CHAPTER 17

AGGREGATE PRODUCTIVITY EFFECTS OF ROAD INVESTMENT: A REASSESSMENT FOR WESTERN EUROPE

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ABSTRACT

Economists have long been interested in the productivity effects of infrastructure investment, and this research has been an important input into budget allocations for investment in transport infrastructure. This chapter analyses the macroeconomic productivity effects of road investment in 13 Western European countries. This chapter shows that the rate of return for many countries on past investment, while positive, has been quite low at around five per cent. Assuming that infrastructure investment is subject to falling returns, the return on future investment in Europe is likely to be even lower. This does not necessarily apply to Ireland which has a relatively undeveloped stock of road infrastructure, suggesting that future road investments are likely to have higher returns than elsewhere in Europe.

1 The author is grateful for the valuable comments received from two anonymous referees.

17.1 Introduction

Transport infrastructure investment, and road infrastructure investment in particular, are seen by a major part of the general public and by many political decision makers as a central instrument to promote regional or national economic growth. Large-scale investment in the road network formed part of long-term growth policies in the US under the Dwight D. Eisenhower System of Interstate and Defence Highways, which was launched in 1956 and led to over 80,000 miles of highways by 1980 (Federal Highway Administration, 1976). In 1998, the Transportation Equity Act was signed, assigning $203 billion to improve the national highway infrastructure. Of this amount, $176 billion was allocated for highway construction (Chandra and Thompson, 2000).

The European Council of October 2003 called on Member States to "...promote investment in networks and knowledge". It highlighted "the importance of speeding up the roll-out of European transport, energy and electronic communications networks and of increasing investment in human capital". These are crucial steps to boost growth, better integrate an enlarged Europe and improve the productivity and competitiveness of European businesses on global markets (Commission of the European Communities, 2003)". The Community budget contributes €700 million annually to fund up to ten per cent of Trans-European Network (TEN) projects. The Structural Funds are foreseen to provide €29.2 billion for transport infrastructure while Cohesion fund resources can mobilise up to €1.5 billion per year for infrastructure investment. Furthermore, the Commission is considering setting up an innovative Guarantee Instrument to facilitate private sector funding through Public Private Partnerships (PPPs) for TEN transport projects. The European Investment Bank (EIB) supports the Growth Initiative with a €50 billion TEN Investment Facility to be allocated to TEN's priority projects. In addition, the EIB reinforces its financing capacity under the Structured Finance Facility which, inter alia, supports the TEN projects. On the national level, transport infrastructure investment is considered to be of equal importance to increase economic growth.

The strong role assigned to transport infrastructure investment as a vehicle for economic growth appears to be worth critical examination for at least two reasons. There is no strong growth theory foundation for the hypothesis that an increase in transport infrastructure investment would lead to an immediate and lasting increase in growth rates of economic activity. Rather, according to the exogenous growth theory, an increase in the investment rate (which does not necessarily result from an increase in transport infrastructure investment) leads to an increase in income levels (Barro and Sala-i-Martin, 1995). Some variants of endogenous growth theory do provide a link between transport infrastructure investment and growth rates. The link is established by the effects of transport infrastructure investment on urban form and the size distribution of cities, and the resulting agglomeration economies (Lucas, 1988; Black and Henderson, 1999; Lucas, 2001; Lucas and Rossi-Hansberg, 2002). However, the links from transport infrastructure investment to economic growth are less direct than claimed in public debates, and related arguments are rarely used in policy discussions.

