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Egger, H; Egger, P; Greenaway, D
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Intra-Industry Trade with Multinational Firms *

Hartmut Egger  
University of Zurich,  
CESifo, Munich, and  
GEP, Nottingham

Peter Egger  
University of Munich,  
Ifo Institute, CESifo, Munich  
and GEP, Nottingham

David Greenaway  
School of Economics  
University of Nottingham

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Key words: intra-industry trade; Grubel-Lloyd index; multinational firms.

JEL classification: F12, F23

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Corresponding author: School of Economics, University of Nottingham, University Park, Nottingham NG7 2RD, United Kingdom.
1 Introduction

The publication of Grubel and Lloyd (1975) stimulated enormous interest in intra-industry trade (IIT), for two reasons. First, the empirical phenomenon of high levels of trade in products within industries between countries with similar factor endowments seemed at odds with the standard Heckscher-Ohlin-Samuelson (HOS) workhorse model of international trade. Second, the observed increase in intra-industry trade coincided with what appeared to be relatively painless adjustment to economic integration in Western Europe. Dislocation anticipated as specialisation occurred did not materialise, giving rise to the so-called ‘smooth adjustment hypothesis’.

In the decade that followed Grubel and Lloyd (1975) the literature exploded and proceeded in three directions: first, the measurement of IIT and its robustness to the use of more disaggregated data (Finger, 1975, Loertscher and Wolter, 1980, Greenaway and Milner, 1983, 1984, 1986, studies in Tharakan, 1983, and Torstensson, 1996); second, its explanation from a theoretical point of view in models of monopolistic competition and international trade (most notably Lancaster 1980, Krugman, 1979, 1980 and 1981, and Helpman and Krugman, 1985) as well as strategic interaction (e.g., Brander, 1981, and Brander and Krugman, 1983); third, the empirical assessment of these models (Helpman, 1987, Bergstrand, 1990, and Hummels and Levinsohn, 1995).

Recent years have seen a revival of interest in intra-industry trade, stimulated by frontier work on trade costs, economic geography and a range of aspects of firm level adjustment to globalization. Of particular interest, from both a theoretical and measurement point of view, is the relationship between intra-industry trade and multinational activity. We have known for a long time that both trade and multinational activity coexist, indeed are often coterminous, and that we need appropriate theoretical and empirical models for explaining this.

An important development in understanding the relationship between IIT and intra-industry affiliate sales is Markusen and Maskus (2002). From a specification based on numerical simulations of a two-factor knowledge capital model (Carr, Maskus and Markusen, 2001 and Markusen, 2002), they find that intra-industry trade between the US and partner economies tends to decrease with greater similarity in size, which is consistent with the findings of Helpman (1987), Bergstrand (1990) or Hummels and Levinsohn (1995). They also find that
the intra-industry trade share decreases with the bilateral level of trade costs, but increases with the bilateral level of investment costs. Greenaway, Lloyd and Milner (2001) are also interested in the relationship between intra-industry trade and intra-industry affiliate production and develop an ‘extended intra-industry trade index’, which accounts for both traditional intra-industry trade and two-way exchange of international production. However, apart from these papers, the issue remains largely unexplored.

This paper contributes to the literature in several ways. First, it demonstrates that the standard and still widely used Grubel-Lloyd index has to be adjusted to reflect the intra-industry trade share in a narrow sense. We show that with multinational firms, unbalanced profit repatriation distorts the index.\(^1\) In this respect, our study is complementary to Greenaway, Lloyd and Milner (2001) and Markusen and Maskus (2002), who discuss measures of intra-industry affiliate sales but do not deal with adjustments of the traditional Grubel-Lloyd index in the presence of multinational producers. We present a bias-corrected index that is robust to changes in foreign direct investment (FDI) and suitable for empirical work based on bilateral industry-level data.

Second, we develop a three-factor general equilibrium model of trade and multinationals to provide a detailed analysis of the role of investment cost differences between countries as a determinant of intra-industry trade. By introducing three factors (physical capital, skilled labour, unskilled labour), we emphasise the distinction between two important characteristics of headquarters: their provision of physical capital to set up plants, and the human-capital intensive generation of firm-specific assets through brand proliferation. Besides this more complete description of headquarters services, there is an advantage of analytical tractability. In this setting, we are able to evaluate not only the role of investment cost levels and differences on intra-industry trade in general, but also their interaction with factor endowments.

Finally, we implement and report on an empirical analysis, where uncorrected and bias-corrected versions of the Grubel-Lloyd index are used as dependent variables. This yields several conclusions. We find that trade-imbalance bias not only influences the overall

\(^1\) The existence of multinational firms matters as well for other strands of the empirical trade literature. Ekholm (1998) remarks, for example, that the usual measures of revealed factor abundance may be substantially biased if trade in headquarters services of multinational firms is not correctly accounted for. In an empirical exercise, she
magnitude of the index but also systematically affects parameter estimates; cross-section estimates tend to be inconsistent if country-specific effects are excluded; the parameter signs are largely consistent with the theoretical hypotheses; determinants such as skilled labour endowments and investment costs suggested by our theoretical model account for a substantial part of the variation in intra-industry trade-share data. Only about half of their variation is explained by traditionally used variables as motivated by ‘new trade theory’ models. Given the crucial importance of accurately estimating intra- relative to inter-industry trade, this is very significant.

The remainder of the paper is organized as follows. Section 2 describes the theoretical background. It introduces a correction to the Grubel-Lloyd index and sets up an analytically solvable theoretical model of intra-industry trade with exporters and multinational firms. A numerical simulation analysis complements the analytical discussion. Section 3 presents our econometric analysis, reports our results and subjects them to a sensitivity analysis. Section 4 concludes.

2 Theoretical background

2.1 The Grubel-Lloyd index

The Grubel and Lloyd (1971) index has become the standard measure for the intensity of intra-industry trade. In the two-country case, it is defined as

\[ GLI = \sum_k \frac{2 \times \min(EX_{ik}, IM_{ik})}{\sum_k EX_{ik} + \sum_k IM_{ik}}, \] (1)

where \(EX_{ik}\) is the value of country \(i\)'s exports of good \(k\). \(IM_{ik}\) represents expenditures for country \(i\)'s imports of good \(k\). Although \(GLI\) has been the standard concept to assess the IIT share for over 30 years, it is less appropriate if there are multinational activities because \(GLI\) does not account for (unbalanced) repatriated profits of multinational firms and, therefore, underestimates the intra-industry trade share. For convenience, we use the term trade imbalance bias to refer to this measurement error.³ To see this, consider two economies with

\[ \text{shows that the usual measures underestimate the abundance of skilled labour and overestimate the abundance of physical capital in the US case.} \]

² We do not distinguish between c.i.f. and f.o.b. data for the moment. For a discussion on different empirical specifications of the Grubel-Lloyd index see Subsection 3.1.

³ Note that this has an entirely different motivation than the case made by Aquino (1978) for a correction of aggregate payments imbalance. As Greenaway and Milner (1981) showed, this is neither defensible on
one sector of production. From payments balance it follows that 
\[ 2 \times \min \{EX_i, IM_i\} < EX_i + IM_i, \]
if there are flows of repatriated profits due to multinational 
activities of country \( i \) firms in \( j \). Thus, \( GLI < 1 \), according to (1). However, in a two-country 
one-sector model there is by definition only intra-industry trade in goods, so that the correct 
\( GLI \) must equal one.

To obtain a better measure of the IIT share, we have to adjust the \( GLI \) for all income flows not 
due to goods trade, like repatriated profits. More precisely, we correct the denominator for all 
output flows that are balanced by income flows not directly related to exports and imports. 
This gives a hypothetical measure of balanced trade.\(^4\) The corrected Grubel-Lloyd index for 
the two-country, multi-sector case is then:

\[
CGLI = \sum_k \frac{2 \times \min \{EX_{ik}, IM_{ik}\}}{\sum_k EX_{ik} + \sum_k IM_{ik} - \sum_k EX_{ik} - \sum_k IM_{ik}}.
\] (2)

In our thought experiment with two one-sector economies and multinational activities of 
country \( i \) firms in country \( j \), \( CGLI \) gives a correct measure of the intra-industry trade share, 
i.e., \( CGLI = 1 \).\(^5\) According to (1) and (2), we obtain

\[
\frac{CGLI}{GLI} = 1 + \frac{\left| \sum_k EX_{ik} - \sum_k IM_{ik} \right|}{\sum_k EX_{ik} + \sum_k IM_{ik} - \sum_k EX_{ik} - \sum_k IM_{ik}} = SHI,
\] (3)

with \( SHI \geq 1 \), as a measure of the trade imbalance bias in relative terms.

In what follows we are interested in the role of multinational activities and repatriated profits 
for income flows \( \left| \sum_k EX_{ik} - \sum_k IM_{ik} \right| \). In particular we investigate how changes in the fixed 
costs of multinational activities (see Amiti and Wakelin, 2003) affect the corrected Grubel-
Lloyd index given in (2) and the trade imbalance bias in (3). To identify the basic economic 
mechanisms, we introduce an analytically solvable general equilibrium model, which 
accounts for horizontal multinational activities.

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4 This adjustment method was in fact first suggested by Grubel and Lloyd (1975). However, they did not develop 
a clear theoretical motivation. Bergstrand (1983) correctly points out that there are other sources of trade 
imbalance (which are not related to multinational activity). The bias correction in (2) captures all sources of 
trade imbalance. However, as will become obvious in the econometric analysis below, there is a systematic 
relationship between bilateral intra-industry trade and the size of investment costs. This indicates that the simple 
two-country motivation for the bias correction is of empirical relevance.
2.2 An analytically solvable model of trade and horizontal FDI

Consider two countries \((i, j)\), which are endowed with three factors, unskilled labour \(L\), skilled labour \(S\) and physical capital \(K\). All three are inelastically supplied in competitive and internationally segmented factor markets. The countries may differ in their endowments of unskilled labour but are assumed to be symmetric with respect to their \(S\)- and \(K\)-supplies. There are two sectors of production. In the industrial \(X\)-sector differentiated goods are produced, while output in the agricultural \(Y\)-sector is homogeneous. Sector \(X\) is characterized by monopolistic competition and perfect competition prevails in sector \(Y\). Throughout our analysis we focus on a parameter domain, which guarantees that both sectors are active in the two economies (\textit{diversification}). Production technologies are given by \(x = L\) and \(Y = L\), respectively. To start up manufacture in the \(X\)-sector, firms have to invest capital and skilled labour as fixed non-production inputs.

