, government has also an important role to play in the formation and maintenance of institutions, but we are not focusing on this aspect in this paper. Essentially, we treat the health, education and physical infrastructure expenditures as those government expenditures which can affect private sector productivity and economic growth, and consequently concentrate to analyse those effects.

To estimate the growth contributions of decomposed public expenditures we construct a measure of broader public capital stock. It is not limited to traditional physical infrastructure but it aims to depict also elements of human capital which have been created by the help of government expenditure. We try to estimate the amount of public health and educational capital in different countries by using the annual public expenditures on health as a basis for estimation of the health capital stock in health. This capital is then used as an input variable in cross-country production function estimation in order to see the impact of health capital on economic growth. Thus, we construct a so-called extended capital stock, which includes both the physical (private and public) capital stock and public educational and health capital stocks. Our aim is to find out whether this extended capital stock has different effect on economic growth than the usual tangible capital stock.

We are aware of the limitations of the production function approach regarding the joint endogeneity of private inputs and outputs. Government spending can be higher in years of high growth, as the state and federal governments have more resources to spend; or it can be higher in years of low growth, if the state and federal governments engage in countercyclical policies.

In an integrated model of human capital formation education and health have an independent impact to the stock of human capital. It is natural to think that good health directly affects labour productivity. Obviously, different determinants of health (or knowledge) have different effects on output. In the case of health, we could also include things like nutrition. Measuring these differences would require a lot of detailed data which we do not unfortunately have. But we hope that our relative rough measures give some sort of first approximations of the true effects.

3. Empirical analysis

The empirical analysis follows the guidelines of Aschauer (1989a, b) in the sense that we focus on the supply side of the economy and try to isolate the impact of productive public expenditures on private output.

Thus, we basically estimate a production function, more precisely, a Cobb-Douglas production function of the type $y = Ae^{\tau t}e^{\alpha}k^{\beta}$ where y denotes output, n labour input, k capital and t time (trend). The estimating equation can be written into the following log linear form:

$$\log(yp_{it}) = b_{0i} + b_1\log(np_t) + b_2\log(k_t) + b_3t + u_{it} \quad (1)$$

where yp now indicates private sector production and np private sector employment. Also k in the first place indicates private sector capital stock but in addition to this concept we use some alternative measures. Thus, $k1$ is the traditional private sector

capital stock while $k2$ is a measure which includes public sector capital (cumulated public sector investment). Finally, $k3$ also includes the human capital stock which is produced within the public sector. For data reasons, this measure includes here only human capital which is produced within formal education and health services.

Obviously, we could include the three capital stocks in the estimating equation but high multicollinearity between the respective time series (Appendix) would have made estimation results too unprecise. Instead, we have experimented with weighting schemes in which $k2$ and $k3$ are obtained by weighting the public sector capital stocks with successively lower weights in computing the aggregate measure of capital stock.

Obviously, the multicollinearity problem can be (in the constant returns to scale case) alleviated a bit by expressing the above-mentioned equation in a ratio form:

$$\log\left(\frac{yp_{it}}{ep_t}\right) = b_{0i} + b_2\log\left(\frac{k_t}{np_t}\right) + b_3 t + u_{it} \tag{2}$$

Still, we have problem in terms of the three capital stocks: private capital stock, public (fixed investment related) capital stock and (public expenditure related) human capital stock[2].

The analysis can be characterized as some sort of horse-race: the performance of the estimated equations with different capital stock measures are compared and on the basis of this comparison we try to see whether different public sector productive activities have any impact on private sector production and thus on total output.

4. The data

Basically, two sets of data are used: an extensive World Development Indicators (WDI) data which cover all world countries for the period 1960-2002 and more limited (although more detailed) OECD data which cover 22 countries for the period 1960-2004. The EDI data include altogether 208 countries but in practice the number of countries is less than half of that number.

The problem with the WDI data is the fact that the data do not allow for a proper distinction between private and public sectors. Thus, we cannot identify the possible spill-over of public sector productive activities to the private sector. We can only focus on the impact of public sector health and educational capital stock on total output. Thus, the competing capital stocks consist of either total fixed capital or total fixed + health and educational capital (Appendix).

