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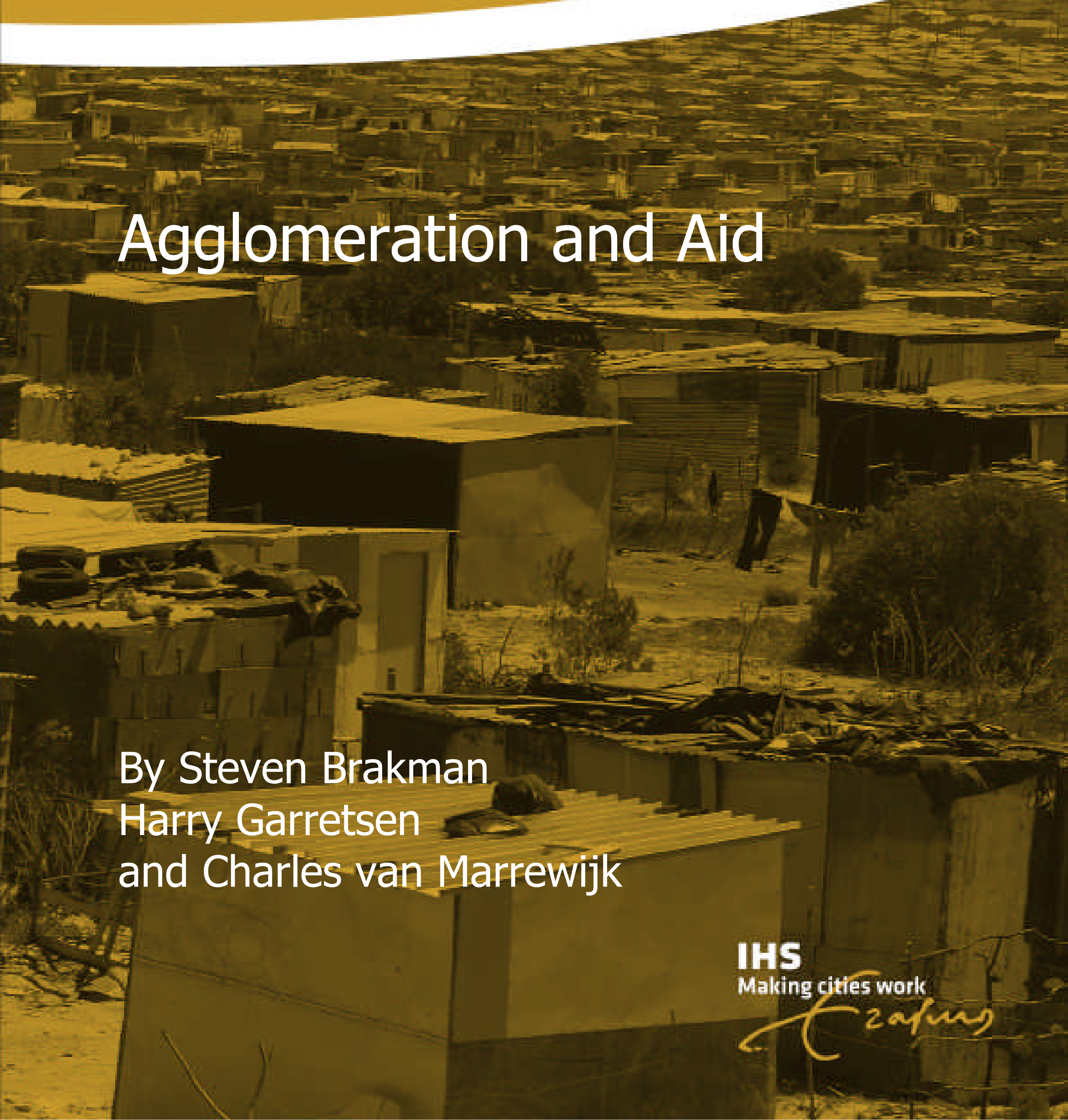

Agglomeration and Aid

By Steven Brakman
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STEVEN BRAKMAN, HARRY GARRETSEN
and CHARLES VAN MARREWIJK*

Abstract

A key issue in development economics is the explanation of core-periphery patterns around the world. Combining this issue with that of analyzing unilateral transfers (e.g. foreign aid) points in the direction of the use of New Economic Geography (NEG) models which, so far, has not been done explicitly. This paper tries to fill this gap in the literature by studying the (possibly 'catastrophic') effects of aid around the so-called break-points and sustain-points in a NEG model. We also analyze the effects of a "bystander", that is a country which is not directly involved in the transfer. In the traditional transfer literature a bystander is known to potentially cause transfer paradoxes. Our findings in this NEG setting are as follows. First, direct transfer paradoxes are not possible in a symmetric setting even if a bystander is present. Second, the effects of foreign aid depend on the level of economic integration between donor and recipient. Third, if the equilibrium from which aid is given is stable, aid only has a temporary effect (even if there is a bystander present). Fourth, if the donor is relatively large, not only the recipient but also the bystander benefits from foreign aid.

JEL-code: F12, F35

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1. Introduction

The theory of international transfers has a long and interesting history. Without doubt the most famous discussion on this topic was the exchange in *The Economic Journal* between Keynes an Ohlin in 1929. But much earlier other well-known economists like Hume, Smith, Ricardo, and Mill had already discussed the effects of international transfers. The early debates mostly revolved around war reparation payments in which the analysis of terms-of-trade effects or exchange rate effects dominated, see Brakman and Van Marrewijk (1998, 2007).

After the Keynes-Ohlin debate the focus of the modern literature on transfers, however, soon moved to the welfare effects of a transfer. By means of a simple example Leontief (1936) raised the possibility of transfer paradoxes (in which the donor gains and/or the recipient loses from the transfer). The main point of reference on this matter has been (and continues to be) Samuelson's (1947) assertion that Leontief's example requires unstable markets. More specifically, in a perfectly competitive, Walrasian stable, two-country world with two traded goods the donor's welfare falls and the recipient's welfare rises, see also Kemp (1964) and Mundell (1960). Samuelson's result, in general, does not hold if productive resources are transferred instead of purchasing power, if distortions are present in the system, if aid is tied, or if there are more than two countries. Transfer paradoxes are thus quite possible in more general settings, see e.g. Jones (1967, 1985), Ohyama (1974), Gale (1974), Chichilnisky (1980), Bhagwati, Brecher and Hatta (1983), Kemp and Kojima (1985), Schweinberger (1990), Kemp (1995), van Marrewijk and Michael (1998), Djajic, Lahiri and Raimondos-Møller (1999), Lahiri et al. (2002), Kemp and Shimomura (2003), and Lahiri and Raimondos-Møller (2004).[1]

Given the recent surge in research in international economics on core-periphery structures, as initiated by the New Economic Geography (NEG) a.k.a. Geographical Economics literature, it is remarkable that an explicit analysis of aid in a such a core-periphery context is lacking. This is also remarkable because Krugman (1993, 1995) partly found his inspiration for NEG in development economics! With some exaggeration one might say that the largest problem in development economics is the

[1] See Brakman and Van Marrewijk (1998) for a survey of the transfer literature.

persistence of global core-periphery patterns. In this chapter we address this gap in the literature and deal explicitly with aid or transfers in the context of a NEG model.[2] We find that transfer paradoxes are not possible under symmetry (even when a bystander is present), that the effects of aid are usually only temporary (given stability of the equilibria from which aid is donated), and that the bystander might benefit from aid even if it is not explicitly targeted by the transfer of foreign aid.

The paper is organized as follows. In section 2 we introduce the basic model and apply it to the study of aid in a two-country setting. Different from most NEG models we also analyze a three-country model in section 3. This is the smallest model that allows for a donor, a recipient and a bystander. In section 4 we evaluate our findings.