Two types of monopolistically competitive \(X\)-producers are distinguished: exporters and horizontal multinational enterprises (MNEs). An exporter serves consumers in both countries from a single production facility (at its headquarters location), while a horizontal multinational firm establishes a separate production plant in either economy and does not engage in final goods trade. Headquartering a firm (of either type) in a certain country induces investment of one unit of skilled labour and one unit of physical capital. Local production can start immediately. To set up a second facility abroad, the multinational has to invest a further amount of \(g - 1 > 0\) units of physical capital. Fixed non-production inputs come from the country of headquarters.\(^6\) In general, countries can differ in their investment cost parameters, i.e., \(g_i >, =, < g_j\).

Exporting differentiated industrial output generates iceberg trade (i.e., transport) costs which are accounted for by parameter \(t > 1\) below. Trade in the homogeneous good does not induce any trade frictions. Hence, choosing the price of the agricultural good (of country \(i\)) as the numéraire, the wage rate of unskilled labour equals one in both economies (under diversification): \(w_{Li} = w_{Lj} = 1\).

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\(^5\) We can substitute \(EX_{ik} = IM_{jk}\) in (2) if f.o.b. measures are used in the calculations of \(CGLI\). This will be important in our analytical investigation below.

\(^6\) This assumption is not crucial. In an extension, which is available from the authors upon request, we study a model variant, where multinational firms use physical capital from the foreign economy to set up an affiliate, there. It turns out that such a modification does not change our analytical results in qualitative terms.
In a next step, we describe profits of exporters \((n)\) and horizontal multinational enterprises \((h)\) in the \(X\)-sector. We denote local sales in country \(i\) \((j)\) by \(x_{ii} (x_{jj})\) and use variables \(x_{ij} (x_{ji})\) to refer to exports from country \(i\) to country \(j\) (from \(j\) to \(i\), respectively). Furthermore, \(p_{ii} (p_{jj})\) and \(p_{ij} (p_{ji})\) are the respective producer prices. Profits of an exporter with headquarters in country \(i\) are given by

\[
\pi^n_i = (p_{ii} - 1)x_{ii} + (p_{jj} - t)x_{ij} / t - w_{Ki} - w_{Si}
\]  

(4)

and profits of a horizontal multinational producer with headquarters in country \(i\) are represented by

\[
\pi^h_i = (p_{ii} - 1)x_{ii} + (p_{jj} - 1)x_{ij} - g_i w_{Ki} - w_{Si},
\]

(5)

with \(w_{Ki}, w_{Si}\) being factor prices of physical capital \(K\) and skilled labour \(S\) in country \(i\). (The respective profits for producers with headquarters in \(j\) are analogous.)

Three remarks are in order. First, \(1 = L = 1\) has been used in (4) and (5). Second, all firms with headquarters in country \(i\) pay identical returns to skilled labour and physical capital if factor markets are perfectly competitive. Third, firm indices have been neglected as local output levels and exports turn out to be identical for all producers in equilibrium.

Preferences of the representative consumer in either economy are Cobb-Douglas:

\[
U = X^\alpha Y^{1-\alpha}, \quad 0 < \alpha < 1
\]

(6)

where \(X \equiv \left[ \sum_j x_j^{(\varepsilon^{-1})/\varepsilon} \right]^{\varepsilon/(\varepsilon-1)}, \varepsilon > 1\), is a CES-index, that accounts for home-produced and imported varieties of the industrial good. Country indices are neglected for the moment. The budget constraint of the representative consumer implies \(\sum_l p_l x_l \leq E\), with \(E\) being the sum of total factor income and profits (in a particular economy) and \(p_l\) denoting the consumer price of variety \(l\). Utility maximization leads to the following demand for variety \(l\) of the industrial good:

\[
x_l = \alpha E p_l^{-\varepsilon} / P
\]

(7)

where \(P \equiv \sum_l p_l^{1-\varepsilon}\) is a (country-specific) price index.
Goods market clearing conditions imply \( x_i = x_{ij} \), if variety \( l \) is produced and consumed in country \( i \), and \( x_i = x_{ji} / t \), if variety \( l \) is produced in country \( j \) and exported to country \( i \). (Analogously, \( x_i = x_{ji} \) if variety \( l \) is produced and consumed in country \( j \) and \( x_j = x_{ij} / t \) if variety \( l \) is produced in country \( i \) and exported to country \( j \).) Since consumer and producer prices are identical, it follows from (4), (5) and (7) that profit maximization leads to a constant price-markup over variable production costs, i.e., \( p_{ii} = p_{jj} = \epsilon / (\epsilon - 1) \) and \( p_{ji} = p_{ij} = t\epsilon / (\epsilon - 1) \), respectively. Then, using \( \tau \equiv t^{1-\epsilon} < 1 \), \( x_{ji} = x_{ij} \tau \) is implied by (7).

Free entry of firms leads to zero profits in the \( X \)-sector. The zero-profit conditions determine equilibrium factor returns to skilled labour and physical capital as functions of output levels \( x_{ii}, x_{jj} \). Focussing on a parameter domain with positive factor returns, the following expressions are obtained:

\[
\begin{align*}
  w_{Ki} &= \frac{1}{\epsilon - 1} \frac{1 - \tau}{g_i - 1} x_{ji}, \\
  w_{Si} &= \frac{1}{\epsilon - 1} \left[ x_{ii} - x_{jj} \frac{1 - g_j \tau}{g_i - 1} \right], \\
  w_{Kj} &= \frac{1}{\epsilon - 1} \frac{1 - \tau}{g_j - 1} x_{ij}, \\
  w_{Sj} &= \frac{1}{\epsilon - 1} \left[ x_{jj} - x_{ii} \frac{1 - g_i \tau}{g_j - 1} \right],
\end{align*}
\]

according to (4) and (5). In addition, the three factor market clearing conditions in country \( i \) are given by

\[
\begin{align*}
  L_i &= \left( h_i + h_j + n_i \right) x_{ii} + \tau n_i x_{jj} + Y_i, \\
  S &= n_i + h_i, \\
  K &= n_i + g_i h_i.
\end{align*}
\]

The respective factor market clearing conditions in country \( j \) lead to analogous expressions. By virtue of (11) and (12), the equilibrium numbers of horizontal multinational firms and exporters are given by

\[
\begin{align*}
  h_i &= \frac{K - S}{g_i - 1}, \\
  n_i &= \frac{g_i S - K}{g_i - 1}, \\
  h_j &= \frac{K - S}{g_j - 1}, \\
  n_j &= \frac{g_j S - K}{g_j - 1}.
\end{align*}
\]

Two properties of our framework should be noted. First, countries do not differ in the total number of local headquarters, if they do not differ in their skilled labour endowments, according to (11). However, it follows from (13) and (14) that countries differ in the
composition of firms if \( g_i \neq g_j \) (or \( K_i \neq K_j \)). This implies countries may be asymmetric in terms of their local production facilities, even if they do not differ in their physical capital and skilled labour endowments. Second, the model is flexible enough to investigate the role of investment cost parameters \( g_i \), \( g_j \) for the composition of producers and the number of local production facilities in the two economies. However, any feedback effects on firm structure variables from output adjustments or income changes are ruled out by our assumption on factor use in production.\(^7\)

Finally, using \( E_i = w_{K_i}K + w_{S_i}S + L_i \), \( E_j = w_{K_j}K + w_{S_j}S + L_j \), \( P_i = p_i^{1-\epsilon}(h_i + h_j + n_i + n_j\tau) \) and \( P_j = p_j^{1-\epsilon}(h_i + h_j + n_j + n_i\tau) \) together with (7), we obtain\(^8\)

\[
x_{ii} = \frac{\alpha}{\epsilon} \frac{\left(h_i + \tau n_i\right)x_{jj} + (\epsilon - 1)L_i}{\left(1 - \alpha / \epsilon\right)(n_j + h_j) + h_j + \tau n_j},
\]

\[
x_{jj} = \frac{\alpha}{\epsilon} \frac{\left(h_j + \tau n_j\right)x_{ii} + (\epsilon - 1)L_j}{\left(1 - \alpha / \epsilon\right)(n_i + h_i) + h_i + \tau n_i}.
\]

Equations (15) and (16) implicitly determine the equilibrium output levels \( x_{ii} \) and \( x_{jj} \) as functions of country-specific factor endowments \( L_i \), \( L_j \) and investment cost parameters \( g_i \), \( g_j \). (Also \( S \), \( K \) and trade costs \( \tau \) are determinants of output levels \( x_{ii} \), \( x_{jj} \). But they are held constant throughout the analytical discussion.)

Let us now turn to the intra-industry trade share. Under our specification, the uncorrected Grubel-Lloyd index is given by

\[
GLI = \frac{2\epsilon \tau \min\left(n_j x_{ii}, n_i x_{jj}\right)}{\epsilon \tau \left(n_j x_{ii} + n_i x_{jj}\right) + \left(\epsilon \tau n_i + h_i\right)x_{jj} - \left(\epsilon \tau n_j + h_j\right)x_{ii}},
\]

\(^{1a}\)

\(^7\) In the numerical simulation exercises reported in Subsection 2.3, we relax the admittedly restrictive assumptions on factor use in X-sector production.

