Standardization of Intermediate Goods and International Trade

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Abstract

This paper analyzes the relationship between standardization of intermediate inputs and international trade. We employ a two-country, general equilibrium model with differentiated manufacturing goods. Production of manufacturing goods requires specific intermediate inputs which can either be specialized or standardized. Standardization and the pattern of trade are determined endogenously in our model. In this framework we derive the effects of trade integration, i.e. a decline in trading costs, on the equilibrium outcome.

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1 Introduction

Many important markets today are characterized by vertically disintegrated production units and by national and international trade with intermediate products. Potential gains from this intermediate goods trade are manifold: For example, firms can specialize vertically according to their comparative cost advantage or they may accommodate to international factor price differences by outsourcing labor intensive parts of production to low wage countries.[1] Another potential gain from a vertical division of labor comes from economies of scale at the intermediate good level. Instead of designing and manufacturing a specialized component for one single firm, upstream suppliers may standardize intermediate goods and produce them on a large scale for many downstream customers. The market for bicycle components, where one dominant supplier (Shimano) delivers to a vast number of bicycle manufacturers, provides a striking example. Standardization of inputs, however, also entails certain costs: A standardized component may be less ideally suited for its specific purpose than an intermediate that is built to match the final good perfectly. Final good producers may need adapters to fit in the standardized intermediate good. Consumers may have a preference for final good varieties that are truly individual and differentiated from their alternatives.

The current paper deals with the standardization of intermediate products and its effects on the equilibrium market structure. More specifically, it analyzes the relationship between standardization and international trade. This relationship can go in both directions: One the one hand, trade makes standardization more attractive as decreasing average costs can be exploited on an international scale. On the other hand, standardization and a geographically concentrated supply can be a reason for international trade with intermediate products—trade between industrialized countries that have similar factor endowments and productivities.

We analyze standardization in a Dixit and Stiglitz (1977) "love of variety" approach with two countries and monopolistic competition as in the seminal work of Krugman (1979,

[1] For a Ricardian model of intermediate goods trade see Yi (2003); for the relationship between trade in intermediate inputs and factor prices in a Heckscher-Ohlin framework see e.g. Arndt (1997) or the survey by Feenstra and Hanson (2003).

1980). For each final good variety there exists a specialized intermediate good which matches the final good perfectly. Producers can either use this specialized intermediate good or replace it by a standardized component which fits for all varieties. The use of the standardized component causes additional variable costs, which account for the disadvantages of standardization mentioned above. There are economies of scale and transport costs at the final and at the intermediate good stage.

In this setting we show that for sufficiently low trading costs an equilibrium can exist where an international monopoly in one country supplies a standardized intermediate good to final good producers in both countries. Standardization then results in one-way trade with intermediates. The local supply of the standardized intermediate good gives one of the countries a cost advantage in the production of the final good. This country supplies more final good varieties and has a higher welfare level than the other country. The asymmetry occurs although countries are assumed to be symmetric at the outset.

We also derive the effects of trade integration on the equilibrium outcome in our model. A reduction in the trading costs for the standardized intermediate good may either cause a regime-switch from specialized supply to international standardization or it may change the supply structure for the standardized intermediate good from a national to an international monopoly. If an international monopoly already exists in the intermediate sector, a further decline in transport costs reduces the price of intermediate goods in the importing country, and the welfare of this country improves.

Our model of standardization builds on a couple of related papers on intermediate goods trade with economies of scale and imperfect competition. Ethier (1982) considers internal and external economies of scale in the production of intermediate and final goods. In his approach differentiated intermediates are assembled to a homogeneous final good according to a Dixit-Stiglitz production function. Countries then specialize in different intermediate goods and trade them internationally. Ethier's path breaking approach has been applied to various settings. Since there is only one final good variety, however, the issue of specialization versus standardization cannot be treated adequately in this framework. Krugman and Venables (1995) extend the model of Ethier (1982) by incorporating trading costs and differentiated final goods in addition to the differentiated intermediates. They identify "backward linkages" and "forward linkages" that determine the equilibrium

geographical allocation of firms. If trading costs fall below a certain critical value, a core-periphery pattern emerges in their model where one country specializes completely in the production of manufacturing goods. As Ethier (1982), Krugman and Venables (1995) do not deal with the decision between specialized and standardized intermediates. Instead, all final good varieties on the market form a composite good that can be used for consumption or as an intermediate.

