The Trade and Welfare Effects of Mergers in Space*

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Abstract

This paper analyzes the consequences of cross-border mergers in a spatial framework, thereby distinguishing three channels of influence: a price increase due to the elimination of product market competition, an adjustment in plant location which reduces overall transportation cost expenditures, and a harmonization in production costs due to a technology transfer within the firm. The welfare analysis illustrates that larger countries are better off after the merger. By contrast, smaller countries may lose, if the pre-merger production cost differential across firms is negligible and/or a post-merger technology transfer across production sites is infeasible. Furthermore, the analysis provides novel insights into the trade pattern effects of a merger. One important result of the paper is that an adjustment of plant location in space can reverse the direction of (net) trade flows.

Key words: Spatial competition; Cross-border merger; Trade pattern; Welfare analysis

JEL classification: F12; F23; L10

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1 Introduction

It is now well established that cross-border mergers are the predominant form of foreign direct investment (FDI). In particular, there is overwhelming empirical evidence that cross-border mergers outnumber foreign greenfield investments and that their share in overall FDI has considerably increased in recent years (UNCTAD, 2007). Despite this empirical regularity, "the theoretical literature on cross-border mergers is tiny, both in absolute terms and relative to the enormous literature on greenfield FDI" (Neary, 2007, p. 1229). It is therefore not surprising that key issues with cross-border mergers are still unexplored. To be more specific, while existing studies emphasize the role of international trade costs and trade as well as competition policy for understanding the patterns of cross-border mergers, an analysis of spatial aspects of mergers in a setting where countries have a geographical dimension is missing so far.[1]

The conclusion that a rigorous treatment of merger effects requires a detailed analysis of spatial implications can be deduced from the empirical observation that "firms that have been involved in a merger or an acquisition are much more likely to relocate than other firms" (Brouwer, Mariotti, and van Ommeren, 2004, p. 345).[2] The relevance of such relocations for the existence of merger gains has been put forward by recent

[1] Falvey (1998), Huck and Konrad (2004), and Saggi and Yildiz (2006) study the interaction between national policy and cross-border mergers. Horn and Persson (2001) and Bjorvatn (2004) have elaborated on the differential impact that changes in trade costs exhibit on the incentives for greenfield FDI and the acquisition of existing plants. They argue that, contrary to the tariff-jumping argument, cross-border mergers may be stimulated by a decline in international trade costs. In a similar vein, Neary (2003, 2007) shows that trade liberalization may trigger merger waves. However, in contrast to previous work he uses a general oligopolistic equilibrium framework and thus allows for income and factor price effects. Hijzen, Görg, and Manchin (2008) provide empirical support for a negative relationship between trade costs and mergers. Aside from these policy-related determinants of foreign investment, Nocke and Yeaple (2007, 2008) have pointed to the role of firm-specific characteristics for explaining the patterns of cross-border mergers and greenfield FDI.

[2] This finding is consistent with the evidence that branch plants of multiplant firms are considerably more geographically mobile than single plant firms (see Siegfried and Sweeney, 2006, p. 89).

theoretical work on the matter (Norman and Pepall, 2000; Posada and Straume, 2004; Cosnita, 2005).[3] However, the existing studies do not account for cross-border mergers which, according to Horn and Stennek (2007), is unsatisfying because these studies cannot contribute to our understanding of one aspect of mergers that is particularly relevant in the context of European merger policy: cross-border relocation of plants and its implication for national welfare and international trade.

Spatial aspects of countries play in general only a minor role in international economic theory. And the small number of existing studies has focused on trade rather than foreign investment. Tharakan and Thisse (2002) crafted a variant of Hotelling's (1929) line model to consider the role of *intra*national transport costs and country size for firm location and the pattern of cross-border goods trade.[4] Egger and Egger (2007) have extended this model to account for international and intranational outsourcing. A seminal contribution to the literature on trade in a spatial setting is Rossi-Hansberg (2005), who considers a continuum of regions (countries) on a line to investigate the relationship between the spatial distribution of economic activity and the trade pattern. A shortcoming of these and related spatial models of international trade is that they do not consider cross-border mergers.

It is the purpose of this paper to link the literature on cross-border mergers to recent work on trade in a spatial model à la Hotelling. The starting point of our analysis is the long-run free trade equilibrium in Tharakan and Thisse (2002) with two unequally sized countries (represented by differently sized segments of a line), quadratic transport costs, and two firms – one located at the Western bound and the other one at the Eastern

[3]Interestingly, in the economic geography literature post-merger plant relocations have been treated as an important fact for years. Green and Cromley (1982, p. 361) emphasize for instance that "[t]he period of post-acquisition integration usually involves not only the reorganization of managerial control and changes in product lines but also a rearrangement in the location of factories and other corporate functions."

[4]Shachmurove and Spiegel (1995) have also used the Hotelling line to study the consequences of trade liberalization in a spatial framework. However, as pointed out by Tharakan (2001), the equilibrium analyzed there does not exist due to the assumption of linear transport costs.

bound of Hotelling's line, respectively. Unlike Tharakan and Thisse (2002), we allow for differences in the production costs of the two firms. In this setting, a (horizontal) merger between the two firms gives rise to three sources of profit gains: (i) higher prices due to reduced product market competition; (ii) a relocation of production sites to reduce transport costs; and (iii) the use of the best-practice technology across production plants rather than the locally available one. While sources (i) and (iii) have been highlighted in the existing merger literature (see Neary, 2007, for an overview), the second source of profit gain points to a new – and at least in the literature dealing with cross-border mergers so far unexplored – channel of influence, which is strictly spatial in nature.[5]

A comparison of the equilibrium with independent (strategic) firm decisions and the equilibrium with joint profit maximization under the umbrella of an integrated firm provides the following insights regarding the possible merger-induced trade and welfare effects. First, the trade pattern in our model is determined by a non-trivial interplay of size and technology differences. And, for certain parameter domains, a merger may lead to a reversal of the direction of (net) trade flows. We characterize these domains and develop a measure for the "likelihood of a trade reversal". We also discuss the relationship between the likelihood of a trade reversal and the (ex ante) cost differential between firms.[6] Second, the welfare analysis confirms the well-established result that a merger leads to profit gains which come at the cost of a loss in consumer surplus due to market

[5]It is worth noting that, by choosing a Hotelling framework, we conduct our analysis in a setting with price competition. Significant differences between models of price competition and ones of quantity competition with regard to possible merger gains are well understood in industrial economics. See Salant, Switzer, and Reynolds (1983), Deneckere and Davidson (1985) for two influential contributions on that matter. However, in our framework this distinction plays a minor role, since a merger induces a monopolization of the product market with a single integrated firm serving all consumers *ex post*. In this case, a merger is always profitable, irrespective of the prevailing mode of product market competition.

[6]It is also worth noting that the merged firm may find it optimal to locate a production plant in either of the two countries and still trade the homogeneous good. Hence our spatial approach offers an explanation for simultaneous horizontal bilateral trade and horizontal multiplant activity. Despite its empirical support, this property is typically absent from existing models of horizontal multinational activity (see, e.g., Markusen and Venables, 1998, 2000)

monopolization. Overall welfare increases due to lower transport costs after an adjustment in firm location and/or due to the transfer of the best-practice technology across production sites. Furthermore, the merger-induced welfare gain rises with the pre-merger cost differential between the two firms. While this outcome is less surprising in the case of a technology transfer, it also holds if a technology transfer is excluded and the two plants differ in their production costs before and after the merger. The reason is that the integrated firm can relocate its production sites in order to (further) increase the market share of its low-cost plant. This points to a so far unexplored channel through which a merger influences welfare: adjustments of plant location in space.

Assuming that total profit income is equally distributed among consumers, we can also derive national (regional) welfare effects. In this respect, the main finding of our analysis is that a country tends to be worse off after the merger if it is sufficiently small and production cost differences are not too large. Again, it is the adjustment of firm location – and the associated increase of transport cost expenditures for consumers at the Eastern and Western end of the Hotelling line – which is responsible for this result.[7] Only if cost differences are sizable and a merger leads to a technology transfer with the best-practice technology being used in both production facilities, a welfare increase in every country is guaranteed, irrespective of the prevailing size differences.

The remainder of the paper is organized as follows. In Section 2, we set up the basic model with free trade and two (independent) firms. The impact of a merger on plant location, prices, welfare and trade pattern is at the agenda of Section 3. There, we distinguish three scenarios. In the first scenario, we assume that firms do not differ in their production costs, in order to obtain a benchmark for the possible merger effects. In scenario two, we consider production cost differences but exclude the possibility of a

[7] Since in our analysis the small country is at risk of losing the local producer after the merger, our welfare results are in line with the respective claim in Horn and Stennek (2007) that cross-border mergers may be detrimental for EU member countries due to adverse international plant relocation. However, our framework gives a more sophisticated picture because it allows us to identify winners and losers within the countries under consideration.

technology transfer. The impact of a technology transfer is addressed in scenario three. A distinction between these three scenarios is useful because it allows us to separate different channels of influence and derive a detailed picture of the possible merger effects in a Hotelling framework. Section 4 provides a short summary and some concluding remarks.

2 Basic model set-up: free trade with two firms

Consider a spatial model à la Hotelling with two producers, one operating in the West (W) and one in the East (E). Producer ℓ is located at address x_ℓ on a line of length one: $x_\ell \in [0,1]$, $\ell = W, E$. x_W is the location of the Western producer: $x_W < x_E$.[8] Firms may differ in their marginal production costs, while fixed firm set-up costs are identical and normalized to zero for the sake of simplicity. Without loss of generality, we can associate the Western firm with the technologically advanced producer and normalize its marginal production costs to zero. The marginal production costs of the Eastern firm are denoted by $c \geq 0$.

