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DETERMINANTS OF TRADE AND SPECIALIZATION: A QUANTITATIVE ANALYSIS

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DETERMINANTS OF TRADE AND SPECIALIZATION:

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ABSTRACT

This dissertation studies the effects of technology, factor endowments, tastes, and transport costs on international trade and specialization. The analysis is performed using two methods: estimation and simulation, both using data from OECD countries. First, the effects of technology and factor endowments on specialization, measured by industry shares in GDP, are jointly estimated. The methodology allows for variable capital utilization and sector-specific capital. Capital utilization is calculated from the electricity consumption, and the efficiency of electricity consumption is calculated for each industry and country. The results show that ignoring variable capital utilization leads to approximately 30-40% overestimation of the effects of technology on specialization. It is also found that once variable capital utilization is accounted for, different assumptions about mobility of capital have little effect on the technology coefficients. Second, a computable model of trade is developed in order to account for the volume, composition, and pattern of international trade. The model incorporates technological, factor endowment, and transport cost differences at the industry level. An important feature of the model is that it relies on within-industry heterogeneity of producers in order to explain intra-industry trade. The model is parametrized and evaluated. It is found that the model accurately predicts trade flows and sizes of intra-industry trade. It is also found that the effects of capital on specialization predicted by the model are close to those obtained by the regression analysis. The model is then used to identify the effects of main determinants of trade on the volume and composition of trade. The results show that, given current trade barriers, within-industry heterogeneity accounts for 93% of the volume of trade, industry-level comparative advantage accounts for 5%, while factor-endowment differences have a negligible effect on the volume of trade. A labor-only version of the model is used to study the consequences of trade wars and trade liberalization. It is found that targeting different industries with these policies produces very different results with respect to employment and welfare.

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Chapter 1

Introduction

The size of merchandise trade, measured by the ratio of merchandise trade to merchandise value added, has increased in most countries over the past century. It has nearly tripled in the United States, growing from 13.2% in 1913 to 35.8% in 1990 (Feenstra and Hanson, 2001).

The study of international trade is one of the oldest branches of economics. In the next few pages, we briefly review the existing theories of international trade with the particular emphasis on their use in computable models. We also discuss the contribution of this dissertation to the study of international trade.

The staples of international trade theory are the Ricardian and Heckscher-Ohlin explanations of trade. The former emphasizes productivity differences while the latter focuses on factor endowment differences across countries in order to explain the pattern of trade. The neoclassical trade model that incorporates Ricardian and Heckscher-Ohlin theories was developed in the 1950s, 60s, and 70s.

Unfortunately, the neoclassical trade model is not computable. Since the number of goods traded between countries is very large, empirical studies in international trade are done on the industry, rather than product, level. However, partial or complete specialization predicted by the neoclassical trade model cannot be reconciled with industry-level data, because trade in similar goods, called intra-industry trade, is a large component of international trade.

Specialization, of course, is necessary for trade, but it occurs on the product, rather than industry, level. Unfortunately, modeling of trade flows of individual goods is not feasible.

The inability of Ricardian and Heckscher-Ohlin models to explain industry-level volumes of trade has not stopped trade economists from performing econometric studies that evaluate various aspects and predictions of these models. These studies typically use industry-level data and focus on trade patterns and specialization, rather than the volume of trade.

The classic Ricardian model, which has two countries, was evaluated several times in the 1950s and 60s with generally positive results. More recent empirical studies have focused on the Heckscher-Ohlin model. Different aspects of this model have been tested numerous times, often with inconclusive results. A good summary of this literature is in Leamer and Levinsohn (1995).

A major recent innovation in this area of research is the development of empirical methodologies that combine technological (Ricardian) and factor endowment (Heckscher-Ohlin) explanations of trade (Trefler, 1995; Harrigan, 1997). It was found that while factor endowment differences across countries matter, they cannot explain the pattern of trade and specialization by themselves. The differences of technologies are important and cannot be ignored.

In one such study, Harrigan (1997) has developed methodology in which the effects of technology and factor endowments on specialization are estimated jointly. Harrigan found that both technology and factor endowments affect specialization, supporting the generalized Ricardian and Heckscher-Ohlin theories.

In Chapter 2, we improve on Harrigan's methodology. We point out that several assumptions implicitly made in Harrigan's methodology are more appropriate for the long run than for the short run. However, the 20-year dataset he used to estimate the model is a short-span dataset and is dominated by business cycles.

We modify Harrigan's methodology to make it suitable for estimation with short-span high-frequency data. We adjust capital stock for changes in capital utilization when calculating total factor productivity. We show that not taking into account variable capital utilization overestimates the effects of technology, measured by TFP, on specialization, measured by industry shares in GDP, by about 30%.

As we already mentioned, the neoclassical trade model, when applied to industry- or country-level data, cannot explain trade volumes or intra-industry trade. In explaining the volume of trade, the most successful model until now has been the gravity model. The gravity model is extremely simple (it is just one equation), yet is able to explain the volume of trade quite well (a typical R^2 is about 0.8). The success of the gravity equation shows that trade barriers are important in determining trade volumes.[1]

In order to reconcile the neoclassical model with data, all computable general equilibrium (CGE) models of trade of the last 40 years have used the Armington (1969) assumption

[1]However, the rest of the gravity equation, that says that trade is directly proportional to trading countries' GDPs, needs a structural foundation to be useful in economic modeling and analysis. Harrigan (2003) surveys the attempts at giving a structural interpretation to the gravity equation. For example, the gravity equation can be derived from the Armington assumption about demand. The monopolistic competition model can be used to provide foundation for the production side.

about demand. Under this assumption, each good can only be produced in one country, and consumers differentiate goods based on their country of origin. The Armington assumption allows CGE models to account for trade volumes and intra-industry trade. The Global Trade Analysis Project (GTAP) is an example of a such a model. The Armington assumption has many shortcomings, which we discuss in Appendix B.

While trade advantage in the Ricardian and Heckscher-Ohlin models is due to technology or factor endowments, in the models of trade that include imperfect competition it is due to scale and monopoly power (Krugman, 1980; Helpman and Krugman, 1985). However, the models with imperfect competition do not explain how this advantage is assigned across countries. Therefore, when implemented in a computable setting, these models assume that countries produce disjoint sets of goods, with demand following the Armington assumption.[2]

The monopolistic competition models can compactly describe the world with many producers.[3] Examples of CGE models that include monopolistic competition are the Brown-Deardorff-Stern (BDS) model (Brown and Stern, 1989; Brown, Deardorff and Stern, 2001) and the model developed in Smith and Venables (1988).[4]

A very significant extension of the Ricardian framework was made in the Dornbusch-Fischer-Samuelson (DFS) (1977) model of trade with a continuum of goods. This was the first attempt to describe trade with many goods using just a few parameters. The DFS model also allowed for easy incorporation of transport costs. However, the applicability of this model to data is limited without the specification of the technology distribution

[2]Helpman (1989, p. 163) says that 'the right approach clearly would be to have a model that endogenously generates a size distribution...". However, such a model does not exist.

[3]The number of producers is finite and can be endogenized by assuming zero profits (as in the BDS model).

[4]In monopolistic competition models, if a producer exports a good, it exports it everywhere. This is a result of the use of Armington assumption, not the imperfect competition per se.

over the continuum of goods. Without it, the model cannot be extended to more than two countries, nor can it be simulated.

A model of producer heterogeneity that describes the distribution of productivities across the continuum of goods was created, in a series of papers, by Eaton and Kortum (2001a; 2002; 2005). They have developed a framework that models the innovation activity and connects it to producer-level productivity differences, which are in turn connected to trade flows. The resulting model is compact and computable. It can include many countries and does not require the Armington assumption in order to explain two-way trade in similar goods. The model can explain the volume of trade between countries, has a role for transport costs and, under certain simplifying assumptions, collapses to the standard gravity model (Eaton and Kortum, 2002).

The Eaton-Kortum (EK) model is also able to explain the newly discovered trade-related facts about producers. These stylized facts came out of several studies that use producer-level data from a variety of countries.[5] These studies have shown that even within a narrowly defined industry, producers have very different productivities. They have also shown that most producers do not export, but sell only domestically. Those that do export, tend to be more productive than those that do not export.(Bernard et al., 2003)

The EK model, however, does not have some of the features that we have come to expect from commonly used neoclassical and computable models of trade. The EK framework does not model industries. The focus of the EK model is on the producer and the country, whereas the focus of most trade models is on the industry. Therefore, the EK model does not allow

[5]See, for example, Bernard and Jensen (1995), Bernard and Jensen (1999), Aw, Chung and Roberts (1998), Clerides, Lach and Tybout (1998), Bernard, Eaton, Jensen and Kortum (2003), and Eaton, Kortum and Kramarz (2004).

the study of specialization in the traditional sense, i.e. specialization in industries.

The EK model has only one factor, labor, whereas most trade models have at least two: capital and labor. As the result, the EK model has no role for factor endowment differences across countries in determining the pattern of trade. Finally, the EK model does not include taste differences across countries. However, the framework of Eaton and Kortum can be combined with the traditional trade framework to create a compact computable model of trade.

We take this step in this dissertation. The resulting model, described in Chapter 3, does not have the shortcomings of other computable models of trade. Most importantly, the model does not require the Armington assumption in order to explain the two-way trade in similar goods. Instead, the intra-industry trade derives naturally from within-industry heterogeneity of producers.

Our parametrization method differs from the method employed by Eaton and Kortum in that we use only domestic data to fit the model. This gives us the ability to evaluate the model by comparing trade flows predicted by the model to the actual ones. We find that the ratio of the sum of squared errors to the actual sum of squares is 0.007 (compare to 0.2 for a typical gravity equation). The predicted Grubel-Lloyd intra-industry trade index, which measures the prevalence of intra-industry trade, is within 0.46% of the actual.

The model can be used to study both specialization and the volume of trade. Therefore, we use two approaches to study specialization in this dissertation: the regression approach, used in Chapter 2, and the simulation approach, used in Chapter 4. We make comparisons between results provided by these two approaches.

We find that average effects of capital stock on specialization predicted by simulation are close to those obtained by regression. We also find that in most industries, the signs and magnitudes of these effects are very different across countries. Therefore, average effects that are estimated by the regression analysis are not particularly meaningful. We further find that the effects of technology on specialization are far more predictable than the effects of capital stock.

Since our model includes all the major determinants of trade, it allows us to perform the accounting for trade exercise in Chapter 4. We determine how much each of the determinants of trade, namely technology, factor endowments, tastes, trade costs, and within-industry heterogeneity, contribute to the volume of trade, size of intra-industry trade, and the pattern of trade.

The intent of this investigation is similar to that of growth accounting. While growth accounting aims to determine how much each component of growth contributes to total growth, we want to find out how much each component of trade contributes to the volume and composition of trade.

We find that within-industry heterogeneity is responsible for 93% of the volume trade. Differences in relative efficiencies across industries, which give rise to industry-level comparative advantage, are responsible for 5%. Thus, productivity differences on product and industry levels together account for 98% of the volume of trade. Factor endowment differences have virtually no effect on the volume of trade, while taste differences across countries actually decrease trade by about 6%.

Similarly, we are able to determine the effects of comparative advantage, factor endowments, and other determinants of trade on the size of inter-industry trade. We find that differences of trade costs are responsible for 78% of inter-industry trade. Comparative advantage is responsible for 12%, taste differences, 8%, and factor endowment differences, the remaining 3%.

In addition to accounting for the volume and composition of trade, we also examine how determinants of trade influence the pattern of trade or net exports. We find that removing industry-level comparative advantage has a major effect on the pattern of trade, causing nearly a half of all trade flows to reverse direction. On the other hand, removing within-industry heterogeneity or differences of factor endowments has a much smaller effect.

Finally, our model can be used to simulate various trade policies. In Chapter 4 we use a simpler version of our model to study the effects of trade wars between the U.S. and E.U., and trade liberalization between rich and poor countries. We find that effects of trade wars and trade liberalizations on employment and welfare vary significantly depending on the industry that is targeted.

While the basic version of our model has exogenous capital, in Section 3.5 we extend the model to include endogenous capital stock and international capital markets. In Appendix D we use this extended model to simulate the effects of a modest technological improvement in the U.S. machinery industry.

Chapter 2

Estimating the neoclassical model

We study how specialization, measured by industry shares in GDP, is affected by technology and factor endowments. By allowing variable capital utilization and sector-specific capital, our methodology permits estimation using short-span high-frequency data, which is the only kind of data currently available for industry-level studies in international economics.[1] We show that if we were to assume constant capital utilization, the effects of technology on specialization would be significantly overestimated.

Over the years, several theories have appeared that explain specialization.[2] The Ricardian theory emphasizes the importance of technological differences when technology is not transferable between countries. The Heckscher-Ohlin theory, on the other hand, assumes the same technology in all countries and emphasizes factor endowment differences when factors are not transferable between countries.

[1] Short-span high-frequency data is data which is dominated by business cycles. An example is annual data over 10 or 20 years.

[2] Product mixes produced by countries can be classified along two dimensions. One is vertical where countries produce similar goods but of different quality. Another is horizontal where countries produce very different products. This paper, as most other studies in international economics, addresses the horizontal differentiation.

Both of these theories have been evaluated empirically. The classic Ricardian theory, which has two countries, had been evaluated several times in the 1950s and 60s with generally positive results. Different aspects of the Heckscher-Ohlin model have been tested numerous times, with inconclusive results. This literature is summarized in Leamer and Levinsohn (1995).

The fact that the tests of the Heckscher-Ohlin model produced mixed results has led some researchers to believe that Ricardian technological differences have to be incorporated into the Heckscher-Ohlin model. In an influential 1995 paper, Trefler allowed sector-neutral differences of technology in the context of the Heckscher-Ohlin model.

The assumption of sector-neutral differences of technology, however, was very restrictive. In a series of papers, James Harrigan (1996a, 1996b) had shown that technological differences between countries are not sector-neutral but sector-specific. Then, in his 1997 paper, he developed methodology in which specialization was determined jointly by the factor endowment differences and sector-specific technological differences. In that study specialization was measured by industry shares in GDP. Harrigan used a neoclassical model with a translog revenue function which resulted in a convenient representation of the industry shares. He estimated the model using data for 7 manufacturing sectors of 10 OECD countries for 1970-90.

Harrigan asked the following question: are differences of factor endowments and technology both significant in determining specialization? He found that both technology and factor endowments affect specialization, supporting the generalized Ricardian and Heckscher-Ohlin theories. The estimated effect of technological differences, measured by TFP, was generally large and positive, in accordance with theory. In other words, countries tended to specialize in industries in which they had a technological advantage. Factor endowment differences were also important in determining specialization. Harrigan's study is a major contribution to the understanding of specialization.

In this paper we build on his results. We modify the empirical methodology to make it suitable for estimation with short-span high-frequency data. Several assumptions implicitly made in Harrigan's methodology are more appropriate for the long run than for the short run. However, the 20-year dataset he used to estimate the model is a short-span dataset and is dominated by business cycles. For example, Harrigan's methodology assumes that capital utilization is constant, which is reasonable in the long run, but not in the short run. His methodology also assumes that capital is freely and instantaneously mobile between industries which is, again, a long-run assumption.

We start by replicating Harrigan's (1997) results using our dataset of 8 industries in 23 countries over 21 years. Using these results as the reference point, we correct the TFP measure for capital utilization and reestimate the model. As explained in the next section, we expect the effect of technology on specialization to decrease once the TFP has been corrected. We will also seek to answer the following questions: (i) Will the technology coefficients still be significant after the TFP has been corrected? (ii) What will be the magnitude of the corrected coefficients? (iii) What will happen to the technology and factor endowment coefficients if we assume that capital is a specific factor? (iv) Will both technology and factor endowments still have a significant effect on the specialization of countries?

2.1 Variable capital utilization

In order to estimate the effect of technology on industry share, a measure of technology is needed. Technological differences are usually measured by the Solow residual, which is obtained by subtracting differences in inputs from differences in output. Inputs should be measured by the quantity of factor services provided in production.

Very often, however, a measure of factor services is not available and a measure of factor stock is used instead. This is particularly true for capital. Using capital stock to proxy for capital services assumes that capital services are a constant proportion of capital stock or, equivalently, that capital utilization is constant. This may be a good approximation in the long run, but a poor one in the short run.

Recent research has shown that there is significant variation of the capital utilization rate during business cycles. In fact, recent literature has documented that behavior and statistical properties of the Solow residual change significantly when variable capital utilization is accounted for. The volatility of the Solow residual σ_A, its relative volatility $\frac{\sigma_A}{\sigma_Y}$, and the correlation between the Solow residual and output ρ_{AY} are all significantly reduced when variable capital utilization is accounted for (Burnside, Eichenbaum and Rebelo, 1995a; Burnside, Eichenbaum and Rebelo, 1995b; Baxter and Farr, 2001a).

Harrigan's model is that of a long-run equilibrium, but was estimated with short-span (20 years) high-frequency (annual) data. Both the Total Factor Productivity and industry share fluctuate over the business cycles which dominate the short-run data. We suspect that if the variable capital utilization is not taken into account, the effect of technology on industry share is overestimated.

Our suspicion is supported by the finding that technology shocks are only weakly correlated across industries (Baxter and Farr, 2001a). If the technology shocks were synchronized across industries, then the industry shares would not change over the business cycle. We expect the effect of technological differences on industry share to decrease significantly when variable capital utilization is introduced into the model.

We calculate capital utilization from the consumption of electricity following Burnside et al. (1995a) and Baxter and Farr (2001b). In the process of calculating capital utilization we calculate a parameter that measures the efficiency of electricity consumption in each country and industry.[3]

2.2 Methodology

In this section we develop our estimation methodology. In Section 3.1 we assume that capital is freely and instantaneously mobile between industries, while in Section 3.2 we assume that it is specific to each industry and, therefore, immobile.

2.2.1 Small-country model with domestically mobile capital

We use a simple small-country model with trade. Factors are mobile between industries but immobile between countries. Countries trade with each other because of differences in their technologies and/or factor endowments. These differences determine comparative advantage. We assume constant returns to scale and free trade. Capital utilization can vary.

[3] Variable capital utilization in the context of the Heckscher-Ohlin model has been studied by Svensson (1982) and Betancourt, Clague and Panagariya (1985). In their models, only country-wide capital utilization could change.

We start with the economy-wide revenue function:

$$Y = R\,(Ap, v), \tag{2.1}$$

where Y is the value added, A is the vector of total factor productivities, p is the vector of prices, and v is the vector of factor endowments.

Using Hotelling's lemma, the revenue share of product i can be obtained by logarithmic differentiation of the revenue function:

$$S_i = \frac{\partial \ln R\,(Ap, v)}{\partial \ln p_i}, \tag{2.2}$$

where $S_i \equiv \dfrac{Y_i}{Y}$ is the share of industry i.

Following Kohli (1978) and Harrigan (1997), we approximate the economy-wide revenue function by the translog function:

$$\begin{aligned}
\ln R\,(Ap, v) \quad = \quad & a_{00} + \sum_i a_{0i} \ln A_i p_i + \frac{1}{2} \sum_i \sum_k a_{ik} \ln A_i p_i \ln A_k p_k \\
& + \sum_j b_{0j} \ln v_j + \frac{1}{2} \sum_j \sum_m b_{jm} \ln v_j \ln v_m \\
& + \sum_i \sum_j c_{ji} \ln A_i p_i \ln v_j, \qquad (2.3)
\end{aligned}$$

where $i, k = 1, ..., N$ are industries, and $j, m = 1, ..., M$ are factors.[4]

Symmetry requires that $a_{ik} = a_{ki}$ and $b_{jm} = b_{mj}$.[5] Linear homogeneity in p and v requires that $\sum_i a_{0i} = 1$, $\sum_k a_{ki} = 0$, $\sum_j b_{0j} = 1$, $\sum_j b_{jm} = 0$, $\sum_i c_{ji} = 0$, and $\sum_j c_{ji} = 0$ (Christensen, Jorgenson and Lau, 1973; Woodland, 1982).

We take the derivative of the revenue function with respect to price and impose linear homogeneity on the resulting share equation.[6] Finally, since we are going to estimate the share equation using a panel of countries over a 20-year period, we add time and country subscripts:

$$S_{ict} = a_{0i} + \sum_{k=2}^{N} a_{ki} \ln \frac{p_{kt}}{p_{1t}} + \sum_{k=2}^{N} a_{ki} \ln \frac{A_{kct}}{A_{1ct}} + \sum_{j=2}^{M} c_{ji} \ln \frac{v_{jct}}{v_{1ct}}. \tag{2.4}$$

The relative goods prices that enter the share equation are not observed by us. The prices of traded goods are the same in all countries while the prices of nontraded goods are not. In addition, the technologies of many sectors, such as government and service sectors, are not observable in this study. Following Harrigan (1997), we treat the sum of nontraded goods' prices and unobserved technologies as a random variable with country fixed effects η_{ic}, time fixed effects δ_{it}, and a random component e_{ict} with constant variance σ_i^2. Since prices of traded goods are the same in all countries, we can treat their sum as a

[4]The translog functional form $\ln f(x) = a_{00} + \sum_{i=1}^{n} a_{0i} \ln x_i + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} a_{ij} \ln x_i \ln x_j$ can be used to provide second-order approximation to any function of x. It is also convenient because it results in simple share equations (Woodland, 1982).

[5]The revenue function is twice continuously differentiable so the Hessian must be symmetric.

[6]The linear homogeneity in prices, TFP, and factors is imposed as follows. Prices and TFP are normalized by sector 1. Factors are normalized by factor 1 (in our case, labor). As explained later on in this section, we end up not imposing linear homogeneity restrictions on TFP because we do not observe TFPs of all industries in the economy.

time fixed effect $\mu_{it} \equiv \sum_{k=2}^{N_1} a_{ki} \ln \left(p_{kt}/p_{1t} \right)$ where the summation is over all traded goods. Our estimating equation is then

$$S_{ict} = \eta_{ic} + \gamma_{it} + \sum_{k=1}^{N_1} a_{ki} \ln A_{kct} + \sum_{j=2}^{M} c_{ji} \ln \frac{v_{jct}}{v_{1ct}} + e_{ict}, \tag{2.5}$$

where $\gamma_{it} \equiv a_{0i} + \mu_{it} + \delta_{it}$. There are no linear homogeneity restrictions on the technology coefficients because the summation is over only some of the industries.

The coefficients a_{ki} and c_{ji} have the following interpretation. An increase of the independent variable by the factor of X raises output share by $a \ln X$ percentage points where a is the value of the appropriate coefficient. For example, if $a_{ki} = 2$ and technology A_{kct} doubles, then the industry share S_{ict} increases by 1.4 percentage points. Since the translog revenue function is simply a second order approximation to any revenue function, the coefficients a_{ki} and c_{ji} have no economic interpretation. They simply tell us how much and in what direction relative technology, capital utilization, and factor endowments affect industry shares.

We estimate (2.5) as a system of 8 seemingly unrelated regressions (SUR) with 28 restrictions given by symmetry requirements.[7] Each equation represents a two-way fixed effects error component model, estimated by a within estimator, as described in Baltagi (2001).

[7] All restrictions that we imposed on the revenue function (2.3) are satisfied in our estimation. Symmetry restrictions are imposed during the SUR estimation. Linear homogeneity restrictions are imposed in the estimating equation.

2.2.2 Model with capital as a specific factor

In the previous section we assumed that capital can move between industries freely and instantaneously. This is an extreme assumption about capital mobility. In reality, there could be costs and delays associated with moving capital between industries. In this section, we make another extreme assumption about capital, one that is the direct opposite of what we assumed in the previous section. In this section we assume that capital is specific to each industry and cannot move between industries. For example, capital can consist of heterogeneous goods that are not substitutable.

We make this assumption because we want to see how the effects of technology and factor endowments on specialization change depending on the assumption about capital mobility. We also want to check that accounting for variable capital utilization is important regardless of the assumption about capital mobility. Finally, we use the two extreme assumptions about capital mobility because they are easy to model in this static setting.[8]

If capital is the specific factor, our estimating equation becomes

$$S_{ict} = \eta_{ic} + \gamma_{it} + \sum_{k=1}^{N_1} a_{ki} \ln A_{kct} + \sum_{k=1}^{N_1} d_{ki} \ln K_{kct} + \sum_{j=3}^{M} c_{ji} \ln \frac{v_{jct}}{v_{1ct}} + e_{ict}. \tag{2.6}$$

Note that the last summation excludes physical capital, which is the factor number two.

[8]See the conclusion for further thoughts on making this model dynamic and modeling capital adjustment costs explicitly.

2.2.3 Measuring capital utilization and technology

In order to estimate equations (2.5) and (2.6) we need to measure the total factor productivity. To compare total factor productivities across countries we use the multilateral translog productivity index derived by Caves, Christensen and Diewert (1982) and first used by Christensen, Cummings and Jorgenson (1981). In each industry, the relative TFP of country c at time t with respect to the reference point is given by

$$\begin{aligned}\ln A_{ct} - \ln A_1 \quad = \quad & \ln Y_{ct} - \ln Y_1 - \widehat{\alpha}_{ct}\left(\ln S_{Kct} - \overline{\ln S}_K\right) - \widehat{\alpha}_1\left(\overline{\ln S}_K - \ln S_{K1}\right) - \\ & - \left(1 - \widehat{\alpha}_{ct}\right)\left(\ln S_{Lct} - \overline{\ln S}_L\right) - \left(1 - \widehat{\alpha}_1\right)\left(\overline{\ln S}_L - \ln S_{L1}\right),\end{aligned}$$

where $\widehat{\alpha}_{ct} = 1/2\left(\alpha_{ct} + \overline{\alpha}\right)$, α is capital share, S_K is capital services, S_L is labor services, a bar indicates the average over all countries and years, and subscript 1 denotes the reference point. The choice of the reference point is inconsequential. In this paper we follow Harrigan (1997) and choose the TFP of the United States in 1988 as the reference point.

In order to calculate relative technology we need measures of capital and labor services. We measure capital services by $Z_{ict}K_{jct}$ where Z_{ict} is the capital utilization rate and K is the capital stock. We describe the measurement of the capital utilization rate in the next section. We measure labor services by total hours worked: $S_{L,ict} = H_{ict}L_{ict}$, where H is the number of hours worked by an average worker and L is the number of workers employed. We obtain H_{ict} from data.

Following Baxter and Farr (2001b) and Burnside et al. (1995b), we assume that energy consumption is proportional to the capital services used:

$$E_{ict} = \phi_{ic} Z_{ict} K_{ict}, \tag{2.7}$$

where E_{ict} is energy consumption and ϕ_{ic} is a country- and industry-specific parameter that measures the efficiency of electricity consumption. To calculate ϕ_{ic} we assume that the differences of electricity consumption across industries and countries are due to different efficiencies. On the other hand, we assume that the variation of electricity consumption in time is due to changing utilization of capital Z_{ict}.

In other words, we assume that ϕ_{ic} is constant over time. Of course, in the long run ϕ_{ic} may decline as industries become more energy-efficient due to stricter environmental regulations and appearance of new energy-saving technologies. However, the 20 years included in our study (1975-95) is a short enough period of time that we felt we could assume constant ϕ_{ic}. To be sure that our assumption is justified, we calculated ϕ_{ic} separately for 1975-85 and 1986-95. We found no significant decline of ϕ_{ic} in any country and industry between the two time periods.

The efficiency parameter ϕ_{ic} is calculated as follows. From (2.7) we have

$$Z_{ict} = \frac{E_{ict}}{\phi_{ic} K_{ict}}. \tag{2.8}$$

The average utilization rate is

$$\overline{Z}_{ic} \equiv \frac{\sum_t Z_{ict}}{T} = \frac{1}{\phi_{ic}} \frac{\sum_t (E_{ict}/K_{ict})}{T},$$

where T is the number of periods. From the equation above we obtain the expression for ϕ_{ic}:

$$\phi_{ic} = \frac{\sum_t (E_{ict}/K_{ict})}{T\overline{Z}_{ic}}. \tag{2.9}$$

We assume that over the 20-year span of our dataset the average utilization rates $\overline{Z}_{ic}$ are the same in all countries. To calculate ϕ_{ic} we use the values of the U.S. average utilization rates $\overline{Z}_{i,US}$.

Knowing ϕ_{ic} we obtain the capital utilization rate from (2.8).

2.3 Results

We start by calculating capital utilization rates and total factor productivities in Section 2.3.1. Then, in Section 2.3.2, we estimate the share equation (2.5) that assumes that capital is mobile between industries. We estimate it first using the unadjusted and then the capital utilization-adjusted measure of technology. In Section 2.3.3 we estimate the share equation (2.6) which assumes that capital is a specific factor. Again, we first estimate this equation using the capital utilization-adjusted measure of technology and then using the unadjusted measure of technology. In Section 2.4 we use the estimated model with variable capital utilization and mobile capital to explain the specialization of several countries in the sample.

2.3.1 Calculating total factor productivities and capital utilization rates

First, we calculate ϕ_{ic} using (2.9). This parameter may be of interest in itself so we present its values in Table 8. In each industry we ranked countries by their value of ϕ_{ic}. Countries with higher efficiency of electricity consumption (lower ϕ_{ic}) are ranked higher.

European countries generally ranked high while developing countries and non-European developed countries ranked low. United States and Canada ranked low in all industries. France had the highest average rank and Norway had the lowest. We believe that the average rank of a country is influenced, among other things, by how strict the environmental regulations are and how cheap the energy is in that country. Environmental regulations are generally very strict in West European countries. They are weaker in North American and developing countries. The low rank of Norway is most likely explained by the availability of oil and gas on its territory.

There is some variation of rankings across industries. Figure 1 shows the rankings as a bar graph grouped by country. Countries are sorted by their average rank with countries on the left having a lower rank. We can see that despite some heterogeneity of rankings, countries with the higher average ranks tend to have higher ranks in all industries.

Having calculated ϕ_{ic}, we calculate the capital utilization rates and total factor productivities. Relative TFPs adjusted for variable capital utilization, for 1975 and 1990, are shown in Table 9. There are clearly significant differences of relative TFPs across countries and industries. The vast majority of countries have lower productivity than the United

States in all industries. The two notable exceptions are Japan and Germany. In 1995 Japan had higher TFP than the U.S. in 6 out of 8 industries. In the same year, Germany had higher TFP than the United States in 5 out of 8 industries.

Less developed countries, of course, have lower TFP than the more developed countries. Most countries have narrowed the TFP gap with the United States between 1975 and 1990. Comparing the TFP in Korea in 1975 and 1990 we see the evidence of the enormous TFP gains made by that country. These gains, of course, are well documented in the literature. Another country with large TFP gains between 1975 and 1990 is Ireland. However, not all countries have had the same degree of success increasing their TFP. In 1975 Mexico had higher TFP than Korea in most industries, but in 1990 the situation was reversed.