An emerging literature deals with outsourcing of specialized intermediate inputs under incomplete contracting.[2] It focuses on the contractual relationship between final good producers and their specific intermediate good suppliers. Since these papers assume that intermediate good firms do not deliver to more than one final good firm, they leave out the possibility of standardization.

The model of standardization we employ is very similar to a recent contribution by van Asche (2004). As we do, van Asche (2004) departs from a Dixit-Stiglitz framework with differentiated final goods and endogenizes the choice between ideal and standardized intermediates.[3] In addition, van Asche (2004) also considers vertical integration, where final good firms produce the intermediate good in-house, and customized outsourcing, where suppliers of the intermediate good bear the additional costs of tailoring the intermediate to the specifications of the final good. Van Asche (2004) analyzes in detail the different possible supply structures for a given industry in a partial equilibrium framework.[4] We apply this set-up to international trade in a general equilibrium setting with trading costs.

Finally, our treatment of standardization bears some similarities to the concept of "flexible manufacturing" where a basic product variant is supplied that can be modified to another variant at certain additional costs (see Eaton and Schmitt, 1994). Eckel (2005) analyzes flexible manufacturing of intermediate goods in a model with Lancaster-type spatial product differentiation and zero trading costs.[5] Comparable to our paper, the extent

[2]See McLaren (2000), Grossman and Helpman (2002), Antras (2003), Antras and Helpman (2004), Grossman and Helpman (2005), and, for a survey, Spencer (2005).

[3]However, there are some differences with respect to the model details. For example, in van Asche (2004) standardizing firms can only produce for at most two final good firms.

[4]Levy (2004) also treats some aspects of standardization in a partial equilibrium model of vertical organization.

[5]For an alternative approach to integrate intermediate goods trade in a Lancaster-style ideal variety

of flexible manufacturing is determined by a trade-off between size effects and customization costs for the modification of the intermediate goods. With respect to the effects of trade on manufacturing flexibility, however, the mechanics and implications of Eckel (2005) are quite different than those of our model: In his paper, trade integration (an increase in market size) raises the number of available intermediate products in each country and thereby reduces the degree of manufacturing flexibility. In our model, trade integration (a decline in transport costs for intermediates) makes a standardized supply of intermediates more attractive.

2 The Model

We assume two perfectly symmetric countries, H and F, and two sectors of production, agriculture and manufacturing. The agricultural sector produces with labor a homogeneous good A under constant returns to scale. Good A, which can be traded without costs, is taken as the numberérare, i.e. its price is normalized to one. Supply of A is perfectly competitive, and the labor productivity in agriculture is set equal to one in both countries; thus, the wage rate is also one. The manufacturing sector produces a differentiated good C under increasing returns to scale and iceberg trading costs.

Both countries are populated by L workers, each endowed with one unit of labor. Consumer preferences in both countries are given by:[6]

$$U = A^{1-\mu} C^{\mu} \mu^{-\mu} (1-\mu)^{\mu-1} , \qquad \text{where} \qquad C = \left(\int_0^{\tilde{N}} (c_k)^{\frac{\sigma-1}{\sigma}} \, dk \right)^{\frac{\sigma}{\sigma-1}} \qquad \text{and} \qquad (1)$$

$0 < \mu < 1 < \sigma$. C is defined as the manufacturing aggregate. c_k is the demand for variety k, $\tilde{N}$ is the total number of varieties of the manufacturing good, μ determines the expenditure share of manufacturing goods, and σ is the elasticity of substitution between manufacturing varieties.[7] Since each consumer is endowed with one unit of labor, his (or

model see Lüthje (2003).

[6] Country indices are dropped where ever possible to improve readability.

[7] We assume $\mu L > \alpha\sigma$.

her) individual income is equal to one. The budget constraint is then given by

$$A + PC = 1, \qquad \text{where} \qquad P = \left(\int_0^{\tilde{N}} (p_k)^{1-\sigma} \, dk \right)^{\frac{1}{1-\sigma}} . \tag{2}$$

P is the consumer price index of the composite good, and p_k is the price of variety k. Utility maximization leads to the individual demand functions and indirect utility V:

$$c_k = \mu P^{\sigma-1} (p_k)^{-\sigma} \ , \quad C = \mu P^{-1} \ , \quad A = 1 - \mu \ , \quad \text{and} \quad V = P^{-\mu}. \tag{3}$$

Turning to the production of manufacturing goods, we assume that each final good variant involves the input of a specific intermediate good. This intermediate is supplied by a different firm than the final good and can be traded subject to specific iceberg trading costs. The intermediate good can either be specialized, i.e. made to match the final good variant perfectly, or standardized, i.e. designed to fit for all varieties. There are increasing returns to scale in producing intermediate goods.

