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The productive role of public infrastructure: A critical review of recent literature

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**The Productive Role of Public Infrastructure. A Critical Review of
Recent Literature**

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Abstract

The publication of two empirical articles by Aschauer in 1989 brought a renewed interest in the study of the productive role of public infrastructure. Since then, many empirical studies as well as a few surveys have been published not only in regional science journals but also in main stream economics journals. The interest in the subject and the controversy are both high, which constitute two major ingredients for our critical review of recent literature. Our purpose in this paper is to evaluate the recent contributions identifying approaches followed, results obtained, major shortcomings of the empirical evidence produced, areas of strong controversy and promising methodologies for future research.

1. Introduction

When we recall the main research issues in the scientific area of economics through time, we realize how cyclical that interest is. Some issues stay forgotten for several years to return to the interest of researchers and, after a certain period, they become forgotten again. The role of public infrastructure in regional growth is certainly one of these issues. Ignored during a long period, since 1989 with the publication of the studies by Ashauer (1989a, 1989b) many journals published several studies on this subject. Surprisingly, the interest for this issue spread to journals outside the regional science field such as the *Journal of Monetary Economics*, *Review of Economics and Statistics*, *Journal of Economic Perspectives*, *Journal of Macroeconomics*, *Journal of Economic Literature*, etc. The interest of main stream economics journals is, in my view, related to the implications the empirical evidence produced by Ashauer have for the crowding-out versus crowding-in debate related with the role of public investment in economic growth. This work became central in the recent debate although it ignored many interesting papers related with the subject published mainly in regional science journals. Fortunately, after the publication of the study by Munnell (1992) the debate recentred on a larger spectrum of studies where the regional economists have a more significant role.

In this study I review the literature mainly published after 1989 on the role of public infrastructure on regional growth. In 1994 Gramlich published a review of the literature on this subject. Despite the publication of this study, the motivation for my paper is two-fold. First, many studies have been published since then. Second, I shall look to the issue through the regional growth perspective and to claim a more important role for the studies by regional economists.

2. Definition of Collective Infrastructures

When defining collective infrastructures researchers are far from reaching a consensus. Some authors stress the natural monopoly nature of most infrastructures (Gramlich, 1994). Other studies call special attention to the external economies generated by this type of capital (World Bank, 1994; Anderson, 1990). Lavergne (1979) proposes a

classification of collective infrastructures according to three criteria: public provision, public control, and public consumption. Biehl (1980) defines collective infrastructures identifying their properties. According to this author, collective infrastructures are characterised by its immobility, indivisibility, and non-substitutability. The immobility property is the most relevant because it constitutes the major reason to separate public capital from private capital when estimating production functions. We can not rely on the mobility of capital to provide collective infrastructures. This type of capital depend on public financing. Furthermore, if there is not a minimum of collective infrastructures there will not be attraction of private capital to the region (Hirschman, 1958). Therefore, intergovernmental transfers play a crucial role on the provision of collective infrastructures. The indivisibility of infrastructures is also very relevant because it may explain why in some areas the public sector provides infrastructures that in more developed regions are provided by the private sector. Navarre and Prud'Homme (1984) consider not only the three properties referred above but also the properties of polyvalence (also referred by Hirschman, 1958) and high cost of exclusion.

Therefore, some studies tend to stress the overall external economies generated by collective infrastructures. This approach is very relevant today taking into consideration the importance the literature on the “milieu innovateurs” have in Europe. Following this approach we should consider not only infrastructures provided by the public sector but also infrastructures that, despite belonging to the private sector, play a crucial role to create a favourable environment to firms. Moreover, we should not confine ourselves only to capital with a corporeous nature.

If many authors tend to recognise the benefits resulting from using a wider concept of collective infrastructures, most empirical studies use a rather restricted concept of collective infrastructure because it identifies this type of capital with public infrastructure. As recognised by Gramlich (1994) we do so because there is no alternative to quantify collective infrastructures.

