Subsidies for wages and infrastructure: How to restrain undesired immigration

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Abstract

This paper investigates regional or international transfers as a means to prevent immigration into unemployment. We analyze a two-country model with free migration in which the rich country is characterized by minimum wage unemployment. Matching grants for investment in infrastructure are superior to wage subsidies because the former instrument leads to a stronger productivity growth in the poor country, reducing both migration flows and unemployment in the rich country. Given a sufficiently low level of the regional policy budget, this result explains the exclusive use of investment subsidies in the EU regional budget.

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1 Introduction

A considerable amount of the budget of the European Union (EU) is spent on subsidies for infrastructure investment in poor regions. Structural funds subsidize national infrastructure spending in underdeveloped regions with a GDP per capita of less than 75% of the EU average. The cohesion funds supports environmental and traffic infrastructure in member states with a GDP per capita of less than 90% of the EU average. In 2005, the EU has used about 35% of its budget for those subsidies (European Commission, 2005). After the recent enlargement of the EU, its budget share for regional transfers is likely to increase significantly in the next planning period 2007-2013.

Why are prospering countries willing to support voluntarily the infrastructure in poorer countries by providing regional transfers? This question is of particular importance in order to understand the motives behind regional policy of the EU. Although integration has deepened in the recent period, the EU is far from being considered as a federation like the United States of America or the Federal Republic of Germany. No central government of the European Union exists. Instead, the EU policies are laid down in multilateral treaties between the member states that fix the aim and form of, for example, the interstate transfers for regions lacking in infrastructure. The member states pay contributions to finance the structural funds and the cohesion funds. It is not easily understood why rich countries agree to subsidize infrastructure in other member states via those EU funds.

An obvious first answer to the question why regional policies are implemented comes from distributional considerations. Rich regions or federal governments give transfers to poor regions due an altruistic motive, where investment subsidies may be helpful to speed up income covergence. The literature on redistributive impacts of regional policies stresses the trade-off between economic growth of the federation and regional income equality, and finds relatively small effects on convergence (Martin, 1998, 1999; Boldrin and Canova, 2001, 2003). Given the supranational structure of the EU, it seems doubtful that the transfer rules were enacted for altruistic reasons or for providing insurance.

Second, regional policy instruments can be justified by the goal of enhancing efficiency. Convential economic wisdom suggests that the existence of positive interregional or international spillovers may lead regional governments to invest too little. This may explain the use of federal matching grants for such investment projects, but not the restricted access by poor regions. Another argument states that locational decisions of firms are distorted when they cannot capture the full social benefit of the investment due to output price reactions (Fuest and Huber, 2006). Again, an appropriate regional policy can correct such a distortion. Further, the transfer rules governing a federal budget may give rise to vertical fiscal externalities. If the federal taxation and transfer rules imply that regions do not capture the full return to their investment, underinvestment results, which calls for correcting subsidies (Fenge and Wrede, 2004).

Several authors have argued that increasing labor mobility across regions puts pressure on intraregional redistribution from the rich to the poor. Earmarked federal subsidies then allow to sustain socially desirable levels of redistribution (Wildasin, 1991; Wellisch and Wildasin, 1996; Figuières and Hindriks, 2002; Drèze et al., 2003).

Finally, it may be possible that transfers according to regional policy rules represent side payments in the multi-national political bargaining process. Our paper also tries to give a positive explanation for the existence of the EU regional policy. However, in our approach the net payers choose the volume and the structure of regional policy.

Our paper presents an additional explanation for the existence of regional policy. According to this view, regional transfers can reduce immigration into unemployment. This line of reasoning seems to be quite relevant in the current accesion period with ten new members, most of them Eastern European low-wage countries. The old member states try to defend their high wages which are supported by generous unemployment benefits. Free migration then leads to higher unemployment among natives in the rich countries. In such a situation, free mobility of labor, being one of the basic liberties in the EU, will yield welfare losses. Hence, rich countries would like to see workers from the new states staying where they are. This may be achieved by regional transfers that improve the lot of workers in Eastern Europe.

We consider a federation with two representative countries or regions that differ in their endowment with private capital and infrastructure. As workers are not perfectly mobile, a differential in expected wages between the two countries remains under free mobility. Unemployment prevails in the rich country where the wage is fixed above the market clearing level due to a benefit granted to the unemployed. Both countries have regional budgets to finance investment in infrastructure. The federal government is represented in a budget that finances the subsidies to the member states. The parameters of the budget are determined by the two countries. The rich country makes a take-it-or-leave-it offer to the poor country in setting the federal tax and the subsidy rates which are available. It can use two instruments to avoid the attraction of workers, wage subsidies and matching grants for infrastructure investment in the poor country.

Wage subsidies obviously directly reduce the migration incentive, as the wage differential becomes smaller. Subsidies in the form of matching grants for infrastructure also serve to reduce the migration incentive by bringing a tax relief to poor countries. Up to this point, the two instruments may be recognized as equivalent. On top of this, subsidies for investment in infrastructure will induce the government of the poor country to invest more. This investment in infrastructure attracts capital and drives up the marginal product of labor. Although both the financial transfer and the outflow of capital harm workers in the rich economies, the losses may be more than offset. The shrinking wage gap helps the rich country to overcome its unemployment problem. Introducing either wage subsidies or matching grants for investment in infrastructure is shown to have a positive impact on the welfare of voters in the rich country. The latter instrument is preferred due to its incentive effect on regional public investment if the level of the regional budget is given and sufficiently small.

The remainder of the paper is organized as follows. Section 2 introduces the model. In Section 3, we analyze the comparative static changes of the migration equilibrium when policy measures are exogenous. The next two sections 4 and 5 then investigate the interactions between the policies in the rich and the poor country and their impacts on the migration equilibrium. Finally, Section 6 concludes and indicates directions for future research.

2 The Model

We consider a one-period model with two countries, the rich country A and the poor country B. In each country, firms produce a private good by using labor L, capital K, and public infrastructure G. While labor and capital are mobile across countries, public infrastructure is a fixed factor. The total output of a representative firm in region $j \in \{A, B\}$ is

$$Y_j = A(G_j)F(K_j, L_j), \tag{1}$$

where K_j is the capital stock in country j and L_j is total employment in j. The neoclassical production function F exhibits constant returns to scale and diminishing marginal products. The public input G_j causes an external effect on production captured by $A > 0$, where $A' > 0$ and $A'' < 0$. The production function can be rewritten in the intensive form as

$$y_j \equiv \frac{Y_j}{L_j} = A(G_j)f(k_j), \tag{2}$$

where $k_j = \frac{K_j}{L_j}$ denotes the capital-labor ratio, and $f' > 0$ and $f'' < 0$ hold. A large number of small firms produce in a competitive market where the external effect on each firm is negligible. Any firm views itself as having a constant returns to scale production function. This preserves exhaustion of firm revenue by factor payments. Each factor is paid according to its respective marginal productivity where changes in the scale parameter A are not taken into account. Since capital is perfectly mobile across countries and capital stocks adjust instantaneously, the interest rate r is the same in both countries:

$$r = A(G_A)f'(k_A) = A(G_B)f'(k_B). \tag{3}$$

The wage rates w_j are then given by

$$w_j = A(G_j)\left[f(k_j) - k_j f'(k_j)\right]. \tag{4}$$

For any given period, the capital market equilibrium dictates that both the capital-labor ratio and the wage rate will be higher in the country with more public infrastructure, that is, we have $k_A > k_B$ and $w_A > w_B$ as long as $G_A > G_B$ is valid. The total supply of capital is given. Capital is fully employed such that

$$K = k_A L_A + k_B L_B \tag{5}$$

is constant.

Public infrastructure in country j, G_j, is the sum of the initial stock, G_{j0}, plus investment, I_j.

$$G_j = G_{j0} + I_j. \tag{6}$$

The countries differ in their initial endowment with the public input. At the outset, the rich country displays a higher stock of infrastructure than the poor country, that is $G_{A0} > G_{B0} > 0$. While an instantaneous or even forward-looking capacity effect of public investment is of course very strange, we use this simplification to keep the structure of our model as simple as possible. If this formulation is taken literally, we need a third economy that delivers the investment goods at an interest rate of zero before production in the period under consideration starts.

