Endogenous trade policies, the location of production and inter-industry input-output linkages.*

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Abstract

This paper explores the role of trade policy in a new economic geography model based on intermediate input linkages within as well as between industries. In a Krugman and Venables (1996) model modified to allow for asymmetric trade cost levels across sectors and countries, the effects of unilateral trade policies on the international production and trade pattern are identified. Also, the national welfare consequences of different trade-policy strategies are obtained in order to identify the endogenous trade-policy positions of the countries when trade policies are used as strategies in a game between benevolent governments. The identified Nash-equilibria are characterised by strategies that are either free-trade positions or highly protectionist. In particular, while free-trade equilibrium strategies can generate locational equilibria characterised by the complete dispersion or concentration of industry categories, protectionist equilibrium strategies always generates a locational equilibrium characterised by a complete international specialisation of production. Furthermore, it is revealed that the presence of inter-industry input-output linkages between firms has two counteracting effects on the international production pattern in the presence of trade costs. First, the fact that an international specialisation of production increases intermediate input costs for producers in both industries works counter to the agglomeration forces. Second, the existence of inter-industry input-output linkages implies that the reduced producer prices caused by firm concentration leads to lower intermediate input prices that further reduces the equilibrium producer prices, thereby increasing the gains from specialisation.

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1 Introduction

During the last decade, a new type of trade models have gained popularity within the field of international economics. In the new setting, called the new economic geography framework, the interaction of increasing returns to scale and trade costs gives rise to demand and cost effects that do not depend on traditional explanatory factors of trade patterns. Rather, input-output linkages between firms and regional labour mobility influence firms' incentives to move to another region or country, thereby influencing the international production and trade pattern. Recently, the role of economic policy has been examined within the framework. One strand of research has examined policies affecting the reciprocal trade cost level between regions. In particular, focus has been placed on the effects of infrastructure improvements and reciprocal trade-liberalising agreements on the regional production pattern (see Martin and Rogers (1995), Martin (1999), Puga and Venables (1998), Baldwin and Robert-Nicoud (2000)). The other main strand of research has explored strategic effects of different tax-policy regimes (e.g. Ludema and Wooton (2000), Anderssson and Forslid (2003), Kind, Midelfart-Knarvik and Schjelderup (2000), and Baldwin and Krugman (2000)). In addition, unilateral trade-policy effects have been examined in different new economic geography settings by Venables (1996), Puga and Venables (1999), and Baldwin et al. (2002). With the exception of an example in Baldwin et al. (2003), all these studies examine trade-policy effects on the international production pattern without allowing for other countries' use of trade-policy.

Thede (2002) attempts to remedy this lack of focus on strategic interactions between countries by letting a simple trade-policy game take place between benevolent governments in a standard international new economic geography setting. Specifically, the setting used is a Krugman and Venables (1995) model modified to allow for trade costs in the homogenous goods sector and asymmetric trade cost levels across countries, in which agglomeration forces are created from input-output linkages between firms in the differentiated goods sector. In that paper, it is shown that the existence of trade costs in the homogenous goods sector implies that the equilibrium protection levels in the differentiated good sector are substantially reduced. In fact, in the identified Nash-equilibria, the equilibrium strategies are always free-trade manufacturing policies. Moreover, in the modified Krugman and Venables (1995) setting, locational equilibria characterised by the symmetric dispersion of industry categories are always generated from the trade-policy equilibrium. The main purpose of this paper is to use the same approach to identify the endogenous trade-policy positions and outcomes in a new economic geography setting characterised by differentiated goods production and input-output linkages within and between industries.

This paper explores the role of unilateral trade policy in a Krugman and Venables (1996) model modified to allow for asymmetric trade cost levels across sectors and countries. Specifically, this is done by assuming that the natural trade cost levels (in form of transport costs, language differences etc.) within sectors are symmetric across countries while the political trade cost levels (in the form of protection) are set independently by the governments. In this setting, the unilateral use of protection in one sector raises the production costs for domestic firms in each sector by raising the price on imported intermediate inputs while at the same time increasing the domestic market share of domestically produced varieties of the protected good. In contrast to the standard new economic geography model used in the related study by Thede (2002), this model construction also strengthens the role of endogenously determined wages in the formation of the international pattern of production. In order to identify Nash equilibria in the strategic trade-policy game, we first examine the exogenous trade-policy effects on the international production pattern and distribution of welfare. In the context, the paper is related to a paper by Puga and Venables (1999), in which one of the considered issues is whether a developing country can use trade policy to become industrialised. In that paper, the setting used is a new economic geography model characterised by input-output linkages between firms in the differentiated goods sector and inherent endowment differences. They find that a developing country can become industrialised by use of a protectionist or trade-liberalising position in the differentiated goods sector. Furthermore, they show that the welfare gain from industrialisation is higher when using the trade-liberalising strategy. In this paper, the setup with two differentiated goods sectors rather displays the production and trade pattern prevailing between developed countries. In this context, a country normally gains from using a protectionist import policy to dissolve an equilibrium characterised by its complete specialisation in the low trade-cost sector. However, a country can lose from using a unilateral trade-liberalising export-sector policy to obtain the same objective under non-extreme model conditions.

In contrast to Thede (2002), both countries can prefer to sustain a locational equilibrium characterised by the complete international specialisation of production under normal model conditions. That is, a locational equilibrium generated from the policy equilibrium is characterised either by a complete dispersion or a complete concentration of industry categories. It is revealed that the presence of inter-industry input-output linkages between firms can work counter to the international specialisation of production through its positive effect on intermediate input costs but that it can also enhance the gains from specialisation since the reduced producer prices caused by industry concentration leads to lower intermediate input prices that further reduces the equilibrium producer prices.

In a broad context, the paper is related to the trade-policy research field focusing on strategic interactions between governments.[1] Within the new economic geography literature, the approach of endogenising the unilateral trade-policy determination by using a game between benevolent governments is related to that used in the tax policy research field. In addition, in endogenising the trade-policy determination in a new economic geography setting, this paper is related to Gallo (2002) who uses a median-voter approach to determine the reciprocal trade cost level between regions in a Forslid and Ottaviano (1998) model. In Baldwin et al. (2002), it is described that the so-called price-lowering-protection effect is present in the standard new economic geography model incorporating the production of one homogenous good and one differentiated good where agglomeration forces are created on the basis of regional labour mobility. This effect refers to the fact that, in an equilibrium characterised by a dispersion of industrial activities, unilateral protection can lower the price on the protected good if the higher protection level leads to a large enough increase in the domestic supply of varieties of the differentiated good. In the Krugman and Venables (1996) setting used in this paper, a higher protection level in one sector in a dispersed locational equilibrium leads to a larger domestic supply of varieties of the good produced in the sector while reducing the domestic supply of varieties of the other differentiated good. This implies that firms in the expanding sector have to import more intermediate input varieties of the other goods type, which places an upward pressure on their production costs. Therefore, the presence of inter-industry input-output linkages counteracts the price-lowering-protection effect of protection. In fact, as previously described, the inter-industry input-output linkages can be strong enough for free trade to be each country's welfare-maximising policy position in an equilibrium characterised by a complete dispersion of industry categories.

The rest of this paper is structured as follows. The model is presented in section 2. Section 3 provides an examination of the trade-policy effects on the equilibrium structure. In section 4, the equilibrium

[1] See Bagwell and Staiger (1990), Bond and Park (2002), Bond and Syropoulos (1996), Johnson (1954), McLaren (1997), Keenan (1988), and Syropoulos (2002).

strategies and outcomes of the trade-policy game are identified. A concluding discussion of the paper's main findings is provided in the last section.

2 The Model

There are two countries without inherent differences in endowments, preferences or technologies. Two goods are produced in industries characterised by the Dixit-Stiglitz (1977) form of monopolistic competition with intermediate inputs and labour used in the production process. Labour is the sole production factor and, for simplicity, the labour force in each country is normalised to one. Labour is mobile between sectors but immobile across country borders. Since the model is symmetric, only the home country's situation is described below. Foreign country variables are denoted by *.

Consumers' preferences take the form of a Cobb-Douglas utility function with an equal expenditure share placed on each good. In turn, the consumption of a good is defined by a constant-elasticity-of-substitution (CES) function across all the produced varieties of the good. The number of produced varieties is assumed to be large, implying that the consumption index of each good is specified over a continuum of varieties. The good-i consumption index, M_i, thus equals:

$$M_i = \left[\int_0^{n_i+n_i^*} m(j)^\rho dj \right]^{1/\rho}, \ \rho = \frac{\sigma - 1}{\sigma}, \ \sigma > 1, \ i = 1, 2, \tag{1}$$

where $m(j)$ is the consumption of the jth good-i variety, n_i is the mass of domestically produced good-i varieties, n_i^* is the mass of good-i varieties produced in the foreign country, ρ is a parameter capturing the intensity of the preference for variety, and σ is the elasticity of substitution between two different varieties of the good.

International trade costs are of the Samuelson iceberg form. If denoting the domestic trade cost level on good-i imports t_i, this implies that a proportion $1/t_i$ of the goods exported from the foreign country arrives at the domestic destination. The total good-i trade cost level, t_i, is equal to:

$$t_i = \pi_i + \tau_i, \ \tau_i \geq 1, \ \pi_i \geq 0, \tag{2}$$

where τ_i is the natural level of good-i trade costs and π_i is the political good-i trade cost level. As previously described, the natural trade cost level in each industry is assumed to be symmetric across countries so that $\tau_i = \tau_i^*$ and $\tau_j = \tau_j^*$. while the political trade cost level is set independently by the governments. Henceforth, the political trade cost level is referred to as the level of protection. Throughout the paper, the natural industry-i trade cost level is assumed to be at least as high as the industry-j trade cost level, so that $\tau_i \geq \tau_j$.

In equilibrium, the price index of the good-i consumption index, Q_i, equals:

$$Q_i = \left[n_i p_i^{1-\sigma} + n_i^* (p_i^* t_i)^{1-\sigma} \right]^{1/(1-\sigma)} \tag{3}$$

where p_i is the domestic price on good-i varieties, and p_i^* is the foreign good-i variety price.

The good-i production function is a Cobb-Douglas with given labour and intermediate input shares. Intermediate inputs of both good types are used in the production process. That is, we use the standard assumption within the new economic geography literature that each produced variety is used as an intermediate input in the final goods production. In addition, the intermediate input variety index is assumed to be equivalent to the final goods consumption index. The input unit cost in the production of good i, C_i, equals:

$$C_i = w_i^{1-\mu-\upsilon} Q_i^{\mu} Q_j^{\upsilon} \tag{4}$$

where w_i is the industry-i labour return, μ is the cost share of intermediate input type i, and υ is the cost share of intermediate input type j. We follow Krugman and Venables (1996) in assuming that the cost share of intermediate inputs of the same goods type exceeds the cost share of intermediate inputs of the other goods type, so that $\mu > \upsilon$.

The total cost of a representative industry-i firm equals:

$$TC_i(x_i) = C_i\,(\alpha + bx_i) \tag{5}$$

where α is the fixed input requirement, b is the marginal input requirement and x_i is the output level. To simplify without loss of generality, units are chosen in such a way that $\alpha = 1/\sigma$ and $b = (\sigma-1)/\sigma$. A firm incurs no additional cost from producing a new variety and since all varieties are demanded, this implies that each firm produces its particular variety. σ is the elasticity of substitution perceived by each firm and there are no strategic interactions between firms. This implies that a profit-maximising representative firm sets marginal revenue equal to marginal costs:

$$p_i(1-1/\sigma) = C_i b. \tag{6}$$

Inserting (4) in (6), rearranging the terms, and using the previously specified unit choice of b yields that the good-i variety price equals the input unit cost in the variety production:

$$p_i = w_i^{1-\mu-\upsilon} Q_i^{\mu} Q_j^{\upsilon}. \tag{7}$$

There is free market entry and exit, implying that each firm's profits are zero in equilibrium. This fact implies that the firm's equilibrium output level is:

$$x_i = (\sigma-1)\alpha/b \tag{8}$$

which equals one in value due to the normalisations of α and b. In addition, the fact that each firm breaks even in equilibrium implies that the sum of wages earned by industry-i workers equals a share $(1-\mu-\upsilon)$ of the total industry-i revenues. Combined with the implication that the equilibrium output level equals one, the following expression is obtained:

$$w_i L_i = (1-\mu-\upsilon) n_i p_i \tag{9}$$

where L_i is the domestic industry-i labour share. Solving (9) for n_i and using the resulting expression, (7) and their foreign counterparts in (3) yields:

$$\begin{aligned} Q_i \;=\; & (1-\mu-\upsilon)^{1/(\sigma-1)} (L_i w_i^{1-\sigma(1-\mu-\upsilon)} Q_i^{-\sigma\mu} Q_j^{-\sigma\upsilon} + \\ & L_i^{*} w_i^{*1-\sigma(1-\mu-\upsilon)} Q_i^{*-\sigma\mu} Q_j^{*-\sigma\upsilon} t_i^{1-\sigma})^{1/(1-\sigma)}. \end{aligned} \tag{10}$$

The domestic income consists of the total labour earnings:

$$Y = w_i L_i + w_j (1 - L_i). \tag{11}$$

The total expenditure on good i comes from the consumer demand for final products and the producer demand for intermediate products. If using the revenue equivalence specified in (9), this implies that the total domestic good-i expenditure equals:

$$E_i = 0.5Y + \left[\frac{\mu w_i L_i + \upsilon w_j (1 - L_i)}{1 - \mu - \upsilon}\right] \tag{12}$$

where the first term is the final goods expenditure and the second term is the intermediate goods expenditure. The first term within brackets, $\mu w_i L_i/(1-\mu-\upsilon)$, comes from the industry i demand for intermediate inputs while the second term, $\upsilon w_i L_i/(1-\mu-\upsilon)$, comes from the demand for intermediate inputs in industry j.