There is no clear, empirical evidence that transport infrastructure investment leads to higher growth or even to a higher level of income. Some authors interpret the strong correlation between public capital and macroeconomic productivity, which was found for the US, as evidence that infrastructure generally provides valuable services to the private sector and that, in particular, the slowdown in US public investment after the early 1970s explains a substantial proportion of the concomitant productivity slowdown.[1] Other authors have argued that public capital is endogenous, in that higher public investment is due to the public sector response to an increased demand for infrastructure services resulting from higher aggregate income.[2] Sectoral and regional disaggregation have led to smaller, positive but more robust effects (see the review in Cohen and Morrison Paul, 2004). A number of studies have looked into issues which complicate the estimation of public infrastructure investment effects, such as the existence of spatial spillovers from public infrastructure investment in geographically linked areas and the temporal dependence of estimated infrastructure effects. Kelejian and Robinson (1997) allowed for spatial lags of dependent and independent variables along with spatial correlation of the error terms. Holtz-Eakin and Schwartz (1995) consider interstate spillovers in a production model based on long lags to accommodate long-run adjustment, and Boarnet (1998) measured cross-county spillovers using a Cobb-Douglas production function approach.

Among the studies which addressed the more specific question of whether road infrastructure investment increased productivity, Carlino and Voith (1992) found that the productivity of US states was higher the greater the density of highways. Holtz-Eakin and Schwartz (1995) could not confirm the strong positive productivity effects of transport infrastructure on the state level. Holtz-Eakin and Lovely (1996) succeeded in relating output growth to the positive effect transport infrastructure investment had on the number of firms in the manufacturing industry, without observing a direct effect on manufacturing productivity.

Within the production function approach, Canning (1999) and Canning and Bennathan (n.d.) have used a different method to solve the problem of the endogeneity of public capital. It is based on the non-stationarity of the data for output per worker and capital stock per worker. This means that the production function may represent a long-run, co-integrating relationship. They use this fact to apply the panel data co-integration methods of Kao and Chiang (2000). Using this method, two assumptions are made. It is assumed that production functions are identical for all countries, and that the relationship between investment and income varies across countries. This allows each country in the sample to have its own short-run investment dynamics, to give consistent estimates of the parameters of the production function which are robust to reverse causality.

This chapter is related to the study of Fernald (1999). He tried to give an answer to the question of how changes in road stock affected the relative productivity performance of US industries from 1953 to 1989. His argument is based on the hypothesis that if roads contribute to industries' productivity, industries which use roads intensively should benefit more from their expansion. Given the complemenarity between vehicle use and road use, and the lack of direct measures for industrial road use, vehicle use is employed as a direct measure of road intensity. The basic result of Fernald's study is that changes in road growth are associated with larger changes in productivity growth in industries which are relatively vehicle-intensive. This finding supports the hypothesis that industries with more than average vehicles benefited more than proportionately from road building. This result, in turn, suggests that the correlation between aggregate productivity and infrastructure reflects causation from changes in road stock to changes in productivity. If roads did not contribute to aggregate productivity at the margin, but governments just built more roads as aggregate income rose, one would not expect any particular relationship between an industry's vehicle intensity and its relative productivity performance when road growth changes. The results do not, however, support the idea that public investment offers a continuing route to increasing income. The US industry data are consistent with the view that the massive road-building of the 1950s and 60s offered a one-off boost to the level of productivity, rather than an instrument to continuing rapid growth in productivity.

This chapter differs from Fernald's (1999) paper in that different congestion levels between countries are taken into account. Moreover, we add bilateral trade between the European countries to the picture. The productivity enhancing effect of road infrastructure investment does not only depend on national road infrastructure stocks, but also on the accumulated road investment in trading partner countries. In contrast to the Fernald study where all industries use the same national road infrastructure, the countries studied here use different national infrastructure and use the roads of the trading partners. We distinguish the Western European countries by their transport intensity, as well as their use of labour and capital. The next section sets out the conceptual framework for the empirical analysis. Section 17.3 explains some data and econometric issues, and the results of the empirical analysis are presented in Section 17.4. In Section 17.5 we make some concluding remarks.