We assume that there is a fixed minimum wage in country A that the government sets above the market clearing wage rate. This minimum wage rate w_A is legally determined to be higher than the unemployment benefit b_A, that is, $w_A > b_A$. Alternatively, w_A can be seen as the workers' reservation wage given the level of the unemployment benefit.

It should be noted that the minimum wage in country A determines all factor prices and capital-labor ratios. At a given level of public infrastructure, the wage in A uniquely corresponds to a capital-labor ratio k_A according to equation (4). With G_A and k_A being fixed, the interest rate can be found on the factor price frontier of country A, as expressed by (3). Perfect capital mobility then enforces the same interest rate in country B, being associated with one particular capital-labor ratio k_B, which again can be seen from (3). Finally, if the stock of infrastructure G_B and the capital-labor ratio k_B are given, the wage in country B is determined through equation (4).

Full employment in country B prevails because the wage is flexible there. If we had some unemployment in country B, workers would underbid the equilibrium wage which attracts capital to country B and drives up the demand for labor. Hence, all unemployment resulting from wages being too high will occur in country A. At given capital-labor ratios $k_A > k_B$, migration from B to A will result in a total employment loss despite the fact that some capital will move along with the immigrants.

Individuals draw utility from consuming c units of a private good and living in a particular country. The total number of individuals is N with $N = N_A + N_B$, where N_j denotes the number of citizens of country j. During the period under consideration, nobody can change her citizenship status. The N individuals differ in their attachment to their home country. There is a continuum of individuals of each type indexed by n, where n varies between 0 and N. Utility is additively separable, where the arguments refer to physical consumption and geographical preferences. The utility $V(c,n)$ of type n is given by:

$$V(c,n) = \begin{cases} c + \alpha (N - n) & if \;\; n \;\; lives \;\; in \;\; A \\ c + \alpha n & if \;\; n \;\; lives \;\; in \;\; B \end{cases} \tag{7}$$

The variable n expresses utility of living in region B, and $N - n$ is utility from living in region A. The parameter $\alpha \geq 0$ measures the degree of individual mobility. If $\alpha = 0$, then individuals have no attachment to their home country and draw utility only from consumption. If $\alpha > 0$ holds, individuals with a small n will choose to live in country A, while individuals with a large n will be found in country B. When mobility is imperfect, free migration will generally not equalize the expected wage rates. In the limiting case $\alpha \rightarrow \infty$, individuals are perfectly immobile.

The distribution of regional preferences is biased towards home attachment. The citizens of country A have regional preference parameters in the range $[0, N_A]$, while the support of regional preference parameters of citizens of country B is $(N_A, N]$. Hence, we will not have migration in both directions. In the following we focus on migration equilibria in which some citzens of country B choose to work in country A.

Each individual has to decide in which region she would like to live. She supplies one unit of labor in her preferred region j at the wage w_j. A nation's capital stock is uniformly distributed among its citizens. The capital stock per capita possessed by citizens of region A is higher than the corresponding property of citizens of country B, that is, $\hat{k}_A > \hat{k}_B$. Hence, a citizen of country i receives a capital income $r\hat{k}_i$. Further, an individual has to pay taxes to the regional government of the country in which she lives, τ_j, and to the federation, θ. In country A, an unemployment insurance contribution t_A finances the unemployment benefit b_A, where the probability of being unemployed is $1 - \pi_A$. The wage rate in country B is supplemented by the federal transfer s_B. Consumption of a citizen of country i living in country j is given by

$$c_j^i = \pi_j \left(w_j + s_j - t_j \right) + \left(1 - \pi_j \right) b_j + r\hat{k}_i - \tau_j - \theta, \tag{8}$$

with $s_A = t_B = b_B = 1 - \pi_B = 0$. The migration equilibrium is characterized by the marginal individual, denoted by $n = M$, who is indifferent between residing in either region:

$$c_A + \alpha \left(N - M \right) = c_B + \alpha M. \tag{9}$$

As the marginal migrant is a citizen of country B, we suppress the superscript index. All individuals of type $n < M$ reside in region A, and all individuals of type $n > M$ live in region B. Hence, M is also the number of individuals living in region A, and the employment probability is given by $\pi_A = L_A/M$.

Assuming that there is no discrimination against foreigners on the labor market, the unemployment rates of native workers and immigrants are identical, as in the Harris-Todaro (1970) framework. The view taken here is that immigrants have immediate access to unemployment benefits and jobs are randomly distributed. The alternative approach that all unemployed are natives due a to smaller reservation wage of foreigners, possibly caused by a delayed inclusion into unemployment insurance, has been pursued by Brecher and Choudhri (1987). This scenario may even strengthen the motive to restrict immigration.

Public investment is pre-financed by increasing public debt. Since the tax τ_j is collected after migration has taken place, it is relevant for migration decisions. The unemployment benefit and the unemployment insurance contribution in country A cancel out against each other as components that affect utility. The migration equilibrium is given by

$$\pi_A w_A - \tau_A + \alpha(N - M) = w_B + s_B - \tau_B + \alpha M. \tag{10}$$

While immigration does not change wages, it harms the native population in the rich country because the unemployment rate among native workers goes up. However, at the same time a given public investment level will be associated with a decreasing regional lump-sum tax.

The federal government subsidizes the poorer region in two ways. First, by a matching grant at rate σ for the regional investment in public infrastructure. Second, by a complementary transfer s_B per worker to the wage income. Its budget equation is

$$\theta\,(N_A + N_B) = \sigma I_B + s_B L_B. \tag{11}$$

Each regional government imposes a lump-sum tax τ_j to finance its cost share of the investment in public infrastructure, I_j. This tax is levied from all residents in country j. The unemployment benefit in country A is high enough to meet this tax requirement. Noting that the federation subsidizes public investment at a matching grant rate σ, the regional investment budget constraints are

$$\tau_j \tilde{N}_j = (1 - \sigma_j)\, I_j \tag{12}$$

with $\tilde{N}_A = M$, $\tilde{N}_B = N - M$, $\sigma_A = 0$, and $\sigma_B = \sigma$.

In addition, the government of country A provides an unemployment benefit b_A financed by a lump-sum unemployment contribution t_A:

$$t_A L_A = b_A(M - L_A). \tag{13}$$

The sequence of events is as follows. Initially, the stocks of public infrastructure, G_{A0} and G_{B0}, the property rights on production capital, the unemployment benefit in the rich country, and the wage in country A are given. The government of A sets its public investment I_A, the wage subsidy s_B and the investment subsidy rate σ so as to maximize aggregate utility of its citizens. The government of the rich country A controls regional policy. Since the federal budget is spent exclusively in the poor country B, enacting some regional policy will generally be in the interest of country B. Knowing the co-financing rate σ and the level of the wage subsidy, the government of country B chooses its investment I_B to maximize utility of the median voter. Since the decision may be modified in a post-migration situation, the median voter is never a migrant. The lump-sum taxes on the federal and regional level are adjusted instantaneously so as to equalize the budget. Capital and labor take all policy variables as given and move until the interest rate is equalized and the migration incentive vanishes. While the government of the poor country B neglects the impact of its investment decision on migration flows, the government of country A has perfect foresight with respect to all adjustment processes.

3 Migration equilibrium and comparative statics

Lemma 1 collects the impacts of changing the public input on capital-labor ratios and factor prices.

Lemma 1: *Increasing public infrastructure in country A reduces the capital-labor ratio in country A, raises the interest rate, and reduces both the capital-labor ratio in country B and the wage rate in country B. Increasing public infrastructure in country B does neither affect the capital-labor ratio in country A nor the interest rate, and raises both the capital-labor ratio in country B and the wage rate in country B.*

Proof. See Appendix A. □

The results can be explained as follows. With an increasing public infrastructure in country A, its factor price frontier shifts outwards. The fixed wage can be achieved at a smaller capital labor-ratio. The new interest rate associated with this wage on the new factor price frontier is higher due to both the increased productivity and the smaller capital-labor ratio. The higher interest rate requires a reduction of the capital labor-ratio in country B to increase the productivity of capital. This reaction reduces the marginal productivity of labor in country B, which in turn drives down the wage rate in its economy.