With respect to the market structure, we assume monopolistic competition between producers of the final goods and contestable markets for the intermediate goods. Thus, we implicitly consider the following three-stage sequence of moves: In the first stage, potential producers of intermediate goods make binding offers for the price of the intermediates and their type, standardized or specialized. In the second stage, producers of differentiated final goods enter the market and choose their intermediate good suppliers. In the third stage, final good producers set the price of the manufacturing goods.

With these assumptions, we can derive the equilibrium prices and quantities for the different supply structures that may arise with respect to intermediate goods. We begin with the case of a specialized intermediate good supply.

2.1 Specialized Intermediate Goods

With specialized intermediate goods each intermediate good variety has to match a final good variety. The production of x_k units of variety k involves exactly x_k units of the specialized intermediate good. For simplicity, there are no additional variable costs in the production of the final good. We have, however, fixed costs: α units of labor are necessary to develop a new variety of the final good. Profits of the final good producer k are then

defined as $\pi_k^p = (\hat{p}_k - q_k)\, x_k - \alpha$, where q_k is the price of the intermediate good and $\hat{p}_k$ is the producer price of the final good. Profit maximization yields:

$$\hat{p}_k = \frac{\sigma}{\sigma - 1}\, q_k \ .$$

Thus, prices are set at a constant mark-up over marginal costs. Because of free entry profits are zero. Inserting the above pricing rule into $\pi_k^p = 0$ then implies:

$$x_k = \frac{\sigma\alpha}{\hat{p}_k} \ .$$

An intermediate good supplier needs $\gamma + \delta x_k$ units of labor to produce x_k units of the intermediate good. Profits are $\pi_k^q = (q_k - \delta)\, x_k - \gamma$. From the assumption of contestable markets follows average cost pricing:

$$q_k = \frac{\gamma}{x_k} + \delta \ .$$

Using this, the following equations can be derived for prices and quantities:[8]

$$q_k^{sp} = \frac{(\sigma-1)\alpha\delta}{(\sigma-1)\alpha - \gamma} \ , \qquad \hat{p}_k^{sp} = \frac{\sigma\alpha\delta}{(\sigma-1)\alpha - \gamma} \ , \qquad \text{and} \qquad x_k^{sp} = \frac{(\sigma-1)\alpha - \gamma}{\delta} \ . \tag{4}$$

Trading costs are of the iceberg type: Of τ shipped units of the final good ($\tau > 1$) $\tau - 1$ units melt away. Hence, the consumer price is $p_k = \tau\hat{p}_k$ for an imported variety and $p_k = \hat{p}_k$ for a variety that is produced domestically. The consumer price index for manufacturing in country i is:

$$P^i = \hat{p}_k \left(N^i + \phi N^j\right)^{1/(1-\sigma)} \ ,$$

where $i, j = H, F$, $j \neq i$, and where $\phi = \tau^{1-\sigma}$ stands for trade freeness.

N^i varieties of the manufacturing good are produced in country i. With a specialized supply of the intermediate good N^i not only determines the number of final good varieties but also that of specialized intermediate goods. The goods market equilibrium in country i requires:[9]

$$x_k = L\left(c_k^{ii} + \tau c_k^{ij}\right) = \mu L\left(\hat{p}_k\right)^{-\sigma}\left(\left(P^i\right)^{\sigma-1} + \phi\left(P^j\right)^{\sigma-1}\right) \ .$$

[8] The superscript *sp* denotes the equilibrium with a specialized intermediate good supply.

[9] The c_k^{ii} stands for country i's consumption and c_k^{ij} denotes country j's consumption of the good produced in i.

Inserting for P^i and P^j yields:

$$x_k \hat{p}_k = \mu L \left(\frac{1}{N^i + \phi N^j} + \frac{\phi}{N^j + \phi N^i} \right) ,$$

where $j \neq i$. Inserting $\hat{p}_k x_k = \alpha\sigma$ from the zero profit condition then leads to:

$$N^i = N^j = \frac{\mu L}{\alpha\sigma} . \tag{5}$$

Thus, the number of final and intermediate good varieties is the same in both countries, such that the aggregate number of varieties $\tilde{N} = N^H + N^F$ is given by $\tilde{N} = 2N^H$.

