Vol. 92 (2007), No. 3, pp. 209–228
DOI 10.1007/s00712-007-0289-8
Printed in The Netherlands

Journal of Economics

Identifying the dynamic home market effect in a three-country model

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Received 15 January 2007; Accepted 13 April 2007;
Published online 6 November 2007

The home market effect (HME) is a distinguishing feature of the "new" trade theory. It is customarily defined as disproportionate positive causation from expenditure to production. Recently it has been argued that this *dynamic* definition of the HME is problematic in a multi-country framework, because it neglects third country effects. In this paper, we show that more than one exogenous parameter change is needed to overturn the dynamic HME. An isolated increase in the size of the home country will unambiguously lead to an overproportional domestic industry expansion. We then illustrate with some specific scenario what type of third country effects can "swamp" the HME.

Keywords: international trade; home market effect; hub effect.

JEL Classifications: F12; F14; R12.

1. Introduction

There are two main paradigms in international trade theory. The neoclassical approach focuses on differences in tastes, technology, and endowments to explain the pattern of trade flows, whereas the "new" trade theory stresses the role of scale economies and imperfect

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competition. A distinguishing feature of the latter is the *home market effect* (HME) as introduced by Krugman (1980). The HME is traditionally understood as a dynamic concept of disproportionate positive causation. In their well known model with two countries and two industries, Helpman and Krugman (1985, chap. 10) show that the larger country will be a net exporter of the differentiated good (featuring internal increasing returns, monopolistic competition, and transport costs) due to market size effects. An increase of some country's expenditure share on this good leads to an over-proportional increase in its production share if the HME is present.[1] This is not true in traditional trade models à la Heckscher-Ohlin or Ricardo (see Feenstra 2003). The HME has, therefore, frequently been used as a criterion to address the empirical relevance of the ''new'' relative to the ''old'' trade theory (Davis and Weinstein 1999, 2003; Trionfetti 2001; Feenstra et al. 2001; Weder 2003; Head and Mayer 2004; Brülhart and Trionfetti 2005).

Moving beyond the usual setup with only two countries, however, the concept of disproportionate positive causation is a problematic definition of the HME. This important insight is due to recent research by Behrens et al. (2005a) (henceforth labelled as ''BLOT''), who develop a multi-country version of the model by Krugman (1980). They prove that an increase in the domestic expenditure share on the differentiated good need not map into an over-proportional increase of the domestic output share, because there exists some parallel perturbation in the expenditure shares among foreign economies (''third country effects'') such that the domestic output reaction is under-proportional, or even negative (see their appendix 3). Due to this flaw of the dynamic interpretation, BLOT develop an alternative static definition of the HME, based on a country ranking of industry over population shares, and suggest using spatially filtered cross-section data with prior control for accessibility. Performing non-parametric sign- and rank-tests BLOT find evidence for the static HME in various industries.

1 There is a voluminous literature on the robustness of the HME in different theoretical setting, see, e.g., Davis (1998), Head et al. (2002), Hanson and Xiang (2004), Medin (2004), Holmes and Stevens (2005), Yu (2005). Common to all these contributions is the assumption that the world consists of only two countries. This paper studies the robustness of the HME in a different direction.

In this paper, we provide a (partial) defence of the familiar dynamic HME by being more explicit on the concept of third country effects. Our basic model setup is taken directly from BLOT. Yet, BLOT's analysis is done entirely in terms of (expenditure and industry) *shares*. We will augment their approach and explicitly keep track of expenditure *levels*. Thereby we are able to separate two effects that are otherwise indistinguishable, but which are crucial for understanding third country effects. To simplify the analysis we limit ourselves and set the number of countries in the BLOT-model equal to three ($M = 3$).[2] The reason why we contemplate this special case is that it becomes almost impossible to derive and to illustrate general results in the M-country framework.[3] Although some conclusions can be generalized, it is therefore clear that our results pertain to the three-country case only. This limitation is in our view compensated, however, by several clear cut insights about the HME and the impact of third country effects, which point at mechanisms that will also be present in a model of higher dimensionality.

The first central result of this paper is that an increase in the domestic expenditure level, holding constant expenditure in all foreign economies, will unambiguously lead to an over-proportional domestic industry expansion (i.e., the dynamic HME). However, parallel developments in the foreign world can ''swamp'' this effect and make it immaterial. The intuition is that the spatial industry equilibrium depends on the entire distribution of expenditure across, and the economic accessibility of all countries. If third country effects harm the home country's industry, they weaken the positive effect that results from the own (domestic) expenditure increase, and – in effect – they may even cancel it out. This

2 Three-country models are of growing popularity in the ''new'' trade theory and have been used to address a number of related issues, for example, the ''hub effect'' (Krugman 1993). Krugman shows that if one country offers better accessibility than the other two, it will host a larger industry share even if all countries are of equal size.

3 This high complexity of general multi-country trade models where M countries of heterogeneous size and accessibility interact has been noted by BLOT in a follow-up paper (see Behrens et al. 2005b): ''no clear results on the impacts of expenditure shifting can be expected when there are more than three countries because the whole structure of trade costs affects the equilibrium outcome'' (p. 12). We will therefore present the simplest possible framework in which third country effects can arise, and which renders unambiguous and interpretable insights.

clarifies the notion of third country effects. The dynamic HME can in fact be generalized from a two-country to a multi-country model if there is only *one* exogenous parameter change: an increase in the expenditure level of the home country. The HME may only be overturn if there are *additional* parameter changes, namely perturbations of foreign expenditure levels, which have an independent effect on the domestic industry.

