Regional policy: What is the most efficient instrument?*

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Abstract. Whatever the reasons at work – differences in locational endowments and/or externalities – a unit of capital is expected to be diversely productive according to the region where it is installed. This article determines which and the extent to which a regional policy could be implemented in order to make up for a productivity handicap. The model allows for comparing the efficiency of a productivity-enhancing instrument (a publicly provided input) with that of instruments that affect capital cost (a lower corporate tax rate, an investment tax credit, or a capital subsidy). The approach is illustrated in the contemporaneous context of France.

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Key words: Regional policy, productivity handicap, corporate tax cut, capital grant, publicly provided input

1 Introduction

Economic development is uneven over space. Regions are characterized by performance disparities in factor productivity: some regions stand ahead, whereas others lag behind. The economic literature has stressed two main explanations, both related to the firms’ location decision: endowments and externalities.

Whatever the reasons at work, a unit of capital is expected to be diversely productive according to the region where it is installed and this productivity gap may not be totally offset by differences in factor prices.

Regional policies have long been implemented in most industrialized countries with the purpose of reducing income disparities over space. Although the new economic geography literature provides support for concentration of activities in successful areas, some economic...
rationales for regional policies are provided by distributional considerations (see Martin 1999) and efficiency arguments (see Fuest and Huber 2006).

Generally speaking, regional policy relies on instruments that can be classified into two broad categories. A first range of instruments affects productivity in the private sector. Public expenditures in infrastructure capital or in education are two examples of such a policy. A second category of instruments is more specifically designed to lessen factor costs. By granting capital (or labour) subsidies, providing fiscal incentives or lowering corporate tax rates, the public sector implements instruments that result in cost decreases and accordingly stimulate factor demand.

Notice that the two broad categories of instruments may also be distinguished in terms of other criteria. For example, the second are rather firm-specific (independently of whether the instrument is automatic or discretionary) while the first are non-specific.

A relevant question is to determine the degree of effectiveness of policy instruments in making up for productivity differentials. The approach adopted in this article, rests on Mignolet (2004) sets out to measure the impact of some regional policy instruments on firm costs. More precisely, we focus on the investment decision and on regional policies aimed at promoting capital formation in backward regions. We leave aside instruments that affect other production factors (such as labour subsidies, for example). The article, and this is its main contribution, compares the effectiveness of a productivity-enhancing instrument (here a publicly provided input) with that of instruments which influence factor costs (a capital grant, a fiscal incentive or a corporate tax cut). These regional policy instruments are designed such as to make up for a same unfavourable productivity differential due to differences in agglomeration economies or in endowments.

The article belongs to the literature on effective taxation. This stream of thought is built on two complementary approaches: the first assesses the impact of a public policy on the firm’s cost of capital – that is the minimum pre-tax rate of return on an investment required by the investor. Its main focus is on effective marginal tax rate (EMTR) that captures the incentive to make a new capital expenditure and accordingly explains the size of investment. The second (see Devereux and Griffith 1998, 2003) measures the effect of tax policies on the choice among several discrete investment options such as the choice of location among alternative places, for example. This issue is governed by the effective average tax rate (EATR), a concept used in particular when the investment is expected to earn some economic rent.

This article is constructed on the first approach. Unlike the EATR approach, it only focuses on investment creation, not investment diversion. This choice is convenient because it allows us to neglect the case of activity displacement in space along with its adverse effects on regions that are abandoned.

The article is organized as follows. section 2 presents the basic model. A general expression is given that links together the cost of capital, investment incentives, public infrastructure, local endowments and agglomeration economies. By totally differentiating this expression, section 3 determines the level at which a particular instrument (such as an increase in a publicly provided input, a capital subsidy, a decrease in the tax base or in the corporate tax rate) must be implemented in order to offset an unfavourable productivity differential. The public cost associated with the different regional policy instruments is also assessed in order to compare their relative performance. A numerical application is then developed in section 4 to illustrate the approach and its relevance. Section 5 concludes.

Before proceeding with the basic model, let us clarify the meaning of the term region in our context. A region represents any territorial unit (a district, a region, a nation or a supranational entity) that may be identified by its productivity performance. In section 4, the numerical example deals with France. It exploits some parameter values estimated for the 21 regions corresponding to the first breakdown of national data (NUTS 1).
2 The basic model

The aim of this article is to compare the effectiveness of different policy instruments in making up for some given productivity handicap. For this, we need a production function combining private capital and a publicly provided input, as well as two factors each capturing agglomeration economies and endowment differences respectively. Such a specification is proposed by Garcia-Milà and McGuire (2002) and is the one adopted here. It rests on the following production function, $Y_r$, in region $r$:

$$Y_r = F(K_r, G_r) \left( \frac{K_r}{a_r} \right)^\alpha H_r$$

(1)

Equation (1) is made up of three components: a function $F$ associating private owned capital, $K_r$, and a publicly provided input, $G_r$, agglomeration economies, $(K_r/a_r)\alpha$, and the endowment level, $H_r$.

Since we concentrate on capital formation decisions, all other arguments (notably labour and land) are ignored for simplicity. Accordingly, $F$ only combines $K_r$ and $G_r$. The latter term refers to any public capital spending that is under government control and that influences firms’ productivity. $F$ is assumed to be at least twice differentiable with respect $K_r$ and $G_r$. Following Oates and Schwab (1991), $G_r$ is supposed to be distributed equally throughout capital stock such that the contribution of publicly provided inputs to marginal productivity in region $r$ is equal to:

$$\frac{G_r}{K_r} F'_{G_r}$$

(2)

where $F'_{G_r}$ represents the partial derivative of function $F$ with respect to the quantity of publicly provided goods, $G_r$, in region $r$. Production in region $r$ is not only determined by $F$ but also by two other factors expressing respectively agglomeration economies and endowment differences between regions that may not be totally accounted for by factor prices.