Using (5), the consumer price index in both countries can be written as:

$$P^i = P^j = \hat{p}_k \left[\frac{\mu L (1+\phi)}{\alpha\sigma} \right]^{1/(1-\sigma)} . \tag{6}$$

The equilibrium on the labor market requires:[10]

$$L = N^i (\alpha + \gamma + \delta x_k) + L A_S^i .$$

Inserting for x_k and N and rearranging yields for the production of the agricultural good per capita:

$$A_S^i = A_S^j = 1 - \mu . \tag{7}$$

Thus, with our assumption of equally sized symmetric countries, both countries produce the same quantity of the agricultural good, and there is no intellectual trade ($A_S = A$) of the agricultural good. The countries also do not trade the intermediate good. Instead, to avoid trading costs each intermediate good variety is produced in the country where the respective final good variety is produced. The only trade we have in this benchmark setting is trade with differentiated final good varieties as in Krugman (1979).

2.2 Standardized Intermediate Goods: National Supply

Now we consider standardization of the intermediate good. Instead of N^i specialized varieties there is only one standardized intermediate good which can be used by all final good producers. With respect to the supply of this intermediate good, we can distinguish

[10] The subscript S denotes the supplied quantity of the agricultural good.

two situations: In the first (this section), one national supplier of the intermediate good exists in each country who delivers the standardized intermediate good to all final good producers in this country. In the second (section 2.3), an international monopoly supplies the intermediate good to final good producers in both countries.

We assume the standardized intermediate good to be less valuable for production than the specialized component. To produce x_k of variety k exactly ϵx_k units of the standardized intermediate are necessary ($\epsilon > 1$), compared to x_k units of the specialized intermediate. The term ϵ then represents higher marginal costs of using a standardized input in the production of the final good. As mentioned in the introduction, this may come from additional adjustment costs, the necessity of adapters or a quality loss through standardization perceived by the consumers. In addition to the variable costs for the intermediate input the final good producer bears the same fixed labor costs of α as before. Profits in the final sector are then $\pi_k^p = (\hat{p}_k - \epsilon q)\, x_k - \alpha$. Profit maximization yields:

$$\hat{p}_k = \frac{\sigma}{\sigma - 1}\, \epsilon q \; .$$

Again, we obtain from the zero profit condition on the final goods market:

$$x_k = \frac{\sigma \alpha}{\hat{p}_k} \; .$$

Profits of the intermediate good producer are $\pi^q = (q - \delta)\, \epsilon N x_k - \gamma$. Contestable markets then imply:

$$q = \frac{\gamma}{N \epsilon x_k} + \delta \; .$$

Hence,[11]

$$q^{stn} = \frac{(\sigma - 1)\, \alpha N \delta}{(\sigma - 1)\, \alpha N - \gamma} \; , \quad \hat{p}_k^{stn} = \frac{\sigma \alpha \epsilon N \delta}{(\sigma - 1)\, \alpha N - \gamma} \; , \quad \text{and} \quad x_k^{stn} = \frac{(\sigma - 1)\alpha N - \gamma}{\epsilon N \delta} \; . \tag{8}$$

The equilibrium number of varieties N and the supply of the agricultural good are the same as in the case of a specialized intermediate good supply. Again, there is no trade of the agricultural good or of the intermediate good.

[11] The superscript *stn* stands for the equilibrium with a national supply of the standardized intermediate good.

2.3 Standardized Intermediate Goods: International Supply

This section deals with the case of an international monopoly in the intermediate sector. This intermediate good firm may locate in one of both countries and delivers to final good producers of both countries. Without loss of generality, we assume the intermediate good producer to be in H. International trade of the intermediate good allows the firm in H to exploit economies of scale on the international level. However, it also gives rise to additional trading costs since the intermediate good has to be shipped to the final good producer in F. As in the previous section, the pricing rule and the supplied quantity of final goods are given by:

$$\hat{p}_k = \frac{\sigma}{\sigma - 1}\,\epsilon q \qquad \text{and} \qquad x_k = \frac{\alpha\sigma}{\hat{p}_k}\,.$$

Iceberg trading costs in the intermediate sector are denoted by t ($t > 1$). The price of the intermediate good is then $q^H = \hat{q}$ for the final good firm in country H, where the intermediate good is produced, and by $q^F = t\hat{q}$ in country F. The $\hat{q}$ denotes the producer price in the country of origin. Because of the trading costs for the intermediate good, the producer price of the final good differs between countries. Country H has a cost and therefore a price advantage over country F, i.e. $\hat{p}_k^F = t\hat{p}_k^H$.

