Department of Economics

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Working Paper No. 639 March 2009 ISSN 1473-0278

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University of London

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18/02/2009

Abstract

We model the channels through which public expenditure on infrastructure influences firm value and shapes its investment decisions *via* both adjustment costs and marginal profitability of capital. We test these hypotheses by using a large panel of Italian firms. Empirical results show that infrastructure interacts with revenues and costs in shaping firm's profitability of capital and influences its adjustment costs. Finally we find that infrastructure expenditure contributes to reduce the economic gap between the North and the South of Italy. These effects vary across regions and sectors.

JEL: D21, D62, D92.

Keywords: Regional Infrastructure, Firm's Value, Corporate Investment.

*This paper has been presented at the Universities of Brescia, Naples, Perugia, Rome and Queen Mary University of London. We are grateful to all participants for helpful comments. We are particularly in debt to Maria De Paola, Walter Distaso, Giulio Fella, Marcelo Fernandes, Hugo Kruiniger, Patrizia Ordine, Domenico Scalera, Vincenzo Scoppa and Roberto Veneziani for very useful suggestions on an earlier version of the paper. The usual disclaimer applies.

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1 Introduction

This paper contributes to the understanding of the effects of public infrastructure expenditure on firm's decision to invest and hence on regional development. We present a theoretical framework which links firm's investment decision with public investment in infrastructure. The model predicts that regional infrastructure affects the value of the firm and thus private investment, both *via* its effects on the marginal profitability of capital and the costs of adjusting current capital stock to the desired level. We derive a reduced form equation for investment and test a number of hypotheses on a large sample of Italian firms.

The question of the influence of infrastructure on the level of economic activity is not a new one. Over the last two decades a large body of literature has analyzed the economic impact of public infrastructure expenditure. The debate began with Aschauer (1989) who suggests that, over the period 1949-1985, public capital had a positive impact on US aggregate output. This evidence, further supported by Munnel (1990), is in line with the so-called "public capital hypothesis", according to which private production depends on the provision of public infrastructure. However, other studies have provided mixed evidence. On the one hand, a positive effect of infrastructure is confirmed by Munnel (1992), Andrews and Swanson (1995), Morrison and Schwartz (1996), Demetrios and Mamuneas (2000), Pereira (2000) and Ahmed and Miller (2000). On the other hand, several researchers provide evidence against the public capital hypothesis: after addressing some econometric issues (such as endogeneity, stationarity of time series and unobservable heterogeneity), they show that the impact of public infrastructure tends to disappear (Tatom, 1991; Hulten and Schwab, 1991; Evans and Karras, 1994; Holtz-Eakin, 1994; Nadiri and Mamuneas, 1994; Baltagi and Pinnoi, 1995).

Despite the above evidence, it is hard to imagine an economy working without roads, railroads, communication infrastructure and all the other services provided by the government. It is more likely that empirical outcomes would be mixed because it is difficult to disentangle, at the aggregate level, the effects of the different components of public expenditure, and especially to identify the channels through which they operate. A common feature of all the above studies is indeed the use of aggregate data, either at industry, region, or country level. As a result of firms' heterogeneity, a study based on microdata because should make "more precise the microeconomic linkage between the provision of infrastructure and the nature of the production process" (Holtz-Eakin, 1994:20) or, similarly, it should limit "the impossibility of capturing all the payoffs to public sector capital formation which is common at the more level of aggregation" (Nadiri and Mamuneas, 1994:23).

With this aim, we build up a model linking firms' behavior with regional public infrastructure expenditure. More specifically, we extend the standard q-model of investment to incorporate two channels through which infrastructure expenditure affects corporate investment. Firstly, we consider firms' adjustment costs. The basic idea is that a change in the level of infrastructure affects the costs that firms face when adjusting the current level of physical capital to the target level. For example, the provision of new services, such as improved transport or communication facilities, allows the firm to reduce the diseconomies of scale associated with the installment of new capital goods; in turn, this affects the value of the firm and thereby its investment. Secondly, we take into account the impact of infrastructure on firms' costs and revenues. In the competitive market, if public investment in infrastructure reduces the price of both intermediate and final goods, for example through reductions in transport costs, then both variable costs and revenues decrease. If this is the case, a change in the value of the firm occurs and, therefore, its investment in physical capital should change accordingly. The reduced form equation which we derive allows us to identify and disentangle all these effects.

When studying the impact of public infrastructure on firm investment two major issues need to be accounted for. The first issue is proximity. Since the effect of infrastructure passes through the value of the firm, the infrastructure existing in the area in which the firm operates is more likely to have a significant impact on the firm's value than infrastructure in place in other areas. The second issue regards the type of infrastructure. As it is directly productive, public expenditure on core infrastructure is likely to be more important than that on non-core expenditure.

We test the predictions of the model we propose by using a panel of 1,097 Italian manufacturing firms over the period 1995-2000. In an analysis of the relationship between public infrastructure and firms' investment, Italy is a particularly interesting case study because it includes both industrialized and less industrialized regions. Moreover, the more efficient industrialized regions are grouped in the Centre-North of the country, while the South of Italy is a case of a lack of industrialization. Thus this paper sheds light on the different effects that infrastructure expenditure has in the two areas of the country and helps in identifying which sector is likely to benefit most from public expenditure on regional infrastructure. A similar question has been greately discussed by other Italian economists. However, by using aggregated data, they tend to focus on the link between public infrastructure and productivity (or output), rather than on the relationship between public infrastructure and firm investment. For instance, Picci (1999) suggests that, over the period 1970-1995, the output elasticity to infrastructure is 0.36. This impact is higher in Southern regions than in other areas of the country, and higher for expenditure on core infrastructure. Bonaglia, La Ferrera and Marcellino (2000) compare results by using three different approaches, namely growth accounting, production function and cost function. All their results indicate a positive contribution of infrastructure expenditure to TFP growth and output. However, there is mixed evidence about which type of infrastructure is most effective. Destefanis and Sena (2005) claim that previous research does not examine the non-stationary nature of the data, the heterogeneity of firms across regions and, also, the fact that the level of public capital may be endogenously determined. Focussing only on the industrial sector they suggest that, over the period 1970-1998, the output elasticity to core-infrastructure is 0.17. They also indicate that infrastructure exerts a higher effect in the Southern regions.

A common characteristic of all the studies above is the use of data at regional, industry or country level. This paper, on the other hand, analyses how private investment interacts with infrastructure expenditure by using data at firm level and this is, *in sè e per sè*, a new contribution to the literature in this field of research. From an empirical perspective, a study based on microdata allows to relax the assumption that all firms respond homogeneously to investment in infrastructure or, to put it differently, it allows us to limit bias from data aggregation. Furthermore, the use of a panel data estimator allows us to control for omitted variable bias, and the employ of an appropriate set of internally generated instruments controls for the endogeneity of regressors, which is commonly found in balance sheet data (Arellano and Bond, 1991). Finally, the proposed approach allows us to study the effects of infrastructure expenditure at industry and regional levels.

Empirical evidence supports model predictions. In line with the theory, the results suggest that core infrastructure affects firm investment both by reducing adjustment costs and by raising the firm's marginal profitability of capital. In particular, we find that the impact of revenues and costs is conditional to expenditure on infrastructure: the higher the investment in infrastructure, the lower the impact of both revenues and costs on firms' investment. However, the effect *via* costs is larger than the effect *via* revenues; for this reason, the net effect of regional infrastructure expenditure on firm investment through the marginal profitability of capital is positive. These effects differ across sectors and regions. In line with the public capital hypothesis, results indicate that regional infrastructure enhances firm investment in Italy as a whole, although in the South the impact is greater than that in the Centre-North. From this perspective, infrastructure expenditure reduces the economic gap between Italian regions. According to the results, the effect in the North passes through firm revenues and costs and in the South mainly through adjustment costs. Finally, some industries (textiles, food, wood and metal manufactories) benefit more than others from infrastructure investment.