There is a unit mass of consumers which is uniformly distributed over the unit interval. Consumers make a binary choice of purchasing one unit of the consumption good or nothing. They are identical with respect to their willingness to pay which we denote by A. A consumer's address is $b \in [0,1]$. The two producers set mill prices p_ℓ and consumers have to bear the shipping costs of $(b - x_\ell)^2$, which are quadratic in order to ensure existence of an equilibrium (see d'Aspremont, Gabszewicz, and Thisse, 1979). Accordingly, the consumer price equals $p(b, x_\ell) = p_\ell + (b - x_\ell)^2$ for a consumer at address b who purchases the good from a producer located at x_ℓ.

By maximizing utility, consumers choose the supplier who offers the lower consumer price. To focus on the relevant aspects of the model, we impose two further assumptions. First, the willingness to pay (A) is sufficiently high to ensure full coverage of consumers in equilibrium: $A > 5/4 + c/2 + c^2/36$. Second, production cost differences are sufficiently

[8] In the borderline case of $x_W = x_E$, the model reduces to one with perfect price competition.

small to guarantee positive demand for each of the two producers in equilibrium: $c \leq 6 - \sqrt{27}$.[9] In this case, consumer demand for output of the two firms is determined by the indifference condition $p(b_i, x_W) = p(b_i, x_E)$, which characterizes the address of the "marginal consumer":

$$b_i = \frac{x_W + x_E}{2} + \frac{p_W - p_E}{2(x_W - x_E)}. \tag{1}$$

Consumer demand for the producer with address x_W is given by $d_W = b_i$, while consumer demand for its competitor with address x_E is given by $d_E = 1 - b_i$. The corresponding profits of the two producers are

$$\pi_W = p_W b_i \tag{2}$$

$$\pi_E = (p_E - c)(1 - b_i). \tag{3}$$

Profit maximization entails two stages. The producers choose their location in the first stage and set prices subsequently. The maximization problem can be solved through backward induction. For given locations, the price reaction functions are

$$p_W = \frac{p_E}{2} + \frac{(x_E - x_W)(x_W + x_E)}{2} \tag{4}$$

$$p_E = \frac{p_W + c}{2} + \frac{(x_E - x_W)[2 - (x_W + x_E)]}{2}, \tag{5}$$

according to (1)-(3). The two reaction functions confirm the well-known result that mill prices are strategic complements. By virtue of (4) and (5), sub-game-perfect equilibrium prices at stage two are given by

$$p_W^*(x_W, x_E) = \frac{c}{3} + \frac{(x_E - x_W)(2 + x_W + x_E)}{3} \tag{6}$$

$$p_E^*(x_W, x_E) = \frac{2c}{3} + \frac{(x_E - x_W)[4 - (x_W + x_E)]}{3}. \tag{7}$$

Substituting (6) and (7) in (1), we can express the marginal consumer's address as a function of firm location:

$$b_i^*(x_W, x_E) = \frac{c}{6(x_E - x_W)} + \frac{2 + x_W + x_E}{6}. \tag{8}$$

[9] See the proof of Proposition 1 in the Appendix for a formal derivation of these conditions.

Furthermore, substituting (6)-(8) in (2) and (3), we can express profits as a function of x_W and x_E:

$$\pi_W^*(x_W, x_E) = \frac{1}{18(x_E - x_W)} \left\{c + 2(x_E - x_W) + (x_E^2 - x_W^2)\right\}^2 \tag{9}$$

$$\pi_E^*(x_W, x_E) = \frac{1}{18(x_E - x_W)} \left\{-c + 4(x_E - x_W) - (x_E^2 - x_W^2)\right\}^2. \tag{10}$$

Solving for the profit-maximizing firm locations and using superscript n to refer to an equilibrium with independent producers (no merger), the following proposition can be established.

Proposition 1 *Consider $A > 5/4 + c/2 + c^2/36$ and $c \leq 6 - \sqrt{27}$. Then, the two firms locate at the boundaries of the unit interval ($x_W^n = 0$, $x_E^n = 1$), the marginal consumer resides at address $b_i^n = 1/2 + c/6$, prices are given by $p_W^n = 1 + c/3$, $p_E^n = 1 + 2c/3$, and profits are given by $\pi_W^n = (3 + c)^2/18$, $\pi_E^n = (3 - c)^2/18$, respectively.*

Proof. See Appendix. ■

Proposition 1 confirms the well-known result of maximum differentiation (in firm location) if transport costs are quadratic (see d'Aspremont, Gabszewicz, and Thisse, 1979). In addition, we see that an increase of production cost parameter c not only leads to a higher mill price of the Eastern producer, but also implies a higher mill price of the Western firm, as prices are strategic complements. However, the price increase of the Eastern firm is larger, so that the marginal consumer moves eastwards. As a consequence, the market share of the Western firm increases, while the market share of the Eastern firm declines.

In the following, we associate the Hotelling line with two integrated countries – thereby abstracting from any additional costs of shipping goods across the common border. The Western country is of length $r \in (0, 1)$ and the Eastern one of length $1-r$. In this case, the trade pattern depends on the location of the common border at r relative to the address of the marginal consumer. If $b_i^n > r$, the Western country exports the consumption good, while the Eastern country exports, if $b_i^n < r$. In the case of identical production costs ($c = 0$), it is the smaller country that exports due to lower transport costs for serving consumers at the common border (see Tharakan and Thisse, 2002). However, in the case of cost asymmetries the differential $c > 0$ matters as well (see Egger and Egger, 2007).

A final element we are interested in is welfare, which, of course, depends on the profit maximizing location and price choices of firms. To be more specific, overall (world) welfare equals the sum of total profits $\Pi^n \equiv \pi_W^n + \pi_E^n = 1 + c^2/9$ and consumer surplus CS:

$$\begin{aligned} CS^n &= \int_0^{b_i^n} [A - p_W^n - b^2] db + \int_{b_i^n}^1 [A - p_E^n - (1-b)^2] db \\ &= A - 4/3 - c/3 + (1/2 - c/6)^2. \end{aligned} \tag{11}$$

Hence, overall welfare is

$$V^n = A - 1/12 - c/2 + 5c^2/36. \tag{12}$$

It is intuitive that welfare declines in cost parameter c, because a higher c can be associated with a less efficient technology in the East.

To determine national welfare levels, the ownership structure of firms is important. For simplicity, we assume that ownership of firms (and thus total profit income Π^n) is equally distributed among consumers.[10] Then, profit income in the Western country is given by $r\Pi^n$, while profit income in the Eastern country equals $(1-r)\Pi^n$. Noting further that national consumer surplus in W is given by

$$CS_W^n(r) = \begin{cases} [A - c/3 - 1]r - r^3/3 & \text{if } r \leq b_i^n \\ [A - c/3 - 1]r - r^3/3 + (r - 1/2 - c/6)^2 & \text{if } r > b_i^n \end{cases} \tag{13}$$

and

$$CS_E^n(r) = \begin{cases} (A - c/3 - 1)(1-r) + (1/2 - c/6)^2 - 1/3 + r^3/3 & \text{if } r \leq b_i^n \\ [A - 2c/3 - 1 + r](1-r) - 1/3 + r^3/3 & \text{if } r > b_i^n \end{cases}, \tag{14}$$

[10]Note that this assumption differs from the respective assumption in Tharakan and Thisse (2002), where firm ownership is country-specific. In the context of mergers, however, our approach is more convenient, because it does not require any further assumptions about the international distribution of merger gains. Similar assumptions regarding firm ownership can be found in the literature on international tax competition. See Haufler and Schjelderup (2000) for an example.

we obtain

$$V_W^n(r) = \begin{cases} [A - c/3 + c^2/9]r - r^3/3 & \text{if } r \leq b_i^n \\ [A - c/3 + c^2/9]r - r^3/3 + (r - 1/2 - c/6)^2 & \text{if } r > b_i^n \end{cases} \tag{15}$$

and

$$V_E^n(r) = \begin{cases} (A - c/3 + c^2/9)(1 - r) + (1/2 - c/6)^2 - 1/3 + r^3/3 & \text{if } r \leq b_i^n \\ [A - 2c/3 + c^2/9 + r](1 - r) - 1/3 + r^3/3 & \text{if } r > b_i^n \end{cases} \tag{16}$$

for the national welfare levels in W and E, respectively.

This completes our discussion of the pre-merger equilibrium. In the next section, we investigate how a merger (and thus joint profit maximization) affects location and price decisions. We also analyze to which extent a technology transfer and the use of the best-practice technology in both production plants influences these decisions. Furthermore, we compare welfare and the trade pattern in the pre- and post-merger equilibrium.

3 A merger between the two firms

To draw a comprehensive picture of the possible merger effects, we distinguish three alternative scenarios. In the first one, we assume that $c = 0$ holds both before and after the merger. This benchmark analysis allows us to investigate in detail how changes in the location decision and the price-setting behavior of firms affect the variables of interest. In the second scenario, we allow for technology differences and consider asymmetric production costs which are the same before and after the merger takes place: $c > 0$. In the third scenario, we account for production cost differences in the pre-merger case, $c > 0$, and assume that the merger leads to a harmonization of production costs: $c = 0$. A comparison of the second and the third scenario highlights the consequences of a technology transfer.

3.1 Costs are identical ex ante and ex post

If $c = 0$, firms do not differ in their production costs. They set identical prices ($p_W^n = p_E^n = 1$) and realize the same level of profits ($\pi_W^n = \pi_E^n = 1/2$) in the pre-merger equilibrium (see Proposition 1). The two producers share the market equally ($b_i^n = 1/2$), so that it is the smaller country, i.e., country W if $r < 1/2$ and country E if $r > 1/2$, that exports the consumption good. This corresponds to the case of a long-run free trade equilibrium in Tharakan and Thisse (2001). Fig. 1 gives a graphical representation of the price-location schedules in the pre-merger equilibrium (dashed lines).