Profits of the intermediate good producer in country H are given by the equation $\pi^q = (\hat{q} - \delta)\left(N^H x_k^H + N^F t x_k^F\right)\epsilon - \gamma$. From contestable markets follows average cost pricing:

$$\hat{q} = \frac{\gamma}{\left(N^H x_k^H + N^F t x_k^F\right)\epsilon} + \delta\,.$$

Hence:[12]

$$\hat{q}^{sti} = \frac{(\sigma-1)\,\alpha\tilde{N}\delta}{(\sigma-1)\,\alpha\tilde{N} - \gamma}\,, \quad \hat{p}_k^{Hsti} = \frac{\sigma\alpha\epsilon\tilde{N}\delta}{(\sigma-1)\,\alpha\tilde{N} - \gamma}\,, \quad \text{and} \quad x_k^{Hsti} = \frac{(\sigma-1)\alpha\tilde{N} - \gamma}{\epsilon\tilde{N}\delta}\,. \tag{9}$$

With $\hat{p}_k^F = t\hat{p}_k^H$ the consumer price index in H and F can be written as:

$$P^H = \hat{p}_k^H(N^H + \phi\psi N^F)^{1/(1-\sigma)} \qquad \text{and} \qquad P^F = \hat{p}_k^H(\psi N^F + \phi N^H)^{1/(1-\sigma)}\,.$$

[12] The superscript *sti* stands for the equilibrium with standardization and an international supply of the intermediate good.

where $\psi = t^{1-\sigma}$ stands for trade freeness on the intermediate level. The goods market equilibrium implies:

$$x_k^H = L\mu \left[\left(\hat{p}_k^H\right)^{-\sigma} \left(P^H\right)^{\sigma-1} + \tau \left(\hat{p}_k^H \tau\right)^{-\sigma} \left(P^F\right)^{\sigma-1} \right] \qquad \text{and}$$
$$x_k^F = L\mu \left[\left(\hat{p}_k^F\right)^{-\sigma} \left(P^F\right)^{\sigma-1} + \tau \left(\hat{p}_k^F \tau\right)^{-\sigma} \left(P^H\right)^{\sigma-1} \right] .$$

Inserting for P^H and P^F, rearranging and employing $\hat{p}_k x_k = \alpha\sigma$ leads to:

$$\alpha\sigma = L\mu \left(\frac{1}{N^H + \phi\psi N^F} + \frac{\phi}{\psi N^F + \phi N^H} \right) \qquad \text{and}$$
$$\alpha\sigma = L\mu \left(\frac{\psi}{\psi N^F + \phi N^H} + \frac{\psi\phi}{N^H + \phi\psi N^F} \right) .$$

These two equations are solved by:

$$N^H = \frac{\mu L}{\sigma\alpha} \left[1 + \frac{\phi\left(1-\psi^2\right)}{\left(\phi\psi - 1\right)\left(\phi - \psi\right)} \right] \quad \text{and} \quad N^F = \frac{\mu L}{\sigma\alpha} \left[1 - \frac{\phi\left(1-\psi^2\right)}{\left(\phi\psi - 1\right)\left(\phi - \psi\right)} \right] . \qquad (10)$$

A necessary condition for an interior solution with a positive number of varieties in both countries is $\psi > 2\phi/\left(1+\phi^2\right)$. We assume for the following that this condition is satisfied. This also means that $\psi > \phi$ or $t < \tau$. The trading costs for the intermediate good have to be lower than those for the final good.

Expression (10) reveals that $N^H > N^F$ in equilibrium. Country H supplies a larger number of varieties than country F. Thus, standardization and the international supply of the intermediate good may influence the trading pattern with respect to the final manufacturing good: country H produces and exports more varieties than country F. This result can be explained by the cost advantage of country H where the intermediate good price is lower. The aggregate number of varieties $\tilde{N}$ is the same as in the settings considered before with $\tilde{N} = 2\mu L/(\alpha\sigma)$.

