The Multinationalization of the Transport Sector

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September 1, 2004

Abstract

Almost all models of new trade theory introduce Samuelson’s iceberg transport costs. This is at odds with the increasing multinational activity in the transport sector. Incorporating a transport sector dominated by multinationals and with economies of scale in a model of the new trade theory shows that relaxing the iceberg transport costs assumption changes the predictions regarding the volume of trade and income and opens up a third possibility for specialization.

Key words: Multinationals; Transport sector; Iceberg transport costs; Economies of Scale

JEL classification: F12; F23

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1 Introduction

Transport costs are important in models of the new trade theory. On the one hand, there are economies of scale, leading to concentration of production at a single location, and on the other hand transport costs, encouraging firms to locate near their customers. However, the introduction of transport costs into models of international trade was long avoided, because factor price equalization does not have to hold any longer and the balance-of-payments condition becomes non-linear, rendering general equilibrium models with increasing returns to scale analytically unsolvable.

Early attempts to introduce transport costs in trade models are Samuelson (1952, 1954), Herberg (1970), Falvey (1976) and Casas (1981). Paul Samuelson formalizes the idea that a fraction of the good shipped melts away in transport and therefore only part of the goods (the "unmelted") reaches the destination. The latter contributions model the transport sector more explicitly. Falvey for example showed that factor intensity differences between goods production and transport services determine who produces the transport service using a Heckscher-Ohlin-framework with three goods, where one is the transport service.

All these models rely on the assumption of perfect competition in both the goods market and the transport sector. To keep matters as simple as possible, most models with imperfect competition in the goods market incorporate iceberg transport costs (see for example Helpman and Krugman, 1985). Models with imperfect competition in the transport sector are Casas and Choi (1990), Francois and Wooton (2001) and Mansori (2003).

Casas and Choi (1990) introduce a transport sector with variable returns to scale into a model of one small country with two traded goods, both produced under constant returns to scale. Their main result is that immiserizing growth can arise in the presence of decreasing returns to scale in the transport sector when increased efficiency in transportation exerts a trade-expanding effect and, in the presence of increasing returns to scale, when increased efficiency in transportation has a trade-
contracting effect.

Francois and Wooton (2001) maintain the assumption of perfect competition in the goods market, but highlight the importance of imperfect competition in the shipping industry. They conclude that trade liberalization in the absence of any form of deregulation of the shipping sector will not result in the increased benefits that would otherwise be expected.

Mansori (2003) introduces iceberg transport costs in a new economic geography model, which are subject to increasing returns to scale by assuming that in each period a fixed cost must be incurred before the transport of goods between two regions can take place. He then shows that increasing returns to scale reinforce the tendency towards a dispersed equilibrium but that trade liberalization may cause a country to move from the dispersed equilibrium to an equilibrium where firms are more concentrated in one region. To the best of our knowledge this is the first attempt to introduce imperfect competition in both the goods market and the transport sector.

Similar as Mansori (2003), we assume imperfect competition in the goods market as well as in the transport sector. But our framework is a new trade theory model, and we explicitly take into account the multinationalization tendency in the transport sector. According to the *World Investment Report* (UNCTAD, 2002), one of the newcomers to the world’s top 100 transnational corporations (TNCs) is the *Deutsche Post*, engaging in transport and storage. In the top 50 non-financial TNCs from developing economies ranked by foreign assets, four TNCs operate in the transport and storage sector\(^1\), and according to the transnationality index\(^2\), two of the top five are in the transport and storage sector\(^3\). This suggests that multinational activities in the transport sector play a crucial role and become more and more important.

If we interpret transport costs in trade models more extensively as trade costs, including telecommunication and insurance, the multinationalization of the "trans-

\(^1\)Namely Neptun Orient Lines (Singapur), Orient Overseas International (Hong-Kong), Singapur Airlines (Singapur), and Varig (Brazil).

\(^2\)The transnationality index is the average of the following three ratios: foreign assets to total assets, foreign sales to total sales and foreign employment to total employment.

\(^3\)Namely Orient Overseas International (Hong-Kong) and Neptun Orient Lines (Singapur).
port” sector gets even more pronounced. Out of the top 20 TNCs ranked by value of cross-border merges and acquisitions (M&As), eight are either in the telecommunications or the insurance industry. In 2001, 33% of the cross-border M&As in the tertiary sector are accounted for by transport, storage and telecommunications, and 20% of total M&As.\(^4\)

In order to account for the large multinationalization in the transport services sector, we assume horizontal multinational enterprises (MNEs) in the transport sector, i.e. firms running plants in both countries and not engaging in trade. This implies that we assume fixed costs to be important in the transport sector, which is well in line with the various statements in the literature\(^5\) and empirical findings\(^6\). Furthermore we explicitly account for the fact that a larger network of firms providing transport services leads to lower prices for the customer (see Janelle and Beuthe, 1997).

Introducing horizontal MNEs in the transport sector no longer relies on iceberg transport costs, which forms a simplifying assumption, but does not come without costs.