When public infrastructure of country B rises, this will not have any effect on the capital-labor ratio in country A, the latter being determined exclusively by the fixed wage and the level of public infrastructure in that economy. With a given stock of public infrastructure in country A and an unchanged capital-labor ratio, the interest rate cannot move. Since the productivity of capital rises in country B, the demand for capital will increase such that B arrives at a higher capital-labor ratio. Both productivity enhancement by the additional public capital stock and the rising capital-labor ratio contribute to a higher marginal productivity of labor, being reflected in a higher wage rate.

Employment in the rich country, L_A, and its population, M, are jointly determined by the full employment condition for capital and the migration equilibrium equation.

$$\begin{aligned} g_1(L_A, M) \quad &: \quad = K - k_A L_A - k_B(N-M) = 0, & (14) \\ g_2(L_A, M) \quad &: \quad = \frac{L_A}{M} w_A - \frac{I_A}{M} + \alpha(N-M) - w_B - s_B & (15) \\ & \qquad + \frac{(1-\sigma) I_B}{N-M} - \alpha M \\ &= \quad 0. \end{aligned}$$

If we had full employment, the inequalities $k_A > K/N > k_B$ are valid. Assuming that we are not too far away from the full employment position, this relation of capital-labor ratios still holds throughout our analysis. The dynamics of the system (14)-(15) is given by

$$\begin{aligned} \dot{L}_A &= h_1[g_1(L_A, M)], & (16) \\ \dot{M} &= h_2[g_2(L_A, M)], & (17) \end{aligned}$$

with $h_1(0) = h_2(0) = 0$, $h_1^{'} > 0$ and $h_2' > 0$. Hence, employment in country A increases if capital is less than fully employed, and will be reduced if there is not enough capital available to keep the capital-labor ratio k_A constant.

The second differential equation states that migration follows the direction of the utility differential. With this specification, the equilibrium $(\bar{L}_A, \bar{M})$ is locally asymptotically stable if the three conditions $\frac{\partial g_1}{\partial L_A} < 0$, $\frac{\partial g_2}{\partial M} < 0$, and $\frac{\partial g_1}{\partial L_A}\frac{\partial g_2}{\partial M} - \frac{\partial g_1}{\partial M}\frac{\partial g_2}{\partial L_A} > 0$ are met at the equilibrium point. In the following, we assume that these sufficient stability conditions are satisfied. While the first stability condition always holds, the second requires that

$$\frac{(1-\sigma)I_B}{(N-M)^2} - 2\alpha - \frac{w_A L_A - I_A}{M^2} < 0 \tag{18}$$

is valid. Otherwise, disturbing the equilibrium by some small movement of population would cause additional migration in the same direction, taking the two economies further away from the equilibrium position.

Insert Figures 1 and 2 about here

The Figures 1 and 2 illustrate the third stability condition. Notice that the slopes of the isoclines $\dot{L}_A = 0$ and $M = 0$ are given by $\left.\frac{dM}{dL_A}\right|_{h_1=0} = -\frac{\partial g_1/\partial L_A}{\partial g_1/\partial M} > 0$ and $\left.\frac{dM}{dL_A}\right|_{h_2=0} = -\frac{\partial g_2/\partial L_A}{\partial g_2/\partial M} > 0$. The third stability condition then requires $\left.\frac{dM}{dL_A}\right|_{h_1=0} > \left.\frac{dM}{dL_A}\right|_{h_2=0}$. Otherwise, the equilibrium is a saddle point, as in Figure 1. If the condition is fulfilled, we have a locally asymptotically stable equilibrium, as shown in Figure 2.

The third stability condition, $\frac{\partial g_1}{\partial L_A}\frac{\partial g_2}{\partial M} - \frac{\partial g_1}{\partial M}\frac{\partial g_2}{\partial L_A} > 0$, can be written as

$$\Delta = k_A \left[2\alpha - \frac{(1-\sigma)I_B}{(N-M)^2} - \frac{I_A}{M^2}\right] + \frac{w_A}{M}\left(k_A\frac{L_A}{M} - k_B\right) > 0. \tag{19}$$

Note that $k_A\frac{L_A}{M} - k_B = \frac{1}{M}[K - Nk_B]$ is positive by assumption. Further, $\Delta > 0$ implies that the second stability condition (18) is also met.

The reaction of employment in the rich country, L_A, and its population M to changes in the two regional policy instruments at given investment policies are summarized in Lemma 2.

Lemma 2: *With given investment levels in both countries, raising either the wage subsidy s_B or the co-financing rate σ increases the population* *of country B and reduces both employment and the unemployment rate in country A.*

Proof. See Appendix B. □

Increasing the wage subsidy or reducing the regional infrastructure tax makes living in country B more attractive. Therefore, population in country A will decline. It should be noted that factor prices and capital-labor ratios are not affected by the population shift. Since workers need less capital at the workplace in country B than in country A, and capital is still fully employed, employment in country A falls less than its population. This however means that the employment probability goes up and that the unemployment rate goes down. Recognizing that Lemma 2 captures only changes of net taxes while ignoring impacts on the investment behavior, it is unsurprising that the two instruments work in a perfectly symmetric fashion.

Lemma 3 considers the impacts of changing the levels of public infrastructure through some additional investment.

Lemma 3: *Increasing investment in infrastructure in country A ($dI_A = dG_A > 0$) raises its population and its employment level if $\frac{\partial w_B}{\partial G_A} \leq -\frac{1}{M}$. The employment probability decreases and the unemployment rate in country A goes up if, in addition, the mobility parameter α is sufficiently small. Increasing investment in infrastructure in country B ($dI_B = dG_B > 0$) raises its population and reduces employment in country A if $\frac{\partial w_B}{\partial G_B} \geq \frac{(1-\sigma)}{N-M}$. The employment probability rises and unemployment in country A decreases if, in addition, α is sufficently small.*

Proof. See Appendix C. □

As already noted in Lemma 1, investment in infrastructure in country A raises the marginal product of labor in this country. Since the wage rate is fixed, the capital-labor ratio will be reduced. Both the higher productivity and the falling capital-labor ratio contribute to an increase in the interest rate, which in turn depresses the capital-labor ratio in country B. The two falling capital-labor ratios lead to a higher employment level in country A as to restore full employment of capital. The rise in the regional tax of country A tends to reduce its population, while there is an opposite impact due to the fall of the wage in country B. If the condition $\frac{\partial w_B}{\partial G_A} \leq -\frac{1}{M}$ is met, the latter effect works stronger.

At a given distribution of the population, more employment in country A translates into a higher employment probability, which again tends to induce migration from country B to country A. Conversely, at given capital-labor ratios, migration from country A to country B will be accompanied by a capital flow in the same direction, which in turn is associated with a falling employment level in country A, and vice versa. Lemma 3 gives a sufficient condition under which both population and employment in country A rise. It is shown that the unemployment rate in country A will go up if household mobility is sufficiently strong.

Investment in public infrastructure in country B increases both the capital-labor ratio and the wage rate in country B. The former effect yields a fall in employment in country A because capital tends to be attracted to country B. While the rising wage rate in country B induces remigration to country B, the increase in the regional tax of country B works in the opposite direction. If the condition $\frac{\partial w_B}{\partial G_B} \geq \frac{(1-\sigma)}{N-M}$ is satisfied, the former effect dominates the latter.

The declining employment level in country A will cause some migration to country B. At given capital-labor ratios, a higher population in country B will induce capital movements to the poor country, which again reduces employment in country A. Hence, under the condition given in Lemma 3, the cross effects reinforce the direct impacts. It can then be concluded that investment in country B reduces both population and employment in country A. At the same time, the employment probability goes up if household mobility is sufficient strong.

As will be demonstrated in the next section, country B chooses its investment policy such that $\frac{\partial w_B}{\partial G_B} \geq \frac{(1-\sigma)}{N-M}$ will always hold.