The market clearing condition for a good-i variety is:

$$x_i = p_i^{-\sigma}\left[E_i Q_i^{\sigma-1} + E_i^* Q_i^{*\sigma-1} t_i^{*1-\sigma}\right] \tag{13}$$

where E_i^* is the foreign expenditure placed on good i, and Q_i^* is the price index of the foreign good i variety index. Inserting (7) in (13) while taking account of the fact that a firm's equilibrium output level equals one and rearranging the terms yields:

$$w_i^{\sigma(1-\mu-\upsilon)} Q_i^{\sigma\mu} Q_j^{\sigma\upsilon} = E_i Q_i^{\sigma-1} + E_i^* Q_i^{*\sigma-1} t_i^{*1-\sigma}. \tag{14}$$

An equilibrium is characterised by equation (10), (12), and (14), their industry j counterparts, equation (11) and all the foreign corresponding equations. Equilibria characterised by the complete international specialisation of production are henceforth referred to as *agglomerated* equilibria. Other equilibria, which we refer to as *dispersed* equilibria, are characterised by the domestic and foreign production in both industries. The equilibrium characterised by identical domestic and foreign variable values is referred to as the *symmetric* equilibrium. Labour is assumed to move gradually into the sector offering the highest wage, so that a *stable* dispersed equilibrium is characterised by a wage equalisation between sectors. This adjustment dynamic implies that a wage gap between sectors can exist only if the country is completely specialised in producing the good in the high-wage sector. Furthermore, it can be shown that a prerequisite for the existence of an agglomerated equilibrium is that the actual domestic and foreign wages are equal.[2] That is, a nominal wage equalisation between the productive sectors in the countries takes place in an agglomerated equilibrium.

3 Trade-policy effects

The protection effects on the equilibrium structure are obtained by using the analytical and simulation tools provided by Fujita, Krugman and Venables (1999). In deriving analytical results for the agglomerated equilibrium case, we follow the new economic geography literature in assuming that the agglomeration forces are weak enough for the agglomerated equilibrium not to always exist when trade cost levels are symmetric across industries and countries. In the Krugman and Venables (1996) model,

[2] This wage condition is derived in section 9.1.

this requires that $\sigma(1-(\mu-\upsilon)) \geq 1$.[3] This parameter condition has the equivalent function of the so-called no-black-hole condition in the Krugman (1991) and the Krugman and Venables (1995) models and will henceforth be referred to as the no-black-hole condition.

In the absence of protection, the symmetric equilibrium is stable at trade costs above a threshold level, *the break point*, while an agglomerated equilibrium structure exists at trade costs below a threshold level referred to as *the sustain point*. Figures 1-3 show examples of the three equilibrium structures that prevail in different intervals when trade costs are symmetric across industries and countries. Above a country's equilibrium curve, the country's industry-j wage exceeds its industry-i wage and this wage discrepancy triggers a labour movement into industry j until the wages are equalised between industries. And below a country's equilibrium curve, the industry-i wage exceeds the industry-j wage in the country which triggers a labour movement into industry i until a wage equalisation is reached between industries. In the case when trade costs are symmetric across industries and countries, the sustain point exceeds the break point, implying that an equilibrium structure incorporating both agglomerated and symmetric equilibria prevails in the trade cost interval between these two points (see figure 2).

Allowing for asymmetric trade cost levels between industries affects the equilibrium structure by influencing the requirements for stable symmetric equilibria and agglomerated equilibria. We continue to refer to the break point and sustain point, but now define these threshold levels in terms of the trade costs in one industry when the trade cost level in the other industry is held constant. Figure 4 illustrates the equilibrium structure prevailing when natural trade cost levels are allowed to differ across industries (at given values of σ, μ, and υ). The inner curve contains the natural trade cost combinations depicting break points while the outer curve marks the natural trade cost combinations depicting sustain points. The figure reveals that the agglomerated equilibrium structure exists if the sum of natural trade cost levels is not too large. That is, the sustain point as specified in terms of the natural trade cost level on one good is decreasing in the natural trade cost level on the other good and diminishes if the level of natural trade costs on the other good is high enough. In addition, figure 4 shows that the symmetric equilibrium can be stable at all natural trade cost levels in one sector if the natural trade cost level in the other sector is high enough. In fact, at an intermediate range of trade cost levels on one good, the symmetric equilibrium is stable below a lower break point and above an upper break point of trade costs on the other good. In this case, the stable symmetric equilibrium prevails only if the natural trade cost difference is sufficiently large. In general, the figure shows that the stable symmetric equilibrium cannot exist at trade cost combinations incorporating relatively low and similar natural trade cost levels. That is, firms in both industries gain from agglomerating together in the same location if the natural trade cost levels are similar in size across industries and sufficiently low.

3.1 In an agglomerated equilibrium

In this section, analytical results are provided only for the agglomerated equilibrium that is characterised by domestic good-i production. This restriction is made since the symmetry of the model implies that mirror-image results are obtained in the opposite agglomerated equilibrium. Due to the wage adjustment mechanism described in the previous section, a necessary condition for the agglomerated equilibrium characterised by domestic good-i production to exist is that the domestic industry-i wage is at least as high as the domestic industry-j wage. The domestic relative industry-i wage in the agglomerated

[3] See section 9.3.

equilibrium characterised by domestic good-i production can be expressed in terms of exogenous and trade cost variables in the following way:[4]

$$\frac{w_i}{w_j} = \left[t_i^{*\sigma\upsilon} t_j^{-\sigma\mu} \left(\frac{(1-\mu+\upsilon)}{2} t_j^{\sigma-1} + \frac{(1+\mu-\upsilon)}{2} t_j^{*1-\sigma} \right) \right]^{-1/(\sigma(1-\mu-\upsilon))}. \tag{15}$$

(15) displays the domestic relative industry-i wage effect that would result if a representative industry-j producer moved to the home country. First, the $t_i^{*\sigma\upsilon}$ factor captures the negative effect on intermediate input costs caused by the fact that the firm no longer has to pay the trade-cost inclusive price on inputs of good-i varieties. Second, the $t_j^{-\sigma\mu}$ factor captures the positive intermediate input cost effect since the firm now has to pay the trade-cost inclusive price on all good-j varieties produced in the foreign country. Third, $((1-\mu+\upsilon)/2)t_j^{\sigma-1}$ captures the domestic demand gain for the variety produced by the firm while $((1+\mu-\upsilon)/2)t_j^{*1-\sigma}$ captures the corresponding foreign demand loss. The domestic good-j expenditure share, $((1-\mu+\upsilon)/2)$, is decreasing in the intermediate input deviation $(\mu-\upsilon)$ while the foreign good-j expenditure share, $((1+\mu-\upsilon)/2)$, is increasing in the intermediate input deviation. The net demand effect of the moving firm is therefore decreasing in the intermediate input deviation, yielding that the domestic relative industry-i wage is increasing in $(\mu-\upsilon)$. This implies that a larger intermediate input gap strengthens the forces of agglomeration.

From (15), it can be seen that the domestic relative industry-i wage is decreasing in the foreign industry-i trade cost level and increasing in the foreign industry-j trade cost level.[5] Moreover, it follows straightforwardly from (15) that the foreign country can dissolve the agglomerated equilibrium characterised by domestic good-i production by use of a high enough protection level on good-i imports. That is, even if the home country utilises the industry-j policy position that maximises the domestic relative industry-i wage, the foreign country can always dissolve this equilibrium since $(w_i/w_j) \to 0$ as $t_i^* \to \infty$. Moreover, the foreign use of good-j protection is consistent with the existence of this equilibrium since the domestic relative industry-i wage is increasing in the foreign good-j trade cost level.

It can be shown that the domestic relative industry-i wage is increasing in the domestic industry-j trade cost level unless $\sigma(1-\mu) > 1$ and the domestic industry-j trade cost level is above the following threshold:[6]

$$t_{j,TH} = \left[\frac{\sigma\mu(1+\mu-\upsilon)t_j^{*1-\sigma}}{-(1-\sigma+\sigma\mu)(1-\mu+\upsilon)} \right]^{1/(\sigma-1)} \tag{16}$$

where $t_{j,TH}$ denotes the domestic industry-j treshold level. That is, unless the demand effect caused by domestic industry-j trade costs is relatively high compared with its cost effect, a higher domestic industry-j trade cost level lowers a foreign representative producer's profitability of moving to the home country. Consequently, if $\sigma(1-\mu) < 1$, the home country's use of good-j protection is also consistent with the existence of this equilibrium. In contrast, if $\sigma(1-\mu) > 1$, the equilibrium can be dissolved by a high enough domestic good-j protection level since $(w_i/w_j) \to 0$ as $t_j \to \infty$.

The symmetry of the model implies that the trade cost effects on the foreign relative industry-j wage in the agglomerated equilibrium characterised by domestic good-i production are mirroring the

[4] The domestic relative industry-i expression is derived in section 9.2.

[5] See section 9.4.

[6] See section 9.4.1.

results obtained for the domestic relative industry-i wage in the same equilibrium.[7] This implies that each country can dissolve the agglomerated equilibrium by use of a high enough protection level on the good produced by the trade partner. For example, the fact that the foreign relative industry-j wage approaches zero as the domestic industry-j trade cost level approaches infinity indicates that the home country can dissolve the equilibrium by use of a high enough industry-j protection level. Furthermore, the symmetry of the model implies that a country's use of protection on its domestically produced good is consistent with the existence of the equilibrium. Provided that the natural trade cost level is sufficiently low, another implication of $\partial(w_i/w_j)/\partial t_j^* > 0$ and $\partial(w_j^*/w_i^*)/\partial t_i > 0$ is that each country can dissolve an agglomerated equilibrium characterised by its relatively high export-sector protection by use of a trade-liberalising strategy in this sector. Table 1 provides examples of unilateral domestic strategies that dissolve the agglomerated equilibrium characterised by domestic good-i production and establishes the opposite agglomerated equilibrium. As revealed by the estimates listed in the table, the strategies that can be used to obtain this objective are normally of small magnitude relative to the common domestic and foreign trade cost levels.

3.2 In a dispersed equilibrium

The simulation results throughout this paper are based on simulations in the following parameter intervals: $2 \leq \sigma \leq 5$, $0.1 \leq \mu \leq 0.5$, $0.1 \leq \upsilon \leq 0.3$, and $1.01 \leq t_i, t_j, t_i^*, t_j^* \leq 18$. The simulation results show that a dispersed equilibrium always can be replaced by the unilateral use of trade policy. This feature is manifested by the fact that the domestic equilibrium curve is shifted outwards and the foreign equilibrium curve is shifted inwards by a raised domestic industry-i protection level or a reduced domestic industry-j protection level. Likewise, the foreign equilibrium curve is shifted outwards and the domestic equilibrium curve inwards by a raised foreign industry-i protection level or a reduced foreign industry-j protection level. This implies that a country can use a (unilateral) protectionist policy in industry i or a trade-liberalising industry-j policy to replace a stable dispersed equilibrium with a stable asymmetric equilibrium characterised by a stronger domestic specialisation in good-i production. (Figure 5 provides an example of this effect for the case when the home country utilises a protectionist industry-i policy to replace the symmetric equilibrium with a dispersed asymmetric equilibrium and figure 6 for the case when a domestic trade-liberalising industry-j policy is used to replace a symmetric equilibrium with the agglomerated equilibrium characterised by domestic good-i production.) In the same way, a country's use of a protectionist industry-j policy or a trade-liberalising industry-i strategy replaces a stable dispersed equilibrium with a stable asymmetric equilibrium characterised by a stronger domestic specialisation in good-j production. In fact, it is this pattern that can lead the use of strong enough unilateral policies to dissolve an agglomerated equilibrium while establishing the opposite agglomerated equilibrium. (See figure 7.) For each level of trade costs in the other sector, the common trade cost level above which the opposite agglomerated equilibrium cannot be triggered by the unilateral use of import-sector protection defines a sustain point for the opposite agglomerated equilibrium.