With the OECD data, the situation is better because a proper distinction can be made and, moreover, we can distinguish between different public sector activities (like education, health and so on). The main problem now is the fact the countries are too similar. We have just the Nordic countries, on the one hand, and the USA and Japan, on the other hand, as some sort of outliers but even then the country differences are relatively small which makes it difficult to trace the effects of different government policies.

The data sets are too extensive to be illustrated here. Here (Appendix), we only display the capital output ratios for the OECD countries with private fixed capital and, alternatively, with the extensive capital concept (i.e. private fixed capital + public fixed capital + public health and educational capital). The details of the data are explained in the data appendix.

The main problem in the empirical analysis is the fact that it is not possible to observe directly the stock of human capital. Therefore, one has to use indirect methodology to

estimate these stocks. In principle, there are two approaches to estimate the public health and educational capital stocks. The first approach starts with the public expenditure data. The idea is to consider annual expenditures as investments. The resources (labour and commodities) devoted to health care and education represent investment in health. After this one can use the perpetual inventory method to accumulate the stock of capital. That methodology requires information about the economic life of investments and depreciation rates.

The other approach uses the returns of investment as a basis for calculating the value of capital. In case of health the returns consists of:

- decrease in mortality (decrease in deaths of workers);
- decrease in disability of labour (decrease in the loss of working time); and
- decrease in debility (loss of productive capacity while at work).

All these reductions increase the effective labour input (working time), which can be used to calculate the output effect. Output effect can be calculated either by using data on output per labour unit (which includes the contribution on capital per worker) or earnings (in this case one neglects the effect of capital on output), cf. Mushkin (1962)[3]. If one is able to estimate the annual output effects in this way, the value of capital stock can be calculated as a discounted present value of future increases in output. In general, expenditure based method and output based methods lead to different estimates of the capital stock.

In our work we have used the first methodology, because the availability of data prevents us to use the output based methodology. The detailed description of the calculation of public capital is presented in the data appendix.

5. Empirical results

The estimation results of equations (1) and (2) are presented in Table I for the World Bank (WDI) data and Table II for the OECD data. The time series properties of the key variables are scrutinized in Table III. The message of the table (and the included panel unit root tests) is quite clear: the level form data are non-stationary while the first differenced form is reasonably well characterized as stationary. In the light of this result, the *t*-ratios of the level form equations should considered with due care (or rather ignored altogether). One might ask whether the series are cointegrated (and whether the models should be estimated with the cointegration terms). That is something which we do not really consider because we do not want to abandon the production function framework for some (possibly) more data consistent specification.

When estimating the model we want to examine the robustness of results by using both level and first differenced specification (in addition to capital/labour ratio forms) and different estimators. Here, the reported results represent un-weighted fixed-effects least squares estimates (using GLS to take cross-section heteroskedasticity into account did not make noticeable change in results).

With levels and first differences we find some differences especially with the OECD data suggesting that dynamic specification is not completely data-consistent. Obviously, this reflects the nonstationarities of the data. The comparison of estimators produces less alarming results suggesting that some awfully volatile output and input growth countries may not dominate the results.

Table I.
Results with the WDI (World Bank) data

Regressors	1	2	3	4	5	6	7	8
Countries	93	93	93	93	26	26	26	26
Period	1960-2002	1960-2002	1961-2002	1961-2002	1980-2002	1980-2002	1981-2002	1981-2002
Observations	3,597	3,480	3,504	3,387	567	565	539	537
Constant	5.992 (0.16)**	4.449 (0.14)**	0.001 (0.01)	−0.005 (0.01)	0.517 (0.90)	−0.529 (0.86)	0.001 (0.005)	−0.002 (0.005)
a_1	0.589	0.456	0.712 (0.29)*	0.639 (0.31)*				
a_2					0.698 (0.08)**	0.697 (0.09)**	0.835 (0.09)**	0.853 (0.09)**
b_1	0.411 (0.01)**		0.331 (0.03)**		0.556 (0.02)**		0.507 (0.05)**	
b_2		0.544 (0.01)**		0.489 (0.04)**		0.593 (0.03)**		0.531 (0.06)**
Trend	−0.002 (0.002)	−0.006 (0.001)**	−0.000 (0.08)	0.000 (0.08)	0.004 (0.004)	0.001 (0.004)	0.0001 (0.13)	0.0002 (0.14)
Trend squared	0.036 (0.03)	0.083 (0.02)**			0.004 (0.07)	0.039 (0.07)		
R^2_{Adj}	0.995	0.996	0.153	0.176	0.999	0.999	0.508	0.506
SEE	0.1620	0.1438	0.0459	0.0450	0.0560	0.0547	0.01932	0.0193
D-W	0.083	0.101	1.631	1.675	0.125	0.133	1.443	1.456