The remainder of the paper is organized as follows. Section 2 presents the theoretical framework. Section 3 describes the empirical methodology and data. Section 4 presents the results and, finally, Section 5 gives some concluding remarks.

2 Theoretical framework

2.1 The model

We model two channels through which public infrastructure expenditure influences firm investment. The first channel acts through firm adjustment costs. As suggested by Turnovsky (1996, 1999) and Ott and Soretz (2006), other things being equal, a change in infrastructure expenditure influences the cost faced by the firm in adjusting its current capital stock to the target level. This is a reasonable assumption, given that adjustment costs depend not only on the firm's internal characteristics but also on external factors, such as the provision of public infrastructure.

Therefore, we assume that:

$$C(I_{it}, G_{it}^{(r)}), \tag{1}$$

where $C(.)$ is the adjustment cost function, I_{it} is the investment made by the i-th firm (with $i = 1, ..., N$) at time $t = 1, ..., T$ and:

$$G_{it}^{(r)} \equiv \{G_{rt} : i \in r\}, \tag{2}$$

is the expenditure on core infrastructure at time t in the r-th region (with $r = 1, ..., R$) where firm i operates; $G_{it}^{(r)}$ is zero when the i-th firm does not operate in region r. The definition of expenditure on infrastructure given in (2) incorporates the idea of proximity, in the sense that only infrastructure in the area where the firm operates matters in the decision to invest; moreover, we assume that the type of infrastructure is also important, in the sense that only public expenditure on core infrastructure matters for the firm (we test this hypothesis in the empirical section).

The second channel of transmission is related to the effect that infrastructure expenditure has on firm revenues and costs. If a new road reduces transportation costs, given a perfect market, the prices of intermediate and final goods will decrease and this, in turn, will lead to changes in total revenues and variable costs. The effect on firm profits depends on the relative change in revenues and costs, respectively. Therefore, we assume that:

$$p_t = p(G_{it}^{(r)}), \tag{3}$$

and:

$$p_t^M = p^M(G_{it}^{(r)}), \tag{4}$$

where, other things being equal, the prices of the final good, $p(.)$, and the intermediate good, $p^M(.)$, depend upon regional infrastructure.

The problem faced by firms when they invest in physical capital is therefore straightforward. Let's consider a generalization of the standard q-model of investment (Hayashi, 1982), where shareholders choose the level of investment which maximizes the expected discounted value of the stream of current and future net revenues. In other words, shareholders maximize the present value of firm i located in region r by taking into account the constraint of capital accumulation. Firm value, $V_t(.)$, is given by:

$$V_t(K_t, G_t^{(r)}) = \max_{\{I_\tau\}_{\tau=0}^{\infty}} E\left\{\sum_{\tau=0}^{\infty} \beta^\tau \left[\pi(K_{t+\tau}, G_{t+\tau}^{(r)}) - I_{t+\tau} - C(I_{t+\tau}, G_{t+\tau}^{(r)})\right] / \Omega_t^{(r)}\right\}, \tag{5}$$

where index i has been omitted for ease of exposition; $E\{.\}$ is the expectation operator conditional on the set of information $\Omega_t^{(r)}$, available at time t in region r; β^τ is the constant discount factor; $\pi(.)$ is a restricted profit function, which is maximized with respect to labour costs. The price of the investment good is normalized to 1. We also assume that the market for final goods is competitive and the capital market is perfect. The capital stock, K_t, is a quasi-fixed input whose dynamics follows a standard accumulation law, $K_t = K_{t-1} + I_t$, where the depreciation rate of capital is assumed to be zero for ease of exposition.

Under these assumptions, it is known that the first order condition with respect to investment is:

$$1 + \frac{\partial C(I_t, G_t^{(r)})}{\partial I_t} = E\left\{\sum_{\tau=0}^{\infty} \beta^\tau \left[\frac{\partial \pi(K_{t+\tau}, G_{t+\tau}^{(r)})}{\partial K_{t+\tau}}\right]\right\}. \tag{6}$$

Eq. (6) states that the firm should invest up to the point where the marginal cost of an additional unit of capital equals q_t, i.e. the expected discounted value of the stream of future profits generated by such an additional unit of capital. By solving eq. (6) for I_t yields:

$$I_t = \phi_{G_t^{(r)}} \left\{ E \sum_{\tau=0}^{\infty} \beta^{\tau} \left[\frac{\partial \pi(K_{t+\tau}, G_{t+\tau}^{(r)})}{\partial K_{t+\tau}} \right] \right\}, \tag{7}$$

where, for any given level of $G_t^{(r)}$, $\phi_{G_t^{(r)}}$ is an increasing function because of the standard hypothesis of convexity of the adjustment costs function. The expression in brackets is the value of the firm at t, namely Tobin's q.

2.2 The channels of transmission

In order to identify the channels through which $G_t^{(r)}$ affects I_t/K_t, it is necessary to specify the adjustment costs function, $C(I_t, G_t^{(r)})$, and the marginal profitability of capital, $\partial \pi_t / \partial K_t$.

Following the standard approach used in the literature on the subject, we assume that the adjustment costs function is convex in the level of investment because of the diseconomies of scale associated with the installation of new capital goods. Therefore:

$$C(I_t, G_t^{(r)}) = \frac{\alpha}{2} \left[I_t - \psi I_{t-1} - a - \lambda G_t^{(r)} \right]^2, \tag{8}$$

where α, ψ, λ, and a are parameters. As in Love (2003) and Baum et al. (2008), eq. (8) includes the term ψI_{t-1}, which captures the persistency in firms' investment behaviour. The inclusion of this term is due to the strong persistence and irreversibility in investment which lead to a partial adjustment model. In specifying eq. (8) we assume that adjustment costs are determined not only by firm-specific characteristics but also by environmental factors, such as infrastructure expenditure. Furthermore, the provision of public infrastructure influences the level of investment required to minimise long run adjustment costs. In eq. (8) this level of investment is represented by the parameter a.

As far as marginal profitability of capital is concerned, uncertainty is entirely due to investment in infrastructure which is perceived as permanent by each firm. Therefore:

$$E(G_{t+j+1}^{(r)} - G_t^{(r)}) = 0 \tag{9}$$

holds $\forall j \geq 0$. If this is the case, the expected marginal profitability of capital equals the current marginal profitability:

$$E \sum_{\tau=0}^{\infty} \beta^{\tau} \left[\frac{\partial \pi(K_{t+\tau}, G_{t+\tau}^{(r)})}{\partial K_{t+\tau}} \right] = \frac{\partial \pi_t(K_t, G_t^{(r)})}{\partial K_t}. \tag{10}$$

Therefore, after observing $G_t^{(r)}$, the firm maximizes profits:

$$\pi(K_t, G_t^{(r)}) = \max_{M_t} \left[p(G_t^{(r)}) X_t(K_t, M_t) - p_t^M (G_t^{(r)}) M_t \right], \tag{11}$$

where X_t is the firm's output and M_t is the market for the intermediate good.

Given the Euler equation for a constant return to scale production function:

$$\frac{\partial X_t}{\partial K_t} = \frac{X_t}{K_t} - \frac{\partial X_t}{\partial M_t} \frac{M_t}{K_t}, \tag{12}$$

and the equilibrium condition in the intermediate good:

$$\frac{\partial X_t}{\partial M_t} = \frac{p_t^M (G_t^{(r)})}{p_t(G_t^{(r)})}, \tag{13}$$

we obtain the marginal profitability of capital which, given the Hayashi (1982) assumptions, is known to be equal to the average profitability of capital:

$$\frac{\partial \pi_t}{\partial K_t} = p(G_t^{(r)}) \frac{\partial X_t}{\partial K_t} = p(G_t^{(r)}) \left[\frac{X_t}{K_t} - \frac{p_t^M (G_t^{(r)})}{p(G_t^{(r)})} \frac{M_t}{K_t} \right] = \frac{\pi_t}{K_t}. \tag{14}$$

By using eq. (14) and eq. (10), eq. (7) can be rewritten as:

$$I_t = a + \psi I_{t-1} + \lambda G_t^{(r)} + \frac{1}{\alpha} \left[p_t(G_t^{(r)}) \frac{X_{rt}}{K_{rt}} - p_t^M (G_t^{(r)}) \frac{M_{rt}}{K_{rt}} \right]. \tag{15}$$

2.3 Discussion

Eq. (15) identifies three channels through which infrastructure expenditure affects firm investment.