Figures 2 through 4 show the unadjusted and adjusted TFPs in levels and differences, as well as some properties of the TFPs for several industries in the dataset.[9] We included these figures to show what happens to Total Factor Productivity when it is adjusted for capital utilization. Consistent with existing literature, the variance of the TFP, measured either in levels or differences, and its correlation with output decrease when variable capital utilization is accounted for.[10]

Figure 2 shows that the TFP in the Metals industry of the United States did not fall during the recessions of the early 1980s and early 1990s as much as the unadjusted TFP

[9]Though our industry classifications are slightly different, the TFP properties in our data and in Baxter and Farr (2001a) are similar. Baxter and Farr (BF) report 17% reduction (when variable capital utilization is accounted for using electricity consumption) of the standard deviation of the TFP growth in the U.S. Metals industry compared with 20% in our data. They report 26% reduction of the standard deviation of the TFP growth in the U.S. Wood industry compared with 25% in our data. BF report the correlation of unadjusted TFP growth with output growth of 0.86 in the Wood and 0.93 in the Metals industry. The correlation in our data is slightly higher: 0.94 in the Wood industry and 0.97 in the Metals industry. After the adjustment, the correlation in the Wood industry is 0.59 in BF and 0.77 in our data while in the Metals industry it is 0.78 in BF and 0.79 in our data.

[10]This occurs in many but not all industries and countries.

would have us believe. This is because the firms have decreased capital utilization during this period. Capital utilization increased during the 1990s and the adjusted TFP did not increase as much as the unadjusted TFP during that time.

In Figure 3 we can see that capital utilization has increased in the U.S. Wood industry between 1975 and late 1980s/early 1990s.[11] We can also see that adjusted TFP is not as volatile as the unadjusted TFP. The same phenomena are observed, albeit to a lesser degree, in Figure 4, which shows Total Factor Productivity for the Machinery industry in Turkey.

2.3.2 Results obtained under the assumption of domestically mobile capital

We start by replicating the results of Harrigan (1997) using our data. The estimating equation is (2.5) and the measure of productivity does not take variable utilization into account. We then estimate the same equation using the capital utilization-adjusted measure of productivity and compare the results.

Using the unadjusted measure of productivity

The total factor productivity in this case is calculated using the capital stock instead of capital services:

[11]The capital utilization has also increased in many other industries and countries during that period. An alternative explanation for this increase would be an increase of parameter ϕ over time. We use U.S. Federal Reserve Bank data as evidence for the rising utilization rates. According to their data, the average capacity utilization rate in U.S. Wood industry in 1975-85 was 76.5% while in 1985-1995 it was 81.5%. We also do not think it is likely that industries actually become less energy-efficient over time.

$$\begin{aligned}\ln A_{ct} - \ln A_1 &= \ln Y_{ct} - \ln Y_1 - \widehat{\alpha}_{ct}\left(\ln K_{ct} - \overline{\ln K}\right) - \widehat{\alpha}_1\left(\overline{\ln K} - \ln K_1\right) \\ &\quad - (1-\widehat{\alpha}_{ct})\left(\ln S_{Lct} - \overline{\ln S}_L\right) - (1-\widehat{\alpha}_1)\left(\overline{\ln S}_L - \ln S_{L1}\right).\end{aligned}$$

The results of estimation are reported in Table 10. The eight columns correspond to the eight estimated equations. Own-TFP coefficients are printed in bold to make the tables easier to read. Standard errors are given in parentheses.

Our own-TFP estimates are very similar to those obtained by Harrigan. One difference is in the Food industry where his estimate is negative while ours is positive. In addition, Harrigan's estimate of the own-TFP coefficient in the Paper industry was positive, but not statistically different from zero. In our results, all own-TFP coefficients are positive and statistically significant, as predicted by theory. With the exception of the Food and Paper industries, however, the signs and magnitudes of our own-technology coefficients are very close to Harrigan's.[12]

Using the capital utilization-adjusted measure of productivity

We now estimate (2.5) using the utilization-corrected measure of TFP. We compare the estimated own-TFP coefficients, reported in Table 11, with those obtained in the previous section using the uncorrected measure of TFP.

As we expected, the own-TFP coefficients in this case are smaller than those of the

[12] There are some differences in the estimated effects of factor endowments. Highly educated workers have a uniformly negative effect in Harrigan's estimation while having a uniformly positive effect in ours. Medium and low-educated workers sometimes match signs but not values. Also, in Harrigan's estimation land has a positive effect in two industries while having negative effect in all industries in our estimation. The coefficients on capital are not comparable because Harrigan has two types of capital while we have one.

previous section. Table 16 summarizes the differences between own-TFP coefficients. The coefficients obtained using the utilization-adjusted measure of the TFP are on average 29% smaller than those obtained using the unadjusted measure of the TFP. This is the main finding of our paper: ignoring variable capital utilization overestimates the effects of technology on specialization.

As can be seen in Table 11, all own-TFP coefficients are again positive and statistically significant, as predicted by theory. The own-TFP terms are in the range between 0.28 and 2.41. To make these numbers meaningful, consider the share of the average industry of the dataset, 2.7%, reported in Table 5. For this average industry an own-TFP coefficient of 1.5 means that if relative TFP doubled, the industry share would increase by about 40%.[13]

Most factor endowment coefficients are statistically significant, giving support to the Heckscher-Ohlin explanation of specialization. Physical capital coefficients are significant at 95% in six industries and at 90% in the remaining two industries. They are positive in the Metals and Machinery industries and negative in all other industries. Capital stock has the largest positive effect in the Machinery industry and the largest negative effect in the Textile industry.

Low-educated workers have a statistically significant effect on industry share in four industries and in all four the effect is positive. The largest effects are in the Food and Metals industries. Medium-educated workers have a statistically significant effect in five industries and this effect is positive in four industries and negative in the Paper industry. Highly educated workers have a statistically significant effect in six out of eight industries. In all of those six industries the effect is positive. These highly educated workers have the

[13] It would increase by $1.5\,(\ln 2) = 1.05$ percentage points, from 2.7 to 3.75%.

largest effect on the shares of the Machinery industry.

Arable land has a statistically significant effect on industry share in all but one industry. The effect of arable land on the industry share is always negative. The largest negative effect is found in the Machinery industry.

Tables 12 and 13 report the estimated country and time fixed effects, respectively. The country fixed effect captures the cross-country variation of nontraded goods prices and unobserved technologies. The time fixed effect captures the variation of goods prices (both traded and nontraded) and unobserved technologies across time. The time fixed effect exhibits a downward trend in all industries. Thus, the model explains the general decline in the share of manufactures over the period by the decline in their relative price as well as changes of productivity in other sectors, such as services.

We conclude that allowing for variable capital utilization reduced own-technology coefficients by between 1/4 and 1/3. Despite the reduction, though, both technology and factor endowments still have a significant effect on specialization of countries.

In Section 2.4 we use the estimated model to account for several examples of specialization observed in our dataset. We use the estimated model to compare and analyze the changes of specialization in Korea and Turkey. We also consider what it would take for Portugal to have as significant Machinery industry as Germany's.

2.3.3 Results obtained under the assumption that capital is a specific factor

Now lets assume that capital is immobile between industries. In other words, the cost of moving capital goods between industries is infinitely large. For example, capital goods used in different industries may not be substitutable. In this case, the estimating equation is (2.6).

We first estimate this equation using the unadjusted measure of TFP. Looking at the results presented in Table 14, we can see that introducing the immobile capital, by itself, increases the TFP coefficients and reduces the factor endowment coefficients. All own-TFP and own-industry capital coefficients are positive and statistically significant.

We then estimate equation (2.6) using the utilization-adjusted measure of TFP. The results are reported in Table 15. We can see that, again, there is significant reduction of own-TFP coefficients when utilization-adjusted measure is used. In this case, own-technology coefficients are reduced, on average, by between 1/3 and 1/2. Thus, our main finding - that ignoring variable capital utilization overestimates the effects of technology on specialization - is confirmed in the case of immobile capital.

As Table 16 shows, the reduction of own-TFP coefficients that occurs when we account for variable capital utilization is greater in the case of immobile capital. The average reduction in this case is about 41%. In fact, the own-TFP coefficients obtained with utilization adjusted measure of TFP are approximately the same whether we assume that capital is mobile or a specific factor.[14] Thus, the assumption we make about mobility of capital does not seem to make much of a difference on technology coefficients once the variable capital utilization has been accounted for.

[14]Some factor endowment coefficients change if capital is assumed to be a specific factor. Comparing Tables 11 and 15 we notice that slightly fewer factor endowment coefficients are statistically significant (In Table 11 about 3/4 of factor endowment coefficients are statistically significant, in Table 15 about 2/3 are significant). Several factor endowment coefficients change signs. Thus it seems that when one factor is fixed for each industry, other factors become less important.

2.3.4 Effects of ignoring variable capital utilization

We have hypothesized that if technology is measured using the capital stock instead of capital services, the effect of technology on industry share will be overestimated. Thus, we have predicted that our estimates of own-TFP coefficients will be smaller than those of Harrigan (1997).

Table 16 summarizes the own-TFP coefficients estimated in this paper. It can be seen that estimates obtained using the capital utilization-adjusted measures of productivity are indeed smaller than those obtained using the unadjusted measure. If the assumption of domestically mobile capital is correct and if variable capital utilization is not taken into account, the effect of TFP on industry share is overestimated, on average, by about 29%. Depending on the industry, the own-TFP coefficient can be overestimated by as much as 36%. If capital is the specific factor and the variable capital utilization is ignored, the own-TFP is overestimated, on average, by about 41%. Thus, the finding that ignoring variable capital utilization overestimates the effect of TFP on industry share is robust to the assumption about mobility of capital.

2.4 Explaining the observed pattern of specialization using the estimated model

In this section we use the estimated model with variable capital utilization and mobile capital to explain the observed pattern of specialization for several countries in our dataset. In Section 2.4.1 we consider what it would take for Portugal to have the same Machinery industry share as Germany. In Section 2.4.2 we look at how different rates of technology and factor accumulation in Korea and Turkey have resulted in different patterns of specialization in these two countries.

2.4.1 Production of machinery in Portugal and Germany

Lets take a look at two European countries, Portugal and Germany. Germany is a world leader of machinery production. Machinery industry constituted almost 14% of its GDP in 1995. In Portugal, the Machinery industry is much smaller, even relative to the size of the economy. It constituted 3.9% of the GDP in 1995. It is Portugal's second-largest industry after Chemicals and only slightly ahead of its third largest industry, Textiles.

What explains this difference of specialization between these two countries? In other words, what would it take for Portugal to have as great of a Machinery industry as Germany? How much would the Machinery industry in Portugal grow if Portugal managed to have Germany's amount of capital stock per worker? Germany's TFP? Germany's level of educational attainment?

Table 17 provides the answers to these questions. Portugal's capital stock per worker in 1995 was 3.11 times smaller than Germany's. If Portugal were able to accumulate as much capital stock per worker as Germany, its Machinery industry would grow by 3.6 percentage points, essentially doubling in size.

Turning our attention to technology, we see that Portugal's TFP in the Machinery industry was 3.15 times lower than Germany's in 1995. If Portugal were able to obtain Germany's level of technology, its Machinery industry would grow by another 2.8 percentage points. Having both German TFP and German level of capital stock per worker would give Portugal a Machinery industry that is 10.3% of its GDP. It would be 2.5 times larger than its current Machinery industry. Finally, increasing the level of education of its workers to that of Germany would increase Portuguese Machinery industry by another 1 percentage point.

Thus we have accounted for most of the difference between Portuguese and German Machinery industry shares.[15] Physical capital and TFP differences were the biggest reasons why Portuguese Machinery industry was so much smaller than Germany's in 1995, relative to the size to the economy. Having the same TFP and physical and human capital as Germany would give Portugal a machinery industry that is almost 3 times larger than its current size.

We have explained the difference of the Machinery industry shares in Portugal and Germany using the model with variable capital utilization and mobile capital. Would our conclusions be different if we did not take variable capital utilization into account? If we use capital stock instead of capital services to measure TFP, we get a larger own-TFP coefficient and a smaller capital stock coefficient in the Machinery industry.[16] Table 18 shows how the model with constant capital utilization explains the difference of shares. Comparing Tables 17 and 18 we can see that if we do not take variable capital utilization into account we would conclude that the TFP gap is the biggest reason for the difference of Machinery industry shares in Portugal and Germany. However, once we adjust for utilization, the accumulation of capital becomes the biggest reason for the share difference. Thus, accounting for variable capital utilization makes an important change in the explanation of why Portugal has a less prominent Machinery industry than Germany.

[15]The remaining 2.5 percentage points are accounted by the differences of available arable land per worker, TFPs of other industries, and country fixed effects.

[16]Compare Tables 10 and 11.

2.4.2 Changes of specialization in Korea and Turkey

To see how our model explains the changes in the observed pattern of specialization over time, we look at two countries in our dataset, Korea and Turkey. Both countries had experienced technological progress and accumulated factors of production between 1975 and 1995. However, the technological progress and factor accumulation did not occur equally in the two countries. We will see how the factor and technology accumulation in the two countries had affected their specialization patterns.

Table 19 summarizes the changes of factor endowments in Korea and Turkey between 1975 and 1995. Both countries had seen near doubling of their labor forces over the 20 years. The available arable land per worker had shrunk by a half in Korea while it had decreased by a little less than a half in Turkey.

Turkey had more physical capital per worker than Korea in 1975. Over the following twenty years, however, Korea had accumulated huge amounts of additional capital while Turkey had accumulated little. Korea's capital per worker had increased 8-fold between 1975 and 1995 while Turkey's had increased only 1.4-fold, meaning that Korea's capital accumulation rate was 5.8 times higher than Turkey's. As the result, Korea had three times more capital per worker than Turkey in 1995.

Both countries had made gains in educating their workers. However, Turkey had a much less educated labor force than Korea in 1975. In fact, most of its workers had no formal education in 1975. So while both countries had increased the average education level of their workers over these twenty years, the patterns of educational attainment were different.

Between 1975 and 1995 the bulk of the Turkish labor force had moved from having no education to having at most the primary school education. At the same time, the bulk of the Korean labor force had moved from having at most the primary school education to having the secondary school education. The proportion of the Korean labor force with at most the primary school education had decreased by a half, from 39 to 18%. Turkey had a slightly greater gain of university-educated workers, perhaps because it had a much lower starting point: less than 2% of its labor force had higher education in 1975.[17]

Finally, Korea had been more successful than Turkey in increasing its total factor productivity. In 1975 the productivity in its industries was around 20%. By 1995, that number had increased to about 60-80%. Turkey had higher productivity than Korea in 1975, but by 1995 Korea was more productive than Turkey in all industries.[18]

Lets take a look now at the changes of specialization that occurred in the two countries between 1975 and 1995. We will focus on the four largest industries in these two countries: Machinery, Chemicals, Textile, and Food.

Both countries had undergone changes of specialization between 1975 and 1995, but the changes were not the same in the two countries. Korea had become much more specialized in the Machinery industry. In fact, while in 1975 its Machinery industry was relatively small, by 1995 Korea had become one of the world's leading machinery-producing countries. At the same time, the shares of its Textile and Food industries had declined.

Turkey did not see as dramatic a change of specialization as Korea. Its Chemical industry had increased its share the most, remaining the largest industry in the country. Its machinery industry also grew, but not nearly as much as Korea's. Its Textile and Food industries had increased their share as well.

[17] 6.9% of Korea's labor force had higher education in 1975.

[18] We can also compare Turkey to Ireland. Both countries had similar levels of TFP in 1975. However, by 1995 Ireland had productivity just slightly less than that of the US. Turkey, however, had increased its productivity only a little during the same period.

Korea's Machinery industry went from being 4.5% of GDP in 1975 to about 20% in 1995. At the same time, Turkey's Machinery industry had increases from 2.3% to 4.4% of GDP. Korea's Chemical industry had increased by 1.6 percentage points while Turkey's increased by 2.7 percentage points. Korea's Textile and Food industries had declined by 1.5 and 1 percentage points, respectively, while Turkey's Textile and Food industries had grown by 1.8 and 0.6 percentage points.

Thus, between 1975 and 1995 Korea had become much more specialized in the Machinery industry at the expense of Textile and Food industries. Turkey had seen some growth, relative to the size of the economy, in all of the industries we consider here.

Let us see how the differences of technology and factor accumulation in the two countries over the twenty years had translated into changes of specialization. We will start with the Machinery industry. We want to explain why Korea's Machinery industry share had increased by 18 percentage points while Turkey's had increased by only 2.1. In other words, we want to explain why the gap between Korea's and Turkey's Machinery industry shares had increased from 2 to 16 percentage points between 1975 and 1995.

Table 20a shows how the differences in the accumulation of technology and factors by the two countries had contributed to the changes of their Machinery industry shares. We can see that faster accumulation of capital was the biggest reason why the share of the Machinery industry had increased so much more in Korea. Because its capital accumulation rate was 5.8 times higher, Korea's Machinery industry grew by 5.54 percentage points more than Turkey's.

The second biggest reason for Korea's increased specialization in Machinery was its much faster accumulation of technology. Having 3 times higher growth rate of technology gave Korea a 3-percentage-point boost to its Machinery industry share. Faster increase of the population density and education, particularly at the lower end of the education ladder, had helped Korea gain another 1.7-percentage-point advantage over Turkey in the Machinery industry.

We note that in this section, as in the previous section, accounting for variable capital utilization makes a difference. If we had not accounted for variable capital utilization, we would have concluded that capital and technology accumulation had an equal role in determining the difference between Korea's and Turkey's Machinery industry shares.[19] Once we account for variable capital utilization, however, we conclude that capital accumulation played a greater role.

To summarize, while both countries had accumulated human capital over the twenty years, Korea had accumulated physical capital and technology much faster than Turkey. This had increased Korea's comparative advantage in the Machinery industry. If, for example, Turkey had accumulated capital at the same pace as Korea, its Machinery share would have been almost 10% of its GDP. If Turkey had also acquired new technology (TFP) at the same pace as Korea, its Machinery share would have been almost 14% of its GDP, making Turkey one of the world's leading producers of machinery and equipment.

The pattern of factor accumulation that gave Turkey a disadvantage in the Machinery industry, helped it in other industries. At the same time, the features that have helped Korea to achieve its prominence in the Machinery industry were less important, or even disadvantageous, in other industries.

[19] We would have found that both the technology and capital contribute about 4.5 percentage points each to the share gap.

Capital stock, which is a friend of the Machinery industry, is an enemy of the Chemicals industry and an even bigger enemy of the Food and Textile industries.[20] The technology (TFP) accumulation is less important in the Chemicals industry than in the Machinery industry. It is even less important in the Food and Textile industries. Educational attainment, which is very important in the Machinery industry, is much less important in the other industries. For example, low-educated workers, which were an enemy of the Machinery industry, are a friend of Chemicals, Food, and Textile industries. Medium-educated workers are also a big friend of the Food and Textile industries. Finally, the availability of arable land per worker, or population density, is much less of an enemy of the Chemical and Textile industries than it was of the Machinery industry. Land becomes statistically insignificant in the Food industry.

In line with their pattern of factor accumulation, both Korea and Turkey saw the shares of their Chemical industries increase, but this increase was greater in Turkey. Shares of the Food and Textile industries had increased in Turkey but declined in Korea. The Textile industry's share had declined in Korea by 1.5 percentage points (or by 1/3), while it had doubled in Turkey (increased by 1.8 percentage points). Table 20b shows how the differences in the accumulation of technology and factors by the two countries had contributed to the changes of their Textile industry shares.

To summarize, both countries had undergone some structural transformation in their economies between 1975 and 1995. This transformation was much more pronounced in Korea, where massive accumulation of technology, physical and human capital, and increase

[20] We use the term 'friend' in the sense similar to that in which Jones and Scheinkman (1977) used it, except that we consider industry share instead of output. Here, a factor is a friend of a particular industry if its increase leads to an increase of the industry share. A factor is an enemy of an industry if its increase leads to the decrease of the industry share.

in the population density had favored Machinery and to some extent Chemicals and Metals industries at the expense of Textile and Food industries.

The changes of specialization we describe and explain here were very much felt by the people living in these two countries. For example, the number of people employed in the Textile industry in Turkey had increased by 150,000 between 1975 and 1995, while about the same number of people had lost their jobs in that industry in Korea. During the same twenty years, the employment in the Machinery industry in Korea had skyrocketed: it increased by almost 1,000,000, a more than a 4-fold increase.[21]

[21] We can tell another story of two countries: the United States and the United Kingdom. Both countries saw the shares of many industries decrease, particularly the Machinery industry. However, the U.K. saw a much larger decrease than the U.S. Why? Over the twenty years, the time fixed effects (which we can think of as representing declining prices of manufacturing output or the increasing productivity of the service sector) had declined. At the same time, not enough happened in these countries to compensate for this decline. There was some increase of the capital stock, educational attainment, technology, and population density, but not enough. Thus, these countries had lost some of their comparative advantage to, for example, Korea. While the U.S. had compensated, to some extent, the declining fixed effects by accumulating factors, little had happened in the U.K. to compensate. For example, educational attainment and population density had increased very little in the U.K during the 20-year period. As the result, between 1975 and 1995 the U.K. Machinery industry had decreased from 14 to 7.5% of GDP, losing 1.5 million or nearly a half of all jobs in that industry. At the same time, the U.S. Machinery industry had added 330,000 new jobs.

Chapter 3

Computable model of international trade

In this chapter, we develop a model of international trade with roles for technology, factor endowments, and distance. The model can be quantified in its structural form and is able to account for observed patterns and volumes of trade.

Because we feel that no single explanation of trade would be sufficient to account for major features of the data, we focus on how best to fit together existing explanations. The genealogy of our model includes the Eaton-Kortum, Ricardian, and Heckscher-Ohlin models of trade, and Hirchman's notion of forward and backward linkages. An extension incorporates the Solow model of endogenous capital accumulation. In adopting this eclectic approach, we follow others.[1]

[1]Dixit and Norman (1980), Helpman (1981), and Ethier (1982b) combine theories of imperfect competition with the Heckscher-Ohlin model; Trefler (1995) allows sector-neutral technological differences in the Heckscher-Ohlin model; Davis (1995) develops a theoretical model that combines the Heckscher-Ohlin model with the Ricardian model to explain intra-industry trade; Harrigan (1997) combines the effects of non-sector-neutral technological differences and factor endowment differences.

Our model has neoclassical features, such as constant returns to scale in production, multiple industries, perfectly competitive markets for goods and services, and several factors that are mobile between industries (Harrigan, 2003). Trade includes both final and intermediate goods. Industries supply each other with intermediate goods, creating backward and forward linkages between themselves. In the basic model, country capital stocks are fixed. Model extensions include endogenous capital stocks and international capital markets.

Countries have several reasons to trade in our framework. First, since industries have different factor intensities and countries have different relative factor endowment, the standard Heckscher-Ohlin motive applies. Second, as in Harrigan (1997), countries have different relative efficiencies across industries, giving them incentives to trade in order to exploit comparative advantage. Third, countries have different tastes. Fourth, within-industry heterogeneity, driven by productivity differences across goods, gives rise to intra-industry trade. Finally, trade is affected by geography and trade barriers.[2]

Our model takes into account the fact that a large portion of intermediate goods consumed by an industry comes from other industries. As evidenced in Table 4, even with a coarse two-digit industry classification, only 20-50% of intermediate goods comes from own industry. This is why we model inter-industry trade, both domestic and international, in intermediate goods. In the terminology of Hirschman (1958), these are forward and backward linkages between industries. For example, higher demand for machinery products also

[2]Compared with traditional CGE models, such as the GTAP project described in Hertel (1997), our specification is much more compact and based on more realistic assumptions about trade. Traditional CGE models use the Armington approach to explain trade, thus modeling products from different countries as different goods. More importantly, our model is based on more realistic assumptions about reasons for trade - differences of technology, factor endowments, and distance.

increases demand for the intermediate goods made by the metals industry.

Despite seeming complexity, the model is compact and easily quantified. We parametrize it using 1989 data on 8 two-digit industries in 19 OECD countries, including Mexico and Turkey. We employ only domestic data to parametrize the model, with the exception of transport costs, which are estimated from a gravity equation.[3]

Since the model if fitted using only domestic data, we can evaluate it by comparing 2,736 trade flows predicted by the model to the actual trade flows. In doing so, we find that the ratio of the sum of squared errors to the actual sums of squares is 0.007. By comparison, this number for a typical gravity model is about 0.2. The predicted Grubel-Lloyd intra-industry trade index, which measures the prevalence of intra-industry trade, is within 0.46% of the actual.

In Section 4.2, we evaluate the model further by comparing the effects of capital stock on industry shares predicted by the model to those obtained by traditional regression analysis. We find that, with the exception of one industry, the results are very similar.

This chapter is structured as follows. The next section discusses intra-industry trade. Section 3.2 describes the model. Section 3.3 describes parameterization of the model, while Section 3.4 tests its fit. Appendix A describes data sources. Appendix C explains our notation by placing it in the context of a standard input-output table.

[3] Our approach is similar to that of real business cycle literature. We parametrize the model and test its fit. We then use simulations to answer questions in which we are interested.

3.1 Intra-industry trade

Industries have long been the focus of analysis in international trade. They are usually characterized by a particular level of technology, set of factor intensities, and demand function. On the other hand, it has been found that individual products within an industry can be produced with very different efficiencies.[4] Our model combines these frameworks by creating two levels of heterogeneity within countries: one at the industry level, and the other at the product level within industry.

Within each industry, producers manufacture different goods, and the production processes for each good have different productivities. However, all producers within an industry draw from the same technology curve, have the same factor intensities, face the same demand shares for intermediate and final goods, and are subject to the same transport costs. In addition, all producers in all industries within a country face the same factor prices.

We model technological differences on the product level following Eaton and Kortum (2002). By allowing product-level heterogeneity of productivities, the Eaton-Kortum (EK) model incorporates two-way trade of similar goods without requiring the Armington assumption. The EK model also allows for easy incorporation of asymmetric transport costs. This ability is crucial because transport cost have been shown to have a major influence on the pattern of international trade.[5,6]

[4]See, for example, Bernard and Jensen (1995), Bernard and Jensen (1999), Aw et al. (1998), Clerides et al. (1998), Bernard et al. (2003), and Eaton et al. (2004).

[5]For extensions of the Eaton-Kortum model see Bernard et al. (2003), who extend it to the Bertrand competition, and Eaton et al. (2004), who extend it to the Cournot competition. A good summary of Eaton and Kortum's ideas is found in Eaton and Kortum (2001a). Alvarez and Lucas (2004) prove the existence of equilibrium and derive the conditions for its uniqueness for a particular version of the Eaton-Kortum model.

[6]Trade costs are reviewed in Anderson and Wincoop (2004).

3.2 Model

There are N countries and J industries. Subscripts i and n refer to countries while subscripts j and m refer to industries. The industry cost function is

$$c_{ij} = r_i^{\alpha_j} w_i^{\beta_j} \rho_{ij}^{1-\alpha_j-\beta_j}, \tag{3.1}$$

where r is return to capital, w is wage, and ρ is price of intermediate inputs. We assume that industries mix intermediate inputs in a Cobb-Douglas fashion, so that the price of inputs ρ_{ij} is the Cobb-Douglas function of industry prices:

$$\rho_{ij} = \prod_{m=1}^{J} p_{im}^{\eta_{jm}}, \tag{3.2}$$

where η_{jm} is the share of industry m goods in the input of industry j, such that $\sum_{m=1}^{J} \eta_{jm} = 1, \forall j$.

Intra-industry production, trade, and prices are modeled following Eaton and Kortum (2002). In each industry, there is a continuum of goods, each produced with its own productivity. Productivities are assigned probabilistically, drawn from the Frechet distribution.[7] Consumers have CES preferences over these goods.[8] Eaton and Kortum (2002) show how prices are determined given technology parameters, transport costs, and costs of produc-

[7]Kortum (1997) and Eaton and Kortum (1999) provide microfoundations for this approach.

[8]The elasticity parameter gets absorbed into parameter γ that enters equations for prices and costs as a constant and has no effect on results. Since we never report the actual values of prices or costs, we can ignore it in this paper.

tion. The reader is referred to their paper for derivation. We add industry dimension to their price index equation. The price index in industry j is:

$$p_{nj} = \left[\sum_{i=1}^{N} T_{ij} \left(d_{nij} c_{ij} \right)^{-\theta} \right]^{-1/\theta}, \tag{3.3}$$

where T_{ij} and θ are technology parameters and d_{nij} is the Samuelson's ('iceberg') transportation cost of delivering goods of industry j from country i to country n.

Parameter T represents inter-level productivity and, therefore, determines comparative advantage across industries. Country n has a comparative advantage in industry j if $T_{nj}/T_{nm} > T_{ij}/T_{im}$.[9] Parameter θ determines the strength of product-level comparative advantage. Within industries, lower value of θ means more dispersion of productivities among producers, leading to stronger forces of comparative advantage. Parameter d_{nij} measures transport costs. It represents the amount of good j that needs to be sent from country i so that 1 unit of this good arrives to country n. Free trade means that $d = 1$ while trade barriers result in $d > 1$.

Plugging (3.2) and (3.3) into (3.1), we get

$$c_{ij} = r_i^{\alpha_j} w_i^{\beta_j} \prod_{m=1}^{J} \left[\sum_{n=1}^{N} T_{nm} \left(d_{inm} c_{nm} \right)^{-\theta} \right]^{-\frac{\eta_{jm}\left(1-\alpha_j-\beta_j\right)}{\theta}}. \tag{3.4}$$

Eaton and Kortum (2002) show how trade is determined given technology parameters,

[9]Parameter T is not the same as total factor productivity (TFP). Parameter T determines the mean of the Frechet distribution and is exogenous in our model. TFP, on the other hand, is endogenous. An analytic relationship between T and TFP is impossible to derive, but we can calculate TFPs given the parameters of the model (see Section 3.2.1).

distance, costs and prices. Adding industry dimension to their import share equation, it becomes:

$$\pi_{nij} \equiv \frac{X_{nij}}{X_{nj}} = T_{ij} \left(\frac{d_{nij} c_{ij}}{p_{nj}} \right)^{-\theta}, \tag{3.5}$$

where X_{nij} is the spending of country n on industry j goods produced in country i, X_{nj} is the total spending in country n on industry j goods, and π_{nij} is country i's share in the amount that country n spends on goods of industry j.

Industry output Q_{ij} is determined as follows. We have

$$Q_{ij} = \sum_{n=1}^{N} X_{nij} = \sum_{n=1}^{N} \pi_{nij} X_{nj} = \sum_{n=1}^{N} \pi_{nij} \left(Z_{nj} + Y_{nj} \right), \tag{3.6}$$

where Z_{nj} are Y_{nj} are amounts spent by country n on industry j's intermediate and final goods, respectively. Spending on final goods Y_{nj} consists of consumption C_{nj} and investment B_{nj}.