Notes: The dependent variable is GDP at constant market prices. Standard errors are in parentheses. All equations are estimated by OLS. All samples are unbalanced. The smaller sample represents high-income countries. Equations (1) and (2) are estimated by imposing constant returns to scale while the other equations are unrestricted. Equations (3), (4), (7) and (8) are estimated in first differences. a_1 is the coefficient of total labour force, and a_2 the coefficient of total employment; b_i is the coefficient of capital. The subscript 1 refers to the sum of private and government capital stocks and to an enhanced capital stock which includes private, government and human capital stocks; *Significant at a 5 percent level; **Significant at a 1 percent level

Table II. Results with the OECD data

Equations	1	2	3	4	5	6	7	8	9
Observations	826	826	826	826	826	826	805	805	805
Constant	7.987 (0.62)**	6.746 (0.62)**	4.590 (0.68)**	4.261 (0.20)**	4.031 (0.20)**	3.29 (0.23)**	0.019 (0.003)**	0.020 (0.003)**	0.023 (0.003)**
α	0.222 (0.04)**	0.285 (0.04)**	0.319 (0.04)**	0.434	0.426	0.377	0.572	0.585	0.595
$\beta_?$	0.549 (0.02)**			0.566 (0.02)**			0.428 (0.05)**		
β_2		0.554 (0.02)**			0.574 (0.02)**			0.415 (0.05)**	
β_3			0.608 (0.02)**			0.623 (0.02)**			0.405 (0.05)**
Trend	0.007 (0.002)**	0.008 (0.001)**	0.008 (0.002)**	0.008 (0.002)**	0.008 (0.001)**	0.007 (0.001)**	−0.00027 (0.08)**	−0.00028 (0.09)**	−0.00037 (0.09)**
Trend squared	0.011 (0.02)	0.016 (0.02)	−0.005 (0.02)	−0.018 (0.03)	0.000 (0.03)	−0.010 (0.02)			
R^2_{Adj}	0.999	0.999	0.999	0.998	0.998	0.998	0.229	0.217	0.197
SEE	0.0740	0.0739	0.0755	0.0771	0.0754	0.0752	0.0257	0.0259	0.0263
D-W	0.138	0.137	0.135	0.117	0.124	0.130	1.658	1.661	1.63

Notes: The dependent variable is private sector production (value-added at constant market prices). Standard errors are in parentheses. All equations are estimated by OLS. All samples are unbalanced. Equations (1)-(3) are estimated with no restrictions, equations (4)-(6) by imposing constant returns to scale and equations (7)-(9) by imposing constant returns to scale with first differences. α is the coefficient of private sector employment, β is coefficient of capital. Subscript 1 refers to private sector capital, 2 to sum of private and government capital stocks and 3 to the sum of private, government and human capital stocks. The sample period is 1960-2004

Table III.
Results from unit root tests

Variable	Private production Level	Private production 1st difference	Private employment Level	Private employment 1st difference	Capital stock Level	Capital stock 1st difference
Im, Pesaran and Shin W-*statistic (null: unit root)*						
Statistic	0.5112	−12.4238	1.0400	−10.4073	−0.4710	−3.6656
Probability	0.6954	0.0000	0.8508	0.000	0.3188	0.0001
Breitung t-*statistic (null: unit root)*						
Statistic	0.0446	−8.3555	0.7104	−9.9890	−1.4935	−2.2119
Probability	0.5178	0.0000	0.7613	0.000	0.0677	0.0135

Notes: Variables are in logarithms. Capital stock includes both private, public and human capital stock