The first factor, $(K_r/a_r)\alpha$, is supposed to capture any productivity increase (decrease) due to a greater (smaller) concentration of private capital, which arises from more or less close proximity either to the output market (as in pecuniary externality models), or to other firms whether in the same industry or not. As in Ciccone and Hall (1996), $(K_r/a_r)$ expresses the private capital density ratio per acre of land (symbolized by $a$) and $\alpha$ indicates the elasticity of output to density.

The second factor, $H_r$, is a Hicks-neutral shifter that controls for any efficiency differential over space that would arise from factors out of the control of the firm and of the public sector in region $r$. It encompasses any locational advantage (or disadvantage) due to natural endowments (any gift of nature) or attributable to any inter-regional spillover effect. Through agglomeration economies, each firm’s decision affects all firms’ outputs, including its own. Following Garcia-Milà and McGuire (2002), none of the firms (unlike the public sector, as shown in Section 3.2) is assumed to take this effect into account. So, a representative firm maximizes its profits by considering the aggregate amount of private capital as constant (see Garcia-Milà and McGuire 2002). That also holds for $H_r$ that captures any locational advantage independent of agglomeration economies. Firms suppose this term to be given as well.

These assumptions are very convenient. Through the way they are modelled, concentration externalities and interregional spillover effects amount to a simple spatial productivity factor. Therefore, when a firm decides about whether or not to invest, it disregards any self-reinforcing effect

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1 See for example Pereira and Roca-Sagalés 2003, 2007 and Lall 2007.
process of agglomeration on its productivity and any interregional spillover effect of possible economic actions in neighboring regions. As highlighted later, contrary to the firm, the public sector recognizes the external benefit to all firms of the increase in the level of capital of any individual firm. Accordingly it pays attention both to the additional unit of capital brought in as a result of the regional policy implemented and to the agglomeration externality that arises from it and that enhances the total productivity of the economy. In its economic calculation, the public sector takes into account any additional revenue that is expected from a tax base increase due to productivity gains. At the optimum, each firm chooses its private capital stock so as to equalize marginal contributions to production in value to marginal cost of capital, as indicated in (3):

\[
P_r \left( \frac{F_{Kr}'}{K_{r}} + \frac{G_r}{K_{Gr}} \right) \left( \frac{K_r}{a_r} \right)^{\alpha} H_r = \frac{(1 - A_{r})}{(1 - \tau_{r})} [(\rho_{Kr} - \pi_{r}) + (\delta - \pi_{Kr})]
\]

The left-hand side (lhs) of expression (3) captures the gain to the firm from implementing an additional unit of (private or public) capital. This is due to the marginal product of capital, \(F_{Kr}'\), and to the marginal output from an increase in the publicly provided input, \((G_r/K_{Gr})\) (see Oates and Schwab 1991). This approach accounts for any locational (dis)advantage expressed by \(H_r(K_r/a_r)\). \(P_r\) is the price of output and \(P_{Kr}\) is the price of investment goods. Accordingly, \((P_{r}/P_{Kr})F_{Kr}'(K_r/a_r)\) and \((P_{r}/P_{Kr})G_r/K_{Gr}F_{Gr}'(K_r/a_r)\) respectively measure the marginal productivity of private capital and the marginal increase of output due to any increase in public inputs, in region \(r\). Both terms are expressed in value per monetary unit.

The right-hand side (rhs) of equality (3) is the well-known expression of gross-of-depreciation capital cost (see King and Fullerton 1984). As Alworth (1988) commented, “it captures in addition to the financial cost, all other features of the tax system which might affect the investment decision of the firm, including depreciation allowance and a wide number of possible indirect investment incentives”. It expresses the before-tax minimum rate of return that an investment project must yield in order to provide the saver with the expected net-of-tax return and to account for the loss of capital value due to depreciation. In this expression, \(\pi_{r}\) and \(\pi_{Kr}\) respectively symbolize the expected inflation rate for goods sold by the firm and the real expected inflation rate on capital goods. \(\delta\) is the exponential rate of economic depreciation. \(\rho_{Kr}\) is the financial cost of capital investment to the firm (on which more is said below), \(\tau_{r}\) is the corporate tax rate, \(A_{r}\) is the present discounted value of any capital grant, tax credit or tax savings due to the allowances entitled for the asset, when the cost of the project is unity. In expression (3), all variables are possibly different between regions (and are noted with subscript \(r\)) except \(\delta\) that is supposed to be the same in all regions. Indeed the loss of value due to economic depreciation is clearly expected to be the same wherever the asset is located. By and large, in this article, the objective is to compare the productivity of different neighboring regions belonging to a larger administrative entity. Accordingly, we shall consider that the variables concerning the general environment are identical in all regions. This is notably the case for the

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2 Above from being convenient, these assumptions also seem reasonable. It is indeed unlikely that firms explicitly take into account the general rise of profitability in the region brought by all the individual decisions in their own investment decision. Furthermore, allowing firms to include agglomeration externalities in their calculation would considerably complicate the analytical development of the model, possibly even preventing us from reaching a solution.

3 \(\pi_{r}\) is equal to \(P_{r} - P\), where a dot over a symbol indicates its rate of change.

4 \((\delta - \pi_{r})\) expresses the effective economic depreciation rate accounting for the expected capital gain on capital goods if \(P_{r} - P\). The specialized literature generally states that \(\delta\) is equal to \(2/L_e\), where \(L_e\) is the economic life of the asset.

5 When the investment is cross-border, \(\tau\) becomes a composite tax rate including the source and home countries statutory tax rates on corporations, as well as any dividend withholding taxes, and taking into account the different methods for relieving double taxation.
financing alternatives. Of course, the degree of public generosity, the grant rate for example, may vary between regions as well as the general rules determining the investment expenditure proportions qualifying for tax allowances or entitled to immediate expensing.