3. The Productive Role of Public Infrastructures

The empirical evidence concerning the impact of collective infrastructure comprises many studies following different methodologies. Good reviews of these methodologies can be found in Bruinsma (1995) and Rietveld (1989). In this paper we will confine ourselves to studies that estimate production functions and quasi-production functions.

In the first approach, a production function is estimated considering as independent variables not only indices for employment and stock of private capital but also an index for public capital. Public capital, as we saw before, is the measure used to approach the stock of collective infrastructure. The production function can be represented as

$$(1) Y_t = A_t \cdot F(L_t, K_t, G_t)$$

Y_t - regional output in the period t

L_t - regional employment in the period t

K_t - stock of private capital in the period t

G_t - stock of public capital in the period t

A_t - measure of total productivity of production factors

Different functional forms have been used, although the translog functional form predominates in the empirical studies published in recent years. Although there is some debate concerning the functional form estimated, the center of the debate has been related with the type of data authors use in their studies.

Aschauer (1989a, 1989b) estimated a Cobb-Douglas production function with time series data for the U.S.A. According to his estimates the elasticity of output related with public capital is 0,39, a rather high value. Based on this result Aschauer argues that public capital, instead of crowding-out, crowds-in private investment. The slowdown in the growth of productivity in the U.S.A., according to Aschauer, is in part due to the low

investment on public infrastructures, the consequence of a more liberal economic policy followed in recent years in the U.S.A..

A major criticism of the studies by Aschauer, as we referred before, is related with the type of data he uses in his estimations. Munnell (1992) argues that the use of time series data may capture spurious correlation between output and stock of public capital and consequently the estimated elasticity of public capital is very high. A possible solution to this problem is to estimate the production function using first differences (Hulten and Schwab, 1993). Munnell recognizes, however, that this approach has important shortcomings. In his view, it is not likely that the growth in the stock of public capital might be correlated with the growth of output in the same year. This is valid not only for public capital but also for the other production factors. So, using first differences we may obtain non-significant estimates not only for public capital, but also for the other production factors. Furthermore, this estimation technique does not allow to capture the long-term causal relationship between the variables, which was what we intended to estimate in first place.

To this purpose, Munnell argues that a better approach is to use cross-section data. This procedure will allow higher variability in the combination of production factors and will avoid the spurious correlation problem of time-series data. The author recognises that in the regional science literature we might have estimates using cross-sectional data that would be very useful to compare with the results obtained by Aschauer. Indeed, for regional scientists the subject had been under discussion for a long time and several studies estimating production functions and quasi-production functions had been published at that time. Munnell selected studies estimating production functions, which we transcribe below:

Author	Level of Aggregation	Functional Form	Eg
Aschauer (1989a)	National	Cobb-Douglas	0,39
Holts-Eakin (1988)	National	Cobb-Douglas	0,39
Munnell (1990a)	National	Cobb-Douglas	0,34

Costa et al. (1987)	States (USA)	Translog		0,20
Eisner (1991)	States (USA)	Cobb-Douglas	0,17	
Mera (1973)	Regions (Japan)	Cobb-Douglas	0,20	
Munnell (1990b)	States (USA)	Cobb-Douglas	0,15	
Duffy et al. (1989)	Metropolitan Areas	Log-levels	0,08	
Eberts (1990)	Metropolitan Areas	Translog		0,03

Source: Munnell (1992)

An analysis of the results transcribed by Munnell leads to the conclusion that the estimates of the elasticity of public capital are sensitive to the geographical desegregation of data. The more desegregated are the data the smaller the estimated elasticity. An explanation for this result is related with the fact that smaller geographical areas do not internalise sufficiently the external economies generated by public capital.