4 Investment policy of country B

The government of country B takes the infrastructure stock of the rich country, G_A, the wage subsidy, s_B, and the matching grant rate for its investment, σ, as given. It chooses its infrastructure investment I_B so as to maximize the interest of its median voter. Since the median voter will never be a migrant, the interests of emigrants are not taken into account. Instead, the government maximizes consumption of a voter living in country B,

$$U_B = w_B(G_B) + s_B + r\hat{k}_B - \frac{(1-\sigma)I_B}{N-M} - \frac{s_B(N-M)+\sigma I_B}{N}, \tag{20}$$

with respect to I_B. The government ignores the impacts on the regional and the federal tax that arise through repercussions of migration responses. These assumptions are taken to illustrate our arguments in a simple fashion. The approach may be justified in the European context, where we have many small countries that receive transfers. In case of an interior solution, the first-order condition is then given by

$$\frac{\partial U_B}{\partial I_B} = \frac{\partial w_B}{\partial G_B} - \frac{(1-\sigma)}{N-M} - \frac{\sigma}{N} = 0. \tag{21}$$

Raising public infrastructure in country B increases the wage in this economy but does not affect capital income per capita. Both the regional tax and the federal tax go up.

Lemma 4 describes how the government of country B reacts to changing regional policy parameters.

Lemma 4: *Increasing either the investment subsidy σ or the wage subsidy s_B induces more investment in infrastructure in country B. Raising investment in infrastructure in the rich country, I_A, decreases investment in infrastructure in country B if the former is associated with a nondecreasing population in country A.*

Proof. See Appendix D. □

With a higher investment subsidy, the regional tax goes down and the federal tax goes up. As the reduction in the regional tax exceeds the increase in the federal tax, the tax price of investment in infrastructure is reduced in country B. This falling price tends to increase investment. Moreover, the higher subsidy rate for public investment will induce migration to country B at any given investment level. Immigration to country B reduces its regional tax, which adds to the stronger incentives for investment in infrastructure.

Raising the wage subsidy reduces the regional tax at any given infrastructure investment plan, because the additional transfer from country A to country B will induce migration to country B. This effect tends to increase investment in country B.

With a higher stock of infrastructure in country A, the response of the wage rate in country B to a higher investment in country B weakens. Taken in isolation, this feature tends to reduce investment in country B. At the same time, if investment in country A raises its population, the rise in the regional tax of country B upon investment in country B becomes stronger. This would reinforce the former effect. However, as a negative correlation between investment and population in country A at the margin cannot be ruled out, the two impacts may also have opposite signs.

5 Policy of country A

Consider now the decision of the government of country A. It chooses its investment plan I_A, the wage subsidy for the poor country, s_B, and the public investment matching grant rate σ. Since all citizens of the rich country A live in their home country, the problem of the government of A is to maximize consumption per capita,

$$U_A = \frac{L_A}{M} w_A + r\hat{k}_A - \frac{I_A}{M} - \frac{s_B(N-M)+\sigma I_B}{N}, \tag{22}$$

with respect to s_B, σ, and I_A.

Country A acts as a Stackelberg leader and takes into account the investment response of country B. If we have interior solutions, the optimality conditions for the policy variables are given by

$$\begin{aligned}
\frac{\partial U_A}{\partial I_A} &= \frac{\partial (L_A/M)}{\partial I_A} w_A + \frac{\partial r}{\partial I_A}\hat{k}_A - \frac{1}{M} + \left[\frac{I_A}{M^2} + \frac{s_B}{N}\right]\frac{\partial M}{\partial I_A} \qquad (23)\\
&\quad + \left[\frac{\partial (L_A/M)}{\partial I_B} w_A - \frac{\sigma}{N} + \left[\frac{I_A}{M^2} + \frac{s_B}{N}\right]\frac{\partial M}{\partial I_B}\right]\frac{\partial I_B}{\partial I_A}\\
&= 0,\\
\frac{\partial U_A}{\partial s_B} &= \frac{\partial (L_A/M)}{\partial s_B} w_A - \frac{N-M}{N} + \left[\frac{I_A}{M^2} + \frac{s_B}{N}\right]\frac{\partial M}{\partial s_B} \qquad (24)\\
&\quad + \left[\frac{\partial (L_A/M)}{\partial I_B} w_A - \frac{\sigma}{N} + \left[\frac{I_A}{M^2} + \frac{s_B}{N}\right]\frac{\partial M}{\partial I_B}\right]\frac{\partial I_B}{\partial s_B}\\
&= 0,\\
\frac{\partial U_A}{\partial \sigma} &= \frac{\partial (L_A/M)}{\partial \sigma} w_A - \frac{I_B}{N} + \left[\frac{I_A}{M^2} + \frac{s_B}{N}\right]\frac{\partial M}{\partial \sigma} \qquad (25)\\
&\quad + \left[\frac{\partial (L_A/M)}{\partial I_B} w_A - \frac{\sigma}{N} + \left[\frac{I_A}{M^2} + \frac{s_B}{N}\right]\frac{\partial M}{\partial I_B}\right]\frac{\partial I_B}{\partial \sigma}\\
&= 0.
\end{aligned}$$

The investment policy of country A will mainly be driven by the motive to raise capital income, as captured by $\frac{\partial r}{\partial G_A}\hat{k}_A > 0$. Moreover, as immigrants will typically be attracted $\left(\frac{\partial M}{\partial I_A} > 0\right)$, the additional individuals share the burden of the regional tax. Since less people remain in country B, the federal tax falls if wage subsidies are positive. These two effects are described by $\left[\frac{I_A}{M^2} + \frac{s_B}{N}\right] \frac{\partial M}{\partial I_A}$. However, there are several negative impacts, such that the boundary solution $I_A = 0$ may well be the outcome. First, as $\frac{\partial(L_A/M)}{\partial I_A} < 0$ typically holds, more investment in country A will reduce wage income of the native workers by decreasing the employment probability in country A. Second, increasing the investment at a given population requires a higher regional tax, as expressed by $-\frac{1}{M} > 0$.

In addition, repercussion via an impact of investment in the poor country B may turn out. A higher investment in country B affects welfare in country A as follows. As explained earlier, it will increase the employment probability in country A and induce migration from country A to country B. The employment effect raises expected labor income in country A, as shown by $\frac{\partial(L_A/M)}{\partial I_B} w_A > 0$. The migration response increases the tax burden on the citizens of the rich country for financing investment and wage subsidies, being expressed by $\left[\frac{I_A}{M^2} + \frac{s_B}{N}\right] \frac{\partial M}{\partial I_B} < 0$. Last, more investment directly increases the federal tax to finance additional investment subsidies, which reduces welfare in country A according to $-\frac{\sigma}{N} < 0$.

The following proposition deals with the introduction of matching grants and wage subsidies.

Proposition 1: *Provided that the mobility parameter α is sufficiently small, introducing either wage subsidies or investment subsidies increases welfare of country A.*

Proof. See Appendix E. □

Proposition 1 shows that both wage subsidies and matching grants for investment in infrastructure serve to increase the welfare of the natives in the rich country. The direct impacts of the two instruments are perfectly symmetric. At a given distribution of the population, the federal tax must increase due to higher wage subsidies or matching grants. As living in the rich country becomes less attractive and living in the poor country becomes more attractive, using either instrument induces migration from the rich country to the poor country. As a consequence, a higher share of the population can be employed in the rich country despite the outflow of physical capital. Moreover, the federal tax goes up if wage subsidies are positive, and the regional tax rises if public investment in country A is positive. It turns out that the fall of the unemployment rate is the dominating impact if the subsidies are at a very low level and labor mobility is sufficiently strong. In addition, both instruments have a positive impact on investment in the poor country. As a consequence, the wage differential diminishes, which again yields remigration to the poor country and a fall of the unemployment rate in the rich country. When subsidies are still small, the gains from a higher employment rate outweigh the additional tax burden arising for individuals living in the rich country.

Surprisingly, it can be shown that an optimum policy is never characterized by an interior solution for the investment subsidy. Considering a situation in which the first-order condition holds, the impact of additional investment in the poor country on welfare in rich country will typically be negative due to a rising tax burden.