2. Analyses of aid and agglomeration: the two-country case

2.1 The model

For our purposes the core model of NEG, as developed by Krugman (1991) and subsequently analyzed in depth by Fujita et al. (1999), suffices for our analysis. Although other useful NEG models have been introduced after Krugman (1991), this first model is essentially the same as later NEG versions (see Robert-Nicoud, 2004). Here, we present only the equilibrium equations of this model. For a short derivation of the model the reader can consult Appendix I.

(1) $$Y_i = \lambda_i W_i \delta L + \phi_i (1-\delta) L$$

(2) $$I_r = \left[\sum_{s=1}^{R} \lambda_s W_s^{1-\varepsilon} T_{rs}^{1-\varepsilon} \right]^{1/(1-\varepsilon)}$$

(3) $$W_s = \left[\sum_{r=1}^{R} Y_r T_{rs}^{1-\varepsilon} I_r^{\varepsilon-1} \right]^{1/\varepsilon}$$

(4) $$w_s = W_s I_s^{-\delta}$$

[2] The only study that addresses regional transfers is Baldwin et al. (2003). They, however, have a different focus than we do as they analyze the effect of subsidies on the home market effect, and conclude, that "*the region that has the larger income or the region that is subsidized has an equilibrium share of industrial firms that is larger than its share of income or its relative subsidy. These biases are magnified by high levels of openness*" (p. 454). Then they proceed by analyzing political issues to determine "*the equilibrium size and direction of subsidies"*(p.454).

Equation (1) indicates that income in country *i*, consists of two parts. Income in the manufacturing sector, $\lambda_i W_i \delta L$, where W is nominal wage rate, δL is the share of the total labor forced employed in manufacturing, of which a share λ_i is employed in country *i*. Income in the numéraire sector is $\phi_i (1-\delta)L$, where ϕ_i is the share of the immobile labor force in country *i*. The parameter ε stands for the elasticity of substitution between manufacturing varieties. In the remainder of the paper we use the symmetry assumption that $\phi_i = 1/2$ in the two-country case and $\phi_i = 1/3$ in the three-country case.

Equation (2) is the exact price-index associated with the CES aggregator in the utility function with regard to manufactures. This is standard in the Dixit-Stiglitz framework we use (see Appendix I). Equation (3) is in essence the market equilibrium equation that reflects that demand equals (break-even) supply. T_{rs} are the standard ice-berg transportation costs between countries *r* and *s* (the number of units that have to be shipped to ensure that one unit arrives). Equation (4), finally, defines the real wage rate that drives migration flows (and the associated redistribution of economic activity) in the model. Migration is determined by real wage differences. If the real wage in a country is higher than in another country, this country will attract footloose labor. It is important to note that this introduces two equilibrium concepts in the model. Equation (3) always holds, and reflects equality between demand and supply on the goods market (short-run equilibrium). This does not necessarily imply that real wages are equalized between countries. If real wages are equalized, through migration, there is no longer an incentive to migrate. This is why the latter equilibrium is known as the long-run equilibrium.

Aid can now relatively easily be introduced by simply subtracting aid, A, from the donor's income, and adding it to the recipient's income. Without loss of generality we always take country 1 to be the donor and country 2 to be the recipient. We do not analyze the effects of taxes explicitly. So, who pays for the foreign aid? Implicitly we make one of two assumptions.

- All countries pay the same tax, and subsequently the proceeds are re-distributed to the recipient. This tax system reflects inter-country regional subsidies, or aid redistributed through a multi-national institution like the World Bank.
- Only the immobile labor force has to pay taxes. Such a system does not affect the decisions made by the footloose sector, which is central in NEG models. For these reasons we do not include the tax rate explicitly, as it would not change the essence of any of our conclusions and only clutter the analysis with an additional parameter.

In the remainder of this chapter, we apply this model to analyze the effects of aid, or in more neutral terms the effects of international or interregional transfers. First, we present the two-country case, and subsequently the three-country case in section 3.

<u>2.2 Aid in the 2-country core model of geographical economics</u>

Given the equations (1)-(4), we have the following set-up of the two-country case in which aid is present:

(5) $Y_1 = \delta\lambda_1 W_1 + (1-\delta)/2 - A$ $\quad\quad$ $Y_2 = \delta\lambda_2 W_2 + (1-\delta)/2 + A$

(6) $I_1 = \left[\lambda_1 W_1^{1-\varepsilon} + \lambda_2 W_2^{1-\varepsilon} T^{1-\varepsilon}\right]^{1/(1-\varepsilon)}$ $\quad\quad$ $I_2 = \left[\lambda_1 W_1^{1-\varepsilon} T^{1-\varepsilon} + \lambda_2 W_2^{1-\varepsilon}\right]^{1/(1-\varepsilon)}$

(7) $W_1 = \left[Y_1 I_1^{\varepsilon-1} + Y_2 T^{1-\varepsilon} I_2^{\varepsilon-1}\right]^{1/\varepsilon}$ $\quad\quad$ $W_2 = \left[Y_1 T^{1-\varepsilon} I_1^{\varepsilon-1} + Y_2 I_2^{\varepsilon-1}\right]^{1/\varepsilon}$

(8) $w_1 = W_1 I_1^{-\delta}$ $\quad\quad$ $w_2 = W_2 I_2^{-\delta}$

Equation (5) reflects the transfer from the donor to the recipient, the other equations are the two-country versions of (2)-(4). First, we investigate the marginal impact of foreign aid *A*, given by country 1 to country 2, around the spreading equilibrium ($\lambda_1 = \lambda_2 = 0.5$) evaluated at $A = 0$. In this set-up the spreading equilibrium in which the countries are identical in all respects is always a long-run equilibrium. Note, that at this spreading equilibrium equations (1)-(3) hold for the following endogenous variables: $W_1 = W_2 = 1$, $Y_1 = Y_2 = 0.5$, and $I_1 = I_2 = \left[(1+T^{1-\varepsilon})/2\right]^{1/(1-\varepsilon)}$.

We like to find out how a transfer affects this equilibrium. Following a similar procedure as developed by Fujita, Krugman, and Venables (1999) to determine the breakpoint; we want to investigate changes in the spreading equilibrium if an infinitesimal transfer A is made from country 1 to country 2.[3] We will ignore all second order effects of induced changes, such that we can write $dY = dY_1 = -dY_2$, $dW = dW_1 = -dW_2$, and similarly for the other variables. Differentiating equation (5) and evaluating at the spreading equilibrium gives equation (9). Similarly, differentiate equation (6) and evaluate at the spreading equilibrium to get equation (10).

(9) $$dY = (\delta / 2)dW - dA$$

(10) $$\frac{dI}{I} = \frac{I^{\varepsilon-1}\left(1-T^{1-\varepsilon}\right)}{2}dW$$

To facilitate notation it is convenient to define $Z \equiv (1-T^{1-\varepsilon})/(1+T^{1-\varepsilon})$. Note, that Z is an index of trade barriers which ranges from 0 when there are no transport costs (T = *1*) to 1 when transport costs are prohibitive ($T \rightarrow \infty$). With this notation we can rewrite equation (10) at the spreading equilibrium as equation (11). Finally, using this notation, differentiating equations (7) and (8) and evaluating at the spreading equilibrium gives equations (12) and (13).

(11) $$\frac{dI}{I} = ZdW$$

(12) $$\varepsilon dW = 2Z\,dY + (\varepsilon - 1)Z\frac{dI}{I}$$

(13) $$I^{\delta} dw = dW - \delta \frac{dI}{I}$$

System (11)-(13) gives us all the necessary information to calculate nominal wage changes (11) and (12) and then real wage changes (13). Substituting equations (9) and (11) in equation (12) and collecting terms gives equation (14), expressing nominal wage changes in terms of parameters. Substituting (14) in (9) gives (15), and shows that the income level in country 1 falls and in country 2 rises. Combining (11) and (14) gives the change of the price index following a transfer; the price index in country 1 falls and rises in country 2 (see equation 16). Using equations (11) and (13) we can nonetheless conclude, despite this price index effect, that the real wage rate in country 1 falls and in country 2 rises, see equation (17).