Total spending on intermediate goods made by industry j, Z_{nj} is

$$\sum_m Z_{nmj} = \sum_m p_{nj} M_{nmj} = \sum_m \eta_{mj} \rho_{nm} M_{nm} = \sum_m \frac{\eta_{mj} \left(1 - \alpha_m - \beta_m\right)}{\beta_m} w_n L_{nm},$$

where Z_{nmj} is the amount spent by industry m on intermediate goods from industry j, and M is the quantity of intermediate goods.[10]

Consumer preferences are two-tier: Cobb-Douglas across industries and, as we men-

[10] Appendix A explains this part in greater detail.

tioned, CES across goods within each industry. Because preferences across industries are Cobb-Douglas, each country spends a constant proportion of its total consumption on goods from each industry. We also assume a fixed savings rate, so that consumption spending on each industry is also a constant proportion of country income: $C_{nj} = \psi_{nj} VA_n$, where VA_n is total income (GDP) in country n.[11] We allow for different tastes across countries by letting ψ_{nj} be country-specific.

We measure capital K in real units (i.e. number of machines). Capital can be freely and instantaneously moved across industries within a country, subject to the constraint $\sum_j K_{ij} = K_i$. The country capital stock K_i is fixed. Rental rate r_i is determined by the market. In Section 3.5 we develope an extension in which we model the evolution of capital stock K_i over time.

Capital good is composite, made up of goods from all industries. We assume that it is a Cobb-Douglas combination. We also assume, for simplicity, that industry shares in this composite good are the same regardless of where the capital is used.[12] Price of the capital good in country i is then:

$$p_i^k = \prod_m p_{im}^{\eta_m^I}, \tag{3.7}$$

where η_m^I is the fixed share of industry m's goods in the composite capital good.[13]

Total investment spending in country i is given by its income and exogenous savings

[11]Consumption C includes private consumption and government consumption.

[12]This assumption is supported by data, which shows that η_m^I is very similar across industries and countries.

[13]Superscript 'I' stands for 'investment'.

rate s_i: $B_i = s_i VA_i$. The portion of total investment spending that goes toward goods from industry j is $B_{ij} = \eta_j^I B_i$.

Plugging the expressions for intermediate, consumption, and investment spending into (3.6), we obtain the output equation:

$$Q_{ij} = \sum_{n=1}^{N} \pi_{nij} \left(\left(\sum_{m=1}^{J} \frac{\eta_{mj} (1 - \alpha_m - \beta_m)}{\beta_m} w_n L_{nm} \right) + \eta_j^I s_n VA_n + \psi_{nj} VA_n \right). \tag{3.8}$$

Industry factor employments are given by

$$K_{ij} = \frac{\alpha_j Q_{ij}}{r_i} \text{ and } L_{ij} = \frac{\beta_j Q_{ij}}{w_i}. \tag{3.9}$$

Factor markets clear:

$$\sum_{j=1}^{J} K_{ij} = K_i \text{ and } \sum_{j=1}^{J} L_{ij} = L_i, \tag{3.10}$$

where L_i and K_i are given.

Due to data limitations, we only model manufacturing industries. We normalize the price index in nonmanufacturing sector to 1 and take nonmanufacturing income as exogenous.[14] Consumption by nonmanufacturing sector of manufacturing intermediate goods is classified

[14]This means that other sectors are not influenced by manufacturing and vice versa. For example, a technological improvement in the Machinery industry has no effect on costs of production or income in nonmanufacturing sectors (e.g. agriculture, mining, services).

as final consumption. Country income VA_i is the sum of manufacturing income VA_i^M and nonmanufacturing income VA_i^O:

$$VA_i = VA_i^M + VA_i^O = w_i L_i + r_i K_i + VA_i^O. \tag{3.11}$$

3.2.1 Solving the model

The model is given by equations (3.3)-(3.5) and (3.7)-(3.11). Model parameters are α_j, β_j, η_{jm}, η_m^I, θ, ψ_{nj}, s_n, d_{nij}, T_{nj}, L_n, K_n, and VA_n^O. We solve for all other variables including all prices, industry factor employments, and trade.

We measure the extent of intra-industry trade by the Grubel-Lloyd index:

$$IIT_{nij} = \frac{2\min\left(Trade_{nij}, Trade_{inj}\right)}{Trade_{nij} + Trade_{inj}}.$$

This index varies between 0 (no intra-industry trade) to 1 (all intra-industry trade).

3.3 Parametrizing the model

Model parameters are obtained by three methodologies. Some parameters are taken from data or literature. Transport costs d_{nij} are estimated from a gravity equation. The rest of the parameters are obtained by fitting a subset of model equations to domestic data. Because these equations rely solely on domestic data, we can examine model performance by comparing trade flows predicted by the model to the actual ones. We do this in Section 3.4.

To obtain most parameters, we use data on 8 two-digit manufacturing industries (listed in Table 1) in 19 OECD countries (listed in Table 22). We use data from 1989 because this is the year for which most observations are available. Data sources are described in Appendix A.

Section 3.3.1 describes parameters which are taken from data or literature. Estimation of transport costs is discussed in Section 3.3.2. Methodology and results for fitted parameters are in Section 3.3.3. For convenience, we summarize parameters in Table 21.

3.3.1 Parameters taken from data and literature

Factor and intermediate input shares are shown in Table 23. Intermediate inputs constitute by far the largest part of output, with shares around 0.7-0.8. Labor shares are around 0.1-0.2 and capital shares are between 0.05-0.1.

To present factor shares in a more familiar form, the last column of Table 23 shows implicit capital shares in value added, calculated as $\alpha_j / \left(\alpha_j + \beta_j\right)$. These shares vary between 0.22 and 0.415 for different industries. Textile and Wood are the two most labor-intensive industries while Chemicals and Metals are the two most capital-intensive industries.

Industry shares for intermediate and investment goods are shown in Table 24. Uses of own intermediate goods are bolded. Own intermediate goods always constitute the largest share of all manufacturing inputs, but never make up more than a half of all inputs. Share of manufacturing inputs varies between 0.27 in the Food industry to 0.96 in the Chemicals industry. Food, Nonmetals, and Wood industries have the largest shares of nonmanufacturing inputs, mostly likely agricultural and natural resource products.

The last column of Table 24 shows industry shares in the capital good. Output of the

Machinery industry constitutes by far the largest share in the capital good, 66%. Output of the nonmanufacturing sector, specifically the construction industry, constitutes 31% of the capital good. Wood industry contributes 1.1%, most likely in the form of furniture.

3.3.2 Transport costs

We follow EK's methodology for estimating transport costs. From (3.5):

$$\frac{\pi_{nij}}{\pi_{nnj}} = \frac{X_{nij}}{X_{nnj}} = \frac{T_{ij}}{T_{nj}} d_{nij}^{-\theta} \left(\frac{c_{ij}}{c_{nj}}\right)^{-\theta}. \tag{3.12}$$

We define

$$S_{ij} \equiv T_{ij} c_{ij}^{-\theta}, \tag{3.13}$$

a measure of international competitiveness of industry j of country i. Taking logs of both sides of (3.12) and using the definition of S_{ij} we get a gravity-like equation:

$$\log \frac{X_{nij}}{X_{nnj}} = -\theta \log d_{nij} + \log S_{ij} - \log S_{nj}. \tag{3.14}$$

Following EK, we proxy transport costs by

$$\log d_{nij} = d_{kj}^{phys} + b_j + l_j + f_j + m_{nj} + \delta_{nij}, \tag{3.15}$$

where d_{kj}^{phys} $(k = 1, ..., 6)$ is the effect of physical distance lying in the kth interval, b is the effect of common border, l is the effect of common language, f is the effect of belonging to the same free trade area, m_n is the overall destination effect, and δ_{ni} is the sum of transport costs that are due to all other factors. Note that all transport costs are industry-specific. Also note that by definition $\log d_{iij} \equiv 0$.

Combining (3.14) and (3.15), we obtain the estimating equation:

$$\log \frac{X_{nij}}{X_{nnj}} = -\theta d_{kj}^{phys} - \theta b_j - \theta l_j - \theta f_j + D_{ij}^{exp} + D_{nj}^{imp} - \theta \delta_{nij}, \tag{3.16}$$

where $D_{ij}^{exp} = \log S_{ij}$ is the exporter dummy and $D_{nj}^{imp} = -\theta m_{nj} - \log S_{nj}$ is the importer dummy. The overall destination effect is calculated as $m_{nj} = -(1/\theta)\left(D_{nj}^{exp} + D_{nj}^{imp}\right)$.

The average (across country pairs and industries) estimated transport cost is 2.27. This transport cost includes all costs necessary to move goods between countries, such as freight, insurance, tariffs, non-tariff barriers (NTBs), translation of documents, and theft in transit. The minimum transport cost in any industry is around 1 and the maximum is 6.62. Average transport costs for each industry are listed in Table 25. Machinery and Textile products are cheapest to move between countries while Wood and Food products are the most expensive.

We present the estimated country-specific import barriers m_n in Table 26. Import barriers in each industry are measured relative to the United States, so that comparisons across industries are not possible. Total transport costs d_{nij}, on the other hand, are measured in absolute terms.

Rankings of countries according to their import barriers in each industry are shown in Table 27. United States is the most open country in all industries except the Textile industry. Turkey and Greece are the most closed countries. The last line on Table 26 shows the average import barrier of all countries other than the U.S. We can see that relative to other countries, U.S. tends to be less open in Textile and Metals industries and more open in Wood, Food, and Machinery industries.

3.3.3 Technology and other fitted parameters

We obtain technology parameters by fitting a subset of our model to data. We take output, spending, wages, world interest rate, estimated transport costs, and all calibrated parameters as given and solve for technology parameters, costs, and rates of return. Note that we only use domestic data in this procedure. This allows us to evaluate our model in Section 3.4 by comparing trade flows predicted by the model to actual.

To parametrize the model, we assume a long-run equilibrium condition that the rates of return normalized by prices of capital are equalized across countries. We use three equations, including the cost equation (3.4):

$$c_{ij} = r_i^{\alpha_j} w_i^{\beta_j} \prod_{m=1}^{J} \left[\sum_{n=1}^{N} T_{nm} \left(d_{inm} c_{nm} \right)^{-\theta} \right]^{-\frac{\eta_{jm}\left(1-\alpha_j-\beta_j\right)}{\theta}}, \tag{3.17}$$

the output equation:

$$Q_{ij} = \sum_{n=1}^{N} \pi_{nij} X_{nj}, \tag{3.18}$$

which is a simplified version of (3.8), and the rate of return equation:

$$r_i = r^w p_i^k, \tag{3.19}$$

where r^w is the world interest rate.

Variables π_{nij}, p_{nj}, and p_n^k are calculated using (3.5), (3.3), and (3.7), and the price index of nonmanufacturing sector is normalized to one. Output, spending, and wage data that we use here to fit the model are described in **??**. We set the world interest rate r^w to 20%.[15]

Note that Eaton and Kortum (2002) use a different procedure to find T's. They calculate them using the competitiveness measure (3.13), estimated as exporter fixed effect in the gravity equation, and data on wages. We cannot use a similar procedure because data on rates of return is not available.[16,17] Instead, we use a subset of our model to simultaneously solve for the rates of return and technology parameters. Our methodology also allows us to find the technology parameter of the nontraded sector. We do not do it in this paper, but describe the procedure in Appendix E.

Having solved for the rates of return r_i, we calculate industry employment and capital stocks using (3.9) and total factor stocks using (3.10). To calculate savings rates, we assume that the economy is in a steady state, so that total savings are just enough to as replenish the depreciated capital stock:

$$s_i = \frac{\delta p_i^k K_i}{VA_i}, \tag{3.20}$$

where δ is the depreciation rate and VA_i is the actual GDP.[18] We set the depreciation rate

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[15]The results are insensitive to the value of the world interest rate.

[16]If data on rates of return were available, technology parameters could be calculated as $\log \frac{T_{ij}}{T_{us,j}} = \log \frac{S_{ij}}{S_{us,j}} + \theta\alpha_j \log \frac{r_i}{r_{us}} + \theta\beta_j \log \frac{w_i}{w_{us}} + \left(1 - \alpha_j - \beta_j\right) \sum_{m=1}^{J} \eta_{jm} \left(\log \frac{X_{iim}/X_{im}}{X_{us,us,m}/X_{us,m}} - \log \frac{S_{im}}{S_{us,m}} \right)$. This expression is derived in Shikher (2004b).

[17]Competitiveness measures S_{ij} that are calculated using calibrated values of T_{ij} and c_{ij} may be different from those that are estimated in the gravity equation.

[18]We assume that net foreign investment is zero.

to 10%. We calculate income in nonmanufacturing, VA_i^O, as the difference between VA_i and manufacturing income $VA_i^M = r_i K_i^M + w_i L_i^M$.

Taste parameters ψ_{nj} are calculated as follows. The amount spent on investment goods from industry j is $B_{ij} = \eta_j^I B_i$. The amount spent on intermediate goods from industry j is

$$Z_{ij} = \sum_{m=1}^{J} \eta_{mj} \left(1 - \alpha_m - \beta_m\right) Q_{im}. \tag{3.21}$$

The amount spent on final goods from industry j is then $Y_{ij} = X_{ij} - Z_{ij}$ and the amount spent on consumption goods from industry j is $C_{ij} = Y_{ij} - B_{ij}$. The proportion of total country income spent on consumption goods from industry j is $\psi_{ij} = C_{ij}/VA_i$. As we mentioned before, we allow for heterogeneity of tastes across countries by letting ψ be country-specific.

Calibrated industry technology parameters relative to the United States are shown in Table 28. Rankings of countries according to their technology parameters in each industry are shown in Table 29. United States has the highest technology parameter in Food, Wood, Paper, and Chemicals industries. Italy has the highest technology parameter in Textile industry while Japan has the highest technology parameter in Nonmetals, Metals, and Machinery. Developing countries are generally at the bottom of the rankings.

Capital-labor ratios in manufacturing, with respect to the United States', are shown in the last column of Table 28. Rankings are shown in the last column of Table 29. U.S., Japan, France, and Germany have the highest capital-labor ratios while Turkey, Mexico, Portugal, and Greece have the lowest.

3.4 Evaluating the model

In Section 3.3.3, the model was fitted to domestic data. In this section, we evaluate the model by checking how well it can predict trade flows and prevalence of intra-industry trade. We also evaluate the model by using it to perform counterfactual simulations and comparing its predictions with results from other empirical studies.

We start by looking at how well the model can predict trade flows. We can use several statistics to summarize the fit of the 19*18*8=2,736 trade flows generated by the model. One is the ratio of predicted to actual sum of squares, which is equal to 1.07.[19] Another is the ratio of error sum of squares to the actual sum of squares, which is equal to 0.007. Both of these measures tell us that the model fit is good.

We can also look at percent deviations of predicted from actual trade flows. Of 2,736 trade flows, 41% are within 5% of the actual, 68% are within 10%, 80% are within 15%, 88% are within 20%, and 96% are within 30%. The average percent deviation is 8.66%.

Figure 5 shows the histogram of these percent deviations. The distribution of deviations is positively skewed and the predicted trade flows are positively biased. So, the model tends to predict trade flows that are greater than actual. One possible explanation can be that we only model a selection of countries, so the total trade predicted by the model is allocated among fewer countries. Or, this could be a shortcoming of the model, perhaps related to our approach to modeling international investment. Yet another reason could be our choice of value for parameter θ. More investigation is required to understand this result.

Figure 6 shows the percent deviations of the predicted from actual trade flows by in-

[19]This measure is called the R^2 in regression. However, here it is not constrained to be between zero and one.

dustry. In all industries, the majority of predicted trade flows fall within 10-15% of actual. Table 30 shows the average and median prediction errors by industry. The average errors vary between 4.6% in Food and Nonmetals industries to 13.95% in the Metals industry. Again, we can see that the model tends to predict more trade than actual.

An important feature of our model is the presence of both inter-industry and intra-industry trade. Therefore, an important test for this model is whether it can correctly predict the prevalence intra-industry trade. To measure intra-industry trade we use the Grubel-Lloyd (GL) IIT index. In each industry, we calculate the GL index for each pair of countries. This results in the industry-level bilateral GL index. Averaging all bilateral GL indices with an industry, we arrive at the industry GL index. Averaging all bilateral GL indices across all industries we arrive at the world GL index.

The predicted and actual industry and world GL indices are shown in Table 31. We can see that the model predicts the size of intra-industry trade quite accurately. The predicted world GL index is within 0.55% of the actual while predicted industry-level IIT indices are within 0.05-6.5% of the actual.[20]

How well does the model predict trade flows and intra-industry trade for each country? Table 32 shows that the model does about as well for individual countries as it does for individual industries. Importantly, it shows that the model predicts trade for poor countries, such as Turkey, Mexico, and Greece, as well as it does for rich countries.

In addition to comparing predicted trade with actual, there is another manner in which

[20]Since parameter θ determines intra-industry comparative advantage, higher θ would lead to lower intra-industry trade. In this paper, for the lack of better information, we assume that θ is the same in all industries. The deviations of the predicted GL index from the actual may be telling us something about the differences of industry θ's. For example, higher than actual GL index in the Textile industry may signal that the θ in the Textile industry is greater than 8.28.

we test our model. We conduct an experiment in which capital-labor ratio in a country is increased and its effect on specialization, measured by industry shares, is recorded. We then compare these results to those obtained by applying regression methodology of Harrigan (1997) to our dataset. This procedure is described in detail in Section 4.2. The effects predicted by the model are close to those estimated by regression, providing further support for our model.

3.5 Extension of the model with endogenous capital stocks and international capital markets

The model can be easily extended to a dynamic setting in which capital stocks vary over time, thus creating a link between trade and growth. We model capital accumulation given the exogenous savings rate, as in the Solow model.[21,22] Since we model individual industries, we are able to endogenously determine the price of capital good separately from the prices of consumption goods, as shown in Section 3.2.[23] Our model makes the distinction between capital stock and financial capital that is used to buy the capital stock. The amount of savings and the quantity of investment are linked to each other by the price of capital, which is determined through trade.

The evolution of capital stock in country i is described by the following equation:

[21] The static version of the model, developed in the previous sections, can be thought of as the short-run version of this dynamic model.

[22] In a steady state, equation (3.23) is compatible with Ramsey-type consumer optimization framework where s varies according to the rate of time preference (and elasticity of intertemporal substitution) provided that there is no technological or population growth.

[23] Eaton and Kortum (2001b) estimate machinery prices across countries, but consider machinery industry in isolation. They do not take inter-industry trade into account, a fact that they discuss in the appendix to their paper.

$$K_{it} = (1 - \delta) K_{i,t-1} + I_{it}, \tag{3.22}$$

where δ is the depreciation rate, and I_{it} is total physical investment (i.e. number of machines bought). The value of investment is $B_{it} \equiv p^k_{it} I_{it}$.

Without international capital markets, domestic investment can only be financed by domestic savings. Given the exogenous savings rate s_i, domestic investment is $B_{it} = s_i VA_{it}$. The quantity of capital good that can be bought with this amount is $I_{it} = s_i VA_{it}/p^k_{it}$. This quantity is higher when price of capital is lower or when country income is higher. The steady-state capital stock is given by

$$K_i = \frac{s_i VA_i}{\delta p^k_i}. \tag{3.23}$$

We also attempt to create a bridge between trade and open-economy macro models by incorporating a simple model of international investment. Admittedly, our representation of international capital markets is simple. We assume, for example, that savings can be freely moved between countries, an assumption that is likely to result in overestimated international capital flows. However, the goal at this point is not to model capital markets as realistically as possible, but simply to demonstrate how they can be integrated into the model.[24]

[24] Some of the more prominent examples of the previous (mostly theoretical) literature that considered capital accumulation and international investment with relation to international trade are: Findlay (1984) and Smith (1984), who discuss growth and capital accumulation in the context of the Ricardian and Heckscher-Ohlin models; Grossman and Helpman (1995), who discuss trade in the context of a model with market imperfections and endogenous growth; and Baxter (1995), who analyzes international trade in the context of a business cycle.

With international capital markets, owners of capital in each country n can sell their machines domestically for the price p^k_{nt}, then take the proceeds and buy machines in country i for p^k_{it} per machine. When they do that, instead of receiving r_{nt}, they receive r_{it}. Competition ensures that the (instantaneous) rate of return, adjusted for the price of capital, r_{nt}/p^k_{nt}, is the same in all countries. We call this number the world interest rate r^w.[25]

Investment is now endogenous and can be negative.[26] The difference between domestic investment and domestic savings, $BF_{nt} \equiv B_{nt} - s_{nt}VA_{nt}$, is the net capital inflow into country n in period t. The negative of net capital inflow is the current account: $CA_{nt} = -BF_{nt}$. The total world savings are still given by $\sum_n s_{nt}VA_{nt}$. Country income VA_{nt} now includes return on savings invested in foreign countries.

[25]This formulation assumes that there is a good that can be traded freely between countries.

[26]Negative investment represents a sale of capital goods on domestic markets. These capital goods are bought either by consumers for final consumption or producers for intermediate consumption.

Chapter 4

Trade, specialization, and trade policy

Having developed and evaluated the computable model of trade in Chapter 3, we proceed to use the model to perform several investigations of trade and specialization. The approach we use is simulation. In this section, we only use the static version of the model in which country capital stocks are fixed.

We begin by studying the effects of different determinants of trade on the volume and pattern of trade. We then proceed to study the effects of technology and factor endowments on specialization. We compare the results from simulation studies to the regression results we obtained in Chapter 2. Finally, we use the model to study the effects of several policy actions. We study the effects of trade wars between the U.S. and E.U. and trade liberalization between rich and poor countries.

4.1 Accounting for international trade

Trade in our model is determined by factor endowments, industry- and product-level comparative advantage, geography, and tastes. Thus, our model combines the determinants of trade found influential in previous literature.

We have the ability to find out how much each of these determinants of trade contributes to the volume of trade and prevalence of intra-industry trade. This exercise is similar to the growth accounting exercise, where structure is imposed on data and the contribution of each component is calculated.

To find the contribution of each determinant of trade, we remove them one-by-one and note the effects on the volume of trade and size of intra-industry trade, measured by the GL index. At the conclusion of this section, we will consider how much the pattern of trade, as measured by net exports, changes when individual determinants of trade are removed.

To remove factor endowment differences, we set capital-labor ratios equal in all countries. We want to determine what would happen to trade if all countries had the same capital stocks. We take capital stock, technology, and other parameters and solve for all prices, including wages and rates of return, as well as trade and industry factor employments.

To remove comparative advantage on the industry level, we set relative technologies to be equal in all countries. In other words, we set $T_{nj}^{new} = \tau_n T_{us,j}$, where τ_n is an average of current relative technology parameters. To remove comparative advantage on the product level, we increase θ.[1]

[1] In practice, we can increase θ twelve times, to 100. For higher values of θ, a numerical solution is not obtainable. Increasing parameter θ also affects the mean of the Frechet distribution, in turn affecting the industry-level comparative advantage. To compensate, we adjust T_{nj}'s so that the means remain constant, resulting in a much greater 'spread' of T_{nj}'s. However, this adjustment has virtually no effect on the results.

We find that the volume of trade depends little on the strength of industry-level technological and factor endowment advantages. Shutting down industry-level comparative advantage causes a 5% reduction in the volume of trade, shutting down factor endowment differences has virtually no effect on the volume of trade, and shutting down both causes a 4% decrease in the volume of trade. Our results indicate that lower inter-industry trade is compensated, to some extent, by higher intra-industry trade. Removing taste differences by setting equal taste parameters in all countries actually increases the volume of trade by 6%.

On the other hand, the volume of trade is very sensitive to the strength of the product-level comparative advantage. Increasing θ to 100 reduces the volume of trade to about 7% of its current level. Both inter-industry and intra-industry portions of trade decline, but the remaining trade is all inter-industry (world average GL index is 0.03). Countries become much more self-sufficient. Trade virtually disappears in some industries, such as Food. The least reduction of trade occurs in the Machinery and Textile industries, likely because the strength of the industry-level comparative advantage is greater in those industries. But even in the Machinery industry, the remaining trade is only 10% of its current level.[2]

The intuition for this result is that trade is driven by outstanding producers. In any country, the average producer does not export.[3] Only producers that are significantly more efficient than the average are able to overcome the trade costs and be competitive in foreign markets. By increasing θ, we make all producers average or mediocre. Therefore, given the

[2]Starting with $\theta = 100$, a moderate reduction of trade barriers leads to only a small increase of trade volume. Setting distance effects 20% closer to one ($d = 1$ mean free trade) brings the volume of trade only 4% closer to its current level. The GL index remains at 0.03 during this experiment. Numerical solutions for lower trade barriers in this case could not obtained.

[3]Producer-level literature is referenced in Section 2.

current levels of trade barriers, trade virtually disappears.

Table 33a summarizes the accounting for the volume of trade. Within-industry heterogeneity, driven by product-level comparative advantage, accounts for 93% of the volume of trade. Different relative efficiencies across industries, which create industry-level comparative advantage, accounts for 6% of the volume of trade. Differences of factor endowments across countries have virtually no effect on trade (they decrease trade by 1.3%). Differences of tastes across countries decrease trade by 6%.

With regard to sizes of inter- and intra-industry trade, removing product-level heterogeneity, as we already noted, removes all intra-industry trade and decreases GL index to 0.03. To account for inter-industry trade, we first shut down factor endowment differences, which increases the GL index by 2.5%. Shutting down industry-level comparative advantage increases inter-industry trade by 13%. Shutting both down increases GL index 15%, from 0.46 to 0.53. The effects of the two sources of industry-level advantage are approximately additive, i.e. removal of one has approximately the same effect regardless of whether the other one has been removed.

To account for the remainder of inter-industry trade, we have to remember that there are two other industry-level determinants of trade: geography and tastes. Geography works through intermediate goods and industry linkages. In the presence of geographic barriers (i.e. trade costs), being close to countries that are productive is an advantage because of access to cheaper intermediate goods. Since this advantage depends on the presence of trade barriers, we can turn it off by removing all trade barriers, i.e. setting all distance parameters to one. Location will then have no effect, since prices will be the same in all countries. Setting all distance parameters to one increases the GL index from 0.53 to

0.9. Removing taste differences raises the GL index to 0.95. Table 33b summarizes the accounting for inter- and intra-industry trade.

We now turn our attention to the pattern of trade, represented by net exports. We find that removing industry-level comparative advantage has dramatic effects on the pattern of trade. Nearly a half (75 out of 152) of observed net exports change signs, meaning that trade flows reverse. Tables 34a and 34b reveal the changes of exports and imports that occur when industry-level comparative advantage is removed. Removing factor endowment differences also has an effect on the pattern of trade, albeit a much smaller one (trade flows reverse in 14 out of 152 cases). The effect of shutting down product-level comparative advantage on the pattern of trade seems to be moderate. Trade becomes mostly one-way and many trade flows shut down. Most of the remaining trade flows follow the original pattern.

The results of this section demonstrate the separate roles of key determinants of trade. Industry-level comparative advantage and factor endowment differences are mostly responsible for the pattern of trade. Within-industry heterogeneity drives the volume of trade. In addition, industry-level comparative advantage and factor endowment differences account for only a small portion of inter-industry trade. Geography-dependent sources of advantage account for most of it.

We also conclude that factor endowment differences have a weaker effect on volumes and patterns of trade than do technological differences. Factor endowment, specifically capital endowment, differences have a negligible effect on the volume of trade and only a small effect on the pattern of trade. Of course, these results are obtained using only manufacturing sector data. They may change when other factors and other sectors are included in the model. For example, including natural resource endowments and mining and agriculture sectors may affect the results.

4.2 Technology, factor endowments, and specialization

Specialization is one of the key topics in international trade. It has been addressed in numerous works. Most of the previous studies analyzed how factor endowments and, to a lesser extent, technology affect specialization.[4] In this section, we use our model to address the same question and compare our results with results of previous studies. Similarity of results provides further validation of our model. Moreover, compared with previous studies, we are able to provide additional insights into the effects of technology and factor endowments on specialization.[5]

A recent empirical study that combines technological and factor endowment explanations of specialization is Harrigan (1997). Harrigan estimates the effects of technology, measured by industry TFP, and factor endowments on specialization, measured by industry shares. Harrigan uses a reduced-form estimating equation derived from the translog revenue function. In Chapter 2, we modify the methodology of Harrigan by using a utilization-adjusted measure of capital stock and a wider set of countries and industries.

Here, we have an opportunity to use a structural model to address the same question. We want to determine the effect of capital stock and technology on specialization. The model we developed in Chapter 3 shares many features with the model we used in Chapter

[4] Good reviews of the latest works in this area are Leamer and Levinsohn (1995) and Harrigan (2003).

[5] Note that only under certain assumptions (not satisfied in our model) is the pattern of trade (net exports) that we talked about in the previous section is the same as specialization in production, which is the focus of this section.

2, such as constant returns to scale and factors that are mobile across industries and fixed for a country. Our computable model has two factors, capital and labor, which allows us to study the effect of capital-labor ratio on specialization. Since we have industry- and country-specific measures of technology, we can also study the effect of technology on specialization. Of course, the measure of technology used in our computable model is different from the measure used in the regression framework of Chapter 2. In Chapter 2 we use TFP, which is exogenous, whereas in the computable model we use the technology parameter T (TFP is endogenous in that model).

There is another difference between the models. In the computable model, we only model manufacturing sector and can change only manufacturing capital stock. In the regression analysis, we assume that capital is mobile across sectors and study the effects of country capital stock on specialization. However, if we assume that a fixed portion of country capital stock goes into manufacturing sector, then changing country capital stock is the same as changing manufacturing capital stock.

To find the effects of capital stock on specialization we will increase manufacturing capital stock in one country while holding capital stocks of other countries constant and simulate the model. After each simulation, we will note the changes in country n's specialization brought about by the increase of country n's capital stock. We will measure specialization by industry shares, just as we did in Chapter 2. We will repeat this for every country in our sample, which means that we will run 19 simulations.

We will use a similar procedure to measure the effect of technology. Holding all other technology parameters constant, we will raise the technology parameter in industry j of country n and measure the resulting changes in specialization in country n. We will repeat this for each industry and each country in the sample (19*8=152 simulations total).

The coefficients estimated in Chapter 2's methodology are semielasticities of industry shares with respect to capital (or technology). To obtain a comparable number, we will divide changes of industry shares by the percent change of capital (or technology) that we simulated. We then average the result across countries:

$$\alpha_j = \frac{1}{N}\sum_n \alpha_{nj} = \frac{1}{N}\sum_n \frac{100\left(S_{nj1} - S_{nj0}\right)}{\log\left(K_{n1}/K_{n0}\right)},$$

where $S_{nj} = VA_{nj}/VA_n$ is the share of industry j in GDP. Note that we calculate coefficients by subtracting the initial values for the same country, so they are comparable to within-country estimates of Chapter 2.[6]

The simulated values of α_j are presented on the second row of Table 35. The coefficient of -1.173 in the Food industry means that if total capital stock increases by 10%, the share of the Food industry will decrease by 0.1173 percentage points.