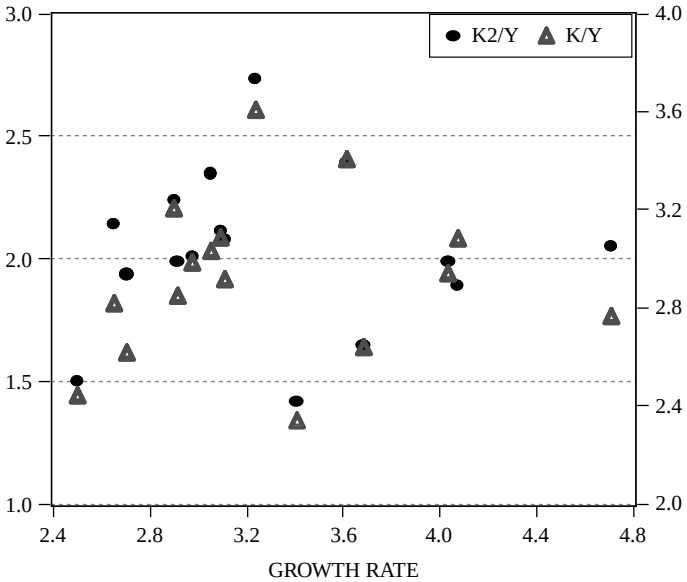
Turn to the economics of the results. Our interpretation is the following: public sector expenditures seem to have a systematically positive effect on both total output and private sector output. The effects are not necessarily very strong and they cannot be estimated very precisely but even then the evidence suggests that the link between public sector production and private sector productivity is an important one and deserves further analysis.

The main problem in all analyses is not necessarily the role of public sector input but the not so good performance of the production function relationship in aggregate time series data – even though we use rather large panel data sets. This may result various reasons but at least the crude way in which technical change is introduced into the model deserves critical attention[4].

With the larger WDI (World Bank) data the coefficients are quite reasonable especially if we move to first differences. Then the estimates come quite close to the typical National Accounts values of 2/3 and 1/3. Even with the level form specification the parameter values make sense, especially if we impose constant returns to scale (equation (2)). With the OECD data we have more problems with the parameter values probably reflecting the smaller sample size. Again imposing constant returns to scale makes the results more sensible.

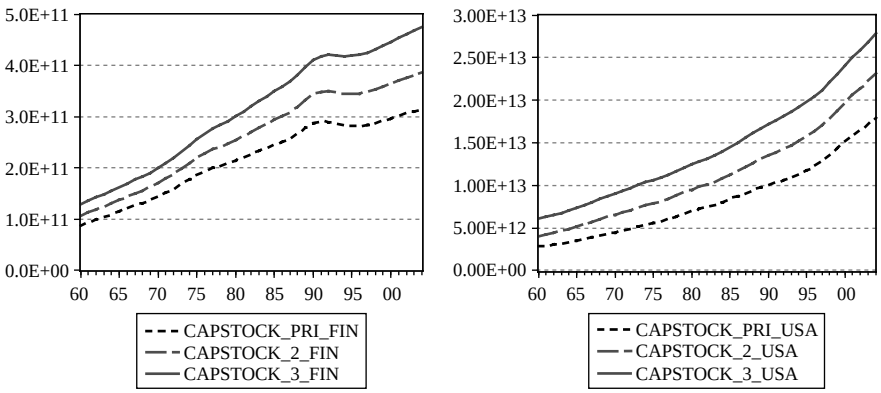
When we arrange the "horse race" between different competing capital stocks, we general outcome is a bit disappointing because we cannot very well discriminate between competing capital stocks. Maybe that is not so surprising given the close correlation between these measures as can be seen from Figures 1 and 2 (to save space, we display here the capital stock data only for two sample countries: Finland and the USA).