First, one of the implicit assumption of iceberg transport costs is that the transport service is produced with the same factor intensities as the good shipped. This seems at odds with empirical facts. In Table 1 we show the division between factor incomes of unskilled labor, skilled labor and capital, neglecting natural resources and land since we do not incorporate these factors into our model.\(^7\) Looking at these facts,

\(^4\)This share reached a peak in 2000 of nearly 44% (32%) of the tertiary sector (total), whereas it was between 1.4% (0.4%) and 26% (11%) in the years between 1987 and 1998. These facts demonstrate that the multinationalization of the transport sector has become more and more important in the last few years.


\(^6\)Hummels (1999) finds that the transportation technology for a particular vessel is almost affine in distance. However, fixed costs vary with the size of the vessels.

\(^7\)The GTAP database version 5 provides data about sources of factor income divided into unskilled labor, skilled labor, capital, land and natural resources for 66 regions and 57 sectors corresponding to the global economy in 1997. For a detailed description of the database see http://www.gtap.agecon.purdue.edu/. We aggregate over these 66 regions and build 13 sectors, where the transport sector is the most disaggregated one.
it is obvious that for example the rice & grains sector, the crops sector as well as the meat sector are much more unskilled labor intensive and use fewer skilled labor than the transport sector. The foods sector and the natural resources sector are much more capital intensive, whereas auto & machinery as well as the other manufacturing, i.e. the high-tech industry sectors, are more skilled labor intensive than the transport services sector.

Table 1

The second shortcut of iceberg costs stem from the fact that in a model with more than one good, transport services are different for every good as they are always a part of the good shipped. Normally, one would think of transport services to be more or less independent of the goods shipped. Let’s take for example trucks. With the same truck one can ship such different goods as diamonds, cars and wood. The early attempt to treat the transport service "as an additional process subject to the same laws and constraints as any other" (Casas, 1981, p. 90), is not accurate, since it ignores the differences between the demand for transport services and that for traded goods. It is therefore necessary to introduce a transport sector, where customers are forced to demand the service when they want to transport goods, but "consumption" of transport services as such does not lead to utility gains.

Third, iceberg costs implicitly assume that the transport service and the good shipped are produced by the same firm. This assumption has strong implications if we have firms producing under economies of scale stemming from fixed costs. In this case, iceberg transport costs imply joint production of the transport service and the good shipped. This means that higher transport costs may reduce exports, but as long as the additional transport service compensates for it, this does not harm domestic goods producers. Furthermore, iceberg transport costs implicitly assume that the market structure and conduct for both, the transport sector and the goods sector, are the same. The transport service is provided by the exporter, i.e., if a consumer wants to import a good, she has no choice from whom she wants to buy the transport service, rather she has to buy the good and the transport service as a
'bundle' from the exporter. Therefore, iceberg transport costs are not able to handel the importance of a transport network for customers.

In order to study the effects of relaxing several of the strong assumptions of iceberg type transport costs, we introduce a transport sector dominated by horizontal MNEs in a model with two countries and two sectors, one homogeneous and one differentiated goods sector. This approach differs from existing ones in several directions: (i) There is imperfect competition in the goods market and in the transport sector. (ii) Transport services are the same for both goods. (iii) Production of the good shipped and the transport service is disentangled, i.e. there is no joint production of goods and transport services. (iv) The factor intensities in the transport sector and in the goods sector are different.

The model is outlined in Section 2. Section 3 studies the effects of introducing a multinationalized transport sector for the the volume of trade. The effects on income will be discussed in Section 4, whereas Section 5 focuses on the possible specialization patterns of countries, which face the addition possibility to export transport sector headquarter services. The last section concludes.

2 The Theoretical Model

Lets assume two sectors, one homogeneous Z-goods sector and one differentiated X-goods sector characterized by love of varieties (Dixit and Stiglitz, 1977). Utility of a representative individual is thus given by:

$$U_i = \left( n_i x_{ii}^\frac{\sigma-1}{\sigma} + n_j x_{ji}^\frac{\sigma-1}{\sigma} \right)^\frac{\sigma}{\sigma-1} (Z_{ii} + Z_{ji})^{1-\alpha},$$

(1)

where $U_i$ is the utility level of a representative individual in country $i$, $i = 1, 2$, $\alpha$ refers to the fixed Cobb-Douglas expenditure share for differentiated goods ($\alpha = 0.8$ in the simulations below), and $\sigma > 1$ denotes the elasticity of substitution between varieties. Consumers buy $x_{ii}$ units from every national firm ($n_i$) and $x_{ji}$ units from every foreign firm ($n_j$). $Z_{ii}$ refers to the quantity of homogeneous goods produced and consumed in $i$, and $Z_{ji}$ indicates the import quantity from $j$ of the homogeneous good consumed in $i$. 
Consumers are forced to demand transport services in a fixed proportion to every unit imported. We denote the necessary amount of transport services for the import of one unit of good \( X \) (\( Z \)) as \( \tau_x \) (\( \tau_z \)). We choose this formulation because it allows a direct comparison with the results of the "standard" model with iceberg transport costs (see for the "standard" model Helpman and Krugman, 1985). The \( \tau \) in our model can directly be translated as the share of goods that melt away in transport in the "standard" model.

