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Regional policy between efficacy and cohesion

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Abstract

Regional policy is traditionally defended on either efficiency or equity grounds. The aim of this article is to model public intervention in its two dimensions. The first is a search for efficacy through expected increased returns, i.e. productivity gains resulting from agglomeration forces. The second is a search for some collective gains that arise from a preservation of social cohesion by limiting disparities.. The key factor in this analysis is the solidarity level between regions. The approach allows to make the trade-off between efficiency and equity more explicit. These theoretical and methodological contributions are then subject of an application to the Belgian economy.

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1 Introduction

The European council has allocated Euro 213 billion for the 2000-2006 period to regions that lag behind in development, i.e. one third of the European budget. National or regional governments also spend large amounts on regional policies. The prime objective of regional policies is to stimulate economic activities in poor regions. The objective is to decrease regional inequality, enhance "social cohesion"[1] and increase productivity in those regions.

However, the European experience of convergence reveals that the catching up of some peripheral countries takes place by an increase of their regional disparities (Brulhart, 1998; Amiti, 1998; Martin, 2003; etc). All thus occurs as if there was a pressure between growth and social cohesion. Is the public intervention able to reduce this pressure and to seek at the same time more effectiveness and interregional cohesion, i.e. equity? Which are the measures to be privileged?

The aim of this paper is to model the public intervention in its two dimensions: effectiveness through the expected outputs, i.e. productivity increase due to agglomeration forces and collective gain, significant of the equity dimension, to preserve social cohesion and thus to reduce disparities.

Among factors that influence the location choice, taxation rates, tax incentives, capital grants and public expenditures and economic infrastructures play an important role. If regions can compete for taxes, they also can compete for supply of public goods in order to attract mobile factors.

Our approach intends to take advantage of several recent theoretical trends. Models of effective taxation, in particular the seminal work of King and Fullerton (1984), have proved to be an appropriate framework to assess the impact of fiscal and financial incentives on firm's investment decisions. In addition, two inspiring studies provide us with an elegant way to take into account both agglomeration economies, which stimulate collective efficacy (Garcia-Milà and McGuire, 2002) and the reduction of interregional disparities (Garcia-Milà and McGuire, 2004). The key factor in our analysis is the level of solidarity between regions. The approach makes the terms of the trade-off between efficiency and equity.

The next section presents the framework, based on a model that first could be used as an ex-ante cost-benefit analysis of the regional policy. Our model tries to capture the gain of efficacy and the gain of cohesion that are expected to result from the public intervention. We distinguish four main categories of public incentives: standard depreciation allowances, immediate expensing or free tax depreciation, capital grants and provision of public inputs. To build up intuition we then analyze in section 3, a numerical example applied to Belgium and its regions. Section 4 concludes.

[1] It means that they are supposed to reduce inequalities in a more general sense.

2 The model

Regional policy is traditionally defended on either efficiency or equity grounds. By and large, it will seek to promote investments in laggings regions by decreasing the costs of production factors. The expected gains of the public intervention have however to be compared with the cost arising from its implementation. In this section, we present a methodology that could be used as an ex-ante cost-benefit analysis of the regional policy. The basis model we shall present first will enable us to subsequently derive the gains and the costs of the regional public incentives.

The private output in a region r is produced according to the following production function:

$$Y_r = F\left(K_r, G_r\right)\left(\frac{K_r}{a_r}\right)^{\alpha} H_r \tag{1}$$

where K_r is private capital and G_r is a publicly provided input. G_r is assumed to be distributed to firms in proportion of their capital stocks.[2] It refers to any public spending that affects the firms' productivity. F is assumed to be twice differentiable with respect to G_r and K_r. This model features agglomeration, if we define agglomeration as the tendency of economic activity to generate forces that encourage further concentration of economic activity. The term $(K_r/a_r)^{\alpha}$ captures any productivity increase due to a greater concentration of private capital. It is our representation of agglomeration economies. With reference to Ciccone and Hall (1996), it expresses the density ratio of private capital in an acre of space (measured by a_r). The elasticity of output to density is determined by α. Finally, we assume that H_r, i.e. a Hicks-neutral shifter term, encompasses any locational advantage (or disadvantage) due to natural endowments or attributable to any inter-regional spillover effects.