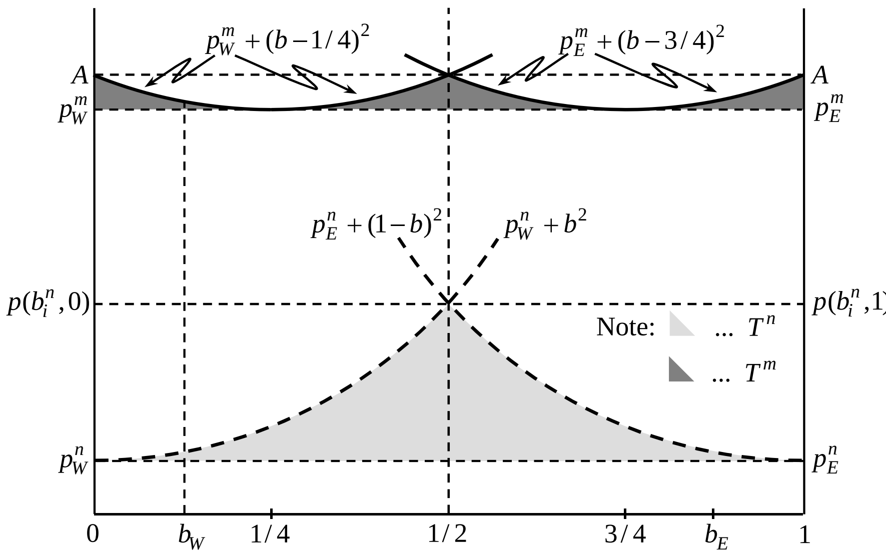

Figure 1: Price location schedules in the pre- and post-merger equilibrium if production costs do not differ across firms.

A merger between the two firms leads to a monopolization of the market and, therefore, to higher mill prices. By maximizing joint profits, the integrated firm increases prices until the most distant consumer that is served from a particular plant is indifferent between purchasing and not purchasing the consumption good. In addition, moving both production sites to the interior of the market reduces transport costs and allows for a further increase in the mill prices. If production costs are identical, the integrated firm will choose those locations for its two production facilities, which minimize overall transport cost expenditures.[11] Altogether, joint profit-maximization leads to plant locations $x_W^m = 1/4$, $x_E^m = 3/4$ and prices $p_W^m = p_E^m = A - 1/16$ (with superscript m referring to a post-merger equilibrium variable). In this case, the marginal (most distant) consumer resides at address $b_i^m = 1/2$ and there is full coverage in equilibrium. The corresponding profits are given by $\Pi^m = A - 1/16$.

Comparing profits in the post-merger equilibrium, Π^m, with total profits in the pre-merger situation, $\Pi^n = 1$, we can see that a merger leads to profit gains of $\Delta\Pi \equiv \Pi^m - \Pi^n = A - 17/16 > 0$. Aside from this positive profit effect, a merger also influences consumer surplus, with the respective change being given by[12]

$$\begin{aligned}\Delta CS &= 17/16 - A + \int_0^{1/2} [b/2 - 1/16]\, db + \int_{1/2}^{1} [7/16 - b/2] \\ &= 18/16 - A, \end{aligned} \tag{17}$$

which is negative if $A > 5/4 + c/2 + c^2/36$. Hence, a merger between the two firms exhibits two counteracting effects on overall (world) welfare. On the one hand, it raises profit income Π, but on the other hand, it reduces consumer surplus CS. For given aggregate demand, the profit gain dominates the consumer surplus loss, implying that overall welfare increases:

$$\Delta V \equiv \Delta CS + \Delta\Pi = 1/16 > 0. \tag{18}$$

This welfare increase is due to a decline in overall transport cost expenditures and equals $\Delta T \equiv T^n - T^m$ in Fig. 1.

[11] This refers to one crucial difference between mergers in spatial and nonspatial models. As pointed out by Norman and Pepall (2000, pp. 668f): "[I]n contrast to the standard nonspatial Cournot model, a merger between two firms need not result in one of them effectively being shut down. Rather, a merger between two firms allows them to coordinate their location decisions (...)". However, as discussed in the more general setting with cost asymmetry in section 3.2, the number of active plants in the post-merger equilibrium crucially depends on the size of c, i.e. the extent of production cost difference.

[12] The consumer surplus in the pre-merger equilibrium is given by $CS^n = A - 13/12$, according to (11), while the consumer surplus in the post-merger equilibrium equals $CS^m = \int_0^{1/2} \left[1/16 - (b - 1/4)^2\right] db + \int_{1/2}^{1} \left[1/16 - (b - 3/4)^2\right] db = 1/24$. Noting $\Delta CS \equiv CS^m - CS^n$, the second line in (17) follows immediately.

The increase in overall (world) welfare, however, does not mean that both countries can equally participate in the respective gains. To determine the national welfare effects, let us first look at consumer surplus changes in the Western economy. They are given by

$$\Delta CS_W(r) = \begin{cases} (17/16 - A)r + (r/4)\,[r - 1/4] & \text{if } \; r \in [0, 1/2] \\ (24/16 - A)r - r^2/4 - 1/8 & \text{if } \; r \in (1/2, 1]. \end{cases} \tag{19}$$

Noting further that profit gains in W equal $\Pi_W(r) = [A - 17/16]r$, we find that welfare effects in the Western economy are given by

$$\Delta V_W(r) = \begin{cases} (r/4)\,[r - 1/4] & \text{if } \; r \in [0, 1/2] \\ (7/16)r - r^2/4 - 1/8 & \text{if } \; r \in (1/2, 1]. \end{cases} \tag{20}$$

By virtue of (20), we can conclude that the Western country is worse off after the merger if $r < 1/4$, while it benefits from the merger if $r > 1/4$.[13] From Fig. 1, we see that consumers on interval $[0, b_W)$ experience a transport cost increase after the merger, as the Western production facility moves eastwards. This group of individuals definitely loses, while consumers on interval (b_W, b_E) gain, as their transport cost expenditures decline. Hence, it is intuitive that there exists a critical country size for welfare gains from a merger. Due to a quadratic shape of the transport cost function, this critical country size is smaller than 1/2. If $r = 1/4$, total transport cost expenditures of W are the same in the pre- and post-merger equilibrium, implying that in this particular case the merger does not affect welfare in the Western economy. However, if $r > (<) 1/4$ total transport costs decline (increase) so that welfare in W is higher (lower) in the post-merger equilibrium. Due to symmetry in the production costs, we can also conclude that the Eastern economy is better off after the merger if $r < 3/4$, while it is worse off if $r > 3/4$.

A final issue we need to address is the impact of a merger on the direction of trade. From Fig. 1 we see that the merger does not influence the position of the marginal

[13] From the first line of (20), it is immediate that $\Delta V_W(r)$ is negative if $r \in (0, 1/4)$, while $\Delta V_W(r)$ is positive if $r \in (1/4, 1/2]$. Furthermore, defining $B(r) \equiv (7/16)r - r^2/4 - 1/8$, with $B'(r) >, =, < 0 \iff 7/8 >, =, < r$ and noting $B(1/2) = 1/32 > 0$, $B(1) = 1/16 > 0$, we can conclude that $\Delta V_W(r) > 0$ holds for all $r \in (1/2, 1]$.

consumer, i.e., $b_i^n = b_i^m = 1/2$. Hence, recollecting from above that the small country exports the consumption good in the pre-merger equilibrium, it is immediate that the direction of trade is unaffected by the merger, as long as $1/4 < r < 3/4$. In this case, the Western production plant remains located in the Western country and the Eastern production plant remains located in the Eastern country. If, however, $r < 1/4$ or $r > 3/4$, the smaller country loses its production facility and, thus, becomes an importer of the consumption good. In this case, a merger reverses the direction of trade.

Proposition 2 summarizes the most important results of the previous analysis.

Proposition 2 *If $c = 0$, a merger raises profits, reduces consumer surplus and increases overall (world) welfare. If $1/4 < r < 3/4$ both countries benefit from the merger and the smaller country exports the consumption good in the pre- as well as the post-merger equilibrium. On the contrary, if $r < 1/4$ ($r > 3/4$), welfare declines in the small Western (Eastern) country and the direction of trade is reversed.*

Proof. Analysis in the text. ■

While the assumption of equal production costs provides an interesting benchmark for our analysis, it seems natural from the viewpoint of empirical facts to allow for production cost differences across firms. Therefore, in a next step we investigate how the results in Proposition 2 change if $c > 0$.

3.2 Costs are different ex ante and ex post

If $c > 0$, the more productive Western producer sets a lower mill price, serves a larger share of consumers and earns higher profits in the pre-merger equilibrium: $p_W^n < p_E^n$, $b_i^n > 1/2$ and $\pi_W^n > \pi_E^n$, according to Proposition 1. In addition, there may be exports of W even if it is the larger country. To be more specific, W exports the consumption good, as long as $r < b_i^n$, with $b_i^n > 1/2$ if $c > 0$.

The analysis of the post-merger equilibrium becomes somewhat more complicated than the respective analysis in Subsection 3.1. In particular, we can distinguish between three sources of profit gains if $c > 0$. First, for a given location choice, the integrated producer can increase either mill price, because $p(b_i^n, 0) = p(b_i^n, 1) < A$ if $A > 5/4 + c/2 + c^2/36$. Second, by moving both production sites to the interior of the market, overall transport costs decline, so that mill prices can be further increased without reducing overall consumer demand. Third, in addition to these two types of profit gains, which are also present in the case of identical production costs, the integrated firm has an incentive to increase the market share of its low-cost Western production facility: $d_W > b_i^n$. Two subcases can be distinguished with respect to the size of d_E, i.e., the market share of the Eastern production facility. If the production cost disadvantage of the Eastern plant is sufficiently small ($0 < c < 3/4$), the integrated firm will operate two production plants at locations $x_W \in (1/4, 1/2)$ and $x_E = (3/4, 1)$, respectively. In this case, we have $d_E > 0$. If, however, production cost differences are sizable ($3/4 \leq c \leq 6 - \sqrt{27}$), the integrated firm shuts down the Eastern production facility and serves all consumers from the center of the market to minimize overall transport costs: $x_W = 1/2$. This implies $d_W = 1$ and $d_E = 0$. We discuss these two subcases, separately.