If the common domestic and foreign trade cost level in each sector is high enough, the shifts in the equilibrium curves that can be obtained by the use of unilateral protection are restricted so that

[7] In the agglomerated equilibrium characterised by the domestic good-i production, the foreign relative industry-j wage expression equals:

$$w_j^*/w_i^* = \left[t_j^{\sigma\upsilon} t_i^{*-\sigma\mu}\left(((1-\mu+\upsilon)/2)t_i^{*\sigma-1} + ((1+\mu-\upsilon)/2)t_i^{1-\sigma}\right)\right]^{-1/(\sigma(1-\mu-\upsilon))}.$$

a dispersed asymmetric equilibrium is established no matter how extensive the protectionist policy. (In table 2, the domestic and foreign industry-i employment shares characterising dispersed asymmetric equilibria triggered by very high domestic industry-i protection levels are provided for different parameter sets.)

4 Strategies and outcomes of the trade-policy game

In this section, the trade-policy positions of the governments are assumed to be used as strategies in a game between national welfare-maximising governments. This way, trade-policy choices are endogenously determined in the model. For symmetric and agglomerated equilibria, the utility levels in the trade-policy game are specified as analytical expressions of the exogenous and trade cost parameters. In addition, simulation estimates are used to approximate utility levels for dispersed asymmetric equilibria. The national welfare level is defined as a domestic representative individual's utility level, which equals:[8]

$$u = wQ_i^{-0.5}Q_j^{-0.5}, \tag{17}$$

where w equals the wage earned by all the domestic workers in a stable equilibrium. The domestic utility level is directly and indirectly influenced by the domestic and foreign trade-policy positions. That is, a trade cost alteration imposes a direct effect on the domestic wages and price indices in each sector in a prevailing equilibrium but also affects these values indirectly by influencing the existence of the equilibrium. If an initial equilibrium is dissolved by the use of trade-policy, the new equilibrium is assumed to be immediately established so that policy-makers only take into account the stable equilibrium outcomes of the game.

4.1 The utility ranking of equilibria

The domestic utility level obtained in the symmetric equilibrium and in the different agglomerated equilibria, respectively, are characterised by the following exogenous and trade cost parameter expressions:[9]

$$u_{ai} = \left[(1-\mu-\upsilon)^2 t_j^{-(1-\sigma+\sigma\mu)} t_i^{*\sigma\upsilon}\right]^{0.5/(1-\sigma+\sigma\mu+\sigma\upsilon)} \tag{18}$$

$$u_s = \left[4(1-\mu-\upsilon)^2(1+t_i^{1-\sigma})^{-1}(1+t_j^{1-\sigma})^{-1}\right]^{0.5/(1-\sigma+\sigma\mu+\sigma\upsilon)} \tag{19}$$

$$u_{aj} = \left[(1-\mu-\upsilon)^2 t_i^{-(1-\sigma+\sigma\mu)} t_j^{*\sigma\upsilon}\right]^{0.5/(1-\sigma+\sigma\mu+\sigma\upsilon)} \tag{20}$$

where the ai, s, and aj subscript denotes the agglomerated equilibrium characterised by domestic good-i production, the symmetric equilibrium, and the agglomerated equilibrium characterised by domestic good-j production. As described in section 2, the natural trade cost level in sector i is assumed to be at least as high as the natural trade cost level in sector j. Sector i will therefore henceforth be referred to as the high natural trade-cost sector.

[8] In addition, this utility level equals a domestic representative individual's real income level. And, since the domestic labour force is normalised to one, it equals the country's level of real income.

[9] These utility level expressions are derived in section 9.5.

From (18) and (20) it can be seen that the domestic utility level in an agglomerated equilibrium is decreasing in the import-sector trade-cost level except when $(1 - \sigma + \sigma\mu)$ is negative with an absolute value exceeded by $\sigma\upsilon$, in which case the domestic utility level is increasing in the import-sector trade-cost level. The former situation is henceforth referred to as the *main case* while the latter situation is referred to as the *exceptional case*.[10] The optimal import-sector policy consistent with the existence of an agglomerated equilibrium is a free-trade position in the main case while it is optimal to use the highest possible protection level (in the sense that it does not dissolve the equilibrium) in the exceptional case.

In the main case, it can be shown that the domestic welfare level is higher in the agglomerated equilibrium characterised by the domestic specialisation in the high natural trade-cost sector than in the opposite agglomerated equilibrium.[11] The economic intuition behind this result is simple: Since less resources are used up in the home country's import transactions, its consumption and production possibilities are larger. Due to the symmetry of the model, this result suggests that the country producing the good traded at low natural costs gains from dissolving the agglomerated equilibrium if the opposite agglomerated equilibrium is established. If the trade cost combination is such that a trade-liberalising export-sector strategy can be used to do so, this strategy is optimal to use since the country's welfare level in the triggered agglomerated equilibrium is decreasing in its former export-sector trade-cost level. Otherwise, the country uses a protectionist import-sector strategy to establish the opposite equilibrium and gains from doing so. This result relies on the fact that a country's utility level in the established agglomerated equilibrium is independent of its former import-sector trade-cost level.

In the exceptional case, the demand increase for domestically produced varieties triggered by the raised import-sector trade-cost level is large enough to reduce the domestic price index for varieties of the domestically produced good in an agglomerated equilibrium. That is, the raised import-sector trade-cost level causes a domestic demand shift towards varieties of the domestically produced good. In turn, the reduced domestic price index on varieties of the domestically produced good leads to a cost reduction large enough to offset the cost increase caused by raised prices on imported intermediate inputs, thereby yielding lower production costs for a domestic representative producer. Since a country's utility level in an agglomerated equilibrium is independent of its export-sector trade-cost level, the optimal import-sector policy can be combined with any export-sector policy that is high enough to be consistent with the existence of the equilibrium. However, to sustain the agglomerated equilibrium, the home country may have to supplement its use of domestic import protection with a raised protection level in its export sector since the relative wage in the foreign productive sector (relative to its unproductive sector) is decreasing in the domestic import-sector trade-cost level and increasing in the domestic export-sector trade-cost level. (So that, in an agglomerated equilibrium characterised by the domestic industry-i specialisation, the foreign relative industry-j wage expression (specified by the foreign counterpart of (15)) is shifted upwards by a raised domestic industry-i trade cost level and shifted downwards by a raised foreign industry-j trade cost level.) This implies that the foreign relative wage expression does

[10] If interpreted in terms of the intermediate input share of the same goods type, the exceptional case prevails when μ is within a particular interval. Specifically, this interval equals $(1 - \upsilon - 1/\sigma) < \mu < (1 - 1/\sigma)$, so that the size of the interval equals υ and the interval location depends on σ.

[11] Since the optimal import policies are free-trade positions in this case, the trade cost parameters in the agglomerated equilibrium utility expressions consist of natural trade cost levels. And since the natural trade cost levels are symmetric across countries by definition, this implies that a utility comparison of the two equilibria equals the utility comparison provided in section 9.6.1.

not effectively restrict the optimal domestic import-sector protection level consistent with the existence of the agglomerated equilibrium for a country willing to complement its protectionist import-sector policy with a protectionist export-sector policy. That is, since the foreign relative wage in its productive sector is increasing in the domestic export-sector trade cost level and the domestic utility level is independent of this trade cost level in the agglomerated equilibrium, the home country will simultaneously raise its import-sector and export-sector trade-cost level up to the point at which a raised import protection level would dissolve the agglomerated equilibrium (by reducing the relative wage in the domestic productive sector to a value below one). Moreover, the fact that the domestic relative wage in the productive sector is increasing in the foreign export-sector trade cost level implies that the domestic maximum import-sector trade-cost level consistent with the existence of the domestic agglomerated equilibrium is raised if the foreign country uses an export-sector protection level higher than the one required to exactly offset the effect of the foreign import-sector protection.

In the exceptional case, under the assumption that trade cost levels are symmetric across countries, it can be shown that the domestic welfare level is higher in the agglomerated equilibrium characterised by the domestic specialisation in the high (protection-inclusive) trade-cost sector than in the opposite agglomerated equilibrium.[12] This implies that the country specialised in the low trade-cost sector always gains from using a protectionist import-sector strategy that dissolves the agglomerated equilibrium and establishes the opposite agglomerated equilibrium. As in the main case, this result hinges on the fact that a country's utility level in the established agglomerated equilibrium is independent of the trade cost level in its former import-sector. In contrast to the main case, the country loses from using a trade-liberalising export-sector strategy to obtain the same objective. In fact, since a country's utility level in an agglomerated equilibrium is increasing in its import-sector trade cost level, it is optimal for the country specialised in the low natural trade-cost sector to combine the dissolving import-sector strategy with a protectionist export-sector policy that is just large enough to maximise the country's utility level in the triggered agglomerated equilibrium.

Combining (18) and (19) under the assumption that trade cost levels are symmetric across countries yields that the domestic utility level is higher in the agglomerated equilibrium characterised by the domestic production of the good traded at high costs than in the symmetric equilibrium if the trade cost level on the good traded at low costs is not too high.[13] Likewise, when trade cost levels are symmetric across countries, combining (20) and (19) yields that the domestic utility level in the agglomerated equilibrium characterised by the domestic production of the good traded at low costs is exceeded by the domestic utility level in the symmetric equilibrium if the trade cost level in the high trade-cost sector is not too low. In fact, the simulation results show that if a large enough trade cost gap exists between sectors, a country's utility level is higher in the agglomerated equilibrium characterised by the domestic specialisation in the high trade-cost sector than in the symmetric equilibrium while a country's utility level in the symmetric equilibrium exceeds that obtained in the agglomerated equilibrium characterised by the domestic specialisation in the low trade-cost sector. (In table 3, domestic utility levels obtained in agglomerated and symmetric equilibria are reported for various exogenous and trade cost parameter combinations.) If the trade cost gap between sectors is not that large, the utility ranking of equilibria is altered so that each agglomerated equilibrium is ranked in the same way to the symmetric equilibrium.

[12] See section 9.6.1.

[13] See section 9.6.2.

Moreover, whether a country's utility level is higher in an agglomerated equilibrium than in a symmetric equilibrium is sensitive to the particular exogenous parameter set.[14]

The simulation results indicate that a trade-liberalising strategy cannot be used to replace an agglomerated equilibrium with a stable dispersed asymmetric equilibrium. This is the result of the fact that the trade-liberalising (export-sector) strategy required to dissolve the agglomerated equilibrium yields a trade-cost combination at which the only stable equilibria are agglomerated equilibria. In contrast, the simulation results indicate that a protectionist (import-sector) strategy can always be used to replace an agglomerated equilibrium with a dispersed asymmetric equilibrium. (In table 4, utility estimates are provided for dispersed asymmetric equilibria established by use of this strategy). However, each country loses from using this strategy unless the trade cost gap is relatively large. Yet, if the trade cost gap is large enough for the country specialised in the low trade-cost sector to gain from replacing an agglomerating equilibrium with a stable dispersed equilibrium characterised by its specialisation in the high trade-cost sector, the gain is always larger from using a policy that establishes the agglomerated equilibrium characterised by its complete specialisation in the high trade-cost sector. That is, the simulation results indicate that the gain from triggering an equilibrium characterised by the opposite specialisation pattern is attributed to the fact that the country becomes specialised in the high trade-cost sector.

It is evident from the simulations that a country always gains from replacing the symmetric equilibrium with a dispersed asymmetric equilibrium by use of a trade-liberalising policy. This is true for the trade-liberalisation taking place in both sectors. In contrast, a country always loses from using a protectionist policy to replace the symmetric equilibrium with a dispersed asymmetric equilibrium. (Table 5 provides some utility level estimates for dispersed asymmetric equilibria replacing symmetric equilibria due to unilateral trade-policy alterations.) In fact, the simulation results indicate that the utility gain from establishing the dispersed asymmetric equilibrium is larger, the stronger the trade-liberalising policy is in each sector. This implies that, for natural trade-cost level combinations above the sustain point, it is optimal for a country to use free-trade policies in each sector to dissolve the symmetric equilibrium and trigger a dispersed asymmetric equilibrium.

4.2 Trade-policy equilibria

As described in the previous section, a country always gains from using a trade-liberalising strategy to dissolve the symmetric equilibrium and replace it with a dispersed asymmetric equilibrium while it loses from using a protectionist policy to do so. Furthermore, the utility gain from using the trade-liberalising strategy is maximised if free-trade policy positions are used in each sector. These results together imply that, if a symmetric equilibrium is generated from the trade-policy game, it is always characterised by mutual free-trade positions and utility levels equal to:

$$u = u^* = (4(1-\mu-\upsilon)^2(1+\tau_i^{1-\sigma})^{-1}(1+\tau_j^{1-\sigma})^{-1})^{0.5/(1-\sigma+\sigma\mu+\sigma\upsilon)} \tag{21}$$

At natural trade cost levels above the sustain point, this symmetric equilibrium is always generated from the trade-policy equilibrium since each country gains from using a trade-liberalising strategy in any symmetric equilibrium characterised by protectionist policies and since each country loses from using protection in a symmetric equilibrium. At natural trade cost levels below this point, the symmetric equilibrium can only be generated from the trade policy game if the trade cost gap between sectors is

[14] See section 9.6.2.

not too large. An additional requirement is that a country's utility level in the symmetric equilibrium incorporating free-trade policies exceeds that obtained in the agglomerated equilibrium characterised by optimal policies consistent with the existence of the equilibrium. In the main case, this requirement is equivalent to the condition that a country's utility level in the symmetric equilibrium exceeds its utility level in each agglomerated equilibrium existing at natural trade cost levels. This result hinges on the facts that the optimal import policies consistent with the existence of the agglomerated equilibrium are free-trade policies, this optimal agglomerated equilibrium can be triggered by the unilateral use of a protectionist strategy in the sector becoming the country's export sector and since a country's utility level is independent of its export-sector policy position. In the exceptional case, this requirement is equivalent to the condition that a country's utility level in the symmetric equilibrium exceeds its utility level in each agglomerated equilibrium characterised by maximum import-sector trade-cost levels (consistent with the existence of the equilibrium).