Following Garcia-Milà and McGuire (2002), we assume that the firm does not take into account that an increase in their stock of capital has productivity effects on all firms in the region, including its own. Therefore, we assume that a representative firm maximizes its profits subject to the production function in (1) taking the aggregate amount of private capital in region r as a constant. The factor representing locational advantage is also supposed to be given. We consider these convenient assumptions so that concentration externalities and interregional spillover effects amount to a simple spatial productivity factor. At the optimum, each firm chooses its private capital stock so as to equalize the marginal contributions to production in value and the marginal cost of capital, as indicated in (2):

$$\frac{P_r}{P_{Kr}}\left(F'_{Kr} + \frac{G_r}{K_r}F'_{Gr}\right)\left(\frac{K_r}{a_r}\right)^{\alpha} H_r = \frac{(1-A_r)}{1-\tau_r}\left[(\rho_r - \pi_r) + (\delta - \pi_{Kr})\right] \tag{2}$$

where P_r is the price of output and P_{Kr} is the price of investment good.

[2] Following Oates ans Schwab (1991).

The left-hand side of expression (2) captures the firm's gain from hiring an additional unit of 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 $(G_r/K_r)\,F'_{Gr}$. It is also attributable to any locational (dis)advantage expressed by $H_r\,(K_r/a_r)^{\alpha}$.

The right hand side in (2) is the well-known expression of the gross-of-depreciation cost of capital (See King and Fullerton, 1984). It expresses the before tax minimum rate of return that an investment project must yield in order to provide the saver with a determined net-of-tax return, i.e. the rate he would receive from lending at the market (risk-free) interest rate. As pointed out by Alworth (1988), "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". In expression (2), δ is the exponential rate of economic depreciation; π_r and π_{Kr} are respectively the general inflation rate and the real inflation rate on capital goods and τ_r is the effective tax rate borne by the firm on undistributed earnings. The nominal financial cost, denoted ρ_r, is used to discount after-tax cash-flows. It varies according to the sources of finance. In a competitive environment, we assume that firms face three broad financing sources: retained earnings, debt and new shares issues.[3] Finally, variable A_r is the present discounted value of any capital grant, tax credit and tax allowances.

Equation (2) can be rewritten as follows:

$$\frac{P_r}{P_{Kr}}F'_{Kr} = H_r^{-1}\left(\frac{K_r}{a_r}\right)^{-\alpha}\frac{(1-A_r)}{1-\tau_r}\left[(\rho_r-\pi_r)+(\delta-\pi_{Kr})\right]-\frac{P_rG_r}{P_{Kr}K_r}F'_{Gr} \quad (3)$$

At the firm's optimum, the marginal return equals the marginal cost of private capital. So the right-hand side of expression (3) is the net marginal productivity that an investment, located in region r, has to earn before taxes in order to be profitable. Following Mignolet (2003), it can be interpreted as the "spatialized" gross cost of capital in region r. Let us denote it below as C_{Kr}. Under these assumptions all investments that earn at least their cost of capital are carried out.

The spatialized cost of capital should be an appropriate framework to assess the impact of fiscal and financial incentives on firm's investment decisions. The rest of the section is devoted to the derivation of the gain of efficacy and the gain of cohesion that are expected to result from the public intervention.

Generally speaking, we can distinguish three main categories of public incentives: standard depreciation allowances, immediate expensing or free tax depreciation and capital grants. The present value of public allowances per unit of investment can therefore be expressed as $A_r = \tau_r A_{dr} + \varphi_r\tau_r + s_r$. The term

[3] See Appendix.

$A_{dr}\tau$ is the present value of tax savings from depreciation allowances;[4] φ_r expresses the proportion of investment expenditure which is entitled to immediate expensing and s_r is the rate of capital grant. By and large, public authorities use these fiscal ($d\varphi_r$) and financial (ds_r) channels to stimulate investment in lagging regions. Regional policy also relies on two further instruments: lowering the corporate tax rate (through a change of τ_r), and financing public services to enterprises or infrastructure, i.e. a variation of G_r.