The estimated coefficients from Chapter 2 are reproduced for convenience on the first row of Table 35. The coefficients obtained from simulation and regression are close for most industries. Without the Machinery industry, the correlation between them is 0.81. The coefficients are also plotted against each other in Figures 7a and 7b. Given that they are obtained using such different methodologies, it is remarkable that the signs and magnitudes of coefficients are so similar. The similarity provides cross-validation of our regression and

[6]We simulate increases of 10, 20, 30, and 40% with no noticeable differences in the results. We report the averages over these experiments. Elasticities, which we report in addition to semielasticities, are measured as $\varepsilon_n = \dfrac{1}{N}\sum_n \dfrac{\log\left(S_{nj1}/S_{nj0}\right)}{\log\left(K_{n1}/K_{n0}\right)}$.

simulation approaches.

The Machinery industry is an obvious outlier. In regression, capital stock has a highly positive effect on the Machinery industry, whereas in simulation, the effect is only slightly positive. One possible explanation is that Machinery industry is more sensitive than other industries to the state of overall domestic infrastructure. Therefore, it is more sensitive to the country stock of capital (which includes infrastructure) than to stock of capital in manufacturing. Further investigation is required to understand the disparity.

When using simulation rather then regression to obtain the coefficients, we have the advantage of being able to look at the coefficients for each country individually. When looking at country-specific coefficients, shown on Table 36, we see that there is a good deal of variability in the effects of capital stock across countries.

Only in two industries, Wood and Metals, the signs of the coefficients are the same for all countries. In Paper, Nonmetals, and Machinery industries, half of coefficients is positive while the other half is negative.[7] The magnitude of the effects can be very different as well, even in industries where the direction of the effect is the same in all countries. For example, the effect of higher capital stock on the share of the Metals industry is three times higher in Norway than it is in Japan.

This variability makes the usefulness of average coefficients questionable. While the average effect of capital stock on industry shares in the Food industry is -1.2, it varies between -2.1 and 0.2 for individual countries. In the Machinery industry, the average coefficient is 0.1 while for individual countries it varies between -1.5 and 1.3. It does not

[7]Notably, these industries are in the middle of capital intensity rankings: they are neither strongly capital-intensive nor strongly labor-intensive.

seem that we can pin down the effects of capital stock on specialization that would be applicable to all, or even most, countries. The size and, for many industries, direction of the effect are country-specific and probably depend on other factors, such as technology and geography.[8,9]

Since it is difficult to get an intuitive feel for semielasticities, we also report elasticities of industry shares with respect to capital in Table 37. To gauge the effects of technology on specialization we will focus exclusively on elasticities. Remember that our measure of industry technology is different from Harrigan's. Therefore, magnitudes of technology effects on specialization are not comparable. However, the effects should be similar qualitatively.

Share elasticities with respect to technology are presented in Table 38. Elasticities with respect to own technology are bolded for convenience. All of them are positive while all cross-industry elasticities are negative. These results echo the estimation results of Chapter 2, where all own-TFP effects were positive while most of cross-industry effects were negative.

Share elasticities with respect to own technology parameters vary between 0.214 for the Food industry and 0.691 for the Metals industry. Most cross-industry elasticities are an order of magnitude less than own-industry elasticities. The exception is the Machinery industry. Its technology parameter has a strong negative effect on the shares of other industries, with the largest effect on the Textile industry. A ten-percent increase of the Machinery industry technology parameter in an average country would result in Machinery

[8] This variability would show up as a low R^2 in a regression. In Harrigan's methodology, most of the variation of the shares is explained by the fixed effects, so it is difficult to tell how well the model would explain the data in the absence of the fixed effects.

[9] Even though there is variation across countries in the elasticities of specialization with respect to capital, we have calculated the correlation between average (across countries) elasticities and capital shares. This correlation is 0.55 for capital share in output and 0.59 for capital share in value added. This number can be interpreted as evidence of the Rybczynski effect (see Ethier (1982a); we can not refer to the Rybczynski theorem since goods prices are not held constant in our model).

share increasing by 3.95% and Textile share decreasing by 3.31%. This result is interesting because there is nothing in the model or parameter values to make this connection obvious.

The magnitudes and signs of elasticities are quite similar across countries (see Tables 38a-38d). Own-industry elasticities are always positive. With a few exception, cross-industry elasticities are negative. Thus, the effect of technology parameters on specialization is much more predictable than the effect of capital stock.

4.3 Trade wars and trade liberalization

In this section, we use a simpler version of the model to simulate several policy actions. We study the effects of trade wars between the United States and the European Union in various industries. We find that trade wars in some industries hurt E.U. more than the U.S., while trade wars in other industries hit the U.S. economy harder.

We also study the effects of trade liberalization between rich and poor countries. We find that depending on policy goals, different industries should be targeted for lower trade barriers. The examples of policy goals are increasing world employment, increasing employment in the poor countries while maintaining employment in the rich countries, or increasing the world welfare.

The model used in this section includes labor as the only factor of production. In addition, labor is mobile between manufacturing and other sectors of the economy. This allows us to study the effects of the policy actions on overall manufacturing employment.

4.3.1 U.S.-E.U. trade wars

The trade volumes between the United States and European Union are very high. However, these two entities often threaten to go to trade war with each other when they perceive an unfairness in trade arrangements or competition. In 1999, United States imposed punitive tariffs on a range of European food products because of a dispute over banana exports by American companies to Europe. This dispute was solved in 2001. In another incident, the imposition by the U.S. of high tariffs on steel imports (to protect its steel industry in a time of recession) in 2002 resulted in reciprocal tariffs by the European Union. That dispute was solved in 2003.

There are several ongoing disputes between the U.S. and E.U. that threaten to deteriorate into trade wars. There is a dispute over genetically-modified organisms/foods (GMOs) that U.S. alleges face unfair restrictions in European markets. There are also challenges by the European Union against the Unites States in the WTO about the U.S. dumping calculations and tax breaks for large corporations.

These disputes and threats of trade wars almost always focus on one particular industry. No one is really talking about an all-out trade war between the United States and the European Union. However, since all industries are linked with each other, even a trade war in one industry will have effects on all industries. Our model allows us to simulate a trade war between the European Union and the United States that is limited to one industry. We will focus on the effects of such a trade war on employment, prices, costs of production, and welfare in the U.S., E.U., and the rest of the world. In 1989, the E.U. included Austria, France, Germany, Greece, Italy, Portugal, Spain, and the United Kingdom. We will simulate a trade war by increasing trade barriers in an industry to the point where trade becomes prohibitively expensive.[10]

Table 39 summarizes the effects of trade wars in different industries on total manufacturing employment while Table 40 summarizes the effects on welfare. The name of the industry in which there is a trade war is at the top of the column. The last column refers to an all-out trade war in all industries. Lets consider, for example, a trade war in the Textile industry. We can see from Table 39 that this trade war would result in a loss of more than 150,000 jobs in the European Union, mostly in Italy and Spain. United States, on the other hand, stands to gain over 116,000 jobs from this trade war. The rest of the world also gains jobs. Korea, with its high technology of producing Textile products, is able to gain 44,000 jobs.

However, this trade war, as all other trade wars, causes lower welfare in all countries because of higher goods prices. However, welfare losses from the trade war in Textiles are relatively small because production is able to move easily between countries. The industry in which a trade war between E.U. and U.S. causes the highest declines in welfare is the Machinery industry because only few countries in the world have the technology to produce Machinery cheaply.

Returning to Table 39, we can see that a trade war in the Food industry also hurts the E.U. manufacturing employment while benefiting the U.S. employment. The rest of the world gains little from this trade war. The trade war in the Food industry mainly transfers manufacturing employment from the E.U. to the U.S. Interestingly, in the 'banana' dispute, the European Union had quickly agreed to U.S. demands once U.S. sanctions against E.U.'s

[10]In the simulation, we increase trade costs 20-fold, though most trade disappears when trade costs are increased 4-fold.

(mainly food) products were in place. The final deal was hailed as a victory for the U.S. Clearly, the European Union felt that a trade war in the Food industry was not in its interest.

If there ever were a trade war in the Machinery industry, the U.S. would lose many more jobs than the European Union. However, the total change of employment in the European Union due to this trade war is misleading. We can see that in fact the United Kingdom and Germany stand to lose a lot of jobs while Spain and France stand to gain nearly as many jobs. Spain and France at least partially substitute disappeared U.S. imports with increased domestic production. The country which stands to gain the most from this trade war is Japan, which would be able to export Machinery with less competition to both U.S. and the European Union.

So far, we have focused on changes in total manufacturing employment. However, changes in total manufacturing employment mask the underlying changes in industry employments. Lets focus on the trade war in the Metals industry. It is a good approximation to the recent trade war in the steel industry since the steel industry is a major component of the Metals industry.

Metals industry has strong forward linkages to the Machinery industry. Therefore, one of the results of the trade war in the Metals industry is higher costs of production in the Machinery industry, as we can see in Table 41. The percentage increase of the costs of production in the Machinery industry is about a half of the increase in the Metals industry. Because the United States depends so much on the imported steel, it suffers one of the highest increases of the costs of production in the Machinery industry (second only to the U.K.).

In the U.S. Metals industry, higher costs of production are offset by the increased domestic demand for domestic metal products. As the results, the U.S. Metals industry actually gains almost 18,000 jobs as the result of the trade war in the Metals industry. In the Machinery industry, on the other hand, higher costs of production are not offset by higher demand and, therefore, the industry looses about 11,000 jobs (see Table 42). Therefore the main employment result for the U.S. of this trade war is the redistribution of employment from the Machinery industry to the Metals industry. The net effect on total manufacturing employment is relatively small. These simulation results explain why the U.S. firms that produce machinery were such vocal opponents of the higher U.S. tariffs on steel.

4.3.2 Reducing trade barriers between rich and poor countries

There has been much political debate about trade barriers between rich and poor countries. Poor countries often accuse richer countries of having high trade barriers for products in which poor countries specialize, for example Textiles. Rich countries, on the other hand, often accuse poor countries of having high trade barriers on products in which poor countries face tough competition from rich countries, for example Machinery.

Our model allows us to simulate industry-specific reductions of trade barriers between rich and poor countries. We will be able to see the effects on employment, specialization, prices, and welfare. The implications for employment, welfare, etc. will, of course, be different depending on which industry the reduction takes place in. For example, a reduction of trade barriers in one industry may increase employment in poor countries while reduction in another industry may decrease it.

The poor countries in our dataset are Greece, Korea, Mexico, Portugal, and Turkey.

All other countries are rich. Only trade barriers between rich and poor countries will be reduced. Trade barriers between rich countries and between poor countries themselves will remain at their present level.

Unfortunately, we do not have absolute measures of policy-related trade barriers (tariffs and NTBs). We can only estimate import barriers relative to the U.S. import barriers. However, we do have absolute measures of total trade barriers between countries, d_{nij}. Anderson and Wincoop (2004) estimate that policy-related trade barriers (tariffs and NTBs) constitute about 10-15% of all international trade costs. Therefore, we will simulate removal of policy-related trade barriers by reducing trade costs by 10%. We realize that the proportion of policy-related trade barriers in total trade costs varies across industries and countries. However, in the absence of data, we will use the 10% approximation.

Tables 43, 44, and 45 summarize what happens to total manufacturing employment and welfare when trade costs between rich and poor countries are reduced by 10% in a particular industry. The name of the industry in which the costs are reduced is at the top of each column in these tables. The last columns refers to the simultaneous 10% reduction of trade barriers in all industries. Poor countries are highlighted in bold. At the bottom of Table 44 there is a summary of employment implications for all rich and all poor countries.

We can see that employment effects vary depending on which industry trade barriers are reduced in. The most dramatic employment implications occur when trade barriers are reduced in the Textile industry. Almost 1/2 million jobs are added in poor countries while about 175 thousand jobs are lost in rich countries. Korea, with its high productivity in Textiles, gains most of the jobs. As a percentage of labor force, Portugal gains almost as much as Korea, 8.5%. All rich countries lose jobs. United States looses the most jobs in absolute terms, about 75,000.

Interestingly, Mexico looses jobs when trade costs are reduced in the Textile industry. This is because Mexico already had easy access to a big market (United States) before the reduction of trade barriers. Therefore, the reduction mostly benefits other developing countries, who can now compete with Mexico on more equal terms. In addition, Mexican technology parameter in the Textile industry is the lowest of all countries in our dataset. As the result, Mexico looses Textile and total manufacturing jobs (see Tables 46 and 47 for details).

Significant employment changes also occur when trade barriers are reduced in the Machinery industry. Korea and Portugal (which have higher technology than other poor countries) gain employment while other poor countries and most of the rich countries loose. Korea gains the most jobs in absolute terms, but Portugal gains almost as much in relative terms. Table 45 shows that reduction of trade barriers in the Machinery industry results in the greatest increase in welfare, particularly in the poor countries. This is because Machinery prices fall significantly in the poor countries when trade barriers in that industry are reduced.

Tables 47 and 48 show price declines that occur when trade barriers are reduced in the Textile and Machinery industries, respectively. Comparing price declines in the target industry (the industry in which barrier reduction took place) as well other industries, we can see that price declines in the poor countries are several times greater when the Machinery industry is the target industry. In the rich countries, on the other hand, price declines are greater in the target industry when the target industry is Textile. However, because of Machinery industry's strong forward linkages, reducing trade barriers in the Machinery industry causes greater price declines in all other industries, which is why targeting the Machinery industry has the greatest potential for increasing welfare.

In five out of 8 industries, poor countries gain jobs and rich countries loose jobs when trade barriers between them are lowered. In these five industries, world as a whole gains manufacturing jobs. In two industries, Wood and Paper, rich countries gain and poor countries loose jobs. In one industry, Food, both rich and poor countries loose as a group. The world looses manufacturing jobs when trade barriers are reduced in the Wood, Paper, and Food industries. Welfare, of course, always increases when trade barriers are reduced.

Which industry is the best target for reducing trade barriers if the goal is to increase world employment? Table 44 shows that the Textile industry is the best target in this case. If the goal is to increase employment in the poor countries while maintaining employment in the rich countries as much as possible, then the Metals industry is the best target for reducing trade barriers (and Machinery is the worst). If the goal is to increase welfare (that is to reduce goods prices), then the best target for trade barrier reduction is by far the Machinery industry.

Chapter 5

Conclusion

We study trade and specialization using two approaches: simulation and estimation. For the estimation approach, we improve the methodology developed by Harrigan (1997). This methodology makes it possible to combine technology and factor endowments in the estimating equation, thus combining the Ricardian and Heckscher-Ohlin explanations for specialization. Our innovation allows us to correctly estimate this equation using the short-span high-frequency data, which is the only data currently available.

Previous literature has established that factor utilization is not constant in the short run. Therefore, to correctly calculate total factor productivity in the short run, factor services must be used as measures of inputs into the production process. If factor stocks are used instead of factor services, the resulting TFP measure is more volatile and more correlated with output than the actual TFP. In this case, the effects of Total Factor Productivity on specialization are overestimated.

Following Burnside et al. (1995a) and Baxter and Farr (2001b), we use consumption of electricity to calculate capital utilization rates. We then use capital and labor services to calculate Total Factor Productivities. For comparison, we also calculate TFPs using capital stock. We find that if variable capital utilization is not accounted for, the effect of TFP on specialization is overestimated. This results shows the importance of short-run effects when using short-run data.

We use two alternative assumptions about capital mobility. We assume that capital is either freely and instantaneously mobile between industries or that it is specific to each industry and cannot move between them. These are two extreme assumptions about capital mobility.

We find that the effect of TFP on industry share is overestimated if variable capital utilization is not taken into account, regardless of the assumption about capital mobility. The overestimation is greater if we assume that capital is not mobile. We also find that once the variable capital utilization has been accounted for, the assumption about mobility of capital has little effect on the technology coefficients.

We show how our model explains the pattern of specialization by providing detailed examples for several countries in our dataset. We use the estimated model to explain why the share of the machinery industry is smaller in Portugal than Germany. We consider why the changes of specialization experienced by Korea and Turkey between 1975 and 1995 were so different. We show that accounting for variable capital utilization significantly affects our explanation of these facts.

We then study trade and specialization using a simulation approach. We develop a new computable model of trade that improves, in several aspects, on previously available models. Our model incorporates all the major determinants of trade: technology, factor endowments, tastes, and trade costs. The model is compact and does not require the

Armington assumption to explain intra-industry trade.

We parametrize the model and test its fit. We find that the model accurately predicts trade flows and prevalence of intra-industry trade. We then use the model to perform several investigations.

In the first investigation, we use the model to analyze the effects of comparative advantage, factor endowments, tastes, geography, and within-industry heterogeneity on the volume and composition of trade. Our results show the separate roles of these key determinants of trade. We find that the volume of trade is determined mostly by within-industry heterogeneity, inter-industry trade is driven largely by geographic advantages, while the pattern of net exports is affected the most by industry-level comparative advantage.

Specifically, 93% of the volume of trade is due to within-industry heterogeneity while 5% is due to industry-level comparative advantage. We find that 78% of inter-industry trade is due to geographic advantages, 12% due to industry comparative advantage, 8% due to taste differences, and 3% due to factor endowment differences. We also find that eliminating industry comparative advantage has the most dramatic effect on the pattern of net exports with nearly a half of trade flows actually reversing. Eliminating factor endowment differences has a much smaller effect.

In the second investigation, we study the effects of factor endowments and technology on specialization, a topic addressed in several recent empirical studies. We find that, barring one outlier industry, average effects of capital stock on industry shares predicted by simulation are similar to those we previously obtained by regression. This similarity provides support to both of our methodologies. However, we find that the signs and magnitudes of these effects vary significantly across countries. Therefore, we conclude that average effects of capital on specialization have limited usefulness in economic analysis.

We find the effects of technology to be more predictable. Higher technology in an industry always increases that industry's share while almost always decreasing shares of other industries.

Our results suggest that the effects of capital endowments on trade and specialization in the manufacturing sector are weaker and more ambiguous than effects of industry technology levels. The effects of capital endowment differences on the volumes of trade are negligible and their effects on the patterns of trade are small.

We also use our model to simulate the effects of several policy actions. We study the effects of trade wars between United States and European Union. We find that trade wars in some industries are more detrimental to the U.S. than E.U., while trade wars in other industries have the opposite result. We also study the effects of trade liberalization between rich and poor countries and find that the choice of industries to target for trade liberalization depends on the policy goal that can be, for example, welfare maximization or employment maximization.

While our basic model has exogenous country capital stocks, we develop two extensions where capital stocks are endogenous. One extension incorporates endogenous capital accumulation, given the exogenous savings rate. This extension links international trade with economic growth. Another extension introduces international capital markets into the model, creating a bridge between our model and open-economy macro models.

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Appendix A

Data

To perform the estimation we construct our own dataset. We use data for eight 2-digit industries of OECD countries. The countries were chosen because of availability of data. The industries are described in Table 1.

A.1 Data for estimation

The time period analyzed is 1975-1995, though the length of time series varies across countries and industries. Each industry has 404 observations. The list of countries included in the study is presented in Table 2.

The industry-level value added, investment, and employment are obtained from the Industrial Statistics Database of the United Nations Industrial Development Organization (UNIDO). Country-wide value added (GDP) is from the International Financial Statistics (IFS) database of the International Monetary Fund.

Industry capital stock is calculated from the investment time series using the perpetual inventory method with geometric depreciation. Industry-level electricity consumption is from the World Basic Energy Statistics database of the International Energy Agency. The average industry-level U.S. utilization rates, which we use to proxy for $\overline{z}_{ic}$, are from the U.S. Federal Reserve Bank. Labor hours are from the International Labor Organization.

Capital and labor shares obtained from industrial surveys are notoriously unreliable (Shikher, 2004a). Capital shares produced by these surveys are much higher than the generally accepted value of slightly less than 0.3. For example, the capital share in U.S. manufacturing, calculated using UNIDO or Annual Survey of Manufactures' data, approaches .7. Shikher (2004a) used a variety of data to produce more accurate values of capital and labor shares in U.S. and Brazilian manufacturing industries. In that study, the average capital share in U.S. manufacturing is 0.26. In this paper we use the average of U.S. and Brazilian shares from Shikher (2004a) to proxy for the capital and labor shares of countries.

The country-wide factor endowments that we use in this study are physical capital, total labor force, human capital, and stock of arable land. Country capital stock is calculated from the investment time series using the perpetual inventory method with geometric depreciation. The investment time series are from the IFS. Country capital stock includes all forms of capital, both public and private. Labor force and stock of arable land are from the World Development Indicators database of the World Bank. Human capital is measured by educational attainment rates obtained from the International Data on Educational Attainment accompanying Barro and Lee (2000).

Industry income shares are shown in Tables 3 and 4 for years 1975 and 1995, respectively. Table 5 shows the average shares of industries in the dataset. Machinery is the largest industry in many countries, but not all. For example, Chemicals is the largest industry in Turkey in both 1975 and 1995. The newly industrialized countries, such as Korea, Ireland, Turkey, and Mexico, had seen their Machinery industry grow over the twenty-year period. For example, in 1975 Food was the largest industry in Mexico, but in 1995 it was Machinery. In another example, Korea had seen its Machinery industry grow from 4.5% of GDP in 1975 to 20.5% of GDP in 1995. At the same time, the Machinery industry had decreased in importance in the 'old' industrial powers such as United States, Germany, and Japan.

The share of the Textile industry had declined in all countries, except Turkey, as Textile manufacturing had moved to less developed countries. This decline was particularly noticeable in Ireland, U.K., Greece, and Korea. Food industry had increased its share in some countries over the twenty years. It had become the largest industry in Australia, New Zealand, and Greece by 1995.

Country endowments are shown in Tables 6 and 7. The United States has the largest labor force of all the countries in the sample, 97.8 million. Ireland has the smallest, 1.2 million. Turkey, Mexico, Portugal, and Greece have several times less capital per worker than the more developed countries in the sample. Korea had seen an eight-fold increase of its capital stock per worker between 1975 and 1995, while seeing an almost two-fold increase of its labor force. In Section 2.4.2 we compare the pattern of technology and factor accumulation in Korea and Turkey and use the estimated model to explain the changes of specialization that occurred in these countries.

There are significant differences of educational attainment among countries in the dataset. Less developed countries tend to have the bulk of their labor forces having at most primary school education. More developed countries tend to have the bulk of their labor forces having secondary or higher education. There had been progress in educational attainment in all countries between 1975 and 1995.

A.2 Data for simulation

We use data for 19 OECD countries, listed in Table 22.[1] We use data from 1989 because this is the year for which most observations are available.

Labor shares in output are from the UNIDO. We use average labor shares of the countries in our sample. Capital shares in output are obtained using ratios of capital to labor shares from the dataset described in Shikher (2004a). We multiply our labor shares by these ratios to obtain capital shares. We do not use value added data from UNIDO to obtain capital shares.[2]

Data for industry shares η_{jm} and η_m^I were obtained from the OECD input-output tables. OECD maintains separate tables for intermediate and investment goods. These tables exist only for some of the countries in our dataset and only for select years. We used input-output tables for Australia, Canada, France, Germany, Japan, U.K., and the U.S. for 1990.[3] Input-output tables for these countries result in very similar shares η_{jm}. We use average shares across these countries.

Input-output tables for investment goods have data on consumption of investment goods for each industry separately. However, we found that industry shares in investment goods are very similar across industries that use them. This means that the composition of capital

[1]We have decided not to include Ireland, Netherlands, and Denmark because in these countries, in several industries, exports exceed output. This problem occurs because these countries are entrepôts. See Feenstra (2000) for discussion. Also, we have decided not to use ISIC industry 'Other' because of many irregularities in its data in many countries.

[2]Using value added data from UNIDO results in improbably high capital shares. See Shikher (2004a) for more detail.

[3]The table for Australia was for 1989.

goods used by different industries is similar. We assume that the capital good is the same in all industries and use the average, across industries, shares for investment goods.

Bilateral trade data needed to estimate equation (3.16) are from Feenstra (1997) and Feenstra (2000). Imports from home X_{iij} are calculated as output minus exports, and spending X_{ij} is calculated as output minus exports plus imports. Industry output and labor compensation are from the UNIDO's statistical database.

Distance measures used on the right-hand-side of equation (3.16) are obtained as follows. We use distance (in miles) between economic centers of countries from Stewart (1999). This distance is the great circle distance between the population weighted average of the latitude and longitude of major cities. Following EK, we divide distance into 6 intervals: [0,375), [375,750), [750,1500), [1500,3000), [3000,6000), and [6000,maximum). We consider the following free trade agreements for the f variable: EC/EU, EFTA, EEA, FTA, NFTA, CER, and a free-trade agreement between Turkey and EFTA.

For some pairs of countries, trade values are missing for 1989. Therefore, we could not estimate δ_{nij} for some n, i, and j, which are part of our distance measure. There are 19*18*8 =2,736 observations of δ_{nij} possible in our data, of which 105 or 3.8% are missing. We proxied most missing observations by estimates from neighboring years. Six observations that could not be proxied in this manner were proxied by estimates of δ_{ni} for total manufacturing.

Appendix B

Armington assumption

Until now, all computable models of trade have used the Armington (1969) assumption about preferences in order to explain intra-industry trade. The use of this assumption was dictated by necessity since no other framework was able to explain intra-industry trade.

It may be better to think of the Armington assumption as a modeling trick rather than a true representation of consumer behavior. It is hard to think that consumers have the knowledge of, and pay much attention to the origin of the good they are consuming. The only exceptions, perhaps, are wine, cheese, and fashion.

The use of the Armington assumption, however, carries with it several difficulties. First, the elasticities of substitution between domestic and imported goods are hard to pinpoint. Their standard estimates are generally considered too small. These elasticities are key parameters, and model predictions are very sensitive to their values (see McDaniel and Balistreri (2003) for the latest review of the literature).

Second, the use of the Armington assumption results in large models. This is because goods that come from different countries are treated as different goods. Their prices, therefore, have to be calculated separately, requiring a large number of equations.

Third, the Armington assumption implies that each country has monopoly power over its products because these products are not produced by any other country. This means that if the Armington assumption is used in a large-country framework (with endogenous prices), the optimal tariff is not zero. In simulations of trade liberalizations, significant worsening of the terms of trade will generally dominate other effects. Therefore, these simulations will predict lower welfare from trade liberalization (Brown, 1987).

If, instead, the Armington assumption is used in a small-country framework, it creates a contradiction pointed out by Panagariya and Duttagupta (2001). On one hand, the small country framework assumes that goods prices are set on world markets and cannot be influenced by any single country. On the other hand, the Armington assumption gives each country the monopoly power over its products, since these products are not produced by any other country. In small-country models, the terms-of-trade effect is completely absent. Therefore, simulations of trade liberalizations usually predict welfare increases.

CGE models that use the Armington assumption also make counterfactual predictions about implications of economic growth on trade. However, this occurs because of the assumption that industries are homogeneous, not because of the Armington assumption. These traditional CGE models predict that with economic growth, a country will export more of the same good (intensive margin), thus lowering the price for this good and worsening its terms of trade. This prediction is counterfactual. The traditional CGE models do not allow for a possibility that with economic growth, a country may also export a greater variety of goods (extensive margin) (Hummels and Klenow, 2002).

Using the Eaton-Kortum framework solves all of these problems. It results in a compact model where goods are not differentiated by their origin.[1] There is no need to estimate the elasticities of substitution between goods of different origins. In the EK model, a country does not have a monopoly over its products. With economic growth, a country will sell more of the same good (intensive margin), but also a greater variety of goods (extensive margin).

[1]Of course, a particular origin may be associated with a particular level of product quality or features, but the differentiation is on quality, not the origin.

Appendix C

Model notation

With many variables and indices, our notation may seem complicated. But in fact, it is easily understood in the context of a national input-output table. Therefore, to explain our notation, we consider a hypothetical input-output table of country n.

In an input-output table, rows represent sources of goods while columns represent uses of goods. In this section, m will represent the source industry (row) and j will represent the use industry (column). The table below shows our notation within a hypothetical input-output table that includes J industries.

At the intersection of each row m and column j is $Z_{njm} = p_{nm} M_{njm}$, spending by industry j on goods from industry m (note the similarity of this notation to the trade notation: goods move from right to left, in this case from m to j). M_{njm} is the quantity of good m used as input in industry j and p_{nm} is the price of industry m goods in country n.

In each row, $Z_{nm} = \sum_j Z_{njm}$ is total spending on intermediate goods made by industry m, Y_{nm} is spending on final goods made by industry m, and $X_{nm} = Y_{nm} + Z_{nm}$ is the total spending on industry m goods. Final spending Y_{nm} is the sum of consumption (private and government) and investment.[1] Total output of industry m in country n is $Q_{nm} = X_{nm} + EX_{nm} - IM_{nm}$, where EX are exports and IM are imports.

	Ind1($j = 1$)	...	Ind$J$	Total	Y	EX	IM	Output
Ind1($m = 1$)	$Z_{n21} = p_{n1} M_{n21}$			Z_{n1}	Y_{n1}	EX_{n1}	IM_{n1}	Q_{n1}
Ind2								
...								
Ind$J$								
Total	$\rho_{n2} M_{n2}$			Z_n	Y_n	EX_n	IM_n	Q_n
Salaries	$w_n L_{n2}$			$w_n L_n$				
Return	$r_n K_{n2}$			$r_n K_n$				
Income	VA_{n2}			VA_n				
Output	Q_{n2}			Q_n				

In each column j of the input-output table, $\rho_{nj} M_{nj} = \sum_m Z_{njm} = \sum_m p_{nm} M_{njm}$ is total amount spent by industry j on purchases of intermediate goods. In that expression, ρ_{nj} is the price of intermediate inputs used in industry j and M_{nj} is the quantity of intermediate inputs used in industry j. The share of industry m goods in all intermediate goods used by industry j is $\eta_{jm} = p_{nm} M_{njm} / \rho_{nj} M_{nj}$.

There are two factors, capital and labor. Therefore, factor payments in industry j consist of payments to labor, $w_n L_{nj}$, and capital, $r_n K_{nj}$. Income or value added is $VA_{nj} = w_n L_{nj} + r_n K_{nj}$. Output is equal to the sum of value added and intermediate inputs used:

[1] If international movement of financial capital is allowed, final spending Y_{nm} includes spending by foreigners.

$Q_{nj} = VA_{nj} + \rho_{nj} M_{nj}$. Capital share in output of industry j is $\alpha_j = r_n K_{nj}/Q_{nj}$ and labor share is $\beta_j = w_n L_{nj}/Q_{nj}$. Share of intermediate goods is then $1 - \alpha_j - \beta_j = \rho_{nj} M_{nj}/Q_{nj}$. Note that each column and each row of the input-output table add up to total output. Of course, $Q_{nj} = Q_{nm}$ for $j = m$.

Appendix D

Technology and endogenous capital

In Section 3.5, we created an extension of the model that included endogenous capital stock and international capital markets. In this section, we use that model to study how trade and investment transmit benefits (positive or negative) of technological progress across countries. In particular, we examine the effects of technological progress in the U.S. Machinery industry. In this analysis, we are interested in the effect of endogenous capital accumulation on outcome. Therefore, we use equations (3.3)-(3.7) as well as the capital accumulation and steady state equations (3.22) and (3.23).

We consider two scenarios. In the first, there is no international investment, and trade is the only connection between countries. In the second scenario, we allow for the international movement of capital to see how it affects the results. We seek to answer the following questions.