First, if a relationship exists between infrastructure and physical private capital, then any investment in infrastructure causes a change in the desired capital stock and, therefore, in the level of investment of each firm. More specifically, if complementarities between public infrastructure and private capital exist, then new infrastructure tends to increase the firm's desired capital stock; in turn, the firm has to invest to adjust the current capital stock to the desider level. This seems quite similar to the spillover effect of public infrastructure which researchers often refer to. Conversely, if the two are substitutes, the higher the level of infrastructure, the lower the desired capital stock. This effect may be regarded as a crowding out effect of infrastructure (see, for instance, Agénor et al, 2005).

Moreover, investment in infrastructure may change the price of intermediate and final goods. If this is the case, there are also spillover effects well beyond the effect of adjustment costs. Indeed, if such prices change, so do current costs and revenues; however, because of irreversibility, a change in infrastructure also induces a change in the expected value of costs and revenues. In turn, this changes the flows of discounted future profits and, as a consequence, private investment adjusts accordingly. An example of this would be if we assume that the change in infrastructure reduces transport costs. In competitive markets, both the price of intermediate and final goods should decrease. However, the lower the price of the intermediate good, the lower the firm's current and expected variable costs; and therefore the higher the firm's value. According to this mechanism, the firm's investment is expected to increase. This effect depends on the level of variable costs: it is expected to be higher, the higher the ratio of variable costs to the firm's capital. Something similar, even though with the opposite sign, happens on the revenue side. Since the price of the good sold decreases, current and expected revenues decrease accordingly. Through this channel, firm's investment is then expected to diminish. As in the case of variable costs, this effect is larger the greater the quantity of final production.

We use a graphical analysis to illustrate the above effects. Panel A in Figure 1 portrays the firm's demand for intermediate goods, M_t. In Panel B, the straight line from the origin represents the revenue function, R_t; the convex curve describes the firm's total cost function, TC_t. When output equals X_t, the distance between revenues and costs is maximum (see Panel C portraying the profit function). Panel D shows the demand for private capital, which is downward sloping because of the decreasing marginal profitability of capital. The position of this function depends on firm investment opportunities, i.e., the expected profitability of capital. In a perfect capital market, the supply of funds is horizontal at the current interest rate, r_t. The first-best capital stock is K_t, where the expected marginal profitability of capital equals the cost of capital. Panel E reports the Marginal Efficiency of Investment (MEI) which relates investment to the opportunity cost of capital:

$$MEI_t = p_t(G_t)\frac{\partial \pi_t(.)}{\partial K_t} - \frac{\partial C_t(.)}{\partial I_t}, \tag{16}$$

This is downward sloping because of the presence of an adjustment cost, $\partial C_t/\partial I_t$. As long as the firm operates at the desired capital stock, K_t, $MEI_t = p_t(\partial \pi_t/\partial K_t) = r_t$, and both investment and adjustment costs are zero.

If a change in expenditure in infrastructure reduces the price of the intermediate good, as a consequence, the quantity of the intermediate good the firm uses will increase from M_t to M_{t+1} (Panel A); the cost function rotates to the right, and equilibrium production increases from X_t to X_{t+1}. The reduction in costs is represented by an upward shift of the profit function (see the bold curve in Panel C) which leads to an increase in the expected future marginal profitability of capital. Therefore, in Panel D the firm's demand for capital shifts to the right (see the bold line). If there were no adjustment costs, the firm would immediately switch to the new optimal capital stock, K_{t+n}. Instead, the presence of adjustment costs slows down the adjustment process. More specifically, when capital stock equals K_t, $p_t(\partial\pi_{t+1}/\partial K_{t+1}) > r_t$ and the firm has an incentive to invest, there is a new MEI schedule, MEI_{t+1}, and investment equals I_t^* (see the higher bold line in Panel E). The capital stock moves from K_t to K_{t+1} (Panel D) because of this investment in new physical capital (Panel E). However, at K_{t+1} the firm has a lower, but still positive, incentive to invest. So, a new MEI schedule can be drawn (see the lower bold line in panel E), and this process continues until the optimal level of capital is K_{t+n}, where the incentive to invest is zero.

There are two additional effects to be considered. On the one hand, investment in infrastructure may change the position of the revenue function (see the dotted line in Panel B); on the other hand, the slope of the adjustment cost function may also be affected (see the dotted lines in Panel E). The final net effect of the change in regional infrastructure expenditure on firm investment depends on the relative sign and magnitude of the three effects.

To summarize these effects, we take the derivative of eq. (15) with respect to $G_t^{(r)}$ and, after rearranging we obtain the (short run) elasticity of private investment to regional infrastructure expenditure, $\xi^I_{G^{(r)}}$,

$$\begin{aligned} \xi^I_{G^{(r)}} &= \frac{\partial I}{\partial G^{(r)}}\frac{G^{(r)}}{I} \\ &= \lambda\frac{G^{(r)}}{I} + \frac{pX}{\alpha IK}\left[(\mu_{G^{(r)}} - \mu'_{G^{(r)}}) + \left(\frac{pX - p^M M}{pX}\right)\mu'_{G^{(r)}}\right], \end{aligned} \tag{17}$$

where $\mu_{G^{(r)}}$ and $\mu'_{G^{(r)}}$ are the price elasticities of the output and the input to infrastructure expenditure respectively. The time index, t, has been dropped for ease of exposition.

Eq. (17) disentangles the channels through which infrastructure expenditure influences firm investment decisions. The final effect depends on the signs of λ, $\mu_{G^{(r)}}$ and $\mu'_{G^{(r)}}$, the determination of which remains an empirical issue. As discussed above, the sign of the effect transmitted through adjustment costs depends on the nature of the relationship between infrastructure expenditure and firms' investment. As far as marginal profitability of capital is concerned, four combinations are possible:

Case A: If $\mu_{G^{(r)}} > 0$, $\mu'_{G^{(r)}} > 0$, the relative strength of the two is of importance.

More specifically, if $\mu_{G^{(r)}} > \mu'_{G^{(r)}}$, then the greater the difference between the price elasticities of final and intermediate goods and the higher profits, the more the firm benefits from an increase in infrastructure expenditure. The opposite holds if $\mu_{G^{(r)}} < \mu'_{G^{(r)}}$.

Case B: If $\mu_{G^{(r)}} > 0$ and $\mu'_{G^{(r)}} < 0$, the larger the two elasticities, the more the firm benefits from changes in infrastructure expenditure. However, the larger the net revenues and the price elasticity of intermediate good to public infrastructure, the less the firm benefits from an increase in infrastructure expenditure.

Case C: If $\mu_{G^{(r)}} < 0$ and $\mu'_{G^{(r)}} > 0$, the greater the two elasticities the less the firm benefits from new infrastructure. In this case, however, the larger the net revenues and the price elasticity of intermediate goods to infrastructure, the more the firm benefits from an increase in infrastructure expenditure.

Case D: If $\mu_{G^{(r)}} < 0$ and $\mu'_{G^{(r)}} < 0$, then, again, the relative strength of the two is relevant. More specifically, if $\mu_{G^{(r)}} > \mu'_{G^{(r)}}$, then the greater the difference between the price elasticities of final and intermediate goods, the less the firm benefits from investments in infrastructure. The opposite holds if $\mu_{G^{(r)}} < \mu'_{G^{(r)}}$. In this case, the greater the net revenues and the price elasticity of intermediate goods to infrastructure, the less the firm benefits from an increase in infrastructure expenditure.