2.1 The efficiency gain

How does regional policy affect output in region r? Broadly speaking, public incentives is expected to reduce the cost of capital in region r, encouraging firms to invest in marginal project. A new investment of aided firms in turn expands nominal profits existing capital stock of region r through positive effects of agglomeration economies. We assume indeed that all firms benefit from external economies as soon as any one firm increases its capital. Accordingly, the variation of output resulting from granting some form of public aid, i.e. the *efficiency* gain, can be computed as follows:

$$dY_r^T = \frac{C_{Kr}dK_r}{[(\rho_r - \pi_r) + (\delta_r - \pi_{Kr})]} + \frac{-\left(\frac{\partial C_{Kr}}{\partial K_r}dK_r\right)K_r}{[(\rho_r - \pi_r) + (\delta_r - \pi_{Kr})]} \tag{4}$$

where $dK_r = \frac{\partial K_r}{\partial C_r}\frac{\partial C_{Kr}}{\partial j_r}dj_r$ and j_r is the investment incentive

In expression (4), the first term of the right hand-side measures the present value of profit generated from the investment projects that benefit from a public aid. The extra nominal profit generated by the existing capital stock K_r and resulting from agglomeration externalities is captured by the second term of the r.h.s. in (4). It is apprehended by the decrease of capital cost, that is the cost of capital differential with respect to the capital stock, but with the opposite sign and during its remaining lifetime.[5]

2.2 The cohesion gain

Let us now turn to the measure of the cohesion gain. We assume two regions (or two groups of regions)noted R and r, which have respectively an income per capita above and below the country's average. The per capita income disparity arises from a spatial productivity factor difference between the two regions, region r being less productive. With reference to expression (3), that means that $H_r(\frac{K_r}{a_r})^\alpha < H_R(\frac{K_R}{a_R})^\alpha$ and thus $C_{KR} < C_{Kr}$. For the sake of simplicity, all other factors in the capital cost expression are supposed to be equal in both

[4] For instance, $A_d = \frac{1}{\rho_r L}\left(1 - e^{-\rho_r L}\right)$ for the straight-line depreciation (where L the lifetime for tax purposes); for the declining balance depreciation, $A_d = \frac{u}{u+\rho_r}$ (with u is the exponential rate at which the asset is depreciated).

[5] Analytically, $-dC_{Kr}\int_0^\infty e^{-[(\rho_r-\pi_r)+(\delta-\pi_{Kr})]u}du = -\frac{\left(\frac{\partial C_{Kr}}{\partial K_r}\right)dK_r}{[(\rho_r-\pi_r)+(\delta-\pi_{Kr})]}$ for each unit of capital.

regions. We can rewrite the productivity differential as $\frac{H_R(\frac{K_R}{a_R})^\alpha}{H_r(\frac{K_r}{a_r})^\alpha} = (1+h)$ with $h > 0$.

The main purpose of regional policies is to achieve or at least to strive for a more balanced economic development between regions. From an equity point of view, the reason is that spatial organization of activities affects the geographical distribution of overall wealth. Therefore, if equity grounds regional policy, there is a collective gain at diminishing regional disparities, what we call a cohesion gain. This latter, noted $d\sigma^2$, is linked by the variance of regional per capita incomes, or more precisely, is apprehended by the variance change due to the granting of public incentives. After some transformations, the cohesion gain can be written as follows:[6]

$$d\sigma^2 = \gamma \frac{dY_r^T}{2}[Y_R - Y_r - \frac{dY_r^T}{2}] \tag{5}$$

where dY_r^T is the income increase in region r due to the implementation of a regional policy instrument (see equation 4) and Y_r and Y_R are the per capita income of region r and R, respectively. The factor γ, borrowed from Garcià-Mila and McGuire (2004), is a key parameter of equation (5). It measures the intensity of the collective preference for interregional solidarity. In a way, it expresses the collective value that people attributes to a cohesion gain.