Case I: $0 < c < 3/4$

If the integrated firm operates two production plants, it serves consumers on interval $[0, b_i]$, with $0 < b_i < 1$, from its Western production facility and consumers on interval $(b_i, 1]$ from its Eastern production facility. In this case, profit-maximization leads to plant locations[14] $x_W = b_i/2$, $x_E = 1/2 + b_i/2$, prices $p_W = A - b_i^2/4$, $p_E = A - (1 - b_i)^2/4$, and joint profits $\Pi = A - c - 1/4 + b_i(c + 3/4) - 3b_i^2/4$. Differentiating the latter expression, with respect to b_i, we can conclude that $b_i < 1$ requires $c < 3/4$. In this case, the marginal consumer has address $b_i^m = 1/2 + 2c/3$, the two production plants are located at $x_W^m = 1/4 + c/3$, $x_E^m = 3/4 + c/3$, respectively, mill prices are given by $p_W^m = A - (1/4 + c/3)^2$, $p_E^m = A - (1/4 - c/3)^2$ and joint profits equal $\Pi^m = A - 1/16 - c/2 + c^2/3$. Fig. 2 displays the pre-merger and the post-merger equilibrium.

[14]Similar to our analysis in Subsection 3.1 we can conclude that if the integrated firm wants to serve consumers on some interval $[b_l, b_r]$ through production in its Western (Eastern) plant, it is always the best strategy to locate this plant in the center of the interval, in order to minimize transport costs.

The monopolization of the market in the post-merger equilibrium leads to an increase in profit income, $\Delta\Pi = A - 17/16 - c/2 + 2c^2/9 > 0$, while the consumer surplus declines, $\Delta CS = 18/16 - A + c/2 + 7c^2/36 < 0$ (consider $A > 5/4 + c/2 + c^2/36$).[15] Summing up, we obtain

$$\Delta V = 1/16 + 5c^2/12, \tag{21}$$

which is positive and strictly increasing in c.[16] With a higher cost differential, the integrated producer has an incentive to increase the market share of the Western plant, by moving both production facilities eastwards. (Formally, we have $dx_W^m/dc = dx_E^m/dc = 1/3$.) This reduces the social costs of a higher c. Since an adjustment of firm location is not feasible in the pre-merger equilibrium, it is intuitive that a higher cost differential c has a positive impact on ΔV.

With the overall welfare effects at hand, we can now turn to the national implications of the merger. Since the formal derivation of the national welfare effects is tedious, we have relegated it to the Appendix with the most important insights being summarized in the following lemma.

[15]It is notable that a higher cost parameter c lowers the profit gain. On the one hand, a higher c reduces the intensity of price competition in the pre-merger equilibrium, thereby leading to higher total profits: $d\Pi^n/dc = 2c/9 > 0$. On the other hand, in the post-merger equilibrium the firm chooses a price strategy that renders the marginal consumer indifferent between buying and not buying. Hence, prices do not depend on marginal production costs (provided that these costs are not too high) and the firm has to bear the entire burden of a c-increase. This explains $d\Pi^m/dc < 0$. Aside from this negative effect of a c increase on $\Delta\Pi$, we can identify a positive effect on ΔCS. On the one hand, there is a negative impact of c on CS^n, because firms increase their mill prices and overall transport cost expenditures rise. On the other hand, with profit-maximizing prices of the integrated firm being independent of production costs, there is only an indirect effect of a c increase on CS^m, due to adjustments in plant location. This relocation effect is of second order, implying that ΔCS increases in c.

[16]See the Appendix for a detailed derivation of (21). There are two sources of welfare gains from a merger, if $c \in (0, 3/4)$. On the one hand, $b_i^n > b_i^m/2$ implies that overall transport cost expenditures fall (i.e., $T^n > T^m$ in Fig. 2). On the other hand, a merger leads to a more efficient production structure, as $d_W^m > d_W^n$ and $d_E^m < d_E^n$.

Lemma 1 *If* $c \in (0, 3/4)$*, there exists a critical level* $\bar{r}_W \equiv [1/16+c/6-2c^2/9]/(1/4+c/3)$*, such that* $\Delta V_W(r) >,=,< 0$ *if* $r >,=,< \bar{r}_W$*. Welfare in the Eastern economy definitely increases if* $c \geq -3/8 + \sqrt{27}/8$*. If, however,* $c < -3/8 + \sqrt{27}/8$*, there exists a critical level* $\bar{r}_E \equiv [3/16 - c/6 + 2c^2/9]/(1/4 - c/3)$*, such that* $\Delta V_E(r) >,=,< 0$ *if* $\bar{r}_E >,=,< r$*.*

Proof. See Appendix. ■

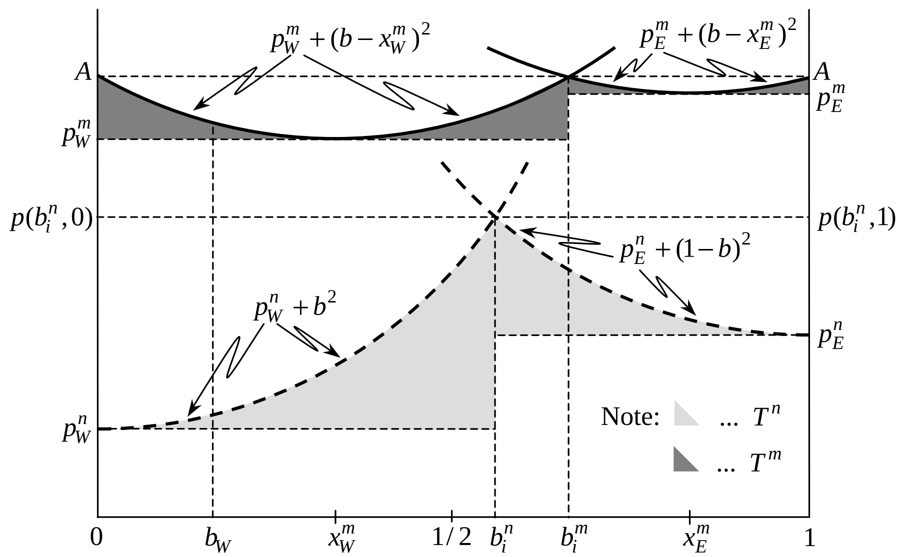

Figure 2: Price location schedules in the pre- and post-merger equilibrium if the production cost differential across firms is small.

For an intuition of the welfare effects in Lemma 1, it is useful to contrast these results with the respective findings in Subsection 3.1. In the case of identical production costs ($c = 0$), the Western economy experiences a welfare loss (gain) in the form of higher (lower) transport cost expenditures if $r < (>) 1/4$. However, if $c > 0$, there are two additional effects. On the one hand, we know from (21) that a higher c raises the positive welfare effect of a merger, due to an adjustment in firm location: $dx_W^m/dc > 0$, $dx_E^m/dc > 0$. This effect tends to lower the critical level of r. On the other hand, an increase in x_W^m leads to higher transport costs for consumers on interval $[0, x_W^m)$, which counteracts the first effect and tends to shift the critical level of r eastwards. If $c > 3/8$, it is the first effect that dominates, implying $\bar{r}_W < 1/4$. In contrast, if $c < 3/8$ the second effect is stronger, so that $\bar{r}_W > 1/4$.

Things are different in the Eastern economy, where 3/4 gives the critical level of r if $c = 0$ (see Proposition 2). In the Eastern country, the two identified effects of an increase in c go in the same direction. For sufficiently high levels of c (i.e., if $c > -3/8 + \sqrt{27}/8$), this implies that the Eastern economy will always benefit from a merger between the two firms. In contrast, if $c < -3/8 + \sqrt{27}/8$, there exists a critical level $\bar{r}_E \in (3/4, 1)$, such that the Eastern economy is better (worse) off after the merger, if $\bar{r}_E > (<) r$.

A final element to determine is the role of a merger for the trade pattern. Similar to Subsection 3.1, we can note that $r < x_W^m$ implies that the Western country exports the consumption good in the pre-merger equilibrium, while it loses its local production facility and, therefore, imports the consumption good in the post-merger equilibrium. In analogy, $r > x_E^m$ implies that the Eastern country loses its local production facility and imports the consumption good in the post-merger equilibrium (although it was an exporter of the consumption good in the pre-merger equilibrium). Furthermore, in contrast to Subsection 3.1, where the address of the marginal consumer was not influenced by a merger between the two firms, we have $b_i^n < b_i^m$ if $c > 0$. Hence, there is a third r-domain, where a merger reverses the direction of trade. If $r \in (b_i^n, b_i^m)$, the Western economy imports the commodity in the pre-merger equilibrium, while it becomes an exporter in the post-merger equilibrium. This result points to a non-trivial interplay of size and production cost differences, because the direction of trade may not only be reversed if countries differ substantially in their size but also if the size difference is rather small.

In a thought experiment, we can sum up the different ranges, in which a trade reversal occurs, and obtain $R = 1/2 + c/2$ if $c \in (0, 3/4)$. This implies that the likelihood of a trade reversal increases with the cost differential c, if country size is randomly drawn from the unit interval. This completes our formal analysis of Case I with a relatively small cost differential $c \in (0, 3/4)$. In a next step, we investigate Case II, in which the cost differential is more pronounced: $c \in [3/4, 6 - \sqrt{27}]$.

Case II: $3/4 \leq c \leq 6 - \sqrt{27}$

If $c \geq 3/4$, operating the high-cost Eastern production facility becomes unattractive for the integrated firm.[17] In this case, profits are maximized by choosing location $x_W^m = 1/2$ and setting a mill price $p_W^m = A - 1/4$. With the Western plant serving all consumers ($d_W = 1$), this implies that profits equal $\Pi^m = A - 1/4$ in the post-merger equilibrium. Fig. 3 illustrates the pre- and the post-merger equilibrium for $c \in [3/4, 6 - \sqrt{27}]$.