All the above effects are expected to be greater in the long run, when the firm completes its adjustment process:

$$I_t = I_{t-1} = \bar{I}, \tag{18}$$

and therefore:

$$\begin{aligned} \xi^{I,l}_{G^{(r)}} &= \frac{\partial \bar{I}}{\partial G^{(r)}} \frac{G^{(r)}}{\bar{I}} \\ &= \frac{\lambda}{1-\psi} \frac{G^{(r)}}{\bar{I}} + \frac{pX}{\alpha \bar{I}(1-\psi)K} \left[(\mu_{G^{(r)}} - \mu'_{G^{(r)}}) + \left(\frac{pX - p^M M}{pX} \right) \mu'_{G^{(r)}} \right], \end{aligned} \tag{19}$$

where $\xi^{I,l}_{G^{(r)}}$ is the long run elasticity of firm investment to infrastructure.

3 Empirical framework and data

3.1 The empirical model

We test all the theoretical hypotheses by using the following empirical model:

$$
\begin{aligned}
I_{it}/K_{it} &= \gamma_1 I_{it-1}/K_{it-1} + \gamma_2 G_{it}^{(r)} + \gamma_3 x_{it} + \\
&\quad \gamma_4 m_{it} + \gamma_5 x_{it} G_{it}^{(r)} + \gamma_6 m_{it} G_{it}^{(r)} + \eta_t + \eta_i + \varepsilon_{it},
\end{aligned}
\tag{20}
$$

where privaty capital expenditure is taken as a proxy of I_{it}, the value of sales as a proxy of X_{it} and the value of variable costs as a proxy of M_{it}. These variables are scaled by K_{it} to obtain x_{it} and m_{it}, respectively. $G_{it}^{(r)}$ is the public expenditure on core infrastructure in region r at time t. The variables η_t and η_i represent time and firm-specific effects respectively. The firm-specific effect, η_i, gauges all unobservable and time-invariant factors influencing the firm investment. On the other hand, η_t varies over time and is common across firms; it captures the impact on investment of all factors which are beyond the control of the firm, such as variation in the exchange and/or interest rates. $\varepsilon_{i,t}$ is the *iid* error term. Since x_{it} and m_{it} measure the revenues and variable costs. The sign of the parameters γ_3 and γ_5 is expected to be positive and negative respectively. In line with the theoretical framework, we test the hypothesis that these parameters are conditional on change in the level of infrastructure expenditure, by including two interaction terms, $\gamma_5 x_{it} G_{it}^{(r)}$ and $\gamma_6 m_{it} G_{it}^{(r)}$.

The inclusion of the lagged dependent variable I_{it-1}/K_{it-1} in the regression is meant to control for the adjustment process of investment, which makes it costly to adjust to new circumstances. This causes the current investment level to differ from the desired level. However, because of the joint presence of this term and unobservable firm-specific effects, the OLS estimator yields inconsistent estimates. This is because the term I_{it-1}/K_{it-1} is necessarily correlated with the time-invariant term, η_i, even though the idiosyncratic component of the error term is serially uncorrelated.

One solution might be to eliminate firm-specific fixed effects η_i by taking first-differences. However, the OLS estimates would still be inconsistent becasue the first difference transformation leads to a correlation between the lagged dependent variable and the differenced errors. Moreover, it is unlikely that the firm-specific variables, x_{it} and m_{it} are strictly exogenous; therefore, shocks affecting private investments are also likely to affect these regressors. These issues suggest the use of an Instrumental Variables (IV) estimator, where the lagged dependent variable and endogenous regressors are instrumented using an appropriate set of instrumental variables.

This paper uses the GMM method of estimation proposed by Arellano and Bond (1991). It allows both for a MA(1) error structure and heteroscedasticity of disturbances across firms in the sample. It is essential that an optimal set of instruments is chosen, where the validity of instruments depends on the absence of a higher-order serial correlation in the idiosyncratic component of the error term. For this reason we test the assumption of the absence of a higher-order serial correlation. Finally, in order to check whether instruments and residuals are independent, we present the Sargan test for over-identification restrictions.

3.2 Data description

Microdata are from the 7th and 8th Surveys of Italian manufacturing firms carried out by Capitalia (2001). Each survey contains standard balance sheet variables and qualitative information on firm characteristics. They consider more than 4,500 firms and include all large Italian manufacturing firms (with more than 500 employees) and a representative sample of small-medium firms - with more than ten employes. The stratification strategy applied by Capitalia considers the firm's location, size and sector. 1,299 firms are present in both surveys. From this sample, we remove those firms for which the information of interest is missing. This provides an unbalanced panel of 1,097 firms for the period 1995-2000, for a total of 5,485 observations. Summary statistics are reported in Table 1.

<Insert table 1 here>

We use investment expenditures to total capital as a proxy for I_{it}/K_{it}, value of sales to total capital as a proxy for x_{it} and variable costs to total capital as a proxy for m_{it}. Since it is likely that labour costs are not directly affected by public expenditure on infrastructure, we use variable costs net of labour costs. To limit the impact of outliers on the estimates, all variables have been winsorised by giving to firm-year observations located before the 1st and after the 99th percentiles of each variable's distribution the values of the 1st and 99th percentiles (Cleary, 1999).

Yearly data from 1994 to 2000 for infrastructure expenditure are from ISTAT (the Italian National Institute of Statistics). ISTAT provides data on public spending on road and airports; railroad and alternative transport; maritime, lake and communication infrastructures; public and social building; household building; hydraulic and electric, sanitary; reclamation and, finally, other infrastructures. The core subset of public infrastructure consists of road and airports; railroads and alternative transport; maritime, lake and communication infrastructure; and hydraulic and electric. All other variables are labelled as non core infrastructure.

Table 2 indicates that investment is highly correlated to the firm's variable costs and revenues. More importantly, private investment appears to be significantly correlated with public expenditure on core and non core infrastructure. This result supports the hypothesis that there is a positive effect of infrastructure expenditure on private investment, i.e. the two appear to be complementary. On the other hand, the positive unconditional correlation between regional infrastructure expenditure and firm costs and revenues supports the hypothesis according to which there are other channels of transmission operating through the components of firm net revenues.

<Insert table 2 here>

4 Empirical results

4.1 Model estimation

Econometrics results are summarized in Table 3. In every model we treat all variables as endogenous. The specifications in columns (3) and (4) allow both for the possibility that current and past values of the variables $x_{it}G_{it}^{(r)}$, $m_{it}G_{it}^{(r)}$ and $G_{it}^{(r)}$ are correlated with current idiosyncratic shocks, and for the likely existence of a feedback from the lagged dependent variable or past shocks to current and future values of the explanatory variables. Finally, although infrastructure expenditure is exogenous at firm level, its interaction with x_{it} and m_{it} is likely to make the variables $x_{it}G_{it}^{(r)}$ and $m_{it}G_{it}^{(r)}$endogenous.

<Insert table 3 here>

The instruments are all the variables dated at $t-2$ and higher. For all specifications we report the results of the Wald test for the joint significance of time and individual dummies, the Sargan test for the validity of instruments, and the AR(1) and AR(2) tests for the presence of first and second order autocorrelation. Results regarding the basic model exclude the presence of second order autocorrelation; moreover, the null hypothesis concerning the validity of instruments is not rejected. Therefore, diagnostic tests do not reject the validity of this specification.

Column (1) presents findings regarding the basic model. As expected, the coefficient of the lagged investment expenditure is positive and statistically significant. It is known that this is due to the time to build characterizing the purchase and installation of new capital goods (Caballero, 1997). The coefficient associated with revenues is, as expected, positive and statistically significant: an increase in profits due to an increase in revenues stimulates firm investment. Further evidence regarding the role of profits comes from the outcomes of the parameter associated with variable costs, which is negative and significant. Thus, it is clear that a firm slows down investment when it observes a reduction in its profits due to an increase in variable costs. Finally, column (2) refers to long-run results. The sign and the statistical significance of the parameters are unchanged; however, as expected, the magnitude of the estimated coefficients is greater (in absolute value) in the long rather than in the short run.