In the main case, an agglomerated equilibrium can only be generated from the trade-policy game if the natural trade cost levels are symmetric across sectors. As described in the previous section, this is the consequence of that the country specialised in the low natural trade-cost sector always gains from using a strategy that dissolves the agglomerated equilibrium and establishes the opposite agglomerated equilibrium. Moreover, the fact that a country obtains the same utility level in the two agglomerated equilibria when the natural trade cost levels are symmetric across sectors indicates that no trade partner gains from using a strategy that replaces an agglomerated equilibrium with the opposite agglomerated equilibrium. In addition, as described in the previous section, when no natural trade cost gap exists between sectors, each country loses from using a (protectionist) policy to replace the agglomerated equilibrium with a dispersed asymmetric equilibrium. These results together indicate that, in the main case, no country wants to dissolve an agglomerated equilibrium characterised by free-trade import policies when the natural trade-cost levels are symmetric across sectors. That is, there exist a Nash equilibrium with the strategy combination $((\pi_{\mathrm{imp}}, \pi_{\mathrm{exp}}), (\pi^*_{\mathrm{imp}}, \pi^*_{\mathrm{exp}})) = ((0, x), (0, z))$, where the subscripts denote import-sector and export-sector policies, $x, z \in [0, \infty]$, and an outcome combination equal to:

$$\begin{aligned} u &= ((1-\mu-\upsilon)^2 \tau_{\mathrm{imp}}^{-(1-\sigma+\sigma\mu)} \tau_{\mathrm{imp}}^{*\sigma\upsilon})^{0.5/(1-\sigma+\sigma\mu+\sigma\upsilon)}, \\ u^* &= ((1-\mu-\upsilon)^2 \tau_{\mathrm{imp}}^{*-(1-\sigma+\sigma\mu)} \tau_{\mathrm{imp}}^{\sigma\upsilon})^{0.5/(1-\sigma+\sigma\mu+\sigma\upsilon)}, \\ \tau_{\mathrm{imp}} &= \tau^*_{\mathrm{imp}}. \end{aligned} \tag{22}$$

If the natural trade cost levels are symmetric across sectors and the exogenous parameter set is such that a country's utility level in (21) is exceeded by its utility level in (22), the agglomerated equilibrium incorporating free-trade import policies is always generated from the trade-policy equilibrium. This is the result of that, in a symmetric equilibrium, a country can use protection in a sector to establish an agglomerated equilibrium characterised by its specialisation in the protected sector and the fact that a country's utility level in an agglomerated equilibrium is independent of its export-sector trade-cost level.

Otherwise, if the natural trade cost levels are symmetric across sectors but a country's utility level is higher in (21) than in (22), both the agglomerated equilibrium characterised by free-trade import policies and the symmetric equilibrium incorporating free-trade policies can be generated from the trade-policy equilibrium. Specifically, no country wants to use a dissolving strategy in the symmetric equilibrium incorporating free-trade policies since each country's welfare level is maximised in this equilibrium while no unilateral strategy can be used to obtain the symmetric equilibrium in an agglomerated equilibrium at natural trade cost levels and each country's welfare level in this equilibrium exceeds its welfare levels in all other attainable equilibria.

To sum up, in the main case, policy equilibria are identified except for the case when a natural trade cost gap exists between sectors and the parameter combination is such that a country's utility level in at least one of the agglomerated equilibria characterised by free-trade import policies exceeds its utility level in the symmetric equilibrium incorporating a free-trade policy position. In this case, no Nash equilibrium exists since, for each equilibrium, at least one of the countries gains from using a strategy that dissolves the current equilibrium and replaces it with the agglomerated equilibrium in which the country is specialised in the high natural trade-cost sector.

In the exceptional case, it can be shown analytically that the agglomerated equilibrium can be generated from the policy equilibrium only if the natural trade cost levels are symmetric across sectors. (See section 9.7.2.) In addition, the agglomerated equilibrium must be characterised by symmetric protection-inclusive import-sector trade-cost levels in order to be generated from the policy equilibrium since one of the countries gains from dissolving the equilibrium otherwise. This is the result of that the country specialised in the low (protection-inclusive) trade-cost sector always gains from using a dissolving protectionist policy. That is, regardless of whether the opposite agglomerated equilibrium or a dispersed asymmetric equilibrium is triggered, the country gains from using a dissolving protectionist policy since it gains from attaining some production in the high trade-cost sector (as described in section 4.1). Moreover, the fact that the import-sector trade-cost levels are symmetric implies that the export-sector trade-cost level are symmetric as well since each country utilises a high enough export-sector trade-cost levels to maximise the optimal protection level in its import sector and since an export sector above this level increases the foreign optimal protection level so that the equilibrium becomes unsustainable. Furthermore, it can be shown analytically that the symmetric import-sector trade-cost level must be at least as high as the symmetric export-sector trade-cost level for this agglomerated equilibrium to be sustainable.[15] (See section 9.7.1.) If an agglomerated equilibrium is generated from the policy equilibrium in the exceptional case, it is therefore characterised by the equilibrium strategy combination $((\pi_{\text{imp}}, \pi_{\text{exp}}), (\pi^*_{\text{imp}}, \pi^*_{\text{exp}})) = ((t_{\text{SP,imp}} - \tau_{\text{imp}}, t_{\text{x,exp}} - \tau_{\text{exp}}), (t^*_{\text{SP,imp}} - \tau^*_{\text{imp}}, t^*_{\text{x,exp}} - \tau^*_{\text{exp}}))$ where the SP subscript denotes the agglomerated equilibrium's sustain point level, the x subscript denotes the export-sector trade-cost level that is just high enough to offset the impact of the country's optimal import protection level on the trade partner's relative wage in its productive sector and $t_{\text{SP,imp}} = t^*_{\text{SP,imp}}$, $t_{\text{X,exp}} = t^*_{\text{X,exp}}$, $t_{\text{SP,imp}} \geq t_{\text{x,exp}}$. In turn, the corresponding equilibrium outcome combination equals:

$$
\begin{aligned}
u &= ((1-\mu-\upsilon)^2 t_{\text{SP,imp}}^{-(1-\sigma+\sigma\mu)} t_{\text{SP,imp}}^{*-\sigma\upsilon})^{0.5/(1-\sigma+\sigma\mu+\sigma\upsilon)}, \\
u^* &= ((1-\mu-\upsilon)^2 t_{\text{SP,imp}}^{*-(1-\sigma+\sigma\mu)} t_{\text{SP,imp}}^{-\sigma\upsilon})^{0.5/(1-\sigma+\sigma\mu+\sigma\upsilon)}, \\
t_{\text{SP,imp}} &= t^*_{\text{SP,imp}}.
\end{aligned}
\tag{23}
$$

If the natural trade cost levels are symmetric across sectors and below the sustain point, the described agglomerated equilibrium is generated from the policy equilibrium if a country's utility level in (23) exceeds its utility level in (21) and each country combines its optimal import policy with the appropriate export-sector policy (specified by the described equilibrium strategies). If the opposite utility ranking

[15] This result hinges on the fact that a country gains from using the maximum import protection level consistent with the existence of the agglomerated equilibrium in the exceptional case.

of equilibria prevails, both this agglomerated equilibrium and the symmetric equilibrium incorporating free-trade policies can be generated in the trade-policy game. That is, no country wants to use a dissolving strategy in the symmetric equilibrium since its utility level is maximised in this equilibrium while the fact that no equilibrium characterised by a higher national welfare level can be attained in the described agglomerated equilibrium implies that no country can gain from using a dissolving strategy in this equilibrium either.

As described previously for the main case, the symmetric equilibrium characterised by a free-trade policy position is generated from the policy equilibrium above the sustain point or when the natural trade cost levels are asymmetric across sectors and the exogenous parameter set is such that the utility level in this symmetric equilibrium exceeds its utility level in each agglomerated equilibrium incorporating optimal import policies. In the case when the natural trade cost levels are asymmetric across sectors and the exogenous parameter combination is such that each country's utility level is higher in one of the agglomerated equilibria characterised by optimal protectionist import policies, no Nash-equilibrium exist since at least one of the countries always gains from dissolving the equilibrium.

5 Concluding Discussion

In this paper, the economic role of trade policy is examined in a Krugman and Venables (1996) model modified to allow for trade cost levels that are asymmetric across sectors and countries. Formally, the iceberg trade cost level of the model is divided into industry-specific trade cost levels containing natural parts that are of equal size in both directions of a trade relation and a country-specific political parts in the form of protection. This modification yields an equilibrium structure that can differ from that of the Krugman and Venables (1996) model even if no protectionist policies are utilised since it allows natural trade cost levels to be asymmetric across sectors. Specifically, if trade cost levels are symmetric across countries, stable symmetric equilibria exists only if the industry trade cost levels are high enough or if a large enough trade cost gap exists between sectors while an agglomerated equilibrium can exist only if the sum of trade cost levels are not too large. These effects indicate that firms in each industry gain from agglomerating together in the same location if the natural trade cost levels are similar in size across industries and sufficiently low. This result hinges on the fact that the presence of inter-industry input-output linkages counteracts the gains from specialisation for the producers in at least one industry if the trade cost level on varieties of one goods type is sufficiently high.

In examining the unilateral trade policy effects on the equilibrium structure in the modified Krugman and Venables (1996) model, the following main results are obtained. It is shown that unilateral trade policies can be used to dissolve any equilibrium configuration in the model providing that the Krugman and Venables (1996) form of the so-called no-black-hole condition prevails. Specifically, it is shown that a protectionist import-sector policy can always be used to dissolve an agglomerated equilibrium while a trade-liberalising export-sector policy can be used to obtain the same objective for some natural trade cost combinations.[16] In addition, the simulation results reveal that a country's use of a protectionist policy on varieties of one goods type always replaces a dispersed equilibrium with an equilibrium characterised by a higher international production share of the particular goods type while a trade-liberalising policy in a sector has the opposite effect.

[16] The simulation results reveal that the only stable equilibrium that can be obtained in this case is the opposite agglomerated equilibrium.

The following main results are obtained from the national welfare comparisons of different equilibria. First, the welfare ranking of equilibria depends on the exogenous parameter set as well as the trade cost gap between sectors. In particular, if the trade cost gap between sectors is sufficiently small, a country's welfare level in a symmetric equilibrium can exceed its welfare level in each agglomerated equilibrium under normal model conditions. If trade costs are symmetric across countries, this result implies that there are situations in which no country wants to use a dissolving strategy in a symmetric equilibrium even if each agglomerated equilibrium can be established by the use of trade policy. This result underlies the outcome that each country can prefer to remain in the symmetric equilibrium characterised by free-trade policy positions even if unilateral strategies that can trigger each agglomerated equilibrium are available. Second, in the main case, the country specialised in producing the good traded at low natural trade costs always gains from using a strategy that dissolves a prevailing agglomerated equilibrium and establishes the opposite agglomerated equilibrium. The economic intuition behind this result is that a country gains from being specialised in producing the good traded at high costs since less resources are used up in the country's import transactions in this case. Moreover, this result is valid even if a protectionist policy is used to trigger the opposite equilibrium since a country's welfare level in the established equilibrium is independent of its export-sector trade-cost level. Third, in the exceptional case, an agglomerated equilibrium can be sustainable only if it is characterised by trade cost levels that are symmetric across import sectors. This is the result of that the country specialised in the low trade-cost sector always gains from using a protectionist import-sector strategy that dissolves the agglomerated equilibrium.

The following policy equilibria are identified. In the main case, the agglomerated equilibrium characterised by free-trade import policies can be generated from the trade policy game if the natural trade cost levels are symmetric across sectors and low enough for an agglomerated equilibrium structure to exist depending on the exogenous parameter set. The result that an agglomerated equilibrium can be generated from the policy equilibrium contrasts to that put forward in Thede (2002), which revealed that agglomerated equilibria can never be generated from the trade-policy game in a Krugman and Venables (1995) setting (whether modified to incorporating trade costs in the homogenous sector or not). The different result in this study can be attributed to the fact that the presence of intermediate input linkages between sectors can generate price-reducing effects between the two sectors so that the gains from agglomeration benefits both trade partners. Another novel result in this paper is that the symmetric equilibrium characterised by free-trade policies can be generated from the trade-policy game under normal model conditions. This is the result of that, under non-extreme conditions, each country's national welfare level can be maximised in the symmetric equilibrium characterised by free-trade policies. In turn, this result indicates that the presence of inter-industry input-output linkages counteract the gains from agglomeration to such an extent that each firm can prefer to remain in an equilibrium characterised by a complete industry dispersion.