2.3 The break-even point

Granting regional aids are thus grounded on the expectation of both efficiency and cohesion gains. But to be worth implementing, the expected return of a regional policy has to be higher than its implementing cost. Analytically, this condition can be expressed as follows:

$$C_j \leq d\sigma^2 + dY_r^a \tag{6}$$

where C_j measures the public outlay of granting an incentive j, $d\sigma^2$ is the cohesion gain and dY_r^a is the productivity increase only attributable to any agglomeration economies, i.e. the second term in the right hand-side of (4). Public authorities indeed only take into account the public impact of incentives arising from concentration externalities and cohesion gain. The private gain (i.e. the first term of the rhs in (4)) is not considered in this economic calculus because it is the exact counterpart of the marginal investment cost.

Behind the expressions of C_j, $d\sigma^2$ and dY_r^a there are of course various economic parameters: interest rate, tax devices, inflation depreciation rates, etc. The policy-makers' preference for regional cohesion, γ is also taken into consideration. The stronger the preference is, the quicker the break-even point is achieved. In other words, the threshold from which a regional policy is "justified" from an economic point of view decreases as cohesion concerns increase.

[6] See Appendix.

The derivation of γ, the level of preference that makes the policy worth realizing, is straightforward using (5) and (6):

$$\gamma \geq 2\frac{C_j - dY_r^a}{dY_r^T[Y_R - Y_r - \frac{dY_r^T}{2}]} \tag{7}$$

From expression (7), it comes that a regional policy is more and more justified as the initial regional income gap is wider $(Y_R - Y_r)$, as the public cost is lower (C_j) or as agglomeration economies are stronger (dY_r^a). Equation (7) provides us with an objective measure of the relevance to implement a regional policy. If the collective preference for interregional cohesion is higher than γ, the regional policy is justified founded from an economic point of view.

The regional policy cost, C_j, varies according to the type of instrument and to the extent of the intervention. In order to make incentives comparable, we assume that the extent of each instrument is determined so to reduce the capital cost of the aided region r to the level of capital cost in the reference region R. So, if $C_{Kr} + dC_{Kr} = C_{KR}$ and as $dC_{Kr} = \frac{\partial C_{Kr}}{\partial j_r} dj_r$, the extent of any incentive j_r is determined by:

$$dj_r = \frac{C_{KR} - C_{Kr}}{\frac{\partial C_{Kr}}{\partial j_r}} \tag{8}$$

Besides, for a same effectiveness, the regional policy instruments are potentially costly in various ways. For an investment project of one monetary unit, the expenditure associated with a capital grant is just equal to the additional amount of capital subsidy itself, ds.[7] Because public aid is assumed to only benefit to marginal investment, the total public cost of a capital grant is equal to:

$$C_s = ds_r dK_r \tag{9}$$

with $dK_r = \frac{\partial K_r}{\partial C_{Kr}} \frac{\partial C_{Kr}}{\partial s_r} ds_r$

The cost of lowering tax rates corresponds to the tax revenue forgone on the income from newly installed capital, throughout its lifetime:

$$C_\tau = -d\tau_r dK_r \int_0^\infty C_{Kr} e^{-[(\rho_{gr} - \pi_r) + (\delta - \pi_{Kr})]u} du = -\frac{d\tau_r dK_r C_{Kr}}{\left[(\rho_{gr} - \pi_r) + (\delta - \pi_{Kr})\right]} \tag{10}$$

with $dK_r = \frac{\partial K_r}{\partial C_{Kr}} \frac{\partial C_{Kr}}{\partial \tau_r} d\tau_r$ and where $C_{Kr} e^{-[(\rho_{gr} - \pi_r) + (\delta - \pi_{Kr})]}$ expresses the nominal profits that increase with inflation, decrease in value at the rate of depreciation, and are discounted at the public opportunity cost, ρ_{gr}.

Similarly, the initial cost of an investment tax credit (or of an immediate expensing) may be expressed in terms of tax revenue forgone on the marginal investment. It is defined by expression (11):

[7] We consider a capital grant expressed in net value, after any corporate tax.

$$C_{\varphi} = \tau_r d\varphi_r dK_r \tag{11}$$

with $dK_r = \frac{\partial K_r}{\partial C_{Kr}} \frac{\partial C_{Kr}}{\partial \varphi_r} d\varphi_r$

Finally, a new public infrastructure involves an initial outlay simply equals to:

$$C_G = dG_r \tag{12}$$

A numerical example will allow us to go further in the analysis.