How does technological progress in the Machinery industry of the United States, a major capital-producing country, affect prices and incomes around the world? Does the presence or absence of international capital markets make any difference? The U.S. is likely to be better off with higher technology parameter in its Machinery industry because it becomes more competitive internationally and is able to buy more capital with the same savings.

Other countries benefit from access to cheaper capital goods, but hurt by greater competition from the United States. Which effect would prevail for them? In the absence of international capital markets, other countries are able to buy more capital. With international capital markets, however, some of their savings are invested into the U.S. where the rate of return is higher. What is the net effect on their capital stock? Finally, is world better off after the technological improvement in the U.S.? Does presence of international investment make any difference? Keep in mind that because of our assumption of free international movement of savings, we probably overestimate the effect of moving to open capital market on the impact of higher technology.

We simulate a 20% increase of the technology parameter in the U.S. Machinery industry. This is a modest increase. For example, as shown on Table 28, the technology parameter in the German Machinery industry is 1/2 of the U.S.'s and the technology parameter in the U.K. is 1/5 of the U.S.'s. Increasing the technology parameter in the U.S. Machinery industry by 20% makes it nearly equal to the Japanese, which is presently about 22.8% higher than the U.S.'s.

Tables 49a-j show the effects, expressed as percent changes, on prices, incomes, factor stocks, and measured productivity.[1] They show the impact (first-period) and steady state effects for the two scenarios: one with and the other without international investment.

Manufacturing consumption price levels fall in all countries. The greatest decline is

[1]Manufacturing consumption price level is calculated as $p_n = \prod_j p_{nj}^{\psi_j/\psi_j^M}$, where ψ_j^M is the portion of country income spent on manufacturing goods. This price level is used to calculate real wages, country income, and consumption.

not in the U.S., but in Canada. The second largest is in the U.S. and third largest is in Mexico. Table 49c shows that prices in industries other then Machinery actually rise in the U.S. This is because factors shift from those industries to the Machinery industry and U.S. imports more of those goods. Canada and Mexico, being close to the U.S., are able to benefit the most from price declines in U.S. Machinery goods while also enjoying higher domestic production and lower imports of other goods.

United States and its two neighbors enjoy even lower prices when international investment is possible while other countries see smaller price declines. This is because with international capital markets, U.S. capital does not shift as much from other industries into Machinery. Instead, it comes from other countries. Labor, however, is not internationally mobile, so it has to shift across industries. With international investment, prices still rise in other industries (not shown), but less than they do without international investment.

Real manufacturing value added rises in the U.S. by 2.5-3.5%. In all other countries, it falls by less than 1%. This effect is more pronounced with international capital markets as savings move from other countries into the United States. Real wages are similarly affected.

Without international investment, all countries accumulate additional capital because the price of the capital good falls. However, in the U.S., the increased demand for capital stock outpaces supply, and the interest rate rises by about 1.5% in the steady state. Interest rates in all other countries fall. Interestingly, interest rates in Canada and Mexico initially rise and then fall. They rise because availability of cheaper intermediate inputs from the U.S. increases demand for capital in those countries. Eventually, with higher income, they are able to accumulate additional capital and their interest rates fall.

With international investment, all countries invest in the United States where productivity has increased. The capital stock in the U.S. increases by 3.8% versus 1.65% in the absence of international investment. All other countries, except Mexico, loose capital stock. The world interest rate increases initially, but then decreases as additional capital is accumulated. It settles just 0.02% above its starting value.

Foreign investment into the U.S. in the steady state constitutes about 2% of total U.S. investment. Japan, being a large economy and facing the lowest interest rate in the absence of international investment, is the largest investor into the U.S., with 43% of total foreign investment.[2] Germany is the second-largest with 15%, while U.K. and France each have 8-9%.

What happens to the total factor productivity (TFP)? Table 49i shows TFP changes for the case of no international investment.[3] It shows that total factor productivity rises in all industries in the Unites States, with the largest increase being in the Machinery industry. TFP also rises in Machinery industries of Canada and Mexico. Total factor productivities fall in other countries.

Table 49j shows the world-wide effects of the technological change in the U.S. Machinery industry. Without international investment, world capital stock rises by about 0.8% in the steady state. World real manufacturing income rises by about 0.7%. Presence of international capital markets results in a more efficient allocation of resources across countries. Therefore, international capital markets have a positive effect on world capital stock and world income, though the effect is not large. Real world income rises 0.03 percentage points

[2]Japan has the lowest interest rate in the absence of international investment, as shown on Table 19f. Its interest rate declines by 0.93% in the steady state of the basic model.

[3]TFP is calcualted as $\log A_{nj} = \log(VA_{nj}/p_{nj}) - (\alpha/(\alpha+\beta))\log K_{nj} - (\beta/(\alpha+\beta))\log L_{nj}$. In that expression, VA_{nj}/p_{nj} measures the real value added in industry j of country n. Remember that K_{nj} is measured in real terms.

more with international investment than without it.

In conclusion, we can answer the questions we posed in the beginning of this section. Technological progress in U.S. Machinery industry increases world income and capital stock. However, there is a redistribution of income from other countries to the United States. In fact, other countries suffer a loss of real income.[4] For them, the availability of cheaper capital is outweighed by the increased competitiveness of the United States on the world markets. Presence of international capital markets has a positive effect on world income, but also increases the redistribution of income: other countries are worse off with international investment than without it.

The effect on the world capital stock is positive. Without international investment, all countries are able to accumulate additional capital stock. With international investment, world capital stock grows even more, but for all countries except United States and Mexico, the effect of capital outflows is greater than the effect of cheaper capital. As the result, they lose capital stock.

[4]This result is driven by the presence of nontraded goods with a fixed price.

Appendix E

Technology in the nontraded sector

How can we estimate the technology parameter in the nontraded sector? In Eaton and Kortum (2002), technology parameters are calculated from estimated exporter dummies, which requires goods to be traded. In this paper, we calibrate technology parameters using the model and data on output and spending. Goods still have to be traded, though. If they are not, output is equal spending and calibration is impossible. So, how can we calibrate the technology parameters for goods that are not traded? We can do it by exploiting inter-industry linkages.

Remember that the price index of the nontraded sector in the baseline economy is normalized to one. The cost equation (3.17), applied to the nontraded sector S ('services') is

$$c_{iS} = r_i^{\alpha} w_i^{\beta} \prod_{m=1}^{J} \left(T_{im}^{1/\theta} c_{im} \right)^{\eta_{Sm}}, \tag{E.1}$$

while the equation for prices (3.3) is

$$p_{iS} = \gamma T_{iS}^{-1/\theta} c_{iS} \tag{E.2}$$

or

$$c_{iS} = \frac{1}{\gamma} T^{1/\theta}. \tag{E.3}$$

Adding equations (E.1) and (E.3) to the baseline model allows us to estimate the technology parameter in the nontraded sector.[1]

For simulation, output and factor stock equations for the nontraded sector are:

$$Q_{iS} = \left(\sum_{m=1}^{J} \frac{\eta_{mS} \left(1 - \alpha_m - \beta_m\right)}{\beta_m} w_i L_{im} \right) + B_{iS} + \psi_{iS} V A_i \tag{E.4}$$

and

$$K_{iS} = \frac{\alpha_S Q_{iS}}{r_i} \text{ and } L_{iS} = \frac{\beta_S Q_{iS}}{w_i}. \tag{E.5}$$

[1]This method allows us to estimate technology parameter for only one nontraded industry (which is why we use the word 'sector'). Also note that during simulations the price index of nontraded goods may change and be different from one. The normalization is only in the baseline economy.

Table 1 Description of industries

ISIC	Name	Description
31	Food	Food, beverage, and tobacco
32	Textile	Textiles, wearing apparel, leather products, footwear (except rubber of plastic)
33	Wood	Wood products including furniture
34	Paper	Paper, paper products, printing, and publishing
35	Chemicals	Industrial chemicals, products of petroleum and coal, rubber, plastics
36	Nonmetals	Pottery, china, glass, other nonmetallic mineral products (except petroleum and coal)
37	Metals	Iron, steel, other metals
38	Machinery	Fabricated metal products, machinery, transport equipment

Table 2 Availability of industry-level data

	Available Years
Australia	1975-1990
Austria	1979-1994
Belgium	1975-1992
Canada	1975-1990
Denmark	1975-1991
Finland	1975-1998
France	1975-1998
Germany	1975-1992
Greece	1975-1992
Ireland	1975-1991
Italy	1975-1994
Japan	1975-1998
Korea	1975-1998
Mexico	1980-1991
Netherlands	1975-1993
New Zealand	1975-1990
Norway	1975-1998
Portugal	1981-1995
Spain	1975-1998
Sweden	1975-1987
Turkey	1975-1997
United Kingdom	1975-1998
United States	1975-1995

Table 3 Income shares of industries and total manufacturing in GDP, 1975

	Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery	Total
Australia	3.6%	1.5%	1.2%	1.7%	2.4%	1.1%	2.2%	6.9%	20.7%
Austria	3.2%	2.2%	1.0%	1.6%	2.8%	1.6%	2.1%	7.3%	21.7%
Belgium	4.4%	2.6%	1.2%	1.5%	3.7%	1.2%	3.4%	7.9%	25.9%
Canada	3.3%	1.7%	1.4%	3.1%	2.7%	0.9%	1.7%	7.4%	22.2%
Denmark	3.9%	1.1%	0.6%	1.7%	2.1%	1.2%	0.3%	6.3%	17.4%
Finland	3.4%	2.3%	1.5%	5.4%	2.9%	1.1%	1.3%	8.1%	26.0%
France	3.5%	2.4%	0.9%	1.8%	4.3%	1.3%	1.7%	9.7%	25.6%
Germany	4.3%	2.2%	1.3%	1.5%	6.0%	1.5%	3.2%	14.3%	34.2%
Greece	2.6%	3.2%	0.4%	0.6%	2.4%	1.0%	1.1%	2.6%	13.8%
Ireland	9.9%	3.2%	0.6%	1.9%	3.1%	2.3%	0.4%	5.5%	27.0%
Italy	2.1%	2.8%	0.6%	1.3%	4.2%	1.4%	2.4%	8.8%	23.8%
Japan	3.1%	2.5%	1.3%	2.6%	4.6%	1.6%	2.6%	12.5%	30.7%
Korea	4.8%	6.1%	0.7%	1.1%	6.0%	1.5%	1.8%	4.5%	26.5%
Mexico	1.9%	0.4%	0.0%	0.4%	1.4%	0.6%	1.1%	1.3%	7.1%
Netherlands	3.8%	1.1%	0.8%	1.9%	3.7%	0.9%	0.9%	7.6%	20.6%
New Zealand	4.8%	2.3%	1.6%	2.3%	1.8%	0.9%	0.6%	5.0%	19.3%
Norway	3.2%	0.9%	1.8%	2.6%	2.3%	0.8%	2.5%	7.6%	21.6%
Portugal	3.4%	4.2%	1.3%	1.8%	2.7%	1.6%	0.6%	4.4%	19.9%
Spain	2.2%	2.4%	0.9%	1.1%	3.4%	1.3%	1.3%	5.0%	17.6%
Sweden	2.9%	1.2%	2.1%	4.3%	2.5%	1.0%	2.0%	12.9%	28.9%
Turkey	2.8%	1.9%	0.2%	0.5%	3.6%	0.6%	1.2%	2.3%	13.0%
United Kingdom	4.5%	2.8%	1.1%	2.7%	5.4%	1.5%	2.3%	14.0%	34.3%
United States	3.2%	1.9%	0.8%	2.6%	4.3%	0.9%	1.8%	11.2%	26.6%

Table 4 Income shares of industries and total manufacturing in GDP, 1995

	Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery	Total
Australia	2.5%	0.6%	0.8%	0.7% *	0.8%	0.6%	0.8% *	1.8%	8.6%
Austria	2.7%	0.9%	1.1%	1.3%	2.4%	1.2%	1.1%	7.1%	17.9%
Belgium	3.5%	1.3%	0.8%	1.3%	3.3%	0.9%	1.3%	5.7%	18.1%
Canada	3.0%	1.0%	1.6%	2.5%	3.3%	0.5%	1.3%	7.5%	20.7%
Denmark	4.1% **	0.7% **	0.9% **	1.6% **	2.8% **	0.8% **	0.2% **	6.0% **	17.1% **
Finland	2.0%	0.6%	1.5%	6.0%	0.9%	0.5%	1.3%	4.4%	17.1%
France	2.7%	1.0%	0.6%	1.6%	3.7%	0.8%	0.9%	7.5%	18.9%
Germany	3.2% ***	1.0% ***	0.9% ***	1.3% ***	5.9% ***	1.1% ***	1.0% ***	13.7% ***	28.1% ***
Greece	2.8%	1.5%	0.3%	0.6%	2.1%	0.7%	0.5%	1.7%	10.2%
Ireland	10.2%	1.0%	0.5%	1.7%	9.5%	1.4%	0.1%	16.7%	41.1%
Italy	1.3%	1.9%	0.5%	0.8%	2.4%	0.8%	0.7%	5.5%	14.0%
Japan	2.6%	1.0%	0.6%	2.1%	3.9%	1.0%	1.2%	11.9%	24.3%
Korea	3.8%	4.6%	0.8%	2.2%	7.6%	2.1%	3.1%	20.5%	44.7%
Mexico	2.0%	0.2%	0.0%	0.3%	1.9%	0.6%	0.9%	2.3%	8.1%
Netherlands	3.4%	0.4%	0.3%	1.6%	2.9%	0.5%	0.6%	4.6%	14.2%
New Zealand	5.3%	1.1% ****	0.9% ****	2.4%	2.4%	0.5% ****	0.5% ****	3.7%	13.8%
Norway	1.9%	0.2%	0.7%	2.0%	0.7%	0.3%	0.7%	2.9%	9.5%
Portugal	2.8%	3.7%	1.0%	1.8%	4.2%	1.7%	0.3%	3.9%	19.3%
Spain	2.8%	1.2%	0.8%	1.4%	2.7%	1.3%	0.9%	5.4%	16.6%
Sweden	1.5%	0.2%	1.1%	2.6%	2.4%	0.4%	1.1%	8.7%	17.9%
Turkey	3.4%	3.7%	0.2%	0.7%	6.2%	1.5%	1.5%	4.4%	21.7%
United Kingdom	2.5%	1.0%	0.6%	2.2%	3.5%	0.7%	0.8%	7.5%	18.9%
United States	2.8%	1.1%	0.7%	2.8%	4.2%	0.6%	0.9%	10.0%	23.1%

(*) 1992
(**) 1991
(***) 1993
(****) 1990

Table 5 Average industry shares, 1975-1995, percent of GDP

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Food	3.82	3.81	3.78	3.85	3.66	3.54	3.53	3.58	3.53	3.49	3.40
Textile	2.31	2.37	2.24	2.23	2.15	2.00	2.04	1.92	1.85	1.86	1.81
Wood	1.05	1.08	1.08	1.09	1.09	1.03	0.92	0.84	0.86	0.83	0.79
Paper	2.11	2.01	1.99	2.03	2.06	1.98	1.91	1.84	1.86	1.96	1.90
Chemicals	3.56	3.59	3.50	3.53	3.68	3.49	3.59	3.39	3.45	3.57	3.51
Nonmetals	1.21	1.21	1.22	1.22	1.22	1.19	1.18	1.10	1.08	1.06	1.02
Metals	1.73	1.65	1.63	1.62	1.71	1.62	1.44	1.32	1.29	1.35	1.29
Machinery	7.99	8.18	8.15	8.19	7.99	7.55	7.43	7.35	7.26	7.38	7.39
Average	2.97	2.99	2.95	2.97	2.95	2.80	2.75	2.67	2.65	2.69	2.64

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Food	3.32	3.33	3.32	3.26	3.25	3.38	2.98	2.88	2.71	2.75
Textile	1.78	1.80	1.72	1.60	1.58	1.57	1.72	1.76	1.89	1.89
Wood	0.75	0.77	0.73	0.73	0.74	0.68	0.72	0.75	0.81	0.78
Paper	1.84	1.93	1.79	1.82	1.74	1.61	1.69	1.88	1.95	2.30
Chemicals	3.63	3.56	3.68	3.65	3.57	3.50	3.44	3.46	3.51	3.75
Nonmetals	1.03	1.06	1.09	1.06	1.05	1.04	1.02	1.07	1.07	1.06
Metals	1.18	1.18	1.35	1.35	1.14	0.96	1.01	0.92	1.09	1.16
Machinery	7.04	7.22	6.90	7.16	7.18	7.04	6.96	6.68	6.97	7.39
Average	2.57	2.61	2.57	2.58	2.53	2.47	2.44	2.43	2.50	2.64

Industry	**Average Share**	**Min. Share**	**Max. Share**
Food	3.444	1.06	9.88
Textile	1.917	0.20	6.74
Wood	0.872	0.02	2.82
Paper	1.908	0.25	6.18
Chemicals	3.55	0.45	7.60
Nonmetals	1.112	0.29	2.43
Metals	1.357	0.18	3.44
Machinery	7.433	0.98	20.45
Average	2.70		

Table 6 Country endowments, part I

	Labor Force (millions)		Capital Stock per Worker (1994 USD)		Arable Land per Worker (hectares)	
	1975	1995	1975	1995	1975	1995
Australia	6.041	9.079	59,638	71,963	6.99	5.30
Austria	3.253	3.655	45,307	87,954	0.46	0.39
Belgium	3.774	4.126	52,482	90,799	0.26	0.18
Canada	10.281	15.550	61,288	64,927	4.28	2.92
Denmark	2.544	2.916	49,883	78,703	1.04	0.80
Finland	2.304	2.588	48,760	79,216	1.15	0.98
France	22.705	25.744	54,340	83,641	0.76	0.71
Germany	29.070	32.300	52,349	99,227	0.33	0.29
Greece	3.584	4.405	20,966	35,025	0.81	0.55
Ireland	1.189	1.418	25,318	50,482	1.04	0.94
Italy	21.815	24.907	37,045	67,335	0.43	0.33
Japan	55.219	66.093	41,799	134,962	0.08	0.06
Korea	13.314	21.617	4,557	36,809	0.15	0.08
Mexico	18.113	35.808	12,424	14,624	1.23	0.72
Netherlands	5.210	7.120	52,648	75,297	0.15	0.12
New Zealand	1.205	1.735	48,430	48,833	2.08	0.91
Norway	1.766	2.215	66,428	111,200	0.45	0.45
Portugal	4.041	4.904	13,525	31,864	0.61	0.47
Spain	12.920	16.601	26,223	51,583	1.22	0.92
Sweden	3.969	4.682	61,985	73,834	0.76	0.59
Turkey	17.356	27.991	7,630	10,662	1.44	0.88
United Kingdom	26.256	29.111	31,003	49,686	0.26	0.20
United States	97.780	132.622	59,205	72,080	1.91	1.40

Table 7 Country endowments, part II

	Educational Attainment of Workers							
	No School (% of total)		Primary School (% of total)		Secondary School (% of total)		Higher Education (% of total)	
	1975	1995	1975	1995	1975	1995	1975	1995
Australia	3.6	2.1	28.7	25.1	47	48.6	20.8	24.2
Austria	3.5	1.1	47.3	31.6	45.6	55.7	3.6	11.7
Belgium	2.9	4.6	60.1	48.8	30.3	30.5	6.7	16.1
Canada	1.8	1.6	30.7	20.3	36.6	29.4	30.9	48.7
Denmark	1.7	0.8	37.6	34.1	44.9	47	15.8	18.9
Finland	0.9	0.4	62	31.3	29.9	49.6	7.2	18.7
France	0.9	0.5	67.2	47.6	26.8	37.3	5.2	14.5
Germany	0.6	4	47.1	27.5	46.8	53.5	5.5	15
Greece	14.4	5.5	67.8	52.2	12.9	31.8	5	10.5
Ireland	3.5	3	62.4	35.4	28.4	45.2	5.7	16.4
Italy	6.6	13.5	70.6	42.5	18.6	32.4	4.3	11.5
Japan	0.8	0	53.8	31.2	38.1	46.8	7.3	22
Korea	25.2	8.7	39.2	18.2	28.7	51.9	6.9	21.1
Mexico	34.4	15	54	47.9	8.3	26.7	3.3	10.3
Netherlands	2.3	2.7	44.4	32	44.3	46.3	9.1	19
New Zealand	1	0	21.8	34.2	57.1	26.6	20.1	39.2
Norway	1.8	1	54.3	11.6	34.8	66.7	9.1	20.8
Portugal	38.7	14.3	49.3	61.4	9.6	14.7	2.4	9.6
Spain	13.6	4	73.9	55.5	8.2	28.6	4.3	11.9
Sweden	1.4	2.1	52	18.1	34.3	58.8	12.3	21
Turkey	59	30.6	31.9	47.2	7.3	15.7	1.8	6.5
United Kingdom	2.4	2.9	55.6	41.4	31	39.9	11	15.8
United States	1.4	0.6	30.7	8.2	42.6	44.6	25.3	46.5

Table 8 Electricity consumption efficiency parameter Φ_{ic} for years 1975-1995

Country	Av. Rank	Food	Textile	Wood	Paper	Chemicals	Non-metals	Metals	Machinery
France	**(3.25)**	(3) 3.66	(8) 5.52	(2) 3.45	(3) 5.84	(4) 5.65	(1) 5.01	(3) 13.94	(2) 2.66
Austria	**(5.75)**	(2) 3.19	(1) 3.92	(7) 5.17	(13) 11.08	(8) 7.06	(4) 7.38	(6) 16.72	(5) 2.81
Denmark	**(6.38)**	(14) 5.47	(4) 4.43	(10) 5.79	(2) 5.67	(2) 4.16	(2) 6.21	(2) 13.61	(15) 4.66
Ireland	**(6.88)**	(11) 5.19	(5) 4.76	(15) 8.53	(1) 4.41	(3) 5.27	(3) 7.17	(10) 20.02	(7) 3.32
Belgium	**(7.63)**	(6) 4.59	(7) 5.25	(4) 3.84	(4) 6.28	(16) 10.78	(10) 9.68	(4) 16.53	(10) 3.51
Netherlands	**(7.88)**	(9) 4.96	(3) 4.36	(3) 3.55	(6) 6.58	(14) 8.83	(5) 7.51	(15) 28.71	(8) 3.41
Greece	**(8.13)**	(1) 2.87	(9) 5.62	(1) 3.41	(7) 9.11	(9) 7.47	(16) 13.42	(19) 42.32	(3) 2.73
United Kingdom	**(8.13)**	(8) 4.86	(11) 6.38	(5) 4.17	(5) 6.37	(5) 6.35	(9) 9.57	(5) 16.56	(17) 4.88
Japan	**(8.88)**	(4) 3.82	(12) 7.17	(8) 5.30	(9) 10.16	(11) 7.59	(13) 12.26	(8) 18.07	(6) 2.95
Germany	**(10.75)**	(7) 4.83	(13) 7.46	(9) 5.32	(11) 10.78	(21) 14.32	(11) 10.99	(13) 23.67	(1) 2.55
Korea	**(10.88)**	(10) 5.17	(17) 8.40	(6) 4.94	(15) 12.06	(10) 7.47	(17) 13.51	(1) 9.53	(11) 3.66
Finland	**(11.13)**	(5) 4.34	(6) 4.86	(13) 7.14	(20) 21.65	(17) 11.22	(6) 8.40	(9) 19.34	(13) 4.20
Italy	**(11.88)**	(15) 5.97	(14) 7.58	(11) 6.34	(10) 10.49	(12) 8.23	(12) 12.22	(7) 16.95	(14) 4.65
Sweden	**(12.13)**	(12) 5.24	(2) 4.16	(12) 6.40	(19) 19.25	(18) 13.03	(7) 9.03	(11) 22.14	(16) 4.80
New Zealand	**(12.50)**	(16) 6.06	(10) 5.81	(22) 65.32	(12) 11.00	(1) 2.40	(8) 9.23	(22) 69.30	(9) 3.47
Portugal	**(13.75)**	(13) 5.41	(15) 7.98	(17) 8.74	(8) 9.28	(13) 8.27	(14) 12.51	(12) 22.16	(18) 4.96
Turkey	**(15.88)**	(23) 13.59	(18) 9.85	(23) 84.40	(17) 13.00	(6) 6.70	(22) 21.32	(14) 23.79	(4) 2.75
Australia	**(16.13)**	(17) 6.89	(22) 13.73	(14) 7.79	(18) 13.42	(7) 6.78	(15) 12.79	(16) 31.32	(20) 5.53
Mexico	**(19.13)**	(18) 7.50	(19) 11.20	(20) 15.00	(21) 22.38	(22) 18.40	(23) 22.75	(18) 41.36	(12) 4.10
United States	**(19.25)**	(22) 8.59	(23) 14.56	(21) 15.14	(14) 11.81	(19) 13.09	(19) 14.83	(17) 33.98	(19) 5.51
Canada	**(19.75)**	(20) 8.22	(20) 11.21	(19) 12.31	(23) 30.75	(15) 9.23	(20) 18.12	(20) 44.94	(21) 6.67
Spain	**(19.75)**	(19) 7.50	(21) 11.32	(18) 8.90	(16) 12.38	(20) 14.13	(21) 21.27	(21) 56.87	(22) 6.93
Norway	**(20.25)**	(21) 8.47	(16) 8.08	(16) 8.66	(22) 26.70	(23) 22.61	(18) 13.59	(23) 135.40	(23) 8.00

* Numbers in parentheses are countries' ranks. 1 is the highest rank (lowest Φ_{ic}), 23 is the lowest rank (highest Φ_{ic}).

Figure 1 Electricity Consumption Efficiency Rankings

(countries are sorted by their average rank)

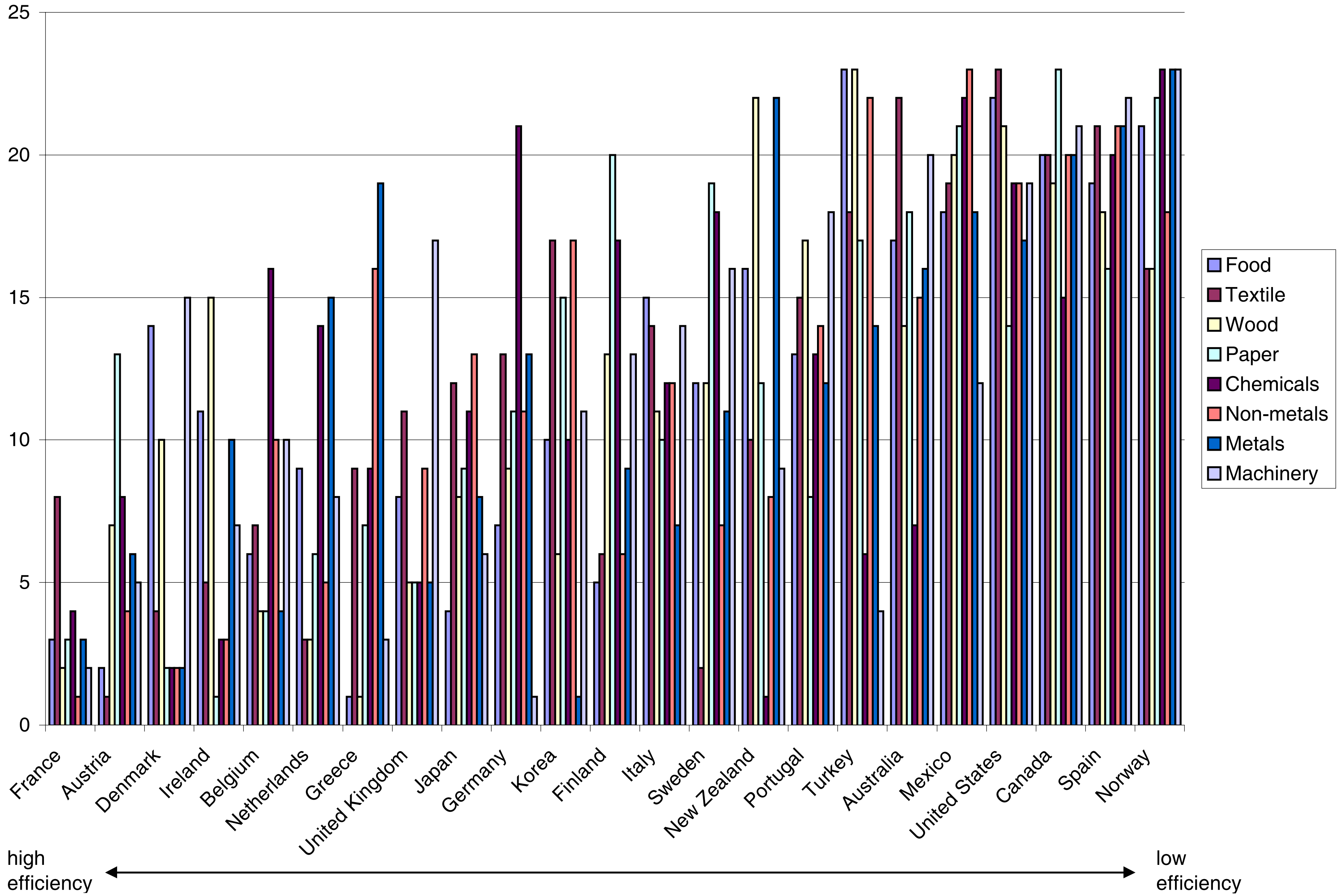

Table 9 Relative total factor productivity, 1975 and 1990

		Food	Textile	Wood	Paper	Chem.	Nonmet.	Metals	Mach.
Australia	**1975**	56.7%	81.5%	96.9%	71.2%	60.5%	70.3%	67.1%	65.6%
	1990	58.5%	89.9%	90.5%	83.6%	74.2%	86.8%	81.7%	74.2%
Austria	**1975**	44.2%	44.6%	54.1%	42.1%	34.9%	47.7%	35.8%	43.4%
	1990	59.5%	65.6%	80.9%	66.1%	48.4%	72.3%	70.2%	62.5%
Belgium	**1975**	64.8%	56.4%	86.7%	52.5%	43.4%	41.8%	66.2%	54.3%
	1990	60.7%	64.8%	93.1%	63.6%	45.6%	60.8%	70.3%	72.6%
Canada	**1975**	73.5%	82.1%	90.6%	74.9%	52.4%	84.2%	62.9%	80.7%
	1990	80.5%	99.3%	91.0%	80.0%	60.8%	101.1%	67.6%	85.1%
Denmark	**1975**	64.7%	71.7%	61.5%	76.5%	58.3%	63.4%	51.4%	70.1%
	1990	53.9%	80.1%	92.2%	63.8%	84.0%	74.9%	65.7%	67.9%
Finland	**1975**	40.4%	57.3%	44.6%	52.5%	45.1%	49.7%	51.4%	52.2%
	1990	54.5%	76.7%	99.2%	72.9%	67.0%	85.3%	72.7%	86.4%
France	**1975**	61.6%	63.0%	76.8%	63.5%	50.0%	51.9%	43.8%	50.7%
	1990	47.7%	93.5%	76.6%	77.7%	65.6%	78.6%	65.0%	69.6%
Germany	**1975**	87.9%	77.1%	85.3%	61.3%	60.9%	73.4%	65.1%	61.3%
	1990	97.7%	107.4%	108.2%	95.7%	113.6%	106.2%	93.9%	103.0%
Greece	**1975**	28.5%	41.5%	30.7%	34.3%	30.6%	32.7%	45.2%	26.2%
	1990	32.2%	44.7%	46.3%	47.4%	41.1%	41.2%	59.0%	33.4%
Ireland	**1975**	42.4%	46.2%	46.5%	39.7%	41.7%	48.7%	44.4%	44.0%
	1990	79.3%	59.3%	83.9%	100.4%	98.8%	90.4%	48.4%	97.1%
Italy	**1975**	48.4%	59.3%	55.6%	59.5%	39.4%	47.4%	49.2%	52.9%
	1990	48.5%	83.9%	94.1%	95.1%	49.3%	73.7%	60.8%	70.9%
Japan	**1975**	56.0%	67.9%	64.5%	59.5%	42.9%	62.3%	47.1%	57.6%
	1990	61.7%	97.9%	108.2%	113.2%	103.1%	105.8%	107.3%	103.6%
Korea	**1975**	27.0%	21.0%	18.7%	16.7%	25.0%	22.8%	23.1%	15.0%
	1990	56.8%	46.6%	58.6%	60.9%	51.7%	62.3%	66.0%	49.8%
Mexico	**1975**	59.9%	40.6%	56.4%	51.2%	45.7%	48.4%	54.3%	63.6%
	1990	86.4%	36.0%	39.5%	33.3%	40.5%	50.0%	57.3%	56.2%
Netherlands	**1975**	50.6%	60.3%	81.2%	58.9%	42.8%	59.9%	47.6%	64.5%
	1990	55.0%	80.2%	78.0%	75.5%	54.0%	68.2%	70.7%	63.1%
New Zealand	**1975**	28.3%	50.2%	67.9%	38.3%	26.9%	50.0%	40.9%	42.2%
	1990	31.2%	49.0%	54.2%	60.5%	29.7%	65.2%	36.3%	43.3%
Norway	**1975**	42.8%	61.0%	82.9%	45.6%	35.2%	56.2%	65.3%	61.7%
	1990	42.9%	72.9%	75.9%	61.6%	49.5%	66.4%	66.8%	63.9%
Portugal	**1975**	26.1%	27.1%	29.1%	27.7%	23.7%	23.1%	19.5%	27.4%
	1990	28.8%	28.8%	26.8%	33.7%	22.2%	31.3%	33.5%	27.8%
Spain	**1975**	32.9%	54.0%	42.3%	39.8%	43.6%	38.6%	46.7%	35.4%
	1990	63.5%	78.3%	79.3%	88.0%	79.8%	86.9%	79.0%	79.5%
Sweden	**1975**	66.5%	83.9%	84.6%	79.8%	50.2%	68.0%	56.4%	73.4%
	1987	55.5%	75.5%	78.9%	75.9%	65.7%	73.5%	62.0%	66.7%
Turkey	**1975**	54.4%	36.6%	39.7%	33.0%	71.8%	28.1%	40.0%	33.1%
	1990	50.5%	41.5%	41.5%	52.7%	86.3%	55.6%	34.8%	45.2%
United Kingdom	**1975**	43.6%	47.1%	69.7%	49.3%	41.4%	54.4%	39.5%	44.0%
	1990	59.5%	85.2%	94.8%	100.2%	78.6%	89.5%	69.9%	79.8%
United States	**1975**	81.4%	85.0%	89.4%	93.8%	76.3%	85.2%	79.4%	89.1%
	1990	101.8%	100.0%	95.8%	101.0%	93.5%	94.2%	93.5%	96.4%