Column (3) reports the results obtained when adding the regional investment in core infrastructure, $G_{it}^{(r)}$, and the two interaction variables, $x_{it}G_{it}^{(r)}$ and $m_{it}G_{it}^{(r)}$to the basic model. The values of the Wald test for the joint significance of the regressors suggest their importance in explaining variations in the dependent variable. Furthermore, when adding $G_{it}^{(r)}$, $x_{it}G_{it}^{(r)}$ and $m_{it}G_{it}^{(r)}$, the value of the Sargan test for the over-identification restrictions improves with respect to the basic model, as does AR(2) statistic.

Similarly to what we have obtained for the basic model, the estimation of the augmented specification shows that the coefficients of revenues and costs are statistically significant and with the expected sign. More importantly, the results point out that core infrastructure expenditure affects the level of firm investment positively and significantly. This evidence supports the hypothesis that public and private investment are complementary. We also find evidence regarding the relevance of the effects working through costs and revenues. Indeed, the coefficient associated with the interaction between core infrastructure and firm costs is positive and statistically significant. This suggests that an increase in costs will increase the sensitivity of firm investment to core infrastructure expenditure. The opposite holds on the revenue side, as the coefficient associated with interaction between core infrastructure and firm revenues is negative, where it is suggested that the greater the firm's revenues the lower is the sensitivity of firm investment to core infrastructure expenditure. It is also worth noticing that the indirect impact working through costs is higher than the indirect impact through revenues. However, they are both lower than the direct impact *via* adjustment costs.

All results hold when we consider the dynamics of the augmented model (column 4), which allows us to switch from short to long run. As is shown by the estimated coefficients, when firms are in equilibrium all the impacts are, as expected, greater than those obtained in the short run analysis.

4.2 Robustness checks

Table (4) presents four robustness checks of our results. As a general result, all the diagnostic statistics (Wald test, Sargan test, AR(1) and AR(2) tests) suggest that the models are correctly specified and the set of instruments is valid - we will not comment on these statistics anymore.

<Insert table 4 here>

An initial question to be asked is whether the total expenditure on infrastructure matters, rather just than investment in core infrastructure. To test this hypothesis, column (1) reports the results when public expenditure on non core infrastructure is added to the other regressors. We find that the coefficient estimated for this additional regressor is not statistically different from zero. Moreover, our previous results entirely hold. We have also substituted the regressors, core and non-core infrastructure with total expenditure on infrastructure, and the conclusions do not change (results are not reported, but are available upon request).

However, when public expenditure on non core infrastructure is added to the set of regressors, the statistical significance of the variable obtained by interacting costs with public expenditure on core infrastructure decreases. This might indicate collinearity between core infrastructure, non core infrastructure and/or variable costs. To investigate this question further, we estimate the model by removing both expenditure on core and on non core infrastructure. Results are presented in column (2), and show that the statistical significance of the interaction variables increases. Furthermore, column (3) reports the results without the interaction terms and with both core and non core infrastructure expenditure. The estimates show that the significance of coefficients associated with expenditure on core infrastructure increases; moreover, the sign of the coefficients does not change. Conversely, the coefficient associated with expenditure on non core infrastructure is not significant: all the evidence suggests that non core infrastructure expenditure does not affect the level of firms' investment.

The final robustness check refers to a model where we add firm ratio of value added to capital to the set of regressors (column 4). Previous results regarding the sign and significance of coefficients hold but the coefficient associated with the value added is not significant. If value added is taken as a proxy of cash flow or firm size, this result seems to support the theoretical and empirical view that, in a perfect capital market, firm investment is not sensitive to any financial variables other than the firm's profitability of capital. In other words, investment does not depend on this financial variable, but only on the profitability of capital (see Hubbard, 1998, for a survey).

4.3 Industry and development effects

This section tests the hypotheses that the relationship between public and corporate investment is sensitive to the geographical area and to the industry the firm belongs to. Indeed, it is likely that the impact of infrastructure expenditure is conditional upon the nature of the good sold and the level of development of the region where the infrastructure is installed.

With this aim, we estimate the following model:

$$\begin{aligned} I_{it}/K_{it} &= \delta_1 I_{it-1}/K_{it-1} + \delta_2 x_{it} + \delta_3 m_{it} + \\ &+ \sum_{0}^{15} S_j(\delta_{3j+4} G_{it}^{(r)} + \delta_{3j+5} x_{it} G_{it}^{(r)} + \delta_{3j+6} m_{it} G_{it}^{(r)}) + \eta_t + \eta_i + \varepsilon_{it}. \quad (21) \end{aligned}$$

In order to obtain a measure of the impact of infrastructure on investment at the sectorial and regional level, we use model (21) to estimate coefficients of the sector dummies S_j, with $j = 0, ..., 15$. We then average across regions to obtain geographical effects.

Estimation results for this model are reported in Table 5.

<Insert table 5 here>

Because of the high number of parameters to be estimated, we report a test for the joint significance of the effects working *via* adjustment costs, revenues and costs respectively. We also present a test for joint significance of all these regressors, and short and long run coefficients.

Results support this empirical strategy. More specifically, the Sargan test does not reject the validity of the set of instruments and the $AR(2)$ test does not reject the null hypothesis of absence of autocorrelation. The opposite holds for the $AR(1)$ test. Regression results also suggest that all additional regressors are statistically significant. This, in turn, supports the hypothesis that the impact of infrastructure expenditure on corporate investment differs across industries, regardless the channel we are analysing.

By using the estimated parameters of eq. (21), we retrieve the elasticity of private investment to infrastructure, for each sector j in region r as:

$$\begin{aligned} \xi^{I,j}_{G^{(r)}} &= \frac{\partial I_j/K_j}{\partial G^{(r)}} \frac{G^{(r)}}{I_j/K_j} \\ &= \lambda_j \frac{G^{(r)}}{I_j/K_j} + \frac{p_j X_j}{\alpha I_j K_j} \left[(\mu^j_{G^{(r)}} - \mu'^j_{G^{(r)}}) + \left(\frac{p_j X_j - p^M_j M_j}{p_j X_j} \right) \mu'^j_{G^{(r)}} \right]. \end{aligned} \tag{22}$$

Table 6 reports the industry elasticities of private investment to regional infrastructure expenditure in the short and long run. More specifically, column (1) reports the fraction of the total elasticity determined by the impact of regional infrastructure *via* adjustment costs, whereas columns (2), (3) and (4) refer to the portions of elasticity explained by the mechanisms working *via* revenues, costs and net revenues respectively. Column (5) reports the net elasticities. The same table also summarizes the elasticities obtained for Italy, as a whole, and for the two macro-areas of the country (South and North-Centre of Italy).

<Insert table 6 here>

Results suggest that elasticity of private investment to infrastructure in Italy is positive: the estimated value is 0.43. The same applies at macro-region level and, broadly speaking, for all sectors. Therefore, our results support the public capital hypothesis. More importantly from a policy perspective, in the South of the country the impact of infrastructure expenditure is higher than in the Northern and Central regions (0.60 *vs* 0.31). In the light of the evidence that this impact is greater in the area of the country that exhibits the lowest level of economic development, we can conclude that infrastructure expenditure contributes to reducing the economic gap between the South and the North of Italy. Also, this result is due to the greater effect operating through the cost adjustment function (the average elasticity is 0.57) and, to the smaller effect *via* the two components of the marginal profitability of capital. This result is not surprising: given that markets are not fully developed in the South of Italy, it is reasonable to expect a smaller effect through this latter channel, while the opposite is true for Northern regions where we observe that the response of costs and revenues to investment in infrastructure is greater.

Moreover, the impacts via revenues and costs suggest that, other things being equal, in both areas of Italy investment in infrastructure helps firms to invest by lowering the impact of marginal profitability of capital. In other words, the higher public infrastructure is, the less important both revenues and costs are for the private investment process. Therefore a certain amount of investment, whatever the level, can be sustained even if revenues are lower and/or costs are higher.