3 Application-Belgium

In order to illustrate the relevance of our approach and to solve the indetermination of some analytical expressions derived in Section 2, we shall consider the following scenario, which captures the main tax devices in force in Belgium. The corporate tax rate (τ_r) amounts to 33.99% for distributed profits as well as for retained earnings and there is no double tax relief for dividends (the classical system is implemented). The personal tax rates are equal to 15% both for interest and dividend income. Capital gains are taxed at the individual level at the rate of 10%. The standard pattern allowed for tax depreciation is the straight-line method. We suppose that the life-time of capital is 10 years. Finally, the following parameters are used to characterise the economic environment: the interest rate (i) and the inflation rate (π_r) are respectively equal to 6% and 1.5%. The capital depreciation rate (δ) supposed to be exponential is equal to 20% and the public opportunity cost (ρ_{gr}) is set at 5%.

Following Mignolet (2005), the ratio (G_r/K_r) is set equal to 0.04 and the value of the marginal products with respect to public capital is assumed to be equal to 0.085.[8] We assume that F''_{Gr} is insignificant. The productivity handicap of region r amounts to 1%, so that $(1+h) = 1.01$. Finally, with reference to Chirinko *et al.* (1999), the user cost elasticity of capital stock is supposed to be equal to -0.25.[9]

We assume that the initial per capita income gap between regions r and R is equal to one that separates income per capita in regions (just) eligible to the Objectif 1 in structural funds policy from the European Union average, i.e. $(Y_R - Y_r) = 0.25$.

[8] Trough lack of measure for Belgium, Mignolet (2004) chooses to take the value attributed to F'_{Gr} from Pereira and Roca-Sagalés (2003), who estimate marginal product with respect to public capital for 17 regions in Spain. The value here considered is the arithmetic average of F'_{Gr} over the 17 regions. The values move from -0.072 to 0.402, respectively for Galicia and Madrid. For the sake of simplicity, F''_{Gr} is set equal to zero.

[9] Chirinko *et al.* (1999) show for the United States that the elasticity of business capital formation with respect to its capital cost is around -0.25. Their study, based on a large sample of more than 26000 observations, stands out with most previous researches, usually based on aggregate data and in which the elasticity is close to one.

Table 1 shows the initial gross capital cost of firms located either in a lagging region r or in the reference region R. this first scenario is the policy-off-scenario.

Table 1: Gross cost of capital of firms located in regions r and R

	Region r	Region R
Debt	0.2541	0.2515
New shares	0.2898	0.2869
Retained earnings	0.2837	0.2809

As shown in Table 1,a productivity handicap equal to one percent weighs down region r economic performance and leads to a higher capital cost in region r with respect to region R. In other words, firms located in region R face a wider range of profitable investments. A regional policy may therefore be implemented on in order to make investment equally profitable whether it is located in region R or in region r. Table 2 shows to what extent the corporate tax rate must be changed, $d\tau_r$, or to what degree a decreasing of tax base, $d\varphi_r$, a capital grant, ds_r, or publicly provided inputs, dG_r have to be implemented to equalize capital costs in both regions.

Table 2: Extent of incentives to be implemented in order to equalize firms' cost of capital in region R and region r

	ds_r	$d\varphi_r$	dG_r	$d\tau_r$
Debt	0.0072	0.0212	0.0300	1.1049
New shares	0.0083	0.0243	0.0343	-0.0176
Retained earnings	0.0081	0.0238	0.0336	-0.0183

In our scenario, as shown in Table 2, the government willing capital cost in region r to reduce so as to reach the same level as in the region R, should optimally grant a net-of-corporate-tax capital subsidy (ds_r) of 0.72%, 0.83% and 0.81% for an investment financed by debt, new shares issue or retained profits, respectively. Efficient public expenditures (dG_r) range from 3.00 to 3.43 cents per unit of private capital for debt and new equity finance investment, respectively. the expense when the firm finances the investment by retained profits is equal to the tax credit ($d\varphi_r$) that equalizes capital costs in both regions amounts to 2.38%.