From utility maximization we can derive demand functions which, together with the assumption of product market clearance, imply:

\[
x_{ii} \geq p_i^{-\sigma} s_i^{-1} \alpha E_i \\
x_{ij} = (p_i + s_{ti} \tau_x)^{-\sigma} s_j^{-1} \alpha E_j, \\
Z_{ii} + Z_{ji} \geq \frac{1 - \alpha}{q_i} E_i
\]

where \( \bot \) indicates that at least one of the adjacent conditions has to hold with equality. \( p \) denotes the price of an \( X \)-good, and \( q \) is the price for one unit of \( Z \)-goods.

\( s_{ti} \) is the price aggregator of the transport services, where we assume that the various transport services are combined to the whole "transport bundle" according to a CES-technology. The CES-technology seems reasonable since one firm alone would not be able to serve all markets. The larger the network of firms providing transport services, the better the customer will be served (see Janelle and Beuthe, 1997).

The technical rate of substitution in the transport sector (\( \sigma_t \)) is a measure for the degree of network reliance in the transport sector. The lower this substitution parameter, the higher is the dependency on a rich network structure in order to ensure low overall trading costs. Think of firms trading overseas which use different types of transport modes (e.g. ships, plains, trucks, trains) and services (e.g. transshipment opportunities, services of forwarding agents and insurance companies) that can not easily be provided by another firm for the same costs because of technical reasons (as it is the case for different modes) or because of special knowledge (think of special country knowledge of a forwarding agent or special expertise in insuring...
specific types of risks of an insurance company).

In accordance with the stylized facts mentioned in the introduction, namely the ongoing multinationalization and the importance of fixed costs, transport firms are assumed to be horizontal MNEs. According to these assumptions, the price index of transportation services in country \( i \) \( (s_{ti}) \) is given by:

\[
s_{ti} = \left( (m_{ti} + m_{tj})p_{ti}^{1-\sigma_i} \right)^{\frac{1}{1-\sigma_i}},
\]

where \( m_{ti}(m_{tj}) \) are the numbers of MNEs in the transport sector with headquarters in \( i(j) \), and \( p_{ti} \) is the price of the transport service.

\( s_i \) denotes the price aggregator of \( X \)-varieties consumed in \( i \):

\[
s_i = \left( n_i p_i^{1-\sigma} + n_j (p_j + s_{ti} \tau_x) \right)^{\frac{1}{1-\sigma}}.
\]

The demand function for the transport services needed is given by:

\[
t_i \geq p_{ti}^{\sigma_i} s_{ti}^{\sigma_i} \left( x_{ji} n_j \tau_x + Z_{ji} \tau_z \right) \quad \perp \quad p_{ti} \geq 0,
\]

where \( t_i \) denotes the service of transport from \( j \) to \( i \) provided by one transport firm.

This assumption implies that every country has to bear the transport costs for its own imports. However, if we assume that the exporting country has to bear the transport costs, the qualitative results in this paper would not change. The reason is that we assumed high fixed costs in the transport sector and that variable costs of production in the transport sector are small compared to these fixed costs.

Note that the introduction of horizontal MNEs in the transport sectors has the advantage that the problem of one-way transport service is mitigated. Horizontal MNEs provide their services in both countries, avoiding the problem of empty runs.

The expression in brackets on the right-hand side \( (x_{ji} n_j \tau_x + Z_{ji} \tau_z) \) of equation (7) gives the total demand for transport services from \( j \) to \( i \). Since the specific trade
services are combined to the whole service bundle according to a CES-technology, the total demand for transport service has to equal the composite of transport services given by the quantity index \((m_i + m_j)^{\frac{n}{n-1}} t_i\).

Z-production uses only unskilled labor \((L)\), and we take the price of one unit of Z-good produced and consumed in country 1 \((q_1)\) as numéraire. Marginal costs then satisfy:

\[
c_{zi} \geq w_{Li} \quad \perp \quad Z_{ii} \geq 0, \tag{8}
\]

where \(w_{Li}\) denotes the wage rate of unskilled labor in \(i\). For imported Z-goods we therefore have:

\[
c_{zi} + s_{ij} \tau_z \geq q_j \quad \perp \quad Z_{ij} \geq 0. \tag{9}
\]

In addition to unskilled labor, we have capital \((K)\) and skilled labor \((S)\) as factors of production for \(X\)-goods in our economies.\(^8\) All three factors are used in fixed proportions, given for country \(i\) by the unit input coefficients \(a_{Kxi}\), \(a_{Lxi}\) and \(a_{Sxi}\). Furthermore, national firms need capital to set up plants \((a_{Kni})\) and skilled labor to generate firm-specific assets \((a_{Sni})\).