There are three ways in which a new investment can be financed: by borrowing, retaining profits and issuing new shares. The financial cost, \( \rho_{jr} \), is the rate at which firms discount their after-tax cash flows.\(^6\) The expression for financial cost is provided by:

\[
\rho_{jr} = \beta (1 - \tau_r) i_r + (1 - \beta) \left[ \varepsilon \frac{(1 - m_{ir}) i_r}{(1 - m_{dr}) \theta_r} + (1 - \varepsilon) \frac{(1 - m_{gr}) i_r}{(1 - m_{gr})} \right]
\]

where \( \beta \) is the fraction of investment financed by debt, \( (1 - \beta) \) is the fraction of equity finance, of which \( \varepsilon \) is the proportion financed from new share issues. In (4), \( m_{ir} \) is the personal tax on interest, \( m_{gr} \) expresses the personal tax rate on capital gains, \( \theta_r \) denotes the opportunity cost of retained earnings in terms of gross dividends foregone and \( m_{dr} \) symbolizes the personal tax rate on dividend remittances. \( \theta_r \) is higher than 1 when a method of alleviating the economic double taxation of dividends (the imputation regime, for instance) is implemented.

3 Public policy impact assessment and comparison

Usually public incentives aimed at reducing the capital cost may take one of the two following forms: a tax device, \( f_r \), \( \tau_r \) or a capital grant \( s_r \), so that \( A_r \) may be written as follows:

\[
A_r = f_r \tau_r + s_r \quad \text{where} \quad f_r = f_{1r} A_{dr} + f_{2r}
\]

In expression (5), \( s_r \) is the rate of capital grant, net of any corporate tax, and \( f_r \) is supposed to capture any tax savings (expressed in present value). These tax savings arise from depreciation allowances, \( f_{1r} A_{dr} \), \( \tau_r \), where \( A_{dr} \) is the discounted value of depreciation allowances on the one hand, and from immediate expensing, investment tax credit or any other device aimed at decreasing the tax base, \( f_{2r} \tau_r \), on the other hand.\(^7\) The parameters \( f_{1r} \) and \( f_{2r} \), respectively express the investment expenditure proportions qualifying for standard depreciation allowances and entitled to immediate expensing, tax credit or other particular devices affecting the tax base.

Because \( A_r \) is the present discounted value of any grants or tax allowances granted by public authorities for an asset that costs unity, only \( (1 - A_r) \) euro needs to be raised from investors to finance one euro of new capital.

By and large, public authorities use these fiscal and financial channels to stimulate investment in lagging regions. Regional policy relies on two further instruments: corporate tax scale adjustments and public infrastructure financing. The question is: which regional policy must be implemented in order to make up for an unfavourable productivity differential?

Before addressing this question, let us rewrite expression (3) as follows:

\[
\left( \frac{P_r}{P_{Kr}} \right) F'_{Kr} = H^\tau_r \left( \frac{K_r}{a_r} \right)^{-\alpha} \left[ \left( \rho_{jr} - \pi_r \right) + (\delta - \pi_{kr}) \right] - \frac{P_{G_{kr}}}{P_{kr} K_r} F'_{G_{kr}}
\]

\(^6\) Following the traditional King and Fullerton’s (1984) approach, financial cost is derived assuming that, at equilibrium, the net-of-tax return required by the shareholder is equal across all sources of financing available to the firm. See also Boadway and Shah (1995).

\(^7\) Immediate expensing and investment tax credit, \( f_{2r} \), are devices that can take any continuous value. By contrast, tax allowances, \( f_{1r} A_{dr} \), refer to different patterns such as straight line, declining balance or other special schemes allowed by tax codes, which yield discontinuous present values in terms of tax exemption. For sake of simplicity, in the remainder of the paper we shall consider that variations of \( f_r \), \( (df_r) \) capture all changes (continuous or discontinuous) of the tax base.
At the firm’s optimum, marginal productivity equals marginal cost of private capital. So the left-hand side of expression (6) expresses the minimum rate of return that the investment must yield when it is located in region $r$ in order to provide the saver with an attractive net-of-tax return. It can be interpreted as the ‘spatialized’ gross cost of capital in region $r$ and will be denoted below by $C_{Kr}$.

Using this framework, one can analytically assess the impact of regional policy instruments by examining how they affect the spatialized gross capital cost. The following expression gives the total differential of $C_{Kr}$.

$$dC_{Kr} = \frac{\partial C_{Kr}}{\partial \tau_r} d\tau_r + \frac{\partial C_{Kr}}{\partial f_r} df_r + \frac{\partial C_{Kr}}{\partial s_r} ds_r + \frac{\partial C_{Kr}}{\partial G_r} dG_r + \frac{\partial C_{Kr}}{\partial [H_r(K_r/a_r)^\alpha]} d[H_r(K_r/a_r)^\alpha]$$

(7)

It measures the sensitivity of capital cost with respect to any productivity differential due to regional disparities either in externalities or endowments, as well as to the four following strategies: lowering of the corporate tax rate, $d\tau$, decreasing of the tax base, $df$, granting of a capital subsidy, $ds$, and provision of a new unit of public capital, $dG$.

From (7), it is easy to calculate the level at which a particular policy has to be set to compensate a regional productivity deficit. It amounts to the estimation of the variation in policy instruments $d\tau$, $df$, $ds$, and $dG$ required to maintain a constant capital cost ($dC_{Kr} = 0$), notwithstanding the productivity differential $d[H_r(K_r/a_r)^\alpha]$. For instance, the corporate tax rate change, $d\tau$, is simply derived as follows:

$$d\tau = -\frac{\frac{\partial C_{Kr}}{\partial [H_r(K_r/a_r)^\alpha]} d[H_r(K_r/a_r)^\alpha]}{\frac{\partial C_{Kr}}{\partial \tau_r}}$$

(8)

We are now in a position to ask which of the alternative policies ($d\tau$, $df$, $ds$, and $dG$) is best to offset a productivity handicap in a region $r$. In order to answer such a question, one may readily solve (7) for each instrument to obtain the analytical expressions of $d\tau^*$, $df^*$, $ds^*$ and $dG^*$.