Proposition 2: *Provided that investment in country A is sufficiently small, and an interior optimum for the level of investment subsidies is achieved, replacing investment subsidies by wage subsidies is beneficial for country A.*

Proof. See Appendix F. □

Proposition 2 rules out candidates for an optimum policy with an interior solution for the investment subsidy. Such a situation displays the feature that the net impact of the fiscal transfer on welfare in the rich country is still positive while at the same time additional investment already harms the natives in the rich economy. Since matching grants give a stronger stimulus for investment in infrastructure in the poor country, replacing them partially by wage subsidies is advantageous for the people living in the rich country. A possible optimum policy may be characterized by a matching grant rate at the maximum level, accompanied by wage subsidies. Alternatively, we may have wage subsidies only. For practical purposes however, it seems plausible to assume a limited budget of the federation, as it is the case with the EU regional budget, where the current expenditure level would be reflected in an income tax of .35 per cent. If the limit is sufficiently low, Proposition 3 shows that an optimum policy will be characterized by using matching grants only. Interpreted in this way, our model explains why matching grants are typically used in such situations while wage subsidies are not observed.

Proposition 3: *If the federal tax θ is constant and small, and if the mobility parameter α is sufficiently small, the optimum policy for country A is to use matching grants for public investment only.*

Proof. See Appendix G. □

Having a federal budget being sufficently small ensures that both types of subsidies have a positive impact on the rich country at the margin. Moreover, the rich country then also benefits from additional investment in country B. Since the matching grant policy has a stronger impact on investment in the poor country, it is the preferred policy instrument.

6 Conclusions

Our analysis has explored a new rationale for the use of matching grants as an instrument of regional policy. When rich countries try to defend their high wages, regional policy serves to reduce immigration into unemployment. While an unconditional transfer or a wage subsidy also makes staying in a poor country more attractive, matching grants for public investment exhibit an additional advantage. They induce more public investment, which in turn increases labor productivity and reduces the wage gap. Given that federal subsidies are relatively small compared to regional budgets, we have demonstrated that giving the transfer in this fashion lies in the best interest of the rich country, as an additional cut of the domestic unemployment rate can be achieved.

Our story heavily relies on sizeable output losses that come about when immigration increases unemployment. Having in-work benefits for the native working poor instead, gains from bribing potential immigrants will be much smaller or even negative for rich economies.

A possible extension of the current model may investigate a scenario in which poor countries take the migration responses to their public investment policies into consideration. While this complicates the analysis substantially, it is not obvious if and how it changes our results.

We have ignored the stylized fact of high unemployment figures in the new EU member states. Having unemployment in the poor country does not change the main line of the argument. Inducing additional investment in infrastructure by matching grants will then help to cut unemployment in the poor country. Technically, incorporating unemployment by fixing wages in both countries yields serious problems, as all mobile capital will typically be found in one country only. Such a boundary equilibrium can turn out due to the absence of a mechanism that equalizes interest rates. Hence, analyzing interior equilibria with unemployment in both countries requires a more complicated structure.

Finally, the impacts that are illustrated in our approach with homogenous labor may be perceived as too strong. With different skill groups in the labor market, only the low skilled may suffer from minimum wage unemployment. As we have migration incentives for all skill groups in the EU context, the problem of immigration into unemployment will be typically be mitigated by skilled migration. This is true when skilled and unskilled labor are complements in production. Skilled immigration then raises the marginal product of labor, which tends to reduce unemployment among the unskilled. However, the mere fact that several old member states in the EU have chosen a transition period regime with restricted labor mobility indicates a widespread fear of strong impacts of free migration on unemployment.

Appendix

A: Proof of Lemma 1

With w_A being fixed, the results $\frac{\partial k_A}{\partial G_B} = 0$ and

$$\frac{\partial k_A}{\partial G_A} = \frac{A'(G_A)\,[f(k_A) - k_A f'(k_A)]}{A(G_A) k_A f''(k_A)} < 0 \tag{26}$$

are an immediate consequence of (4). Recalling that $r = A(G_A) f'(k_A)$ holds, we have $\frac{\partial r}{\partial G_B} = 0$ and

$$\frac{\partial r}{\partial G_A} = A'(G_A) f'(k_A) + A(G_A) f''(k_A) \frac{\partial k_A}{\partial G_A} = A'(G_A) \frac{f(k_A)}{k_A} > 0. \tag{27}$$

Using these results when considering (3) yields $\frac{\partial k_B}{\partial G_B} = -\frac{A'(G_B) f'(k_B)}{A(G_B) f''(k_B)} > 0$ and $\frac{\partial k_B}{\partial G_A} = \frac{\frac{\partial r}{\partial G_A}}{A(G_B) f''(k_B)} < 0$. Turning to equation (4), this implies

$$\begin{aligned} \frac{\partial w_B}{\partial G_B} &= A'(G_B)\,[f(k_B) - k_B f'(k_B)] - A(G_B) k_B f''(k_B) \frac{\partial k_B}{\partial G_B} \\ &= A'(G_B) f(k_B) > 0, \end{aligned} \tag{28}$$

and

$$\frac{\partial w_B}{\partial G_A} = -A(G_B) k_B f''(k_B) \frac{\partial k_B}{\partial G_A} = -A'(G_A) f(k_A) \frac{k_B}{k_A} < 0. \tag{29}$$

B: Proof of Lemma 2

The Jacobian of the two equations (14) and (15) is

$$\begin{vmatrix} -k_A & k_B \\ \frac{w_A}{M} & \frac{(1-\sigma) I_B}{(N-M)^2} - 2\alpha - \frac{w_A L_A - I_A}{(M)^2} \end{vmatrix} \tag{30}$$

Its determinant,

$$\Delta = k_A \left[2\alpha - \frac{(1-\sigma) I_B}{(N-M)^2} - \frac{I_A}{(M)^2} + \frac{w_A}{M} \left(\frac{L_A}{M} - \frac{k_B}{k_A} \right) \right], \tag{31}$$

is positive due to the stability condition $\frac{\partial q_1}{\partial L_A}\frac{\partial q_2}{\partial M} - \frac{\partial q_1}{\partial M}\frac{\partial q_2}{\partial L_A} > 0$.

The vector of derivatives with respect to s_B and σ are given by

$$\begin{pmatrix} 0 \\ -1 \end{pmatrix}$$

and

$$\begin{pmatrix} 0 \\ -\frac{I_B}{N-M} \end{pmatrix},$$

respectively. Applying the implicit function theorem leads to

$$\frac{\partial M}{\partial s_B} = -\frac{k_A}{\Delta} = \frac{N-M}{I_B}\frac{\partial M}{\partial \sigma} < 0, \tag{32}$$

$$\frac{\partial L_A}{\partial s_B} = -\frac{k_B}{\Delta} = \frac{N-M}{I_B}\frac{\partial L_A}{\partial \sigma} < 0, \tag{33}$$

$$\begin{aligned} \frac{\partial (L_A/M)}{\partial s_B} &= \frac{M\frac{\partial L_A}{\partial s_B} - L_A\frac{\partial M}{\partial s_B}}{M^2} = \frac{L_A k_A - M k_B}{\Delta M^2} \\ &= \frac{K - k_B N}{\Delta M^2} = \frac{N-M}{I_B}\frac{\partial (L_A/M)}{\partial \sigma} > 0. \end{aligned} \tag{34}$$

Notice that $L_A k_A - M k_B = K - k_B N > 0$ has to hold in order to satisfy the stability condition $\Delta > 0$ even if we have small values of α. □

C: Proof of Lemma 3

The vectors of derivatives of (14) and (15) with respect to I_A and I_B are

$$\begin{pmatrix} -\frac{\partial k_A}{\partial G_A}L_A - \frac{\partial k_B}{\partial G_A}(N-M) \\ -\frac{1}{M} - \frac{\partial w_B}{\partial G_A} \end{pmatrix}$$

and

$$\begin{pmatrix} -\frac{\partial k_B}{\partial G_B}(N-M) \\ \frac{1-\sigma}{N-M} - \frac{\partial w_B}{\partial G_B} \end{pmatrix},$$

respectively. Applying the implicit function theorem then yields

$$\frac{\partial M}{\partial I_x} = -\frac{\Delta_{MI_x}}{\Delta}, \tag{35}$$

$$\frac{\partial L_A}{\partial I_x} = -\frac{\Delta_{L_A I_x}}{\Delta}, \tag{36}$$

with $\Delta > 0$ as above and

$$\Delta_{MI_A} = k_A \left[\frac{1}{M} + \frac{\partial w_B}{\partial G_A}\right] + \frac{w_A}{M}\left[\frac{\partial k_A}{\partial G_A} L_A + \frac{\partial k_B}{\partial G_A}(N-M)\right], \tag{37}$$

$$\begin{aligned} \Delta_{L_A I_A} &= k_B \left[\frac{1}{M} + \frac{\partial w_B}{\partial G_A}\right] \\ &\quad - \left[\frac{\partial k_A}{\partial G_A} L_A + \frac{\partial k_B}{\partial G_A}(N-M)\right] \\ &\quad \cdot \left[\frac{(1-\sigma) I_B}{(N-M)^2} - 2\alpha - \frac{w_A L_A - I_A}{M^2}\right], \end{aligned} \tag{38}$$

$$\Delta_{MI_B} = k_A \left[\frac{\partial w_B}{\partial G_B} - \frac{1-\sigma}{N-M}\right] + \frac{w_A}{M}\frac{\partial k_B}{\partial G_B}(N-M), \tag{39}$$

$$\begin{aligned} \Delta_{L_A I_B} &= -\frac{\partial k_B}{\partial G_B}(N-M)\left[\frac{(1-\sigma) I_B}{(N-M)^2} - 2\alpha - \frac{w_A L_A - I_A}{M^2}\right] \\ &\quad + k_B \left[\frac{\partial w_B}{\partial G_B} - \frac{1-\sigma}{N-M}\right]. \end{aligned} \tag{40}$$