17.2 Conceptual Background

This section provides the conceptual background of the estimation equation. The estimation makes use of data on transport infrastructure investment in 13 Western European countries, for which transport infrastructure investment data are available for the years 1975 to 2000. The estimation function relates that part of national value added growth which cannot be explained by increased usage of private inputs to the services derived from road stock available to national road users. Road stock services are not only dependent on national road stocks but also on foreign roads to the extent that they are used for international trade. Moreover, the road services depend on the number of vehicles and the level of congestion.

The derivation of the estimation equations starts out from a macroeconomic production function. This function relates the individual country's gross output to labour inputs, the capital stock of private firms and the input of transport services. The transport services are in turn produced by combining road services and vehicles. With the assumption of decreasing marginal productivities of vehicles and of infrastructure stock, use of vehicles per kilometre of road infrastructure could be used as a proxy to account for congestion. As the demand for road services cannot be directly observed, the complemenarity with the demand for vehicles is used to estimate the contribution of road stock to the growth in gross output.

To be able to use the value added statistics, instead of having to use gross production statistics which are unavailable for some of the panel countries, the Divisa index of value added growth as a function of gross output growth and the growth of intermediate goods' input is used. The value added growth equation is used to derive the value added residual that cannot be traced back to the growth of capital, labour and vehicles. This residual is a linear function of the growth of road services and a technology shock.

The growth in national road service consumption depends first on the increase in domestic road stock and on the increase in the road stock in foreign countries weighted by the respective shares of the partner country in the total of bilateral trade. Secondly, the availability of road services depends on the level of congestion, proxied by the number of vehicles per kilometre of road infrastructure.

With an estimation equation derived in this way, there would still be an endogeneity problem. In other words, the empirical analysis could still suffer from transport infrastructure investment growth being induced by higher national incomes rather than the growth of road services contributing to income growth. To address the endogeneity problem, the country-specific technology shocks are broken down into a component that represents a joint random income shock of the entire group of countries in the panel and a country-specific random deviation from this average. This deviation is by construction orthogonal to the national productivity shocks and hence to government expenditures on transport infrastructure.

The income growth which is not explained by the expansion of the use of private inputs is computed as a Tornquist index of value added growth, both for the country group and for individual countries. The final estimation equation assesses the difference of income growth between individual countries and the panel of Western European economies as a function of differences in transport infrastructure growth, taking into account differences in transport requirements per unit of output of the different countries.

17.3 Data and Econometric Issues

The empirical analysis includes Western European countries for which data on all the variables involved are available. The largest gaps in the data were found for transport infrastructure investment, and for the real value of vehicle stock. The countries in the sample are Austria, Belgium, Finland, France, Germany, Italy, the Netherlands, Norway, Portugal, Spain, Sweden and the UK.

A major part of the data used was taken from the OECD's STAN (Structural Analysis) database (OECD, 2004e). This holds for gross production figures, value added, gross capital stock figures and the data on labour compensation. The employment figures in terms of hours worked have been taken from the OECD Productivity database (OECD, 2004d). The changes in vehicle stock were computed from the STAN figures on the production of motor vehicles, trailers and semi-trailers, subtracting exports and adding imports. The vehicle stock figures were calculated by applying the permanent inventory method and using the depreciation rate of 25.3 per cent proposed by Joergensen and Yan (1991b). The long-term interest rate reported in the OECD Outlook (OECD, 2004c) is used as the required rate of return on capital. Lacking information on the relevant taxes and subsidies, the user cost of capital is approximated by the sum of the discount rate and the required rate on return to capital. The total cost of vehicle capital divided by nominal value added gives the share of the vehicle capital cost in value added which is used to compute the Tornquist index of productivity growth. Nominal figures have been deflated using the deflator for private capital investment provided by the OECD Economic Outlook (OECD, 2004c).