Despite the solution to the spurious correlation problem, two more kinds of criticism have been raised to the empirical evidence published on the productive role of public infrastructures. A first criticism is that we still have a specification problem. When we use data for regions, states or metropolitan areas, the estimated parameters capture specificities of the areas considered and consequently are biased (Holtz-Eakin, 1994). According to this author, when we estimate the production function we ignore important factors of differentials in regional productivity. These factors include climate, location, endowments of raw-materials, entrepreneurship, etc. In order to avoid this bias in the estimated parameters, Holtz-Eakin proposes alternative estimation procedures and arrives at elasticities of public capital that do not change with the desegregation of data. Moreover, the estimated coefficient of public capital is not statistically significant. Recognising that it is far-fetched to conclude that public capital does not have a significant impact on production, Holtz-Eakin admits that we might need to use micro data in order to determine what kind of infrastructure produce external economies and what activities benefit from them.

A second criticism is related with the causality issue. Do public infrastructures influence output or is it the other way around? To answer this difficult question Frutos and

Pereira (1995) construct a simultaneous equations model. Public capital influences output both directly and indirectly. It influences directly output as any production factor. It influences indirectly the level of output through the effect it has on the productivity of other production factors. Therefore, the increase in the stock of public capital has two effects of opposite signs over the other production factors. A negative effect because it works as their substitute. A positive effect because it increases their productivity. Simultaneously, the increase in the output induces an increase in fiscal receipts which can be used to finance new public infrastructures.

Considering the above referred interdependencies and introducing assumptions about the behaviour of economic agents, the authors estimate a simultaneous equation model. According to the results obtained by Frutos and Pereira, the growth rate in the stock of public capital depends, with a lag of two years, on the growth rate of output. Nevertheless, the authors also conclude that public capital has a significant impact on output. This result confirms the claim that public infrastructures crowds-in private capital, a familiar result to regional scientists but strongly opposed by macroeconomists.

An alternative that has been followed to solve the causality problem is to estimate only one equation but for sectorial output. The argument is that for sectorial output the causality runs from public capital towards sectorial output and not the other way around. This approach allows one to determine for which sectors the impact of public infrastructures is highest. Following this approach, Shah (1992) estimate translog cost functions for twenty three sectors in Mexico. This author concludes that public capital has a statistically significant impact on output but with small magnitude. Nevertheless, we expect a smaller impact of public infrastructures when the level of aggregation decreases because there will be a smaller degree of internalisation of external economies generated by this type of capital.

An issue over which few authors address is the study of what kind of public capital has the highest influence on regional output. The studies that estimate quasi-production

functions have addressed this question. One of the first works addressing this problem is the study by Looney and Frederiksen (1989) which confirms that, in a first period, infrastructures related with economic activity (economic overhead capital) must be a priority in intermediate regions (see Hansen,1965). In lagging regions the priority must be given to infrastructures oriented to people (social overhead capital). Other studies present inconclusive empirical evidence on this subject (Costa, 1988; Cutanda and Parício, 1994).

Among the studies that estimate production functions, this issue is almost forgotten. Costa (1984) is an exception, although the conclusions obtained for USA states are also inconclusive. An explanation for this lack of interest, results, in my view, from the fact that fundamental theoretical contributions in the field of regional science, such as Hansen (1965) and Hirschman (1958), are ignored and there is an excessive concentration on the works by Aschauer (1989a, 1989b). Surprisingly, in recent years regional scientists have been influenced by the studies by macroeconomists to the point that fundamental research produced by regional scientists is overlooked!

An important limitation of the empirical studies on the productive role of public infrastructures is the fact that the space dimension is ignored. An exception is the study by Biehl (1991). This author estimates a quasi-production function where the dependent variable is the regional development potential and the explanatory variables are location, agglomeration, sectorial structure, and public infrastructures. The regional development potential is proxied by per-capita gross domestic product. Location is measured as the sum of the distance between the region and all the others. Agglomeration is captured using the population densities. For the sectorial structure, Biehl uses the percentage regional gross domestic product that is generated in the industry.