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[3] For the validity of this procedure see Baldwin (2001) and Ottaviano and Robert-Nicoud (2006).

(14) $$\frac{dW}{dA} = \frac{-2Z}{\varepsilon - \delta Z - (\varepsilon - 1)Z^2} < 0$$

(15) $$\frac{dY}{dA} = \frac{\delta}{2}\frac{dW}{dA} - 1 < 0$$

(16) $$\frac{dI}{dA} = I\,Z\frac{dW}{dA} < 0$$

(17) $$\frac{dw}{dA} = I^{-\delta}(1 - \delta Z)\frac{dW}{dA} < 0$$

We summarize these findings in proposition 1.

Proposition 1

The impact effects of an infinitesimal income transfer in the spreading equilibrium of the 2-country core model of geographical economics are:

- *an increase in the wage rate for the recipient and a decrease of the wage rate for the donor (eq. 14).*
- *an increase in the income level for the recipient and a decrease of the income level for the donor (eq. 15).*
- *an increase in the price index level for the recipient and a decrease in the price index level for the donor (eq. 16)*
- *an increase in the real wage rate for the recipient and a decrease in the real wage rate for the donor (eq. 17)*

In contrast to most models in standard international transfer theory, see Brakman and van Marrewijk (1998), the core model of geographical economics is well suited to analyze the dynamic implications of foreign aid. Most of this dynamics is based on the simple, ad hoc assumption of a redistribution of manufacturing workers from countries with low real wages to countries with high real wages, see equation (18). This is not only substantiated by extensive empirical literature, but can also be grounded in evolutionary game theory, see Weibull (1995), or justified in an endogenous growth framework, see Baldwin and Forslid (2000). Furthermore, Baldwin (2001) shows that this simple equation is consistent with forward looking behaviour. We restrict attention to the standard dynamics as given in equation (18), where η indicates the speed of adjustment and $\overline{w}$ is the average real wage rate.

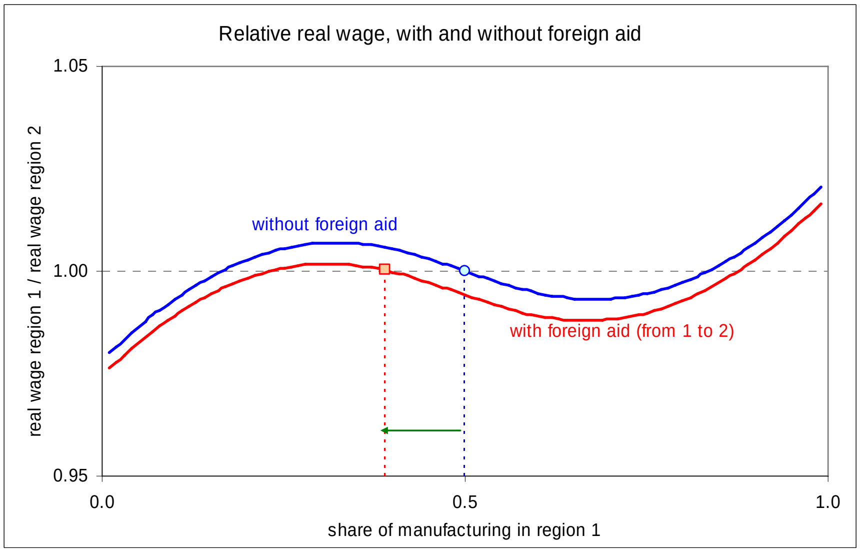
(18) $$\frac{d\lambda_i}{\lambda_i} = \eta(w_i - \overline{w}), \quad \textit{for } i = 1,2; \quad \textit{where } \overline{w} = \sum_i \lambda_i w_i$$

Using a procedure similar to that used above to derive equations (14)-(17), Fujita, Krugman, and Venables (1999) show that the spreading equilibrium is locally stable if, and only if, the no-black-hole condition holds ($\rho > \delta$) and if the transport costs are large enough, more specifically if condition (19) holds.[4]

(19) $$Z \equiv \frac{(1 - T^{1-\varepsilon})}{(1 + T^{1-\varepsilon})} > \frac{\delta(1+\rho)}{(\delta^2 + \rho)}$$

This puts us in a position to determine the dynamics of foreign aid around the spreading equilibrium. First, write the relative real wage w_1 / w_2 as a function, f say, of the distribution of the manufacturing workforce λ_1 and the amount of foreign aid A, conditional, of course, on the parameters of the model: $w_1 / w_2 = f(\lambda_1, A)$. If condition (19) holds, we know that $f'_\lambda(0.5,0) < 0$. Combining this with Proposition 1 (which established that $f'_A(0.5,0) < 0$) and the dynamics of equation (14) shows that the transfer of foreign aid around the spreading equilibrium leads to a reduction of manufacturing activity for the donor and an increase for the recipient.

Figure 1 The dynamic impact of foreign aid (intermediate transport costs)



Parameters: $\delta = 0.4$; $\varepsilon = 5$; $T = 1.7$; $A = 0$ *and* $A = 0.01$

[4] The parameter ρ is the is the so called love-of-variety parameter associated with the Dixit-Stiglitz model underlying our NEG model, see Appendix I. The relationship between the elasticity of substitution ε and this parameter is that $\varepsilon \equiv 1/(1-\rho)$.

Figure 1 illustrates the discussion above for the case of *intermediate* transport costs ($T = 1.7$). The figure depicts the real wage in country 1 relative to country 2 for all possible short-run equilibria (distributions of manufacturing workers). If the real wage in country 1 is higher than in country 2 workers will migrate from country 2 to country 1, and vice versa if the real wage is lower in country 1 than in country 2. As a consequence, there are three stable long-run equilibria in Figure 1, namely the spreading equilibrium and complete agglomeration in either country 1 or country 2. As a result of the transfer of foreign aid, the real wage falls for the donor and rises for the recipient around the spreading equilibrium, as can be seen by the downward shift of the short-run relative real wage curve, which causes an outflow of manufacturing activity from the donor to the recipient. There are two other cases to consider as well, see Brakman, Garretsen, and van Marrewijk (2001) for details. If transport costs are *large*, the spreading equilibrium is the only stable equilibrium and we arrive at a similar (local) conclusion as for the case of intermediate transport costs. If transport costs are *small*, however, the spreading equilibrium is unstable and the transfer of foreign aid leads to complete agglomeration of manufacturing activity in the recipient. Proposition 2 summarizes our discussion.

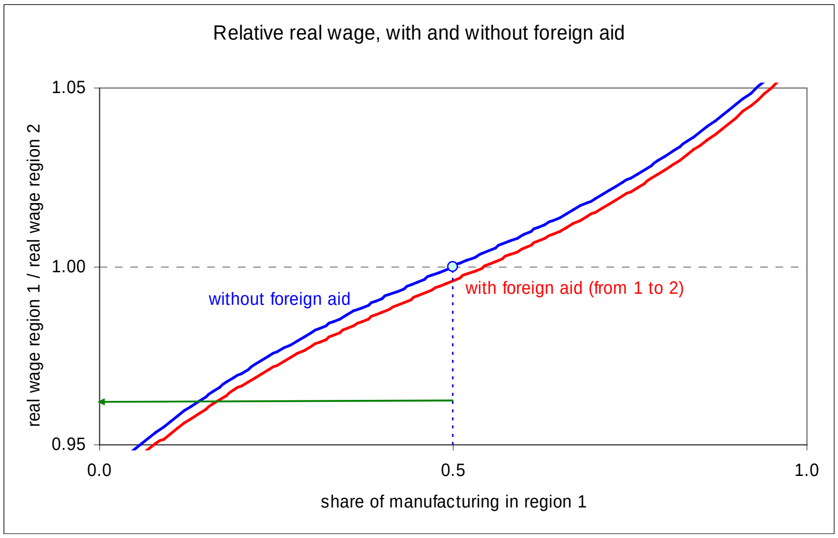
Proposition 2

The dynamic effect of an infinitesimal transfer of aid in the spreading equilibrium of the 2-country core model of geographical economics is:

- *a small influx of manufacturing activity for the recipient and a small reduction for the donor if the spreading equilibrium is locally stable.*
- *complete agglomeration of manufacturing activity in the recipient if the spreading equilibrium is locally unstable.*

We are now in a position to discuss the extent to which foreign aid has temporary or permanent effects on agglomeration. First, look at Figure 1. The transfer of foreign aid shifts the short-run relative real wage curve down causing an increase of manufacturing activity for the recipient and a decrease for the donor. It is important to note that the downward shift, and therefore the impact on the distribution of manufacturing activity, only continues as long as country 1 continues to give foreign aid to country 2. Once country 1 ceases to provide foreign aid, the short-run relative real wage curve shifts back to its old position and the effect on the distribution of manufacturing activity is reversed. In this situation, the effects of the transfer of foreign aid are only *temporary* and conditional on the continuation of the flow of foreign aid. The situation is quite different in Figure 2, where the transfer of foreign aid also leads to a downward shift of the short-run relative real wage curve, which causes complete agglomeration of manufacturing activity in the recipient country.

Figure 2 The dynamic impact of foreign aid (low transport costs)



Parameters: $\delta = 0.4$; $\varepsilon = 5$; $T = 1.5$; $A = 0$ *and* $A = 0.01$

Again, once country 1 seizes to transfer foreign aid to country 2 the short-run relative real wage curve shifts back to its old position. This time, however, the consequences of the initial transfer are *permanent* as agglomeration in country 2 continues to be a stable equilibrium. Proposition 3 summarizes our discussion.

Proposition 3

The dynamic effects of an infinitesimal transfer of foreign aid in the spreading equilibrium of the 2-country core model of geographical economics are temporary *if the spreading equilibrium is locally stable (i.e. stopping the flow of foreign aid reverses the economy to its original position). These dynamic effects are* permanent *if the spreading equilibrium is locally unstable (i.e. stopping the flow of foreign aid does not reverse the economy to its original position).*

In practice, propositions 2 and 3 imply that the consequences of aid are fundamentally different depending on the level of integration between donor and recipient. If economic integration is high, that is if the level of transportation costs is low, aid can have dramatic, lasting effects on the distribution of economic activity. On the other hand, if the level of economic integration is low, that is transportation costs are high, the effects of foreign aid are temporary and the distribution of economic activity is only affected as long as the foreign aid flow continues. Empirical research indicates that even for the EU regions, which a priori presents an example of an highly integrated economy, the 'extent of agglomeration forces' is still quite small, indicating that the likelihood of only temporary effects of interregional transfers is high (Brakman, Garretsen, and Schramm, 2006).

2.2 Complete agglomeration

In section 2.1 we studied the consequences of aid in the spreading equilibrium. What happens if the donor and the recipient are not equal in size? The standard motivation for aid is a welfare difference between donor and recipient, where the donor is rich and the recipient is poor. In the NEG literature a limiting case is complete agglomeration: all footloose production takes place in the donor country (here, country 1). So, doing the analysis of aid in a NEG setting with complete agglomeration might be more relevant than taking the spreading equilibrium as our focal point. Equations (5)-(8) are again the starting point for our investigation. First, note that complete agglomeration in country 1 implies $\lambda_1 = 1$ and $\lambda_2 = 0$. Using this information in equations (5)-(8) shows that they are solved for the following values of the endogenous variables: $W_1 = I_1 = w_1 = 1$, $Y_1 = [(1+\delta)/2] - A$, $Y_2 = [(1-\delta)/2] + A$, and $I_2 = T$. The impact effects of a transfer are therefore straightforward.

Proposition 4

The impact effects of a transfer of aid in the agglomeration equilibrium of the 2-country core model of geographical economics are:

- *no change in the wage rate of manufacturing workers or the price index for the donor*
- *an increase in the income level for the recipient and a decrease of the income level for the donor*

Since there are no manufacturing workers in the recipient it is not really appropriate to talk of their wage rate W_2, but we can calculate what this wage rate would have been by using equation (7), see equation (20). Similarly, we can calculate the implied real wage rate w_2 by using equation (8), see equation (21).

$$(20) \qquad W_2 = \left[\left(\frac{1+\delta}{2} - A\right)T^{1-\varepsilon} + \left(\frac{1-\delta}{2} + A\right)T^{\varepsilon-1}\right]^{1/\varepsilon}$$

$$(21) \qquad w_2 = \left\{\left(\frac{1+\delta}{2} - A\right)T^{1-\varepsilon} + \left(\frac{1-\delta}{2} + A\right)T^{\varepsilon-1}\right\}^{1/\varepsilon} T^{-\delta}$$

Noting that the real wage rate for mobile workers is equal to one in the donor country, it follows that it will be attractive for mobile workers to relocate from the donor country to the recipient once the implied real wage w_2 is larger than one. If that occurs, complete agglomeration of manufacturing activity in the donor country is no longer sustainable. Since this is equivalent to requiring w_2^{ε} larger than one, we can define the auxiliary function $g(T,A) \equiv w_2^{\varepsilon}$ as given in equation (22).

$$(22) \qquad g(T,A) \equiv \left(\frac{1+\delta}{2} - A\right)T^{-(\rho+\delta)\varepsilon} + \left(\frac{1-\delta}{2} + A\right)T^{(\rho-\delta)\varepsilon}$$

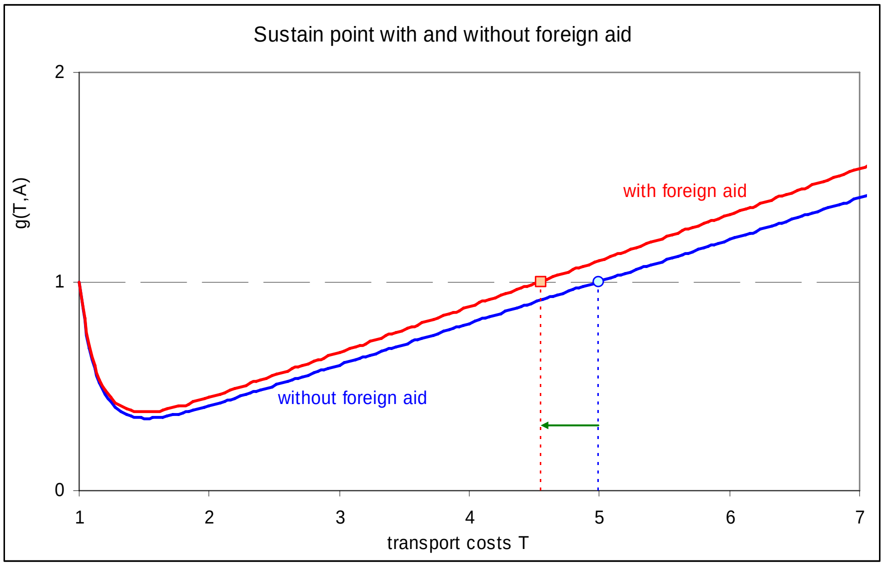
$$\text{(i)} \qquad g'_T(T,A) = \varepsilon\left\{-\left(\frac{1+\delta}{2} - A\right)(\rho+\delta)T^{-(\rho+\delta)\varepsilon-1} + \left(\frac{1-\delta}{2} + A\right)(\rho-\delta)T^{(\rho-\delta)\varepsilon-1}\right\}$$

$$\text{(ii)} \qquad g(1,A) = 1\,; \quad g'_T(1,A) = -\varepsilon[\delta(1+\rho) - 2\rho A]\,; \quad \lim_{T\to\infty} g(T,A) = \infty \; iff \; \rho > \delta$$

$$\text{(iii)} \qquad g'_A(T,A) = T^{(\rho-\delta)\varepsilon} - T^{-(\rho+\delta)\varepsilon} > 0 \quad if \quad T > 1$$

The main properties of function $g(T,A)$ are listed below equation (22). We note that its value is one if there are no transport costs ($T = 1$), it is declining for sufficiently small transport costs and aid flows (as $g'_T(1,A) < 0$ provided $A < \delta(1+\rho)/2\rho$), and its value is above one for sufficiently large transport costs (provided $\rho > \delta$, the so-called no-black-hole condition). As illustrated in Figure 3, the agglomeration equilibrium is sustainable for sufficiently small transport costs (for T below a critical value such that $g(T,A) < 1$), but not for sufficiently large transport costs.