BLOT have forcefully shown that the dynamic HME can be a fundamentally flawed concept to guide empirical research that uses a time series or panel approach, because typically expenditure, size and production of *all* countries will change between any two points in time in real world data. This poses the conceptual identification problems, since it is required that the expenditure of only one country has changed ceteris paribus. The message of this paper is that there are instances where the dynamic HME can in fact be used, BLOT's results notwithstanding. For these instances it is crucial, however, that it is safe to neglect third country effects. There may have been some unique historical situations that are close to an exogenous expenditure increase of only one country (e.g., the German re-unification). Such quasi-natural experiments may be a promising, and methodologically sound alternative to identify the HME, although it is beyond the scope of this paper to apply such empirical methods.

The second contribution of this paper is to illustrate explicitly *what type* of third country effects can overturned the HME. BLOT suffice with the statement that there generally exists *some* foreign expenditure perturbation that can do this. To preview some scenarios, we show that an expenditure shift from one foreign economy to another, which per se does not change the domestic expenditure share, affects the domestic industry negatively if it goes from the more remote towards the better accessible economy. If this shift occurs parallel to an enlargement of the home country, the HME will only be "observable" if the increase of the domestic expenditure level is sufficiently large. Afterwards we look at a parallel expenditure increase in home and one foreign country. The HME might not be visible, despite an increase in the domestic expenditure share, if trade with the enlarged foreign country is sufficiently free. We shall discuss below that these results may give rise to independently testable hypotheses about the HME.

The rest of this paper is organized as follows. In Sect. 2, we present the basic model setup. In Sect. 3, we derive the condition for the validity of the HME in presence of third country effects, and analyze some specific cases. A conclusion is provided in Sect. 4.

2. The model

In this section we outline a simplified version of the multi-country model by BLOT, which is the basis for our analysis. The number of countries is set equal to $M = 3$.[4] Each country $i = 1, 2, 3$ is populated with L_i individuals, who inelastically supply one unit of labor. The world population has the size $\bar{L} = L_1 + L_2 + L_3$. Labor is the only factor of production, and immobile across countries. There are two industries, between which labor can move freely. In the perfectly competitive sector a homogenous good H_i is produced with a unit input requirement. This good can be shipped without transport costs. If this sector is active in all countries, which we will assume below, there is factor price equalization and the wage is equal to the numeráire everywhere.

The differentiated Dixit–Stiglitz sector is denoted by X_i. Every firm produces a single commodity and faces a fixed and a variable labor requirement (F and c, respectively). Profits must be non-positive due to potential entry of competitors. The total number of varieties and firms is determined endogenously by entry and exit, and is denoted by $\bar{N} = n_1 + n_2 + n_3$. Transportation across countries is subject to "iceberg" costs, where $\tau_{ij} > 1$ units have to be dispatched in country i for one unit to arrive in country j.

2.1 Demand and supply

Preferences are identical across countries and of a Cobb–Douglas type with CES sub-utility,

$$U_i = X_i^{\mu} \cdot H_i^{1-\mu}, \quad X_i = \left[\int_0^{\bar{N}} [x_i(\omega)]^{(\sigma-1)/\sigma} \cdot d\omega \right]^{\sigma/(\sigma-1)}, \tag{1}$$

$$0 < \mu < 1, \ \sigma > 1.$$

4 Readers familiar with the BLOT-model can jump directly to Sect. 2.2. We use here a simplified version with one monopolistically competitive sector only. In BLOT there is an arbitrary number of industries.

This preference structure yields the following aggregate demand from country j for a variety produced in country i

$$x_{ij} = \frac{p_{ij}^{-\sigma}}{P_j^{1-\sigma}} \cdot \mu \cdot E_j, \tag{2}$$

p_{ij} is the delivered price in country j (inclusive trade costs),[5] E_j is the aggregate consumption expenditure in country j, and P_j is the standard CES price index,

$$P_j = \left(\int_0^{\bar{N}} \left[p_{ij}(\omega) \right]^{1-\sigma} \cdot d\omega \right)^{1/(1-\sigma)} = \left(\sum_i n_i \cdot p_{ij}^{1-\sigma} \right)^{1/(1-\sigma)}. \tag{3}$$

We shall focus below on interior equilibria with factor price equalization. The formal condition for this case is that the expenditure share μ is not too large (see Appendix A). With wages equal to one, the profit function for a firm in country i is

$$\pi_i = \sum_j \left[\left(p_{ij} - c \cdot \tau_{ij} \right) \cdot \frac{p_{ij}^{-\sigma}}{P_j^{1-\sigma}} \cdot \mu \cdot E_j \right] - F, \tag{4}$$

where we have made use of aggregate demand (2). Maximizing (4) with respect to p_{ij}, while taking P_j as given (as it is commonly assumed in Chamberlinian models of monopolistic competition), yields the familiar rule that prices are a constant mark-up over marginal costs, $p_{ij} = (\sigma/(\sigma - 1)) \cdot c \cdot \tau_{ij}$. Inserting this in (4), and bearing in mind that profits must be non-positive in equilibrium, the scale of every active firm must satisfy $x_i \leq F(\sigma - 1)/c$, where $x_i = \sum_j \left(\tau_{ij} \cdot x_{ij} \right)$ is total firm production including the fraction lost in transportation. Using Eq. (2), the pricing rule, and the fact that $E_j = L_j$, the market clearing condition commands that