Combining the conditions in Lemma 3 with the stability condition (18) yields the result for population and employment level in both countries. The change of the employment probability in country A upon more investment in country A is given by

$$\begin{aligned} \frac{\partial (L_A/M)}{\partial I_A} &= \frac{M\frac{\partial L_A}{\partial I_A} - L_A \frac{\partial M}{\partial I_A}}{M^2} \\ &= \frac{1}{\Delta M}\left[\left(\frac{1}{M} + \frac{\partial w_B}{\partial G_A}\right)\left(\frac{L_A}{M} k_A - k_B\right)\right. \\ &\quad \left. + \left(\frac{\partial k_A}{\partial G_A} L_A + \frac{\partial k_B}{\partial G_A}(N-M)\right)\left(\frac{(1-\sigma) I_B}{(N-M)^2} - 2\alpha + \frac{I_A}{M^2}\right)\right]. \end{aligned} \tag{41}$$

The reaction of this employment probability to a higher investment in country B can be seen from

$$\begin{aligned}\frac{\partial(L_A/M)}{\partial I_B} &= \frac{M\frac{\partial L_A}{\partial I_B} - L_A\frac{\partial M}{\partial I_B}}{M^2} \\ &= \frac{1}{\Delta M}\left[\left(\frac{\partial w_B}{\partial G_B} - \frac{1-\sigma}{N-M}\right)\left(\frac{L_A}{M}k_A - k_B\right)\right. \\ &\quad \left. + \frac{\partial k_B}{\partial G_B}(N-M)\left(\frac{(1-\sigma)I_B}{(N-M)^2} - 2\alpha + \frac{I_A}{M^2}\right)\right].\end{aligned} \tag{42}$$

Note that $\frac{L_A}{M}k_A - k_B = \frac{1}{M}\left[K - Nk_B\right] > 0$. If $\alpha \longrightarrow 0$ and under the conditions for marginal changes of w_B in the lemma unemployment increases with infrastructure investment in country A and decreases with infrastructure investment in country B. □

D: Proof of Lemma 4

Notice that

$$\frac{\partial I_B}{\partial \sigma} = -\frac{\frac{\partial^2 U_B}{\partial I_B \partial \sigma}}{\frac{\partial^2 U_B}{\partial I_B^2}}, \frac{\partial I_B}{\partial s_B} = -\frac{\frac{\partial^2 U_B}{\partial I_B \partial s_B}}{\frac{\partial^2 U_B}{\partial I_B^2}}, \tag{43}$$

with $\frac{\partial^2 U_B}{\partial I_B^2} < 0$,and

$$\frac{\partial^2 U_B}{\partial I_B \partial \sigma} = \frac{1}{N-M} - \frac{1}{N} - \frac{(1-\sigma)I_B}{[N-M]^2}\frac{\partial M}{\partial \sigma} > 0, \tag{44}$$

$$\frac{\partial^2 U_B}{\partial I_B \partial s_B} = -\frac{(1-\sigma)I_B}{[N-M]^2}\frac{\partial M}{\partial s_B} > 0 \tag{45}$$

hold. Accordingly, $\frac{\partial I_B}{\partial I_A}$ displays the same sign as

$$\frac{\partial^2 U_B}{\partial I_B \partial I_A} = \frac{\partial^2 w_B}{\partial G_B \partial G_A} - \frac{(1-\sigma)}{[N-M]^2}\frac{\partial M}{\partial I_A}. \tag{46}$$

Recognizing that $\frac{\partial^2 w_B}{\partial G_B G_A} = \frac{A'(G_B)f'(k_B)}{A(G_B)f''(k_B)}A'(G_A)\frac{f(k_A)}{k_A} < 0$ holds then proves the claim. □

E: Proof of Proposition 1

From Lemma 4, we have $\frac{\partial I_B}{\partial \sigma} > 0$ and $\frac{\partial I_B}{\partial s_B} > 0$. Using the optimality condition for investment in country B (21) and the comparative static results from Lemma 3, it turns out that

$$\begin{aligned} Z_1 = & \left[\frac{\partial(L_A/M)}{\partial I_B} w_A - \frac{\sigma}{N} + \left[\frac{I_A}{M^2} + \frac{s_B}{N}\right]\frac{\partial M}{\partial I_B}\right] \qquad (47) \\ = & \frac{w_A}{\Delta M}\left[\frac{\sigma}{N}\left(k_A \frac{L_A}{M} - k_B\right) + \frac{\partial k_B}{\partial G_B}(N-M)\left(\frac{(1-\sigma)I_B}{(N-M)^2} - 2\alpha - \frac{s_B}{N}\right)\right] \\ & -\frac{\sigma}{N} - \left[\frac{I_A}{M^2} + \frac{s_B}{N}\right]\left[k_A \frac{\sigma}{N} + \frac{w_A}{M}\frac{\partial k_B}{\partial G_B}(N-M)\right] \\ = & \frac{(N-M)w_A}{\Delta M}\frac{\partial k_B}{\partial G_B}\left(\frac{(1-\sigma)I_B}{(N-M)^2} - 2\alpha - \frac{s_B}{N}\right) \\ & + \frac{\sigma}{N}\frac{k_A}{\Delta}\left(\frac{(1-\sigma)I_B}{(N-M)^2} + \frac{I_A}{M^2} - 2\alpha - \frac{s_B}{N}\right). \end{aligned}$$

This term is positive if α, s_B, and σ are sufficiently small.

Notice that

$$\begin{aligned} Z_2 = & \frac{\partial(L_A/M)}{\partial s_B} w_A - \frac{N-M}{N} + \left[\frac{I_A}{M^2} + \frac{s_B}{N}\right]\frac{\partial M}{\partial s_B} \qquad (48) \\ = & \left[\left(k_A \frac{L_A}{M} - k_B\right)\frac{w_A}{M} - \frac{I_A}{M^2} k_A\right]\frac{1}{\Delta} - \frac{N-M}{N} - \frac{s_B}{N}\frac{k_A}{\Delta} \\ = & \frac{k_A}{\Delta}\left(\frac{(1-\sigma)I_B}{(N-M)^2} - 2\alpha - \frac{s_B}{N}\right) + \frac{M}{N}, \end{aligned}$$

where

$$\frac{\partial(L_A/M)}{\partial \sigma} w_A - \frac{I_B}{N} + \left[\frac{I_A}{M^2} + \frac{s_B}{N}\right]\frac{\partial M}{\partial \sigma} = \frac{I_B}{N-M} Z_2 \qquad (49)$$

holds. Again, we have $Z_2 > 0$ if the mobility parameter α is sufficiently small. If this condition holds, and if we consider $s_B = \sigma = 0$, we arrive at $\frac{\partial U_A}{\partial \sigma} > 0$ and $\frac{\partial U_A}{\partial s_B} > 0$. □