Very few ECMT (European Conference of Ministers of Transport) member countries provide data on transport infrastructure stocks. The road stock figures are computed by applying the permanent inventory method to the ECMT data (ECMT, 2004b) on transport infrastructure investment. Following Boskin et al. (1989), it is assumed that roads depreciate geometrically at a rate of 1.9 per cent per year. Constant national currency values for road stock are calculated by using the deflator for government investment, reported in the OECD Economic Outlook (OECD, 2004c). As mentioned above, the variable 'road services' takes account of international trade relations and congestion. Bilateral trade coefficients are based on the bilateral trade data provided by the STAN Bilateral Trade Data Base (OECD, 2004a; 2004b). Congestion is depicted by dividing the constant currency value of road stock by the number of vehicles. The data on the number of vehicles are collected in the ECMT Statistical Report on Road Accidents (ECMT, 2004a).

Wherever absolute national currency values have had to be added up or compared, they have been made commensurable by using the Purchasing Power Parity (PPP) conversion factors of the OECD Economic Outlook (OECD, 2004c).

17.4 Results

For all the countries in the sample, the Tornquist index of productivity increased during the period from 1975 to 2000 (see Figure 17.1), Portugal, Finland and Sweden having the greatest overall increase of Total Factor Productivity (TFP). The increase in the index was highly volatile, but decreased on average over the whole period, as can be seen from Figure 17.2.

The transport infrastructure investment data show that the absolute numbers for transport infrastructure investment, and road infrastructure in particular, are highly volatile. Moreover, the share of transport infrastructure investment, including all modes, in GDP is secularly decreasing for the western European countries. They do, however, show a continuous increase in road stock which is, however, unable to keep pace with GDP growth. For road stock, this implies continuous growth, as shown by Figure 17.3, but at substantially decreasing rates (see Figure 17.4).