\(^8\) Using \( E_i \), \( E_j \), \( P_i \) and \( P_j \) together with (7) gives \( x_{ii} = \frac{\alpha}{p_{ii}} \frac{w_{K_i}K + w_{S_i}S + L_i}{h_i + h_j + n_i + n_j \tau} \) and \( x_{jj} = \frac{\alpha}{p_{jj}} \frac{w_{K_j}K + w_{S_j}S + L_j}{h_i + h_j + n_j + n_i \tau} \). Then, substituting for final goods prices \( p_{ii} \), \( p_{jj} \) and factor returns \( w_{K_i} \), \( w_{S_i} \), \( w_{K_j} \), \( w_{S_j} \), according to (8) and (9), and noting \( n_i + h_i = n_j + h_j = S \), straightforward calculations lead to (15) and (16).
according to (1). Note that \( \left( \varepsilon \tau n_i + h_j \right) x_{jj} - \left( \varepsilon \tau n_j + h_j \right) x_{ij} \) is \( Y \)-trade according to the balance of payments condition.\(^9\) Furthermore, by virtue of (2), the corrected Grubel-Lloyd index is given by

\[
CGLI = \frac{2 \varepsilon \tau \min(n_j x_{ii}, n_j x_{jj})}{\varepsilon \tau (n_j x_{ii} + n_j x_{jj}) + \left( \varepsilon \tau n_i + h_j \right) x_{jj} - \left( \varepsilon \tau n_j + h_j \right) x_{ij} - h_j x_{ij} - h_j x_{ii}},
\]

(2a)

with \( h_j x_{ij} - h_j x_{ii} \) being the balance of repatriated profits for which the denominator of \( CGLI \) is adjusted. The ratio \( CGLI / GLI \) of the corrected and uncorrected indexes can be written as

\[
SHI = 1 + \frac{h_j x_{ij} - h_j x_{ii}}{\varepsilon \tau (n_j x_{ii} + n_j x_{jj}) + \left( \varepsilon \tau n_i + h_j \right) x_{jj} - \left( \varepsilon \tau n_j + h_j \right) x_{ij} - h_j x_{ij} - h_j x_{ii}}.
\]

(3a)

With equilibrium output levels and firm numbers at hand, we can investigate, how changes in the investment cost parameter affect the intra-industry trade share \( CGLI \) and the relative trade imbalance bias \( SHI \). According to (2a) and (3a), a number of cases can be distinguished, as different combinations of \( n_i x_{jj} >,=,< n_j x_{ii} \) and \( h_j x_{jj} >,=,< h_j x_{ii} \) are possible. For expository reasons and to focus on the most important features of our model, we restrict the number of possible scenarios by assuming \( g_i = g_j \). Taking this as a starting point, we can determine the impact of a marginal \( g_i \)-increase (over \( g_j \)).

To proceed with the formal analysis, it is useful to introduce a new variable:

\[
\xi(g_i, g_j, L_i, L_j) = \frac{(\alpha / \varepsilon)(h_j / n_j + \tau)L_i + \left[ (1 - \alpha / \varepsilon)(h_j / n_j + 1) + h_j / n_j + \tau \right] L_j}{(\alpha / \varepsilon)(h_i / n_i + \tau)L_j + \left[ (1 - \alpha / \varepsilon)(h_i / n_i + 1) + h_i / n_i + \tau \right] L_i},
\]

(17)

which gives the firm number-weighted output ratio \( n_j x_{jj} / n_j x_{ii} \) in a diversification equilibrium, according to (15) and (16).\(^10\) Two comparative-static results are notable. First, there is a market size effect. A higher \( L_j / L_i \) raises the volume (and value) of differentiated goods exports from country \( i \) to country \( j \) as compared to the volume (and value) of

\( ^9 \) By assumption, consumers prefer the home-supplied homogeneous good in the case of identical prices. This implies a unique value of \( Y \)-trade in the absence of any trade friction for homogeneous goods. Moreover, note that we consider f.o.b. trade flows (net of any iceberg trade costs) in eqs. (1a)-(3a) and throughout the rest of the theoretical analysis. This implies that \( EX_{ij} = IM_{ji} \) (see Footnote 5). For a rigorous discussion on different concepts of the Grubel-Lloyd index, see Subsection 3.1.

\( ^{10} \) One can solve system (15), (16) explicitly for \( x_{ii} \) and \( x_{jj} \). Then, multiplying the ratio \( x_{jj} / x_{ii} \) with \( n_i / n_j \) gives (17).
differentiated goods exports from country $j$ to country $i$. According to (17), this leads to an increase in $\xi(\cdot)$. Second, there is an *investment cost effect*. The higher $g_i$ the lower is the ratio between the number of multinational firms and the number of exporters in country $i$ ($h_i/n_i$), according to (13). A lower $h_i/n_i$, however, leads to an increase in the volume (and value) of differentiated goods exports from country $i$ to country $j$ relative to the volume (and value) of affiliate sales of country $i$ multinationals in $j$. Thus, $\xi(\cdot)$ increases in $g_i$, according to (17) (see Appendix for further details).

Substituting (17) into (2a) and noting that $\xi\left(g,g,L_i,L_j\right)>1$ if $L_j > L_i$ and $\xi\left(g,g,L_i,L_j\right)<1$ if $L_j < L_i$, one can show that

$$CGLI\big|_{g_i=g_j} = \begin{cases} \xi(\cdot) & \text{if } L_j < L_i \\ 1/\xi(\cdot) & \text{if } L_j > L_i \end{cases}$$

(18)

By virtue of (3a), we can also conclude that

$$SHI\big|_{g_i=g_j} = \begin{cases} 1 + \frac{h_j/n_j}{2\varepsilon} \left(1 - \frac{h_i/n_i}{h_j/n_j} \xi(\cdot)\right) & \text{if } L_j < L_i \\ 1 + \frac{h_i/n_i}{2\varepsilon} \left(1 - \frac{h_j/n_j}{h_i/n_i} \frac{1}{\xi(\cdot)}\right) & \text{if } L_j > L_i \end{cases}$$

(19)

Then, using (18) and (19), we can formulate two propositions.

**Proposition 1.** Consider $L_j < L_i$ and $g_i = g_j$. Then, a marginal increase of $g_i$ (over $g_j$) raises both the *intra-industry trade share* ($CGLI$) and the trade imbalance bias in relative terms ($SHI$).

**Proof.** See Appendix.

If $L_j < L_i$ and $g_i = g_j$, there is a market size advantage of country $i$ and $\xi(\cdot) < 1$. If $g_i$ is (marginally) increased over $g_j$ the associated investment cost effect counteracts the market

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11 Recall our assumption that both sectors are active in the two countries. This requires that $L_i$ and $L_j$ are not too different.
size advantage of country $i$ and $\xi(\cdot)$ increases (see our discussion below equ. (17)). By virtue of equ. (18) this leads to a higher $CGLI$. Loosely speaking, the increase in $g_i$ makes the two countries ‘more similar’ in terms of their economic capacity, so that the $CGLI$ result in Proposition 1 is in line with a key insight from the literature on intra-industry trade, namely that the IIT share increases in the similarity of countries (see Helpman, 1987, Bergstrand, 1990, Hummels and Levinsohn, 1995). The fact that countries become more similar tends to reduce $SHI$ ceteris paribus, according to (19). However, since an increase in $g_i$ reduces $h_i / n_i$, according to (13), there is a counteracting effect. It turns out that the firm structure effect dominates, explaining a negative impact of $g_i$ on $SHI$. Summing up, if $L_j < L_i$ and $g_i = g_j$, an increase of $g_i$ (over $g_j$), makes countries more similar in terms of their goods trade and raises $CGLI$. At the same time, the difference in repatriated profits increases relative to the sum of ‘trade-imbalance corrected’ trade flows and $SHI$ goes up.

**Proposition 2.** Consider $L_j > L_i$ and $g_i = g_j$. Then, a marginal increase of $g_i$ (over $g_j$) lowers both the intra-industry trade share ($CGLI$) and the trade imbalance bias in relative terms ($SHI$).

**Proof.** See Appendix.

If $L_j > L_i$, an increase in $g_i$ reinforces $j$’s market size advantage due to its better endowment of $L$. This leads to an increase in $\xi(\cdot)$ and, by virtue of (18), to a decline in $CGLI$. The increase in $\xi(\cdot)$ stimulates $SHI$, according to (19). However, the induced decline in $h_j / n_j$ counteracts and dominates this effect, so that $SHI$ goes down.

### 2.3 Numerical simulation analysis

The theoretical framework in Subsection 2.2 has built upon two critical simplifications that have been imposed for analytical tractability. First, our assumptions concerning factor use in production of $X$- and $Y$-goods ruled out any feedback effects on firm structure variables $h$ and $n$. Second, by focussing on horizontal multinational enterprises we did not account for vertical motives of foreign direct investment, which may be prevalent if countries differ sufficiently in their factor endowments or production technologies.
To relax these two restrictive assumptions, we use numerical simulation techniques and investigate the impact of investment costs and other determinants of intra-industry trade in an extended theoretical framework, in which all three factors are used by $X$-producers as variable production inputs in a CES-technology. In addition, we allow for existence of exporters and horizontal as well as vertical multinational enterprises (but keep the assumptions of Subsection 2.2 in all other respects). This gives us a variant of the so-called knowledge-capital (KK) model. For expositional reasons, we relegated a summary of the details on the set-up and the numerical simulation of the model to Appendix B.

In the extended model variant, we can analyse the role of bilateral country size, relative capital-to-unskilled labour endowment ratios, relative skilled-to-unskilled labour endowment ratios, trade costs, and investment costs for the corrected Grubel-Lloyd index ($CGLI$). Thereby, we choose a parameterisation that leads to both two-way trade and two-way horizontal multinational activity in the benchmark scenario of two fully symmetric countries (see Appendix B for details on the underlying parameter values). As we would expect, there is no reason for vertical MNE activity or homogeneous goods trade, and both (differentiated) goods trade flows as well as flows of repatriated profits are balanced in this case.

Taking a scenario with full symmetry as a starting point, we first consider the impact of country size differences on $CGLI$ (assuming that relative factor endowments, trade costs, and investment costs remain identical in the two economies). To illustrate this impact in Figure 1, we vary a country’s endowments with all factors of production (as a measure of its GDP) between 40 percent and 60 percent of the overall world endowments. From this exercise, we can conclude that the $CGLI$ increases in country size (i.e., GDP) similarity.

---

12 Note that both the model of vertical MNEs (Helpman, 1984, Helpman and Krugman, 1985) and that of horizontal MNEs (Markusen, 1984, Markusen and Venables, 1998, 2000) can be seen as restricted variants of the KK model, in which both types of firms may endogenously arise (Carr, Maskus and Markusen, 2001, Markusen, 2002).

13 Due to space limitations, we do not provide a detailed discussion of the determinants of the trade imbalance bias ($SHI$), here. Rather, it is the aim of this subsection to derive empirically testable hypothesis for the main determinants of the bias-corrected IIT share.

14 Bergstrand (1990) derives a similar result for the relationship between country size symmetry and the intra-industry trade share in a setting without multinational activity.
Besides the relationship between country size and $CGLI$, we are also interested in the impact of relative factor endowments, trade costs, and investment costs. To avoid clutter, we investigate the role of these variables separately and assume countries to be symmetric in all other respects. Similar to the analysis of country size effects and $CGLI$, we design the simulation set-ups such that countries are identical in the centre of each of the figures associated with the different experiments. Our findings are summarized in Figures 2a-2d (in Figures 2c and 2d countries are identical at all configurations along the main diagonal).