Inserting (10) into P^H and P^F leads to

$$P^H = \hat{p}_k^H \left[\frac{\mu L \psi\left(1-\phi^2\right)}{\alpha\sigma\left(\psi - \phi\right)} \right]^{1/(1-\sigma)} \quad \text{and} \quad P^F = \hat{p}_k^H \left[\frac{\mu L \psi\left(1-\phi^2\right)}{\alpha\sigma\left(1 - \phi\psi\right)} \right]^{1/(1-\sigma)} . \qquad (11)$$

The relative price of H's manufacturing good is then

$$P^H/P^F = \left(\frac{1-\phi\psi}{\psi - \phi} \right)^{1/(1-\sigma)} < 1 .$$

The manufacturing price in H is lower than in F. Since the consumer welfare $V = P^{-\mu}$ decreases in the price index, we obtain the result that welfare in H exceeds welfare in F. This result may have important policy implications: a country can increase its welfare if it is able to attract producers of a standardized intermediate good. A decline in the trading costs for the intermediate good lowers the price index P^F whereas P^H increases. Thus, welfare levels of both countries converge with a further economic integration, and in the limit $\psi \to 1$ the price advantage of country H vanishes.

As in section 2.1 supply of the agricultural good in both countries can be derived from the labor market equilibrium. In H it is given by $L = \alpha N^H + \gamma + \delta\epsilon\tilde{N}x_k^H + LA_S^H$ and in F by $L = \alpha N^F + LA_S^F$. With $N^F < N^H$ we obtain from these equations $A_S^H < A_S^F$. Country H produces the intermediate good and more varieties of the final good than F. Thus, it has fewer resources left to produce the agricultural good and therefore has to import this good from F.

Finally, comparing (6) with (11) illuminates the welfare effects of intermediate input trade for both countries. For country H trade in intermediates clearly improves welfare. On the one hand, the intermediate good is traded only if p_k^{Hsti} is lower than p_k^{sp} or p_k^{stn}. On the other hand, since the term $\psi\left(1-\phi^2\right)/\left(\psi-\phi\right)$ in (11) exceeds $(1+\phi)$ in (6), the transport cost effect on the price index in H is lower with intermediate goods trade than without. For country F, we obtain the opposite result with respect to the transport costs: the term $\psi\left(1-\phi^2\right)/\left(1-\psi\phi\right)$ is smaller than $(1+\phi)$. Country F thus not necessarily gains from intermediate goods trade.

3 Equilibrium Supply

In the previous section we have characterized different types of equilibrium with different supply structures. This section now derives conditions for the existence of these equilibrium structures.

Given the CES-utility function prices are set as a constant mark-up over marginal costs and profits of the final good producers strictly decrease in their marginal costs. The final good producers then buy the intermediate good from the supplier which leads to the lowest marginal cost and therefore the lowest price. Thus, to find the equilibrium supply structure

we can directly compare the final goods prices in the different settings. For convenience, these prices are restated as follows:

$$\hat{p}_k^{sp} = \frac{\sigma\alpha\delta}{(\sigma-1)\alpha-\gamma}\,, \quad \hat{p}_k^{stn} = \frac{\sigma\alpha\epsilon\tilde{N}\delta}{(\sigma-1)\alpha\tilde{N}-2\gamma}\,, \quad \hat{p}_k^{Hsti} = \frac{\sigma\alpha\tilde{N}\delta\epsilon}{(\sigma-1)\,\alpha\tilde{N}-\gamma}\,, \tag{12}$$

and $\hat{p}_k^{Fsti} = tp_k^{Hsti}$. From comparing $\hat{p}_k^{Hsti}$ with $\hat{p}_k^{stn}$ we see that the final good producer in the country H always prefers to buy the standardized intermediate good from an international monopoly than from a purely national supplier, i.e. $\hat{p}_k^{Hsti} < \hat{p}_k^{stn}$. However, because of the trading costs, this does not necessarily hold for the final good firm in F. Instead, for $\hat{p}_k^{Fsti} < \hat{p}_k^{stn}$ the following inequality needs to be satisfied:

$$\frac{\gamma}{\tilde{N}} > \frac{t-1}{2t-1}\;(\sigma-1)\,\alpha\,. \tag{13}$$

This inequality holds for sufficiently low trading costs t and for sufficiently high $\gamma/\tilde{N}$, which can be interpreted as a measure for economies of scale. Then the international monopoly dominates a supply structure with national suppliers of the standardized intermediate good.