In the exceptional case, the symmetric equilibrium characterised by free-trade policies is normally the identified policy equilibrium. However, an agglomerated equilibrium characterised by trade cost levels that are symmetric across import sectors and export sectors, respectively, may be generated from the policy equilibrium under certain conditions. Especially, besides the condition that the natural trade cost levels are symmetric across sectors and that the import-sector trade-cost level must exceed the export-sector trade-cost level, the fact that each country's optimal import-sector protection level must be combined with a unique export-sector protection level for a simultaneous policy implementation not to dissolve the equilibrium suggests that this equilibrium can be generated from the policy equilibrium only under extreme model conditions. Nevertheless, this potential policy equilibrium provides an example of a case in which each country prefers the non-cooperative Nash-equilibrium to a free-trade situation. That is, the result suggests that a so-called large country (i.e. a country with a non-negligible part of the world market for the protected good(s)) can gain from using a protectionist policy position even if an equivalent protectionist policy is used by the trade partner. Yet, the policy-implication of the result that free-trade policy equilibria normally are identified is more noteworthy in several respects. First, the result is general in the modified Krugman and Venables (1996) model, implying that the presence of inter-industry input-output linkages can generate sufficiently large gains to outweigh the gains that a large country can incur by use of a protectionist policy under normal model conditions. Second, the fact that agglomerated locational equilibria can be generated from free-trade policy equilibria illustrates that a large country can prefer to remain in an equilibrium characterised by a complete international concentration of production at the natural trade cost levels. Third, the result that symmetric locational equilibria always are generated from free-trade policy equilibria implies that the presence of inter-industry input-output linkages provides an alternative explanation of the institutionalised cooperative behaviour compared to that provided by previous researchers in the strategic trade-policy interaction literature. (See e.g. Bagwell and Staiger (1999)).

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7 Figures

Table 1

Domestic Unilateral Dissolving Policies that Trigger the Opposite Agglomerated Equilibrium[a]

$\mu - \upsilon$	σ	$(t_i, t_j)^b$	$\triangle\pi^c_{i,D}$	$\triangle\pi^c_{j,D}$
0.1	2	(1.3,1.4)	-0.27	+0.34
0.2	3	(1.5,1.6)	-0.36	+0.23
0.2	4	(1.4,1.1)	-0.23	+0.13
0.3	4	(1.6,1.6)	-0.52	+0.23
0.3	5	(1.5,1.4)	-0.25	+0.1
0.4	5	(1.3,1.4)	-[d]	+0.7

[a] The initial agglomerated equilibrium is characterised by domestic good-i production
[b] The third column depicts the initial trade cost levels that are symmetric across countries.
[c] These are minimum required unilateral sector-specific alterations.
[d] A domestic industry-j trade-liberalisation can not dissolve the equilibrium.

Table 2

Dispersed Asymmetric Equilibria Triggered by the Use of Protection[a]

$\mu - \upsilon$	σ	$(t_i, t_j)^b$	$\triangle\pi^c_i$	(L_i, L_i^*)
0.1	2	(4.0,3.0)	11.0	(0.37,0.62)
0.2	3	(2.0,3.0)	12.5	(0.36,0.61)
0.3	3	(5.0,2.0)	3.0	(0.47,0.53)
0.2	4	(2.0,1.5)	11.5	(0.40,0.60)
0.3	4	(1.7,2.0)	16.3	(0.29,0.69)
0.3	5	(4.0,2.0)	4.0	(0.49,0.51)
0.4	5	(4.0,2.0)	3.0	(0.49,0.51)
0.4	5	(1.7,2.0)	6.3	(0.39,0.59)

[a] All trade cost combinations are above the sustain point.
[b] The third column depicts the initial trade cost levels that are symmetric across countries.
[c] The fourth column reports the unilateral policy alterations from the initial situation.

Table 3

Symmetric and Agglomerated Equilibrium Utility Levels

υ	μ	σ	$(t_i, t_j)^a$	u_{ai}	u_s	u_{aj}
0.1	0.2	2	(1.5,1.8)[b]	1.495	1.329	1.264
0.2	0.3	3	(1.3,1.25)	2.674	2.610	2.622
0.2	0.3	3	(1.3,1.15)	2.930	2.795	2.756
0.1	0.4	4	(1.7,1.6)	1.868	2.031	1.813
0.1	0.4	4	(1.7,1.2)	2.948	2.281	2.477
0.2	0.4	5	(1.3,1.26)	1.713	1.717	1.662
0.2	0.4	5	(1.3,1.15)	1.907	1.821	1.793

[a] The third column depicts trade cost levels that are symmetric across countries.
[b] The combined symmetric and agglomerated equilibrium structure does not exist for sector-j trade cost levels below this treshold point.

Table 4

Equilibrium Utility Levels Before and After a Unilateral Policy Alteration[a]

$\mu - \upsilon$	σ	$(t_i, t_j)^b$	$t_{i,1}$	$u_{aj,0}$	$u_{s,0}$	$u_{da,1}$
0.2	3	(1.9,1.4)	2	1.144	1.200	1.159
0.2	3	(1.4,1.9)	1.45	1. 332	1.200	1.161
0.2	3	(1.9,1.3)	1.98	1.156	1.240	1.185[b]
0.3	4	(1.7,1.7)	1.8	1.389	1.077	1.120
0.3	4	(1.8,1.5)	1.95	1.222	1.088	1.212
0.4	5	(1.45,1.45)	1.5	1.165	1.338	1.144
0.4	5	(1.4,1.5)	1.45	1.186	1.135	1.148
0.4	5	(1.5,1.4)	1.55	1.145	1.135	1.141

[a] The 0 and 1 subscripts denote variable intial and policy-induced variable values, respectively.
[b] The third column depicts the initial trade cost levels that are symmetric across countries.
[c] Raising t_i to 2.1 and triggering the agglomerated equilibrium with domestic good-i production ,yields u_{ai}= 1. 3078.

Table 5

Equilibrium Utility Levels Before and After a Unilateral Policy Alteration[a]

$\mu - \upsilon$	σ	$(t_i, t_j)_0^b$	$t_{x,1}$	u_0	u_0^*	u_1	u_1^*
0.2	2	(4.0,4.0)	$x = i, j$, 3	1.226	1.226	1.483	1.377
0.2	2	(4.0,4.0)	$x = j$, 5	1.226	1.226	1.211	1.213
0.2	2	(4.0,4.0)	$x = i, j$, 5	1.226	1.226	1.131	1.076
0.2	3	(3.0,3.0)	$x = i$, 2	0.908	0.908	0.943	0.930
0.2	3	(3.0,3.0)	$x = i$, 4	0.908	0.908	0.894	0.897
0.2	3	(3.0,3.0)	$x = i$, 2, $x = j$, 4	0.908	0.908	0.943	0.927
0.2	3	(3.0,3.0)	$x = i$, 2, $x = j$, 2	0.908	0.908	0.980	0.952
0.3	4	(2.0,3.0)	$x = i$, 3	1.080	1.080	1.052	1.055
0.3	4	(2.0,3.0)	$x = j$, 4	1.080	1.080	1.075	1.089
0.3	4	(2.0,3.0)	$x = i$, 1.5	1.080	1.080	1.120	1.105
0.3	4	(2.0,3.0)	$x = j$, 2	1.080	1.080	1.105	1.106
0.3	4	(2.0,3.0)	$x = i$, 1.5, $x = j$, 2	1.080	1.080	1.136	1.124
0.3	5	(2.0,3.0)	$x = j$, 2	1.025	1.025	1.032	1.048
0.3	5	(2.0,3.0)	$x = j$, 4	1.025	1.025	1.023	1.023
0.2	2	(2.0,1.5)	$x = j$, 1.2	1.005	1.005	1.026	1.027
0.2	2	(2.0,1.5)	$x = j$, 1.8	1.005	1.005	0.981	0.990

[a] The 0 and 1 subscripts denote variable intial and policy-induced variable values, respectively.

[b] The third column depicts trade cost levels that are symmetric across countries.

8 Figures

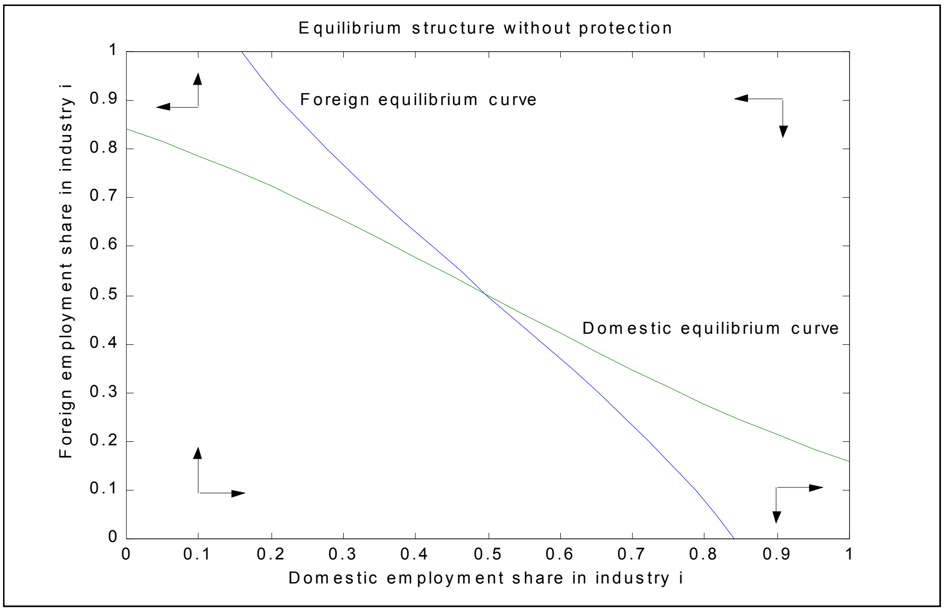

Figure 1. Parameter values: $\mu = 0.47$, $\upsilon = 0.08$, $\sigma = 4$, and $t_i = t_j = t_i^* = t_j^* = 1.5$.

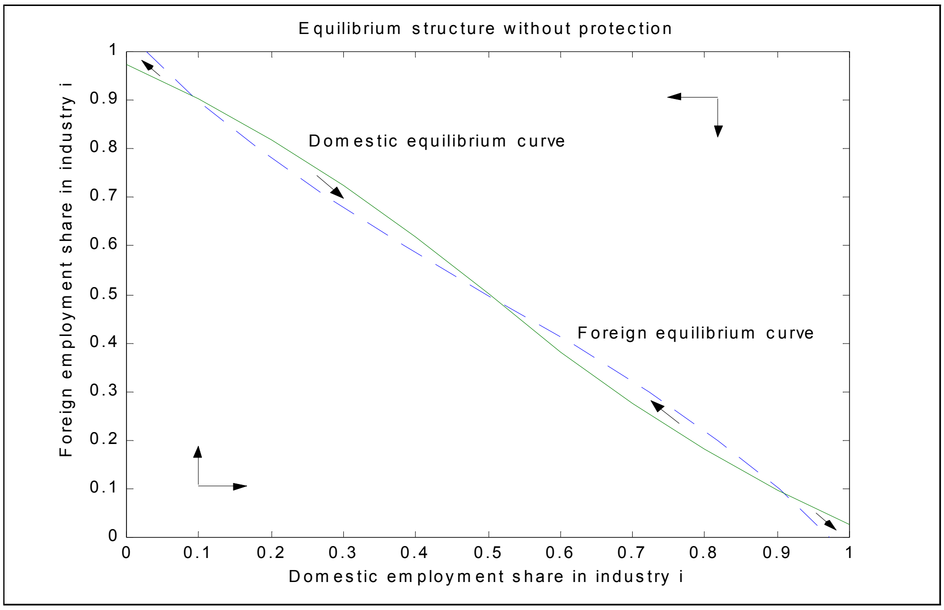

Figure 2. Parameter values: $\mu = 0.47$, $\upsilon = 0.08$, $\sigma = 4$, and $t_i = t_j = t_i^* = t_j^* = 2.15$.

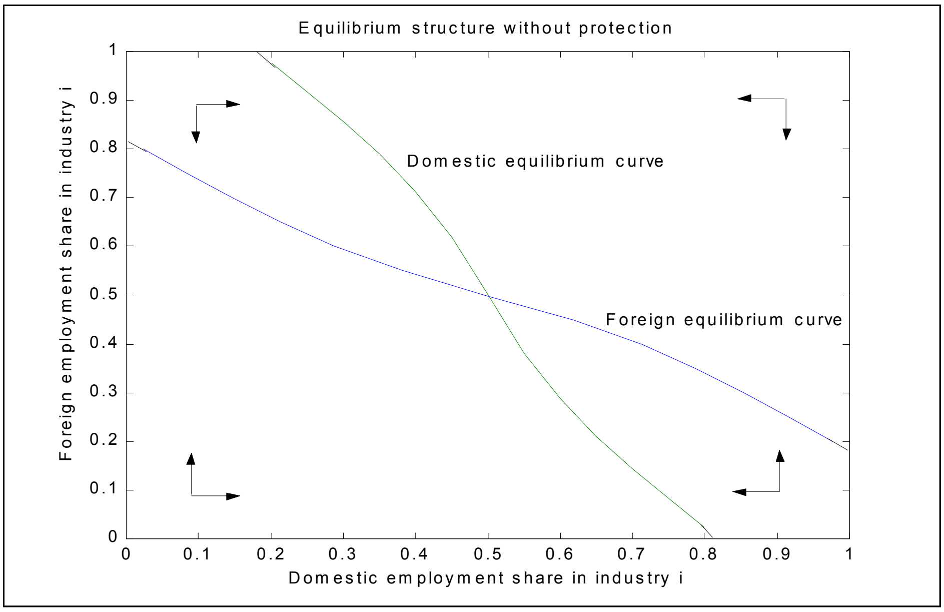

Figure 3. Parameter values: $\mu = 0.47$, $\upsilon = 0.06$, $\sigma = 4$, and $t_i = t_j = t_i^* = t_j^* = 3$.