Factor market clearing implies:

\[
L_i \geq Z_{ii} + Z_{ij} + a_{Lxi} n_i (x_{ii} + x_{ij}) + a_{Lii} (m_i + m_j) t_i \quad \perp \quad w_{Li} \geq 0, \tag{10}
\]

\[
K_i \geq a_{Kxi} n_i (x_{ii} + x_{ij}) + a_{Kli} (m_i + m_j) t_i + a_{Kni} n_i + a_{Kmti} m_i \quad \perp \quad w_{Ki} \geq 0, \tag{11}
\]

\[
S_i \geq a_{Sxi} n_i (x_{ii} + x_{ij}) + a_{Sli} (m_i + m_j) t_i + a_{Sni} n_i + a_{Smti} m_i \quad \perp \quad w_{Si} \geq 0, \tag{12}
\]

with \(w_{Ki}\), \(w_{Li}\), and \(w_{Si}\) denoting factor rewards in \(i\). We set \(a_{Kni} = a_{Sni} = 1\), and assume \(a_{Kxi} = 0.3\), \(a_{Lxi} = 0.6\) and \(a_{Sxi} = 0.1\). For the transport sector we assume in a first step exactly the same coefficients as in the \(X\)-sector in order to ensure the maximum comparability with the iceberg transport cost assumption, i.e.

\(^8\)In the simulation below, world factor endowments are set at \(L = 100\), \(K = 60\) and \(S = 40\).
\( a_{Kmti} = a_{Smtri} = 1, \quad a_{Kli} = 0.3, \quad a_{Lti} = 0.6 \) and \( a_{Sti} = 0.1. \)

Variable unit costs of \( X \)-production in \( i \) are
\[ c_{xi} = a_{Kxi}w_{Ki} + a_{Lxi}w_{Li} + a_{Sxi}w_{Si}. \]

Fixed markup pricing in the \( X \)-sector yields:
\[
p_{ti} \leq c_{xi} \frac{\sigma}{\sigma - 1} \quad \perp \quad x_{ii} \geq 0. \tag{13}
\]

Transport service production implies variable unit costs of
\[ c_{t} = a_{Kti}w_{Ki} + a_{Lti}w_{Li} + a_{Sti}w_{Si}, \]
and quite similar as in the \( X \)-sector, fixed markup pricing leads to:
\[
p_{ti} \leq c_{ti} \frac{\sigma_t}{\sigma_t - 1} \quad \perp \quad t_{i} \geq 0. \tag{14}
\]

We assume free entry and exit of firms in both, the \( X \)-sector and the transport sector. This implies zero profits, and the determination of the number of firms by Chamberlin’s ”tangency solution”. For the \( X \)-sector this implies:
\[
a_{Kni}w_{Ki} + a_{Sni}w_{Si} \geq \frac{p_{i}(x_{ii} + x_{ij})}{\sigma} \quad \perp \quad n_{i} \geq 0, \tag{15}
\]

where the left-hand side represents the fixed costs and the right-hand side denotes the mark-up profits.

Similar, the number of firms in the transport sector is given by:
\[
a_{Kmti}w_{Ki} + a_{Smtri}w_{Si} \geq \frac{p_{ti}t_{i} + p_{tj}t_{j}}{\sigma_t} \quad \perp \quad m_{ti} \geq 0, \tag{16}
\]

since we have assumed horizontal MNEs in the transport sector producing in both countries.

To close the model, we assume that all factors are owned by households, so that consumer’s income in country \( i \) is given by:
\[
E_i = w_{Ki}K_i + w_{Li}L_i + w_{Si}S_i. \tag{17}
\]
3 Effects on the Volume of Trade

First, we want to investigate the effects of introducing a multinationalized transport sector on the volume of trade when the countries are identical.\(^9\)

We focus on the volume of trade \((VT)\) as defined in Helpman and Krugman (1985) as a percentage of GDP:

\[
VT = \frac{n_i p_i x_{ij} + Z_{ij} p_{ij}^n + n_j p_j x_{ji} + Z_{ji} p_{ji}^n}{E_i + E_j} \times 100,
\]

(18)

where \(p_{ij}^n(\ p_{ji}^n)\) is the net-of-transport-costs price for \(Z\) goods exported from \(i(j)\) to \(j(i)\), which is given by \(p_{ij}^n = \frac{p_{zj}}{1 + \tau}\) in the case of iceberg transport costs, and as \(p_{ij}^n = p_{zj} - s_{ij} \tau\) in the model with the transport sector, and similar for \(p_{ji}^n\).

As expected, the volume of trade declines with rising transport costs (see Figure 1). Two things are worth noting. First, for low levels of trade costs the iceberg type model suggests a lower trade volume than the transport sector model, but for higher levels this prediction changes. The reason is that firms in the \(X\)-sector have to be larger in the transport sector model, since they do not have to produce the transport service on their own, but have to bear the same fixed costs as firms producing transport services on their own. Larger firm size implies less firms with a higher production level leading to a higher volume of trade due to the love of variety assumption. When the elasticity of substitution between variants is lower (higher), this mechanism becomes stronger (weaker). If transport costs are very high, the amount of transport service demanded shrinks, and transport services become more expensive in the transport sector model, since less transport firms are able to to finance fixed costs.

Second, in the iceberg transport costs model, exports shrink with higher transport costs but are never exactly zero. This is not the case if we model the transport sector explicitly (see the case with \(\sigma = 6\) in Figure 1).