Regarding corporate tax rate policy, the productivity handicap that penalizes investment projects financed by new equity and retained profits is offset when the tax rate is reduced by 0.83 and 0.81 point of percentage, to 32.23% and 32.16%, respectively. However, in case of debt financing, Table 2 shows that public authorities should actually raise the corporate tax rate (by 101points of percentage!) in order to lower the capital cost of firms located in region r.

How to explain this latter outcome? Broadly speaking, whatever the source of finance, lowering the corporate tax rate has a direct impact on the firm's tax liability. The tax burden diminishes. However, this effect is lessened by

the reducing of the tax savings due to depreciation allowances and possible immediate expensing. This negative effect is still reinforced in case of debt financing: it reduces the tax savings due to the deductibility of interests from the tax base.[10] In our scenario, these last two indirect effects prevail on the positive impact of a tax rate cut. As a result, the sensitivity of the capital cost with respect to the corporate tax rate is slightly negative for debt financing, i.e. $(\partial C_{Kr}/\partial \tau_r) = -0.0023$. On the other hand, the extent of the corporate tax change has to be all the larger since the sensitivity of the capital cost is small, to reach in our case an obviously unacceptable level. We shall come back further to this result.

Regional policy should be considered as founded if the cost associated to the public intervention is lower than the expected gains, both in terms of efficacy and cohesion. The main contribution of this paper consists in proposing a method to evaluate the threshold from which a regional policy is justified. To this end, let us shed a light on parameter denoted γ, that measures policymakers' preference for a better balanced regional growth. Table 3 shows the minimum values that must be taken by γ for making each four policies fully justifiable.

Table 3: Values of γ for a capital subsidy, a tax rebate, a corporate tax change and for publicly provided inputs

	Capital subsidy	Tax rebate	Public inputs	Corporate tax change
Debt	0.0788	0.0788	0.9748	0 $^{(*)}$
New shares	0.0704	0.0704	0.9582	0.1536
Retained earnings	0.0715	0.0715	0.9606	0.1613

$^{(*)}$ The actual value of γ is -8.8545.

What are the main results ? As shown in Table 3, the preference threshold γ associated with a regional policy based on either a capital subsidy or a tax rebate is lower than a policy resorting to public expenditures. In other words, for a given level of preference towards regional cohesion, the probability that a policy is economically founded, i.e. an intervention whose expected gains are higher than its implementing cost, is higher when policymakers resort either to a capital grant or a tax rebate instead of providing public inputs.

Regarding corporate tax cut, two cases has to be considered. Firstly, for an investment financed by either new equity or retained earnings, the preference threshold is higher than for a capital subsidy or a tax rebate, but lower compared to publicly provided inputs. Secondly, in case of debt financing, the preference factor γ is null. This is obvious. Raising the corporate tax rate (as shown in Table 2) is a measure that generates no cost but additional fiscal revenue. The measure is thus always economically founded.

[10] Moreover, as long as depreciation allowances are not immediate, their discounted value are still lowered when the financial cost of borrowing increases.

4 Conclusion

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A Appendix

A.1 Financial costs

The financial costs for the three sources of finance are equal to:

Debt	$\rho_{Dr} = (1-\tau_r)i_r$
New shares	$\rho_{Sr} = \frac{(1-m_{ir})i_r}{(1-m_{dr})\theta_r}$
Retained earnings	$\rho_{Rr} = \frac{(1-m_{ir})i_r}{(1-m_{gr})}$

where τ_r is the corporate tax rate; i_r is the nominal interest rate; m_{ir}, m_{dr} and m_{gr} are the individual tax on interest, dividends and capital gains, respectively. θ_r denotes the opportunity cost of retained earnings in term of gross dividends forgone. It enables to account for possible economic double taxation alleviating methods, i.e. θ_r is higher than one when such methods are implemented.