5 Due to symmetry all n_i firms from country i will charge the same producer price. The delivered price in country j is p_{ij} and we do not need firm subscripts.

$$\sum_j \left[\frac{\phi_{ij}L_j}{\sum_k \phi_{kj}\cdot n_k}\right] \leq \frac{\sigma F}{\mu} \quad \text{for } i = 1, 2, 3, \tag{5}$$

where $\phi_{ij} \equiv \tau_{ij}^{1-\sigma} \in [0,1]$ is the usual measure of trade freeness (trade "phi-ness") between countries i and j. If (5) holds with strict inequality for country j, $n_j = 0$ in equilibrium as no firm can break even in this location. Multiplying (5) by the positive n_i's, and summing across the three countries, the total number of firms in the modern sector can be derived. It is given by $\bar{N} = \mu\bar{L}/F\sigma$, which is fixed in equilibrium and proportional to world expenditure (or, respectively, to world population as labor supply and expenditure can be used interchangeably). This allows expressing the equilibrium conditions in terms of the exogenous expenditure shares $\theta_i = E_i/\bar{E} = L_i/\bar{L}$, and the endogenous production shares $\lambda_i = n_i/\bar{N}$. One obtains:

$$\sum_j \left[\frac{\phi_{ij}\theta_j}{\sum_k \phi_{kj}\cdot \lambda_k}\right] \leq 1 \quad \text{for } i = 1, 2, 3. \tag{6}$$

2.2 General equilibrium

An equilibrium condition like (6) has been derived by BLOT for the general case with M countries (see their eq. (8)). It consists of M equations and M unknowns, namely the countries' industry shares λ_i, given the exogenous distribution of expenditure (the θ_j's), and the economic accessibility of all countries ("geography" – the ϕ_{ij}'s). Referring to this equilibrium condition, BLOT prove that factor price equalization implies a unique and globally stable equilibrium distribution of the modern sector across countries (see their proposition 1). The formal condition is presented in our Appendix A, adapted for the three-country case. Assuming factor price equalization and focussing on interior equilibria with $0 < \lambda_i^* < 1$ for all countries i, BLOT are able to derive closed form solutions for the countries' equilibrium industry shares, see their eq. (14).

Using their results directly, we can write the equilibrium output share of the home country, λ_1^*, in the following convenient form (with analogous expressions for λ_2^* and λ_3^*):

$$\lambda_1{}^* = I_{11}\theta_1 + I_{12}\theta_2 + I_{13}\theta_3, \tag{7}$$

where

$$I_{11} = \frac{f_{11}}{f_{11} + f_{12} + f_{13}} = \frac{1 - (\phi_{23})^2}{1 - \phi_{12} - \phi_{13} + \phi_{12}\phi_{23} + \phi_{13}\phi_{23} - (\phi_{23})^2}, \tag{8}$$

$$I_{12} = \frac{f_{12}}{f_{21} + f_{22} + f_{23}} = \frac{-(\phi_{12} - \phi_{13}\phi_{23})}{1 - \phi_{12} + \phi_{12}\phi_{13} - (\phi_{13})^2 - \phi_{23} + \phi_{23}\phi_{13}}, \tag{9}$$

$$I_{13} = \frac{f_{13}}{f_{31} + f_{32} + f_{33}} = \frac{-(\phi_{13} - \phi_{12}\phi_{23})}{1 - (\phi_{12})^2 + \phi_{12}\phi_{13} - \phi_{13} - \phi_{23} + \phi_{23}\phi_{12}}. \tag{10}$$

We call the coefficients I_{1j} in (8)–(10) the "impact factor" that depicts how country j's expenditure share θ_j affects the domestic industry share λ_1^*. The impact factors depend on the bilateral levels of trade freeness only. They are determined by the cofactors (i, j) of the general (3×3) trade freeness matrix Φ, denoted by f_{ij}. It is assumed that $\phi_{ii} = 1$ and $\phi_{ij} = \phi_{ji}$, i.e., there are no trade costs inside one country, and trade freeness between any two countries does not depend on the direction of the trade flow. Moreover, the triangle inequality $\tau_{ij} < \tau_{ik} \cdot \tau_{kj} \Rightarrow \phi_{ij} > \phi_{ik} \cdot \phi_{kj}$ is required to hold: It is not cheaper for producers from country i to ship goods to j via country k.

Up to now, we have simply reproduced the model by BLOT for the case with $M = 3$. From now on, we will depart from the original by making use of the simplicity of the three-country case, which will allow us to derive some intuitive and clear results about the HME in the next section. One reason for this tractability is, in fact, that we can establish the following straightforward properties of the impact factors that will turn out to be useful below.

Lemma 1 (Impact factors):

(i) I_{11} is strictly positive, whereas both I_{12} and I_{13} are strictly negative.
(ii) If $\phi_{12} > \phi_{13}$, then $I_{12} < I_{13}$. If $\phi_{12} < \phi_{13}$, then $I_{12} > I_{13}$. If $\phi_{12} = \phi_{13}$, then $I_{12} = I_{13} < 0$.