> Figures 2a-2d <

Figure 2a displays the numerical surface of $CGLI$ for different capital-to-unskilled labour endowment ratios. In the figure, $k_i$ and $l_i$ refer to country $i$’s shares of $K_i + K_j$ and $L_i + L_j$, respectively. Each country’s skilled labour endowment amounts to 50 percent of the world endowment. Figure 2b illustrates the corresponding relationship between skilled-to-unskilled labour endowment ratios and $CGLI$ at identical endowments with physical capital. In that figure, $s_i$ refers to country $i$’s shares of $S_i + S_j$ and $l_i$ has the same interpretation as in Figure 2a. In Figures 2c and 2d, we display the impact of trade costs for exports from country $i$ to $j$ ($t_{ij}$) and vice versa ($t_{ji}$) and fixed factor requirements for foreign subsidiary set-up in the two markets ($g_i$ and $g_j$), given symmetry in the remaining parameters. A general insight from these figures is that $CGLI$ tends to increase with greater symmetry in relative factor endowments (Figures 2a and 2b), trade costs (Figure 2c) and investment costs (Figure 2d).

One further remark is in order here. In our simulation experiments, we do not consider a change in the overall market size or the magnitude of world-wide factor endowments. In the empirical model, however, we have to account for overall size effects and therefore control for the maximum and the minimum value of a bilateral variable separately (see Hummels and Levinsohn, 1995, for a specification including maximum and minimum values of bilateral

---

15 In terms of our analytical model, $t_{ij}$ gives the volume of production in country $i$ that is necessary if one unit of the differentiated good is consumed in country $j \neq i$. Recall that $t_{ij} = t_{ji}$ has been assumed in Subsection 2.2.

16 In Figures 2a and 2b we see that the impact of symmetry in relative factor endowments becomes less clear if we allow for pronounced differences in relative factor endowments. These are the relative factor endowment regions, associated with vertical multinational activity. Hence, our numerical exercises indicate that the impact of relative factor endowments on $CGLI$ depends on the mode of multinational activity.
determinants of intra-industry trade). To obtain a proper empirical specification, we define $LCGLI_{ij}$ as the logistically transformed, corrected Grubel-Lloyd index\(^{17}\) and write:

\[
LCGLI_{ij} = \delta_0 + \delta_1 \max \{\ln GDP_i, \ln GDP_j\} + \delta_2 \min \{\ln GDP_i, \ln GDP_j\} + \delta_3 \max \{\ln (K_i / L_i), \ln (K_j / L_j)\} + \delta_4 \min \{\ln (K_i / L_i), \ln (K_j / L_j)\} + \delta_5 \max \{\ln (S_i / L_i), \ln (S_j / L_j)\} + \delta_6 \min \{\ln (S_i / L_i), \ln (S_j / L_j)\} + \delta_7 \max \{\ln (g_i), \ln (g_j)\} + \delta_8 \min \{\ln (g_i), \ln (g_j)\} + \delta_9 \max \{\ln (t_{ij}), \ln (t_{ji})\} + \delta_{10} \min \{\ln (t_{ij}), \ln (t_{ji})\} + \zeta_{ij}
\]

where $\zeta_{ij}$ is an error term. If overall size effects do not matter, we expect from the simulation exercises that a higher maximum of bilateral GDP, relative factor endowments, trade or investment costs exhibit a negative impact on $CGLI$, while a higher bilateral minimum of these variables should have a positive effect. However, if absolute size effects are of relevance, at least the difference in the coefficients between the minimum and maximum variables should be positive, as $CGLI$ tends to increase in the similarity of countries, according to Figures 1 and 2a-2d (at least, if horizontal multinational firms are prevalent).

3 Empirical analysis

3.1 The Grubel-Lloyd index, an empirical approach

Grubel and Lloyd (1971) had in mind a model without multinational firms. However, MNE activities are now understood as an essential channel of international exchange. With multinational firms, trade is unlikely balanced (even in a two-country setting). This makes a correction of the $GLI$ necessary. Since it is difficult to find reliable data on flows of repatriated profits for a large country sample, we apply the adjustment method formulated by equ. (2) in the empirical analysis. Using data at the bilateral level, this means that we correct the denominator of the Grubel-Lloyd index for bilateral trade imbalance.\(^{18}\) To provide insights into the role of multinational activity for the intra-industry trade share and the trade

\(^{17}\) Formally, we have $LCGLI_{ij} = \ln \left( \frac{CGLI_{ij}}{1 - CGLI_{ij}} \right)$.

\(^{18}\) Using data on bilateral OECD trade between 1990 and 2000, we can show that the downward bias of the uncorrected index due to trade imbalance is about 14 percentage points on average, which is more than 50% of the mean. For an extensive discussion on different biases that affect the Grubel-Lloyd index in empirical data and a quantification of these biases, we refer the interested reader to the working paper version of this paper (see the References for the URL).
imbalance bias, we use investment costs as an explanatory variable. Theoretical hypotheses for the impact of these costs have been derived in Subsections 2.2 and 2.3.

A further issue that arises in an empirical analysis of intra-industry trade is the role of trade costs. First, trade costs themselves may be a key determinant of the intra-industry trade share and the volume of multinational activity. Hence, they should be used as an explanatory variable in the empirical analysis (see our theoretical results in Subsection 2.3). To the best of our knowledge, however, the role of trade costs has not been rigorously accounted for in previous work on the Grubel-Lloyd index. Second, it makes a difference, whether c.i.f. or f.o.b. data are used for constructing the (corrected or uncorrected) GLI variable. To account for this fact, we introduce two alternative versions of the corrected index. The following table summarises different definitions.\(^{19}\)

<table>
<thead>
<tr>
<th>Table</th>
<th>Definition</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLI(_i)</td>
<td>(2 \cdot \sum_k \min(EX_{ijk}, IM_{ijk}) / (EX_{ij} + IM_{ij}))</td>
<td>Where (EX_{ij} = \sum_k EX_{ijk}) are aggregate f.o.b. exports of and (IM_{ij} = \sum_k IM_{ijk}) are the corresponding c.i.f. imports of country (i). Missing values at the disaggregated level are treated as 0.</td>
</tr>
<tr>
<td>CGLI(_i^a)</td>
<td>(\sum_k \min(EX_{ijk}, IM_{ijk}) / \min(EX_{ij}, IM_{ij}))</td>
<td>As GLI(_i), but corrected for bilateral trade imbalances.</td>
</tr>
<tr>
<td>CGLI(_i^b)</td>
<td>(\sum_k \min(EX_{ijk}, EX_{jik}) / \min(EX_{ij}, EX_{ji}))</td>
<td>As CGLI(_i^a), but based on trade flows at f.o.b.</td>
</tr>
</tbody>
</table>

In the case of a two-country, new trade theory model with zero trade costs and no MNE activity, \(GLI = CGLI^a = CGLI^b\).\(^{20}\) However, trade imbalance (e.g. due to multinational activity), leads to a downward bias of the uncorrected index. The two candidates of the bias-corrected index, \(CGLI^a\) and \(CGLI^b\), differ if trade costs are positive. If we use export data at f.o.b., the corrected GLI has the same value for either member of a country pair. Then, one should only rely on a single observation for each country-pair to avoid an upward bias in significance levels in empirical applications. While this leads to a reduced number of

\(^{19}\) The Grubel-Lloyd indices measure bilateral intra-industry trade in a multi-country world. Hence, \(EX_{ij}\) are country \(i\)'s exports to and \(IM_{ij}\) are country \(i\)'s imports from country \(j\). Index \(k\) indicates different industries.

\(^{20}\) To improve readability, we suppress country indices from now on.
observations (see below), such an approach is more closely related to our theoretical analysis. For the latter reason, $CGLI^b$ serves as our preferred measure of the intra-industry trade share. However, we also report regression results for $CGLI^a$ and compare the estimated coefficients for the two variants of bias-corrected indices with the respective coefficients for the uncorrected index.

### 3.2 Econometric analysis

We estimate model (20) for the three concepts of the Grubel-Lloyd index ($LGLI$, $LCGLI^a$ and $LCGLI^b$—with ‘$L$’ referring to a logistically transformed variable). Our data base comprises 422 observations of 1990-2000 bilateral average IIT share data of OECD countries for $LCGLI^b$ after excluding missing values, while there are about twice as many observations for $LGLI$ and $LCGLI^a$. (A detailed data description is provided in Appendix C.) Table 1 summarizes our findings.

| Table 1 |

Those variables not usually considered in empirical work but motivated by our theoretical analysis (with the parameters $\delta_5, \ldots, \delta_{10}$) account for 41%-49% of the regression models’ explanatory power. This emphasises the relevance of the MNE-related new trade theory literature for core empirical issues of international trade. Note further that the reported F-tests on the parameters indicate that using a simple measure of similarity or also the average of bilateral size, factor endowments, and trade and investment impediments is inferior to the chosen strategy of including each variable’s bilateral maximum and minimum value separately. The $R^2$ is higher for the uncorrected $GLI$-based model in Table 1 than for the two $CGLI$-based ones. However, the $R^2$s are not directly comparable for two reasons. First, we use logistically transformed values of the dependent variable and, in our application, the transformation leads to a bigger variance of the corrected Grubel-Lloyd indices as compared to their uncorrected counterpart. Second, the model for $LCGLI^b$ relies on a much smaller sample than the other two models.\(^{21}\)

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\(^{21}\) In addition, there might be other variables facilitating trade imbalances that do not enter our empirical model. For instance, cross-national transfers (e.g. in the form of foreign aid payments or remittances of migrants) could lead to both moderate explanatory power and biased parameter estimates. In a cross-sectional framework with country-pair data, these variables can be captured by fixed country effects (see the sensitivity analysis in the next subsection).
The results – especially those for the preferred $LCGLI^b$ measure – are well in line with the three-factor KK-model of multinational activity in Subsection 2.3. In particular, the evidence in Table 1 supports our theoretical finding that similarity as such tends to raise the share of intra-industry trade in total trade. As expected from the surfaces of the numerically solved model, the difference between the coefficients of the minimum and maximum values of determinants at the bilateral level is almost always positive: $\delta_2 - \delta_1 > 0, ..., \delta_{10} - \delta_9 > 0$. The only exception from this is the finding for the impact of minimum and maximum capital-to-unskilled labour ratios in specification $LCGLI^b$. Our numerical simulation results in Figures 2a and 2b indicate that the existence of vertical multinational enterprises may be responsible for that outcome (see Footnote 16).\textsuperscript{22}

It turns out that measurement biases in IIT share indices do not only affect the mean (as picked up by the constant), but there is some systematic bias, which is correlated with important explanatory variables. This becomes obvious, in particular, if we compare the coefficients of the $LGLI$ model with their counterparts in the preferred $LCGLI^b$ model. In line with the simulation results in Subsection 2.3, a higher maximum GDP exhibits a significantly negative impact on intra-industry trade in the $LCGLI^b$ regression, while the respective impact is positive and insignificant if the $LGLI$ concept is used. In addition, the negative effect of an increase in the maximum skilled-to-unskilled labour ratio is almost four times higher if $LCGLI^b$ is used instead of $LGLI$.