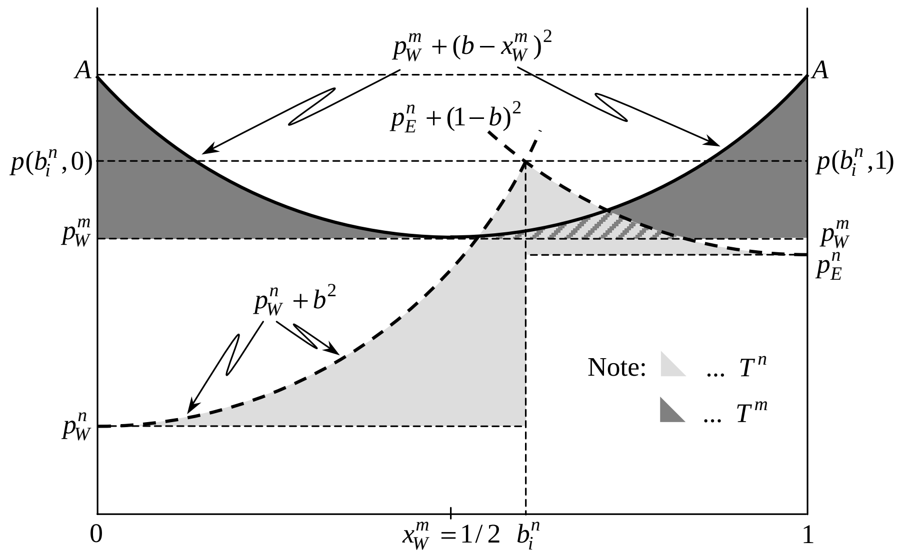

Figure 3: Price location schedules in the pre- and post-merger equilibrium if the production cost differential across firms is sizable.

Profit gains are given by $\Delta\Pi = A - 5/4 - c^2/9$ and the consumer surplus change $\Delta CS = 5/4 - A + c/2 - c^2/36$ is negative due to our assumption about A. Summing up, overall welfare changes can be expressed in the following way

$$\Delta V = c/2 - 5c^2/36, \tag{22}$$

with the derivation details being deferred to the Appendix. Noting that $c \leq 6 - \sqrt{27}$, we can conclude that a merger raises welfare, i.e., $\Delta V > 0$, with the respective welfare gain

[17] Note that $\lim_{c \to 3/4} b_i^m = 1$ holds under Case I.

being increasing in the cost differential c.[18] This confirms the respective result of Case I. Furthermore, the national welfare effects can be summarized as follows.

Lemma 2 *If $c \in [3/4, 6 - \sqrt{27})$, there exists a critical $\bar{r}_W^1 = 1/2 - 2c/3 + 2c^2/9$, such that $\Delta V_W(r) >, =, < 0$ if $r >, =, < \bar{r}_W^1$. Welfare in the Eastern country increases, i.e., $\Delta V_E(r) > 0$, for any r.*

Proof. See Appendix. ■

The results in Lemma 2 confirm our previous insight that the Western economy is better off after the merger if it is sufficiently large ($r > \bar{r}_W^1$, with the critical country size, $\bar{r}_W^1$, being smaller than 1/4 if $c \geq 3/4$), while the Eastern economy always benefits if the cost differential is sizable (with $c \geq 3/4$ being sufficient).

A final issue to be addressed is the impact of a merger on the trade pattern. In Fig. 3, we see that a merger reverses the direction of trade if $r < 1/2$. In this case, the smaller Western country exports in the pre-merger equilibrium, while it becomes an importer after the merger, because the consumption good is produced in the larger Eastern country in the post-merger equilibrium. Furthermore, if $r > b_i^n$, country E exports in the pre-merger equilibrium, while it imports the consumption good in the post-merger equilibrium. Finally, the merger leaves the direction of trade unaffected, if $r \in (1/2, b_i^n)$. Hence, in contrast to Case I, there are only two intervals where a merger changes the direction of trade, if $c \in [3/4, 6 - \sqrt{27}]$ renders an operation of the Eastern production facility unattractive.

Similar to Case I, we can sum up the parameter ranges over which a merger reverses the direction of trade and obtain $R = 1 - c/6$. An increase in cost differential c reduces the likelihood of a trade reversal if country size is randomly drawn from the unit interval.

[18] Closing the Eastern production plant and locating the Western facility at the center of the market, gives rise to two types of welfare gains. On the one hand, $b_i^n > 1/2$ implies that overall transport cost expenditures are lower in the post-merger equilibrium, due to the assumption of quadratic transport costs (i.e., $T^n > T^m$ in Fig. 3). On the other hand, there is a decline in overall production costs if the Western facility serves all consumers.

Together with the insights of Case I, this implies that the likelihood of a trade reversal reaches a maximum at $c = 3/4$.

With the formal analysis of cases I and II at hand, we can now summarize the main effects of a merger on welfare and the trade pattern.

Proposition 3 *If $c > 0$ a merger raises profits and reduces consumer surplus. Overall welfare goes up, with the respective gain rising in the cost differential c. The Western country benefits only, if it is sufficiently large, while the Eastern country always benefits, if the cost differential c is not too small, i.e., if $c > -3/8 + \sqrt{27}/8$. Otherwise (if $c < -3/8 + \sqrt{27}/8$), the Eastern country may be worse off after the merger, if it is sufficiently small. Regarding the trade pattern effects, we find that the likelihood of a trade reversal is always higher in the case of cost asymmetry ($c > 0$) than in the case of identical production costs ($c = 0$) and that it reaches a maximum at $c = 3/4$.*

Proof. Proposition 3 follows from the analysis above. ■

3.3 Costs are different ex ante but identical ex post

In this subsection, we address the consequences of a technology transfer.[19] For this purpose, we assume that production costs differ *ex ante*, i.e., $c > 0$, rendering the pre-merger equilibrium in Subsection 3.2 the starting point of our analysis. After the merger, the integrated firm uses the best-practice technology in both production plants, implying that the post-merger equilibrium is the same as in Subsection 3.1. Fig. 4 depicts the price-location schedules for the pre- as well as the post-merger scenario.

Similar to the previous two subsections, the monopolization of the market induces a profit gain: $\Delta\Pi = A - 17/16 - c^2/9 > 0$. The consumer surplus change is given by $\Delta CS = [18/16 - A + c/2 - c^2/36]$, which is negative due to our assumption about A.

[19] There is strong empirical support for intra-firm technology transfer within the boundaries of multinational enterprises. See among others Fors (1998) and Girma and Görg (2007). Similar to Long and Vousden (1995) and Ferrett (2006) we assume that techonology can be costlessly transferred between production plants.

Summing up, we obtain[20]

$$\Delta V = 1/16 + c/2 - 5c^2/36. \tag{23}$$

ΔV is positive, because a merger lowers transport cost expenditures (i.e., $T^n > T^m$ in Fig. 4) and leads to a more efficient production structure if $c > 0$ and a technology transfer is possible. Similar to the analysis in Subsection 3.2, a higher cost differential c raises the merger-induced welfare gain. However, ΔV in (23) is larger than the respective values in (21) and (22). As compared to Case I, there are gains from the technology transfer, as the inferior Eastern production technology is replaced by the superior Western technology. In Case II, the whole market was served by a single plant (using the Western technology), so that two-plant production exhibits a welfare gain due to a considerable decline in overall transport cost expenditures. Let us now turn to the national welfare effects, with the main insights being summarized in the following lemma.

Lemma 3 *If the merger leads to a technology transfer and the use of the best-practice technology in both production plants, the following national welfare effects can be derived. First, if* $c \geq 6/4 - \sqrt{27}/4$*, then* $\Delta V_W(r) > 0$ *for any* $r \in (0, 1)$*. In contrast, if* $c < 6/4 - \sqrt{27}/4$*, then there exists a critical* $\bar{r}_W^2 \equiv 1/4 - 4c/3 + 4c^2/9$*, such that* $\Delta V_W(r) >, =, < 0$ *if* $r >, =, < \bar{r}_W^2$*. Second, welfare in the Eastern country unambiguously increases, if* $c \geq 3(1 - \sqrt{15/16})$*, while* $c < 3(1 - \sqrt{15/16})$ *implies that there exists a critical* $\bar{r}_E^2 \equiv 3/4 + 8c/3 - 4c^2/9$*, such that* $\Delta V_E(r) >, =, < 0$*, if* $\bar{r}_E^2 >, =, < r$*.*

Proof. See Appendix. ■

Lemma 3 confirms our previous insight that a technology transfer provides an additional source of welfare gain. As the positive effect of a technology transfer increases with the cost differential c, it is intuitive that even very small countries can benefit from a merger if c is sufficiently large.

Let us now turn to the trade pattern effects. Similar to Subsection 3.1, we can identify $r = 1/4$ and $r = 3/4$ $(> b_i^n)$ as two critical levels of r for a trade-reversing effect of a

[20] See the Appendix for a detailed derivation of (23).

merger. If $r < 1/4$, the Western country exports the consumption good in the pre-merger equilibrium, while it loses its local production facility and, therefore, becomes an importer in the post-merger equilibrium. In analogy, if $r > 3/4$ the Eastern economy loses its local production facility and becomes an importer of the consumption good in the post-merger equilibrium (although it was an exporter in the pre-merger equilibrium). The trade reversal in these two cases arises due to an adjustment in firm location. However, similar to the analysis in Subsection 3.2 (Case I), there is a third parameter range, where a trade reversal occurs. If $r \in (1/2, b_i^n)$, the Western country exports the consumption good in the pre-merger equilibrium, while it imports the consumption good in the post-merger equilibrium. In this case, the trade reversal occurs due to a shift in the address of the marginal consumer.