F: Proof of Proposition 2

Suppose that $(I_{A0}, s_{B0}, \sigma_0)$ represents a candidate for an optimum policy of country A, with $0 < \sigma_0 < 1$. From Lemma 4, we have $\frac{\partial I_B}{\partial \sigma} > 0$ and $\frac{\partial I_B}{\partial s_B} > 0$. Considering Z_1 and Z_2 as defined in the proof of Proposition 1, it immediately follows that we must have $Z_2 > 0 > Z_1$ in any interior optimum with respect to σ. Recall that $\frac{\partial(L_A/M)}{\partial s_B} = \frac{N-M}{I_B}\frac{\partial(L_A/M)}{\partial \sigma}$ and $\frac{\partial M}{\partial s_B} = \frac{N-M}{I_B}\frac{\partial M}{\partial \sigma}$ hold. Reducing s_B and increasing σ such that $d\sigma = -\frac{I_B}{N-M} ds_B$, it turns out that

$$\left.\frac{\partial U_A}{\partial \sigma}\right|_{d\sigma=-\frac{I_B}{N-M}ds_B} = Z_1 \left[\frac{\partial I_B}{\partial \sigma} - \frac{I_B}{N-M}\frac{\partial I_B}{\partial s_B}\right]. \tag{50}$$

Evaluating the second factor yields

$$\frac{\partial I_B}{\partial \sigma} - \frac{I_B}{N-M}\frac{\partial I_B}{\partial s_B} = -\frac{\frac{1}{N-M} - \frac{1}{N}}{\frac{\partial^2 U_B}{\partial I_B^2}} > 0. \tag{51}$$

Hence, $(I_{A0}, s_{B0}, \sigma_0)$ cannot be an optimum policy of country A. □

G: Proof of Proposition 3

Varying the investment subsidy and the wage subsidy against each other such that the federal tax θ remains constant requires

$$\left.\frac{d\sigma}{ds_B}\right|_{\theta=\overline{\theta}} = -\frac{N-M+\sigma\frac{\partial I_B}{\partial s_B} - s_B\left[\frac{\partial M}{\partial s_B} + \frac{\partial M}{\partial I_B}\frac{\partial I_B}{\partial s_B}\right]}{I_B + \sigma\frac{\partial I_B}{\partial \sigma} - s_B\left[\frac{\partial M}{\partial \sigma} + \frac{\partial M}{\partial I_B}\frac{\partial I_B}{\partial \sigma}\right]}. \tag{52}$$

Notice that both the numerator and the denominator of this expression are positive. The impact of increasing θ on the representative voter's utility at a balanced federal budget is thus given by

$$\left.\frac{dU_A}{d\sigma}\right|_{\theta=\overline{\theta}} = \frac{\partial U_A}{\partial \sigma} + \frac{\partial U_A}{\partial s_B}\frac{ds_B}{d\sigma}. \tag{53}$$

The sign of this expression is the same as the sign of

$$
\begin{aligned}
S_1 \;=\; & \left[N - M + \sigma\frac{\partial I_B}{\partial s_B} - s_B\left[\frac{\partial M}{\partial s_B} + \frac{\partial M}{\partial I_B}\frac{\partial I_B}{\partial s_B}\right]\right] \\
& \cdot\left[\frac{\partial (L_A/M)}{\partial \sigma} w_A - \frac{I_B}{N} + \left[\frac{I_A}{M^2} + \frac{s_B}{N}\right]\frac{\partial M}{\partial \sigma} + \frac{\partial U_A}{\partial I_B}\frac{\partial I_B}{\partial \sigma}\right] \\
& - \left[I_B + \sigma\frac{\partial I_B}{\partial \sigma} - s_B\left[\frac{\partial M}{\partial \sigma} + \frac{\partial M}{\partial I_B}\frac{\partial I_B}{\partial \sigma}\right]\right] \\
& \cdot\left[\frac{\partial (L_A/M)}{\partial s_B} w_A - \frac{N-M}{N} + \left[\frac{I_A}{M^2} + \frac{s_B}{N}\right]\frac{\partial M}{\partial s_B} + \frac{\partial U_A}{\partial I_B}\frac{\partial I_B}{\partial s_B}\right].
\end{aligned} \tag{54}
$$

Simplifying this expression yields

$$
\begin{aligned}
S_1 \;=\; & \left[\sigma\frac{\partial I_B}{\partial s_B} - s_B\left[\frac{\partial M}{\partial s_B} + \frac{\partial M}{\partial I_B}\frac{\partial I_B}{\partial s_B}\right]\right] \\
& \cdot\left[\frac{\partial (L_A/M)}{\partial \sigma} w_A - \frac{I_B}{N} + \left[\frac{I_A}{M^2} + \frac{s_B}{N}\right]\frac{\partial M}{\partial \sigma}\right] \\
& - \left[\sigma\frac{\partial I_B}{\partial \sigma} - s_B\left[\frac{\partial M}{\partial \sigma} + \frac{\partial M}{\partial I_B}\frac{\partial I_B}{\partial \sigma}\right]\right] \\
& \cdot\left[\frac{\partial (L_A/M)}{\partial s_B} w_A - \frac{N-M}{N} + \left[\frac{I_A}{M^2} + \frac{s_B}{N}\right]\frac{\partial M}{\partial s_B}\right] \\
& + \frac{\partial U_A}{\partial I_B}\frac{\partial I_B}{\partial \sigma}\left[N - M + \sigma\frac{\partial I_B}{\partial s_B} - s_B\left[\frac{\partial M}{\partial s_B} + \frac{\partial M}{\partial I_B}\frac{\partial I_B}{\partial s_B}\right]\right] \\
& - \frac{\partial U_A}{\partial I_B}\frac{\partial I_B}{\partial s_B}\left[I_B + \sigma\frac{\partial I_B}{\partial \sigma} - s_B\left[\frac{\partial M}{\partial \sigma} + \frac{\partial M}{\partial I_B}\frac{\partial I_B}{\partial \sigma}\right]\right] \\
= \; & \left[\sigma\frac{\partial I_B}{\partial s_B} - s_B\frac{\partial M}{\partial I_B}\frac{\partial I_B}{\partial s_B}\right]\left[\frac{\partial (L_A/M)}{\partial \sigma} w_A - \frac{I_B}{N} + \left[\frac{I_A}{M^2} + \frac{s_B}{N}\right]\frac{\partial M}{\partial \sigma}\right] \\
& - \left[\sigma\frac{\partial I_B}{\partial \sigma} - s_B\frac{\partial M}{\partial I_B}\frac{\partial I_B}{\partial \sigma}\right] \\
& \cdot\left[\frac{\partial (L_A/M)}{\partial s_B} w_A - \frac{N-M}{N} + \left[\frac{I_A}{M^2} + \frac{s_B}{N}\right]\frac{\partial M}{\partial s_B}\right] \\
& + \frac{\partial U_A}{\partial I_B}\left[\frac{\partial I_B}{\partial \sigma}\left[N - M - s_B\frac{\partial M}{\partial s_B}\right] - \frac{\partial I_B}{\partial s_B}\left[I_B - s_B\frac{\partial M}{\partial \sigma}\right]\right].
\end{aligned} \tag{55}
$$

Inserting for $\frac{\partial I_B}{\partial s_B}$ and $\frac{\partial I_B}{\partial \sigma}$ shows that

$$\begin{aligned} S_1 &= -\left[\sigma - s_B\frac{\partial M}{\partial I_B}\right]\left(-\frac{\frac{1}{N-M}-\frac{1}{N}}{\frac{\partial^2 U_B}{\partial I_B^2}}\right) \\ &\quad \cdot\left[\frac{\partial(L_A/M)}{\partial s_B}w_A - \frac{N-M}{N} + \left[\frac{I_A}{M^2}+\frac{s_B}{N}\right]\frac{\partial M}{\partial s_B}\right] \\ &\quad +\frac{\partial U_A}{\partial I_B}\left(-\frac{\frac{1}{N-M}-\frac{1}{N}}{\frac{\partial^2 U_B}{\partial I_B^2}}\right)\left[N-M-s_B\frac{\partial M}{\partial s_B}\right] \end{aligned} \tag{56}$$