The asterisks associated with the policy variables indicate the level of the implemented instrument which exactly offsets a productivity differential equal to $d[H_r(K_r/a_r)^\alpha]/H_r(K_r/a_r)^\alpha$. Notice that this latter term is negative when the region faces a productivity handicap.

3.1 Analytical expressions of $d\tau^*$, $df^*$, $ds^*$ and $dG^*$

After some transformations, one obtains expressions (9) to (12). First, in order to offset an unfavourable productivity differential in region $r$, public authorities have to modify the corporate tax rate by $d\tau^*$, as shown in (9).

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8 Expression (9) is obtained by calculating (8), which corresponds to the division of the two following terms: the first derivative of the spatialized cost of capital expression (6) with respect to the productivity differential by the first derivative of the spatialized cost of capital with respect to the corporate tax rate.
The extent of \( d\tau^*_r \) is the result of the product of the following two factors. The first term (on the rhs) is the productivity handicap that is to be compensated. The second term, between brackets, is the inverse of the tax base relative to which the corporate tax is calculated. This tax base is obtained by the algebraic summation of three terms: the required profit before corporate tax that yields one euro after tax, the expected effect of a variation of the corporate tax rate on financial cost and tax savings from immediate expensing and tax allowances.

Expressions (10) to (12) indicate the extent to which tax incentives \( df^*_r \), capital subsidies, \( ds^*_r \), or publicly provided inputs, \( dG^*_r \), have to be implemented to offset a regional productivity handicap.
so that each of the three fiscal instruments activates an investment project of the same amount, \( dK_{pr} \).

\[
dK_{pr} = \frac{\partial K_{pr}}{\partial C_{Kr}} \frac{\partial C_{Kr}}{\partial s_r} ds_r^* = \frac{\partial K_{pr}}{\partial C_{Kr}} \frac{\partial C_{Kr}}{\partial \tau_r} df_r^* = \frac{\partial K_{pr}}{\partial C_{Kr}} \frac{\partial C_{Kr}}{\partial \lambda} d\tau_r^* \tag{13a}
\]

On the contrary, as public capital has, at least partially, the characteristics of public goods, other firms can benefit from it and the variation of capital stock in the economy depends on the elasticity of private capital to public capital in region \( r \). Let us write it \( \lambda dK_{pr} \), with \( \lambda \geq 1 \).

\[
\lambda dK_{pr} = \frac{\partial K}{\partial C_{Kr}} \frac{\partial C_{Kr}}{\partial G_r} dG_r^* \tag{13b}
\]

### 3.2 Regional policy comparisons

In order to compare policies whose effects are rather different in kind and which are costly in various ways, let us measure the impact of each incentive on the public treasury. As mentioned before, unlike the firm, the public sector takes into account the increase in total productivity of the economy attributable to agglomeration economies. More precisely, public authorities consider in their calculation not only the amount of public resources that have to be spent to balance a negative productivity differential (section 3.2.1) but also any additional public revenue that arises from a tax base increase due to the enlarged capital income in the economy (section 3.2.2).

#### 3.2.1 Public cost of the initial outlay

What is the initial public outlay, \( C_i \), that is necessary to balance a productivity handicap? We assume that policy instruments that lower factor costs (a capital subsidy, a fiscal incentive or a corporate tax cut) are only granted to marginal investment projects. This hypothesis is common in the literature. It prevents ‘windfall gains’ to existing capital, keeping any public advantage to the sole new capital. On the contrary a productivity-enhancing instrument, a new publicly provided input, affects the productivity of both new and existing capital.

Let us first examine the cost-decreasing instruments. For an investment project of one monetary unit, the expenditure associated with a capital grant is just equal to the additional amount of the capital subsidy itself, \( ds_r^* \), since it is expressed in net value, after any corporate tax.

\[
C_i = ds_r^* \tag{14a}
\]

The cost–per unit of capital–of lowering tax rates, \( C_t \), corresponds to the tax revenue foregone on the income from newly installed capital, throughout its whole lifetime:

\[
C_t = -d\tau_r^* \int_0^\infty C_{Kr} e^{-[\rho_{gr} - \pi_r + (\delta - \pi_{Kr})]u} du = -\frac{d\tau_r^* C_{Kr}}{[\rho_{gr} - \pi_r + (\delta - \pi_{Kr})]} \tag{14b}
\]

In (eq14b), \( C_{Kr} e^{-[\rho_{gr} - \pi_r + (\delta - \pi_{Kr})]} \) expresses the nominal profits that increase with inflation, decrease in value at the rate of depreciation, and are discounted at the public opportunity cost, \( \rho_{gr} \).
Similarly, the initial cost of an investment tax credit (or of an immediate expensing), $C_f$, may be expressed in terms of tax revenue foregone on marginal investment income. The total budget associated with this policy instrument is equal to:

$$C_f = \tau \cdot d f^*$$  \hspace{1cm} (14c)

Finally, as a productivity-enhancing instrument benefits all investment projects, not only new ones, the initial public outlay necessary to create $dK_{pr}$, is equal to:

$$C_G = \frac{dG^*}{K_r + \lambda dK_{pr}}$$  \hspace{1cm} (14d)

### 3.2.2 Additional revenues due to an enhanced tax base in the economy

What are the public additional revenues arising from increases in capital income due to the regional policy implemented? Let us distinguish once again factor-cost-reducing instruments from a productivity-enhancing policy. When a capital subsidy, a tax incentive or a corporate tax cut is granted to a firm to stimulate its investment expenditure, agglomeration economies appear that reduce the cost of existing capital in the economy. All firms, possibly in a closed neighborhood (see van Soest et al. 2006), benefit indeed from external economies as soon as any one firm increases its level of capital. These concentration externalities expand nominal profits generated by existing capital during its remaining lifetime and therefore the firms’ tax base.