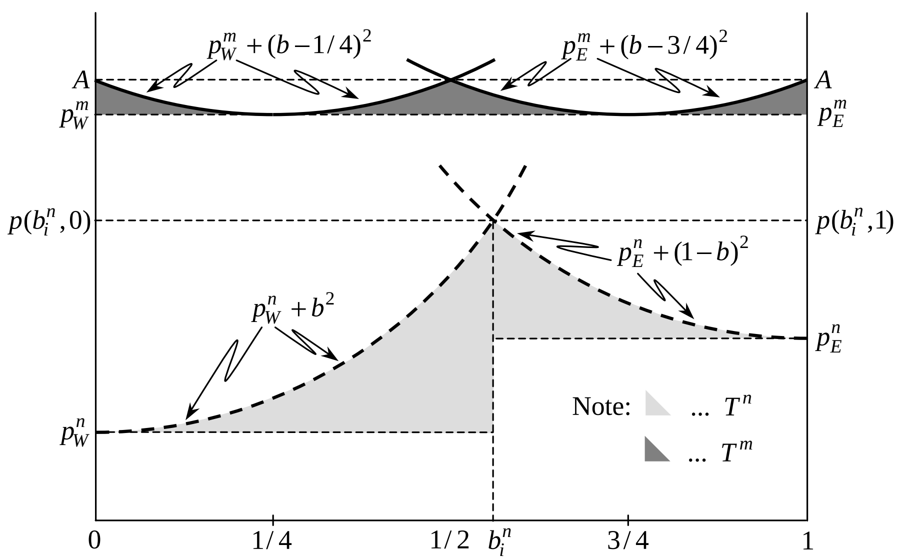

Figure 4: Price location schedules in the pre- and post-merger equilibrium if a technology transfer leads to a harmonization of production costs.

We can sum up the different ranges, where a trade reversal occurs and obtain $R = 1/2 + c/6$. Interpreting R as the likelihood of a trade reversal after the merger if country size r is randomly drawn from the unit interval, we can conclude that this likelihood increases with the *ex ante* cost differential c and is smaller than the respective values in

Subsection 3.2. Hence, all other things equal, a technology transfer reduces the likelihood of a trade reversal after the merger. This completes our formal analysis of Subsection 3.3, with the main insights on welfare and trade structure effects being summarized in the following proposition.

Proposition 4 *A technology transfer reinforces the positive welfare effects of a merger, implying that, irrespective of the prevailing size differences, both countries are better off after the merger, if the ex ante cost differential and thus the gains from the technology transfer are sufficiently high. The likelihood of a trade reversal is reduced as compared to a scenario with asymmetric production costs and no technology transfer.*

Proof. Proposition 4 follows from the analysis above. ■

4 Concluding remarks

This paper uses a spatial model à la Hotelling to shed light on the consequences of a cross-border merger for firm location, welfare and the trade pattern. Starting point of the analysis is the long-run free trade equilibrium in Tharakan and Thisse (2002) with two asymmetrically sized countries, quadratic transport costs, and two firms located at the Western and Eastern boundaries of the Hotelling line, respectively. In this setting, we show that joint profit maximization after the merger not only leads to an increase in mill prices but also to a relocation of production sites towards the center of the market in order to reduce transport cost expenditures. In addition, we also account for the possibility of an intra-firm technology transfer. By separating these channels of influence, the analysis provides a detailed picture of the possible merger effects.

With respect to the welfare implications, the main insights of our analysis can be summarized as follows. A merger raises profit income and reduces consumer surplus. Global welfare unambiguously rises in response to a merger, and the merger-induced welfare gain increases in the *ex ante* cost differential across firms. There are interesting national implications, as well. Contrasting the results in this paper with the findings in

Tharakan and Thisse (2002), we can formulate the following conclusion. In the benchmark scenario with identical production costs, a movement from autarky to a long-run free trade equilibrium lowers welfare in the large country and, depending on the magnitude of the size difference, may render the small country better or worse off. By way of contrast, a merger unambiguously increases welfare in the large country but lowers welfare in the small country if the size difference is sufficiently pronounced. With *ex ante* production cost differences and a technology transfer after the merger, there are additional positive welfare effects, so that both countries may benefit from a merger, irrespective of the prevailing size differences.

Our analysis also points to the possibility of a trade reversal after the merger. Such a trade reversal may either arise, if the smaller country loses the local production facility after the adjustment in plant location, or it may be triggered by a change in the address of the marginal consumer, who is indifferent between purchasing from the two producers. Neither of these two explanations for a trade reversing effect can be discussed in traditional models of trade which lack a spatial dimension.

In summary, the analysis in this paper contributes to the more general insight that accounting for intranational adjustments is necessary to obtain a detailed picture of how the recent wave of globalization affects trade patterns and welfare. Focusing on cross-border mergers and the triggered relocation of production plants in space, the paper points to a new channel through which globalization works. This channel has sparked considerable interest in the controversial discussion on how to design EU merger policy (Horn and Stennek, 2007), but has not been addressed by previous economic research.

Of course, being the first study that emphasizes this channel of influence, our analysis cannot tackle all questions that may be relevant in this context. In particular, we focus on two firms, which guarantees the existence of merger gains and, at the same time, rules out a discussion about the attractiveness of national relative to international mergers. Second, we depict our analysis in a linear Hotelling model, which is somewhat specific due to the existence two endpoints. Finally, by abstracting from international trade impediments, our model may be a good representation of two EU member countries but it is less adequate for the analysis of two countries which are not member of a free trade area. While extensions in all of these dimensions are important, they are clearly outside the scope of the analysis in this paper and thus left open for future research.

Appendix

Proof of Proposition 1

Consider $x_W \in [0,1]$, $x_E \in [0,1]$ and (for the moment) $c \leq 1$. In a first step, we show that in this case, an interior equilibrium with $b_i \in (0,1)$ requires $x_W = 0$ and $x_E = 1$. For this purpose, we hypothesize that $b_i \in (0,1)$ and differentiate $\pi_\ell(x_W, x_E)$ w.r.t. x_ℓ. This gives:

$$\begin{aligned}\frac{\partial \pi_W(x_W,x_E)}{\partial x_W} &= \frac{\pi_W(x_W,x_E)}{(x_E - x_W)} - \frac{4(1+x_W)\pi_W(x_W,x_E)}{c+(2+x_E+x_W)(x_E-x_W)} \\ &= \frac{\pi_W(x_W,x_E)}{c+(2+x_E+x_W)(x_E-x_W)}\left[\frac{c}{x_E-x_W} - 2 - 3x_W + x_E\right] \qquad (24)\end{aligned}$$

$$\begin{aligned}\frac{\partial \pi_E(x_W,x_E)}{\partial x_E} &= \frac{4(2-x_E)\pi_E(x_W,x_E)}{-c+(4-x_E-x_W)(x_E-x_W)} - \frac{\pi_E(x_W,x_E)}{(x_E-x_W)} \\ &= -\frac{\pi_E(x_W,x_E)}{-c+(4-x_E-x_W)(x_E-x_W)}\left[\frac{-c}{x_E-x_W} - 4 + 3x_E - x_W\right]. \qquad (25)\end{aligned}$$

According to (24) and (25), we can conclude that, for any $x_W \leq x_E$, $\partial\pi_W(\cdot)/\partial x_W < 0$ and $\partial\pi_E(\cdot)/\partial x_E > 0$ if $c = 0$. This confirms the well-known result that two producers maximize the distance between their production sites in a linear model with quadratic transport costs and identical production costs (see d'Aspremont, Gabszewicz, and Thisse, 1979).

But what happens if production costs differ? To answer this question, note that $\partial\pi_E(\cdot)/\partial x_E > 0$ if $c > 0$. This implies $x_E = 1$. Furthermore, let us hypothesize that there exists a $\tilde{x}_W \in (0,1)$ that fulfills $\partial\pi_W(x_W,1)/\partial x_W = 0$. From the second line of (24), we see that $\partial\pi_W(x_W,1)/\partial x_W = 0$ requires $c/(1-x_W) - 1 - 3x_W = 0$ and thus

$$\tilde{x}_W^{1,2} = \frac{1}{3} \pm \sqrt{\frac{4}{9} - \frac{c}{3}}. \qquad (26)$$

Noting further that[21]

$$\partial^2\pi(\tilde{x}_W, 1)/\partial x_W^2 >, =, < 0 \quad \Longleftrightarrow \quad \tilde{x}_W >, =, < 1/3 \tag{27}$$

follows from (24), it is obvious that $\tilde{x}_W \leq 1/3$ is required for a profit maximizing location decision on interval $(0,1)$ – and $b_i(\tilde{x}_W, 1) \in (0,1)$. From (26), we can therefore conclude that $c \leq 1$ rules out an equilibrium with $x_W \in (0,1)$, $x_E = 1$ and $b_i \in (0,1)$.

Put differently, if an interior equilibrium with $b_i \in (0,1)$ exists, then $c \leq 1$ implies $x_W = 0$ and $x_E = 1$. Substituting into (6)-(10) gives $p_W^*(0,1) = 1 + c/3$, $p_E^*(0,1) = 1 + 2c/3$, $b_i^*(0,1) = 1/2 + c/6$, $\pi_W^*(0,1) = (3+c)^2/18$ and $\pi_E^*(0,1) = (3-c)^2/18$. Furthermore, noting that $p(b_i, 0) = p(b_i, 1) = 5/4 + c/2 + c^2/36$, it is clear that condition $A > 5/4 + c/2 + c^2/36$ ensures full coverage in such an equilibrium.

So far, we have assumed that an equilibrium with positive demand of both producers exists. In principle, however, it may be attractive for the technologically advanced W-producer to deviate from $x_W = 0$ in order to serve all consumers. Profit-maximizing prices in this case are determined by $p_W^D = \min[A - (x_W^D)^2, c - (1 - x_W^D)^2]$, with x_W^D being the optimal location if the Western producer serves the whole market.[22] This pricing rule establishes an upper bound for the deviation profit: $\pi_W^D \leq c$. Hence, deviation is unattractive if $\pi_W^*(0,1) \geq c$ or, equivalently, if $(3+c)^2/18 \geq c$. From this condition, we can derive an upper bound for cost differential c, namely $\bar{c} \equiv 6 - \sqrt{27}$, such that the Western producer has no incentive to deviate from location $x_W = 0$ if $c \leq \bar{c}$. (Of course, if the Western firm has no incentive to deviate from $x_W = 0$, it is straightforward that the Eastern firm clearly prefers $x_E = 1$ to any other location on the unit interval.)