Proof: See Appendix A.

3. When does the dynamic HME arise?

Reminiscent of BLOT's definition, the dynamic HME can be defined as follows, always with the understanding that the economy remains in an interior equilibrium:

Definition 1 (dynamic HME): The *X*-sector exhibits the dynamic HME in country *i* at the distribution $\{\theta_1, \theta_2, \theta_3\}$ and for the perturbation $d\theta$ if and only if $(d\lambda_i{}^*/d\theta_i) \cdot (\theta_i/\lambda_i{}^*) > 1$, where $d\theta$ is a small variation satisfying $d\theta_i > 0$ and $\sum_j \theta_j = 1$.

This definition of the HME has been proven insufficient in a multi-country world, because there always exists some perturbation $d\theta$ such that the industry reaction in country *i* is not over-proportional, despite an increase in the expenditure share ($d\theta_i > 0$). We now show for the three-country case why this is so, by disentangling the perturbation of expenditure *shares* ($d\theta$) into the changes of the countries' expenditure *levels*. For the dynamic HME to arise in the home country $i = 1$, the following must be true:

$$\frac{d\lambda_1{}^*}{d\theta_1} \cdot \frac{\theta_1}{\lambda_1{}^*} > 1 \quad \Leftrightarrow \quad \frac{d\lambda_1{}^*}{d\theta_1} > \frac{\lambda_1{}^*}{\theta_1} = \frac{I_{11}E_1 + I_{12}E_2 + I_{13}E_3}{E_1}, \tag{11}$$

where the expression for $\lambda_1{}^*/\theta_1$ follows directly from (7). Using (11) we can then derive the following general condition for the validity of the dynamic HME in a three-country model:

Proposition 1 (Dynamic HME in a three-country model):

Given expenditure levels $\{E_1, E_2, E_3\}$ and perturbations of those expenditure levels $\{dE_1, dE_2, dE_3\}$, the dynamic HME is valid if and only if the following condition is satisfied:

$$\frac{dE_1}{E_1} > \frac{I_{12} \cdot dE_2 + I_{13} \cdot dE_3}{I_{12} \cdot E_2 + I_{13} \cdot E_3} \equiv \Psi(\Phi, E_2, E_3, dE_2, dE_3). \tag{12}$$

Proof: Totally differentiating (7) yields

$$d\lambda_1{}^* = I_{11} \cdot d\theta_1 + I_{12} \cdot d\theta_2 + I_{13} \cdot d\theta_3. \tag{13}$$

By the definition of the expenditure share, $\theta_i = E_i/\bar{E}$, we have

$$d\theta_1 = \left(\frac{E_2 + E_3}{\bar{E}^2}\right) dE_1 - \left(\frac{E_1}{\bar{E}^2}\right)(dE_2 + dE_3), \tag{14}$$

$$d\theta_2 = \left(\frac{E_1 + E_3}{\bar{E}^2}\right) dE_2 - \left(\frac{E_2}{\bar{E}^2}\right)(dE_1 + dE_3), \tag{15}$$

$$d\theta_3 = \left(\frac{E_1 + E_2}{\bar{E}^2}\right) dE_3 - \left(\frac{E_3}{\bar{E}^2}\right)(dE_1 + dE_2). \tag{16}$$

Using (14)–(16) in (13), the change in λ_1^* can be written as

$$d\lambda_1{}^* = \frac{1}{\bar{E}^2} \begin{pmatrix} I_{11}((E_2 + E_3)dE_1 - E_1(dE_2 + dE_3)) \\ + I_{12}((E_1 + E_3)dE_2 - E_2(dE_1 + dE_3)) \\ + I_{13}((E_1 + E_2)dE_3 - E_3(dE_1 + dE_2)) \end{pmatrix}, \tag{17}$$

which together with (14) implies

$$\frac{d\lambda_1{}^*}{d\theta_1} = \frac{1}{(E_2 + E_3)dE_1 - E_1(dE_2 + dE_3)} \times \begin{pmatrix} dE_1[I_{11}(E_2 + E_3) - I_{12}E_2 - I_{13}E_3] \\ + dE_2[I_{12}(E_1 + E_3) - I_{11}E_1 - I_{13}E_3] \\ + dE_3[I_{13}(E_1 + E_2) - I_{11}E_1 - I_{12}E_2] \end{pmatrix}. \tag{18}$$

Combining (18) and (11), and using the results from Lemma 1 that $I_{12} < 0$ and $I_{12} < 0$, the condition (12) follows immediately. □

An over-proportional expansion of the domestic industry share arises if the relative increase of the home country's expenditure level (dE_1/E_1) exceeds some term $\Psi(\bullet)$ that depicts the relative expenditure increase of the foreign world corrected for accessibility differences.