Figure 3 Sustain point with and without foreign aid



Parameters: $\delta = 0.6$; $\varepsilon = 5$; $A = 0$ *and* $A = 0.02$

The impact of the transfer of foreign from the agglomeration or core to the periphery on the sustain point is also illustrated in Figure 3, see also (22.iii). The flow of foreign aid increases the income level in the periphery, which makes it more attractive as a base for production. This shifts the $g(T, A)$ curve upwards as $g'_A(T, A) > 0$ for $T > 1$, leading to a shift to the left of the critical sustain point value, and thus to a smaller range of transport costs for which agglomeration of manufacturing activity is a sustainable equilibrium. Our findings are summarized in Propositions 5 and 6.

Proposition 5

The dynamic effect of a transfer of foreign aid in the agglomeration equilibrium of the 2-country core model of geographical economics is:

- *no reallocation of manufacturing activity from core to periphery for sufficiently small foreign aid flows*
- *a large reallocation of manufacturing activity from a core-periphery setting to an (asymmetric) spreading equilibrium or complete agglomeration in the recipient once the foreign aid flow exceeds a critical level*

Proposition 6

If the transfer of foreign aid in the agglomeration equilibrium of the 2-country core model of geographical economics has a dynamic effect, then this effect is permanent *(i.e. stopping the flow of foreign aid does not reverse the economy to its original position). More specifically, stopping the foreign aid flow will either lead to the spreading equilibrium (if the aid-induced economy is in its basin of attraction) or to complete agglomeration in the recipient country.*

3. The effects of a bystander: foreign aid in the 3-country model

The analysis of international transfers benefited enormously from examples that aimed to show under what circumstances transfer paradoxes might arise (see Brakman and Van Marrewijk, 1998, for a survey and discussion of these examples). Although not without some problems, the examples pointed out that if a bystander is present a transfer paradox might arise (the donor gains and/or the recipient looses from a transfer).[5] A general derivation was given by Bhagwati, et al. (1983), who explicitly show that the presence of a bystander, which must actively be involved in international trade, is essential for paradoxes to arrive. A paradox may arise if the bystander's offer curve is inelastic (backward-bending) or if the bystander's export good is an inferior good for either the recipient or the donor. We therefore extend our analysis to include a third party, or 'bystander' that is not directly involved in the initial transfer. The set-up of this model is a straightforward extension of the two-country case analysed above.[6]

(5') $$Y_1 = \delta\lambda_1 W_1 + (1-\delta)/3 - A$$

$$Y_2 = \delta\lambda_2 W_2 + (1-\delta)/3 + A$$

$$Y_3 = \delta\lambda_3 W_3 + (1-\delta)/3$$

(6') $$I_1 = \left[\lambda_1 W_1^{1-\varepsilon} + \lambda_2 W_2^{1-\varepsilon} T^{1-\varepsilon} + \lambda_3 W_3^{1-\varepsilon} T^{1-\varepsilon}\right]^{1/(1-\varepsilon)}$$

$$I_2 = \left[\lambda_1 W_1^{1-\varepsilon} T^{1-\varepsilon} + \lambda_2 W_2^{1-\varepsilon} + \lambda_3 W_3^{1-\varepsilon} T^{1-\varepsilon}\right]^{1/(1-\varepsilon)}$$

$$I_3 = \left[\lambda_1 W_1^{1-\varepsilon} T^{1-\varepsilon} + \lambda_2 W_2^{1-\varepsilon} T^{1-\varepsilon} + \lambda_3 W_3^{1-\varepsilon}\right]^{1/(1-\varepsilon)}$$

(7') $$W_1 = \left[Y_1 I_1^{\varepsilon-1} + Y_2 T^{1-\varepsilon} I_2^{\varepsilon-1} + Y_3 T^{1-\varepsilon} I_3^{\varepsilon-1}\right]^{1/\varepsilon}$$

$$W_2 = \left[Y_1 T^{1-\varepsilon} I_1^{\varepsilon-1} + Y_2 I_2^{\varepsilon-1} + Y_3 T^{1-\varepsilon} I_3^{\varepsilon-1}\right]^{1/\varepsilon}$$

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[5] The reason for such paradoxes is that a transfer from country 1 to 2, affects the terms of trade. Because the bystander is also involved in international trade with countries 1 and 2, the price change also affects the value of the trade relations between countries 1 and 2 with respect to the bystander, thus influencing the total welfare change.

[6] Note that the position of the countries is symmetric relative to one another, that is the transport costs between countries 1 and 2 are equal to those between countries 1 and 3 and between 2 and 3.

$$W_3 = \left[Y_1\, T^{1-\varepsilon} I_1^{\varepsilon-1} + Y_2\, T^{1-\varepsilon} I_2^{\varepsilon-1} + Y_3\, I_3^{\varepsilon-1} \right]^{1/\varepsilon}$$

(8’) $$w_1 = W_1\, I_1^{-\delta} \qquad w_2 = W_2\, I_2^{-\delta} \qquad w_3 = W_3\, I_3^{-\delta}$$

The distribution or geography of economic activity in this set-up is be depicted as an equilateral triangle, where the share of manufacturing production at the corners represents complete agglomeration in one of the countries, see also the discussion of Figures 4 and 5 below. The great advantage of the depiction of space in our 3 country model as a equilateral triangle is that we can normalize distance and thereby ensure symmetry to the extent that transportation costs are the same between any pair of countries. Without this assumption the analysis below does not carry through, see also Brakman, Garretsen, and Schram (2006) on this issue.

We again investigate the marginal impact of foreign aid *A*, given by country 1 to country 2, around the spreading equilibrium ($\lambda_1 = \lambda_2 = \lambda_3 = 1/3$ and initially $A = 0$). At this spreading equilibrium equations (5’)-(7’) hold for the following endogenous variables: $W_1 = W_2 = W_3 = 1$, $Y_1 = Y_2 = Y_3 = 1/3$, and $I_1 = I_2 = I_3 = \left[(1 + 2T^{1-\varepsilon})/3\right]^{1/(1-\varepsilon)}$. We will ignore all second order effects of induced changes, such that: $dY = dY_1 = -dY_2$, $dW = dW_1 = -dW_2$, and similarly for the other variables. Differentiating equation (5’) and evaluating at the spreading equilibrium gives equation (9’). Similarly, differentiate equation (6’) and evaluate at the spreading equilibrium to get equation (10’).

(9’) $$dY = (\delta/3)dW - dA \qquad\qquad dY_3 = (\delta/3)dW_3$$

(10’) $$\frac{dI}{I} = \frac{I^{\varepsilon-1}\left(1 - T^{1-\varepsilon}\right)}{3}dW + \frac{I^{\varepsilon-1}T^{1-\varepsilon}}{3}dW_3 \qquad\qquad \frac{dI_3}{I_3} = \frac{I^{\varepsilon-1}}{3}dW_3$$

Define $\bar{Z} \equiv (1 - T^{1-\varepsilon})/(1 + 2T^{1-\varepsilon})$, and note that $\bar{Z}$ is an adjusted index of trade barriers (for three countries instead of two) which ranges from 0 when there are no transport costs (T = *1*) to 1 when transport costs are prohibitive ($T \to \infty$). With this notation we can rewrite equation (10’) at the spreading equilibrium as equation (11’). Finally, by using this notation, differentiating equations (7’) and (8’) and evaluating at the spreading equilibrium, we arrive at equations (12’) and (13’).