Final good firms in F prefer an international monopoly to a supply structure with specialized intermediate goods if $\hat{p}_k^{Fsti} < \hat{p}_k^{sp}$ or

$$\frac{\gamma}{\tilde{N}} > \frac{\epsilon t-1}{\tilde{N}\epsilon t-1}\;(\sigma-1)\,\alpha\,. \tag{14}$$

According to inequality (14), the term ϵt, which combines adjustment and trading costs, measures the relative costs of international standardization in comparison to specialized intermediate goods. $\tilde{N}$ in the denominator on the right-hand-side of (14) stands for the cost savings from mass production of the standardized intermediate instead of producing $\tilde{N}$ varieties. If both (13) and (14) hold, then an international monopoly supplying a standardized intermediate good is the equilibrium supply structure; it is preferred by final good producers of both countries to its alternatives.

If an international monopoly can not exist, it may still be possible that the intermediate good is standardized—with national suppliers. This is the case for $\hat{p}^{stn} < \hat{p}^{Fsti}$ and $\hat{p}^{stn} < \hat{p}^{sp}$. The latter inequality is equivalent to

$$\frac{\gamma}{\tilde{N}} > \frac{\epsilon-1}{\tilde{N}\epsilon-2}\;(\sigma-1)\,\alpha\,. \tag{15}$$

The right-hand-side of (15) increases in the adjustment costs ϵ and decreases in $\tilde{N}$. Thus national standardization becomes more attractive the lower are adjustment costs and the higher is the number of varieties. For sufficiently small ϵ ($\epsilon \to 0$) inequality (15) is satisfied. Apparently, (15) is independent of trade costs at the intermediate level since with only national suppliers intermediate goods are not traded.

If we have $\hat{p}^{sp} < \hat{p}^{Fsti}$ and $\hat{p}^{sp} < \hat{p}^{stn}$ then the intermediate good is specialized.

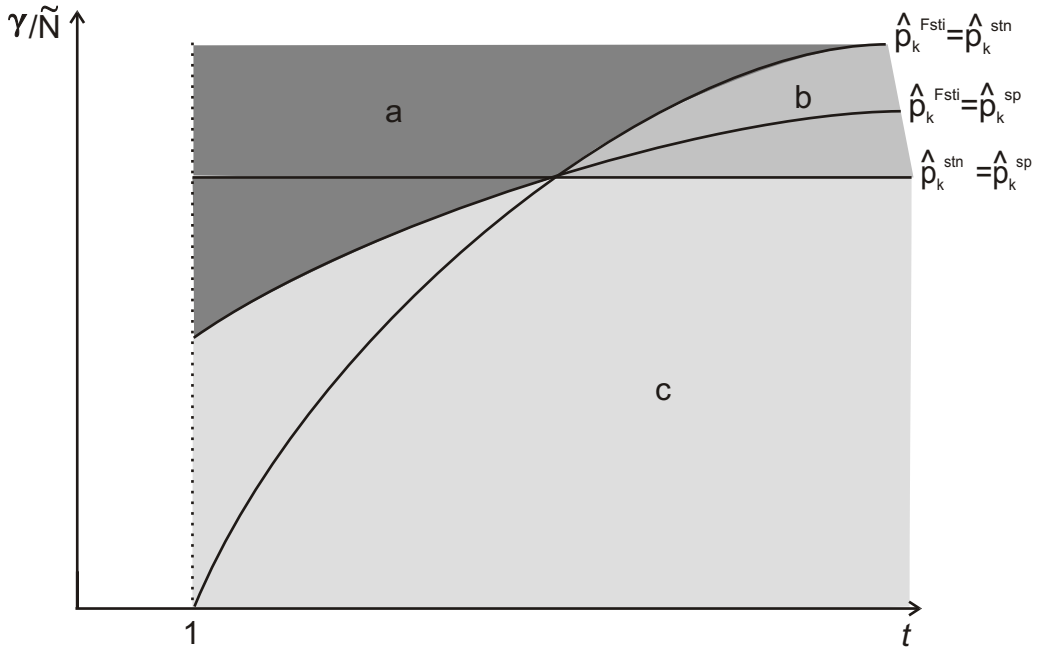

Figure 1: Equilibrium Supply Structures

Figure 1 illustrates the possible equilibria that may arise with respect to the supply of the intermediate good. In the shaded area (a), both inequalities (13) and (14) are satisfied and we have an international monopoly as the equilibrium outcome. In area (b) national firms supply standardized intermediates in both countries. In area (c) the intermediate good is specialized. The right-hand sides of (13), (14) and (15) pairwise coincide if $t = \hat{t}$, where