### 3.3 Sensitivity analysis

We check the sensitivity of our results with respect to the exclusion of extreme outliers and the inclusion of exporter and importer fixed effects. Thereby, we concentrate on the two bias-corrected concepts of the $GLI$. With respect to outliers, we follow Belsley, Kuh and Welsch (1980) and exclude all observations with absolute residuals exceeding two standard errors of the regression. Only 2% (1%) of observations have to be eliminated in the $LCGLI^b$ ($LCGLI^a$) model. Fixed country-specific effects are able to control for all country-specific unobserved variables – such as cross-national transfers or third-country influences on one of

\textsuperscript{22} It should be noted that the positive impact of both the minimum and the maximum capital-to-unskilled labour ratios for all three concepts of intra-industry does not support previous empirical findings by Bergstrand (1990), who reports a negative impact of the average capital-labour endowment ratio and an insignificant impact of a country pair’s inequality of the capital-labour endowment ratio.
the two trading partners in a multi-country setting – which may otherwise be picked up by the parameters of interest (see Baltagi, 2001). The parameters of the included variables can still be estimated, since there is enough variation in maximum and minimum values of the explanatory variables.

Excluding extreme outliers substantially increases the explanatory power of our empirical model (see the $R^2$ values in Table 1 and in the first two columns of Table 2). Inclusion of fixed exporter and importer effects leads to a further increase of the $R^2$'s and a convergence of the respective values for the $LCGLI^a$ and the $LCGLI^b$ model.$^{23}$ The share of $R^2$'s accounted for by variables 5-10 (which are usually not controlled for in the empirical literature on intra-industry trade) increases if we exclude outliers and include exporter and importer fixed effects.

Accounting for country-specific effects to guard against an omitted variable bias has also consequences for the qualitative results of the empirical analysis. In particular, the minimum GDP coefficients as well as the maximum GDP coefficient in the $LCGLI^a$ model become negative if fixed country effects are accounted for. Furthermore, the negative impact of the maximum skilled-to-unskilled labour ratio becomes insignificant in both models of corrected indices and the positive impact of the minimum skilled-to-unskilled labour ratio becomes significant in the $LCGLI^b$ model. Finally, the minimum trade cost variable turns out to be insignificant in the $LCGLI^a$ as well as the $LCGLI^b$ fixed effects model. Again, the majority of the estimated coefficients points to a positive impact of country similarity on bilateral IIT shares. However, the negative impact of GDP similarity in the fixed effects model for $LCGLI^b$ is not in line with our theoretical hypotheses based on Figure 1.

3.4 Extensions

In this subsection, we address two further issues that appeared in the theoretical analysis in Subsection 2.2. First, we study the impact of unskilled labour endowments on the bias-

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$^{23}$ If we exclude outliers and include fixed effects, the $R^2$ for the uncorrected $GLI$ model (not reported in Table 2) is, with a value of 0.87, slightly lower than the respective $R^2$'s in the last two columns of Table 2. See our discussion on that issue in the last subsection.
corrected IIT share and, second, we investigate the role of unskilled labour endowments and investment costs for the trade-imbalance bias in relative terms, $SHI$.

> Table 3 <

Our analytical results in Subsection 2.2 suggest that the impact of an increase in investment costs on the corrected $GLI$ is the more likely positive, the larger is $L_i$ compared to $L_j$. To assess this hypothesis empirically, we construct an interaction term between the difference of maximum and minimum log investment costs and the unskilled labour endowment variable (see Table 3). According to the theoretical insights presented in Subsections 2.2 and 2.3, we expect a negative (positive) sign of the maximum (minimum) investment cost effect ($\delta_7<0$, $\delta_8>0$) and a positive one for the interaction term ($\delta_{11}>0$). As the point estimates in Table 3 indicate, the empirical findings support our theoretical hypotheses, irrespective of which $CGLI$ concept is used.

> Table 4 <

With respect to the trade-imbalance bias in relative terms, we would expect that $SHI$ falls with the difference between maximum and minimum investment costs, in particular, if the country with the maximum investment costs is less well endowed with unskilled labour.$^{24}$ Table 4 provides insights in the empirical relevance of this hypothesis. There, we distinguish between the two variants of bias-correction when constructing the $SHI$ variable. To ensure that the calculated coefficients do not capture an impact that is due to the different treatment of trade costs in the bias-corrected and the uncorrected $GLI$, we distinguish two variants of the uncorrected $GLI$, namely $GLI^a$ (where exports are used at a f.o.b. basis and imports are used at a c.i.f. basis) and $GLI^b$ (where all trade flows are at a f.o.b. basis). The two variants of the trade-imbalance bias measure are given by $SHI^a = CGLI^a / GLI^a$ and $SHI^b = CGLI^b / GLI^b$, respectively.

Three results in Table 4 are particularly notable. First, the point estimates of the interaction term between investment costs and unskilled labour endowments have the signs expected from our theoretical analysis. Second, country-specific effects are important, indicating that
bilateral trade-imbalances have a country-specific component and are not the same for all country pairs. Third, we have to concede that investment costs explain a relatively small though significant share of the deviation between the two indices as indicated by the $R^2$ figures. The other explanatory variables in previous tables only contribute insignificantly. Hence, other macro-economic variables, not accounted for in the theoretical model and empirical specifications are probably relevant, too. However, to study their impact is beyond the scope of this analysis.

4 Conclusions

In a review of the empirical analysis of international trade flows spanning the last 50 years, Leamer (1994, p. 68) identifies “the extensive amount of intra-industry trade catalogued by Grubel and Lloyd (1975)…..” as “….. one of the only two major empirical findings (which) seem to have had a major impact on the way (trade) economists think”. That conclusion articulates a widely accepted view that the apparent pervasiveness of intra-industry trade stimulated a revolution in the theoretical and empirical modelling of international trade.

From the standpoint of empirical investigation, it is obviously vital that the intra-industry trade share is measured as accurately as possible. Thirty years after the publication of Grubel and Lloyd (1975), their famous index remains the measure of choice for most investigators. Yet we know it is grounded in the assumption of arms-length trade. However, multinational activity is a feature of the landscape which should not be ignored. In this paper we have brought their presence to centre-stage. We have constructed a three factor general equilibrium model of trade with multinationals, to identify precisely the impact of investment costs and multinational activity on intra-industry trade. The model and measures of intra-industry trade derived from it have been subjected to extensive simulation analysis and rigorous econometric assessment (for trade flows of 31 OECD countries).

Our analysis demonstrates clearly the role of investment costs and biases inherent in the Grubel-Lloyd index when we fail to account for the presence of multinationals. It also shows that it is important to consider various new determinants of IIT alongside more traditional explanatory variables. We hope that the theoretical underpinning provided for our new measures and their robust empirical performance will commend their wider use.

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24 Proposition 2 shows that the $SHI$-effect of a $g_i$ increase is negative if $L_j > L_i$. 

21
References


Baier, Scott L., Gerald P. Dwyer and Robert Tamura (2002), How Important Are Capital and Total Factor Productivity for Economic Growth?, unpublished manuscript.


Appendix

A. Analytical appendix

Recall that we focus on a parameter domain, which gives rise to diversification in the production structure.

Proof of Proposition 1

Substituting \( \frac{h_i}{n_i} = \frac{(K - S) / (g_i S - K)}{g_j} \), according to (13), into (17), it is straightforward to derive \( \partial \xi \left( g_i, g_j, L_i, L_j \right) / \partial g_i > 0 \). Noting further that \( CGLI = \xi(\cdot) \) if \( L_j < L_i \) and \( g_i = g_j \), the CGLI-effect in Proposition 1 follows immediately. In addition, (19) implies that

\[
SHI = 1 + \frac{h_j / n_j}{2 \varepsilon} \left( 1 - \frac{h_i / n_i}{h_j / n_j} \xi(\cdot) \right),
\]

if \( L_j < L_i \) and \( g_i = g_j \). Substituting

\[
\frac{h_i / n_i}{h_j / n_j} \xi(\cdot) = \frac{(\alpha / \varepsilon) \left( 1 + \tau n_j / h_j \right) L_i + \left[ (1 - \alpha / \varepsilon) \left( 1 + n_j / h_j \right) + (1 + \tau n_j / h_j) \right] L_j}{(\alpha / \varepsilon) \left( 1 + \tau n_i / h_i \right) L_j + \left[ (1 - \alpha / \varepsilon) \left( 1 + n_i / h_i \right) + (1 + \tau n_i / h_i) \right] L_i}
\]

into (A1) and differentiating the respective expression with respect to \( g_i \), it follows from (13) and (14) that \( \partial SHI / \partial g_i > 0 \) if evaluated at \( g_i = g_j \) and \( L_j < L_i \). This completes the proof of Proposition 1. QED.

Proof of Proposition 2:

Using \( \partial \xi \left( g_i, g_j, L_i, L_j \right) / \partial g_i > 0 \) and noting that \( CGLI = 1 / \xi(\cdot) \) if \( L_j > L_i \) and \( g_i = g_j \), the CGLI-effect in Proposition 2 follows immediately. Furthermore, (19) implies

\[
SHI = 1 + \frac{h_j / n_j}{2 \varepsilon} \left( \frac{h_i / n_i}{h_j / n_j} - \frac{1}{\xi(\cdot)} \right)
\]

if \( L_j > L_i \) and \( g_i = g_j \).