Figure 17.1: Tornquist Index of Real Productivity

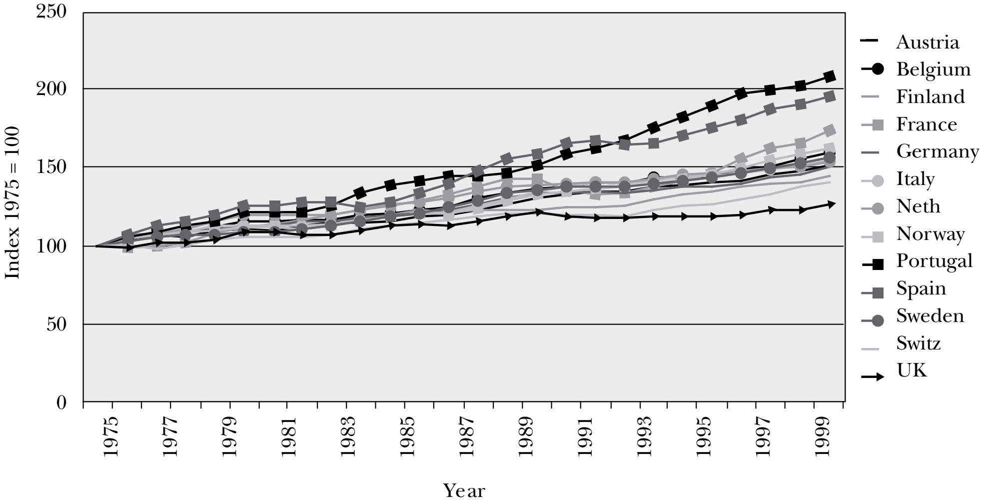


Figure 17.2: TFP Growth

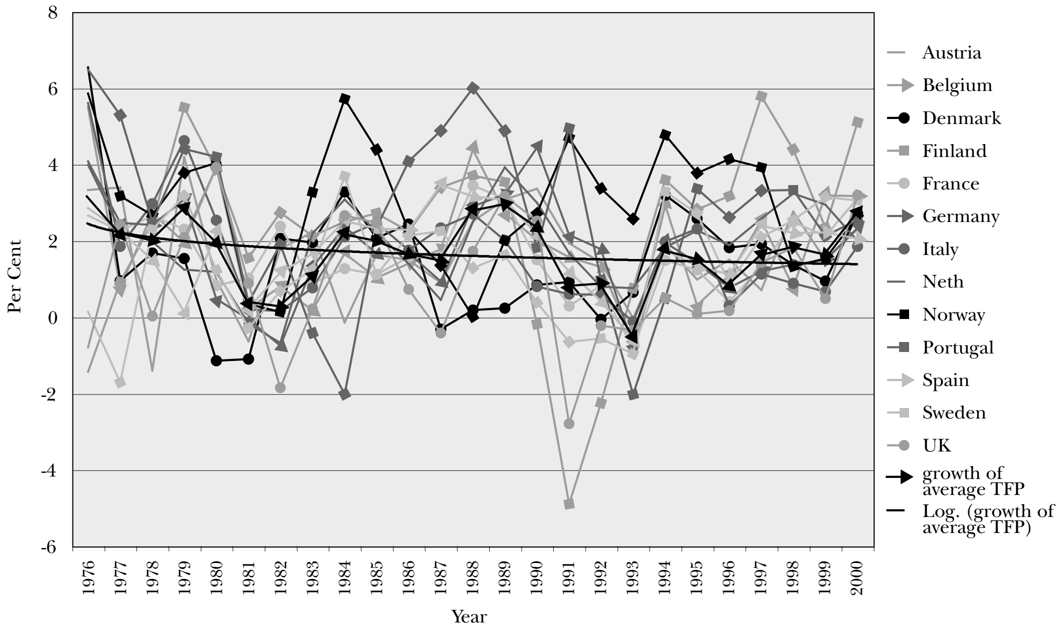


Figure 17.3: Road Stock in 1975 International Dollars (millions)

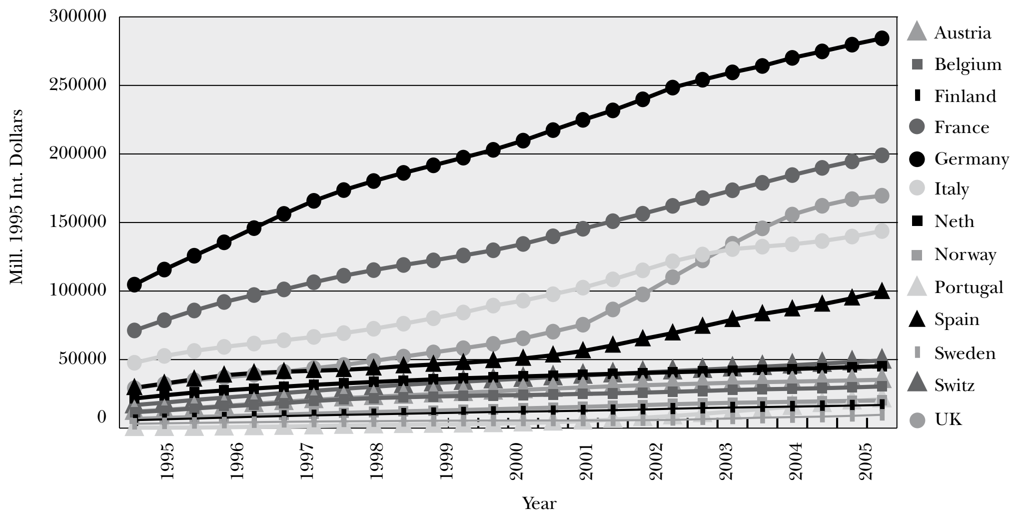
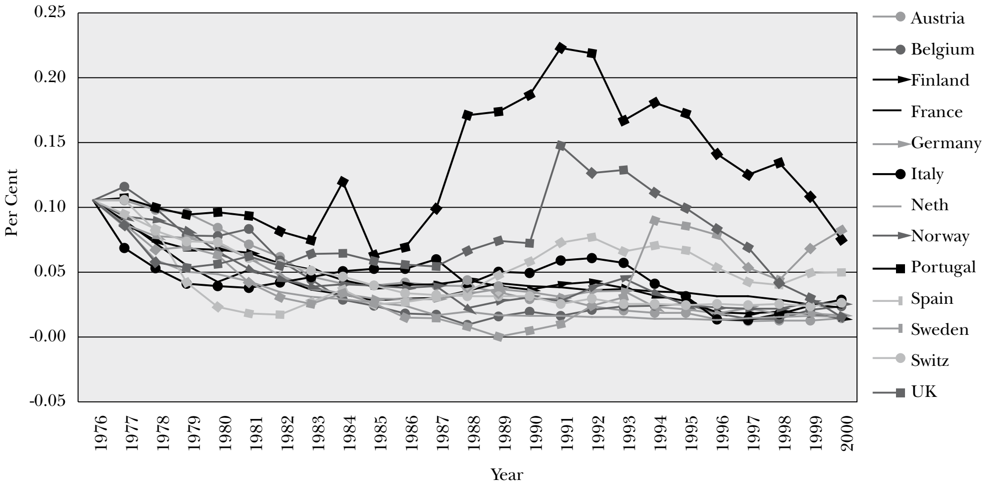