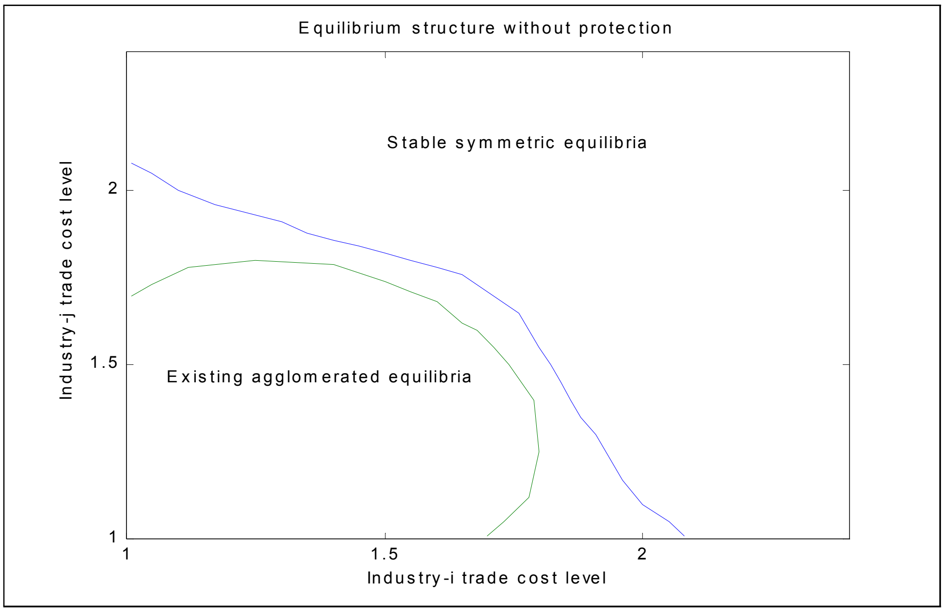

Figure 4. Parameter values: $\mu = 0.4$, $\upsilon = 0.1$, and $\sigma = 4$. The upper curve contains the sustain points and the lower curve consists of the break points, indicating that agglomerated equilibria exists in combination with stable symmetric equilibria in between the two curves.

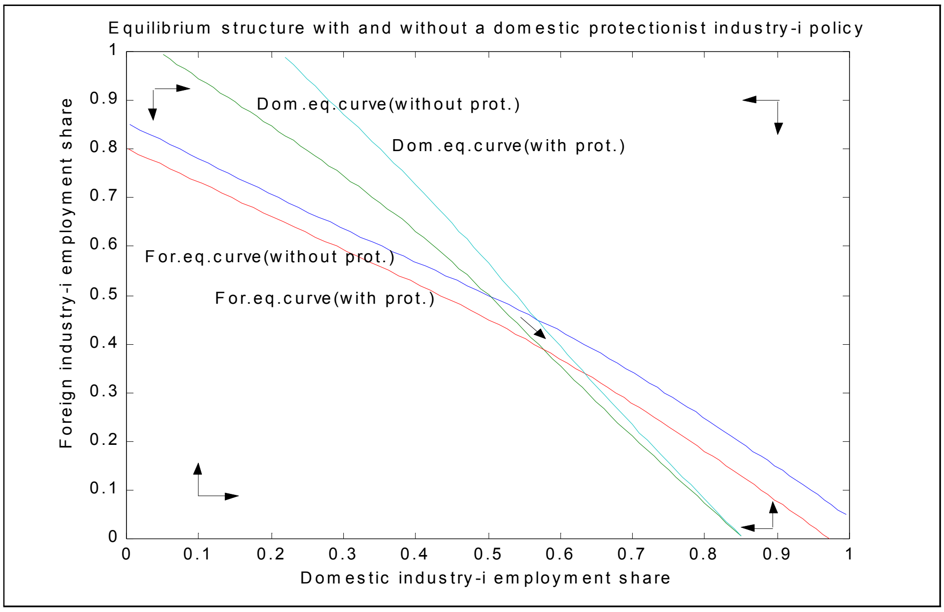

Figure 5. Parameter values: $\mu = 0.3$, $\upsilon = 0.1$, $\sigma = 3$, $t_i(\pi_i = 0) = t_i^* = 1.5$, $t_i(\pi_i = 1.5) = 3, t_j = t_j^* = 3$.

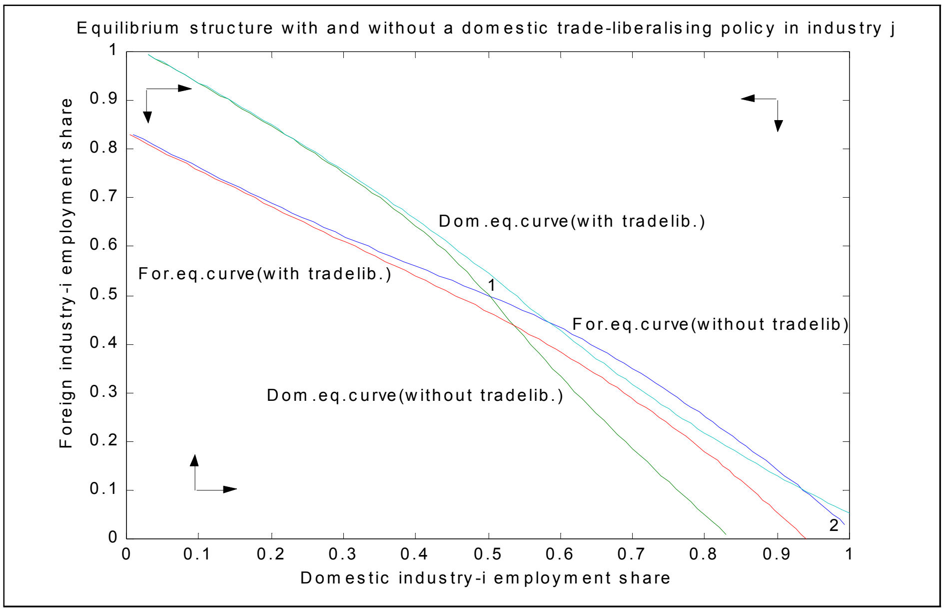

Figure 6. Parameter values: $\mu = 0.4$, $\upsilon = 0.1$, $\sigma = 3$, $t_i = t_i^* = 4$, $t_{j,1} = t_j^* = 2$, $t_{j,2} = 2.5$, where 1 and 2 denotes the equilibrium before and after the trade-liberalising policy is implemented.

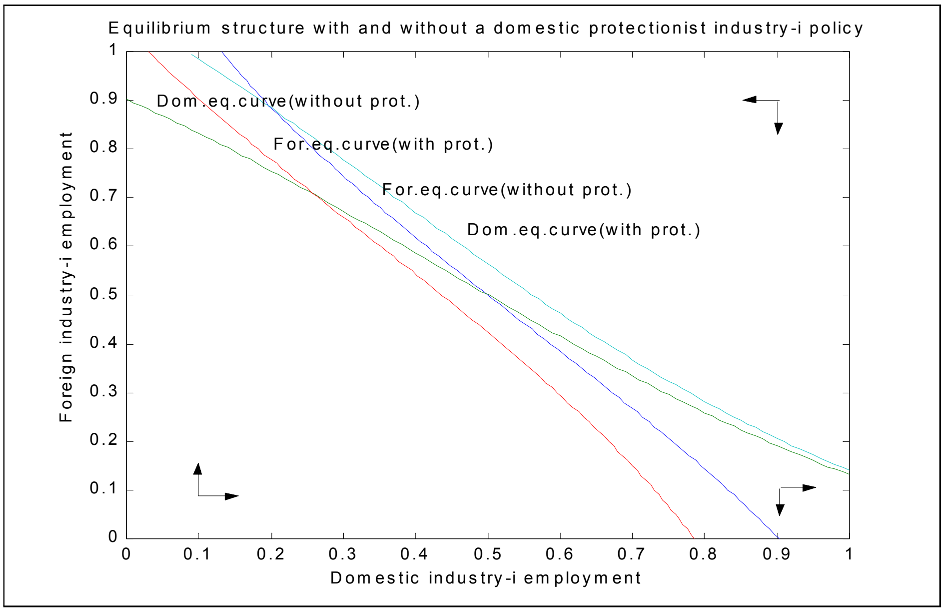

Figure 7. Parameter values: $\mu = 0.4$, $\upsilon = 0.1$, $\sigma = 3$, $t_i(\pi_i = 0) = t_i^* = 1.5$, $t_i(\pi_i = 1.5) = 3, t_j = t_j^* = 2$.

9 Appendix

9.1 Deriving the agglomerated equilibrium wage condition

The agglomerated equilibrium characterised by the domestic specialisation in good i production exists when the following equilibrium equations are fulfilled. (They are derived by imposing the employment share restrictions $L_i = 1$ and $L_j^* = 1$ on the set of equilibrium equations):

$$Q_i = (1-\mu-\upsilon)^{1/(\sigma-1)} \left[w_i^{1-\sigma(1-\mu-\upsilon)} Q_i^{-\sigma\mu} Q_j^{-\sigma\upsilon} \right]^{1/(1-\sigma)} \tag{24}$$

$$Q_j = (1-\mu-\upsilon)^{1/(\sigma-1)} \left[w_j^{*1-\sigma(1-\mu-\upsilon)} Q_j^{*-\sigma\mu} Q_i^{*-\sigma\upsilon} t_j^{1-\sigma} \right]^{1/(1-\sigma)} \tag{25}$$

$$Q_i^* = (1-\mu-\upsilon)^{1/(\sigma-1)} \left[w_i^{1-\sigma(1-\mu-\upsilon)} Q_i^{-\sigma\mu} Q_j^{-\sigma\upsilon} t_i^{*1-\sigma} \right]^{1/(1-\sigma)} \tag{26}$$

$$Q_j^* = (1-\mu-\upsilon)^{1/(\sigma-1)} \left[w_j^{*1-\sigma(1-\mu-\upsilon)} Q_j^{*-\sigma\mu} Q_i^{*-\sigma\upsilon} \right]^{1/(1-\sigma)} \tag{27}$$

$$E_i = 0.5 w_i (1+\mu-\upsilon)/(1-\mu-\upsilon) \tag{28}$$

$$E_j = 0.5 w_i (1-\mu+\upsilon)/(1-\mu-\upsilon) \tag{29}$$

$$E_i^* = 0.5 w_j^* (1-\mu+\upsilon)/(1-\mu-\upsilon) \tag{30}$$

$$E_j^* = 0.5 w_j^* (1+\mu-\upsilon)/(1-\mu-\upsilon) \tag{31}$$

$$w_i = Q_i^{-\mu/(1-\mu-\upsilon)} Q_j^{-\upsilon/(1-\mu-\upsilon)} \left[E_i Q_i^{\sigma-1} + E_i^* Q_i^{*\sigma-1} t_i^{*1-\sigma} \right]^{1/\sigma(1-\mu-\upsilon)} \tag{32}$$

$$w_j = Q_j^{-\mu/(1-\mu-\upsilon)} Q_i^{-\upsilon/(1-\mu-\upsilon)} \left[E_j Q_j^{\sigma-1} + E_j^* Q_j^{*\sigma-1} t_j^{*1-\sigma} \right]^{1/\sigma(1-\mu-\upsilon)} \tag{33}$$

$$w_i^* = Q_i^{*-\mu/(1-\mu-\upsilon)} Q_j^{*-\upsilon/(1-\mu-\upsilon)} \left[E_i^* Q_i^{*\sigma-1} + E_i Q_i^{\sigma-1} t_i^{1-\sigma} \right]^{1/\sigma(1-\mu-\upsilon)} \tag{34}$$

$$w_j^* = Q_j^{*-\mu/(1-\mu-\upsilon)} Q_i^{*-\upsilon/(1-\mu-\upsilon)} \left[E_j^* Q_j^{*\sigma-1} + E_j Q_j^{\sigma-1} t_j^{1-\sigma} \right]^{1/\sigma(1-\mu-\upsilon)} \tag{35}$$