Collecting arguments and noting that $\bar{c} < 1$, we can finally conclude that under conditions $A > 5/4 + c/2 + c^2/36$, $c \leq 6 - \sqrt{27}$ there exists a unique interior equilibrium,

[21] Straightforward calculations give $\partial\pi_W^2(\tilde{x}_W, 1)/\partial x_W^2 = c/(1-\tilde{x}_W)^2 - 3$. Substituting $c = (1-\tilde{x}_W)(1+3\tilde{x}_W)$, according to (24), we further obtain $\partial\pi_W^2(\tilde{x}_W, 1)/\partial x_W^2 = 2(3\tilde{x}_W - 1)/(1-\tilde{x}_W)$.

[22] This location is determined by the following condition:

$$x_W^D = \begin{cases} (A - c + 1)/2 & \text{if} \quad A < c + 1 \\ 1 & \text{if} \quad A \geq c + 1 \end{cases}.$$

which is characterized by $p_W^n = p_W^*(0,1)$, $p_E^n = p_E^*(0,1)$, $b_i^n = b_i^*(0,1)$, $\pi_W^n = \pi_W^*(0,1)$ and $\pi_E^n = \pi_E^*(0,1)$. This completes the proof of Proposition 1. *QED.*

Derivation of eq. (21) and Proof of Lemma 1

Consider $c \in (0, 3/4)$ and $r \in (0,1)$. Then, profit gains in the Western country (with size r) are given by $\Delta\Pi_W(r) = (\Pi^M - \Pi^N)r = [A - 17/16 - c/2 + 2c^2/9]\, r$. Furthermore, defining

$$B_1(r) \equiv \int_0^r \left[p_W^n - p_W^m + 2x_W^m b - (x_W^m)^2\right] db, \quad B_2(r) \equiv \int_{b_i^n}^r \left[p_E^n - p_W^n + 1 - 2b\right] db$$
$$B_3(r) \equiv \int_{b_i^m}^r \left[p_E^n - p_E^m + (1 - (x_E^m)^2) - 2b(1 - x_E^m)\right] db,$$

consumer surplus changes in the Western economy can be written in the following way

$$\Delta CS_W(r) = \begin{cases} B_1(r) & \text{if } r \in (0, b_i^n] \\ B_1(r) + B_2(r) & \text{if } r \in (b_i^n, b_i^m] \\ B_1(b_i^m) + B_2(b_i^m) + B_3(r) & \text{if } r \in (b_i^m, 1) \end{cases}.$$

Using $p_W^n = 1 + c/3$, $p_E^n = 1 + 2c/3$, $b_i^n = 1/2 + c/6$ from Proposition 1 and $p_W^m = A - (1/4 + c/3)^2$, $p_E^m = A - (1/4 - c/3)^2$, $b_i^m = 1/2 + 2c/3$ from the analysis in Subsection 3.2, this expression can be simplified to

$$\Delta CS_W(r) = \begin{cases} [1 - A + c/3 + r(1/4 + c/3)]r & \text{if } r \in (0, b_i^n] \\ [1 - A + c/3 + r(1/4 + c/3)]r - [r - (1/2 + c/6)]^2 & \text{if } r \in (b_i^n, b_i^m] \\ [3/2 - A - r(1/4 - c/3)]r + c/6 + 7c^2/36 - 1/8 & \text{if } r \in (b_i^m, 1) \end{cases},$$

where $\lim_{r \to 1} \Delta CS_W(r) = 18/16 - A + c/2 + 7c^2/36$ determines ΔCS in the text.

Furthermore, noting that the welfare effect in W is given by $\Delta V_W(r) = \Delta\pi_W(r) +$

$\Delta CS_W(r)$, we obtain

$$\Delta V_W(r) = \begin{cases} [-1/16 - c/6 + 2c^2/9 + r(1/4 + c/3)]\, r & \text{if } r \in (0, b_i^n] \\ [-1/16 - c/6 + 2c^2/9 + r(1/4 + c/3)]\, r - [r - (1/2 + c/6)]^2 & \text{if } r \in (b_i^n, b_i^m] \\ [7/16 - c/2 + 2c^2/9 - r(1/4 - c/3)]\, r + c/6 + 7c^2/36 - 1/8 & \text{if } r \in (b_i^m, 1) \end{cases} \cdot \tag{28}$$

To determine the role of r for the sign of $\Delta V_W(r)$, it is useful to consider the different parameter domains in (28) separately. Accounting for $c \leq 3/4$ and using $\bar{r}_W \equiv [1/16 + c/6 - 2c^2/9]/(1/4 + c/3)$, it follows from the first line of (28) that $\Delta V_W(r) < 0$ if $r \in (0, \bar{r}_W)$, while $\Delta V_W(r) > 0$ if $r \in (\bar{r}_W, b_i^n]$. In a next step, we can look at interval $r \in (b_i^n, b_i^m]$. Noting that $\Delta V_W'(r) = 15/16 + c/6 + 2c^2/9 - r(3/2 - 2c/3) > 0$ holds for all $r \in [b_i^n, b_i^m]$,[23] it follows from $\Delta V_W(b_i^n) = [1/16 + c/24 + 5c^2/18](1/2 + c/6) > 0$ that $\Delta V_W(r) > 0$ holds for any $r \in (b_i^n, b_i^m]$.

In a final step, we can concentrate on interval $r \in (b_i^m, 1)$. In this case, differentiating $\Delta V_W(r)$ gives $\Delta V_W'(r) = 7/16 - c/2 + 2c^2/9 - r(1/2 - 2c/3)$ and $\Delta V_W''(r) < 0$. Accounting for $\Delta V_W(b_i^m) = 1/32 + c/8 + c^2/12 + 8c^3/27 > 0$ and $\lim_{r \to 1} \Delta V_W(r) = 1/16 + 5c^2/12 > 0$ (which determines ΔV in (21)), it follows that $\Delta V_W(r)$ must be positive for any $r \in (b_i^m, 1]$. Collecting the arguments, we can therefore conclude that $\Delta V_W(r) >,=,< 0$ if $r >,=,< \bar{r}_W$.

Let us now turn to the Eastern economy. First, from the analysis above, we know that $\Delta V_W(r) < 0$ if $r \in (0, \bar{r}_W]$. Due to $\Delta V = \Delta V_W(r) + \Delta V_E(r) > 0$ (see (21)), this implies $\Delta V_E(r) > 0$ for any $r \in (0, \bar{r}_W]$. Second, noting from (28) that $\Delta V_W'(r) > 0$ holds for any $r \in [\bar{r}_W, b_i^m]$ (see our discussion above), we can safely conclude that $\Delta V_E(r)$ is positive for any $r \in [\bar{r}_W, b_i^m)$, if $\Delta V_E(b_i^m) > 0$. Substituting from above, we obtain $\Delta V_E(b_i^m) = \Delta V - \Delta V_W(b_i^m) = 1/32 - c/8 + c^2/3 - 8c^3/27 > 0$.[24] Hence, $\Delta V_E(r) > 0$ holds

[23] $\Delta V_W''(r) < 0$ implies that $\Delta V_W'(r) > 0$ holds for any $r \in [b_i^n, b_i^m]$ if $\Delta V_W'(b_i^m) = 3/16 - c/2 + 2c^2/3 > 0$. Noting that $\Delta V_W'(b_i^m)$ reaches a minimum at $c = 3/8$, we can therefore conclude that $\Delta V_W'(b_i^m) > 0$ holds for any $c \in [0, 3/4]$, if $\Delta V_W'(b_i^m)|_{c=3/8} > 0$. Evaluating $\Delta V_W'(b_i^m)$ at $c = 3/8$ gives $3/32 > 0$, so that the sign of $\Delta V_W'(r)$ in the considered interval is immediate.

[24] Define $\xi(c) \equiv 1/32 - c/8 + c^2/3 - 8c^3/27$. Then, $\xi'(c) = -1/8 + 2c/3 - 8c^2/9$, with $\xi'(c) = 0$ (and

for any $r \in [0, b_i^m)$ and we can focus on interval $r \in (b_i^m, 1]$ in the subsequent analysis.

Accounting for $\Delta V_E(r) = \Delta V - \Delta V_W(r)$ and substituting (21) and the third line of (28), the welfare change in the Eastern country can be written in the following way

$$\Delta V_E(r) = [3/16 - c/6 + 2c^2/9 - r(1/4 - c/3)](1 - r), \tag{29}$$

if $r \in [b_i^m, 1]$. We can now define $\phi(r) \equiv 3/16 - c/6 + 2c^2/9 - r(1/4 - c/3)$, with $(1 - r)\phi = \Delta V_E(r)$, according to (29) and $\phi'(r) < 0$. Furthermore, while $\phi(b_i^m) > 0$ follows from $\Delta V_E(b_i^m) > 0$ (see above), the sign of $\phi(1) = -1/16 + c/6 + 2c^2/9$ is not clear in general. To be more specific, we can conclude that $\phi(1) > 0$ and thus $\Delta V_E(r) > 0$ for any $r \in (0, 1)$ if $c \geq -3/8 + \sqrt{27}/8$. Otherwise (if $c < -3/8 + \sqrt{27}/8$), we have $\phi(1) < 0$, implying that there exists a critical $\bar{r}_E \equiv [3/16 - c/6 + 2c^2/9]/(1/4 - c/3)$, such that $\Delta V_E(r) >, =, < 0$ if $\bar{r}_E >, =, < r$. This completes the proof. *QED.*