(11’) $\frac{dI}{I} = \overline{Z} dW + \frac{I^{\varepsilon-1}T^{1-\varepsilon}}{3} dW_3$ $\frac{dI_3}{I_3} = \frac{I^{\varepsilon-1}}{3} dW_3$

(12’) $\varepsilon dW = 3\overline{Z}\, dY + (\varepsilon-1)\overline{Z}\frac{dI}{I} + T^{1-\varepsilon}I^{\varepsilon-1}\left(\frac{\varepsilon-1}{3}\frac{dI_3}{I_3} + dY_3\right)$

$$\varepsilon dW_3 = I^{\varepsilon-1}\left(\frac{\varepsilon-1}{3}\frac{dI_3}{I_3} + dY_3\right)$$

(13’) $I^{\delta} dw = dW - \delta\frac{dI}{I}$ $I^{\delta} dw_3 = dW_3 - \delta\frac{dI_3}{I_3}$

Investigating equations (11’)-(13’) for country 3 quickly reveals that the first order effect of the transfer for the bystander is no change at all: $dW_3 = dY_3 = dI_3 = dw_3 = 0$. This follows because from country 3’s perspective any changes from the spreading equilibrium in a particular direction caused by country 1 are exactly compensated by opposite changes caused by country 2. Note that this effect would thus not hold if the transportation costs from the bystander to the donor would be different from those to the recipient. In any case, this symmetry assumption greatly simplifies the subsequent analysis for donor and recipient even if a bystander is present. Substituting the simplified equations (9’) and (11’) in equation (12’) and collecting terms gives equation (14’), determining what happens to the wage rate in country 1. From equation (9’), it follows that the income level in country 1 falls and in country 2 rises (see equation 15’), while using equation (11’), the price index in country 1 falls and in country 2 rises (see equation 16’). Using equations (11’) and (13’) we can nonetheless conclude, despite this price index effect, that the real wage rate in country 1 falls and in country 2 rises, see equation (17’). Also note that the bystander exacerbates the wage rate effect (cp 14 and 14’) but mitigates the income effect (cp. 15 and 15’).

(14’) $\frac{dW}{dA} = \frac{-3\overline{Z}}{\varepsilon - \delta\overline{Z} - (\varepsilon-1)\overline{Z}^2} < 0$ $\frac{dW_3}{dA} = 0$

(15’) $\frac{dY}{dA} = \frac{\delta}{3}\frac{dW}{dA} - 1 < 0$ $\frac{dY_3}{dA} = 0$

(16’) $\frac{dI}{dA} = I\,\overline{Z}\frac{dW}{dA} < 0$ $\frac{dI_3}{dA} = 0$

(17’) $\frac{dw}{dA} = I^{-\delta}(1-\delta\overline{Z})\frac{dW}{dA} < 0$ $\frac{dw_3}{dA} = 0$

Proposition 7

The impact effects of an infinitesimal transfer of aid in the spreading equilibrium of the 3-country core model of geographical economics are:

- *an increase in the wage rate for the recipient, a decrease of the wage rate for the donor, and no effect for the bystander (eq. 14').*
- *an increase in the income level for the recipient, a decrease of the income level for the donor, and no effect for the bystander (eq. 15').*
- *an increase in the price index level for the recipient, a decrease in the price index level for the donor, and no effect for the bystander (eq. 16')*
- *an increase in the real wage rate for the recipient, a decrease in the real wage rate for the donor, and no effect for the bystander (eq. 17')*

Lemma 1

The spreading equilibrium in the 3-country core model of geographical economics is locally stable if, and only if, the no-black-hole condition holds ($\rho > \delta$) and the transport costs are large enough, more specifically if condition (*) holds.

(*) $$\overline{Z} \equiv \frac{(1-T^{1-\varepsilon})}{(1+2T^{1-\varepsilon})} > \frac{\delta(1+\rho)}{(\delta^2+\rho)}$$

Proof: see appendix II.

Proposition 8

The dynamic effect of an infinitesimal transfer of aid for a locally stable spreading equilibrium of the 3-country core model of geographical economics is:

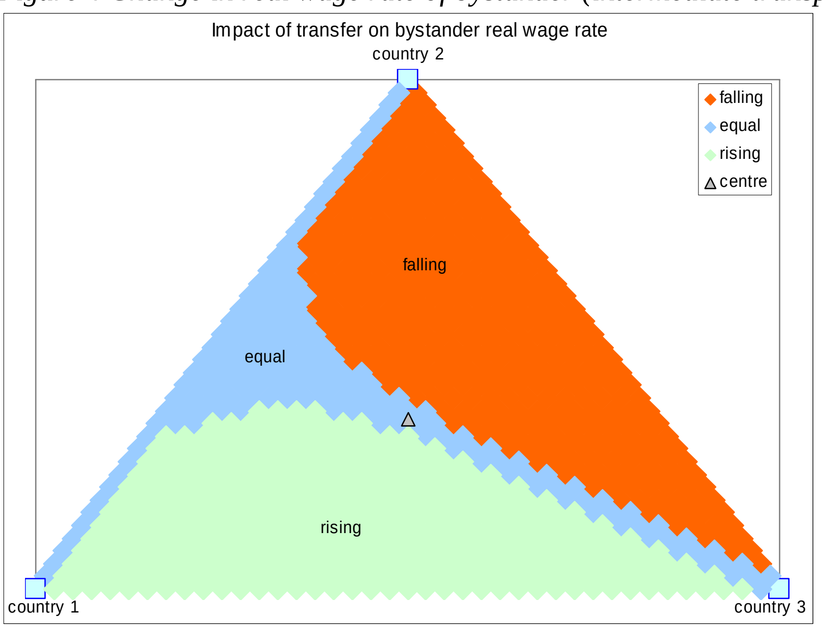
- *a small influx of manufacturing activity for the recipient, a small reduction of manufacturing activity for the donor, and no effect for the bystander.*

Proposition 9

The dynamic effects of an infinitesimal transfer of foreign aid in the spreading equilibrium of the 3-country core model of geographical economics are temporary *if the spreading equilibrium is locally stable (i.e. stopping the flow of foreign aid reverses the economy to its original position).*

So, in contrast to the traditional analysis of infinitesimal or marginal transfers, in our NEG setting the bystander has no additional influence on the donor or the recipient as compared to the two-country case! However, by explicitly calculating (numerically) discrete, or large, transfers we can easily show that the effects for the bystander can be influential in our NEG model. This is illustrated in Figure 4, which shows the effects of a *discrete* transfer on the real wage rate of the bystander as a function of the distribution of the mobile labor force in a unit simplex. Figure 4 is a two-dimensional representation of the three-country model. If one gets closer to one of the corners this means that the country in question produces a larger share of total manufacturing output. We can distinguish three different areas in figure 4: an area where the real wage increases, an area where it remains the same, and an area where it decreases. Figure 4 illustrates, therefore, that the effects of the transfer depend on the initial distribution of the footloose workers.