Let us express the tax revenue, $T$, brought by the general increase in productivity as $T = \tau \cdot d(TB)$, where $d(TB)$ denotes the additional tax base. As shown in Appendix A, $d(TB)$ is computed as followed:

$$d(TB) = \left[ \alpha H_r \left( K_r \right)^{a - 1 - A_r} \left[ 1 - A_r \right] - \frac{P_r G_r}{P_r K_r} \left[ (\rho_{pr} - \pi_r) + (\delta - \pi_{kr}) \right] \right]$$  \hspace{1cm} (15)

In (15) the additional tax base is influenced by two terms. The first term on the rhs is positive. It expresses the extra corporate tax revenue that is attributable to agglomeration economies, for the whole economic lifetime of the asset. The latter term on the rhs, whose sign is negative, indicates the corporate tax loss that arises from a reduced ratio between $G_r$ and $K_r$. Private capital increases competition on existing publicly provided inputs and accordingly reduces the contribution of public inputs to the productivity of every unit of private capital.

Let us now consider the additional tax revenue associated with a productivity-enhancing instrument. It is affected in two ways. First a new public infrastructure directly increases the productivity of existing capital, or equivalently, decreases its capital cost. Appendix A provides the detail of this calculation. Secondly, as for the three instruments aimed at reducing capital cost, any increase in private capital due to a new publicly provided input results in external economies that increase the marginal profitability of any unit of existing capital and raises the associated tax revenues as given by (15). Total tax revenue resulting from a productivity-enhancing instrument, $T_G$, is finally given by (16).

$$T_G = \tau \left[ P_r \left[ \frac{dG^*}{K_r + \lambda K_{pr}} \right] \left( F_{Gr}' + G_r F_{Gr}'' \right) \right] + \tau \cdot d(TB)$$  \hspace{1cm} (16)
3.2.3 Net public cost

Let us define \( NC_s, NC_f, NC_t \) and \( NC_G \) as the net public cost associated respectively with a capital grant, a fiscal incentive, a corporate tax cut and a new publicly provided input. Net public costs are calculated by subtracting the additional tax revenue \( T(15) \) or \( TG(16) \) from the initial public outlay \( C_j(14) \). In order to measure the effectiveness of the different instruments, we chose to calculate the following ratios: \( NC_s/NC_f, NC_s/NC_t \) and \( NC_s/NC_G \). In this formulation, the capital grant is considered the benchmark. This choice has no effect on the interpretation of the results.

Simplifying and taking (9), (10), (11) and (12) into account leads to the following resulting analytical expressions:

\[
\frac{NC_s}{NC_f} = \frac{C_s - \tau_t d(TB)}{C_f - \tau_t d(TB)} \quad (17)
\]

\[
\frac{NC_s}{NC_t} = \frac{C_s - \tau_t d(TB)}{C_t - \tau_t d(TB)} \quad (18)
\]

\[
\frac{NC_s}{NC_G} = \frac{C_s - \tau_t d(TB)}{C_G - \tau_t P_t K_t P_{KR} dG^* \left[ F_{Gr} + G_t F_{Gr}'' \right] - \tau_t d(TB)} \quad (19)
\]

Expressions (17) and (18) directly enable us to identify the most efficient instrument to be implemented in order to make up for a given productivity handicap. All terms in these expressions are indeed identifiable. A lower-than-unity ratio indicates that the instrument mentioned in the numerator, i.e. the grant, is less costly than that appearing in the denominator.

Implementing expression (19) is less straightforward, essentially because of the public good nature of productivity-enhancing instruments. In this case, public spending is indeed expected to stimulate not only the targeted project, increasing the private capital stock by \( dK_{pr} \), but also to benefit a potentially larger number of firms, leading to a global growth of regional private capital stock of \( l dK_{pr} \). Accordingly, whether a publicly provided input is more or less efficient than a capital subsidy, depends on the one hand on their relative costs and on the other hand on the number of private investments that are created on account of both instruments. As \( \lambda dK_{pr} \) is in principle unknown, we have to adopt a new comparison rule. By transforming (19), one may show that a publicly provided input becomes the most efficient instrument when the relative variation of capital stock it generates is greater than the following threshold:

\[
\frac{\lambda dK_{pr}}{K_t} > \frac{dG^* \left[ 1 - \tau_t P_t P_{KR} \left[ F_{Gr} + G_t F_{Gr}'' \right] \right]}{K_t \left[ (\rho_{Gr} - \pi_t) + (\delta - \pi_{Kr}) \right]} - 1 \quad (20)
\]

In other words, public authorities willing to make up for a productivity handicap should efficiently choose to implement a productivity-enhancing instrument if and only if it impacts on the investment behavior of enough firms, since publicly provided inputs are generally much more expensive than factor-cost-reducing devices. A numerical example will help us go further in the analysis.
4 A numerical example

In order to illustrate the approach and show its relevance, let us apply it to an investment project in French regions taken, as mentioned earlier, at the NUTS 1 level. The question we will ask here is: if a region \( r \) faces a productivity handicap equal to 1% of a benchmark region \( R \), what regional policy must be implemented in order to make new investments equally profitable in location \( r \) compared to location \( R \) ?

The values attributed to tax variables, summed up in Table 1, are taken from the general tax code in 2006. The corporate tax rate, \( \tau_r \), is equal to 34.43%. Personal tax rates (including social contribution) are respectively equal to 27%, 11% and 26.6% for interests (\( m_{ir} \)), capital gains (\( m_{gr} \)) and dividends (\( m_{dr} \)). There is no double tax relief for dividends so that the \( \theta_r = 1 \). Nevertheless, in order to reduce double taxation, only 50% of the profits distributed to the shareholder are taxed.

The other tax parameters are as follows: the straight-line method is the pattern implemented for tax depreciation, so that \( A_{dr} = \frac{1}{L \rho_{jr}} \left(1 - e^{-L \rho_{jr}}\right) \). The economic life of physical assets is supposed to be equal to 10 years. The same holds for tax purposes (i.e. \( L_r = L = 10 \)). The whole investment expenditure is entitled to depreciation allowances so that \( f_{1r} = 1 \). Neither special fiscal provision (such as a tax credit) nor discretionary public incentive (such as a capital grant) is considered, so that \( f_{2r} = sr = 0 \).