In the two-country model by Krugman (i.e., with $E_3 = dE_3 = 0$) this condition would be satisfied whenever $dE_1/E_1 > dE_2/E_2$, i.e., for every $d\theta_1 > 0$. With at least three countries this need not be the case any longer, but it requires that dE_1/E_1 is sufficiently large. The reason is that an increase in the domestic expenditure share $d\theta_1 > 0$ can now be accompanied by a parallel increase in the expenditure share of *one* foreign economy. This foreign enlargement may imply an industry re-location into this market that is so substantial that it dominates the increase in the domestic market potential, provided the domestic expenditure increase is not as large as indicated by the threshold $\Psi(\cdot)$ given above. In effect, if the domestic enlargement falls short of this threshold, the home country ends up with an under-proportional, or even a negative industry reaction, because it is trapped in a "home market shadow" of the enlarged foreign economy. Intuitively, for this to occur, the foreign economy ought to be an attractive industry location. I.e., with increasing returns and transport costs in the monopolistically competitive sector, it ought to be well accessible so that the foreign size increase triggers strong endogenous relocation of the modern industry, reminiscent of the "home market magnification effect" that is familiar from the two-country model (see, e.g., Baldwin et al. 2003). Below we will illustrate some specific scenarios where the domestic HME is swamped. All these cases require, however, that the expenditure level increases not only in the home country, but also in one foreign country.

If there is actually just *one* exogenous change, namely an increase in the expenditure level of the home country, we can use (12) to establish the following important result:

Corollary 1 (Pure domestic expenditure increase without third country effects):
The dynamic HME unambiguously arises in a three-country model if the only exogenous parameter change is an increase in the domestic expenditure level.

This is readily shown because $\Psi(\cdot) = 0$ if $dE_2 = dE_3 = 0$, hence condition (12) is satisfied for any $dE_1 > 0$. The dynamic HME can, therefore, be generalized in a strict ceteris paribus sense. Notice also that this particular result will hold with more than three countries.[6] Hence, Corollary 1 suggests that the dynamic HME – which seems to be the traditional definition of this effect – can potentially be identified when exogenous third country effects do not arise. As argued in the

6 In a model with M countries, the equilibrium industry share (7) can also be written as $\lambda_1{}^* = \sum_{j=1}^{M} I_{1j}\theta_j$ (reminiscent of BLOT Eq. (14)). The threshold in (12) would become $\Psi(\cdot) = \sum_{j=2}^{M} (I_{1j}dE_j / I_{1j}E_j)$, hence it would be equal to zero if there is no expenditure level increase in any foreign country (i.e., if $E_j = 0\ \forall j \geq 2$). Corollary 1 therefore can give guidance for empirical research which naturally has to work in a multi-country context. It should be stressed, however, that the other corollaries below will not hold unambiguously with $M > 3$.

introduction, this may be challenging for empirical work in practice. But in the context of a quasi-natural experiment with an exogenous expenditure increase in only one country it would be methodologically safe to use the dynamic HME. It is beyond the scope of this paper to apply such empirical methods. We will rather take up the related issue and illustrate two specific scenarios in the remainder of this paper that show *how* parallel third country effects can overturn the HME.[7]

3.1 Foreign expenditure shift

The first specific type is a shift in expenditure from one foreign country to the other. Suppose that $dE_2 = -dE_3 = d\tilde{E}$, i.e., with $d\tilde{E} > 0$ we consider a shift from country 3 to country 2, and vice versa. This shift does not alter the domestic expenditure share θ_1. We first consider the effect of this shift on λ_1^* in isolation. Using (17) with $dE_1 = 0$ and $dE_2 = -dE_3 = d\tilde{E}$, the effect on the domestic industry share is given by

$$d\lambda_1{}^* = \frac{(I_{12} - I_{13})}{\bar{E}} d\tilde{E}. \tag{19}$$

Making use of Lemma 1 we know that $(I_{12} - I_{13}) < 0$ if $\phi_{12} > \phi_{13}$. Hence, $d\lambda_1{}^*/d\tilde{E} < 0$ if $d\tilde{E} > 0$. With $\phi_{13} > \phi_{12}$ we have $d\lambda_1^* > 0$ if $d\tilde{E} > 0$. That is, an expenditure shift towards (away from) the better accessible foreign economy negatively (positively) affects the industry share of the home country (λ_1^*) in an interior equilibrium. With $\phi_{12} = \phi_{13}$, $I_{12} = I_{13}$ and thus $d\lambda_1{}^*/d\tilde{E} = 0$.

Now think of an exogenous increase in the home country's size ($dE_1 > 0$) parallel to an expenditure shift towards the better accessible foreign economy (without loss of generality, country 2). With $dE_2 = -dE_3 = d\tilde{E} > 0$ the general condition for the HME, Eq. (12), reduces to

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7 Some further corollaries of condition (12) shall only be mentioned briefly here. If both foreign economies were equally well accessible ($\phi_{12} = \phi_{13}$), the HME would hold when the relative increase of domestic expenditure exceeds the relative increase of the "aggregate foreign country", $dE_1/E_1 > d(E_2 + E_3)/(E_2 + E_3)$. Assuming, alternatively, accessibility differences but equal initial size simplifies (12) to $dE_1 > (I_{12}/(I_{12} + I_{13}))dE_2 + (I_{13}/(I_{12} + I_{13}))dE_3$. This states that the absolute enlargement dE_1 must exceed the "trade-freeness weighted" average foreign enlargement, and implies validity of the HME for any $dE_1 > \max(dE_2, dE_3)$. In our analysis we shall allow for parallel heterogeneity of (initial) expenditure levels *and* geographical accessibility.