$$\hat{t} = \frac{1 - \epsilon\left(\tilde{N} - 1\right)}{\epsilon\left(2 - \tilde{N}\right)} .$$

Hence, all curves intersect at $\hat{t}$ and an equilibrium always exist.[13]

From figure 1 we can also see the effects of a decline in the trading costs for intermediate good supply. If the economies of scale and the trading costs are comparatively high, then national firms supply the intermediate good (area b). With a decline in the trading costs an international monopoly becomes more attractive and eventually replaces national supply of the intermediate good. Trade integration and the decline of trading costs then does not influence the decision for standardization but only the question whether an international or a national firm supplies the standardized intermediate good. Things are different, however, if economies of scale are comparatively low. The supply structure for high trading costs is then one with specialized intermediate goods (area c). If t decreases in this setting, then the economy may switch from specialized intermediate good firms to an international standardizing monopoly. Trading costs then influence the decision on standardization of intermediate products and an economic integration of both countries can lead to standardization of the intermediate good. In both cases, we obtain a consolidation in the supplier sector, albeit on a very different scale. The number of intermediate good suppliers either declines from two or from $\tilde{N}$ to only one worldwide.

Figure 1 also shows the impact of increasing economies of scale for a given degree of trade integration. If trade costs at the intermediate level are low, an increase in economies of scale leads directly from specialized production to international standardization. By way of contrast, for high trading costs standardization at the national level replaces specialization when economies of scale arise. Only with very strong economies of scale a single international supplier survives.

4 Concluding Remarks

Our paper has incorporated standardization of intermediate inputs into a Dixit-Stiglitz model of intra-industry trade. We have shown that—depending on the level of transport costs, economies of scale and other exogenous parameters—an equilibrium can exist where an international monopoly supplies and exports standardized intermediates. Final good

[13] $\hat{t} > 1$ requires $\tilde{N} > 2$ which has been assumed.

producers in the country where this international supplier locates have a transport cost advantage over foreign final good producers. As a consequence, the host country of the intermediate good supplier produces more varieties and enjoys a higher welfare level than the other country.

Our simple model can only be a first step toward an understanding of the interaction between standardization and international trade in intermediate goods. Nevertheless, it already makes some clear predictions that can be tested empirically. For example, since countries which export intermediates also supply more final goods varieties, there should be a positive correlation between exports of intermediates and exports of final goods. Another hypothesis concerns market structure and intermediate goods trade: as only international monopolies export intermediates, an increase in the level of trade in intermediate goods should go hand in hand with a consolidation in the number of intermediate good suppliers.

We can think of several promising ways to extend the benchmark model of this paper: First, we could introduce firm heterogeneity as in Melitz (2003) and Helpman et al. (2004) into the analysis. For example, adjustment costs ϵ might differ between different final good firms such that standardized and specialized intermediates can co-exist in the same industry: Firms with a low ϵ then use standardized components whereas the others rely on specialized inputs. As the first group of firms makes higher profits on average than the second, we should expect a positive relationship between trade, or more precisely *imports*, of standardized intermediate goods and profitability of final good firms.

A second point of departure for further research would be to merge our model with the recent literature on outsourcing, which has been mentioned in the introduction. According to this literature, outsourcing of intermediates is characterized by incomplete contracting, search frictions and relation-specific investments hold-up problems (Spencer, 2005). All these elements should differ fundamentally between the case of small specialized intermediate good suppliers and that of a large standardizing international monopoly.

Finally, we could also take a closer look at the standardization process itself. In our paper standardization was simply a choice open to the intermediate good firms when entering the market. However, in reality, standardization may be much more involved: There may be specific costs of developing standardized components, which are useful for a large number of downstream firms, and final good firms (and in some cases also the

government) may participate in finding an appropriate standard. Further research on these topics may provide a deeper understanding of standardization and its effects in international markets.

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