Let us define \( \Omega \left( g_i, g_j, L_i, L_j \right) = \frac{h_i / n_i}{h_j / n_j} - \frac{1}{\xi \left( g_i, g_j, L_i, L_j \right)} \). Then, substituting (13), (14) and (17) into \( \Omega(\cdot) \) and differentiating the resulting expression with respect to \( g_i \), we obtain

A1
\[
\frac{\partial \Omega(\cdot)}{\partial g_i} = 1 - \frac{(\alpha / \varepsilon)(h_j / n_j)L_j + \left(2 - \alpha / \varepsilon\right)h_j / n_j L_i}{(\alpha / \varepsilon)(h_j / n_j + \tau)L_i + \left(1 - \alpha / \varepsilon\right)(h_j / n_j + 1) + \left(h_j / n_j + \tau\right)L_j}
\]

(A4)

with \(\partial (h_j / n_j) / \partial g_i < 0\). Hence, we can conclude from (A4) that \(\partial \Omega(\cdot) / \partial g_i >,=,< 0\) if

\[
\left[2\left(1 - \alpha / \varepsilon\right)h_j / n_j - (\alpha / \varepsilon)\tau\right]L_i,=,<\left[\left(1 - \alpha / \varepsilon\right)\left(2h_j / n_j + 1\right) + \tau\right]L_j.
\]

(A5)

Thus, \(L_j \geq L_i\) is sufficient for \(\partial \Omega(\cdot) / \partial g_i < 0\). And, as a consequence, \(\partial SHI / \partial g_i < 0\) if evaluated at \(g_i = g_j\) and \(L_j > L_i\). This completes the proof of Proposition 2. \(\text{QED.}\)

B. Simulation appendix

We set up a numerically solvable model, where horizontal and vertical MNEs may endogenously arise. We use a CES production technology in the \(X\)-sector. The corresponding input coefficients are denoted by \(a_{LXi}, a_{HXi},\) and \(a_{KXi}\) (and derived as a function of factor prices below). The encompassing framework consists of the following set of equations (only outlined for country \(i\)):

**Pricing conditions**

\[
\begin{align*}
\alpha &\geq W_{Li} + \alpha_{SLi}S_{Li} + \alpha_{KL}K_{Li} \geq P_{ii} \left(1 - 1 / \varepsilon\right) \\
\perp &\quad x_{ii} \geq 0 \\
\left(a_{LXi}w_{Li} + a_{SLi}w_{Si} + a_{KXi}w_{Ki}\right) l_{ij} &\geq P_{ij} \left(1 - 1 / \varepsilon\right) \\
\perp &\quad x_{ij} \geq 0 \\
w_{Li} &\geq 1 \\
\perp &\quad Y_{ii} \geq 0 \\
w_{Li} &\geq P_{Yj} \\
\perp &\quad Y_{ij} \geq 0
\end{align*}
\]

where \(P_{Yj}\) denotes the price of good \(Y\) in country \(j\) and \(\perp\) indicates that one of the adjacent conditions holds with equality (see Markusen, 2002, for an excellent discussion of complementary slackness in general equilibrium models with MNEs).
Goods market clearing conditions

Let us first define the modified price aggregator as \( P_i = p_{ii}^{1-\varepsilon} \left( h_i + h_j + n_i + v_j \right) + \left( n_j + v_i \right) p_{ji}^{1-\varepsilon} \).

Then, the goods market clearing conditions in the \( X \)-sector imply
\[
x_{ij} \geq \alpha p_{ij}^{-\varepsilon} P_i^{-1} E_i
\]
\[
\perp p_{ii} \geq 0
\]
\[
x_{ij} / t_{ij} \geq \alpha p_{ij}^{-\varepsilon} P_j^{-1} E_j
\]
\[
\perp p_{jj} \geq 0
\]

Note that the goods market clearing condition for local homogeneous goods demand in country \( i \) (\( Y_{ii} \)) is redundant due to the choice of numéraire. However, that one of country \( j \) implies\(^25\)
\[
P_{ij} \left( Y_{ij} + Y_{ij} \right) \geq (1 - \alpha) E_j
\]
\[
\perp P_{jj} \geq 0
\]

Factor market clearing conditions\(^26\)
\[
L_i \geq a_{LXi} \left( h_i + h_j + n_i + v_j \right) x_{ii} + a_{LXi} \left( n_i + v_j \right) x_{ij} + Y_{ii} + Y_{ij}
\]
\[
\perp w_{Li} \geq 0
\]
\[
S_i \geq a_{SXi} \left( h_i + h_j + n_i + v_j \right) x_{ii} + a_{SXi} \left( n_i + v_j \right) x_{ij} + n_i + h_j + v_i
\]
\[
\perp w_{Si} \geq 0
\]
\[
K_i \geq a_{KXi} \left( h_i + h_j + n_i + v_j \right) x_{ii} + a_{KXi} \left( n_i + v_j \right) x_{ij} + n_i + g_i h_i + (g_i - 1) v_i
\]
\[
\perp w_{Ki} \geq 0
\]

Conditions on firm entry (i.e., non-negative profit conditions)
\[
w_{Si} + w_{Ki} \geq \left( p_{ii} x_{ii} + p_{jj} x_{jj} / t_{ij} \right) / \varepsilon
\]
\[
\perp n_i \geq 0
\]
\[
w_{Si} + g_i w_{Ki} \geq \left( p_{ii} x_{ii} + p_{jj} x_{jj} \right) / \varepsilon
\]
\[
\perp h_i \geq 0
\]
\[
w_{Si} + (g_i - 1) w_{Ki} \geq \left( p_{jj} x_{jj} / t_{jj} \right) / \varepsilon
\]
\[
\perp v_i \geq 0
\]

\(^{25}\) Being interested in intra-industry trade, we consider a parameter domain, which guarantees diversification in the production pattern of both economies. Hence, \( P_{ij} = 1 \) holds in equilibrium.
**Numerical simulation of the model**

We assume the following values for world factor endowments: \( K_i + K_j = 300; \)
\( S_i + S_j = 200; \) \( L_i + L_j = 100 \). For the demand parameters, we assume: \( \varepsilon = 6 \) and \( \alpha = 0.8 \).

The choice of the elasticity of substitution parameter between varieties is well in line with the findings in Feenstra (1994).

Regarding production, we assume a constant elasticity of scale technology, with the following (cost-minimizing) input coefficients:

\[
\begin{align*}
    a_{LXi} &= w_i^{\frac{1}{1}} b^{\frac{1}{\rho-1}} \left[ a^{\frac{1}{\rho-1}} w_{Ki}^{\frac{1}{\rho-1}} + b^{\frac{1}{\rho-1}} w_{Li}^{\frac{1}{\rho-1}} + (1-a-b)^{\frac{1}{\rho-1}} w_{Si}^{\frac{1}{\rho-1}} \right]^{\frac{1}{\rho}} \\
    a_{SXi} &= w_{Si}^{\frac{1}{1}} (1-a-b)^{\frac{1}{\rho-1}} \left[ a^{\frac{1}{\rho-1}} w_{Ki}^{\frac{1}{\rho-1}} + b^{\frac{1}{\rho-1}} w_{Li}^{\frac{1}{\rho-1}} + (1-a-b)^{\frac{1}{\rho-1}} w_{Si}^{\frac{1}{\rho-1}} \right]^{\frac{1}{\rho}} \\
    a_{KXi} &= w_{Ki}^{\frac{1}{1}} a^{\frac{1}{\rho-1}} \left[ a^{\frac{1}{\rho-1}} w_{Ki}^{\frac{1}{\rho-1}} + b^{\frac{1}{\rho-1}} w_{Li}^{\frac{1}{\rho-1}} + (1-a-b)^{\frac{1}{\rho-1}} w_{Si}^{\frac{1}{\rho-1}} \right]^{\frac{1}{\rho}}
\end{align*}
\]

The technology parameters take the following values: \( \rho = -10; \) \( a = 0.3; \) \( b = 0.5 \). Our choice of the parameter related to the technical rate of substitution points to a complementary relationship between factors of production, which is in line with recent evidence (see Sharma, 2002). Furthermore, in the baseline scenario we assume that \( g_i = g_j = 1.2 \) and that \( t_{ij} = t_{ji} = 1.15 \). The assumption that iceberg trade costs vary around 15% is well in line with the stylized facts (see Baier and Bergstrand, 2001).

**C. Data appendix**

**Data sources and definition**

We use bilateral export and import flow data at the Standard International Trade Classification 5-digit level as published by the OECD (International Trade by Commodity Statistics, 1990-2000). Bilateral trade costs are based on trade-weighted averages of c.i.f./f.o.b. figures from this source. Table A.1 provides summary statistics for the dependent variable.

---

Note that a vertical multinational firm operates a single production plant abroad and, therefore, has to invest the amount of \( g_i - 1 \) units of physical capital before it can start to produce.
Real GDP figures are from the World Bank’s World Development Indicators and measured in constant US dollars of 1995. Capital stock data had to be computed by the perpetual inventory method as discussed in Leamer (1984, pp.232-234). Since no data on depreciation rates are available for our countries, the same value as in Leamer (i.e., 13.3%) is assumed. Capital stock computations are based on gross fixed capital formation data and the corresponding investment cost deflators published in the World Development Indicators. Data on human capital measure the average years of schooling of participants in the active labour force (see Baier, Dwyer and Tamura, 2002, for more details). Data on both physical capital and skilled labour endowments were kindly provided by Scott Baier. Investment cost data are based on score variables published in the World Economic Forum’s Global Competitiveness Report. Amiti and Wakelin (2003) provide a detailed description. The data were kindly provided by Keith Maskus. Table A.2 provides the correlation matrix and summary statistics for the explanatory variables.