$$\frac{dE_1}{E_1} > \frac{I_{12} - I_{13}}{E_2 I_{12} + E_3 I_{13}} d\tilde{E} \equiv \hat{\Psi}\left(\Phi, E_2, E_3, d\tilde{E}\right). \tag{20}$$

The coefficient $\hat{\Psi}(\cdot)$ is strictly positive with $\phi_{12} > \phi_{13}$, hence (20) sets a lower bound for dE_1/E_1 in order for the HME to become visible. One can show that the minimum domestic expenditure increase $\hat{\Psi}(\cdot)$ must be the larger, the better accessible the foreign destination country of the shift, and the more remote the foreign country of origin (see Appendix B). This is so, because the isolated negative impact of the foreign expenditure shift is stronger negative, the larger is the difference in accessibility of the two foreign countries from a domestic point of view. It is also stronger negative the freer trade among the two foreign economies, because this will exacerbate the industry reallocation between them. Hence, the compensating domestic expenditure must be larger $\left(\partial\hat{\Psi}(\cdot)\big/\partial\phi_{23} > 0\right)$. To sum up, we have

Corollary 2 (HME with foreign expenditure shift):

For a given expenditure shift towards the better accessible foreign economy $(d\tilde{E} > 0)$, the increase in the domestic expenditure level (dE_1/E_1) must exceed the lower bound $\hat{\Psi}(\cdot) > 0$ given in Eq. (20) in order for the dynamic HME to be visible.

To grasp some intuition, one might think of the three countries as Germany, France and Great Britain. From Germany's point of view, France (country 2) is better accessible than Great Britain, e.g., due to the North Sea. If expenditure shifts from England to France, one would a priori expect two conflicting impacts on the German industry. One is positive, stemming from the fact that the market potential increases due to the larger effective market size, as French consumers can purchase German goods at lower transport costs than British consumers. The second impact is negative, because German producers are exposed to fiercer competition. Corollary 2 suggests that the German industry share will unambiguously decline, and implies that the pro-competitive effect dominates.[8] To compensate this, Germany's

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8 Equation (20) entails only the net effect on the domestic industry. To disentangle the two effects analytically one can refer to the equilibrium condition (5). An increase in L_2 with a parallel decrease in L_3 necessitates n_1 to go up (with $\phi_{12} > \phi_{13}$) in order for the left-hand side of the equation to stay constant. This is the increase in German market potential. On the other hand, an increase in n_2 with a parallel decrease in n_3 necessitates n_1 to go down (with $\phi_{12} > \phi_{13}$) for the left-hand side to stay constant. This is the competitive effect, which is the dominating one.

expenditure level – i.e., its market potential – must increase sufficiently for the HME to become visible. If the increase in German expenditure is too small, the German industry share will rise only under-proportionally or it may even decline.

3.2 Foreign expenditure increase

Another illustrative third country effect that can swamp the HME is a parallel increase in the expenditure level of one foreign economy. Suppose the expenditure level of, say, country 2, and of the home country increase, whereas the size of country 3 remains constant ($dE_3 = 0$). The domestic expenditure *share* θ_1 rises if

$$d\theta_1 > 0 \quad \Leftrightarrow \quad \frac{dE_1}{E_1} > \frac{dE_2}{E_2 + E_3}. \tag{21}$$

An increase of θ_1 would be sufficient for the HME in a two-country model. In the three-country case, it turns out that the increase of the domestic industry share λ_1^* can be less than proportional. Using (12) with $dE_2 > 0$ und $dE_3 = 0$, we find that the HME is going to be valid only if

$$\frac{dE_1}{E_1} > \frac{I_{12} \cdot dE_2}{E_2 I_{12} + E_3 I_{13}}. \tag{22}$$

It is straightforward to check that this lower bound for dE_1/E_1 is stricter than the one implied by (21) if I_{12} is stronger negative than I_{13}. Using Lemma 1 we know that $I_{12} < I_{13} < 0$ if country 2 is better accessible than country 3 from a domestic point of view ($\phi_{12} > \phi_{13}$). Hence, provided the enlarged foreign economy 2 is better accessible than the other foreign economy whose size does not change, there is always a range for the home countries' expenditure increase such that the HME does not occur *despite a rising domestic expenditure share*. This range is given by

$$\frac{dE_2}{E_2 + E_3} < \frac{dE_1}{E_1} < \frac{I_{12} \cdot dE_2}{E_2 I_{12} + E_3 I_{13}}. \tag{23}$$

It can be shown that the range described in (23) is larger, the higher is ϕ_{12}, the higher is ϕ_{23}, and the lower is ϕ_{13} (see Appendix C). This is so, because the *isolated* impact of $dE_2 > 0$ on λ_1^* is stronger negative the freer trade between country 2 and either country 1 or 3, due to the standard "home market magnification effect" for country 2. Similarly, the range in (23) is larger the lower is ϕ_{13}, because less industry reallocation takes place between countries 1 and 3 following the other exogenous change, $dE_1 > 0$. To sum up, we have

Corollary 3 (HME with foreign expenditure increase):
Suppose there is a parallel increase in the expenditure level of the home country and one foreign economy (country 2, without loss of generality) such that the domestic expenditure share θ_1 increases. Provided that country 2 is better accessible than country 3, there is always a range for the domestic expenditure increase, such that the HME does not arise.