which has the same sign as

$$\begin{aligned} S_2 &= \frac{\partial U_A}{\partial I_B}\left[N-M-s_B\frac{\partial M}{\partial s_B}\right] \\ &\quad -\left[\sigma - s_B\frac{\partial M}{\partial I_B}\right]\left[\frac{\partial(L_A/M)}{\partial s_B}w_A - \frac{N-M}{N} + \left[\frac{I_A}{M^2}+\frac{s_B}{N}\right]\frac{\partial M}{\partial s_B}\right] \\ &= \left[\frac{\partial(L_A/M)}{\partial I_B}w_A - \frac{\sigma}{N} + \left[\frac{I_A}{M^2}+\frac{s_B}{N}\right]\frac{\partial M}{\partial I_B}\right]\left[N-M-s_B\frac{\partial M}{\partial s_B}\right] \\ &\quad -\left[\sigma - s_B\frac{\partial M}{\partial I_B}\right]\left[\frac{\partial(L_A/M)}{\partial s_B}w_A - \frac{N-M}{N} + \left[\frac{I_A}{M^2}+\frac{s_B}{N}\right]\frac{\partial M}{\partial s_B}\right] \\ &= \frac{\partial(L_A/M)}{\partial I_B}w_A\left[N-M-s_B\frac{\partial M}{\partial s_B}\right] \\ &\quad -\frac{N-M}{N}s_B\frac{\partial M}{\partial I_B} + \left[\frac{I_A}{M^2}+\frac{s_B}{N}\right](N-M)\frac{\partial M}{\partial I_B} \\ &\quad -\frac{\partial(L_A/M)}{\partial s_B}w_A\left[\sigma - s_B\frac{\partial M}{\partial I_B}\right] + \frac{\sigma}{N}s_B\frac{\partial M}{\partial s_B} - \sigma\frac{\partial M}{\partial s_B}\left[\frac{I_A}{M^2}+\frac{s_B}{N}\right] \\ &= \frac{\partial(L_A/M)}{\partial I_B}w_A\left[N-M-s_B\frac{\partial M}{\partial s_B}\right] + \frac{I_A}{M^2}(N-M)\frac{\partial M}{\partial I_B} \\ &\quad -\frac{\partial(L_A/M)}{\partial s_B}w_A\left[\sigma - s_B\frac{\partial M}{\partial I_B}\right] - \sigma\frac{\partial M}{\partial s_B}\frac{I_A}{M^2} \end{aligned} \tag{57}$$

Evaluating the comparative static expressions and using the definition of Δ then yields

$$
\begin{aligned}
S_2 &= \frac{w_A}{M\Delta}\left[\frac{\sigma}{N}\left[\frac{L_A}{M}k_A - k_B\right] + \frac{\partial k_B}{\partial G_B}(N-M)\left[\frac{(1-\sigma)I_B}{(N-M)^2} - 2\alpha + \frac{I_A}{M^2}\right]\right] \\
&\quad \cdot \left[N - M + s_B\frac{k_A}{\Delta}\right] \qquad (58) \\
&\quad -\frac{I_A}{M^2}\frac{(N-M)}{\Delta}\left[k_A\frac{\sigma}{N} + (N-M)\frac{w_A}{M}\frac{\partial k_B}{\partial G_B}\right] \\
&\quad -\frac{\frac{L_A}{M}k_A - k_B}{M\Delta}w_A\left[\sigma + \frac{s_B}{\Delta}\left[k_A\frac{\sigma}{N} + \frac{w_A}{M}\frac{\partial k_B}{\partial G_B}(N-M)\right]\right] + \sigma\frac{I_A}{M^2}\frac{k_A}{\Delta} \\
&= \frac{\partial k_B}{\partial G_B}\frac{w_A(N-M)}{M\Delta}\frac{s_B}{\Delta} \\
&\quad \cdot\left(k_A\left[\frac{(1-\sigma)I_B}{(N-M)^2} - 2\alpha + \frac{I_A}{M^2}\right] - \frac{w_A}{M}\left[\frac{L_A}{M}k_A - k_B\right]\right) \\
&\quad + \frac{\partial k_B}{\partial G_B}\frac{(N-M)^2}{M\Delta}\left[\frac{(1-\sigma)I_B}{(N-M)^2} - 2\alpha\right]w_A \\
&\quad + \frac{\sigma M}{N\Delta}\left[k_A\frac{I_A}{M^2} - \frac{w_A}{M}\left[\frac{L_A}{M}k_A - k_B\right]\right] \\
&= \frac{\partial k_B}{\partial G_B}\frac{(N-M)^2}{M\Delta}w_A\left[\frac{(1-\sigma)I_B}{(N-M)^2} - 2\alpha - \frac{s_B}{N-M}\right] \\
&\quad -\frac{\sigma M}{N} + \frac{\sigma M}{N\Delta}k_A\left[\frac{(1-\sigma)I_B}{(N-M)^2} - 2\alpha\right].
\end{aligned}
$$

The sign of the last expression is ambiguous. It will be positive for small α and a sufficiently small public budget θ, where the latter implies small values of σ and s_B. In this event S_2 is governed by $\frac{\partial k_B}{\partial G_B}\frac{(N-M)^2}{M\Delta}w_A\frac{(1-\sigma)I_B}{(N-M)^2} > 0$. Hence, for a sufficiently small budget, replacing wage subsidies by matching grants for infrastructure at a balanced budget increases welfare in country A. □

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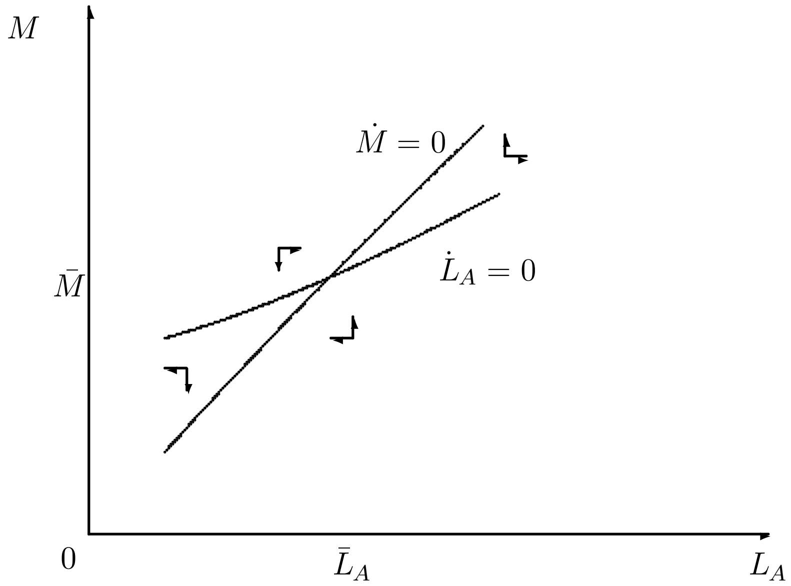

Fig. 1. Saddle point

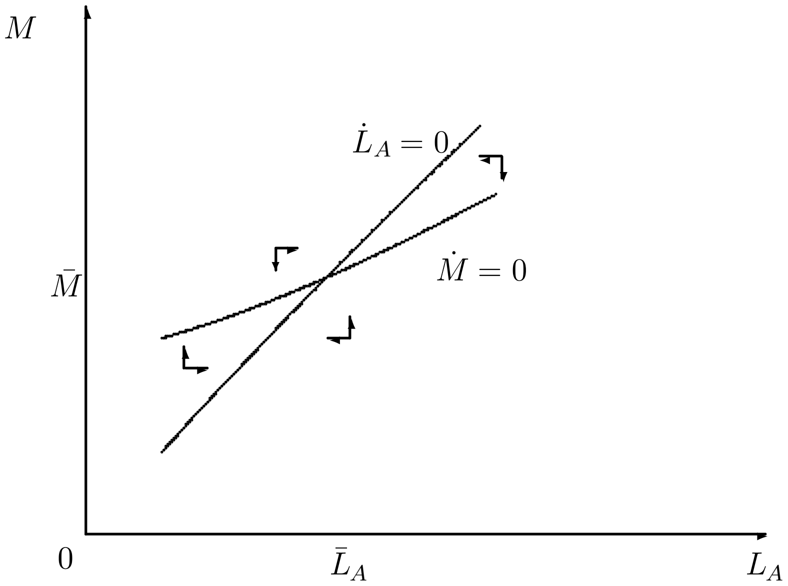

Fig. 2. Stable equilibrium