Results presented in Table 7 (Table 8) allow us to verify sector-by-sector whether the short run (long run) elasticity of private investment differs from one macro-region to another.

<Insert table 7 here>

<Insert table 8 here>

Investment in infrastructure induces an increase in private investment in all sectors, except in rubber and furniture. This holds true both in the North-Centre and in the South of Italy (the only exception is that in the South, net elasticity in the rubber sector is positive). However, the magnitude of this impact differs from one sector to another. It ranges from 3.32 (textile sector in the South) to -0.27 (rubber sector in the North). Again, in a given sector, we find great differences in the impact at regional level (see, what clearly emerges from the textile, clothing, leather and footwear industries).

Another interesting piece of evidence refers to how a single channel of transmission contributes to determining net elasticity. At macro-regional level, the final outcome is mainly driven by the impact infrastructure expenditure has on adjustment costs (0.33 in the North-Centre and 0.57 in the South of Italy, Table 6). This is also true when the national average impact at industry level is concerned and when results refer to the disaggregation which combines the industry and geographical dimensions (Table 7). Exceptions are represented by the findings obtained for the clothing, paper and machinery industries where the impact via net revenue is greater than that via adjustment costs.

Finally, results in Table 7 indicate that when we find a negative impact via net revenue at national level this is due to a negative influence of capital expenditure in infrastructure on firm investment be it in the North-Centre or in the South of Italy. However, the negative impact is, in absolute terms, always greater in the North-Centre than in the South: the highest regional differences are those estimated for the leather and footwear sectors (-0.63 in the North-Centre and -0.12 in the South) and for the furniture (-0.57 and -0.05) sector. Table 8 shows that all elasticities are larger in the long run than in the short run.

5 Concluding remarks

This paper analyses the impact of regional infrastructure expenditure on firm investment. We model how infrastructure expenditure in a region contributes to determining firm value and argue that the two main channels for the transmission of infrastructure effects on firm investment are those working through adjustment costs and the marginal profitability of capital.

In order to test the theoretical predictions of the model, we use a large panel of Italian firms and regional data regarding public spending on core infrastructure. Empirical results show that core infrastructure affects the level of firm investment positively and significantly *via* adjustment costs. We also find that infrastructure affects firm investment *via* the components of profit, i.e., through costs and revenues. More specifically, when variable costs interact with core infrastructure expenditure, the coefficient is positive and statistically significant; hence, it indicates that an increase in costs reduces the sensitivity of firms' investment to infrastructure. On the other hand, the coefficient of the interaction between core infrastructure and firm revenues is negative; thus, the greater firm revenues, the lower the sensitivity of firm investment to core infrastructure expenditure. It is also interesting that the indirect impact working through costs is greater than that working through revenues. However, they are both lower than the direct impact of infrastructure expenditure on private investment *via* adjustment costs.

These results provide a number of interesting insights for policy makers. First, investment in infrastructure tends to boost private investment. Moreover, given the strong direct impact of infrastructure expenditure on private investment, infrastructure may be used to reduce the productivity gap between the North and South of the country, as suggested by the evidence that the effect of infrastructure is larger in the less developed Italian regions than in the more developed regions. Second, the kind of infrastructure matters: non core infrastructure does not seem to affect private investment. Of course, the positive effect of infrastructure expenditure on firm investment may hold not only for core infrastructure, but also for other components of public expenditure, such as education, health or service expenditure. Testing these hypotheses requires a different theoretical model and a more complete set of information. This exercise is left for future research.

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Figure 1

From public infrastructure to private investments: channels of transmission

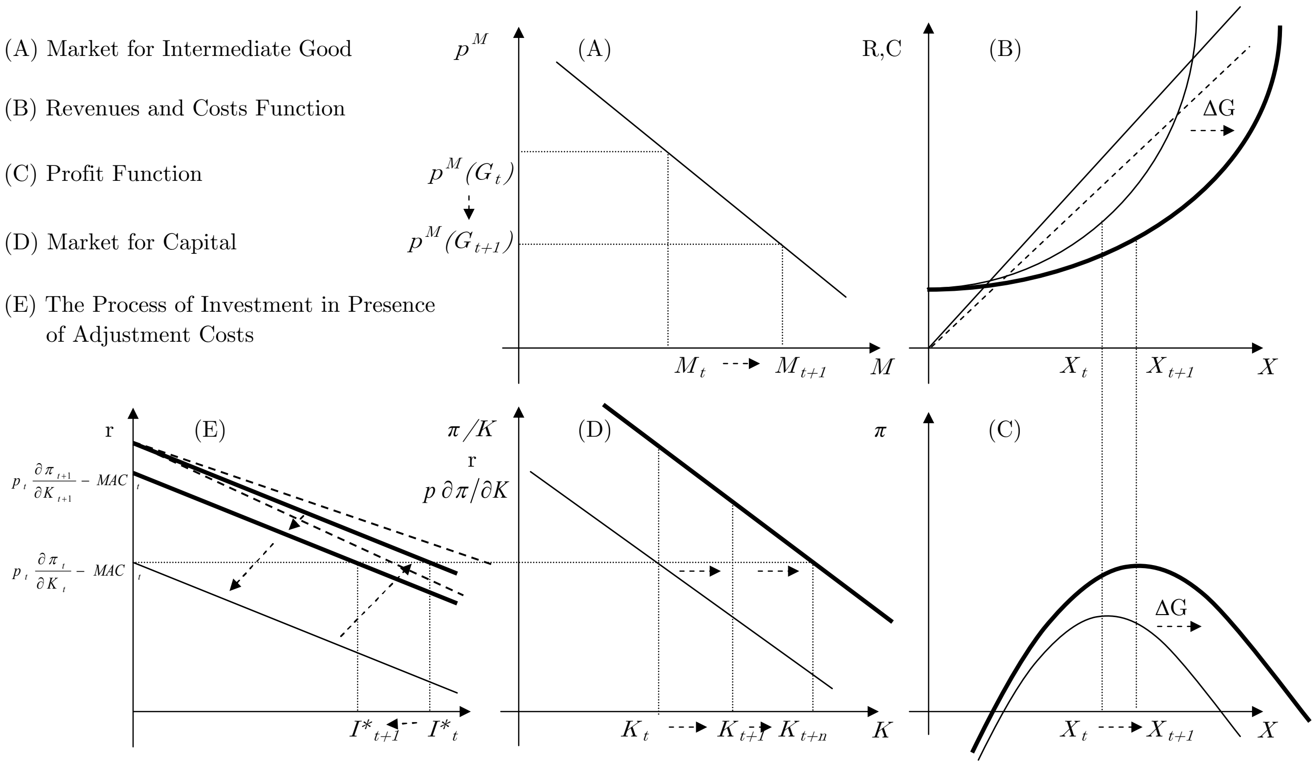

Table 1
Descriptive Statistics

Data of financial variables refer to the average across firms, regions and time (1995-2000).

Variables	Min	25%	Mean	75%	Max
I_{it}/K_{it}	0.000	0.016	0.881	0.289	30.00
x_{it}	0.010	0.575	18.342	7.503	600.00
m_{it}	0.005	0.249	8.920	3.873	200.00
$G_t^{(r)} + G(\text{Non Core})_t^{(r)}$	47,085	730,958	1,196,794	1,394,703	2,278,938
$G_t^{(r)}$	19,410	350,219	513,638	721,129	1,466,093
$G(\text{Non Core})_t^{(r)}$	25,591	349,025	683,156	869,793	1,557,809

Table 2
Correlation Coefficients

Variables	I_{it}/K_{it}	x_{it}	m_{it}	$G_t^{(r)}$ + $G(\text{Non Core})_t^{(r)}$	$G_t^{(r)}$	$G(\text{Non Core})_t^{(r)}$
I_{it}/K_{it}	1.000					
x_{it}	0.703***	1.000				
m_{it}	0.684***	0.934***	1.000			
$G_t^{(r)} + G(\text{Non Core})_t^{(r)}$	0.043***	0.058***	0.046***	1.000		
$G_t^{(r)}$	0.041***	0.055***	0.044***	0.964***	1.000	
$G(\text{Non Core})_t^{(r)}$	0.040***	0.053***	0.041***	0.882***	0.725***	1.000

*** stands for significance at the 1 %.

Table 3

Firm Investment and Public Infrastructure: Basic and Augmented Models

Column (1) reports the basic specification. Column (2) reports its long run coefficients. Column (3) reports the augmented model, and Column (4) its long run coefficients. In all models, t is time, i is the firm and r the region where the firm operates.