Combining the price index equations to solve for the price indices in terms of exogenous and trade cost variables yields:

$$\begin{aligned} Q_i = ((1-\mu-\upsilon)^{-(1-\sigma+\sigma\mu-\sigma\upsilon)} w_i^{(1-\sigma+\sigma\mu)(1-\sigma+\sigma\mu+\sigma\upsilon)} \\ w_j^{*-\sigma\upsilon(1-\sigma+\sigma\mu+\sigma\upsilon)} t_i^{*\sigma^2\upsilon^2} t_j^{-\sigma\upsilon(1-\sigma+\sigma\mu)})^{1/((1-\sigma+\sigma\mu)^2-\sigma^2\upsilon^2)}, \end{aligned} \tag{36}$$

$$\begin{aligned} Q_j = ((1-\mu-\upsilon)^{-(1-\sigma+\sigma\mu-\sigma\upsilon)} w_j^{*(1-\sigma+\sigma\mu)(1-\sigma+\sigma\mu+\sigma\upsilon)} \\ w_i^{-\sigma\upsilon(1-\sigma+\sigma\mu+\sigma\upsilon)} t_i^{*-\sigma\upsilon(1-\sigma+\sigma\mu)} t_j^{(1-\sigma+\sigma\mu)^2})^{1/((1-\sigma+\sigma\mu)^2-\sigma^2\upsilon^2)}, \end{aligned} \tag{37}$$

$$Q_i^* = ((1-\mu-\upsilon)^{-(1-\sigma+\sigma\mu-\sigma\upsilon)} w_i^{(1-\sigma+\sigma\mu)(1-\sigma+\sigma\mu+\sigma\upsilon)} \\ w_j^{*-\sigma\upsilon(1-\sigma+\sigma\mu+\sigma\upsilon)} t_i^{*(1-\sigma+\sigma\mu)^2} t_j^{-\sigma\upsilon(1-\sigma+\sigma\mu)})^{1/((1-\sigma+\sigma\mu)^2-\sigma^2\upsilon^2)}, \tag{38}$$

$$Q_j^* = ((1-\mu-\upsilon)^{-(1-\sigma+\sigma\mu-\sigma\upsilon)} w_j^{*(1-\sigma+\sigma\mu)(1-\sigma+\sigma\mu+\sigma\upsilon)} \\ w_i^{-\sigma\upsilon(1-\sigma+\sigma\mu+\sigma\upsilon)} t_i^{*-\sigma\upsilon(1-\sigma+\sigma\mu)} t_j^{\sigma^2\upsilon^2})^{1/((1-\sigma+\sigma\mu)^2-\sigma^2\upsilon^2)}. \tag{39}$$

It can be noted that this equilibrium is characterised by $Q_i^* = Q_i t_i^*$ and $Q_j = Q_j^* t_j$. Furthermore, it can be shown that this equilibrium is characterised by $w_i = w_j^*$ by inserting the domestic and foreign good-j expenditure equations and using the domestic industry-i and industry-j price index equations together with the foreign industry i price index equation in (32).

9.2 Deriving the relative wage expression in the agglomerated equilibrium

For the agglomerated equilibrium characterised by the domestic specialisation in good-i production, the relative industry-i wage condition is derived as follows. First, (29),(31),(36),(37), and (39) are inserted into (33), thereby yielding the following expression:

$$w_j^{\sigma(1-\mu-\upsilon)} = 2^{-1} w_j^{*-(1-\sigma+\sigma\mu+\sigma\upsilon)} t_j^{-(1-\sigma+\sigma\mu)} t_i^{*\sigma\upsilon} \\ [w_i(1-\mu+\upsilon) + w_j^*(1+\mu-\upsilon) t_j^{1-\sigma} t_j^{*1-\sigma}].$$

Second, using the fact that the domestic industry-i wage equals the foreign industry-j wage by exchanging w_j^* for w_i in the expression and rearranging the terms yields the domestic relative industry-i wage expression:

$$\frac{w_i}{w_j} = \left[2 t_j^{(1-\sigma+\sigma\mu)} t_i^{*-\sigma\upsilon}[(1-\mu+\upsilon) + (1+\mu-\upsilon) t_j^{(1-\sigma)} t_j^{*1-\sigma}]^{-1}\right]^{1/(\sigma(1-\mu-\upsilon))}.$$

9.3 The no-black-hole condition

Using the Krugman and Venables (1996) model assumption that all trade cost levels are symmetric across industries and countries, yields that the (15) expression can be rewritten into:

$$\frac{w_i}{w_j} = \left[\frac{(1-\mu+\upsilon)}{2} t^{-(1-\sigma(1-\mu+\upsilon))} + \frac{(1+\mu-\upsilon)}{2} t^{(1-\sigma(1+\mu-\upsilon))}\right]^{-1/(\sigma(1-\mu-\upsilon))}. \tag{41}$$

If $t = 1$, the right-hand side of this expression equals one. If the parameter condition $\sigma(1-\mu+\upsilon) \geq 1$ is invalid, both trade cost parameters are increasing in the trade cost level,[17] thereby implying that (41) always is above one in value when trade costs exist. That is, if the no-black-hole condition is invalid, the agglomerated equilibrium characterised by the domestic good-i production exists at all trade cost levels that are symmetric across industries and countries.

[17] That is, the first trade cost parameter is decreasing in the trade cost level if the no-black-hole condition is valid while the second trade cost parameter is always decreasing in the trade cost level.

9.4 Deriving trade cost effects on the relative industry-i wage

In this subsection, the trade cost effects on the relative industry-i wage in an agglomerated equilibrium characterised by domestic good-i production are examined by use of trade cost derivatives of (15). In order to simplify the derivation, (15) is rewritten into:

$$\frac{w_i}{w_j} = \left[(1-\mu+\upsilon)2^{-1}t_j^{-(1-\sigma+\sigma\mu)}t_i^{*\sigma\upsilon} + (1+\mu-\upsilon)2^{-1}t_j^{-\sigma\mu}t_i^{*\sigma\upsilon}t_j^{*1-\sigma}\right]^{-1/(\sigma(1-\mu-\upsilon))}.$$

The derivative of (w_i/w_j) with respect to Z, which denotes the within-brackets expression, equals:

$$\begin{aligned}\frac{\partial(w_i/w_j)}{\partial Z} &= -\frac{1}{\sigma(1-\mu-\upsilon)}((1-\mu+\upsilon)2^{-1}t_j^{-(1-\sigma+\sigma\mu)}t_i^{*\sigma\upsilon} \\ &\quad +(1+\mu-\upsilon)2^{-1}t_j^{-\sigma\mu}t_i^{*\sigma\upsilon}t_j^{*1-\sigma})^{-1/(\sigma(1-\mu-\upsilon))-1}.\end{aligned}$$

9.4.1 For the domestic industry-j trade cost level

The derivative of Z with respect to t_j is equal to:

$$\frac{\partial Z}{\partial t_j} = -(1-\sigma+\sigma\mu)(1-\mu+\upsilon)2^{-1}t_j^{-(2-\sigma+\sigma\mu)}t_i^{*\sigma\upsilon} - \sigma\mu(1+\mu-\upsilon)2^{-1}t_j^{-\sigma\mu-1}t_i^{*\sigma\upsilon}t_j^{*1-\sigma}.$$

If the parameter condition $\sigma(1-\mu) < 1$ is valid, this expression is negative. Otherwise, the derivative of Z with respect to t_j is negative for domestic industry-j trade cost levels below the following threshold point:

$$t_{j,TH} = t_j^{*-1}\left[\frac{\sigma\mu(1+\mu-\upsilon)}{-(1-\sigma+\sigma\mu)(1-\mu+\upsilon)}\right]^{1/(\sigma-1)} \tag{43}$$

where $t_{j,TH}$ denotes the domestic industry-j trade cost level threshold. For domestic industry-j trade cost levels above this threshold point, the derivative of Z with respect to t_j is negative.

In combination with the negative derivative of (w_i/w_j) with respect to Z, these results imply that the domestic relative industry-i wage is increasing in the domestic industry-j trade cost level unless the parameter condition $\sigma(1-\mu) > 1$ is valid and the domestic industry-j trade cost level is above the threshold point specified in (43), in which case the domestic relative industry-i wage is decreasing in the domestic industry-j trade cost level.

9.4.2 For the foreign industry-i trade cost level

The derivative of Z with respect to t_i^* equals:

$$\frac{\partial Z}{\partial t_i^*} = \sigma\upsilon(1-\mu+\upsilon)2^{-1}t_j^{-(1-\sigma+\sigma\mu)}t_i^{*\sigma\upsilon-1} + \sigma\upsilon(1+\mu-\upsilon)2^{-1}t_j^{-\sigma\mu}t_i^{*\sigma\upsilon-1}t_j^{*1-\sigma}$$

which is always positive in value. Combined with the negative derivative of (w_i/w_j) with respect to Z, this result implies that the domestic relative industry-i wage is decreasing in the foreign industry-i trade cost level.

9.4.3 For the foreign industry-j trade cost level

The derivative of Z with respect to t_j^* equals:

$$\frac{\partial Z}{\partial t_j^*} = (1-\sigma)(1+\mu-\upsilon)2^{-1}t_j^{-\sigma\mu}t_i^{*\sigma\upsilon}t_j^{*-\sigma}$$

which is always negative in value. Since $\partial(w_i/w_j)/\partial Z < 0$, this result indicates that the domestic industry-i wage is increasing in the foreign industry-j trade cost level.

9.5 Deriving the utility level expression

9.5.1 In the agglomerated equilibrium characterised by domestic good-i production

The domestic utility level is expressed in terms of exogenous, trade cost and wage variables if inserting (36) and (37) in (17). This yields:

$$u = w_i^{0.5}w_j^{*-0.5}\left[(1-\mu-\upsilon)^2 t_j^{-(1-\sigma+\sigma\mu)}t_i^{*\sigma\upsilon}\right]^{0.5/(1-\sigma+\sigma\mu+\sigma\upsilon)}. \tag{44}$$

In turn, using the wage condition that the domestic industry-i wage must equal the foreign industry-j wage in (44) yields the following expression:

$$u = \left[(1-\mu-\upsilon)^2 t_j^{-(1-\sigma+\sigma\mu)}t_i^{*\sigma\upsilon}\right]^{0.5/(1-\sigma+\sigma\mu+\sigma\upsilon)}. \tag{45}$$

The foreign utility level expression is obtained by first inserting (38) and (39) in the foreign counterpart of (17). This yields:

$$u^* = w_i^{-0.5}w_j^{*0.5}\left[(1-\mu-\upsilon)^2 t_j^{\sigma\upsilon}t_i^{*-(1-\sigma+\sigma\mu)}\right]^{0.5/(1-\sigma+\sigma\mu+\sigma\upsilon)}. \tag{46}$$

Second, the agglomerated equilibrium wage condition that the domestic industry-i wage equals the foreign industry-j wage is used in (46) to obtain the foreign utility level expressed in terms of exogenous and trade cost variables:

$$u^* = \left[(1-\mu-\upsilon)^2 t_j^{\sigma\upsilon}t_i^{*-(1-\sigma+\sigma\mu)}\right]^{0.5/(1-\sigma+\sigma\mu+\sigma\upsilon)}. \tag{47}$$

9.5.2 In the symmetric equilibrium

The symmetric equilibrium is characterised by $L_i = L_i^* = 0.5$, $Q_i = Q_i^*$, $Q_j = Q_j^*$, $Y = Y^*$, $E_i = E_i^*$, $E_j = E_j^*$, $w_i = w_i^*$, and $w_j = w_j^*$, which yields the following equation system:

$$Q_i = (1-\mu-\upsilon)^{1/(\sigma-1)}\left[0.5w_i^{1-\sigma(1-\mu-\upsilon)}Q_i^{-\sigma\mu}Q_j^{-\sigma\upsilon}(1+t_i^{1-\sigma})\right]^{1/(1-\sigma)}$$

$$Q_j = (1-\mu-\upsilon)^{1/(\sigma-1)}\left[0.5w_j^{1-\sigma(1-\mu-\upsilon)}Q_j^{-\sigma\mu}Q_i^{-\sigma\upsilon}(1+t_j^{1-\sigma})\right]^{1/(1-\sigma)}$$

$$Y = 0.5(w_i + w_j)$$

$$E_i = 0.5Y + 0.5\left[(\mu w_i + \upsilon w_j)/(1-\mu-\upsilon)\right]$$

$$E_j = 0.5Y + 0.5\left[(\mu w_j + \upsilon w_i)/(1-\mu-\upsilon)\right]$$

$$w_i = Q_i^{-\mu/(1-\mu-\upsilon)} Q_j^{-\upsilon/(1-\mu-\upsilon)} \left[E_i Q_i^{\sigma-1}(1+t_i^{1-\sigma})\right]^{1/\sigma(1-\mu-\upsilon)}$$

$$w_j = Q_j^{-\mu/(1-\mu-\upsilon)} Q_i^{-\upsilon/(1-\mu-\upsilon)} \left[E_j Q_j^{\sigma-1}(1+t_j^{1-\sigma})\right]^{1/\sigma(1-\mu-\upsilon)}$$