Figure 4 Change in real wage rate of bystander (intermediate transport costs)

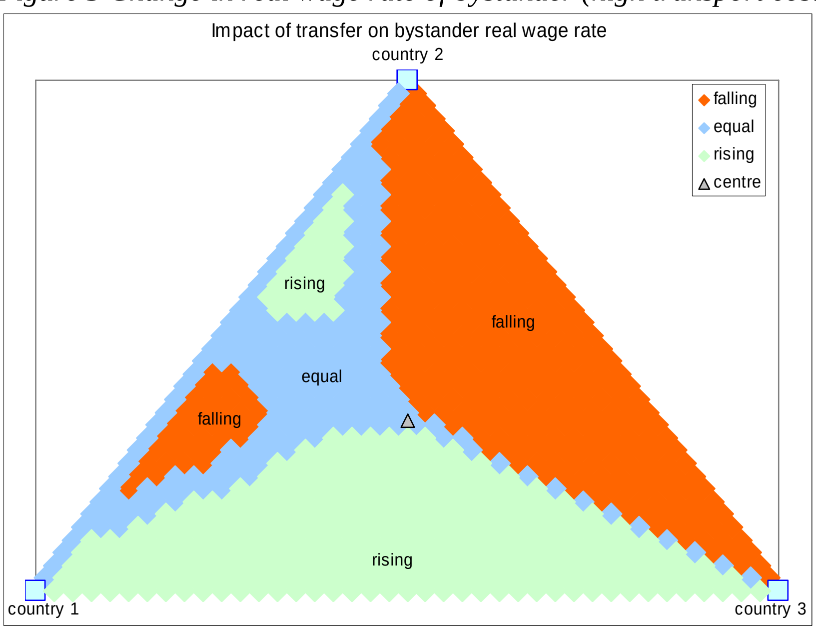


Parameters: $\delta = 0.4$; $\varepsilon = 5$; $T = 1.7$ *and* $A = 0.01$; "equal" is relative change smaller than 0.0001.

A closer investigation of Figure 4 reveals that in the area in which the donor (country 1) and the recipient (country 2) are similar in size (along the perpendicular line from the bystander's (country 3) corner) the effect on the real wage for the bystander is zero. If the donor and the bystander are relatively small compared to the recipient (in the north-east of the figure) the real wage rate declines, while if the donor and the bystander are relative large compared to the recipient (in the south-west of the figure) the real wage increases.

The effects thus depend on whether or not the transfer is substantial for the recipient. For a small recipient a given transfer ($A = 0.01$) has a substantial effect on its income and real wage. Workers in the bystander country benefit because the 'extent of agglomeration forces' from the relatively large donor country become smaller, thus increasing the relative attractiveness for the bystander (note: the real wage rate always increases for the recipient and falls for the donor in Figure 4). Analogous reasoning holds for the north-east part of the figure, resulting in a decrease of the real wage rate for the bystander. This leads to the interesting conclusion that if aid is given to a particular recipient, other developing countries are also affected. Since we can safely assume that the income level of the donor is usually large compared to that of developing countries, Figure 4 indicates that the non-targeted bystander country usually benefits.

Figure 5 Change in real wage rate of bystander (high transport costs)



Parameters: $\delta = 0.4$; $\varepsilon = 5$; $T = 2$ *and* $A = 0.01$; "equal" is relative change smaller than 0.0001.

Figure 5 illustrates a similar exercise as Figure 4, but now for a *higher* level of transport costs ($T = 2$ instead of $T = 1.7$). Relative to Figure 4 two new areas appear in the north-western part of Figure 5. These new areas reflect the fact that for sufficiently high transport costs a transfer from a donor to a recipient that is similar in size reduces the attractiveness (real wage in the donor), making both re-location to the recipient country and the bystander country more attractive, thus also increasing the bystander's real wage rate.

Note finally that when one starts from a spreading equilibrium in Figure 5 (the triangle Δ in the middle of the Figure), the real wage for the donor falls, increases for recipient and remains the same for the bystander (recall proposition 7). In this case the 1^{st} order dynamic effect in terms of Figure 5 is a move in the north-eastern direction which leads the economy to the area where the real wage for the bystander falls. The 2^{nd} order dynamic effect after reallocation when we start from the spreading equilibrium is thus negative for the bystander.

4. Conclusions

Traditionally the analysis of the economics of international transfers is based on models characterized by perfect competition where the location of economic activity is not an issue. It is, however, a stylized fact that economic activity is distributed unevenly across space, which calls for an analysis of the effects of transfers or aid using models where location matters and where, consequently, imperfect competition rules. It is for this reason that we think that new economic geography (NEG) models can be useful for the analysis of international transfers.

Using the working horse model of the NEG literature due to Krugman (1991), this chapter provides such an analysis. We first analyze the effects of a transfer in a two-country world, and subsequently extend the analysis with a bystander country. In the standard literature on international transfers the presence of a bystander is essential for transfer paradoxes to arise. Our main findings can be summarized as follows. First, transfer paradoxes are not possible even if bystanders are present. Second, the effects of foreign aid depend on the level of economic integration between donor and recipient. Third, if the equilibrium from which aid is given is stable, aid only has a temporary effect (even if a bystander is present). Fourth, if the donor is relatively large, not only the recipient but also the bystander benefits from foreign aid.

Appendix I, The core NEG model (Krugman, 1991)

Demand

Assume an economy with two sectors, a numéraire sector (H), and a Manufacturing (M) sector. As a short cut one often refers to H as the agricultural sector to indicate that this industry is tied to a specific location. Every consumer in the economy shares the same, Cobb-Douglas, preferences for both types of commodities:

$$U = M^{\delta} H^{(1-\delta)}$$

The parameter δ is the share of income spent on manufactured goods. M is a CES sub-utility function of many varieties.

$$M = \left(\sum_{i=1}^{n} c_i^{\rho} \right)^{1/\rho}$$

Maximizing the sub-utility subject to the relevant income constraint, that is the part of income that is spent on manufactures, δY, gives the demand for each variety, j:

$$c_j = p_j^{-\varepsilon} I^{\varepsilon-1} \delta Y \ ,$$

in which $I = [\sum_i (p_i)^{(1-\varepsilon)}]^{1/(1-\varepsilon)}$ is the CES-price index for manufactures, $\varepsilon = \frac{1}{1-\rho}$ the elasticity of substitution, and Y= income.

Manufacturing Supply

Next, turn to the supply side. Each variety, i, is produced according to the following cost function, $C(x_i)$:

$$C(x_i) = W_i \ (\alpha + \beta x_i)$$

where the coefficients α and β describe, the fixed and marginal input requirement per variety. Maximizing profits gives the familiar mark-up pricing rule:

$$p_i (1 - \frac{1}{\varepsilon}) = W\beta \ ,$$

Using the zero profit condition, $p_i x_i = W(\alpha + \beta x_i)$, and the mark-up pricing rule, gives the break- even supply of a variety *i* (each variety is produced by a single firm):

$$x_i = \frac{\alpha(\varepsilon - 1)}{\beta} = x^*$$

Labour Market

There is only one factor of production, Labour, L (which can be normalized to 1). The total amount of labour is given and fixed. Initially, the labour force is distributed over Manufacturing (a share δ of L), and the numéraire sector (a share (1- δ) of L). Labour in the manufacturing sector is mobile over countries. The distribution of δL over countries, *r*, is represented by the share λ_r of δL, the distribution of the immobile labor force is represented by a share φ_r of (1- δ)L.