Variables	Basic Model: Short Run Coefficient (1)	Basic Model: Long Run Coefficient (2)	Extended Model: Short Run Coefficient (3)	Extended Model: Long Run Coefficient (4)
Dependent Variable: I_{it}/K_{it}				
I_{it-1}/K_{it-1}	0.361 (3.39)***		0.359 (3.18)***	
x_{it}	0.039 (3.85)***	0.060 (3.36)***	0.066 (4.33)***	0.103 (3.85)***
m_{it}	-0.034 (-2.09)**	-0.054 (-1.99)**	-0.122 (-2.43)***	-0.191 (-2.75)***
$G_t^{(r)}$			1.03e^{-5} (1.77)*	1.60e^{-5} (1.71)*
$x_{it}G_t^{(r)}$			-4.95e^{-8} (-4.03)***	-7.73e^{-8} (-3.28)***
$m_{it}G_t^{(r)}$			2.04e^{-7} (2.00)**	3.18e^{-7} (2.30)**
Wald test (joint)	43.90 (0.00)		45.11 (0.00)	
Sargan test (p-value)	49.02 (0.43)		33.94 (0.33)	
AR(1)	-2.53 (0.01)		-2.40 (0.02)	
AR(2)	1.38 (0.17)		0.92 (0.36)	

The sample period is 1995-2000. Number of firms: 1097; number of observations: 5485. All models are estimated by means of the Arellano and Bond (1991) GMM estimator, using variables dated at *t-2* as instruments. The Wald test for the joint significance of dummies, the Sargan test and the test for first and second correlation are reported. Heteroskedasticity consistent asymptotic t-statistics are shown in brackets. *** (**) [*] stand for statistical significance at 1% (5%) [10%] level.

Table 4

Firm Investment and Public Infrastructure: Robustness Checks

In column (1), $G_t^{(r)}$ has been excluded from the set of regressors. In Column (2), the interaction terms have been excluded from the set of regressors. In Column (3) non-core infrastructure, $G(Non\ Core)_t^{(r)}$, has been added to the set of regressors. In Column (4), the ratio of value added to total capital has been added to the set of regressors. In all Models, t is time, i is the firm and r the region where the firm operates.

Variables	(1)	(2)	(3)	(4)
Dependent Variable: I_{it}/K_{it}				
I_{it-1}/K_{it-1}	0.360	0.401	0.407	0.411
	(3.32)***	(3.94)***	(3.06)***	(3.93)***
x_{it}	0.066	0.047	0.077	0.063
	(4.39)***	(3.42)***	(3.84)***	(4.46)***
m_{it}	-0.123	-0.129	-0.047	-0.124
	(-2.44)**	(-2.78)***	(-2.06)**	(-2.25)**
$G_t^{(r)}$	$1.03e^{-5}$		$5.48e^{-8}$	$7.50e^{-6}$
	(1.73)*		(2.32)**	(1.72)*
$x_{it}G_t^{(r)}$	$-4.94e^{-8}$	$-2.90e^{-8}$		$-4.23e^{-8}$
	(-3.89)***	(-2.78)***		(-4.78)***
$m_{it}G_t^{(r)}$	$2.06e^{-7}$	$2.29e^{-7}$		$2.20e^{-7}$
	(1.90)*	(2.35)**		(1.92)*
$G(Non\ Core)_t^{(r)}$	$-2.71e^{-8}$		$-5.21e^{-9}$	
	(-0.26)		(-0.33)	
VA_{it}/K_{it}				$1.48e^{-3}$
				(1.45)
Wald test (joint)	46.92 (0.00)	54.69 (0.00)	24.53 (0.00)	62.86 (0.00)
Sargan test (p-value)	39.60 (0.42)	37.81 (0.36)	40.41 (0.39)	52.60 (0.27)
AR(1)	-2.44 (0.02)	-2.72 (0.01)	-2.69 (0.01)	-2.64 (0.01)
AR(2)	1.32 (0.17)	1.11 (0.27)	1.45 (0.11)	1.31 (0.19)

The sample period is 1995-2000. Number of firms: 1097; number of observations: 5485. All models are estimated by means of the Arellano and Bond (1991) GMM estimator, using variables dated at *t-2* as instruments. The Wald test for the joint significance of dummies, the Sargan test and the test for first and second correlation are reported. Heteroskedasticity consistent asymptotic t-statistics are shown in brackets. *** (**) [*] stand for statistical significance at 1% (5%) [10%] level.

Table 5

Firm Investment and Public Infrastructure: Sectoral Effects

In Model (1) three sets of slope dummies, $S_1G_t^{(r)}$, ..., $S_{16}G_t^{(r)}$; $S_1x_{it}G_t^{(r)}$, ..., $S_{16}x_{it}G_t^{(r)}$; and $S_1m_{it}G_t^{(r)}$, ..., $S_{16}m_{it}G_t^{(r)}$ have been added to the model. Model (2) refers to long-run estimates. In all Models, t is time, i is the firm and r the region where the firm operates.

Variable	Short Run Coefficient (1)	Long Run Coefficient (2)
Dependent Variable: I_{it}/K_{it}		
I_{it-1}/K_{it-1}	0.308	
	(4.14)***	
x_{it}	0.031	0.045
	(3.45)***	(2.84)***
m_{it}	-0.024	-0.035
	(-2.45)**	(-2.12)**
$S_1G_t^{(r)}$, $S_2G_t^{(r)}$, ..., $S_{16}G_t^{(r)}$	64.5	46.8
	(0.00)***	(0.00)***
$S_1x_{it}G_t^{(r)}$, $S_2x_{it}G_t^{(r)}$, ..., $S_{16}x_{it}G_t^{(r)}$	9707.3	4142.4
	(0.00)***	(0.00)***
$S_1m_{it}G_t^{(r)}$, $S_2m_{it}G_t^{(r)}$, ..., $S_{16}m_{it}G_t^{(r)}$	104.7	60.9
	(0.00)***	(0.00)***
$S_1G_t^{(r)}$, ..., $S_{16}G_t^{(r)}$; $S_1x_{it}G_t^{(r)}$, ..., $S_{16}x_{it}G_t^{(r)}$; $S_1m_{it}G_t^{(r)}$, ..., $S_{16}m_{it}G_t^{(r)}$	28840.6	15700.5
	(0.00)***	(0.00)***
Wald test (joint)	23.56 (0.00)	
Sargan test (p-value)	30.94 (0.45)	
AR(1)	-3.53 (0.00)	
AR(2)	1.08 (0.27)	

The sample period is 1995-2000. Number of firms: 1097; number of observations: 5485. All model are estimated by means of the Arellano and Bond (1991) GMM estimator, using variables dated at *t-2* as instruments. The Wald test for the joint significance of dummies, the Sargan Test and the Test for first and second correlation are reported. Heterosckedasticity consistent asymptotic t-statistics are shown in brackets. *** (**) [*] stands for statistical significance at 1% (5%) [10%] level.