Figure 17.4: Growth Rates of Capital Stock



We estimate the relationship between the growth of road services and the change in the Tornquist index of value added by using a fixed-effects model. That is, we allow for country-specific, unobserved characteristics influencing the relationship between road infrastructure investment and macroeconomic productivity effects, which are assumed to be constant over time.

Whether road infrastructure investment has an impact on macroeconomic productivity growth is determined by the sign of the parameter ϕ. With a positive sign, we obtain an indication that infrastructure investment has a positive influence on productivity growth. In the first regression, we estimate the difference between national growth of TFP, measured by the Tornquist index of national value added, and the average TFP growth of the group of Western European countries overall (difftfp) as a function of the national shares of vehicle expenditures in value added multiplied by the growth rate of national road services (prod1) and the average vehicle share in national value added multiplied by the growth rate of the overall road services (prod2).

Table 17.1: Fixed Effects Regression 1

(Independent variables for national and international road stock).

Number of obs. = 300

difftfp	Coefficient	Standard Error	t	P > ||t||	95 p.c. Confidence Interval
prod1	.7143729	.1921074	3.72	0.000	.3362493 1.092497
prod2	-2.478365	.49504	-5.01	0.000	-3.452749 -1.503981
constant	.2947857	.0294078	10.02	0.000	.2369025 .352669

R-sq: within = 0.0882
between = 0.0266
overall = 0.0458
F test that all $U_i = 0$: F(11,286) = 53.41 Prob > F = 0.0000

Table 18.1 shows difftfp as the dependent variable, prod1 and prod2 as the explanatory variables, the estimation coefficients of the latter, the t values, the P values and the 95 per cent confidence intervals. The table shows that the estimation coefficients have the expected signs (i.e., ϕ is positive), as both, national vehicle shares in value added and the average vehicle share in average value added are positive by definition and the coefficient for the product of the national vehicle share and the national road services is positive, and negative for the product of the overall vehicle share and the overall road stock. An increase in national road services by investment in national road infrastructure improves, *ceteris paribus*, national productivity growth relative to the productivity growth of the country group. All coefficients are highly significant and the F-test shows desired results. However, as can be seen from the reported coefficients, the share in the variation of productivity growth explained by road investment is very low.

Estimating the difference in productivity growth on the national and country group levels as a function of the difference between the products of vehicle shares and road services on the national and international levels does not change the fundamental results, as can be seen from Table 17.2. The ratio of production elasticities (i.e., ϕ) of road stock and vehicle stock remains positive. The significance of the estimation coefficient is, however, slightly decreased and the regression coefficient is even smaller than in the first model.