By assumption, the project is equally financed by debt, undistributed profits and new share issues, so that \( \beta = 1/3 \) and \( \epsilon = 0.5 \).

In order to calibrate the general parameters of the model, we suppose that the inflation rate (\( \pi_r \)) is equal to 2%, the real capital gain is nil (\( \pi_a \)) and the interest rate or debt is equal to 8.5%. The term expressing the locational position of productivity, \( H (K_r/a_r)^\theta \), is set to unity.

According to the literature (Ciccone and Hall 1996; Ciccone 2002; Harris and Ioannides 2000; Rice, Venables and Patacchini 2006), the elasticity of output with respect to density is set to 0.05.

Regarding regional statistics, we use the data and results of Charlot et al. (2003). Investigating the French regions, they built regional public and private capital stock figures. The average ratio \( G_r/K \) is found equal to 0.245, with values varying between 0.142 and 0.417 from region to region. Besides, we may determine the marginal productivity of public capital. They estimated the elasticity of regional output with respect to public capital between 0.229 and 0.309. Note that these elasticity values seem rather high. However, reviewing the economic literature, Nijkamp and Poot (2004) observed a great variance in empirical studies results, with output elasticities ranging from 0.03 to 0.39. Moreover, elasticities are very dependent on the nature of the investment (Lall 2007; Puga 2002) and on the location of this investment (Pereira and Roca-Sagalés 2003 and 2007). Further on, we will consider different hypotheses for this

<table>
<thead>
<tr>
<th>Table 1. Fiscal parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \tau_r )</td>
</tr>
<tr>
<td>( \theta_r )</td>
</tr>
<tr>
<td>( m_{ir} )</td>
</tr>
<tr>
<td>( m_{gr} )</td>
</tr>
<tr>
<td>( m_{dr} )</td>
</tr>
</tbody>
</table>

\( L_L = L_e = 10 \)

\( f_{1r} = 1 \)

\( f_{2r} = sr = 0 \)

---

9 This level of disaggregation was chosen because of estimated data availability (see Charlot et al. 2003).
elasticity setting a value of 0.2 in our reference scenario. As in Pereira and Roca-Sagalés (2003, 2007), the marginal product of public capital is obtained by multiplying the elasticity value by the average ratio $Y_r/G_r$, so that $F_{Gr}'$ is equal to 0.341 in the reference scenario. The second derivative, $F_{Gr}''$, is supposed to be nil. These values are summed up in Table 2.

**Table 2. Economic parameters–reference scenario**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Marginal Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta$</td>
<td>0.33</td>
<td>0.341</td>
</tr>
<tr>
<td>$\epsilon$</td>
<td>0.5</td>
<td>0</td>
</tr>
<tr>
<td>$P_r/P_{Kr}$</td>
<td>1</td>
<td>$G_r/K_r$</td>
</tr>
<tr>
<td>$\pi_r$</td>
<td>0.02</td>
<td>$\alpha$</td>
</tr>
<tr>
<td>$\alpha_r$</td>
<td>0</td>
<td>$H_r(K_r/a_r)$</td>
</tr>
<tr>
<td>$i$</td>
<td>0.085</td>
<td></td>
</tr>
</tbody>
</table>

We now address our main question: if a region $r$ faces a productivity handicap equal to 1% (that is if $d[H_r(K_r/a_r)^{\alpha}/H_r(K_r/a_r)]^{\alpha} = -0.01$), what regional policy must be implemented in order to make new investments equally profitable in locations $r$ and $R$?

Table 3 shows the extent to which the instruments (the corporate tax rate, $d\tau^{*}_r$, the tax base, $df^{*}_r$, a capital subsidy, $ds^{*}_r$, and a publicly provided input, $dG^{*}_r$) must be changed in order to make up for the unfavourable productivity differential.

**Table 3. The extent of regional policy**

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>$d\tau^{*}_r$</td>
<td>$-0.0241$</td>
</tr>
<tr>
<td>$df^{*}_r$</td>
<td>$+0.0219$</td>
</tr>
<tr>
<td>$ds^{*}_r$</td>
<td>$+0.0075$</td>
</tr>
<tr>
<td>$dG^{*}_r$</td>
<td>$+0.0084K_r$</td>
</tr>
</tbody>
</table>

The productivity handicap in region $r$ is fully offset when the corporate tax rate is reduced by 2.41 percentage points to 32.02%, when a 2.19% tax credit is put in place or when a 0.75% net-of-corporate-tax capital subsidy is granted. Likewise, a public expenditure of 0.84 cent per unit of private capital is required to offset the spatial disadvantage.

What is the least costly policy to be implemented in order to make up for a regional productivity handicap of 1%? Table 4 shows the cost ratios of the factor-cost-reducing instruments that have been considered, namely a lowering of the corporate tax rate, a decrease of the tax base and the granting of a capital subsidy. In order to measure $C_r$, the public opportunity cost, $\rho_{cr}$, has been set to 3.64%, which is the average 10-year treasury bond constant maturity rate in 2006.

**Table 4. Cost ratios between factor-cost-reducing instruments**

<table>
<thead>
<tr>
<th>Cost Ratio</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$NC_r/NC_t$</td>
<td>0.87</td>
</tr>
<tr>
<td>$NC_r/NC_f$</td>
<td>1</td>
</tr>
</tbody>
</table>

What are the main results? As shown in Table 4, granting a financial incentive or an investment credit are the least costly policies in the France’s current context. These two upfront incentives require a public expense, net of any tax return, equal to 0.75 cent per Euro of private
capital, in order to make the firm equally profitable in spite of a 1% productivity handicap in region $r$.