Obviously, aggregation of different measures should be more sophisticated than just a sum aggregate of various private and public capital stocks. We have indeed made some preliminary steps towards this direction by weighting the public sector (broad) measure by a set of constant weights ranging from 0 to 1 (the weight of private capital stock is always 1). This exercise gives the public sector capital stock a weight of 0.3-0.5 which sounds relatively reasonable. With the WDI data, a general tendency is that the coefficient of the broader capital stock become bigger and the explanatory power gets better. With the smaller (OECD) data the coefficient values follow the same pattern but the explanatory power remains more or less the same. Taking together the results imply that including public productive capital into the (private sector)



Note: *K* refers to the private sector capital stock and *K2* to the enhanced capital stock

Figure 1.
Capital-output ratios and the growth rate of GDP with the OECD data



Notes: Pri – private capital stock; 2 – private and government capital stocks; 3 – private, government and human capital stocks

Figure 2.
Capital stock graphs for Finland and USA

production function does not make the results worse. One might even say that the outcome is slightly the contrary.

Looking at the sub-sample estimates suggests that there is no clear declining tendency in the impact of public sector capital on private sector output or total productivity. This is especially interesting because in all countries public sector (fixed)

investment has declined and if in fact the productivity of public sector capital has not declined that may explain some part of overall productivity decline. Of course, matters are not that simple because the decline in public sector fixed investment is probably (partially or even totally) compensated by an increase in public sector investment in education and health.

6. Concluding remarks

Our analysis does not unambiguously show that public capital is productive but neither does the analysis support the interpretation that public capital has no productive effect on private sector output. Had public sector capital – in its all forms – been completely unproductive it would have shown up in the results in the way that the broad concepts of capital show poorer performance than the traditional narrow (private) definitions. That was not, however, the case. It can also be argued that the idea that all sorts of government investment have zero effect on private sector production is intuitively a bit hard to swallow.

Our empirical findings suggest that in addition to traditional public investment in infrastructure also public health and education expenditures (i.e. intangible public investments in human capital) have contributed positively to private sector productivity growth in almost all countries. This finding clearly motivates construction of more sophisticated measures of public sector production and capital accumulation – in the similar way that has happened with the private sector, and the ICT sector, in particular.

The idea that private sector productivity is affected by public sector production and capital accumulation is by no means novel but, unfortunately, it has not been analyzed properly. If indeed changes in private sector productivity are affected by government policies the rate of return from various government investments has to be reconsidered and the optimal level of expenditures has to be adjusted accordingly.

Notes

1. The study by Tanzi and Schuknecht (2000) shows that public spending did not grow much between 1870 and 1913, 1913 and 1960 the growth was moderate and after that very rapid. In 1960-1980, especially expenditures for public subsidies and transfers and various social welfare purposes, like education and health, have been growing. On the other hand, there has been much less growth in public investments and defence. In conclusion, the authors argue that government expenditures are now in many countries much too high when considering the achievement of the goals of social welfare.
2. Instead of estimating all parameters of the model at the same time we have also used a two-step procedure and estimated (or, in fact, calibrated) in the first stage the standard CD production function (without public capital) and derived the Solow residual from it. Then we regressed this residual on either public expenditures or public sector capital stock. Results from this analysis came so close to results reported in Tables I and II that there is point of presenting them here.
3. Just to give an example, Denison (1962) estimated that health investments had increased the annual growth rate of GDP in the USA for 1900-1960 by 0.3 per cent points.
4. As one can see from the tables, all level from equations suffer from autocorrelation and heteroskedasticity. Although we correct the *t*-values, the correction may not solve the whole problem. One should also keep in mind that that the data inevitably include measurement errors which may bias the coefficients.

5. The data is available upon request from the Government Institute of Economic Research.
6. Based on national accounts provided by OECD and general government expenditure statistics provided by Eurostat.

References

Aschauer, D. (1989a), "Is public expenditure productive?", *Journal of Monetary Economics*, Vol. 23, pp. 177-200.

Aschauer, D. (1989b), "Does public capital crowd out private capital?", *Journal of Monetary Economics*, Vol. 24, pp. 171-88.

Banister, D. and Berechman, J. (2003), "Economic development effects of transport investment", in Pearman, A., Mackie, P. and Nellthorp, J. (Eds), *Transport Projects, Programs and Policies*, Ashgate Publishing, Aldershot.

Denison, E. (1962), *The Sources of Economic Growth in the United States and the Alternative before Us*, Committee for Economic Development, New York, NY.