The difference between the effective and the estimated values are used to determine if there is over or under-use of public infrastructures. To this purpose, Biehl computes the differences between the estimates obtained without and with spatial variables. If the differences are positive, the region will have under-use of public

infrastructures. If the differences are negative, the public infrastructures do not constitute a restriction to regional development. Comparing the estimated values of regional per-capita gross domestic product following the procedure referred before, Biehl concludes that the majority of the developed regions have under-use of public infrastructure whereas lagging regions have over-use of public infrastructures. Based on these results, the author defends the implementation of a policy of intergovernmental transfers in favour of less developed regions.

Evaluating the over-all empirical evidence produced in recent years, we observe that the group of studies concluding that public infrastructures play a crucial role on regional development is larger. Also, we find that there is a significant progress in the econometric methodologies used in the estimations. It is interesting, however, that the procedures used to estimate public capital have been subject to the debate. Many authors avoid the problem, using estimates of other authors which constitutes a limitation of recent empirical literature.

A question that we may raise is how is it possible to conclude that there is lack of public infrastructures if there is a clear indication that the elasticity of regional output relative to public infrastructures is high? Should not the cost-benefit studies confirm this prediction and therefore should not investment in public infrastructure be higher? A possible explanation is the “S” curve relating growth rate in public infrastructures and the growth rate of regional output (Jorritsma, 1994).

A second explanation is that private investors claim a reduction in taxes and not an increase in public expenditure which might be an indication that the return to public investment is not that high (Gramlich, 1994). Extending this argument with the teachings of Public Choice we may say that private investors defend a reduction in public expenditure because they are not sure their taxes will be used to finance investments in public infrastructures. If the median voter is decisive the winning platforms will be redistributive which may explain the behaviour of private investors despite the significant

role of public infrastructures in regional development. One can argue that political platforms defending a reduction in taxes have been winning elections. This result can be explained by a change of tastes of voters which may have been influenced by the crowding-out thesis, and by the lack of rigor how public funds are allocated to alternative uses.

If the problem is the choice of uses to public funds, the lack of public infrastructures should not be observed in political systems where there is a direct connection between taxes and their use. The case of the USA where in many cases large public investments are decided with a referendum does not confirm this expectation. An argument is that politicians tend to be cautious in order to have a yes decision and consequently under-provide public infrastructures (Gramlich, 1994). If confirmed this behaviour of voters' representatives, we would have a case that contradicts the predictions of the bureaucracy theory.

The discussion on the reasons why democratic political systems under-provide infrastructures, specially in less developed regions, ignores the immobility of public capital. In less developed regions the level of taxes receipts is not high enough to finance public investment in public infrastructures, despite the recognised productive role of this type of capital. So, at least for less developed regions, there is no contradiction between the major empirical evidence on the productive role of public infrastructure and the lack of public infrastructures.

4. Conclusions

A major conclusion we derive is that, in recent years, many studies on the subject have been published with the majority of them providing empirical evidence that public

infrastructures have a significant impact on regional output. Nevertheless this impact is still subject to discussion.

First, the value of the elasticity vary with the level of aggregation of the data used in the estimations. The explanation usually presented is that the smaller the area the more difficult to internalise external economies generated by public infrastructures. Nevertheless, the values estimated for national time series data are excessive and constitute a major argument of the authors against the significance of public infrastructures as determinants of regional output. More sophisticated techniques using time series data tend to confirm this perspective since the value of the elasticity, despite being statistically significant, is much lower.

Second, the causality problem is far from being solved. Several studies have confirmed that the causality runs mainly from infrastructures to regional output, but further empirical evidence is necessary.

Third, the definition of collective infrastructures needs further developments. To measure this type of capital more precisely and to adopt wider concepts of collective infrastructures should be included in the agenda of researchers on this subject..

Finally, from the study of the majority of studies published in recent years, we get the feeling that there is a progressive divorce between studies analysing the overall impact of public infrastructures and the literature analysing the impact of specific types of public infrastructures. The approximation of these approaches and specially the inclusion of spatial variables in the analysis are very promising in terms of future research.

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