Table 6
Elasticities of Firm Investment to Infrastructure by Sector

Sector/Region	Impact *via* Adjustment Costs	Impact *via* Profitability			Net Impact
		Impact *via* Revenues	Impact *via* Costs	Net Impact *via* Profits	
	(1)	(2)	(3)	(4)=(2)+(3)	(5)=(1)+(4)
		Short-Run			
Food Products	0.74	-0.19	0.05	-0.14	0.60
Textiles	0.47	-0.05	0.06	0.01	0.48
Clothing	-0.08	0.43	0.00	0.43	0.36
Leader and Footwear	1.14	-0.67	0.09	-0.58	0.55
Wood and Furniture	1.06	-0.31	0.10	-0.21	0.84
Paper and Publishing	-0.13	-0.12	0.56	0.44	0.31
Chemicals	0.24	-0.29	0.48	0.19	0.43
Rubber and Plastic Products	-0.05	-0.18	-0.02	-0.20	-0.26
Non Metalliferous Minerals	0.31	-0.49	0.34	-0.15	0.16
Metals	0.32	-0.06	-0.06	-0.12	0.19
Metal Manufactures	0.18	0.05	0.04	0.09	0.27
Machinery for Ind. and Agr.	0.13	0.20	0.06	0.25	0.38
Electrical Machinery	0.36	-0.12	0.04	-0.08	0.28
Transports	0.49	-0.04	-0.17	-0.20	0.28
Furniture	0.32	-0.65	0.09	-0.57	-0.24
Other Manufactures	0.77	-0.11	0.02	-0.09	0.68
North-Centre	0.33	-0.12	0.11	-0.02	0.31
South	0.57	-0.04	0.07	0.04	0.60
Total	0.45	-0.11	0.09	-0.02	0.43
		Long-Run			
Food Products	0.94	-0.21	0.08	-0.13	0.81
Textiles	0.58	-0.06	0.09	0.04	0.62
Clothing	-0.11	0.54	0.01	0.55	0.43
Leader and Footwear	1.22	-1.13	0.14	-0.99	0.23
Wood and Furniture	1.35	-0.57	0.46	-0.12	1.23
Paper and Publishing	-0.17	-0.16	0.78	0.62	0.45
Chemicals	0.28	-0.52	0.57	0.05	0.33
Rubber and Plastic Products	-0.09	-0.34	-0.03	-0.37	-0.46
Non Metalliferous Minerals	0.32	-0.68	0.60	-0.08	0.24
Metals	0.40	-0.09	-0.08	-0.18	0.23
Metal Manufactures	0.79	0.22	0.06	0.27	1.07
Machinery for Ind. and Agr.	0.27	0.26	0.06	0.33	0.60
Electrical Machinery	0.46	-0.14	0.05	-0.09	0.37
Transports	0.53	-0.21	-0.23	-0.44	0.10
Furniture	0.80	-1.01	0.14	-0.87	-0.08
Other Manufactures	0.98	-0.17	0.04	-0.14	0.84
North-Centre	0.53	-0.27	0.14	-0.13	0.41
South	0.68	-0.06	0.10	0.03	0.71
Total	0.61	-0.17	0.09	-0.07	0.53

Table 7

Elasticities of Firm Investment to Infrastructure by Sector and Area: The Short Run

Sector/Region		Impact *via* Adjustment Costs	Impact *via* Profitability			Total Impact
			Impact *via* Revenues	Impact *via* Costs	Total Impact *via* Profits	
		(1)	(2)	(3)	(4)=(2)+(3)	(5)=(1)+(4)
Food Products						
	North	0.80	-0.25	0.06	-0.19	0.61
	South	0.62	-0.06	0.02	-0.05	0.57
Textiles						
	North	0.46	-0.05	0.06	0.01	0.47
	South	3.32	-0.02	0.02	0.00	3.32
Clothing						
	North	-0.21	1.44	0.02	1.46	1.25
	South	0.00	0.39	0.00	0.40	0.40
Leader and Footwear						
	North	1.10	-0.73	0.10	-0.63	0.47
	South	1.54	-0.13	0.01	-0.12	1.42
Wood and Furniture						
	North	1.37	-0.39	0.13	-0.26	1.11
	South	0.43	-0.17	0.04	-0.12	0.31
Paper and Publishing						
	North	-0.13	-0.15	0.72	0.57	0.44
	South	-0.13	-0.05	0.48	0.43	0.30
Chemicals						
	North	0.22	-0.29	0.48	0.19	0.41
	South	1.10	-0.42	0.65	0.23	1.33
Rubber and Plastic Products						
	North	-0.05	-0.19	-0.03	-0.22	-0.27
	South	-0.06	-0.08	-0.01	-0.09	-0.16
Non Metalliferous Minerals						
	North	0.32	-0.57	0.40	-0.18	0.14
	South	0.24	-0.06	0.04	-0.01	0.23
Metals						
	North	0.51	-0.09	-0.10	-0.19	0.32
	South	0.04	-0.01	-0.01	-0.02	0.02
Metal Manufactures						
	North	0.20	0.05	0.04	0.10	0.29
	South	0.10	0.01	0.01	0.02	0.11
Machinery for Ind. and Agr.						
	North	0.13	0.20	0.06	0.25	0.38
	South	0.10	0.17	0.11	0.28	0.38
Electrical Machinery						
	North	0.36	-0.12	0.04	-0.08	0.28
	South	0.13	-0.01	0.00	-0.01	0.12
Transports						
	North	0.47	-0.04	-0.18	-0.21	0.26
	South	0.74	-0.02	-0.13	-0.15	0.59
Furniture						
	North	0.32	-0.65	0.09	-0.57	-0.24
	South	0.11	-0.06	0.01	-0.05	0.06
Other Manufactures						
	North	0.77	-0.11	0.02	-0.09	0.68
	South	0.79	-0.05	0.01	-0.03	0.76

Table 8

Elasticities of Firm Investment to Infrastructure by Sector and Area: The Long Run

Sector/Region		Impact *via* Adjustment Costs	Impact *via* Profitability			Total Impact
			Impact *via* Revenues	Impact *via* Costs	Total Impact *via* Profits	
		(1)	(2)	(3)	(4)=(2)+(3)	(5)=(1)+(4)
Food Products						
	North	1.02	-0.39	0.10	-0.29	0.73
	South	0.79	-0.10	0.03	-0.07	0.72
Textiles						
	North	0.56	-0.07	0.10	0.02	0.59
	South	4.06	-0.02	0.03	0.00	4.06
Clothing						
	North	-0.62	1.80	0.03	1.84	1.22
	South	0.01	0.49	0.01	0.50	0.51
Leader and Footwear						
	North	1.17	-1.22	0.15	-1.07	0.11
	South	1.65	-0.22	0.02	-0.20	1.45
Wood and Furniture						
	North	1.75	-0.71	0.59	-0.12	1.63
	South	0.55	-0.31	0.20	-0.11	0.44
Paper and Publishing						
	North	-0.17	-0.25	0.96	0.71	0.54
	South	-0.18	-0.09	0.64	0.56	0.38
Chemicals						
	North	0.25	-0.52	0.57	0.05	0.30
	South	1.25	-0.76	0.78	0.02	1.27
Rubber and Plastic Products						
	North	-0.09	-0.72	-0.04	-0.76	-0.85
	South	-0.11	-0.30	-0.02	-0.32	-0.43
Non Metalliferous Minerals						
	North	0.34	-0.80	0.70	-0.09	0.24
	South	0.25	-0.08	0.08	0.00	0.25
Metals						
	North	0.65	-0.15	-0.13	-0.28	0.37
	South	0.05	-0.02	-0.01	-0.04	0.02
Metal Manufactures						
	North	0.85	0.24	0.07	0.31	1.16
	South	0.42	0.03	0.01	0.05	0.46
Machinery for Ind. and Agr.						
	North	0.27	0.26	0.06	0.33	0.60
	South	0.20	0.23	0.12	0.35	0.55
Electrical Machinery						
	North	0.46	-0.14	0.05	-0.09	0.37
	South	0.17	-0.02	0.01	-0.01	0.16
Transports						
	North	0.58	-0.21	-0.23	-0.45	0.13
	South	0.91	-0.11	-0.17	-0.27	0.63
Furniture						
	North	0.80	-1.01	0.14	-0.87	-0.08
	South	0.27	-0.09	0.01	-0.07	0.20
Other Manufactures						
	North	0.98	-0.18	0.04	-0.14	0.84
	South	1.01	-0.07	0.02	-0.05	0.96

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