\(^{9}\)Note that this assumption rules out trade in the homogeneous goods sector.
One important aspect concerning the volume of trade is the underlying dependence on the network structure in the transport sector. Van Schijndel and Dinwoodie (2000) argue that higher congestion should lead transport companies to switch to multimodal transport. However, they point out that a competitive multimodal service will demand more co-operation between transport companies, involving large investments depending on dense goods-flows capable of generating sufficient scale economies to cover their capital costs.

As this evidence suggests, rising congestion costs could lead to a strong dependence on different providers and induce more trade. Our model predicts a greater volume of trade with a higher network dependence, i.e. a lower value of $\sigma_t$. The reason is that the strong demand for different transport services leads to more firms in the transport sector producing at a lower scale. On the one hand, this rises the price of the service supplied by one firm ($p_{ti}$), but on the other hand it lowers the price of the whole transport service bundle ($s_{ti}$) (see Figure 2). This seems to be a reasonable prediction and is well in line with the findings of van Schijndel and Dinwoodie (2000). Longer trading distances need more complex transport service networks\(^{10}\), but in order to be able to cover the additional fixed costs of such a network, the volume of trade has to rise.

– Figure 2 –

As shown in Table 1 and discussed in the introduction, factor intensities vary quite a lot between different industries. With a transport sector, different factor intensity assumptions lead to different volumes of trade (see Figures 3 and 4).\(^{11}\) The volume of trade is highest if $X$-goods production needs only skilled labor.\(^{12}\) In this case additional transport service demand rises factor prices of capital and unskilled labor, leading to more income which partly is spent on foreign variants. Overall

\(^{10}\)See also Janelle and Beuthe (1997).

\(^{11}\)We have chosen the following values: Transport sector: $a_{Lti} = 0.45$, $a_{Kti} = 0.4$, $a_{Sti} = 0.15$; Agricultures: $a_{Lxi} = 0.6$, $a_{Kxi} = 0.35$, $a_{Sxi} = 0.05$; Natural Resources: $a_{Lxi} = 0.3$, $a_{Kxi} = 0.6$, $a_{Sxi} = 0.1$; High-tech industry: $a_{Lxi} = 0.4$, $a_{Kxi} = 0.25$, $a_{Sxi} = 0.35$.

\(^{12}\)The labels in the figures have to be interpreted in the following way: In the case of “Capital only” $X$-goods production only needs capital. Similar “Skilled labor only” (“Unskilled labor only”) indicates that $X$-goods production only requires skilled (unskilled) labor.
we can conclude that the volume of trade is typically higher when factor intensities are different in the transport sector and in the differentiated goods sector, due to possibility of a more flexible allocation of resources.

— Figures 3 and 4 —

With iceberg transport costs the volume of trade for completely symmetric countries is given by:\(^{13}\)

\[
V_T = \frac{2np(pt)^{-\sigma} (np^{1-\sigma} + n(tp)^{1-\sigma})^{-1} \alpha E}{2E} = \frac{\alpha np}{(pt)^{\sigma} (np^{1-\sigma} + n(tp)^{1-\sigma})} = \frac{\alpha}{t^{\sigma} (1 + t^{1-\sigma})} = \frac{\alpha}{t + t^{\sigma}}.
\]

(19)

Therefore, the \(VT\) as percentage of GDP does not depend on income or factor intensities in production at all. Furthermore, the first derivative with respect to \(\sigma\) indicates\(^{14}\), that a higher substitutability between variants leads to a lower volume of trade, which is also true if a transport sector is present.

4 Effects on Income

So far we focussed on the VT. Now we want to investigate the effects of introducing a multinationalized transport sector on the GDP of the countries. Samuelson’s iceberg transport costs generate income in the country where the good to be shipped is produced. The income is distributed according to the factor intensities in the production of the shipped goods. Introducing a transport sector relaxes the assumption of where the income has to be earned and breaks up the tie of the same factor income distribution as in goods production.

Let us take the first step and change the elasticity of substitution for variants, but stick to the assumption of symmetric countries. In Figure 5 the percentage changes in GDP are calculated relative to the GDP-level when there are no transport costs. The transport sector model suggests that for higher values of \(\sigma\) income raises,

\(^{13}\)Due to symmetry the country index is omitted here.

\(^{14}\)\(\frac{\partial V_T}{\partial \sigma} = -\frac{\sigma t^{\sigma-1} \ln t}{(t + t^{\sigma})^2} < 0.\)
whereas it falls for lower values. If $\sigma$ is equal to the technical rate of substitution in the transport sector, income does not vary with changes in the amount of transport services needed. The reason for this result lies in the resources needed to provide the goods. If the reliance on a tight transport network is higher than the demand for differentiated products\textsuperscript{15}, more and more factors (mainly capital) are needed to set up transport firms as trade costs rise. This leads to higher factor price of capital and, therefor, to a higher income. In the opposite case, i.e. $\sigma_t > \sigma$, higher transport costs implies that less $X$-goods producing firms are able to survive because resources are needed to provide the transport services. But as the transport sector is more competitive, less firms are able to finance their fixed costs, which leads to a lower demand of resources needed to set-up firms.