This result is also illustrated in Fig. 1, which plots the German against the French enlargement for given initial sizes of all three countries. For any given $dE_2/(E_2 + E_3)$ the German expenditure share θ_1 rises if dE_1/E_1 is to the right of the 45°-line. However, the dynamic HME arises for Germany only if dE_1/E_1 is large enough to be located outside the shaded "cone" in that figure. If dE_1/E_1 lies inside the cone, which corresponds to the range given in (23), the German industry share rises under-proportionally despite an increase in the expenditure share. This is more likely to occur the freer German–French and British–French trade are, and the more restricted German–British trade is. That means the curve DHME becomes flatter with higher ϕ_{12} and ϕ_{23} and with lower ϕ_{13}, thereby enlarging the size of the "No HME"-cone.

This insight again neatly illustrates the usefulness of paying attention to expenditure levels. An increase in the domestic expenditure share

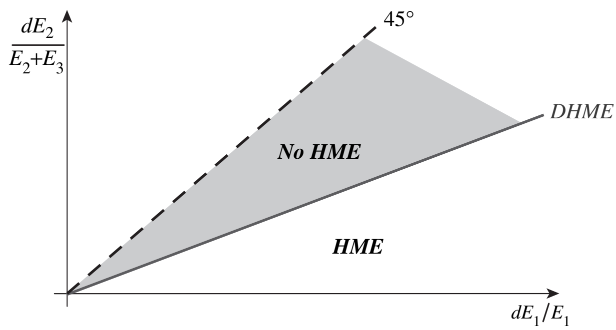

Figure 1

that is brought about by an *isolated* exogenous enlargement of the home country is always associated with the dynamic HME (see Corollary 1). However, a higher domestic expenditure share does not automatically imply the HME if there is a parallel increase in the expenditure level of the home country and the better accessible foreign economy. If France is an attractive industry location to begin with (which is likely if it is a well accessible "hub"), its expenditure enlargement induces a large industry re-location into France. This effect overlaps with the increase in the German market potential and throws an "home market shadow" over Germany, as mentioned above. Consequently, the dynamic HME will only arise if the German enlargement is sufficiently large.

Corollaries 2 and 3 are both examples where the dynamic HME is only observable for the home country if the domestic expenditure level increases sufficiently strongly. If for a given perturbation in foreign expenditure the increase of dE_1/E_1 is too small, say for example only 2%, the domestic industry share may only rise by 1% or it may even decline. However, if dE_1/E_1 rises stronger, say 5%, we may also observe an over-proportional domestic output expansion (say, by 7%). This suggests that there is a nonlinear (possible even non-monotonic) relationship between $d\theta_1$ and $d\lambda_1^*$. This may be a useful theoretical observation for applied, empirical work on the HME that may want to take possible nonlinearities into account.[9] Our Corollaries 2 and 3 also gives rise to independently testable hypotheses that future work could use. For example, we have argued that the attractiveness of a country as industry location declines as competition moves closer in economic-geographical terms – a scenario that might be investigated in border regions exposed to trade integration.

4. Conclusion

In this paper, we have presented a three-country version of the seminal model by Krugman (1980). If the expenditure level of the home country rises, holding constant expenditure in both foreign economies, there will always be an over-proportional domestic output expansion in the differentiated goods industry. However, parallel third country develop-

9 I owe these observations to one of the referees of this paper.

ments can overturn this effect. We have explicitly derived the type, and the necessary strength of these foreign expenditure perturbations.

Our paper partially defends the familiar dynamic definition of the HME as the basis for empirical research. At the same time it emphasizes that the identification strategy must properly control for parallel third country effects. Failure in doing so will result in biased estimates of the HME. One immediate consequence for applied empirical research is that identification of the dynamic HME is possible in a setting of a quasi-natural experiment where it is safe to neglect third country effects. Maybe the German re-unification can act as such an experiment where the size of just one country has changed. Empirical work in this direction seems to be a fruitful research agenda to complement BLOT's cross-section approach that relies on a static definition of the HME.

It should be noted that the three-country case abstracts from complications that would arise in a model with more countries, where results on the impact of third country developments (e.g., on a foreign expenditure shift) are not as unambiguous. Deriving entirely general results regarding the impact of foreign perturbations on the domestic industry in multi-country trade models appears to be almost impossible, however (Behrens et al. 2005b). Contemplating the simplest model in which third country effects can arise is useful for illustrating mechanisms that will also be relevant over certain (potentially large) parameter domains in the general case.

Appendix A

BLOT show that factor price equalization across countries requires that labor demand in the *X*-sector does not exceed the inelastic total labor supply in every country (see their appendix 1). Adjusted for the three-country case, the necessary and sufficient condition for existence, uniqueness and stability of interior equilibrium with $\lambda_i^* > 0$ for i = 1, 2, 3 reads as

$$0 < \mu \cdot \sum_{j=1}^{3} \frac{f_{ij}}{f_{1j} + f_{2j} + f_{3j}} \cdot \theta_j < \theta_i \quad \text{for } i = 1, 2, 3. \tag{24}$$

The share μ of the modern good must be sufficiently small for (24) to hold. This entails the following (weaker) necessary condition for an interior equilibrium: $\theta_i < \varphi_i$ for i = 1, 2, 3, where φ_i is the sum of the ith row elements of the inverse matrix $\varphi = \Phi^{-1}$. That is,

$$\theta_i < \varphi_i \equiv \frac{f_{i1} + f_{i2} + f_{i3}}{|\Phi|} \quad \text{for } i = 1, 2, 3 \tag{25}$$

must hold. BLOT furthermore show that the trade cost matrix Φ will be positive definite, hence the determinant $|\Phi|$ is strictly positive. Taking this into account, we can infer from (25) that

$$f_{i1} + f_{i2} + f_{i3} > 0 \quad \text{for } i = 1, 2, 3. \tag{26}$$

Equations (8)–(10) then imply that the signs of the impact factors I_{11}, I_{12} and I_{13} are determined solely by the signs of the cofactors f_{11}, f_{12} and f_{13}, respectively. We now consecutively prove the two parts of Lemma 1.