* Relative to the U.S. of 1988

Figure 2 TFP of the Metals Industry in the United States

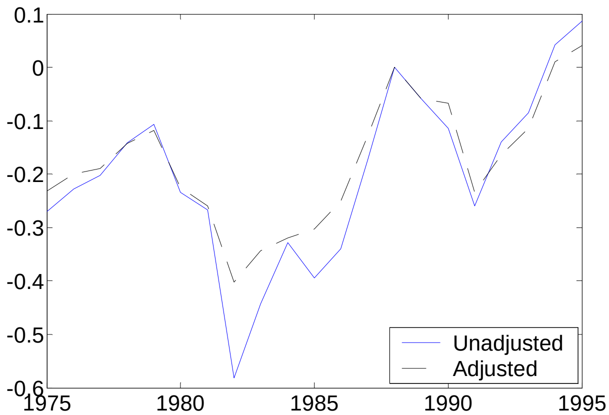

Figure 2a
Unadjusted and Adjusted TFP (in levels) of the Metals Industry in the United States

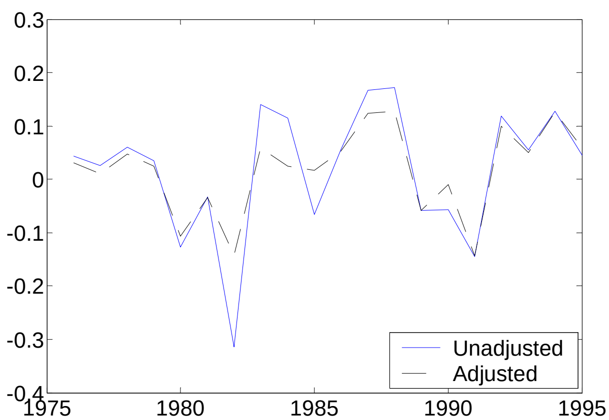

Figure 2b
Unadjusted and Adjusted TFP (in differences) of the Metals Industry in the United States

Selected Properties of Unadjusted and Adjusted Measures of TFP

	Unadjusted	Adjusted		Unadjusted	Adjusted
σ^2_{TFP}	0.026	0.016	$\sigma^2_{\Delta TFP}$	0.015	0.010
$\rho_{TFP,Y}$	0.83	0.58	$\rho_{\Delta TFP,\Delta Y}$	0.97	0.79

Figure 3 TFP of the Wood Industry in the United States

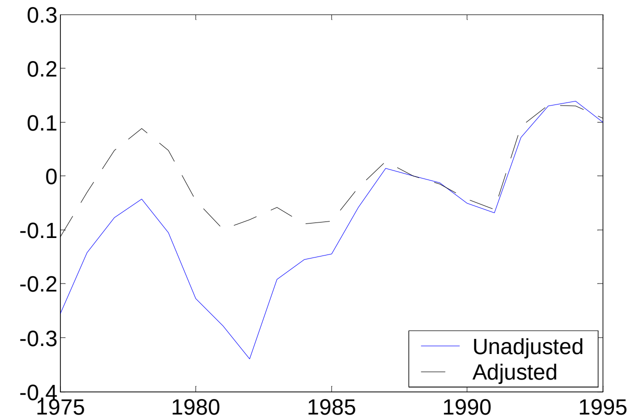

Figure 3a
Unadjusted and Adjusted TFP (in levels) of the Wood Industry in the United States

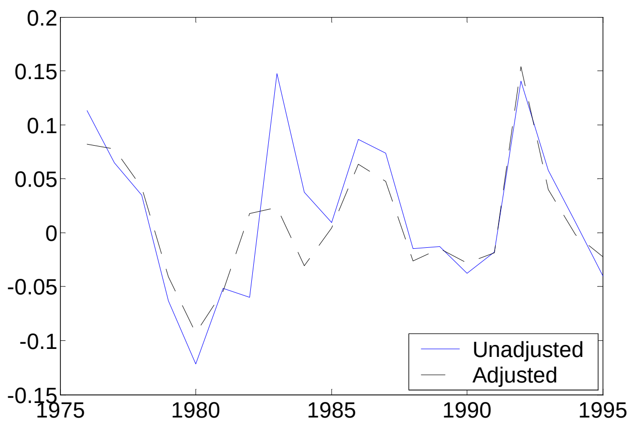

Figure 3b
Unadjusted and Adjusted TFP (in differences) of the Wood Industry in the United States

Selected Properties of Unadjusted and Adjusted Measures of TFP

	Unadjusted	Adjusted		Unadjusted	Adjusted
σ^2_{TFP}	0.018	0.006	$\sigma^2_{\Delta TFP}$	0.0053	0.0032
$\rho_{TFP,Y}$	0.96	0.89	$\rho_{\Delta TFP,\Delta Y}$	0.94	0.77

Figure 4 TFP of the Machinery Industry in Turkey

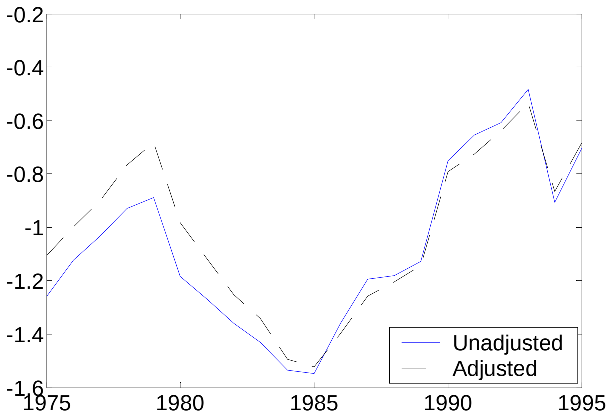

Figure 4a
Unadjusted and Adjusted TFP (in levels) of the Machinery Industry in Turkey

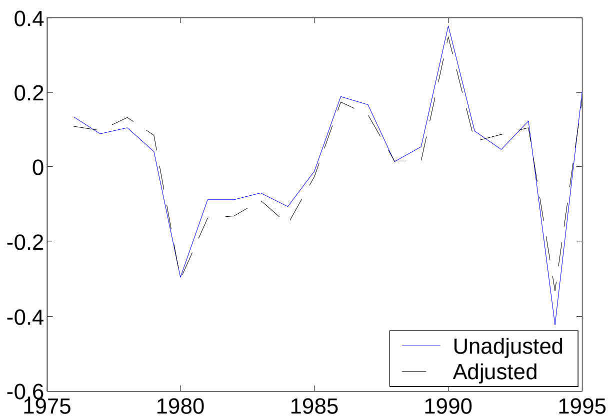

Figure 4b
Unadjusted and Adjusted TFP (in differences) of the Machinery Industry in Turkey

Selected Properties of Unadjusted and Adjusted Measures of TFP

	Unadjusted	Adjusted		Unadjusted	Adjusted
σ^2_{TFP}	0.095	0.081	$\sigma^2_{\Delta TFP}$	0.031	0.029
$\rho_{TFP,Y}$	0.93	0.82	$\rho_{\Delta TFP,\Delta Y}$	0.98	0.93

Table 10 - Estimates, constant capital utilization and mobile capital

	Food	Textile	Wood	Paper	Chem.	Nonmet.	Metals	Mach.
TFP Food	**1.778**	-0.105	0.038	-0.211	-0.234	-0.135	-0.123	-0.614
	(0.09)†	(0.08)	(0.05)	(0.06)†	(0.06)†	(0.05)†	(0.06)†	(0.12)†
TFP Textile	-0.105	**0.421**	-0.110	-0.085	-0.228	-0.007	-0.056	-0.564
	(0.08)	**(0.01)†**	(0.07)	(0.08)	(0.07)†	(0.06)	(0.07)	(0.15)†
TFP Wood	0.038	-0.110	**0.723**	-0.002	-0.077	0.071	0.016	-0.373
	(0.05)	(0.07)	**(0.07)†**	(0.06)	(0.04)††	(0.04)††	(0.04)	(0.09)†
TFP Paper	-0.211	-0.085	-0.002	**0.394**	-0.238	0.034	0.058	-0.789
	(0.06)†	(0.08)	(0.06)	**(0.07)†**	(0.05)†	(0.05)	(0.05)	(0.11)†
TFP Chemicals	-0.234	-0.228	-0.077	-0.238	**2.035**	-0.149	-0.202	0.367
	(0.06)†	(0.07)†	(0.04)††	(0.05)†	**(0.10)†**	(0.03)†	(0.06)†	(0.14)†
TFP Nonmetals	-0.135	-0.007	0.071	0.034	-0.149	**0.408**	-0.010	-0.432
	(0.05)†	(0.06)	(0.04)††	(0.05)	(0.03)†	**(0.05)†**	(0.04)	(0.08)†
TFP Metals	-0.123	-0.056	0.016	0.058	-0.202	-0.010	**0.592**	-0.251
	(0.06)†	(0.07)	(0.04)	(0.05)	(0.06)†	(0.04)	**(0.03)†**	(0.12)†
TFP Machinery	-0.614	-0.564	-0.373	-0.789	0.367	-0.432	-0.251	**3.479**
	(0.12)†	(0.15)†	(0.09)†	(0.11)†	(0.14)†	(0.08)†	(0.12)†	**(0.12)†**
Capital	-0.907	-1.370	-0.070	-0.119	-0.503	-0.001	0.297	2.671
	(0.11)†	(0.12)†	(0.07)	(0.10)	(0.22)†	(0.07)	(0.12)†	(0.46)†
Low-ed. workers[1]	0.358	0.274	0.150	0.016	0.049	0.029	0.280	-0.516
	(0.07)†	(0.07)†	(0.04)†	(0.06)	(0.13)	(0.04)	(0.07)†	(0.28)††
Mid-ed. workers[2]	0.468	0.372	-0.091	-0.327	0.004	0.163	0.451	-0.010
	(0.09)†	(0.10)†	(0.06)	(0.08)†	(0.18)	(0.06)†	(0.10)†	(0.38)
High-ed. workers[3]	0.745	0.579	0.292	0.251	0.178	0.131	0.088	1.592
	(0.11)†	(0.12)†	(0.07)†	(0.10)†	(0.22)	(0.07)†	(0.12)	(0.47)†
Arable land	-0.527	-1.610	-0.713	-1.081	-3.055	-1.270	-1.139	-9.195
	(0.22)†	(0.24)†	(0.14)†	(0.19)†	(0.44)†	(0.13)†	(0.24)†	(0.92)†

† means that the estimate is significant at 95% level
†† means that the estimate is significant at 90% level
Standard errors in parentheses
[1] Those having primary education
[2] Those having secondary education
[3] Those having higher education

Table 11 - Estimates, variable capital utilization and mobile capital

	Food	Textile	Wood	Paper	Chem.	Nonmet.	Metals	Mach.
TFP Food	**1.237**	-0.032	-0.028	-0.122	-0.059	-0.054	0.045	-0.601
	(0.09)†	(0.07)	(0.05)	(0.06)†	(0.06)	(0.04)	(0.06)	(0.11)†
TFP Textile	-0.032	**0.340**	0.002	0.121	-0.174	0.146	-0.065	-0.986
	(0.07)	**(0.02)†**	(0.06)	(0.08)	(0.06)†	(0.05)†	(0.07)	(0.12)†
TFP Wood	-0.028	0.002	**0.613**	-0.028	-0.093	0.049	-0.149	-0.075
	(0.05)	(0.06)	**(0.06)†**	(0.05)	(0.04)†	(0.04)	(0.04)†	(0.08)
TFP Paper	-0.122	0.121	-0.028	**0.283**	-0.230	-0.047	0.162	-0.557
	(0.06)†	(0.08)	(0.05)	**(0.04)†**	(0.05)†	(0.04)	(0.05)†	(0.10)†
TFP Chemicals	-0.059	-0.174	-0.093	-0.230	**1.678**	-0.117	-0.334	0.017
	(0.06)	(0.06)†	(0.04)†	(0.05)†	**(0.09)†**	(0.03)†	(0.05)†	(0.13)
TFP Nonmetals	-0.054	0.146	0.049	-0.047	-0.117	**0.312**	0.121	-0.531
	(0.04)	(0.05)†	(0.04)	(0.04)	(0.03)†	**(0.05)†**	(0.03)†	(0.06)†
TFP Metals	0.045	-0.065	-0.149	0.162	-0.334	0.121	**0.513**	-0.268
	(0.06)	(0.07)	(0.04)†	(0.05)†	(0.05)†	(0.03)†	**(0.06)†**	(0.10)†
TFP Machinery	-0.601	-0.986	-0.075	-0.557	0.017	-0.531	-0.268	**2.409**
	(0.11)†	(0.12)†	(0.08)	(0.10)†	(0.13)	(0.06)†	(0.10)†	**(0.17)†**
Capital	-1.097	-1.257	-0.286	-0.318	-0.394	-0.149	0.270	3.158
	(0.13)†	(0.13)†	(0.07)†	(0.10)†	(0.23)††	(0.07)†	(0.14)††	(0.51)†
Low-ed. workers	0.349	0.165	0.167	-0.026	0.216	0.046	0.234	-0.398
	(0.07)†	(0.07)†	(0.04)†	(0.06)	(0.14)	(0.04)	(0.08)†	(0.29)
Mid-ed. workers	0.357	0.368	-0.083	-0.150	-0.022	0.178	0.284	-0.107
	(0.10)†	(0.10)†	(0.06)	(0.08)††	(0.18)	(0.05)†	(0.11)†	(0.40)
High-ed. workers	0.655	0.669	0.251	0.092	0.605	0.127	0.060	1.700
	(0.12)†	(0.12)†	(0.07)†	(0.09)	(0.22)†	(0.06)†	(0.13)	(0.49)†
Arable land	-0.202	-1.701	-0.608	-1.132	-3.007	-1.198	-1.056	-9.521
	(0.24)	(0.24)†	(0.14)†	(0.19)†	(0.45)†	(0.13)†	(0.26)†	(0.96)†

† means that the estimate is significant at 95% level
†† means that the estimate is significant at 90% level
Standard errors in parentheses

Table 12 - Estimated country fixed effects, variable capital utilization rate and mobile capital

	Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery
Australia	1.04	1.88	0.90	0.57	2.51	1.67	1.86	9.35
Austria	0.84	-1.15	-0.18	-2.19	-4.21	-0.75	-0.95	-11.15
Belgium	1.24	-2.32	-1.11	-3.32	-5.72	-1.85	-1.36	-20.04
Canada	0.35	0.98	0.89	1.27	1.50	0.84	1.05	3.36
Denmark	1.43	-1.52	-0.38	-1.59	-3.09	-0.32	-1.45	-7.51
Finland	1.02	-0.22	0.81	2.27	-1.95	-0.10	-0.60	-4.67
France	0.98	-0.51	-0.43	-1.76	-1.63	-0.44	-0.67	-5.33
Germany	0.69	-2.30	-0.74	-2.74	-1.92	-1.36	-0.79	-6.10
Greece	0.11	-0.05	-0.80	-2.83	-3.58	-0.31	-0.95	-7.14
Ireland	6.26	0.18	-0.46	-1.33	-0.71	0.85	-1.24	-3.68
Italy	-0.49	-1.05	-1.04	-3.27	-4.33	-1.02	-1.05	-11.96
Japan	-0.21	-4.75	-1.74	-3.81	-8.55	-3.08	-2.30	-24.93
Korea	0.12	-1.43	-1.67	-4.07	-5.38	-2.01	-0.92	-14.52
Mexico	-1.61	-1.89	-1.01	-2.69	-4.02	-0.26	-0.13	-5.91
Netherlands	0.72	-4.70	-1.82	-3.59	-7.28	-2.93	-3.22	-25.31
New Zealand	2.92	0.26	0.61	0.12	-1.05	0.19	-0.38	-2.24
Norway	0.70	-2.34	-0.36	-1.83	-5.14	-1.62	-1.53	-17.16
Portugal	0.64	1.18	-0.22	-2.09	-3.82	0.31	-0.75	-6.55
Spain	0.87	0.08	-0.14	-1.84	-1.63	0.44	-0.02	-2.19
Sweden	0.02	-1.97	0.34	0.24	-3.61	-0.89	-0.66	-6.12
Turkey	-0.15	0.38	-0.76	-2.39	-0.86	0.70	1.44	1.80
United Kingdom	0.69	-3.00	-1.30	-2.21	-4.76	-1.66	-1.59	-12.66
United States	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 13 - Estimated time fixed effects, variable capital utilization rate and mobile goods

	Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery
1975	10.89	12.72	3.46	7.38	8.14	2.18	-2.38	-20.70
1976	10.91	12.75	3.47	7.33	8.14	2.15	-2.46	-21.02
1977	10.90	12.60	3.45	7.26	8.01	2.11	-2.54	-21.57
1978	10.92	12.56	3.42	7.24	7.93	2.05	-2.63	-22.09
1979	10.80	12.47	3.42	7.25	7.99	1.99	-2.66	-22.66
1980	10.82	12.37	3.38	7.21	7.85	1.94	-2.74	-23.28
1981	10.95	12.33	3.33	7.23	7.96	1.98	-2.74	-23.30
1982	11.02	12.19	3.27	7.20	7.85	1.93	-2.83	-23.31
1983	11.00	12.09	3.28	7.22	7.76	1.91	-2.84	-23.51
1984	10.95	12.07	3.27	7.30	7.84	1.90	-2.80	-23.38
1985	10.88	11.96	3.23	7.21	7.68	1.85	-2.86	-23.48
1986	10.67	11.78	3.16	7.07	7.61	1.71	-3.05	-24.13
1987	10.61	11.73	3.12	7.02	7.42	1.62	-3.21	-24.67
1988	10.50	11.62	3.11	6.98	7.48	1.57	-3.23	-25.08
1989	10.52	11.57	3.13	6.99	7.43	1.56	-3.27	-25.34
1990	10.44	11.53	3.09	6.91	7.24	1.49	-3.43	-26.02
1991	10.54	11.47	3.05	6.88	6.93	1.48	-3.50	-26.89
1992	10.51	11.43	3.01	6.81	6.72	1.45	-3.65	-27.83
1993	10.58	11.45	3.03	6.90	6.82	1.48	-3.64	-27.94
1994	10.45	11.43	3.09	6.90	6.78	1.41	-3.68	-28.18
1995	10.34	11.38	3.03	6.94	6.86	1.39	-3.73	-28.34

Table 14 - Estimates, constant capital utilization and immobile capital

	Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery
TFP Food	**1.840**	0.047	0.045	-0.305	-0.415	-0.165	-0.015	-0.926
	(0.09)†	(0.07)	(0.05)	(0.06)†	(0.05)†	(0.04)†	(0.05)	(0.11)†
TFP Textile	0.047	**0.513**	-0.170	-0.181	-0.385	-0.233	-0.018	-0.813
	(0.07)	**(0.02)†**	(0.06)†	(0.07)†	(0.06)†	(0.05)†	(0.06)	(0.13)†
TFP Wood	0.045	-0.170	**0.756**	0.049	-0.279	0.081	-0.122	-0.277
	(0.05)	(0.06)†	**(0.07)†**	(0.06)	(0.04)†	(0.04)†	(0.04)†	(0.09)†
TFP Paper	-0.305	-0.181	0.049	**0.492**	-0.454	0.029	-0.099	-0.611
	(0.06)†	(0.07)†	(0.06)	**(0.02)†**	(0.05)†	(0.04)	(0.05)†	(0.10)†
TFP Chemicals	-0.415	-0.385	-0.279	-0.454	**2.456**	-0.168	-0.127	-0.121
	(0.05)†	(0.06)†	(0.04)†	(0.05)†	**(0.08)†**	(0.03)†	(0.05)†	(0.12)
TFP Nonmetals	-0.165	-0.233	0.081	0.029	-0.168	**0.441**	0.000	-0.527
	(0.04)†	(0.05)†	(0.04)†	(0.04)	(0.03)†	**(0.01)†**	(0.03)	(0.06)†
TFP Metals	-0.015	-0.018	-0.122	-0.099	-0.127	0.000	**0.679**	-0.620
	(0.05)	(0.06)	(0.04)†	(0.05)†	(0.05)†	(0.03)	**(0.01)†**	(0.10)†
TFP Machinery	-0.926	-0.813	-0.277	-0.611	-0.121	-0.527	-0.620	**3.836**
	(0.11)†	(0.13)†	(0.09)†	(0.10)†	(0.12)	(0.06)†	(0.10)†	**(0.15)†**
K(i) Food	**0.675**	-1.362	0.036	-0.053	-1.558	-0.567	0.149	-1.412
	(0.20)†	(0.22)†	(0.14)	(0.18)	(0.31)†	(0.11)†	(0.17)	(0.69)†
K(i) Textile	0.175	**1.067**	0.088	0.097	-0.191	0.015	-0.078	-0.484
	(0.12)	**(0.14)†**	(0.09)	(0.11)	(0.19)	(0.07)	(0.11)	(0.42)
K(i) Wood	0.304	-0.056	**0.270**	0.226	-0.078	0.001	-0.274	-0.033
	(0.09)†	(0.10)	**(0.06)†**	(0.08)†	(0.15)	(0.05)	(0.08)†	(0.32)
K(i) Paper	-1.180	-0.698	-0.365	**0.191**	-0.951	-0.282	-0.598	-1.666
	(0.14)†	(0.15)†	(0.09)†	**(0.04)†**	(0.21)†	(0.07)†	(0.12)†	(0.47)†
K(i) Chemicals	-0.219	-0.006	-0.094	-0.088	**1.764**	0.062	0.135	0.805
	(0.09)†	(0.10)	(0.06)	(0.08)	**(0.14)†**	(0.05)	(0.08)††	(0.31)†
K(i) Nonmetals	-0.295	0.373	-0.071	-0.380	0.102	**0.599**	0.333	-0.465
	(0.14)†	(0.15)†	(0.09)	(0.12)†	(0.21)	**(0.08)†**	(0.12)†	(0.46)
K(i) Metals	0.324	0.296	-0.081	-0.002	0.297	0.159	**0.615**	0.188
	(0.06)†	(0.07)†	(0.05)††	(0.06)	(0.10)†	(0.04)†	**(0.06)†**	(0.22)
K(i) Machinery	0.191	-0.031	0.325	0.498	0.956	0.157	0.378	**5.669**
	(0.12)	(0.13)	(0.08)†	(0.11)†	(0.19)†	(0.07)†	(0.11)†	**(0.41)†**

	Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery
Low-ed. workers	0.254	0.174	0.122	0.031	0.464	-0.011	0.203	-0.283
	(0.07)†	(0.08)†	(0.05)†	(0.06)	(0.11)†	(0.04)	(0.06)†	(0.25)
Mid-ed. workers	-0.175	-0.085	-0.216	-0.357	-0.309	-0.219	-0.303	-0.966
	(0.13)	(0.14)	(0.09)†	(0.11)†	(0.20)	(0.07)†	(0.11)†	(0.44)†
High-ed. workers	0.523	0.284	0.192	0.115	0.500	0.089	0.111	1.660
	(0.11)†	(0.13)†	(0.08)†	(0.10)	(0.18)†	(0.06)	(0.10)	(0.39)†
Arable land	0.048	-0.178	-0.294	-0.487	0.251	-0.547	0.152	-1.548
	(0.27)	(0.30)	(0.19)	(0.24)†	(0.42)	(0.15)†	(0.23)	(0.93)††

† means that the estimate is significant at 95% level
†† means that the estimate is significant at 90% level
Standard errors in parentheses

Table 15 - Estimates, variable capital utilization and immobile capital

	Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery
TFP Food	**1.253**	0.062	-0.020	-0.168	-0.110	-0.050	-0.047	-0.897
	(0.05)†	(0.07)	(0.05)	(0.06)†	(0.06)††	(0.03)	(0.05)	(0.11)†
TFP Textile	0.062	**0.310**	-0.104	-0.051	-0.211	-0.039	-0.062	-0.905
	(0.07)	**(0.01)†**	(0.06)††	(0.07)	(0.06)†	(0.05)	(0.06)	(0.12)†
TFP Wood	-0.020	-0.104	**0.591**	0.059	-0.218	0.018	-0.149	-0.053
	(0.05)	(0.06)††	**(0.06)†**	(0.05)	(0.04)†	(0.03)	(0.04)†	(0.08)
TFP Paper	-0.168	-0.051	0.059	**0.334**	-0.353	-0.174	0.088	-0.515
	(0.06)†	(0.07)	(0.05)	**(0.04)†**	(0.05)†	(0.04)†	(0.05)††	(0.10)†
TFP Chemicals	-0.110	-0.211	-0.218	-0.353	**1.651**	-0.110	-0.373	-0.319
	(0.06)††	(0.06)†	(0.04)†	(0.05)†	**(0.09)†**	(0.03)†	(0.05)†	(0.12)†
TFP Nonmetals	-0.050	-0.039	0.018	-0.174	-0.110	**0.297**	0.134	-0.489
	(0.03)	(0.05)	(0.03)	(0.04)†	(0.03)†	**(0.06)†**	(0.03)†	(0.06)†
TFP Metals	-0.047	-0.062	-0.149	0.088	-0.373	0.134	**0.499**	-0.381
	(0.05)	(0.06)	(0.04)†	(0.05)††	(0.05)†	(0.03)†	**(0.07)†**	(0.09)†
TFP Machinery	-0.897	-0.905	-0.053	-0.515	-0.319	-0.489	-0.381	**2.384**
	(0.11)†	(0.12)†	(0.08)	(0.10)†	(0.12)†	(0.06)†	(0.09)†	**(0.19)†**
K(i) Food	**0.323**	-1.198	0.218	0.379	-2.149	-0.562	-0.084	-1.932
	(0.09)†	(0.22)†	(0.14)	(0.17)†	(0.36)†	(0.10)†	(0.20)	(0.72)†
K(i) Textile	-0.017	**0.728**	0.157	0.291	-0.094	0.088	-0.461	-0.040
	(0.13)	**(0.14)†**	(0.09)††	(0.11)†	(0.23)	(0.06)	(0.13)†	(0.45)
K(i) Wood	0.169	-0.142	**0.112**	0.207	0.272	-0.031	-0.053	-0.042
	(0.10)††	(0.10)	**(0.02)†**	(0.08)†	(0.17)	(0.05)	(0.09)	(0.34)
K(i) Paper	-1.248	-0.684	-0.326	**0.411**	-0.687	-0.284	-0.982	-1.534
	(0.15)†	(0.15)†	(0.10)†	**(0.08)†**	(0.25)†	(0.07)†	(0.14)†	(0.50)†
K(i) Chemicals	-0.015	0.067	-0.012	-0.046	**1.024**	0.204	0.193	0.913
	(0.10)	(0.10)	(0.06)	(0.08)	**(0.16)†**	(0.05)†	(0.09)†	(0.32)†
K(i) Nonmetals	-0.116	0.572	-0.215	-0.565	-0.033	**0.412**	0.671	-0.161
	(0.15)	(0.15)†	(0.09)†	(0.12)†	(0.25)	**(0.07)†**	(0.14)†	(0.49)
K(i) Metals	0.325	0.298	-0.040	0.116	0.382	0.150	**0.197**	0.412
	(0.07)†	(0.07)†	(0.04)	(0.06)†	(0.12)†	(0.03)†	**(0.06)†**	(0.23)††
K(i) Machinery	0.301	0.063	0.179	0.280	1.329	0.109	0.975	**5.461**
	(0.13)†	(0.13)	(0.08)†	(0.11)†	(0.22)†	(0.06)††	(0.12)†	**(0.44)†**

	Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery
Low-ed. workers	0.302	0.086	0.134	-0.098	0.561	0.053	0.273	-0.309
	(0.08)†	(0.08)	(0.05)†	(0.06)	(0.13)†	(0.04)	(0.07)†	(0.27)
Mid-ed. workers	-0.343	-0.237	-0.187	-0.327	-0.185	-0.122	-0.477	-0.976
	(0.14)†	(0.14)††	(0.09)†	(0.11)†	(0.23)	(0.06)††	(0.13)†	(0.46)†
High-ed. workers	0.537	0.378	0.142	-0.109	0.779	0.103	0.145	1.747
	(0.12)†	(0.13)†	(0.08)††	(0.10)	(0.21)†	(0.06)††	(0.12)	(0.41)†
Arable land	0.536	-0.278	-0.243	-0.442	-0.128	-0.414	0.463	-1.444
	(0.29)††	(0.30)	(0.19)	(0.24)††	(0.49)	(0.14)†	(0.27)††	(0.99)

† means that the estimate is significant at 95% level
†† means that the estimate is significant at 90% level
Standard errors in parentheses

Table 16 - Summary of estimated own-TFP coefficients

Capital mobility:	Mobile			Immobile		
Capital utilization:	Constant	Variable	% change[1]	Constant	Variable	% change[1]
Food	1.78	1.24	35.87%	1.84	1.25	38.19%
Textile	0.42	0.34	21.52%	0.51	0.31	48.78%
Wood	0.72	0.61	16.56%	0.76	0.59	25.04%
Paper	0.39	0.28	33.84%	0.49	0.33	39.02%
Chemicals	2.04	1.68	18.96%	2.46	1.66	38.71%
Nonmetals	0.41	0.31	28.02%	0.44	0.30	37.84%
Metals	0.59	0.51	14.63%	0.68	0.50	29.73%
Machinery	3.48	2.41	36.33%	3.84	2.38	46.99%
Value-weighted average			**29.21%**			**41.19%**

Tables 17-18 Explaining the difference of the Machinery industry shares in 1995 between Portugal and Germany, using the estimated model

Table 17 Using the model with variable capital utilization

	Relative factor stock[1]	Contrib. to share[2]	Share
Portugal			3.9
TFP	3.15	2.8	
Capital per worker	3.11	3.6	
Low-educated	0.45	0.3	
Medium-educated	3.64	-0.1	
Highly educated	1.56	0.8	
Total TFP and factors			7.3
All other			2.5
Germany			13.7

Table 18 Using the model with constant capital utilization

	Relative factor stock[1]	Contrib. to share[2]	Share
Portugal			3.9
TFP	3.15	4.0	
Capital per worker	3.11	3.0	
Low-educated	0.45	0.4	
Medium-educated	3.64	0.0	
Highly educated	1.56	0.7	
Total TFP and factors			8.1
All other differences			1.6
Germany			13.7

[1]Germany(95)/Portugal(95)

[2]Contribution of the relative factor stock to the difference of shares

Tables 19-20 Explaining the evolution of the Machinery and Textile industries' shares between 1975 and 1995 in Korea and Turkey, using the estimated model

Table 19 Industry shares, technology, and factors in Korea and Turkey

	Korea			Turkey			Relative
	1975	1995	Change	1975	1995	Change	accum. rate[1]
Machinery share	4.5%	20.5%	15.9%	2.3%	4.4%	2.1%	
Machinery TFP	15	81	5.4	33	51	1.5	3.49
Textile share	6.1%	4.6%	4.6%	1.9%	3.7%	1.8%	
Textile TFP	21	65	3.1	37	48	1.3	2.35
Capital per worker	$4,557	$36,809	8.1	$7,630	$10,662	1.4	5.78
Low-educated	39.20	18.20	0.5	31.90	47.20	1.5	0.31
Medium-educated	28.70	51.90	1.8	7.30	15.70	2.2	0.84
Highly educated	6.90	21.10	3.1	1.80	6.50	3.6	0.85
Land per worker	0.15	0.08	0.5	1.44	0.88	0.6	0.87

Table 20a Machinery industry in Korea vs Turkey

	Relative accum. rate	Contrib. to share[2]	Share
1975 share difference			2.2
TFP	3.49	3.03	
Capital per worker	5.78	5.54	
Low-educated	0.31	0.46	
Medium-educated	0.84	0.02	
Highly educated	0.85	-0.28	
Land per worker	0.87	1.30	
Total due to accumulation			10.1
All other			3.8
1995 share difference			16.1

Table 20b Textile industry in Korea vs Turkey

	Relative accum. rate	Contrib. to share[2]	Share
1975 share difference			4.2
TFP	2.35	0.29	
Capital per worker	5.78	-2.21	
Low-educated	0.31	-0.19	
Medium-educated	0.84	-0.06	
Highly educated	0.85	-0.11	
Land per worker	0.87	0.23	
Total due to accumulation			-2.1
All other			-1.2
1995 share difference			0.9

[1] [Korea(95)/Korea(75)]/[Turkey(95)/Turkey(75)]

[2] Contribution of the relative accumulation rate of this factor to the difference of shares

Table 21 List of model parameters

Name	How obtained
α_j	production data and Shikher (2004a)
β_j	production data
η_{im}	input-output tables
η_m^I	input-output tables
θ	8.28, Eaton and Kortum (2002)
d_{nij}	estimated, trade and output data
ψ_{nj}	fitted, output and spending data
T_{ij}	fitted, output and spending data
L_n	fitted, output and spending data
K_n	fitted, output and spending data
VA_n^O	fitted, output and spending data
s_i	fitted, output and spending data

Table 22 List of countries in the dataset

Country Name
Australia
Austria
Canada
Finland
France
Germany (West)
Greece
Italy
Japan
Korea
Mexico
New Zealand
Norway
Portugal
Spain
Sweden
Turkey
United Kingdom
United States

Table 23 Shares of factors and inputs

Industry	Capital	Labor	Inputs	Cap. in VA
Food	0.062	0.103	0.835	0.37
Textile	0.058	0.201	0.741	0.22
Wood	0.064	0.182	0.755	0.26
Paper	0.081	0.185	0.733	0.31
Chemicals	0.082	0.115	0.803	0.42
Nonmet.	0.106	0.185	0.709	0.36
Metals	0.086	0.133	0.781	0.39
Machinery	0.071	0.186	0.743	0.28

Table 24 Industry shares in intermediate and investment goods

SOURCES, m	USES, j: Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery	Capital
Food	**0.224**	0.001	0.002	0.042	0.045	0.012	0.001	0.034	0.002
Textile	0.017	**0.487**	0.001	0.024	0.125	0.001	0.001	0.019	0.002
Wood	0.002	0.040	**0.281**	0.019	0.084	0.013	0.023	0.058	0.011
Paper	0.006	0.008	0.020	**0.439**	0.090	0.002	0.003	0.027	0.001
Chemicals	0.014	0.008	0.002	0.023	**0.392**	0.007	0.012	0.030	0.004
Nonmetals	0.003	0.005	0.007	0.045	0.100	**0.186**	0.020	0.050	0.001
Metals	0.001	0.002	0.002	0.004	0.049	0.013	**0.459**	0.046	0.004
Machinery	0.002	0.008	0.007	0.014	0.073	0.011	0.152	**0.440**	0.661
Manuf.	0.268	0.559	0.322	0.610	0.959	0.245	0.671	0.704	0.686
Nonmanuf.	0.732	0.441	0.678	0.390	0.041	0.755	0.329	0.296	0.314
Total	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Note: The above data is the average of the following countries and years:
Countries: Australia, Canada, France, Germany, Japan, UK, US
Australia: 1989, all other countries: 1990

Table 25 Average transport costs in each industry

ISIC2	**Av. transport cost**
Food	2.45
Textile	2.02
Wood	2.57
Paper	2.44
Chemicals	2.21
Nonmetals	2.38
Metals	2.04
Machinery	2.01
Average	2.27
Max	6.62
Min	~1
St. Dev.	0.77

Table 26 Estimated relative import barriers for 1989

	Food	Textile	Wood	Paper	Chemicals	Nonmet.	Metals	Machinery
Australia	1.28	1.51	1.92	1.43	1.45	1.62	1.29	1.51
Austria	2.20	1.41	2.31	1.57	1.74	1.73	1.81	1.62
Canada	1.25	1.28	1.26	1.07	1.42	1.42	1.05	1.38
Finland	2.59	1.74	2.02	1.46	1.77	2.00	1.62	1.80
France	1.34	1.22	1.70	1.35	1.29	1.38	1.37	1.40
Germany	1.48	1.09	1.43	1.13	1.20	1.24	1.24	1.21
Greece	1.72	1.80	2.73	2.18	2.37	1.93	1.88	2.61
Italy	1.39	1.10	1.40	1.33	1.35	1.30	1.50	1.41
Japan	1.50	1.22	1.55	1.37	1.18	1.19	1.16	1.29
Korea	1.64	0.96	1.82	1.44	1.28	1.49	1.18	1.38
Mexico	1.77	1.81	2.10	2.11	1.67	1.81	1.70	1.86
New Zeal.	1.27	1.59	2.04	1.48	1.52	1.91	1.34	1.88
Norway	1.76	1.73	2.33	1.81	1.58	2.01	1.41	1.90
Portugal	1.91	1.14	2.39	1.73	2.25	1.80	1.80	1.86
Spain	1.58	1.59	1.95	1.54	1.61	1.60	1.63	1.72
Sweden	1.87	1.30	1.80	1.30	1.48	1.54	1.41	1.36
Turkey	2.37	2.09	3.29	2.98	2.28	2.11	1.98	2.83
U.K.	1.36	1.19	1.59	1.20	1.26	1.35	1.28	1.27
U.S.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Av. non-U	1.68	1.43	1.98	1.58	1.60	1.63	1.48	1.68

Table 27 Country rankings according to their estimated relative import barriers

Food	Textile	Wood	Paper	Chemicals	Nonmet.	Metals	Machinery
U.S.	Korea	U.S.	U.S.	U.S.	U.S.	U.S.	U.S.
Canada	U.S.	Canada	Canada	Japan	Japan	Canada	Germ.
N.Z.	Germ.	Italy	Germ.	Germ.	Germ.	Japan	U.K.
Austral.	Italy	Germ.	U.K.	U.K.	Italy	Korea	Japan
France	Portugal	Japan	Sweden	Korea	U.K.	Germ.	Sweden
U.K.	U.K.	U.K.	Italy	France	France	U.K.	Canada
Italy	France	France	France	Italy	Canada	Austral.	Korea
Germ.	Japan	Sweden	Japan	Canada	Korea	N.Z.	France
Japan	Canada	Korea	Austral.	Austral.	Sweden	France	Italy
Spain	Sweden	Austral.	Korea	Sweden	Spain	Norway	Austral.
Korea	Austria	Spain	Finland	N.Z.	Austral.	Sweden	Austria
Greece	Austral.	Finland	N.Z.	Norway	Austria	Italy	Spain
Norway	N.Z.	N.Z.	Spain	Spain	Portugal	Finland	Finland
Mexico	Spain	Mexico	Austria	Mexico	Mexico	Spain	Portugal
Sweden	Norway	Austria	Portugal	Austria	N.Z.	Mexico	Mexico
Portugal	Finland	Norway	Norway	Finland	Greece	Portugal	N.Z.
Austria	Greece	Portugal	Mexico	Portugal	Finland	Austria	Norway
Turkey	Mexico	Greece	Greece	Turkey	Norway	Greece	Greece
Finland	Turkey	Turkey	Turkey	Greece	Turkey	Turkey	Turkey

Table 28 Technology parameters and capital-labor ratios, relative to the United States

	Technology parameters								
	Food	Textile	Wood	Paper	Chem.	Nonmet.	Metals	Mach.	Capital
Australia	0.253	0.098	0.018	0.040	0.048	0.045	0.408	0.054	0.524
Austria	0.027	0.154	0.029	0.087	0.063	0.201	0.137	0.073	0.604
Canada	0.266	0.292	0.503	0.753	0.153	0.139	0.914	0.149	0.799
Finland	0.013	0.080	0.089	0.434	0.056	0.048	0.238	0.072	0.641
France	0.368	0.702	0.138	0.260	0.372	0.792	0.587	0.318	0.921
Germany	0.215	0.676	0.220	0.332	0.522	0.914	0.683	0.521	0.894
Greece	0.043	0.044	0.001	0.003	0.008	0.033	0.040	0.002	0.202
Italy	0.178	1.435	0.339	0.206	0.249	1.387	0.369	0.356	0.884
Japan	0.080	0.776	0.119	0.309	0.571	1.491	1.007	1.228	0.979
Korea	0.032	0.319	0.008	0.017	0.069	0.043	0.148	0.061	0.263
Mexico	0.010	0.009	0.001	0.001	0.017	0.010	0.022	0.003	0.121
New Zeal.	0.358	0.058	0.020	0.042	0.031	0.009	0.056	0.015	0.380
Norway	0.101	0.032	0.030	0.123	0.084	0.036	0.313	0.053	0.684
Portugal	0.018	0.028	0.004	0.011	0.006	0.024	0.011	0.004	0.171
Spain	0.117	0.140	0.026	0.058	0.080	0.211	0.193	0.048	0.428
Sweden	0.033	0.067	0.076	0.255	0.088	0.092	0.248	0.135	0.644
Turkey	0.014	0.019	0.000	0.000	0.007	0.015	0.027	0.001	0.090
U.K.	0.232	0.320	0.055	0.166	0.256	0.342	0.352	0.197	0.624
U.S.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table 29 Country rankings according to their technology parameters and capital-labor ratios

Technology parameters								
Food	Textile	Wood	Paper	Chem.	Nonmet.	Metals	Mach.	Capital
U.S.	Italy	U.S.	U.S.	U.S.	Japan	Japan	Japan	U.S.
France	U.S.	Canada	Canada	Japan	Italy	U.S.	U.S.	Japan
N.Z.	Japan	Italy	Finland	Germ.	U.S.	Canada	Germ.	France
Canada	France	Germ.	Germ.	France	Germ.	Germ.	Italy	Germ.
Austral.	Germ.	France	Japan	U.K.	France	France	France	Italy
U.K.	U.K.	Japan	France	Italy	U.K.	Austral.	U.K.	Canada
Germ.	Korea	Finland	Sweden	Canada	Spain	Italy	Canada	Norway
Italy	Canada	Sweden	Italy	Sweden	Austria	U.K.	Sweden	Sweden
Spain	Austria	U.K.	U.K.	Norway	Canada	Norway	Austria	Finland
Norway	Spain	Norway	Norway	Spain	Sweden	Sweden	Finland	U.K.
Japan	Austral.	Austria	Austria	Korea	Finland	Finland	Korea	Austria
Greece	Finland	Spain	Spain	Austria	Austral.	Spain	Austral.	Austral.
Sweden	Sweden	N.Z.	N.Z.	Finland	Korea	Korea	Norway	Spain
Korea	N.Z.	Austral.	Austral.	Austral.	Norway	Austria	Spain	N.Z.
Austria	Greece	Korea	Korea	N.Z.	Greece	N.Z.	N.Z.	Korea
Portugal	Norway	Portugal	Portugal	Mexico	Portugal	Greece	Portugal	Greece
Turkey	Portugal	Greece	Greece	Greece	Turkey	Turkey	Mexico	Portugal
Finland	Turkey	Mexico	Mexico	Turkey	Mexico	Mexico	Greece	Mexico
Mexico	Mexico	Turkey	Turkey	Portugal	N.Z.	Portugal	Turkey	Turkey

Figure 5 Histogram of the percent deviations of predicted from actual trade flows

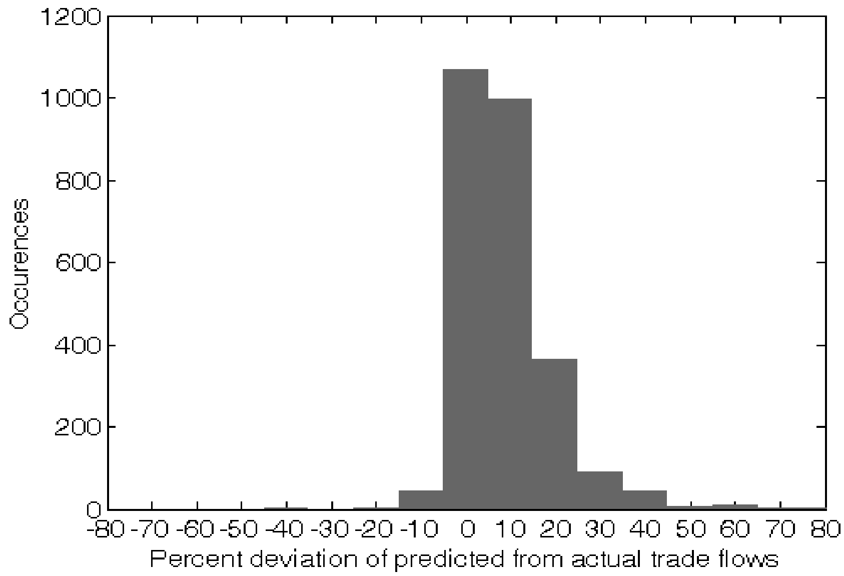

Table 30 Average and median percent deviations
of predicted from actual trade flows by industry

	Food	Textile	Wood	Paper	Chem.	Nonmet.	Metals	Mach.	World
Mean	4.60	12.24	6.81	7.49	8.27	4.60	13.95	11.11	8.66
Median	3.23	9.54	3.56	4.96	7.27	3.92	11.57	11.16	6.23

Table 31 Predicted and actual Grubel-Lloyd intra-industry trade indices

	Food	Textile	Wood	Paper	Chem.	Nonmet.	Metals	Mach.	World
Model	0.487	0.4071	0.4245	0.3465	0.5508	0.4427	0.5489	0.4421	0.4562
Data	0.4886	0.3901	0.4247	0.3407	0.5408	0.4722	0.5503	0.4224	0.4541
Difference	-0.32%	4.27%	-0.05%	1.69%	1.84%	-6.46%	-0.26%	4.57%	0.46%

Figure 6 Histograms of percent deviation of predicted from actual trade flows, by industry

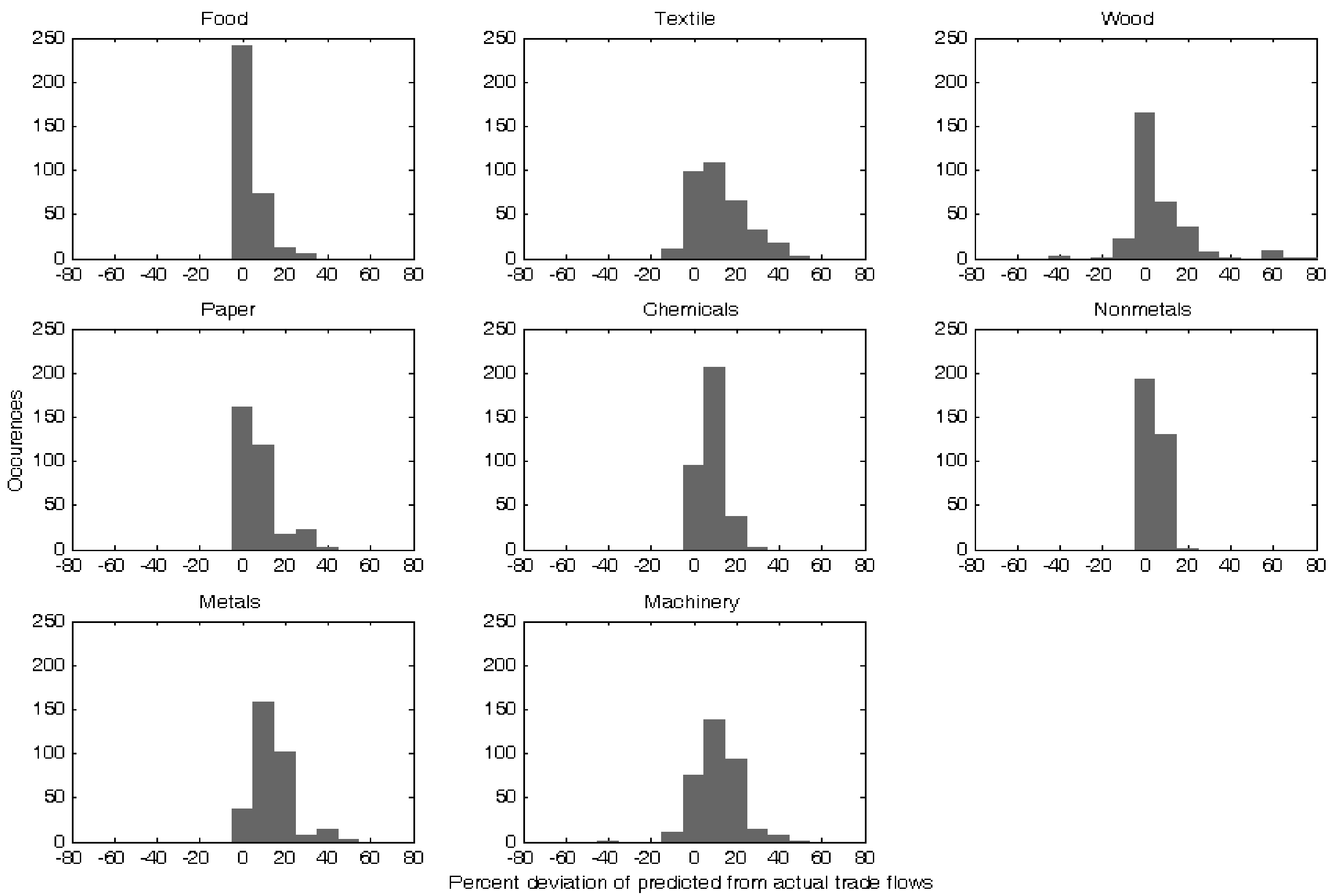

Table 32 Country-level diagnostics

	% deviations of trade flows			GL IIT index		
	Mean	Median	Std. Dev.	Model	Data	Difference
Australia	6.62	3.82	9.10	0.28	0.28	-1.17%
Austria	10.01	10.15	8.89	0.49	0.49	0.14%
Canada	5.63	4.26	6.87	0.46	0.45	2.11%
Finland	12.31	9.47	11.39	0.45	0.45	-0.71%
France	10.07	8.96	7.00	0.57	0.56	1.91%
Germany	14.13	12.63	8.64	0.55	0.53	4.43%
Greece	4.72	3.96	5.46	0.37	0.37	0.31%
Italy	11.90	11.28	10.48	0.49	0.48	3.53%
Japan	6.82	4.68	7.94	0.44	0.43	2.16%
Korea	10.15	5.09	12.19	0.46	0.45	3.37%
Mexico	1.25	2.13	6.59	0.37	0.36	3.51%
New Zealand	9.37	5.13	9.71	0.31	0.32	-2.29%
Norway	12.06	7.72	13.88	0.46	0.46	-0.02%
Portugal	10.12	6.47	11.06	0.45	0.44	2.72%
Spain	6.47	5.64	6.49	0.55	0.54	2.12%
Sweden	12.14	11.06	9.23	0.50	0.48	3.07%
Turkey	7.80	4.64	9.61	0.33	0.35	-5.70%
United Kingdom	7.88	5.71	7.43	0.57	0.55	2.88%
United States	4.53	3.55	7.39	0.56	0.55	2.10%

Table 33a Accounting for volume of trade

Determinants of trade that are removed	Percent change in the volume of trade
Industry-level	
Factor endowments	1.36%
Comparative advantage	-5.09%
Tastes	6.08%
Product-level	
Comparative advantage	-93.40%

Table 33b Accounting for inter- and intra-industry trade

	Change in GL index	% contri- bution to total	GL index value (balance)
Current value of GL index			0.46
Removing determinants of trade:			
Industry-level			
Factor endowments	0.01	3%	0.47
Comparative advantage	0.06	12%	0.53
Tastes	0.04	8%	0.57
Geography-related	0.39	78%	0.96
Total industry-level	0.50	100%	0.96
Product-level			
Comparative advantage	-0.43	N/A	0.03

Table 34a Removing industry-level comparative advantages, percentage changes of exports

	Food	Textile	Wood	Paper	Chem.	Nonmet.	Metals	Mach.
Australia	-196%	53%	96%	72%	58%	58%	-209%	28%
Austria	87%	-8%	40%	-52%	26%	-46%	-22%	7%
Canada	-27%	6%	-125%	-161%	69%	70%	-120%	58%
Finland	194%	93%	-105%	-248%	71%	129%	-63%	35%
France	-31%	-25%	37%	29%	-3%	-18%	11%	18%
Germany	88%	23%	0%	22%	-20%	1%	26%	-12%
Greece	-166%	-129%	198%	124%	48%	-80%	-109%	187%
Italy	108%	-114%	-64%	66%	66%	-95%	102%	10%
Japan	273%	-11%	232%	149%	17%	-76%	-18%	-94%
Korea	-48%	-192%	183%	187%	-19%	115%	-82%	11%
Mexico	-62%	-40%	205%	199%	-136%	-56%	-142%	57%
New Zealand	-298%	-4%	-105%	-119%	20%	152%	22%	115%
Norway	-81%	161%	32%	-112%	-25%	92%	-122%	46%
Portugal	-102%	-68%	-12%	-75%	58%	-59%	50%	87%
Spain	-41%	-39%	35%	5%	-3%	-58%	-56%	50%
Sweden	147%	129%	-45%	-132%	40%	69%	-33%	-11%
Turkey	-208%	-140%	194%	380%	-38%	-60%	-180%	227%
United Kingdom	-7%	7%	124%	15%	-38%	4%	-6%	2%
United States	-84%	78%	-91%	-7%	-14%	24%	87%	7%

Table 34b Removing industry-level comparative advantages, percentage changes of imports

	Food	Textile	Wood	Paper	Chem.	Nonmet.	Metals	Mach.
Australia	177%	-55%	-125%	-74%	-55%	-123%	155%	-27%
Austria	-49%	1%	-18%	22%	-15%	25%	14%	-3%
Canada	28%	-29%	68%	87%	-44%	-64%	98%	-17%
Finland	-144%	-32%	61%	135%	-49%	-109%	37%	-17%
France	51%	-7%	-41%	-30%	6%	-3%	15%	-8%
Germany	-79%	-40%	-10%	-44%	20%	-10%	-19%	6%
Greece	98%	18%	-153%	-120%	-21%	26%	64%	-91%
Italy	-50%	40%	56%	-69%	-48%	66%	-60%	-4%
Japan	-265%	-87%	-207%	-182%	-24%	70%	-35%	80%
Korea	-74%	-18%	-237%	-182%	8%	-117%	40%	-23%
Mexico	47%	24%	-59%	-138%	66%	31%	74%	-17%
New Zealand	190%	-1%	33%	48%	-7%	-173%	67%	-69%
Norway	134%	-22%	-36%	21%	15%	-75%	-14%	-22%
Portugal	56%	-53%	1%	28%	-36%	29%	31%	-7%
Spain	55%	1%	-32%	-18%	8%	33%	72%	-24%
Sweden	-105%	-22%	16%	57%	-25%	-44%	-5%	0%
Turkey	115%	82%	-185%	-389%	25%	62%	147%	-167%
United Kingdom	39%	-23%	-102%	-42%	28%	-21%	3%	-2%
United States	69%	-139%	28%	-35%	31%	-47%	-80%	-9%

Table 35 Effects of capital stock on specialization

	Food	Textile	Wood	Paper	Chem.	Nonmet.	Metals	Mach.
Regression	-1.097	-1.257	-0.286	-0.318	-0.394	-0.149	0.270	3.158
Simulation								
Average coeff.	-1.173	-0.718	-0.414	-0.014	0.761	-0.073	1.513	0.117
Std. dev.	0.56	0.58	0.29	0.45	0.62	0.22	0.59	0.74
Max	0.24	0.46	-0.02	1.07	2.01	0.45	2.88	1.28
Min	-2.08	-2.03	-0.92	-0.60	-0.68	-0.43	0.72	-1.49

Figure 7 Simulation and regression estimates

Figure 7a All industries

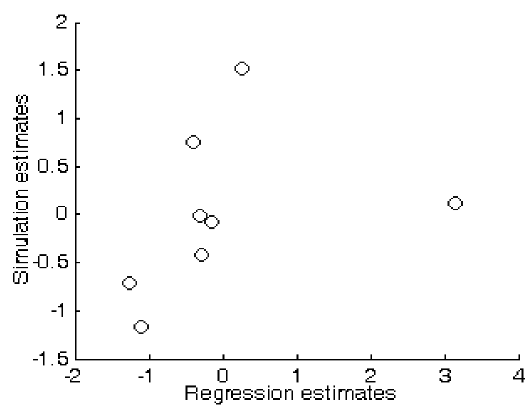

Figure 7b Without the Machinery industry

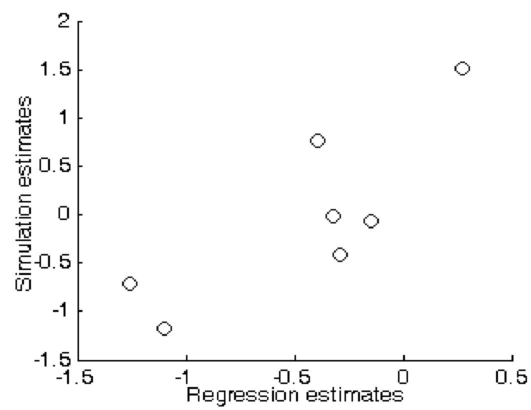

Table 36 Simulated capital stock coefficients, by industry

	Food	Textile	Wood	Paper	Chem.	Nonmet.	Metals	Mach.
Australia	-1.34	-0.77	-0.74	-0.60	0.52	-0.42	2.62	0.72
Austria	-1.59	-1.03	-0.72	0.27	1.57	-0.05	2.03	-0.47
Canada	-1.28	-0.67	-0.55	0.38	0.67	0.00	1.76	-0.31
Finland	-1.95	-0.41	-0.85	1.07	0.97	-0.26	1.59	-0.15
France	-1.12	-0.67	-0.28	-0.30	1.09	0.00	1.38	-0.10
Germany	-0.80	-0.49	-0.25	0.11	0.74	0.03	1.29	-0.63
Greece	-1.21	-1.58	-0.22	0.15	0.64	0.11	1.82	0.28
Italy	-0.75	-1.53	-0.20	-0.13	1.05	0.21	1.07	0.28
Japan	-0.52	-0.22	-0.11	-0.38	0.02	-0.19	0.78	0.62
Korea	-0.64	-1.14	-0.13	-0.17	0.09	-0.25	1.44	0.78
Mexico	-1.67	-0.64	-0.02	-0.04	0.82	-0.12	1.98	-0.32
New Zealand	0.24	-1.03	-0.74	-0.29	1.27	-0.10	1.09	-0.43
Norway	-2.08	-0.21	-0.74	-0.46	2.01	0.10	2.88	-1.49
Portugal	-1.08	-2.03	-0.41	0.81	1.04	0.45	0.72	0.51
Spain	-1.88	-0.69	-0.39	-0.12	0.62	-0.23	1.41	1.28
Sweden	-1.33	-0.26	-0.92	0.33	1.28	0.06	1.77	-0.93
Turkey	-1.30	0.46	-0.09	0.07	-0.68	-0.43	0.90	1.05
United Kingdom	-1.23	-0.53	-0.33	-0.41	0.82	-0.29	1.33	0.63
United States	-0.75	-0.22	-0.17	-0.55	-0.10	-0.02	0.87	0.93