Form this reasoning Figure 6 naturally follows. A higher reliance on different transport firms leads to more firms engaging in transport, storage and telecommunication as demand for this services rises. This leads to a higher income, because the capital price, mainly needed to set-up firms, rises. The opposite holds true for higher values of $\sigma_t$.

- Figures 5 and 6-

Figure 7 shows the effect of different factor intensities in the transport sector and in the differentiated goods sector. As can be seen, whether GDP rises or falls strongly depends on the factor intensities in the differentiated goods industry. If the $X$-sector is very unskilled labor intensive, capital and skilled labor is mainly needed in the transport sector and to set up plants. A rise in transport costs can therefore lead to a rise in GDP by rising factor rewards of skilled labor and capital. On the other hand, if the differentiated sector is capital and/or skilled labor intensive, transport costs are relatively more unskilled labor intensive. Higher transport costs increase the factor demand for unskilled labor but lower factor demand of skilled labor and capital. This leads to lower factor rewards of the latter two, and consequently, to a lower GDP. Calculating real GDP (defined as $E_t s_t^{-\alpha} q_t^{1-\alpha}$), we find that rising transport costs always lower real GDP, irrespective of factor intensities.

\textsuperscript{15}$\sigma_t < \sigma$. Note that in Figure 5 $\sigma_t = 4.$
In the model with iceberg transport costs income does not change as transport costs rise (see Appendix A). The reason is that higher transport costs lead to higher domestic consumption. But this does not change the factors needed to produce the goods. Therefore, factor demands and, hence, factor rewards remain unchanged. The same holds true with a transport sector, as long as factor intensities in the transport sector and the differentiated goods sector are equal. In the case of different factor intensities, income does vary with transport costs as was demonstrated above.

5 Effects on Specialization Patterns

In new trade theory models with two countries and two sectors, every country has two possibilities for specialization: On the one hand it can focus on producing homogeneous goods, and on the other hand a concentration in the differentiated sector is possible. Considering a multinationalized transport sector opens up a third possibility: to specialize in the transport sector. We therefore will now investigate, which country will specialize in transport services and whether predictions concerning the specialization pattern of goods production do change or not by explicitly considering a transport sector.

We have three factors of production and, therefore, present only slices through the factor cube. One slice is the capital to unskilled labor endowment box when skilled labor is divided equally between countries and another slice shows the capital to skilled labor endowment box when unskilled labor is symmetrically distributed.\(^{16}\)

Transport services concentrate in the relatively skilled labor and/or capital abundant country. The reason is that headquarter services and setting up plants are capital and skilled labor intensive activities. If capital or skilled labor is scarce, the country

\(^{16}\)Factor intensities are as in the base case, i.e. \(a_{Lxi} = 0.6\), \(a_{Kxi} = 0.3\) and \(a_{Sxi} = 0.1\). \(\tau_x = \tau_s = 0.5\).
specializes in Z-sector production and to some extend in X-sector production, but does not run horizontal MNEs in the transport sector.

If we assume that the X-sector is the natural resources sector, than transport sector MNEs mainly concentrate in the skilled labor to capital abundant country, since the natural resources sector is very capital intensive. Still, an unskilled labor abundant country will not run MNEs in the transport sector. Taking the X-sector to be the high-tech industry, we find a concentration of transport service MNEs in the skilled labor to capital scarce country, as the skilled labor abundant country has a comparative advantage in high-tech X-goods production.

To sum up, different endowments and factor intensity assumptions exert important effects for the distribution of the transport sector between countries. According to our model, transport MNEs are mainly headquartered in the skilled labor abundant countries and unlikely in an unskilled labor abundant one. This fits nicely with the empirical facts. According to the *World Investment Report* (UNCTAD, 2002), across the developing countries mainly Hong Kong and Singapore headquarter MNEs in the transport sector. Sorting countries by their relative skilled labor endowment using information from the GTAP database, we find that Hong Kong and Singapore are on the top of the developing countries. Similarly, Sweden, the United Kingdom, the United States and Germany, countries which are on the list of the top 100 MNEs ranked by foreign assets engaging in transport, storage and telecommunications, are in the top 17 according to skilled worker endowments.\(^\text{17}\) On the other hand, very unskilled labor intensive countries like Uganda, China and Tanzania do not host (large) transport MNEs according to the *World Investment Report*.

The distribution of sectors between countries has been widely discussed in the literature. A main theoretical finding is that in a world with transport costs and two sectors, one homogeneous goods sector and one increasing returns to scale sector, a country with higher demand has a proportionally larger share of production in the increasing returns to scale sector. This phenomenon is called the home-market-effect (HME). Accordingly, the larger region becomes more and more industrialized.

\(^{17}\text{The first three are even in the top 7.}\)
whereas smaller regions continue to produce primary products. However, Davis (1998) introduced transport costs in the homogeneous sector and proved that with equal transport costs in both sectors, the homogeneous good will not be traded and therefore production of the differentiated sector is in proportion to country size.