Country sample
The regression results are based on bilateral trade flows between the following 31 countries: Australia, Austria, Belgium, Canada, China, Czech Republic, Denmark, Finland, France, Germany, Greece, Hong Kong, Hungary, Iceland, Ireland, Italy, Japan, Republic of Korea, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom, USA.
Figure 1 – Relative country size as a determinant of CGLI
Figure 2 – Relative factor endowments, trade costs, and investment costs as determinants of CGLI
<table>
<thead>
<tr>
<th></th>
<th>LGLI</th>
<th>LCGLI⁷</th>
<th>LCGLI⁸</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum GDP: max{ln(GDPᵢ),ln(GDPⱼ)}</td>
<td>δ₁</td>
<td>0.066 *</td>
<td>0.035</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.89</td>
<td>1.00</td>
</tr>
<tr>
<td>Minimum GDP: min{ln(GDPᵢ),ln(GDPⱼ)}</td>
<td>δ₂</td>
<td>0.498 ***</td>
<td>0.470 ***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13.18</td>
<td>12.35</td>
</tr>
<tr>
<td>Maximum Capital-to-Unskilled Labour Ratio: max{ln(Kᵢ/Lᵢ),ln(Kⱼ/Lⱼ)}</td>
<td>δ₃</td>
<td>0.255 ***</td>
<td>0.304 ***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.64</td>
<td>3.12</td>
</tr>
<tr>
<td>Minimum Capital-to-Unskilled Labour Ratio: min{ln(Kᵢ/Lᵢ),ln(Kⱼ/Lⱼ)}</td>
<td>δ₄</td>
<td>0.283 ***</td>
<td>0.346 ***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.35</td>
<td>5.23</td>
</tr>
<tr>
<td>Maximum Skilled-to-Unskilled Labour Ratio: max{ln(Sᵢ/Lᵢ),ln(Sⱼ/Lⱼ)}</td>
<td>δ₅</td>
<td>-1.047 *</td>
<td>-2.070 ***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.72</td>
<td>3.34</td>
</tr>
<tr>
<td>Minimum Skilled-to-Unskilled Labour Ratio: min{ln(Sᵢ/Lᵢ),ln(Sⱼ/Lⱼ)}</td>
<td>δ₆</td>
<td>0.112</td>
<td>-0.278</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.24</td>
<td>0.59</td>
</tr>
<tr>
<td>Maximum Investment Costs: max{ln(gᵢ),ln(gⱼ)}</td>
<td>δ₇</td>
<td>-1.039 ***</td>
<td>-0.878 ***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.74</td>
<td>4.79</td>
</tr>
<tr>
<td>Minimum Investment Costs: min{ln(gᵢ),ln(gⱼ)}</td>
<td>δ₈</td>
<td>0.043</td>
<td>0.166</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.24</td>
<td>0.90</td>
</tr>
<tr>
<td>Maximum Trade Costs: max{ln(tᵢ),ln(tⱼ)}</td>
<td>δ₉</td>
<td>-0.735 ***</td>
<td>-0.544 ***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11.11</td>
<td>8.15</td>
</tr>
<tr>
<td>Minimum Trade Costs: min{ln(tᵢ),ln(tⱼ)}</td>
<td>δ₁₀</td>
<td>0.187 **</td>
<td>0.142 *</td>
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<tr>
<td></td>
<td></td>
<td>2.47</td>
<td>1.87</td>
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<tr>
<td>Constant</td>
<td>δ₀</td>
<td>-20.650 ***</td>
<td>-17.838 ***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10.64</td>
<td>9.10</td>
</tr>
<tr>
<td>Observations</td>
<td></td>
<td>866</td>
<td>866</td>
</tr>
<tr>
<td>R²</td>
<td></td>
<td>0.52</td>
<td>0.43</td>
</tr>
<tr>
<td>Share of R², accounted for by variables 5-10 in %</td>
<td></td>
<td>48.96</td>
<td>41.39</td>
</tr>
<tr>
<td>F-tests (p-values):</td>
<td></td>
<td>0.000 ***</td>
<td>0.000 ***</td>
</tr>
<tr>
<td>δ₁=δ₂</td>
<td></td>
<td>0.000 ***</td>
<td>0.000 ***</td>
</tr>
<tr>
<td>δ₃=δ₄</td>
<td></td>
<td>0.000 ***</td>
<td>0.000 ***</td>
</tr>
<tr>
<td>δ₅=δ₆</td>
<td></td>
<td>0.153</td>
<td>0.000 ***</td>
</tr>
<tr>
<td>δ₇=δ₈</td>
<td></td>
<td>0.000 ***</td>
<td>0.000 ***</td>
</tr>
<tr>
<td>δ₉=δ₁₀</td>
<td></td>
<td>0.000 ***</td>
<td>0.000 ***</td>
</tr>
</tbody>
</table>

The left-hand-side variables are logistically transformed and based on 5-digit SITC figures. Absolute t-statistics below coefficients. *** significant at 1%; ** significant at 5%; * significant at 10%.
### Table 2 - Sensitivity Analysis of Trade-Imbalance Corrected Models

<table>
<thead>
<tr>
<th></th>
<th>Between Models</th>
<th>Fixed Exporter and Importer Effects Models</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LCGL*</td>
<td>LCGL*</td>
</tr>
<tr>
<td>Maximum GDP: (\max{\ln(GDP_i),\ln(GDP_j)})</td>
<td>(\delta_1)</td>
<td>-0.106 ***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-0.254 *</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-2.181 ***</td>
</tr>
<tr>
<td>Minimum GDP: (\min{\ln(GDP_i),\ln(GDP_j)})</td>
<td>(\delta_2)</td>
<td>0.064 ***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.75</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.68</td>
</tr>
<tr>
<td>Maximum Capital-to-Unskilled Labour Ratio: (\max{\ln(K_i/L_i),\ln(K_j/L_j)})</td>
<td>(\delta_3)</td>
<td>0.441 ***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.204 *</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.254 *</td>
</tr>
<tr>
<td>Minimum Capital-to-Unskilled Labour Ratio: (\min{\ln(K_i/L_i),\ln(K_j/L_j)})</td>
<td>(\delta_4)</td>
<td>23.91</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.81</td>
</tr>
<tr>
<td>Maximum Skilled-to-Unskilled Labour Ratio: (\max{\ln(S_i/L_i),\ln(S_j/L_j)})</td>
<td>(\delta_5)</td>
<td>4.57</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8.08</td>
</tr>
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<td></td>
<td></td>
<td>3.70</td>
</tr>
<tr>
<td>Minimum Skilled-to-Unskilled Labour Ratio: (\min{\ln(S_i/L_i),\ln(S_j/L_j)})</td>
<td>(\delta_6)</td>
<td>0.357 ***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.796 ***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.698 **</td>
</tr>
<tr>
<td>Maximum Investment Costs: (\max{\ln(g_i),\ln(g_j)})</td>
<td>(\delta_7)</td>
<td>-0.809 ***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-0.482 ***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-1.080 ***</td>
</tr>
<tr>
<td>Minimum Investment Costs: (\min{\ln(g_i),\ln(g_j)})</td>
<td>(\delta_8)</td>
<td>9.22</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.62</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.152 *</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.585 ***</td>
</tr>
<tr>
<td>Maximum Trade Costs: (\max{\ln(t_{ij}),\ln(t_{ji})})</td>
<td>(\delta_9)</td>
<td>-0.559</td>
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<tr>
<td></td>
<td></td>
<td>-0.996</td>
</tr>
<tr>
<td>Minimum Trade Costs: (\min{\ln(t_{ij}),\ln(t_{ji})})</td>
<td>(\delta_{10})</td>
<td>4.38</td>
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<tr>
<td></td>
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<td>3.759 ***</td>
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<td>3.29</td>
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<td>Observations</td>
<td>859</td>
<td>413</td>
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<tr>
<td>R²</td>
<td>0.82</td>
<td>0.74</td>
</tr>
<tr>
<td>Share of R², accounted for by variables 5-10 in %</td>
<td>46.10</td>
<td>51.45</td>
</tr>
<tr>
<td>F-tests (p-values):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\delta_1-\delta_2)</td>
<td>0.000 ***</td>
<td>0.000 ***</td>
</tr>
<tr>
<td>(\delta_2-\delta_3)</td>
<td>0.000 ***</td>
<td>0.000 ***</td>
</tr>
<tr>
<td>(\delta_3-\delta_4)</td>
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<td>0.000 ***</td>
</tr>
<tr>
<td>(\delta_4-\delta_5)</td>
<td>0.000 ***</td>
<td>0.000 ***</td>
</tr>
<tr>
<td>(\delta_5-\delta_6)</td>
<td>0.000 ***</td>
<td>0.000 ***</td>
</tr>
<tr>
<td>Fixed exporter effects</td>
<td>No</td>
<td>0.000 ***</td>
</tr>
<tr>
<td>Fixed importer effects</td>
<td>No</td>
<td>0.000 ***</td>
</tr>
</tbody>
</table>

The left-hand-side variables are logistically transformed and based on 5-digit SITC figures. All estimated models exclude extreme outliers. Absolute t-statistics below coefficients. *** significant at 1%; ** significant at 5%; * significant at 10%.
Table 3 - The Role of Labour for the Impact of Investment Costs

<table>
<thead>
<tr>
<th></th>
<th>LCGLIa</th>
<th>LCGLIb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum GDP: $\max{\ln(GDP_i),\ln(GDP_j)}$</td>
<td>$\delta_1$</td>
<td>$-0.249^{***}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10.76</td>
</tr>
<tr>
<td>Minimum GDP: $\min{\ln(GDP_i),\ln(GDP_j)}$</td>
<td>$\delta_2$</td>
<td>$-0.185^{***}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10.57</td>
</tr>
<tr>
<td>Maximum Capital-to-Unskilled Labour Ratio: $\max{\ln(K_i/L_i),\ln(K_j/L_j)}$</td>
<td>$\delta_3$</td>
<td>$2.024^{***}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.27</td>
</tr>
<tr>
<td>Minimum Capital-to-Unskilled Labour Ratio: $\min{\ln(K_i/L_i),\ln(K_j/L_j)}$</td>
<td>$\delta_4$</td>
<td>$2.047^{***}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.31</td>
</tr>
<tr>
<td>Maximum Skilled-to-Unskilled Labour Ratio: $\max{\ln(S_i/L_i),\ln(S_j/L_j)}$</td>
<td>$\delta_5$</td>
<td>$-0.575$</td>
</tr>
<tr>
<td></td>
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<td>1.04</td>
</tr>
<tr>
<td>Minimum Skilled-to-Unskilled Labour: $\min{\ln(S_i/L_i),\ln(S_j/L_j)}$</td>
<td>$\delta_6$</td>
<td>$0.556$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.91</td>
</tr>
<tr>
<td>Maximum Investment Costs: $\max{\ln(g_i),\ln(g_j)}$</td>
<td>$\delta_7$</td>
<td>$-0.682^{***}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.80</td>
</tr>
<tr>
<td>Minimum Investment Costs: $\min{\ln(g_i),\ln(g_j)}$</td>
<td>$\delta_8$</td>
<td>$0.930^{***}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6.11</td>
</tr>
<tr>
<td>Maximum Trade Costs: $\max{\ln(t_{ij}),\ln(t_{ji})}$</td>
<td>$\delta_9$</td>
<td>$-0.22^{***}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7.36</td>
</tr>
<tr>
<td>Minimum Trade Costs: $\min{\ln(t_{ij}),\ln(t_{ji})}$</td>
<td>$\delta_{10}$</td>
<td>$0.025$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.83</td>
</tr>
<tr>
<td>Interaction: $\Delta{\ln(g_i),\ln(g_j)} - \ln(L_i)$ if $g_i &gt; g_j$, else $\Delta{\ln(g_i),\ln(g_j)} - \ln(L_j)$</td>
<td>$\delta_{11}$</td>
<td>$0.033^{***}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.24</td>
</tr>
<tr>
<td>Interaction: $\Delta{\ln(g_i),\ln(g_j)} - \ln(K_i)$ if $g_i &gt; g_j$, else $\Delta{\ln(g_i),\ln(g_j)} - \ln(K_j)$</td>
<td>$\delta_{12}$</td>
<td>$-$</td>
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<td></td>
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<td>$-$</td>
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<tr>
<td>Constant</td>
<td>$\delta_0$</td>
<td>$-38.86^{**}$</td>
</tr>
<tr>
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<td>2.55</td>
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</tr>
<tr>
<td>$R^2$</td>
<td>0.90</td>
<td>0.89</td>
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</tbody>
</table>