Combining the price index equations to solve for the price indices yields:

$$\begin{aligned} Q_i &= w(2(1-\mu-\upsilon))^{-1/(1-\sigma+\sigma\mu+\sigma\upsilon)} \\ &\quad ((1+t_i^{1-\sigma})^{(1-\sigma+\sigma\mu)}(1+t_j^{1-\sigma})^{-\sigma\upsilon})^{1/((1-\sigma+\sigma\mu)^2-\sigma^2\upsilon^2)} \end{aligned} \tag{48}$$

$$\begin{aligned} Q_j &= w(2(1-\mu-\upsilon))^{-1/(1-\sigma+\sigma\mu+\sigma\upsilon)} \\ &\quad ((1+t_i^{1-\sigma})^{-\sigma\upsilon}(1+t_j^{1-\sigma})^{(1-\sigma+\sigma\mu)})^{1/((1-\sigma+\sigma\mu)^2-\sigma^2\upsilon^2)} \end{aligned} \tag{49}$$

The domestic utility level expressed in terms of exogenous and trade cost variables is obtained by using (48) and (49) in (17), which yields:

$$u_s = \left[4(1-\mu-\upsilon)^2(1+t_i^{1-\sigma})^{-1}(1+t_j^{1-\sigma})^{-1}\right]^{0.5/(1-\sigma+\sigma\mu+\sigma\upsilon)} \tag{50}$$

9.6 The utility ranking of equilibria when trade costs are symmetric across countries

9.6.1 Between agglomerated equilibria

If trade costs are symmetric across countries, (18) and (20) becomes equal to the following expressions:

$$u_{ai} = \left[(1-\mu-\upsilon)^2 t_j^{-(1-\sigma+\sigma\mu)} t_i^{\sigma\upsilon}\right]^{0.5/(1-\sigma+\sigma\mu+\sigma\upsilon)}. \tag{51}$$

$$u_{aj} = \left[(1-\mu-\upsilon)^2 t_i^{-(1-\sigma+\sigma\mu)} t_j^{\sigma\upsilon}\right]^{0.5/(1-\sigma+\sigma\mu+\sigma\upsilon)}, \tag{52}$$

The domestic utility level in the agglomerated equilibrium characterised by the domestic good-i production relative to that characterised by foreign good-j production equals:

$$\frac{u_{ai}}{u_{aj}} = \frac{\left[(1-\mu-\upsilon)^2 t_j^{-(1-\sigma+\sigma\mu)} t_i^{\sigma\upsilon}\right]^{0.5/(1-\sigma+\sigma\mu+\sigma\upsilon)}}{\left[(1-\mu-\upsilon)^2 t_i^{-(1-\sigma+\sigma\mu)} t_j^{\sigma\upsilon}\right]^{0.5/(1-\sigma+\sigma\mu+\sigma\upsilon)}}$$

which is equal to:

$$\frac{u_{ai}}{u_{aj}} = \sqrt{\frac{t_i}{t_j}}$$

The relative utility level expression reveals that the domestic utility levels are equal in the two agglomerated equilibria only if the symmetric industry-i and industry-j trade cost levels are identical. In addition, it shows that the domestic utility level is higher in the agglomerated equilibrium characterised by the domestic production of the good traded at relatively higher costs.

9.6.2 Between agglomerated and symmetric equilibria

The domestic utility level in the agglomerated equilibrium characterised by domestic good-i production relative to that obtained in the symmetric equilibrium is equal to:

$$\frac{u_{ai}}{u_s} = \frac{\left[(1-\mu-\upsilon)^2 t_j^{-(1-\sigma+\sigma\mu)} t_i^{\sigma\upsilon}\right]^{0.5/(1-\sigma+\sigma\mu+\sigma\upsilon)}}{\left[4(1-\mu-\upsilon)^2(1+t_i^{1-\sigma})^{-1}(1+t_j^{1-\sigma})^{-1}\right]^{0.5/(1-\sigma+\sigma\mu+\sigma\upsilon)}}$$

$$\frac{u_{ai}}{u_s} = \left[0.25(t_i^{\sigma\upsilon} + t_i^{1-\sigma+\sigma\upsilon})(t_j^{-(1-\sigma+\sigma\mu)} + t_j^{-\sigma\mu})\right]^{0.5/(1-\sigma+\sigma\mu+\sigma\upsilon)} \tag{53}$$

It can be shown that (53) is always increasing in t_i. If $(1-\sigma+\sigma\upsilon)$ is positive, so that the parameter condition $(1-\sigma+\sigma\mu+\sigma\upsilon) \geq 0$ is fulfilled (since $\sigma\mu \geq 0$ by definition), the first parenthesis in (53) is increasing in t_i since the exponents of both t_i-terms are positive and the brackets expression is raised by a positive constant. If $(1-\sigma+\sigma\mu+\sigma\upsilon) \geq 0$ is valid and $(1-\sigma+\sigma\upsilon)$ is negative, the absolute value of $(1-\sigma+\sigma\upsilon)$ is lower than $\sigma\upsilon$. This is the result of the previously explained fact that the negative $(1-\sigma+\sigma\mu)$ expression has an absolute value exceeded by $\sigma\upsilon$ in combination with the assumption that the intermediate input share of the own goods type exceeds that of the other goods type. In turn, this indicates that the first parenthesis is increasing in t_i since the positive exponent of the first t_i-term exceeds the negative exponent of the second t_i-term and the brackets expression is raised by a positive constant. If the parameter condition $(1-\sigma+\sigma\mu+\sigma\upsilon) \leq 0$ is valid, $\sigma\mu$ is exceeded by the absolute value of the negative $(1-\sigma+\sigma\upsilon)$ expression. Since the parameter restriction $\mu > \upsilon$ is assumed to hold, this indicates that the absolute value of $(1-\sigma+\sigma\upsilon)$ exceeds $\sigma\upsilon$. Within the first parenthesis of (53), this implies that the positive exponent of the first t_i-term is exceeded by the negative exponent of the second t_i-term, yielding a negative overall effect. In turn, this implies that (53) is increasing in t_i since the brackets expression is rased by a negative constant.

(53) is always decreasing in t_j. If the parameter condition $(1-\sigma+\sigma\mu+\sigma\upsilon) \geq 0$ is fulfilled and $(1-\sigma+\sigma\mu)$ is positive, the exponential of both t_j-terms within the second parenthesis are negative and since the brackets expression is raised by a positive constant, this implies that (53) is decreasing in t_j. If $(1-\sigma+\sigma\mu)$ is negative with an absolute value exceeded by $\sigma\upsilon$, the fact that the intermediate input share of the own goods type exceeds the intermediate input share of the other goods type implies that the absolute value of $(1-\sigma+\sigma\mu)$ is exceeded by $\sigma\mu$. In turn, this indicates that the positive exponent of the first t_j-term is exceeded by the negative exponent of the second t_j-term within the second parenthesis. Since the brackets expression is raised by a positive constant, this yields that (53) is decreasing in t_j. If the parameter condition $(1-\sigma+\sigma\mu+\sigma\upsilon) \leq 0$ is valid, so that $(1-\sigma+\sigma\mu)$ is negative with an absolute value exceeding $\sigma\upsilon$ in value, the positive exponent of the first t_j-term exceeds the negative exponent of the second t_j-term. Combined with the fact that the brackets expression is raised by a negative constant, this implies that (53) is decreasing in t_j.

Put differently, the trade cost level effects on (53) indicates that the domestic utility level in the agglomerated equilibrium characterised by good-i production can exceed that obtained in the symmetric equilibrium if the trade cost level in sector i is high enough at given exogenous parameter values and a given trade cost level in sector j. Likewise, the same utility ranking of equilibria prevails if the sector-j trade cost level is low enough at given exogenous parameter values and a given trade cost level in sector i. In the same way, the opposite utility ranking of equilibria can prevail only if the trade cost level is low enough in sector i or high enough in sector j.

9.7 Policy equilibria characteristics in the exceptional case

9.7.1 The utility ranking of agglomerated equilibria when trade costs are asymmetric across countries

Since the optimal trade-policy positions in agglomerated equilibria yields the utility expressions (51) and (52) in the main case, this section is restricted to the exceptional case when $(1-\sigma+\sigma\mu)$ is negative and exceeded by $\sigma\upsilon$. Combining (18) and (20) yields that the domestic utility level in the agglomerated equilibrium characterised by the domestic good-i production relative to that characterised by the domestic good-j production is equal to:

$$\frac{u_{ai}}{u_{aj}} = \left[\left(\frac{t_j}{t_i}\right)^{-(1-\sigma+\sigma\mu)}\left(\frac{t_i^*}{t_j^*}\right)^{\sigma\upsilon}\right]^{0.5/(1-\sigma+\sigma\mu+\sigma\upsilon)}. \tag{54}$$

As described in section 4, the agglomerated equilibrium generated from the policy equilibrium is characterised by trade cost levels that are symmetric across import-sectors and export-sectors, respectively. Using this condition on the trade cost levels in (54) yields:

$$\frac{u_{ai}}{u_{aj}} = \sqrt{\left(\frac{t_j}{t_i}\right)^{-(1-\sigma+\sigma\mu-\sigma\upsilon)/(1-\sigma+\sigma\mu+\sigma\upsilon)}}, t_i = t_j^*,\ t_j = t_i^*. \tag{55}$$

Likewise, combining the foreign counterpart of (18) and (20) yields that the foreign utility level in the agglomerated equilibrium characterised by the foreign good-j production relative to that characterised by the foreign good-i production equals:

$$\frac{u_{aj}^*}{u_{ai}^*} = \left[\left(\frac{t_i^*}{t_j^*}\right)^{-(1-\sigma+\sigma\mu)}\left(\frac{t_j}{t_i}\right)^{\sigma\upsilon}\right]^{0.5/(1-\sigma+\sigma\mu+\sigma\upsilon)}. \tag{56}$$

Using the policy equilibrium condition that an agglomerated equilibrium must be characterised by symmetric import-sector and symmetric export-sector trade-cost levels yields:

$$\frac{u_{aj}^*}{u_{ai}^*} = \sqrt{\left(\frac{t_j}{t_i}\right)^{-(1-\sigma+\sigma\mu-\sigma\upsilon)/(1-\sigma+\sigma\mu+\sigma\upsilon)}}, t_i = t_j^*,\ t_j = t_i^*. \tag{57}$$

Since $\sigma\upsilon$ exceeds the absolute value of $(1-\sigma+\sigma\mu)$ in the exceptional case, expression (55) and (57) together show that an agglomerated equilibrium generated from the policy equilibrium must be characterised by a symmetric import-sector trade-cost level that is at least equal to the symmetric export-sector trade-cost level.

9.7.2 The natural trade cost characteristics of an agglomerated equilibrium

It can be shown that an agglomerated equilibrium can be generated from the trade-policy equilibrium only if the natural trade cost levels are symmetric across sectors by using the fact that a policy equilibrium is characterised by each country's unilateral protectionist import-policy position yielding a total import-sector trade-cost level at the sustain point and trade cost levels that are symmetric across import and export sectors. For example, in the agglomerated equilibrium characterised by the domestic specialisation in sector i, the domestic import trade cost level is such that:

$$\tau_i^{*\sigma\upsilon} t_{j,SP}^{-\sigma\mu}\left(\frac{(1-\mu+\upsilon)}{2}t_{j,SP}^{\sigma-1} + \frac{(1+\mu-\upsilon)}{2}\tau_j^{*1-\sigma}\right) = 1,\ \tau_i^* = \tau_i\ \tau_j^* = \tau_j,$$

and the foreign trade cost level is such that:

$$\tau_j^{\sigma\upsilon} t_{i,SP}^{*-\sigma\mu} \left(\frac{(1-\mu+\upsilon)}{2} t_{i,SP}^{*\sigma-1} + \frac{(1+\mu-\upsilon)}{2} \tau_i^{1-\sigma} \right) = 1.$$

Using that the left-hand sides of these conditions are equalised, that the import trade cost levels must be symmetric in order for this equilibrium to be generated from the policy equilibrium, and rearranging the terms yields:

$$\tau_i^{\sigma\upsilon} t_{SP}^{-\sigma\mu} \left(\frac{(1-\mu+\upsilon)}{2} t_{SP}^{\sigma-1} + \frac{(1+\mu-\upsilon)}{2} \tau_j^{*1-\sigma} \right) = \tau_j^{\sigma\upsilon} t_{SP}^{-\sigma\mu} \left(\frac{(1-\mu+\upsilon)}{2} t_{SP}^{\sigma-1} + \frac{(1+\mu-\upsilon)}{2} \tau_i^{1-\sigma} \right)$$

$$(\tau_i^{\sigma\upsilon} - \tau_j^{\sigma\upsilon}) t_{SP}^{\sigma-1-\sigma\mu} \frac{(1-\mu+\upsilon)}{2} + (\tau_i^{\sigma\upsilon}\tau_j^{1-\sigma} - \tau_j^{\sigma\upsilon}\tau_i^{1-\sigma}) \frac{(1+\mu-\upsilon)}{2} t_{SP}^{-\sigma\mu} = 0$$

If the natural trade costs are asymmetric across sectors, the left-hand side expression exceeds zero since sector i is assumed to be the high trade-cost sector. In fact, the expression can only be valid for natural trade cost levels that are symmetric across sectors.