Does the possibility to specialize in transport services change the prediction regarding the home market effect? When comparing the outcome concerning the HME of the model with iceberg transport costs and the transport sector model, we have to make one important decision: Should we add the transport service or not? So far, in the literature, the HME was calculated as the production of the $X$-good in one country. As one part of the good shipped melts away, but has to be produced, iceberg transport costs are included in the computation of the HME. If one is interested in the specialization pattern of countries, this seems not to be the natural way. One would only include the $X$-sector output and not the transport service. In Figure 10 we compare both, the HME when transport costs are included, and the HME if the transport costs are excluded. The latter is computed as follows:

$$HME = \frac{n_i(x_{ii} + x_{ij})}{\frac{\phi}{1-\phi}},$$

(20)

where $\phi$ is country $i$’s share of world factor endowment.

When we include transport costs, the HME in the case of iceberg transport costs is given by:

$$HME = \frac{n_i(x_{ii} + x_{ij}(1+\tau_x))}{\frac{\phi}{1-\phi}},$$

(21)

For the transport sector model, the HME is given by:

$$HME = \frac{n_i(x_{ii} + x_{ij}) + x_{ji} n_j \tau_x}{\frac{\phi}{1-\phi}}.$$  

(22)

Including transport costs, we see from Figure 10 that, as predicted by Davis (1998), the HME disappears in the case of iceberg transport costs. In the case of a transport sector, however, the HME even exists if transport costs are identical for the two commodities. The disappearance of the HME in the case of equal transport costs is,
therefore, due to the assumption of iceberg transport costs and therefore a highly artificial case.

The additional possibility to specialize in transport services does not change the prediction of the specialization patterns in goods trade, but rather reinforces the tendency that the large country has a comparative advantage in the differentiated goods sector. As discussed above, the country which is relatively skilled labor abundant, specializes in transport services. If both countries relative endowments with all three factors is identical, but one country is larger and produces more X-goods, the smaller country is the skilled labor abundant one and will run transport sector MNEs and export the homogenous goods.

For the industrialization of countries, the comparison of sectors without transport costs would be more accurate. In this case, the HME even appears in the model with iceberg transport costs. We therefore can conclude in line with Helpman and Krugman (1985) that the HME is quite pervasive.

— Figure 10 —

6 Conclusions

Models of the new trade theory heavily depend on the introduction of transport costs. To simplify the model, most of them introduce Samuelson’s iceberg transport costs, which assume that a part of the good ”melts” away in transport.

According to the World Investment Report (UNCTAD, 2002), multinational activities in the transport sector play a crucial role and become more and more important. In order to account for the multinationalization in transport services, we assume horizontal multinational enterprises in the transport sector, i.e. firms running plants in both countries and not engaging in trade. We therefore incorporate imperfect competition in the goods market as well as in the transport sector.

By explicitly modelling the transport sector we can relax some of the assumptions implied by iceberg transport costs. That means (i) transport services are no longer the same for both goods, (ii) production of the good shipped and the transport
service are disentangled, (iii) there is no joint production of goods, and (iv) transport services and the factor intensities in the transport sector and in the goods sector can differ.

Concerning the volume of trade, we find that the assumption of iceberg transport costs leads to an underestimation (overestimation) of the volume of trade for low (high) transport costs. Furthermore, the volume of trade (expressed as percentage of GDP) is independent of income and factor intensity assumptions when iceberg transport costs are assumed. This independency vanishes by introducing a transport sector dominated by multinationals.

Varying transport costs when countries are equal leads to no income changes in both countries when iceberg transport costs are assumed. With a multinationalized transport sector, rising transport costs may increase or decrease GDP, depending on factor intensity assumptions in the goods sector.

Concerning the specialization pattern, we found that skilled labor abundant countries specialize in transport sector services. Further, the tendency of agglomeration of the increasing returns to scale sector in the larger country, is more pronounced if we introduce a transport sector compared to a model with iceberg transport costs, as the smaller country does not only export the homogeneous good, but also specializes in running transport sector MNEs.
References


A Appendix

Samuelson’s iceberg transport costs and income invariance when transport costs change

In the model with iceberg transport costs, one factor reward, either capital or skilled labor, approaches zero. This can be seen by comparing the factor market equations for capital and skilled labor, given by:

\[ K_i \geq a_{Kx_i} n_i (x_{ii} + x_{ij}(1 + \tau_x)) + a_{Kn_i} n_i \]  
\[ S_i \geq a_{Sx_i} n_i (x_{ii} + x_{ij}(1 + \tau_x)) + a_{Sn_i} n_i. \]  

(A1)  

(A2)

They only differ by constants and therefore both equations will only hold with equality by coincidence. Assume skilled labor abundance. In this case, the factor reward in both countries for skilled labor approaches zero. \( (w_{Si} = w_{Sj} = 0) \). This simplifies Chamberlin’s ”tangency solution” to (assuming \( n_i > 0 \)):

\[ a_{Kni} w_{Ki} = \frac{p_i(x_{ii} + x_{ij}(1 + \tau_x))}{\sigma}. \]  