Garcia-Milà, T., McGuire, T.J. and Porter, R.H. (1996), "The effects of public capital in state-level production functions reconsidered", *Review of Economics and Statistics*, Vol. 78 No. 1, pp. 177-80.

Hulten, C.R. and Schwab, R.M. (1991), "Public capital formation and the growth of regional manufacturing industries", *National Tax Journal*, Vol. 44 No. 4, pp. 121-34.

Kamps, C. (2006), "New estimates of government net capital stocks for 22 OECD countries 1960-2001", *IMF Staff Papers*, Vol. 52, pp. 120-50.

Lamo, A. and Strauch, R. (2002), "The contribution of public finances to the European growth strategy", *The Impact of Fiscal Policy*, paper presented at Public Finance Workshop, Banca d'Italia, Research Department, Perugia, 21-23 March.

Mankiw, N.G., Romer, D. and Weil, D.N. (1992), "A contribution to the empirics of economic growth", *Quarterly Journal of Economics*, Vol. 107, pp. 407-37.

Mushkin, S.J. (1962), "Health as an investment", *Journal of Political Economy*, Vol. 70, pp. 129-57.

Perotti, R. (2004), "Public investments: another (different) look", IGIET Working Paper No. 277, Universita Bocconi, Milan.

Perotti, R. (2005), *The Empirical Case Against the Golden Rule of Government Investment*, ECO/GEN 2005(2), OECD, Paris.

Sturm, J-E. and De Haan, J. (1995), "Is public expenditure really productive? New evidence from the USA and the Netherlands", *Economic Modelling*, Vol. 12, pp. 60-72.

Tanzi, V. and Schuknecht, L. (2000), *Public Spending in the 20th Century: A Global Perspective*, Cambridge University Press, Cambridge.

Tatom, J.A. (1991), "Should government spending on capital goods be raised?", *Federal Reserve Bank of St. Louis Review*, March/April, pp. 3-15.

Further reading

Kamps, C. (2004), *The Dynamic Effects of Public Capital: VAR Evidence for 22 OECD Countries*, Kiel Studies 331, Kiel Institute for World Economics, Kiel.

Appendix. Definitions and sources of the data

Data[5]

The two main data sources are the World Bank and the OECD. In the next section, both sources are treated separately.

The World Bank's annual data contains 34 time series from 208 countries. The longest possible time interval is from 1960 to 2002, but several countries have much shorter time series. About 93 countries are selected to be used in this study. This includes the countries that have all essential time series and capital-output ratios. Following time series have been used in empirical analysis:

- y GDP (constant)
- g general government final consumption expenditure (constant)
- – gross capital formation, total (constant)
- l labor force, total
- – unemployment rate, total

Generated time series are:

- k capital stock, total
- h human capital stock
- kh enhanced capital stock, which includes total and human capital stocks
- n employment, total

Capital stocks have been generated using gross capital formation series, capital-output ratios and average depreciation rate. Initial value of the capital stock has been counted by multiplying initial year's gross domestic product by same year's capital-output ratio. The capital-output ratios have been obtained from King and Levine's (1994) article "Capital fundamentalism, economic development, and economic growth". The article does not cover capital-output ratios for all the countries or all possible years. That is one of the reasons why some countries have to be left out. The capital stock of the following year has been counted assuming that the annual depreciation rate is 5 per cent for all the countries. This depreciation rate may be an overestimation, because total investment series includes both private and public investments. Knowing the initial value, the gross capital formation series and the assumption about the annual depreciation rate, counting the capital stock series is trivial. The capital stock series have been counted separately for each included country, because countries have different initial years in the gross capital formation series.

Human capital stock is much more puzzling, because it is harder to generate human capital investment series and even harder to figure out the initial value of the human capital stock. In this study, it is assumed that the human capital investments include all education expenditure and 60 per cent of health expenditure. It is approximately true that in Finland about 60 per cent of the health expenditure is used on children or people at working age. (This does not mean that the health expenditure used on retired people is waste. It just means that this expenditure has no direct impact on private sector productivity or production growth.) All the education expenditure and 60 per cent of the health expenditure is about 35 per cent of total government consumption in the OECD-countries[6]. That is why annual human capital investment is assumed to be 35 per cent of the government's consumption expenditure. The initial value is assumed to be ten times the first year's investment in other words 3.5 times the first year's government total consumption expenditure. Human capital stock is assumed to depreciate 10 per cent per year. By means of these assumptions the human capital stock can be easily calculated.