Conversely, a lowering of the tax rate appears to be a bad choice for the policy maker because it costs 0.86 cent to offset a productivity deficit of 1% for an investment expenditure of 1 Euro. This outcome is easily explained. The benefits of a corporate tax cut are actually lessened by the following double effect. First, a lower corporate tax rate proportionally reducing the tax savings due to the depreciation allowances and accordingly, lowers the net present value of $A_r$. Secondly, it produces a higher financial cost for the proportion of investment that is financed by debt. Upfront incentives are thus more effective in encouraging investment than the lowering of the corporate tax rate. In addition, a corporate tax cut is generally applied both to the income from new investment, as considered here, and from existing capital stock. If it is the case, the previous result is reinforced because the revenue loss is still higher for the public sector. Lowering corporate tax rate generates a windfall gain for shareholders from existing capital stock without stimulating new installed capital.

Publicly provided inputs are also costly. However, because they have, at least partly, the attributes of non-excludability and non-rivalry, these instruments may benefit a (potentially large) number of capital units, either new or existing. Accordingly, whether publicly provided inputs are a better or a worse public device than direct public incentives to the firm depends on the number of firms affected by these public goods, as shown in expression (20). Accordingly, as shown in Table 5, $dG_r^*$ becomes the most efficient instrument in the French regional context as soon as it generates a relative increase of private capital stock above a threshold value $\lambda dK_r/K_r$ equal to 0.013. This result means that $dG_r^*$ is the most efficient instrument if and only if it increases the capital stock of at least 1.3% in region $r$. This threshold value is dramatically dependent on the assumption about the output elasticity to public capital. To shed some light on the sensitivity of this result, let us consider two alternative values of output elasticity to public capital, respectively 0.1 and 0.3.

Table 5. Efficiency threshold of public capital

<table>
<thead>
<tr>
<th>output elasticity</th>
<th>$\lambda dK_r/K_r$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>0.013</td>
</tr>
<tr>
<td>0.1</td>
<td>1.184</td>
</tr>
<tr>
<td>0.3</td>
<td>-0.412</td>
</tr>
</tbody>
</table>

Without surprise, public capital is the best policy when the elasticity value is high (with an output elasticity of 0.3, the threshold value is even negative). Conversely, weak values of elasticity imply that this policy has to be rejected.

The French tax code also includes a local business tax, the so-called ‘taxe professionnelle’, of 25.27%. This tax has been neglected so far. The model may easily be generalized in order to add this tax device. Appendix B gives the details of this extension. The introduction of a business tax is not neutral on results, even if the general conclusions still hold. The dominance of direct incentives is still stressed because a third negative effect counteract gains to firms from a corporate tax rate cut. Indeed, a decrease of the corporate tax rate reduces the saving coming from the deductibility of the business tax against this tax. Table 6 shows the extent to which the instruments (the corporate tax rate, $d\tau_r^*$, the tax base, $dfr^*$, a capital subsidy, $dsr^*$, and a publicly provided input, $dGr^*$) must be changed in order to make up for the unfavourable productivity differential. It also shows by how much the business tax, $dtb^*$, must be lowered in order to reach the same objective.
5 Conclusion

Lagging regions are characterized by unfavourable productivity differentials. This article has investigated ways in which regional policies help lagging regions bridge the gap with some benchmark region. The approach proposed in this article can be helpful for thinking up a new European policy of Structural Funds and for adopting objective criteria to reduce imbalances between regions.

Our model is based on the effective marginal tax theory. It compares the efficiency of some policy instruments: a first kind of measures, namely a lowering of the corporate tax rate, an investment tax credit and a capital subsidy, decreases capital cost while the other measure, a publicly provided input, improves regional productivity of capital. Results suggest that a lowering of the corporate tax rate is not an efficient policy tool. A net-of-corporate-tax subsidy and a decrease of the tax base produce similar effects at a lower cost. Whether a publicly provided input is a better or a worse public device than an upfront incentive depends on the number of capital units whose productivity is enhanced by these public goods. The efficiency of public capital policy is then sensitive to the value of the public capital elasticity. For weak elasticity values, the policy must be rejected for other alternatives. On the contrary, for high values (i.e. higher than 0.2 in the example of France), this instrument is the most efficient of all.
Though useful, the approach also has its limitations. First, the model does not take human capital into account, when evidence from recent studies show that it is a valuable policy instrument (see Puga 2002; Rodríguez-Pose and Fratesi 2004). Moreover, the approach rests on an important assumption. Authorities are supposed to tell marginal investments from inframarginal ones. Although the literature often relies on this hypothesis, it is far from being an obvious one to assume.

References


Rodríguez-Pose A, Fratesi U (2004) Between development and social policies: The impact of European structural Funds in Objective 1 regions. Regional Studies 38: 97–113


Appendices

A How to derive the expressions (16) and (17)?

First, let us consider the additional tax income, $T$, associated with factor-cost reducing-instrument. As proved in equation (13), implementing a regional policy to offset a determined productivity handicap generates a same increase in capital expenditure, $dK_{pr}$, whatever the fiscal instrument, capital subsidy ($d_{sr}$), corporate tax cut ($d_{r}\tau$), or fiscal device ($d_{fr}$). For one unit of capital, the extra nominal profit is apprehended by the decrease in capital cost. In other words, it equals the capital cost differential, with the opposite sign, during its remaining lifetime. For new capital creation equal to one monetary unit, the profitability gain recorded by any existing unit of capital is given by expression (21).

$$-dC_{Kr}\int_{0}^{\infty} e^{-[(\rho_{r}-\pi_{r})+(\delta-\pi_{kr})]u}du = -\frac{\partial C_{Kr}/\partial K_{r}}{[(\rho_{r}-\pi_{r})+(\delta-\pi_{kr})]} \quad (21)$$

where

$$\frac{\partial C_{Kr}}{\partial K_{r}} = -\alpha H_{r}^{-1}\left(\frac{K_{r}}{a_{r}}\right)^{-1}(1-A_{r})\left[(\rho_{r}-\pi_{r})+(\delta-\pi_{kr})\right] + \frac{P_{r}G_{r}}{P_{Kr}K_{r}^{2}}F'_{Gr}$$