Derivation of eq. (22) and Proof of Lemma 2

Consider $c \in [3/4, 6 - \sqrt{27}]$ and $r \in (0, 1)$. Then, profit gains in the Western country (with size r) are given by $\Delta\Pi_W(r) = [A - 5/4 - c^2/9]r$. Furthermore, the consumer surplus change in W is determined by

$$\Delta CS_W(r) = \begin{cases} \int_0^r [p_W^n - p_W^m + b - 1/4]db & \text{if } r \in (0, b_i^n] \\ \int_0^{b_i^n} [p_W^n - p_W^m + b - 1/4]db + \int_{b_i^n}^r [p_E^n - p_W^m + 3/4 - b]db & \text{if } r \in (b_i^n, 1) \end{cases}.$$

Substituting $p_W^n - p_W^m = 5/4 + c/3 - A$, $p_E^n - p_W^m = 5/4 + 2c/3 - A$ and $b_i^n = 1/2 + c/6$, this gives

$$\Delta CS_W(r) = \begin{cases} [1 - A + c/3 + r/2]r & \text{if } r \in (0, b_i^n] \\ [2 + 2c/3 - A - r/2]r - (1/2 + c/6)^2 & \text{if } r \in (b_i^n, 1) \end{cases},$$

where $\lim_{r\to 1} \Delta CS_W(r) = \Delta CS = 5/4 - A + c/2 - c^2/36$ confirms the respective result in the text. Taking into acount that $\Delta V_W(r) = \Delta\Pi_W(r) + \Delta CS_W(r)$, welfare changes in

$\xi''(c) = 0)$ if $c = 3/8$, while $\xi'(c) < 0$ if $c \in (0, 3/8)$ or $c \in (3/8, 3/4)$. Then, $\xi(0) = 1/32$ and $\xi(3/4) = 0$ implies that $V_E(b_i^m) > 0$ holds for any $c \in [0, 3/4)$.

W are given by

$$\Delta V_W(r) = \begin{cases} [-1/4 + c/3 - c^2/9 + r/2]r & \text{if } r \in (0, b_i^n] \\ [3/4 + 2c/3 - c^2/9 - r/2]r - (1/2 + c/6)^2 & \text{if } r \in (b_i^n, 1) \end{cases}. \tag{30}$$

The first line of (30) determines a critical $\bar{r}_W^1 \equiv 1/2 - 2c/3 + 2c^2/9$, such that $\Delta V_W(r) < 0$ if $r \in (0, \bar{r}_W^1)$, while $\Delta V_W(r) > 0$ if $r \in (\bar{r}_W^1, b_i^n]$. Furthermore, $\Delta V_W(r)$ increases in r if $r \geq \bar{r}_W^1$. Differentiating the second line of (30) with respect to r, gives $3/4 + 2c/3 - c^2/9 - r \equiv \psi(c)$, with $\psi'(c) > 0$ for any $c \leq 6 - \sqrt{27}$. Substituting $c = 3/4$, we obtain $\psi(3/4) = 19/16 - r$, which is positive for any $r \in (0, 1)$. Hence, the second line in (30) strictly increases in r if $c \in [3/4, 6 - \sqrt{27})$, implying that $\Delta V_W(r) > 0$ holds for any $r \in (b_i^n, 1)$, because $\Delta V_W(b_i^n) > 0$ (see above). Overall, this implies that $\Delta V_W(r) >, =, < 0$ if $r >, =, < \bar{r}_W^1$. Finally, $\lim_{r\to 1} \Delta V_W(r)$ gives ΔV in (22).

Let us now turn to the welfare effects in the Eastern economy. They are determined by $\Delta V_E(r) = \Delta V - \Delta V_W(r)$. Hence, it follows from the analysis above that $\Delta V_E(r) > \Delta V > 0$ if $r < \bar{r}_W^1$. Furthermore, $\Delta V_E(r)$ is decreasing in r if $r \geq \bar{r}_W^1$, implying that $\Delta V_E(r)$ reaches a minimum when r approaches 1. Noting $\lim_{r\to 1} \Delta V_E(r) = 0$, we can conclude that $\Delta V_E(r) > 0$ holds for any $r \in (0, 1)$. This completes the proof. *QED.*

Derivation of eq. (23) and Proof of Lemma 3

Consider $r \in (0, 1)$. Then, Profit gains in the Western economy equal $\Delta\Pi_W(r) = [A - 17/16 - c^2/9]r$ and consumer surplus changes are given by

$$\Delta CS_W(r) = \begin{cases} B_4(r) & \text{if } r \in (0, 1/2] \\ B_4(r) + B_5(r) & \text{if } r \in (1/2, b_i^n] \\ B_4(b_i^n) + B_5(b_i^n) + B_6(r) & \text{if } r \in (b_i^n, 1) \end{cases}$$

with

$$B_4(r) \equiv \int_0^r [p_W^n - p_W^m + b^2 - (b - 1/4)^2]db, \quad B_5(r) \equiv \int_{1/2}^r [p_W^m - p_E^m + (b - 1/4)^2 - (b - 3/4)^2]db,$$

$$B_6(r) \equiv \int_{b_i^n}^r [p_E^n - p_E^m + (1 - b)^2 - (b - 3/4)^2]db.$$

Substituting $p_W^n = 1 + c/3$, $p_E^n = 1 + 2c/3$ and $b_i^n = 1/2 + c/6$, according to Proposition 1, as well as $p_W^m = p_E^m = A - 1/16$ from our analysis in Subsection 3.3, we obtain

$$\Delta CS_W(r) = \begin{cases} [1 + c/3 - A + r/4]r & \text{if } r \in (0, 1/2] \\ [1/2 + c/3 - A + (3/4)r]r + 1/8 & \text{if } r \in (1/2, b_i^n] \\ [3/2 + 2c/3 - A - r/4]r - 1/8 - c/6 - c^2/36 & \text{if } r \in (b_i^n, 1) \end{cases}, \quad (31)$$

where $\lim_{r\to 1} \Delta CS_W(r) = 18/16 - A + c/2 - c^2/36$ gives ΔCS in the text.

Noting $\Delta V_W(r) = \Delta\Pi_W(r) + \Delta CS_W(r)$, we can further conclude that welfare changes in the Western economy are given by

$$\Delta V_W(r) = \begin{cases} [-1/16 + c/3 - c^2/9 + r/4]r & \text{if } r \in (0, 1/2] \\ [-9/16 + c/3 - c^2/9 + (3/4)r]r + 1/8 & \text{if } r \in (1/2, b_i^n] \\ [7/16 + 2c/3 - c^2/9 - r/4]r - 1/8 - c/6 - c^2/36 & \text{if } r \in (b_i^n, 1) \end{cases} \quad (32)$$

To determine the sign of $\Delta V_W(r)$ let us first consider interval $(0, 1/2]$. Then, it follows from the first line of eq. (32) that $c \geq 6/4 - \sqrt{27}/4$ ensures a positive value of $\Delta V_W(r)$ for any $r \in (0, 1/2]$. However, if $c < 6/4 - \sqrt{27}/4$ there exists a critical $\bar{r}_W^2 \equiv 1/4 - 4c/3 + 4c^2/9$, such that $\Delta V_W(r) < 0$ if $r \in (0, \bar{r}_W^2)$ and $\Delta V_W(r) > 0$ if $r \in (\bar{r}_W^2, 1/2]$. Furthermore, noting from the second line of (32) that $\Delta V_W(r)$ increases in r if $r \in (1/2, b_i^n]$, it is clear that $\Delta V_W(r) > 0$ also extends to this case.

Finally, differentiating the third line of in (32) with respect to r, gives $\Delta V_W'(r) = 7/16 + 2c/3 - c^2/9 - r/2$ and $\Delta V_W''(r) < 0$. Hence, noting $\Delta V_W(b_i^n) > 0$ from above and $\lim_{r\to 1} \Delta V_W(r) = 1/16 + c/2 - 5c^2/36 > 0$ (which determines ΔV in (23)) it is immediate that $\Delta V_W(r) > 0$ if $r \in (b_i^n, 1)$. Putting together, we can conclude that $\Delta V_W(r) > 0$ for any $r \in (0, 1)$ if $c \geq 6/4 - \sqrt{27}/4$, while $c < 6/4 - \sqrt{27}/4$ implies that $\Delta V_W(r) >, =, < 0$ if $r >, =, < \bar{r}_W^2$.

Let us now turn to the Eastern economy and consider $\Delta V_E(r) = \Delta V - \Delta V_W(r)$. Then, noting that $\Delta V_W(r)$ reaches a maximum on interval $r \in (0, b_i^n]$ if r approaches b_i^n, it is immediate that $\Delta V_E(r)$ must be positive for any $r \in (0, b_i^n]$ if $\Delta V_E(b_i^n) > 0$. Subtracting the second line of (32) from (23) and evaluating the respective expression at $r = b_i^n$, we obtain $\Delta V_E(b_i^n) = 1/32 + 29c/96 - 23c^2/144 + c^3/54 > 0$, implying that $\Delta V_E(r) > 0$ must hold for any $r \in (0, b_i^n]$. We can therefore focus on interval $(b_i^n, 1)$ in the subsequent analysis. Subtracting the third line of (32) from (23) gives $\Delta V_E(r) = [3/16 + 2c/3 - c^2/9 - r/4](1 - r)$ if $r \in (b_i^n, 1)$. It is easy to show that $\Delta V_E(r) > 0$ holds for any $r \in (b_i^n, 1)$ if $c \geq 3(1 - \sqrt{15/16})$. In contrast, $c < 3(1 - \sqrt{15/16})$ implies that there exists a critical $\bar{r}_E^2 \equiv 3/4 + 8c/3 - 4c^2/9$, such that $\Delta V_E(r) > 0$ if $r \in (b_i^n, \bar{r}_E^2)$, while $\Delta V_E(r) < 0$ if $r \in (\bar{r}_E^2, 1)$. Altogether, we can therefore derive the following conclusion: if $c \geq 3(1 - \sqrt{15/16})$, then $\Delta V_E(r) > 0$ for any $r \in (0, 1)$; however, if $c < 3(1 - \sqrt{15/16})$, then $\Delta V_E(r) >, =, < 0$ if $\bar{r}_E^2 >, =, < r$. This completes the proof. *QED*.

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