The OECD's annual data contains time series from 29 OECD-countries. Necessary data is available from 21 countries and they are all included in the empirical analysis. Following time series have been used:

- *y* GDP (volume)
- *g* government consumption (volume)
- – government investment (volume)
- – private fixed investment (volume)
- – employment, total
- – employment, government

Generated time series are:

- *np* employment, private
- *k*1 private fixed capital stock
- *kg* government capital stock
- *kh* human capital stock
- *k*2 enhanced capital stock, which includes private and government capital stocks
- *k*3 enhanced capital stock, which includes private, government and human capital stocks
- *yp* private production

Generating private employment and enhanced capital stock series is trivial. Private production has been counted deducting government consumption and investments from the gross domestic product. The capital stock series have been generated using the same principles as with the World Bank's data. Assumed annual depreciation rates for private capital, government capital and human capital are 5.9, 3.8 and 10 per cent, respectively. The depreciation rates are assumed to be same for all the countries and the depreciation rates that are used with the OECD's data have been counted for Finland by using time series released by the Statistics Finland. The annual depreciation rate has been counted as average for the time period of 1975-2002 using time series of net capital stock by industry and consumption of fixed capital by industry. The initial value of the capital stock has been counted as in the World Bank's case, but now it had to be divided into private and public sector. This has been done by using average shares of private and public investments. These values have been corrected by the difference of the depreciation rates, because the public investments sustain longer than the private ones. The initial value has been distributed among the sectors based on these corrected average investment shares. When these are known counting the private and government capital stocks is trivial.

Country groups

In estimation, the World Bank data has been used as a whole and some equations has been estimated also for a subgroup, that includes only countries classified as high income countries by the World Bank (*World Development Report 2004: Making Services Work for Poor People,* pp. 250-51). These countries had gross national income per capita over $9,076 in the year 2002.

High income countries are: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Hong Kong, Iceland, Ireland, Italy, Japan, Republic of Korea, Luxembourg, The Netherlands, New Zealand, Norway, Portugal, Singapore, Spain, Sweden, Switzerland, UK and USA (altogether 26 countries).

Other countries are: Algeria, Argentina, Bangladesh, Benin, Bolivia, Botswana, Brazil, Burundi, Cameroon, Chile, Colombia, Congo Republic, Costa Rica, Dominican Republic, Ecuador, Egypt, El Salvador, Ethiopia, Gabon, Gambia, Ghana, Guatemala, Guinea Bissau, Guyana, Haiti,

Honduras, India, Indonesia, Iran, Ivory Coast, Jordan, Kenya, Lesotho, Madagascar, Malawi, Malaysia, Mali, Mauritania, Mauritius, Mexico, Morocco, Mozambique, Nicaragua, Niger, Nigeria, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Rwanda, Senegal, Sierra Leone, South Africa, Sri Lanka, Swaziland, Syria, Thailand, Togo, Tunisia, Turkey, Uganda, Uruguay, Venezuela, Zambia and Zimbabwe (67 countries).

The 21 selected countries from the OECD data are: Austria, Belgium, Canada, Germany, Denmark, Finland, France, UK, Greece, Ireland, Iceland, Italy, Japan, Republic of Korea, Mexico, The Netherlands, Norway, New Zealand, Portugal, Sweden and USA.

Data sources

Eurostat (2005), "General government expenditure by COFOG function and type" (accessed 20 March).

King, R. and Levine, R. (1994), "Capital fundamentalism, economic development, and economic growth" *Carnegie-Rochester Conference Series on Public Policy*, Vol. 40, North-Holland, Amsterdam, pp. 259-92.

OECD (1998), *National Accounts*, Vol. II, OECD, Paris.

OECD (2004), *Economic Outlook No 76: Annual and Quarterly Data*, OECD, Paris.

World Bank (2004), World Development Indicators 2004.

Corresponding author

Matti Viren can be contacted at: matvir@utu.fi