Table 17.2: Fixed Effects Regression 2

Difference between vehicle share weighted national and international road stock
Number of obs. = 300

difftfp	Coefficient	Standard Error	t	P > ||*t*||	95 p.c. Confidence Interval
diffprod	.6563709	.1964768	3.34	0.001	.2696527 1.043089
constant	.2159342	.0223437	9.66	0.000	.1719559 .2599126

R-sq: within = 0.0374
between = 0.0266
overall = 0.0282
F test that all $U_i = 0$: F(11,287) = 50.81 Prob > F = 0.0000

The third estimation model adds a time dummy to estimation model 2. This improves the performance of the estimate in that the statistical significance of the estimated ϕ is improved and the regression coefficients are increased. The low coefficient for the time variable suggests that there is no problem of spurious correlation, due to the independent and dependent variables following the same time trend.

Table 17.3: Fixed Effects Regression 3

Difference of vehicle share weighted national and international road stock and year dummy
Number of obs. = 300

difftfp	Coefficient	Standard Error	t	P > ||t||	95 p.c. Confidence Interval
diffprod	.7982335	.1919924	4.16	0.000	.4203362 1.176131
year	.0139947	.0029731	4.71	0.000	.0081427 .0198466
constant	-27.6085	5.911197	-4.67	0.000	-39.24347 -15.97353

R-sq: within = 0.1066
between = 0.0266
overall = 0.0528
F test that all U_i = 0 : F(11,286) = 54.46 Prob > F = 0.0000

Including the time dummy leads to the result that road infrastructure services have a positive effect on productivity growth. According to the result in Table 17.3, the variance in growth of road services explains about ten per cent of the variance of the growth of TFP. The results do not suggest that there is an overall shortfall of road infrastructure investment. The rates of return for country i, which using a Cobb-Douglas function, can be computed by the expression $\phi s^{*}_{vi}\frac{Y_i}{G_i}$, i.e., by multiplying the ratio of transport elasticities of vehicles to road services with the vehicle share in value added and the ratio of value added to road services, is on average about five per cent. This result is remarkably close to what Fernald (1999) obtained for the United States of America, using a sectoral panel.

17.5 Concluding Remarks

This chapter has argued that investment in road infrastructure indeed has positive macroeconomic productivity effects. The results of the paper do not, however, justify a general conclusion that national road infrastructure investment levels should be increased.

The rate of return implied by the above analysis does not seem to be high (for many countries around five per cent). A relatively low rate of return might not necessarily be due to too high a level of investment but could be due to a misallocation at the local level. As demand for transport services is highly unequally distributed over space and even over time, local road infrastructure investment projects might have high expected rates of return, even if the overall implied rate of return is low.

The greater income that can be achieved with the given resources may be associated with greater external costs, in particular in the form of environmental damage. On the other hand, the under provision of transport infrastructure services leads to external costs in the form of time costs, which are not reflected in the national accounts data used here. While it is certainly true that GDP is an imperfect welfare measure, further research is required to identify how the impact of transport infrastructure on income differs from the impact on welfare.

An analysis such as the above can, however, give a broad indication as to an appropriate level of infrastructure investment, at least based on the hypothetical assumption that the assignment of investment resources to individual projects is rational. To link the above macroeconomic analysis to planning tools to allocate regional infrastructure resources and cost-benefit analysis at the project level is a matter for future research.

Notes

1 Aschauer (1989, 1990) started the discussion on the productivity effects of public investment. His finding of large positive productivity effects being caused by public investment has been confirmed by Munnel (1990, 1992), Nadiri and Manuneas (1994), Kocherlakota and Yi (1996), Morrison and Schwartz (1996) as well as Duggal et al. (1999).

2 See, for example, Aaron (1990), Hulten and Schwab (1991a), Holtz-Eakin (1994) as well as Sturm and de Haan (1995).

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