Finally, the extra nominal profits for the whole economy may be represented by $-dC_{Kr}\int_{0}^{\infty} e^{-[(\rho_{r}-\pi_{r})+(\delta-\pi_{kr})]u}du$ and the tax revenue, $T$, due to the general increase of productivity becomes equal to:

$$T = -dC_{Kr}\tau_{r}K_{r}\int_{0}^{\infty} e^{-[(\rho_{r}-\pi_{r})+(\delta-\pi_{kr})]u}du$$

Let us now consider the additional tax revenue specifically associated with a productivity-enhancing instrument. It is affected in two ways. First, as for the three instrument aimed at reducing capital cost, any increase in private capital due to a new publicly provided input results in external economies that increase the marginal profitability for any unit of existing capital and raise the associated tax revenue as in (15). Secondly, a new public infrastructure increases the productivity of existing capital, or what amounts to the same thing, decreases its capital cost. The expected effect for the whole economy is equal to

$$-dC_{Kr}\int_{0}^{\infty} e^{-[(\rho_{r}-\pi_{r})+(\delta-\pi_{kr})]u}du \quad \text{where} \quad dC_{Kr} = (\partial C_{Kr}/\partial G_{r})\frac{dG_{r}^{*}}{K_{r} + \lambda K_{pr}}$$

so that a tax revenue equal to $\tau_{r}\frac{P_{r}}{P_{Kr}}\frac{(F'_{Gr} + G_{r}F''_{Gr})}{[(\rho_{r}-\pi_{r})+(\delta-\pi_{kr})]}\frac{dG_{r}^{*}}{K_{r} + \lambda K_{pr}}$ by unit of benefiting capital is expected.

B The local business tax as an additional public instrument

The French tax code includes a local business tax that is deductible against corporate tax base. Generally speaking, its tax base is equal to the rent value of fixed assets, i.e. around 16% of the assets’ price. The average tax rate for 2006 is equal to 25.27%. In pursuance of the law, a new investment is exempt from tax during the first year and respectively one third and two thirds are taxable the second and the third year.

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The business tax can be considered as a wealth tax, one additional unit of capital raises the business tax base by $x$ so that expression (6) in the original model is modified as follows:

$$
\left( \frac{P_r}{P_{Kr}} \right) F_{Kr}' = H_r^{-1} \left( \frac{K_r}{a_r} \right)^{-\alpha} \left[ \left( \frac{\rho_{Kr} - \pi_r}{} + \left( \delta - \pi_{Kr} \right) \right) \right] \frac{1}{1 - \tau_r} \left[ (1 - A_r) + (1 - \tau_r) w_{cr} \right] = \frac{PG_r}{P_{Kr}K_r} F_{Gr}'
$$

where $w_{cr}$ is the present discounted value of the business tax during the whole asset lifetime. The business tax is to be paid annually and tax base is not subject to depreciation. A new investment is completely exempt from tax during the first year and respectively one third and two thirds are taxable the second and the third year. So $w_{cr}$ can be expressed as follows:

$$
w_{cr} = -t_b \frac{x}{\rho_{Kr}} e^{-\rho_{Kr}u} + 0.33 t_b \frac{x}{\rho_{Kr}} e^{-2\rho_{Kr}u} + 0.33 t_b \frac{x}{\rho_{Kr}} e^{-3\rho_{Kr}u} \left( e^{\rho_{Kr}u} + e^{-2\rho_{Kr}u} + e^{-3\rho_{Kr}u} - e^{-4\rho_{Kr}u} \right)
$$

where $t_b$ is the business tax rate, $x$ represents the business tax base (i.e. about 16% of the capital asset). As the business tax is deductible against corporate tax base, the additional tax burden is equal to $(1 - \tau_r)w_{cr}$.

The approach is exactly the same as before. Using the total differential of capital cost (see expressions (7) and (8)), now including a business tax, we may easily calculate the level of the business tax rate change ($dt_b^*$) required to offset a productivity handicap in region $r$:

$$
dt_b^* = \frac{d \left[ H_r(K_r/a_r) \right]}{\left[ H_r(K_r/a_r) \right]} \frac{((1 - A_r) + (1 - \tau_r) w_{cr})}{(1 - \tau_r) \left[ 0.33 \left( x/\rho_{Kr} \right) \left( e^{-\rho_{Kr}u} + e^{-2\rho_{Kr}u} + e^{-3\rho_{Kr}u} - e^{-4\rho_{Kr}u} \right) \right]}
$$

For public authorities, the direct cost of lowering the business tax rate, denoted $C_{tb}$, corresponds to the tax revenue foregone on the professional base (i.e. 16% of the capital stock) from newly installed capital, throughout its whole lifetime. For a new investment of one monetary unit, we have:

$$
C_{tb} = -dt_b^* \int_0^\infty xe^{-\rho_{Kr}u} du = -dt_b^* \frac{x}{\rho_{Kr}} (1 - e^{-\rho_{Kr}u})
$$

On the other hand, the additional revenues from taxes resulting from agglomeration economies are equal to:

$$
T = \tau_r \left[ \alpha H_r^{-1} \left( \frac{K_r}{a_r} \right)^{-\alpha} \left[ (1 - A_r) + (1 - \tau_r) w_{cr} \right] - \frac{PG_r}{P_{Kr}K_r} \left[ \left( \rho_{Kr} - \pi_r \right) + \left( \delta - \pi_{Kr} \right) \right] \right]
$$

so that the net public cost associated to a change of the business tax is equal to:

$$
NC_{tb} = -dt_b^* \frac{x}{\rho_{Kr}} (1 - e^{-\rho_{Kr}u}) - \tau_r d(TB)
$$

with $d(TB) =$

$$
\left[ \alpha H_r^{-1} \left( \frac{K_r}{a_r} \right)^{-\alpha} \left[ (1 - A_r) + (1 - \tau_r) w_{cr} \right] - \frac{PG_r}{P_{Kr}K_r} \left[ \left( \rho_{Kr} - \pi_r \right) + \left( \delta - \pi_{Kr} \right) \right] \right].
$$