(A3)

Using the factor market equation for capital (A1) and for unskilled labor, given by

\[ L_i \geq a_{Kx_i} n_i (x_{ii} + x_{ij}(1 + \tau_x)) + Z_{ii} + Z_{ij}(1 + \tau_x), \]  

and solving both for \( n_i \) leads to:

\[ n_i = \frac{K_i}{a_{Kx_i}(x_{ii} + x_{ij}(1 + \tau_x)) + a_{Kn_i}}. \]  

(A4)

\[ n_i = \frac{L_i - (1 - \alpha)E_i}{a_{Lxi}(x_{ii} + x_{ij}(1 + \tau_x))}, \]  

(A5)

where we used \( (1 - \alpha)E_i = Z_{ii} \), which holds because the Z-good is not traded between equal countries.

By equating (A4) and (A5) we can write:

\[ (x_{ii} + x_{ij}(1 + \tau_x)) \left[ \frac{a_{Kxi}(L_i - (1 - \alpha)E_i)}{K_i} - a_{Lxi} \right] + a_{Kni} \left[ \frac{L_i - (1 - \alpha)E_i}{K_i} \right] = 0. \]  

(A6)
\[ x_{ii} + x_{ij}(1 + \tau_x) = \frac{-a_{Kni} \left[ \frac{L_i - (1 - \alpha)E_i}{K_i} \right]}{\frac{a_{Kxi}(L_i - (1 - \alpha)E_i)}{K_i} - a_{Lxi}}. \]  

(A7)

Using \( E_i = w_{K_i}K_i + L_i \), \( p_i = \frac{\sigma(a_{Kxi}w_{K_i} + a_{Lxi})}{\sigma - 1} \) and combining (A3) and (A7) leads to:

\[ a_{Kni}w_{K_i} = \left( \frac{a_{Kxi}w_{K_i} + a_{Lxi}}{\sigma - 1} \right) \left( \frac{\sigma(a_{Kxi}w_{K_i} + a_{Lxi})}{\sigma - 1} \right) \left[ \frac{L_i - (1 - \alpha)E_i}{K_i} \right] - a_{Lxi} \cdot \]  

(A8)

After some manipulation, this equation turns out to be a quadratic one:

\[ w_{K_i}^2(-a_{Kni}a_{Kxi}(1 - \alpha)\sigma) + w_{K_i} \left[ \frac{\alpha a_{Kni}a_{Kxi}L_i\sigma}{K_i} - a_{Lxi}a_{Kni}(\sigma - \alpha) \right] + \]  

\[ + \frac{\alpha a_{Lxi}a_{Kni}L_i}{K_i} = 0, \]  

(A9)

with solutions as follows:

\[ w_{K_i} = \frac{1}{2a_{Kxi}K_i(1 - \alpha)\sigma} \left( a_{Lxi}K_i(\alpha - \sigma) + a_{Kxi}L_i\alpha \sigma \right) \]  

\[ \pm \sqrt{-4a_{Kxi}a_{Lxi}K_iL_i(\alpha - 1)\alpha \sigma + (a_{Lxi}K_i(\alpha - 1)\alpha \sigma + a_{Kxi}L_i\alpha \sigma)^2}. \]  

(A10)

Noting that the first expression of the right hand side is always positive, we can conclude that one solution is always negative and one is always positive, because the two terms in the brackets and outside the square root are identical to the expression under the square root which is squared. Since we restrict factor prices to be non-negative, we find one definite and valid solution.

Together with the income definition \( (E_i = w_{K_i}K_i + L_i) \), this shows that income does not vary with transport costs, since they do not appear in the solution for \( w_{K_i} \).
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<th>Unskilled Labor</th>
<th>Skilled Labor</th>
<th>Capital</th>
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<td>Rice &amp; Grains</td>
<td>61.57</td>
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<tr>
<td>Other Crops</td>
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<td>Meat</td>
<td>58.20</td>
<td>5.78</td>
<td>36.03</td>
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<td>Other Food</td>
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<td>9.59</td>
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<td>Natural Resources</td>
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<td>10.38</td>
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<td>Other Services</td>
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<td>26.41</td>
<td>44.61</td>
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</table>

Table 1: Factor intensities in selected sectors (% of total factor income of all three factors). Source: GTAP database version 5, corresponding to the global economy in 1997.
Figure 1: Volume of trade as % of world GDP if $\sigma$ changes ($\sigma_t = 4$).

Figure 2: Volume of trade as % of world GDP if $\sigma_t$ changes.
Figure 3: Volume of trade as % of world GDP if factor intensities change.

Figure 4: Volume of trade as % of world GDP if factor intensities change.
Figure 5: GDP changes in % if $\sigma$ changes.

Figure 6: GDP changes in % if $\sigma_t$ changes.
Figure 7: GDP changes in % if factor intensities change.

Figure 8: Existence of MNEs in the transport sector; $L_t = 50\%$ of world endowment.
Figure 9: Existence of MNEs in the transport sector; $S_t = 50\%$ of world endowment.

Figure 10: The Home-Market-Effect