The left-hand-side variables are logistically transformed and based on 5-digit SITC figures. The estimated models exclude extreme outliers and include country effects. $\Delta\{\ln(g_i),\ln(g_j)\}$ is defined as $\max\{\ln(g_i),\ln(g_j)\} - \min\{\ln(g_i),\ln(g_j)\}$. Absolute t-statistics below coefficients. *** significant at 1%; ** significant at 5%; * significant at 10%.
Table 4 - Explaining the Trade-Imbalance in Relative Terms (SHI)

<table>
<thead>
<tr>
<th></th>
<th>SHI\textsuperscript{a}</th>
<th>SHI\textsuperscript{b}</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta{\ln(g_i),\ln(g_j)}$</td>
<td>-2.191</td>
<td>-89.663 **</td>
</tr>
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<td></td>
<td>1.52</td>
<td>2.12</td>
</tr>
<tr>
<td>Interaction: $\Delta{\ln(g_i),\ln(g_j)}\cdot\ln(L_i)$ if $g_i &gt; g_j$, else $\Delta{\ln(g_i),\ln(g_j)}\cdot\ln(L_j)$</td>
<td>1.551 *</td>
<td>7.719 **</td>
</tr>
<tr>
<td></td>
<td>1.80</td>
<td>2.06</td>
</tr>
<tr>
<td>Constant</td>
<td>-2.452</td>
<td>-9.184</td>
</tr>
<tr>
<td></td>
<td>0.20</td>
<td>0.18</td>
</tr>
<tr>
<td>Observations</td>
<td>857</td>
<td>413</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.11</td>
<td>0.03</td>
</tr>
<tr>
<td>F-tests (p-values):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Joint significance of all other explanatory variables (see Footnote)</td>
<td>0.199</td>
<td>0.433</td>
</tr>
<tr>
<td>Fixed exporter effects</td>
<td>0.000 ***</td>
<td>0.000 ***</td>
</tr>
<tr>
<td>Fixed importer effects</td>
<td>0.011 **</td>
<td>0.000 ***</td>
</tr>
</tbody>
</table>

$\Delta\{\ln(g_i),\ln(g_j)\}$ is defined as $\max\{\ln(g_i),\ln(g_j)\} - \min\{\ln(g_i),\ln(g_j)\}$. Coefficients of $\max\{\ln(GDP_i), \ln(GDP_j)\}$, $\min\{\ln(GDP_i), \ln(GDP_j)\}$, $\max\{\ln(K_i/L_i), \ln(K_j/L_j)\}$, $\min\{\ln(K_i/L_i), \ln(K_j/L_j)\}$, $\max\{\ln(S_i/L_i), \ln(S_j/L_j)\}$, $\min\{\ln(S_i/L_i), \ln(S_j/L_j)\}$, $\max\{\ln(t_i), \ln(t_j)\}$ $\min\{\ln(t_i), \ln(t_j)\}$ not reported due to their insignificance (see the F-statistics).

Absolute t-statistics below coefficients. *** significant at 1%; ** significant at 5%; * significant at 10%.
<table>
<thead>
<tr>
<th>5-digit SITC data</th>
<th>Observations</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Time Invar. (^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLI (usual definition)</td>
<td>8429</td>
<td>0.14</td>
<td>0.13</td>
<td>0.00</td>
<td>0.64</td>
<td>0.92</td>
</tr>
<tr>
<td>CGLI(^a) (GLI balance-adjusted)</td>
<td>8429</td>
<td>0.23</td>
<td>0.23</td>
<td>0.00</td>
<td>1.00</td>
<td>0.91</td>
</tr>
<tr>
<td>CGLI(^b) (GLI export-based, balance adjusted)</td>
<td>7259</td>
<td>0.24</td>
<td>0.27</td>
<td>0.00</td>
<td>1.00</td>
<td>0.94</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4-digit SITC data</th>
<th>Observations</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Time Invar. (^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLI (usual definition)</td>
<td>8495</td>
<td>0.17</td>
<td>0.15</td>
<td>0.00</td>
<td>0.71</td>
<td>0.91</td>
</tr>
<tr>
<td>CGLI(^a) (GLI balance-adjusted)</td>
<td>8495</td>
<td>0.27</td>
<td>0.24</td>
<td>0.00</td>
<td>1.00</td>
<td>0.90</td>
</tr>
<tr>
<td>CGLI(^b) (GLI export-based, balance adjusted)</td>
<td>6878</td>
<td>0.13</td>
<td>0.19</td>
<td>0.00</td>
<td>1.00</td>
<td>0.92</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3-digit SITC data</th>
<th>Observations</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Time Invar. (^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLI (usual definition)</td>
<td>8491</td>
<td>0.21</td>
<td>0.17</td>
<td>0.00</td>
<td>0.78</td>
<td>0.91</td>
</tr>
<tr>
<td>CGLI(^a) (GLI balance-adjusted)</td>
<td>8491</td>
<td>0.33</td>
<td>0.25</td>
<td>0.00</td>
<td>1.00</td>
<td>0.88</td>
</tr>
<tr>
<td>CGLI(^b) (GLI export-based, balance adjusted)</td>
<td>7472</td>
<td>0.21</td>
<td>0.18</td>
<td>0.00</td>
<td>1.00</td>
<td>0.89</td>
</tr>
</tbody>
</table>

\(^a\) This is the share of time-invariant information in the data.
Table A.2 - Correlation Matrix and Descriptive Statistics of Explanatory Variables (Variables in Logs)

<table>
<thead>
<tr>
<th></th>
<th>Max GDP</th>
<th>Min GDP</th>
<th>Max K/L</th>
<th>Min K/L</th>
<th>Max S/L</th>
<th>Min S/L</th>
<th>Max INVC</th>
<th>Min INVC</th>
<th>Max TC</th>
<th>Min TC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum GDP: max(ln(GDP\text{A}),ln(GDP\text{B}))</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum GDP: min(ln(GDP\text{A}),ln(GDP\text{B}))</td>
<td>0.45</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Capital-to-Unskilled Labour Ratio: max(ln(K\text{A}/L\text{A}),ln(K\text{B}/L\text{B}))</td>
<td>0.28</td>
<td>0.16</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum Capital-to-Unskilled Labour Ratio: min(ln(K\text{A}/L\text{A}),ln(K\text{B}/L\text{B}))</td>
<td>0.13</td>
<td>0.11</td>
<td>0.45</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Skilled-to-Unskilled Labour Ratio: max(ln(S\text{A}/L\text{A}),ln(S\text{B}/L\text{B}))</td>
<td>0.41</td>
<td>0.27</td>
<td>0.44</td>
<td>0.36</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum Skilled-to-Unskilled Labour Ratio: min(ln(S\text{A}/L\text{A}),ln(S\text{B}/L\text{B}))</td>
<td>0.17</td>
<td>-0.05</td>
<td>0.37</td>
<td>0.70</td>
<td>0.50</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Investment Costs: max(ln(g\text{A}),ln(g\text{B}))</td>
<td>0.05</td>
<td>0.20</td>
<td>-0.23</td>
<td>-0.02</td>
<td>-0.26</td>
<td>-0.20</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum Investment Costs: min(ln(g\text{A}),ln(g\text{B}))</td>
<td>-0.02</td>
<td>-0.06</td>
<td>-0.39</td>
<td>-0.29</td>
<td>-0.37</td>
<td>-0.23</td>
<td>0.56</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Trade Costs: max(ln(t\text{ij}),ln(t\text{ji}))</td>
<td>-0.09</td>
<td>-0.15</td>
<td>-0.12</td>
<td>-0.24</td>
<td>-0.15</td>
<td>-0.26</td>
<td>-0.12</td>
<td>-0.01</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Minimum Trade Costs: min(ln(t\text{ij}),ln(t\text{ji}))</td>
<td>-0.14</td>
<td>-0.17</td>
<td>-0.12</td>
<td>-0.17</td>
<td>-0.13</td>
<td>-0.17</td>
<td>-0.07</td>
<td>-0.01</td>
<td>0.71</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Descriptive Statistics

<table>
<thead>
<tr>
<th></th>
<th>Max GDP</th>
<th>Min GDP</th>
<th>Max K/L</th>
<th>Min K/L</th>
<th>Max S/L</th>
<th>Min S/L</th>
<th>Max INVC</th>
<th>Min INVC</th>
<th>Max TC</th>
<th>Min TC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>27.04</td>
<td>25.46</td>
<td>11.13</td>
<td>10.23</td>
<td>1.90</td>
<td>1.77</td>
<td>3.58</td>
<td>3.34</td>
<td>-1.46</td>
<td>-2.09</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>1.28</td>
<td>1.21</td>
<td>0.57</td>
<td>1.04</td>
<td>0.08</td>
<td>0.14</td>
<td>0.29</td>
<td>0.30</td>
<td>1.21</td>
<td>1.29</td>
</tr>
</tbody>
</table>