(i) Since $f_{11} = 1 - (\phi_{23})^2 > 0$, we have $I_{11} > 0$. Similarly, applying the triangle inequality $\phi_{ij} > \phi_{ik} \cdot \phi_{kj}$, both $f_{12} = \phi_{13}\ \phi_{23} - \phi_{12}$ and $f_{13} = \phi_{12}\ \phi_{23} - \phi_{13}$ must be strictly negative.
Hence, $I_{12} < 0$ and $I_{13} < 0$.

(ii) With $\phi_{12} > \phi_{13}$, the numerator of I_{12} must be stronger negative than the numerator of I_{13}, because $(\phi_{12}\phi_{23} - \phi_{13}) < (\phi_{13}\phi_{23} - \phi_{12}) < 0 \Leftrightarrow \phi_{23} < -1$ is a contradiction. Moreover, the (positive) denominator of I_{12}, $(1 - \phi_{13})(1 - \phi_{23} - (\phi_{12} - \phi_{13}))$, must be smaller than the (positive) denominator of I_{13}, $(1 - \phi_{12})(1 - \phi_{23} + (\phi_{12} - \phi_{13}))$, because both individual (positive) terms must be smaller. Hence, I_{12} is stronger negative than I_{13} if $\phi_{12} > \phi_{13}$, and vice versa. With $\phi_{12} = \phi_{13} = \phi$, we have $I_{12} = I_{13} = -(\phi/(1 - \phi)) < 0$.

Appendix B

Making use of (9) and (10) we find that

$$\frac{\partial \hat{\Psi}(\cdot)}{\partial \phi_{12}} = \frac{\phi_{13}(E_2 + E_3)\left(1 - (\phi_{23})^2\right)}{(E_2(\phi_{12} - \phi_{13}\phi_{23}) + E_3(\phi_{13} - \phi_{12}\phi_{23}))^2} > 0,$$

$$\frac{\partial \hat{\Psi}(\cdot)}{\partial \phi_{13}} = -\frac{\phi_{12}(E_2 + E_3)\left(1 - (\phi_{23})^2\right)}{(E_2(\phi_{12} - \phi_{13}\phi_{23}) + E_3(\phi_{13} - \phi_{12}\phi_{23}))^2} < 0,$$

$$\frac{\partial \hat{\Psi}(\cdot)}{\partial \phi_{23}} = \frac{(E_2 + E_3)(\phi_{12} + \phi_{13})(\phi_{12} - \phi_{13})}{(E_2(\phi_{12} - \phi_{13}\phi_{23}) + E_3(\phi_{13} - \phi_{12}\phi_{23}))^2} > 0 \quad \text{with } \phi_{12} > \phi_{13}.$$

Appendix C

Let $\breve{\Psi} \equiv \frac{I_{12}}{E_2 I_{12} + E_3 I_{13}}$. Making use of (9) and (10) we find that

$$\frac{\partial \breve{\Psi}}{\partial \phi_{12}} = \frac{\phi_{13} \cdot E_3 \left(1 - (\phi_{23})^2\right)}{\left(E_2(\phi_{12} - \phi_{13}\phi_{23}) + E_3(\phi_{13} - \phi_{12}\phi_{23})\right)^2} > 0,$$

$$\frac{\partial \breve{\Psi}}{\partial \phi_{13}} = -\frac{\phi_{12} \cdot E_3 \left(1 - (\phi_{23})^2\right)}{\left(E_2(\phi_{12} - \phi_{13}\phi_{23}) + E_3(\phi_{13} - \phi_{12}\phi_{23})\right)^2} < 0,$$

$$\frac{\partial \breve{\Psi}}{\partial \phi_{23}} = \frac{E_3(\phi_{12} + \phi_{13})(\phi_{12} - \phi_{13})}{\left(E_2(\phi_{12} - \phi_{13}\phi_{23}) + E_3(\phi_{13} - \phi_{12}\phi_{23})\right)^2} > 0 \quad \text{with } \phi_{12} > \phi_{13}.$$

Acknowledgements

The author is grateful to three anonymous referees, Kristian Behrens, Marius Brülhart, Wilfred Ethier, Martin Kolmar, Gianmarco Ottaviano, Michael Pflueger, Philipp Schroeder, Albert Schweinberger and Takatoshi Tabuchi for helpful comments and suggestions. All remaining errors and shortcomings are solely my responsibility. This work was supported by a grant from the Ministry of Science, Research and the Arts of Baden-Württemberg (Az: 21-655.042-5-2/1) to Jens Suedekum.

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