Equilibrium with transport costs

Furthermore, transportation of manufactures is costly. Transportation costs T are so-called iceberg transportation costs: $T_{12}>1$ units of the manufacturing good have to be shipped from country 1 to country 2 for one unit of the good to actually arrive in country 2. Assume, for illustration purposes, that the two countries - 1 and 2 - are the only countries. Total demand for a product from, for example country 1, now comes from two countries, 1 and 2. The consumers and firms in country 2 have to pay transportation costs on their imports. This leads to the following total demand for a variety produced in country 1:

$$x_1 = Y_1 p_1^{-\varepsilon} I_1^{\varepsilon-1} + Y_2 p_1^{-\varepsilon} (T_{12}\ )^{-\varepsilon} I_2^{\varepsilon-1}$$

We already know that the break-even supply equals $x_1 = \frac{\alpha(\varepsilon-1)}{\beta}$, equating this to total demand gives (note that the demand from country 2 is multiplied by T_{12} in order to compensate for the part that melts away during transportation):

$$\frac{\alpha(\varepsilon-1)}{\beta} = Y_1 p_1^{-\varepsilon} I_1^{\varepsilon-1} + Y_2 p_1^{-\varepsilon} (T_{12})^{1-\varepsilon} I_2^{\varepsilon-1}$$

Inserting the mark-up pricing rule in this last equation and solving for the wage rate gives the two-country version of the wage equation.[7] The wage equation for the 2 country case can be stated as:

$$W_1 = Const(Y_1 I_1^{\varepsilon-1} + Y_2 (T_{12})^{1-\varepsilon} I_2^{\varepsilon-1})^{1/\varepsilon},$$

where the constant, Const, is a function of (fixed) model parameters. Similarly, for the n country ($n = 1,..,r$) case we arrive at the following equilibrium wage equation, and this is the wage equation (3) that is used in the main text of the paper:

$$W_r = Const\left[\sum_s Y_s I_s^{\varepsilon-1} T_{rs}^{\ (1-\varepsilon)}\right]^{1/\varepsilon}$$

W_r is the country's r (nominal) wage rate, Y_s is expenditures (demand for final consumption), I_s is the price index for manufactured goods, ε is the elasticity of substitution for manufactured goods and T_{rs} are the iceberg transport costs between countries r and s. With interregional labour mobility a long run equilibrium is reached interregional real wages are equalized, where the real wage is defined as $w_r = W_r(\ I_s)^{-\delta}$. (See for more details Fujita, Krugman, and Venables, 1999 (ch. 4 and 5) or Brakman, Garretsen and Van Marrewijk, 2001 (ch. 3 and 4).

Appendix II Stability around the spreading equilibrium in the 3-country model

We investigate the marginal impact of a movement of manufacturing workers from country 1 to country 2 around the spreading equilibrium ($\lambda_1 = \lambda_2 = \lambda_3 = 1/3$ and $A = 0$). Note that at this spreading equilibrium equations (5')-(7') hold for the following endogenous variables: $W_1 = W_2 = W_3 = 1$, $Y_1 = Y_2 = Y_3 = 1/3$, and $I_1 = I_2 = I_3 = \left[(1 + 2T^{1-\varepsilon})/3\right]^{1/(1-\varepsilon)}$. We will ignore all second order effects of induced changes, such that we can write $dY = dY_1 = -dY_2$, $dW = dW_1 = -dW_2$, and similarly for the other variables. Differentiating equation (1') and evaluating at the spreading equilibrium gives equation (A1). Similarly, differentiate equation (2') and evaluate at the spreading equilibrium to get equation (A2).

(A1) $dY = \delta d\lambda + (\delta/3)dW \qquad\qquad dY_3 = (\delta/3)dW_3$

(A2) $(1-\varepsilon)\frac{dI}{I} = I^{\varepsilon-1}\left(1 - T^{1-\varepsilon}\right)\left(\frac{1-\varepsilon}{3}dW + d\lambda\right) + \frac{(1-\varepsilon)I^{\varepsilon-1}T^{1-\varepsilon}}{3}dW_3$

$$\frac{dI_3}{I_3} = \frac{I^{\varepsilon-1}}{3}dW_3$$

[7] The reason to derive a wage equation instead of a traditional equilibrium price equation is that labour migration between countries is a function of (real) wages.

Define $\overline{Z} \equiv (1-T^{1-\varepsilon})/(1+2T^{1-\varepsilon})$, and note that $\overline{Z}$ is an adjusted index of trade barriers (for three countries instead of two) which ranges from 0 when there are no transport costs ($T = 1$) to 1 when transport costs are prohibitive ($T \to \infty$). With this notation we can rewrite equation (A2) at the spreading equilibrium as equation (A3). Finally, using this notation, differentiating equations (3') and (4') and evaluating at the spreading equilibrium gives equations (A4) and (A5).

(A3) $$\frac{dI}{I} = \frac{3\overline{Z}}{1-\varepsilon}d\lambda + \overline{Z}dW + \frac{I^{\varepsilon-1}T^{1-\varepsilon}}{3}dW_3 \qquad \frac{dI_3}{I_3} = \frac{I^{\varepsilon-1}}{3}dW_3$$

(A4) $$\varepsilon dW = 3\overline{Z}\,dY + (\varepsilon-1)\overline{Z}\frac{dI}{I} + T^{1-\varepsilon}I^{\varepsilon-1}\left(\frac{\varepsilon-1}{3}\frac{dI_3}{I_3} + dY_3\right)$$

$$\varepsilon dW_3 = I^{\varepsilon-1}\left(\frac{\varepsilon-1}{3}\frac{dI_3}{I_3} + dY_3\right)$$

(A5) $$I^{\delta}dw = dW - \delta\frac{dI}{I} \qquad I^{\delta}dw_3 = dW_3 - \delta\frac{dI_3}{I_3}$$

Investigating the equations for country 3 reveals that the first order effect of the migration flow is no change at all: $dW_3 = dY_3 = dI_3 = dw_3 = 0$. This follows because from country 3's perspective any change from the spreading equilibrium caused by country 1 are exactly compensated by opposite changes caused by country 2. Note that this effect only hold if the transportation costs from the bystander to the donor are the same as those to the recipient which greatly simplifies the subsequent analysis for countries 1 and 2 as:

(A3') $$\frac{dI}{I} = \frac{3\overline{Z}}{1-\varepsilon}d\lambda + \overline{Z}dW$$

(A4') $$\varepsilon dW = 3\overline{Z}\,dY + (\varepsilon-1)\overline{Z}\frac{dI}{I}$$

Substituting (A1) in (A4') and combining with (A5') gives

(A6) $$\begin{bmatrix} 1 & -\overline{Z} \\ \overline{Z} & (\varepsilon-\delta\overline{Z})/(1-\varepsilon) \end{bmatrix}\begin{bmatrix} dI/I \\ dW \end{bmatrix} = \begin{bmatrix} 3\overline{Z}/(1-\varepsilon) \\ 3\delta\overline{Z}/(1-\varepsilon) \end{bmatrix}d\lambda$$

(A7) $$\begin{bmatrix} dI/I \\ dW \end{bmatrix} = \frac{1}{\Delta}\begin{bmatrix} (\varepsilon-\delta\overline{Z})/(1-\varepsilon) & \overline{Z} \\ -\overline{Z} & 1 \end{bmatrix}\begin{bmatrix} 3\overline{Z}/(1-\varepsilon) \\ 3\delta\overline{Z}/(1-\varepsilon) \end{bmatrix}d\lambda$$

where $\Delta \equiv \left((1-\varepsilon)\overline{Z}^2 - \delta\overline{Z} + \varepsilon\right)/(1-\varepsilon)$, such that

$$\frac{dI}{I} = \frac{d\lambda}{\Delta}\frac{3\varepsilon\overline{Z}}{(1-\varepsilon)^2}(1-\delta\overline{Z}) \qquad dW = \frac{d\lambda}{\Delta}\frac{3\overline{Z}}{(1-\varepsilon)}(\delta-\overline{Z})$$

Finally, substituting in (A5) gives the change in the real wage

$$\frac{dw}{d\lambda} = \frac{3\overline{Z}I^{-\delta}}{(\varepsilon-1)}\left[\frac{\delta(2\varepsilon-1)-\overline{Z}[\varepsilon(1+\delta^2)-1]}{\varepsilon-\delta\overline{Z}-(\varepsilon-1)\overline{Z}^2}\right] = \frac{3\overline{Z}I^{-\delta}(1-\rho)}{\rho}\left[\frac{\delta(1+\rho)-\overline{Z}(\delta^2+\rho)}{1-\delta\overline{Z}(1-\rho)-\rho\overline{Z}^2}\right]$$ The second equality follows from the definition of ρ. The sign of the real wage change is then determined by the sign of the numerator of the expression in square brackets, which gives the expression in the text.

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