A.2 The cohesion gain

The cohesion gain, i.e. the collective gain at diminishing regional disparities is determined as the regional income variance change due to the granting of public incentives or:

$$\begin{aligned} d\sigma^2 = & \frac{\gamma}{2}\left[\left(Y_r - \tfrac{Y_r+Y_R}{2}\right)^2 + \left(Y_R - \tfrac{Y_r+Y_R}{2}\right)^2\right] \\ & -\frac{\gamma}{2}\left[\left(\left(Y_r + dY_r^T\right) - \frac{\left(Y_r+dY_r^T\right)+Y_R}{2}\right)^2 + \left(Y_R - \frac{\left(Y_r+dY_r^T\right)+Y_R}{2}\right)^2\right] \\ & = \gamma\frac{dY_r^T}{2}[Y_R - Y_r - \tfrac{dY_r^T}{2}] \end{aligned}$$

where $dY_r^T = \frac{\frac{\partial K_r}{\partial C_r}\frac{\partial C_{Kr}}{\partial j_r}dj_r}{[(\rho_r-\pi_r)+(\delta_r-\pi_{Kr})]}\left(C_{Kr} - \frac{\partial C_{Kr}}{\partial K_r}K_r\right)$ and j_r is the public incentive;

A.3 The extent of public incentives

The extent of each instrument is determined so to reduce the capital cost of aided region r to the level of capital cost in the reference region R. The extent of any incentive j_r is then determined by:

$$dj_r = \frac{C_{KR} - C_{Kr}}{\frac{\partial C_{Kr}}{\partial j_r}}$$

The sensitivity of the capital cost with respect to the corporate tax rate, tax incentives, capital grants or publicly provided inputs are written as follow:

$\frac{\partial C_r}{\partial s_r} = -H_r^{-1}\left(\frac{K_r}{a_r}\right)^{-\alpha}\frac{[(\rho-\pi)+(\delta-\pi_K)]}{(1-\tau)}$ for a capital grant;

$\frac{\partial C_r}{\partial \varphi_r} = -H_r^{-1}\left(\frac{K_r}{a_r}\right)^{-\alpha}\frac{[(\rho-\pi)+(\delta-\pi_K)]}{(1-\tau)}\tau_r$ for a corporate tax credit;

$\frac{\partial C_{Kr}}{\partial G_r} = -\left(\frac{P_r}{P_{Kr}K_r}F'_{Gr} + G_r F''_{Gr}\right)$ for publicly provided inputs;

$\frac{\partial C_r}{\partial \tau_r} = H_r^{-1}(\frac{K_r}{a_r})^{-\alpha}[\frac{(1-A_r)-(1-\tau_r)\frac{\partial A_r}{\partial \tau_r}}{(1-\tau_r)^2}[(\rho-\pi)+(\delta-\pi_K)]+\frac{(1-A_r)}{(1-\tau_r)}\frac{\partial \rho}{\partial \tau_r}]$ for a corporate tax cut.

A.4 The break-even point

The level of preference γ that makes the policy worth realizing is written:

$\gamma = 2\frac{ds_r[(\rho-\pi)+(\delta-\pi_K)]+\left(\frac{\partial C_r}{\partial K_r}\right)K_r}{\left(C_r-\frac{\partial C_r}{\partial K_r}K_r\right)[Y_R-Y_r-\frac{d^T Y_r}{2}]}$ for a capital grant;

$\gamma = 2\frac{\tau_r d\varphi_r[(\rho-\pi)+(\delta-\pi_K)]+\frac{\partial C_r}{\partial K_r}K_r}{\left(C_r-\frac{\partial C_r}{\partial K_r}K_r\right)[Y_R-Y_r-\frac{d^T Y_r}{2}]}$ for a corporate tax credit;

$\gamma = 2\frac{\frac{[(\rho_r-\pi_r)+(\delta_r-\pi_{Kr})]}{\frac{\partial K_r}{\partial C_{Kr}}\frac{\partial C_{Kr}}{\partial G_r}}+\left(\frac{\partial C_r}{\partial K_r}\right)K_r}{\left(C_r-\frac{\partial C_r}{\partial K_r}K_r\right)[Y_R-Y_r-\frac{d^T Y_r}{2}]}$ for publicly provided inputs;

$\gamma = 2\frac{-d\tau_r C_r+\left(\frac{\partial C_r}{\partial K_r}\right)K_r}{\left(C_r-\frac{\partial C_r}{\partial K_r}K_r\right)[Y_R-Y_r-\frac{d^T Y_r}{2}]}$ for corporate tax cut.