Table 37 Summary of elasticities of specialization with respect to capital

	Food	Textile	Wood	Paper	Chem.	Nonmet.	Metals	Mach.
Av. elasticity	-0.087	-0.083	-0.079	-0.004	0.052	-0.012	0.178	0.005
Std. dev.	0.033	0.035	0.025	0.033	0.045	0.033	0.050	0.021
Max	0.009	0.022	-0.031	0.070	0.156	0.054	0.250	0.052
Min	-0.143	-0.126	-0.117	-0.051	-0.023	-0.061	0.064	-0.040

Table 38a Elasticities of specialization with respect to technology parameters

Source \ Effect	Food	Textile	Wood	Paper	Chem.	Nonmet.	Metals	Mach.
Food	**0.214**	-0.039	-0.031	-0.015	-0.024	-0.022	-0.058	-0.047
Textile	-0.041	**0.681**	-0.060	-0.059	-0.036	-0.063	-0.104	-0.099
Wood	-0.011	-0.020	**0.394**	-0.014	-0.013	-0.012	-0.025	-0.022
Paper	-0.025	-0.065	-0.038	**0.445**	-0.036	-0.044	-0.093	-0.076
Chemicals	-0.044	-0.052	-0.059	-0.051	**0.411**	-0.054	-0.099	-0.084
Nonmetals	-0.009	-0.023	-0.011	-0.014	-0.011	**0.274**	-0.016	-0.017
Metals	-0.051	-0.111	-0.067	-0.089	-0.065	-0.053	**0.691**	-0.037
Machinery	-0.147	-0.331	-0.205	-0.252	-0.183	-0.172	-0.096	**0.395**

Table 38b Standard deviation of elasticities

Source \ Effect	Food	Textile	Wood	Paper	Chem.	Nonmet.	Metals	Mach.
Food	**0.113**	0.047	0.034	0.027	0.034	0.023	0.067	0.048
Textile	0.040	**0.226**	0.060	0.059	0.036	0.059	0.085	0.093
Wood	0.007	0.015	**0.202**	0.015	0.010	0.009	0.020	0.018
Paper	0.024	0.071	0.044	**0.221**	0.038	0.044	0.087	0.075
Chemicals	0.015	0.028	0.024	0.027	**0.183**	0.022	0.037	0.030
Nonmetals	0.005	0.013	0.008	0.010	0.007	**0.123**	0.011	0.012
Metals	0.020	0.045	0.034	0.041	0.034	0.025	**0.256**	0.036
Machinery	0.037	0.111	0.086	0.108	0.066	0.061	0.087	**0.156**

Table 38c Minimum of elasticities

Source \ Effect	Food	Textile	Wood	Paper	Chem.	Nonmet.	Metals	Mach.
Food	**0.057**	-0.200	-0.154	-0.112	-0.151	-0.095	-0.314	-0.220
Textile	-0.137	**0.210**	-0.184	-0.230	-0.117	-0.193	-0.276	-0.281
Wood	-0.028	-0.051	**0.108**	-0.046	-0.029	-0.026	-0.065	-0.055
Paper	-0.091	-0.291	-0.173	**0.068**	-0.145	-0.161	-0.350	-0.308
Chemicals	-0.069	-0.097	-0.116	-0.091	**0.112**	-0.091	-0.163	-0.128
Nonmetals	-0.021	-0.054	-0.028	-0.040	-0.025	**0.054**	-0.043	-0.046
Metals	-0.091	-0.208	-0.162	-0.166	-0.167	-0.115	**0.183**	-0.141
Machinery	-0.187	-0.527	-0.351	-0.475	-0.299	-0.266	-0.283	**0.079**

Table 38d Maximum of elasticities

Source \ Effect	Food	Textile	Wood	Paper	Chem.	Nonmet.	Metals	Mach.
Food	**0.537**	0.000	-0.006	0.012	0.000	-0.003	-0.011	-0.008
Textile	-0.006	**0.975**	-0.005	-0.005	-0.002	-0.009	-0.018	-0.014
Wood	-0.001	-0.002	**0.915**	0.003	-0.001	-0.001	-0.001	0.000
Paper	-0.001	-0.003	0.003	**0.793**	-0.001	-0.004	-0.009	-0.007
Chemicals	-0.015	-0.004	-0.013	-0.009	**0.812**	-0.014	-0.017	-0.017
Nonmetals	-0.002	-0.004	-0.002	-0.002	-0.002	**0.464**	-0.002	-0.003
Metals	-0.021	-0.041	-0.026	-0.027	-0.021	-0.020	**1.108**	0.004
Machinery	-0.070	-0.169	-0.031	-0.088	-0.072	-0.064	0.043	**0.725**

Tables 39-42 Effects of industry trade wars between the U.S. and E.U.

Table 39 Changes of total manufacturing employment

	Food	Textile	Wood	Paper	Chem.	Nonmet.	Metals	Mach.	Manuf.
Australia	194	276	49	124	713	95	1,288	5,012	7,743
Austria	**-456**	**-1,345**	**371**	**944**	**244**	**-1,918**	**-1,316**	**2,650**	**-911**
Canada	710	3,094	1,806	1,130	3,945	1,463	7,484	28,359	48,213
Finland	-36	103	379	1,641	760	-35	760	5,196	8,786
France	**-6,816**	**-12,475**	**33**	**3,439**	**-2,055**	**-5,312**	**-13,207**	**17,889**	**-18,886**
Germany	**-633**	**-12,098**	**193**	**6,433**	**-8,693**	**-7,614**	**-13,647**	**-35,818**	**-73,581**
Greece	**-1,148**	**-8,522**	**574**	**511**	**556**	**-3,625**	**-384**	**2,461**	**-9,559**
Italy	**-3,145**	**-59,925**	**-5,199**	**3,648**	**8**	**-14,133**	**-1,764**	**16,041**	**-64,905**
Japan	557	5,261	706	851	9,276	2,365	16,654	141,099	177,570
Korea	483	44,462	358	486	5,976	1,209	6,676	47,383	107,478
Mexico	1,142	5,533	271	245	3,353	2,747	8,251	15,621	37,206
New Zeal.	199	73	14	42	222	33	158	960	1,701
Norway	49	17	68	397	555	-11	782	3,069	4,926
Portugal	**-272**	**-17,378**	**337**	**698**	**-245**	**-3,617**	**-293**	**-112**	**-20,855**
Spain	**-5,682**	**-22,094**	**1,586**	**1,950**	**1,571**	**-9,352**	**-6,057**	**39,203**	**1,012**
Sweden	-52	2	575	2,444	1,723	-55	1,888	17,999	24,542
Turkey	171	7,316	135	664	3,058	46	1,392	9,019	21,844
U.K.	**-8,780**	**-16,783**	**468**	**1,949**	**-6,880**	**-7,878**	**-15,018**	**-44,084**	**-97,079**
U.S.	21,279	116,429	-76	-25,842	-5,646	40,727	6,932	-208,561	-53,543
Total E.U.	-26,932	-150,620	-1,638	19,571	-15,495	-53,449	-51,684	-1,771	-284,763
Total U.S.	21,279	116,429	-76	-25,842	-5,646	40,727	6,932	-208,561	-53,543
Total other	3,418	66,136	4,361	8,023	29,581	7,859	45,333	273,716	440,010
World	-2,236	31,945	2,648	1,753	8,439	-4,864	581	63,385	101,703

E.U. countries are bolded

Table 40 Percentage change in country welfare

	Food	Textile	Wood	Paper	Chem.	Nonmet.	Metals	Mach.	Manuf.
Australia	0.000%	-0.001%	0.000%	-0.001%	-0.006%	-0.001%	-0.007%	-0.032%	-0.048%
Austria	**-0.006%**	**-0.005%**	**-0.003%**	**-0.015%**	**-0.058%**	**-0.001%**	**-0.012%**	**-0.208%**	**-0.306%**
Canada	0.000%	-0.003%	-0.001%	-0.001%	-0.010%	-0.002%	-0.016%	-0.051%	-0.084%
Finland	0.000%	-0.002%	0.000%	-0.002%	-0.010%	0.000%	-0.008%	-0.053%	-0.076%
France	**-0.014%**	**-0.007%**	**-0.003%**	**-0.011%**	**-0.062%**	**-0.002%**	**-0.020%**	**-0.271%**	**-0.390%**
Germany	**-0.011%**	**-0.009%**	**-0.007%**	**-0.020%**	**-0.055%**	**-0.004%**	**-0.015%**	**-0.266%**	**-0.385%**
Greece	**-0.010%**	**-0.008%**	**-0.017%**	**-0.024%**	**-0.039%**	**-0.001%**	**-0.014%**	**-0.272%**	**-0.384%**
Italy	**-0.015%**	**-0.009%**	**-0.014%**	**-0.020%**	**-0.054%**	**-0.003%**	**-0.014%**	**-0.214%**	**-0.340%**
Japan	0.000%	0.000%	0.000%	0.000%	-0.002%	0.000%	-0.002%	-0.006%	-0.010%
Korea	0.000%	-0.001%	0.000%	-0.001%	-0.004%	-0.001%	-0.005%	-0.019%	-0.031%
Mexico	-0.001%	-0.007%	-0.002%	-0.001%	-0.013%	-0.002%	-0.019%	-0.063%	-0.107%
New Zeal.	0.000%	-0.001%	0.000%	-0.001%	-0.007%	-0.001%	-0.008%	-0.035%	-0.052%
Norway	0.000%	-0.003%	0.000%	-0.002%	-0.012%	-0.001%	-0.010%	-0.058%	-0.086%
Portugal	**-0.065%**	**-0.008%**	**-0.002%**	**-0.010%**	**-0.033%**	**-0.001%**	**-0.014%**	**-0.283%**	**-0.414%**
Spain	**-0.019%**	**-0.007%**	**-0.009%**	**-0.013%**	**-0.050%**	**-0.002%**	**-0.011%**	**-0.262%**	**-0.372%**
Sweden	0.000%	-0.003%	-0.001%	-0.002%	-0.013%	-0.001%	-0.011%	-0.065%	-0.095%
Turkey	0.000%	-0.001%	0.000%	-0.001%	-0.007%	0.000%	-0.007%	-0.045%	-0.063%
U.K.	**-0.009%**	**-0.014%**	**-0.008%**	**-0.016%**	**-0.066%**	**-0.004%**	**-0.030%**	**-0.454%**	**-0.600%**
U.S.	-0.022%	-0.033%	-0.007%	-0.005%	-0.048%	-0.019%	-0.029%	-0.194%	-0.355%
Av. E.U.	-0.019%	-0.008%	-0.008%	-0.016%	-0.052%	-0.002%	-0.016%	-0.279%	-0.399%
U.S.	-0.022%	-0.033%	-0.007%	-0.005%	-0.048%	-0.019%	-0.029%	-0.194%	-0.355%
Av. other	0.000%	-0.002%	-0.001%	-0.001%	-0.008%	-0.001%	-0.009%	-0.043%	-0.065%

E.U. countries are bolded

Table 41 Percent changes of the costs of production due to the trade war between the U.S. and E.U. in the Metals industry

	Food	Textile	Wood	Paper	Chem.	Nonmet.	Metals	Mach.
Australia	0.002%	0.002%	0.003%	0.004%	0.003%	0.003%	0.006%	0.010%
Austria	**0.003%**	**0.004%**	**0.007%**	**0.006%**	**0.006%**	**0.006%**	**0.043%**	**0.025%**
Canada	0.005%	0.005%	0.008%	0.008%	0.007%	0.007%	0.032%	0.028%
Finland	0.003%	0.003%	0.004%	0.004%	0.004%	0.004%	0.012%	0.013%
France	**0.005%**	**0.006%**	**0.013%**	**0.009%**	**0.010%**	**0.011%**	**0.117%**	**0.055%**
Germany	**0.004%**	**0.004%**	**0.010%**	**0.007%**	**0.008%**	**0.008%**	**0.079%**	**0.039%**
Greece	**0.004%**	**0.004%**	**0.009%**	**0.006%**	**0.007%**	**0.007%**	**0.065%**	**0.033%**
Italy	**0.004%**	**0.004%**	**0.009%**	**0.006%**	**0.007%**	**0.007%**	**0.063%**	**0.033%**
Japan	0.001%	0.001%	0.001%	0.001%	0.001%	0.001%	0.003%	0.002%
Korea	0.002%	0.002%	0.003%	0.003%	0.002%	0.002%	0.006%	0.007%
Mexico	0.006%	0.006%	0.011%	0.009%	0.008%	0.008%	0.031%	0.030%
New Zeal.	0.002%	0.003%	0.004%	0.004%	0.004%	0.003%	0.010%	0.012%
Norway	0.003%	0.004%	0.005%	0.005%	0.005%	0.005%	0.022%	0.018%
Portugal	**0.004%**	**0.004%**	**0.008%**	**0.006%**	**0.006%**	**0.007%**	**0.041%**	**0.027%**
Spain	**0.003%**	**0.004%**	**0.007%**	**0.005%**	**0.006%**	**0.006%**	**0.042%**	**0.025%**
Sweden	0.003%	0.004%	0.005%	0.005%	0.005%	0.005%	0.019%	0.018%
Turkey	0.002%	0.002%	0.004%	0.004%	0.003%	0.003%	0.009%	0.011%
U.K.	**0.008%**	**0.008%**	**0.022%**	**0.013%**	**0.016%**	**0.019%**	**0.220%**	**0.095%**
U.S.	0.008%	0.008%	0.021%	0.013%	0.015%	0.017%	0.189%	0.085%

Table 42 Changes of employment due to the trade war between the U.S. and E.U. in the Metals industry

	Food	Textile	Wood	Paper	Chem.	Nonmet.	Metals	Mach.
Australia	9	16	12	21	68	18	514	630
Austria	**-2**	**-4**	**-2**	**-8**	**-42**	**-19**	**-1,354**	**115**
Canada	21	74	123	104	375	113	3,730	2,944
Finland	2	9	13	12	35	12	358	320
France	**-24**	**-82**	**-75**	**-114**	**-468**	**-139**	**-10,527**	**-1,776**
Germany	**-22**	**-55**	**-60**	**-112**	**-575**	**-214**	**-11,889**	**-719**
Greece	**1**	**-6**	**-2**	**-3**	**-18**	**-5**	**-340**	**-10**
Italy	**2**	**-18**	**4**	**-10**	**-75**	**-35**	**-2,082**	**450**
Japan	79	323	202	258	880	244	3,180	11,488
Korea	26	407	67	98	369	95	1,720	3,893
Mexico	31	49	33	72	286	148	5,603	2,029
New Zeal.	8	3	3	4	12	3	37	89
Norway	3	2	6	8	26	11	517	209
Portugal	**1**	**-11**	**2**	**-7**	**-11**	**-7**	**-349**	**89**
Spain	**-6**	**-26**	**-31**	**-47**	**-237**	**-117**	**-5,781**	**188**
Sweden	5	5	21	16	71	24	861	886
Turkey	9	68	18	19	60	24	621	574
U.K.	**-57**	**-209**	**-125**	**-186**	**-746**	**-219**	**-7,113**	**-6,362**
U.S.	-39	-281	-184	-88	278	175	17,973	-10,902

Tables 43-48 Effects of industry trade barrier reductions between rich and poor countries

Table 43 Percentage change in manufacturing employment

	Food	Textile	Wood	Paper	Chem.	Nonmet.	Metals	Mach.	Manuf.
Australia	0.032%	-0.404%	-0.004%	-0.023%	-0.086%	-0.018%	-0.006%	-0.291%	-0.816%
Austria	-0.026%	-0.282%	0.005%	0.014%	-0.026%	0.007%	-0.051%	-0.135%	-0.505%
Canada	0.006%	-0.374%	0.005%	0.044%	-0.030%	-0.016%	-0.034%	-0.198%	-0.609%
Finland	-0.012%	-0.444%	0.031%	0.119%	-0.049%	-0.022%	-0.028%	-0.163%	-0.582%
France	-0.014%	-0.209%	-0.001%	-0.009%	-0.012%	-0.003%	-0.044%	-0.161%	-0.467%
Germany	-0.009%	-0.136%	0.002%	-0.004%	0.004%	-0.003%	-0.037%	-0.118%	-0.312%
Greece	**1.529%**	**2.804%**	**-0.714%**	**-0.591%**	**-0.056%**	**0.276%**	**1.145%**	**-1.514%**	**3.164%**
Italy	-0.040%	-0.419%	0.013%	-0.018%	-0.033%	0.006%	-0.027%	-0.147%	-0.682%
Japan	-0.052%	-0.242%	-0.008%	-0.004%	-0.014%	-0.004%	-0.038%	0.023%	-0.346%
Korea	**0.216%**	**9.954%**	**-0.080%**	**-0.138%**	**0.584%**	**0.143%**	**1.017%**	**5.208%**	**17.163%**
Mexico	**-1.027%**	**-0.237%**	**-0.216%**	**-0.790%**	**0.167%**	**0.088%**	**1.085%**	**-0.661%**	**-1.410%**
New Zeal.	0.580%	-0.333%	0.067%	0.032%	-0.062%	-0.022%	0.076%	-0.248%	0.070%
Norway	0.030%	-0.170%	-0.004%	0.035%	-0.019%	-0.030%	-0.054%	-0.196%	-0.420%
Portugal	**0.346%**	**8.508%**	**0.482%**	**0.958%**	**0.640%**	**0.789%**	**1.004%**	**3.926%**	**17.189%**
Spain	0.021%	-0.300%	-0.009%	-0.005%	-0.012%	0.007%	-0.025%	-0.282%	-0.625%
Sweden	-0.014%	-0.128%	0.011%	0.068%	-0.032%	-0.025%	-0.046%	-0.106%	-0.280%
Turkey	**0.149%**	**2.619%**	**-0.286%**	**-0.435%**	**0.086%**	**0.196%**	**0.605%**	**-3.106%**	**0.056%**
U.K.	0.002%	-0.321%	-0.009%	-0.009%	-0.021%	-0.009%	-0.034%	-0.169%	-0.585%
U.S.	0.022%	-0.338%	0.014%	0.020%	-0.014%	-0.012%	-0.038%	-0.125%	-0.481%

Table 44 Change in manufacturing employment

	Food	Textile	Wood	Paper	Chem.	Nonmet.	Metals	Mach.	Manuf.
Australia	342	-4,384	-39	-247	-928	-199	-67	-3,157	-8,849
Austria	-145	-1,600	30	81	-150	41	-291	-769	-2,869
Canada	144	-8,388	114	988	-664	-362	-762	-4,433	-13,650
Finland	-58	-2,124	147	568	-232	-103	-135	-779	-2,782
France	-456	-7,060	-26	-318	-388	-118	-1,495	-5,435	-15,762
Germany	-583	-8,357	96	-272	233	-203	-2,283	-7,290	-19,206
Greece	**4,848**	**8,890**	**-2,263**	**-1,873**	**-179**	**875**	**3,630**	**-4,798**	**10,032**
Italy	-1,172	-12,279	371	-529	-967	169	-799	-4,304	-19,985
Japan	-6,875	-32,115	-1,106	-585	-1,864	-500	-5,021	3,028	-45,957
Korea	**8,128**	**374,529**	**-3,015**	**-5,175**	**21,960**	**5,394**	**38,262**	**195,973**	**645,808**
Mexico	**-18,953**	**-4,369**	**-3,993**	**-14,581**	**3,073**	**1,624**	**20,019**	**-12,202**	**-26,029**
New Zeal.	1,234	-708	142	67	-133	-46	163	-527	149
Norway	87	-490	-10	100	-55	-86	-154	-565	-1,207
Portugal	**2,094**	**51,411**	**2,912**	**5,789**	**3,868**	**4,767**	**6,064**	**23,723**	**103,874**
Spain	463	-6,720	-198	-113	-276	156	-569	-6,319	-14,008
Sweden	-131	-1,214	109	648	-307	-237	-435	-1,006	-2,663
Turkey	**2,316**	**40,624**	**-4,441**	**-6,744**	**1,340**	**3,035**	**9,379**	**-48,189**	**864**
U.K.	99	-14,249	-393	-415	-925	-407	-1,518	-7,485	-25,962
U.S.	4,999	-75,396	3,173	4,554	-3,049	-2,648	-8,553	-27,961	-107,268
All poor	-1,566	471,084	-10,800	-22,584	30,062	15,696	77,355	154,506	734,549
All rich	-2,051	-175,084	2,409	4,527	-9,706	-4,543	-21,917	-67,001	-280,019
Total	-3,618	296,000	-8,391	-18,057	20,356	11,152	55,438	87,505	454,530
Poor gain/rich loss		2.69			3.10	3.45	3.53	2.31	2.62

Table 45 Percentage change in welfare

	Food	Textile	Wood	Paper	Chem.	Nonmet.	Metals	Mach.	Manuf.
Australia	0.003%	0.023%	0.000%	0.002%	0.014%	0.002%	0.006%	0.038%	0.090%
Austria	0.004%	0.022%	0.000%	0.003%	0.005%	0.001%	0.004%	0.026%	0.068%
Canada	0.003%	0.025%	0.000%	0.001%	0.006%	0.002%	0.006%	0.031%	0.076%
Finland	0.002%	0.042%	0.000%	0.001%	0.008%	0.002%	0.005%	0.023%	0.083%
France	0.004%	0.016%	0.001%	0.002%	0.005%	0.001%	0.004%	0.020%	0.055%
Germany	0.004%	0.017%	0.000%	0.002%	0.005%	0.001%	0.005%	0.020%	0.056%
Greece	**0.189%**	**0.116%**	**0.081%**	**0.152%**	**0.314%**	**0.050%**	**0.077%**	**1.400%**	**2.347%**
Italy	0.010%	0.009%	0.000%	0.002%	0.007%	0.001%	0.006%	0.018%	0.056%
Japan	0.008%	0.018%	0.001%	0.000%	0.005%	0.001%	0.007%	0.010%	0.050%
Korea	**0.102%**	**0.025%**	**0.036%**	**0.056%**	**0.158%**	**0.020%**	**0.056%**	**0.490%**	**0.930%**
Mexico	**0.201%**	**0.100%**	**0.140%**	**0.143%**	**0.286%**	**0.036%**	**0.063%**	**1.116%**	**2.062%**
New Zeal.	0.002%	0.019%	0.000%	0.001%	0.015%	0.002%	0.016%	0.043%	0.102%
Norway	0.003%	0.058%	0.000%	0.001%	0.009%	0.003%	0.005%	0.041%	0.124%
Portugal	**0.185%**	**0.082%**	**0.029%**	**0.070%**	**0.297%**	**0.043%**	**0.081%**	**1.131%**	**1.900%**
Spain	0.005%	0.013%	0.002%	0.004%	0.008%	0.002%	0.007%	0.033%	0.076%
Sweden	0.004%	0.051%	0.000%	0.002%	0.011%	0.003%	0.005%	0.025%	0.104%
Turkey	**0.080%**	**0.033%**	**0.029%**	**0.096%**	**0.170%**	**0.019%**	**0.057%**	**1.040%**	**1.499%**
U.K.	0.003%	0.021%	0.001%	0.002%	0.006%	0.001%	0.005%	0.026%	0.068%
U.S.	0.002%	0.018%	0.000%	0.001%	0.005%	0.002%	0.006%	0.021%	0.057%
Av. poor	0.151%	0.071%	0.063%	0.104%	0.245%	0.034%	0.067%	1.035%	1.748%
Av. rich	0.004%	0.025%	0.001%	0.002%	0.008%	0.002%	0.006%	0.027%	0.076%
Av. world	0.043%	0.037%	0.017%	0.029%	0.070%	0.010%	0.022%	0.292%	0.516%

Table 46 Employment changes when trade barriers are reduced in the Textile industry

	Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery
Australia	-21 (-0.0%)	-4,021 (-3.3%)	-9 (-0.0%)	-61 (-0.1%)	-155 (-0.1%)	-5 (-0.0%)	4 (0.0%)	-115 (-0.0%)
Austria	-9 (-0.0%)	-1,500 (-2.2%)	4 (0.0%)	-19 (-0.0%)	-47 (-0.1%)	-1 (-0.0%)	-5 (-0.0%)	-22 (-0.0%)
Canada	-43 (-0.0%)	-7,763 (-3.5%)	21 (0.0%)	-95 (-0.0%)	-280 (-0.1%)	-8 (-0.0%)	-21 (-0.0%)	-199 (-0.0%)
Finland	-12 (-0.0%)	-2,043 (-5.3%)	17 (0.0%)	-18 (-0.0%)	-64 (-0.1%)	-1 (-0.0%)	1 (0.0%)	-4 (-0.0%)
France	-47 (-0.0%)	-6,272 (-1.8%)	-25 (-0.0%)	-117 (-0.0%)	-304 (-0.1%)	-11 (-0.0%)	-48 (-0.0%)	-237 (-0.0%)
Germany	-59 (-0.0%)	-7,241 (-1.6%)	-47 (-0.0%)	-149 (-0.0%)	-397 (-0.0%)	-19 (-0.0%)	-48 (-0.0%)	-398 (-0.0%)
Greece	**55 (0.1%)**	**8,162 (7.2%)**	**47 (0.3%)**	**107 (0.6%)**	**302 (0.9%)**	**19 (0.1%)**	**16 (0.1%)**	**185 (0.4%)**
Italy	-61 (-0.0%)	1,030 (-1.8%)	-83 (-0.1%)	-159 (-0.1%)	-429 (-0.1%)	-28 (-0.0%)	-56 (-0.0%)	-434 (-0.0%)
Japan	-202 (-0.0%)	9,937 (-2.2%)	-69 (-0.0%)	-390 (-0.1%)	-835 (-0.1%)	-35 (-0.0%)	-20 (-0.0%)	-626 (-0.0%)
Korea	**2,230 (0.8%)**	**5,654 (27.3%)**	**792 (0.8%)**	**5,238 (3.4%)**	**16,790 (4.4%)**	**553 (0.5%)**	**1,079 (0.6%)**	**12,192 (0.9%)**
Mexico	**2 (0.0%)**	**-5,179 (-2.3%)**	**137 (0.4%)**	**28 (0.0%)**	**44 (0.0%)**	**46 (0.0%)**	**65 (0.0%)**	**488 (0.1%)**
New Zeal.	0 (0.0%)	-669 (-2.4%)	2 (0.0%)	1 (0.0%)	-23 (-0.1%)	-1 (-0.0%)	0 (0.0%)	-18 (-0.0%)
Norway	-1 (-0.0%)	-529 (-5.6%)	9 (0.1%)	-1 (-0.0%)	-6 (-0.0%)	1 (0.0%)	5 (0.0%)	31 (0.0%)
Portugal	**259 (0.4%)**	**8,594 (19.2%)**	**206 (0.5%)**	**573 (1.2%)**	**1,294 (2.5%)**	**64 (0.2%)**	**24 (0.2%)**	**397 (0.4%)**
Spain	-37 (-0.0%)	-6,229 (-1.9%)	-42 (-0.0%)	-78 (-0.1%)	-184 (-0.1%)	-12 (-0.0%)	-13 (-0.0%)	-126 (-0.0%)
Sweden	-7 (-0.0%)	-1,376 (-4.6%)	51 (0.1%)	9 (0.0%)	-31 (-0.0%)	3 (0.0%)	12 (0.0%)	125 (0.0%)
Turkey	**262 (0.2%)**	**37,254 (5.6%)**	**115 (0.2%)**	**474 (0.7%)**	**1,228 (1.0%)**	**63 (0.1%)**	**114 (0.2%)**	**1,114 (0.3%)**
U.K.	-76 (-0.0%)	3,124 (-2.5%)	-42 (-0.0%)	-168 (-0.1%)	-499 (-0.1%)	-18 (-0.0%)	-37 (-0.0%)	-284 (-0.0%)
U.S.	-371 (-0.0%)	8,715 (-2.5%)	-197 (-0.0%)	-943 (-0.1%)	-2,692 (-0.1%)	-116 (-0.0%)	-260 (-0.0%)	-2,103 (-0.0%)

Table 47 Percentage change of goods prices
when trade barriers are reduced in the Textile industry

	Food	Textile	Wood	Paper	Chem.	Nonmet.	Metals	Mach.
Australia	-0.002%	-0.456%	-0.018%	-0.006%	-0.005%	-0.003%	-0.002%	-0.005%
Austria	-0.002%	-0.454%	-0.017%	-0.006%	-0.005%	-0.003%	-0.002%	-0.005%
Canada	-0.002%	-0.508%	-0.020%	-0.006%	-0.005%	-0.003%	-0.002%	-0.005%
Finland	-0.003%	-0.849%	-0.034%	-0.010%	-0.008%	-0.006%	-0.003%	-0.008%
France	-0.001%	-0.323%	-0.014%	-0.005%	-0.004%	-0.002%	-0.002%	-0.004%
Germany	-0.001%	-0.339%	-0.015%	-0.005%	-0.004%	-0.003%	-0.002%	-0.005%
Greece	**-0.005%**	**-2.444%**	**-0.072%**	**-0.019%**	**-0.019%**	**-0.012%**	**-0.005%**	**-0.011%**
Italy	-0.001%	-0.171%	-0.010%	-0.003%	-0.003%	-0.002%	-0.001%	-0.003%
Japan	-0.001%	-0.356%	-0.015%	-0.005%	-0.004%	-0.003%	-0.002%	-0.005%
Korea	**-0.002%**	**-0.495%**	**-0.019%**	**-0.006%**	**-0.005%**	**-0.004%**	**-0.002%**	**-0.006%**
Mexico	**-0.005%**	**-2.135%**	**-0.027%**	**-0.015%**	**-0.015%**	**-0.011%**	**-0.005%**	**-0.010%**
New Zeal.	-0.001%	-0.383%	-0.016%	-0.005%	-0.004%	-0.003%	-0.002%	-0.005%
Norway	-0.004%	-1.200%	-0.045%	-0.013%	-0.009%	-0.007%	-0.003%	-0.009%
Portugal	**-0.004%**	**-1.726%**	**-0.061%**	**-0.016%**	**-0.013%**	**-0.009%**	**-0.003%**	**-0.007%**
Spain	-0.001%	-0.256%	-0.012%	-0.004%	-0.003%	-0.002%	-0.002%	-0.004%
Sweden	-0.003%	-1.060%	-0.040%	-0.012%	-0.009%	-0.006%	-0.003%	-0.008%
Turkey	**-0.002%**	**-0.659%**	**-0.026%**	**-0.008%**	**-0.007%**	**-0.005%**	**-0.003%**	**-0.007%**
U.K.	-0.002%	-0.420%	-0.019%	-0.006%	-0.005%	-0.003%	-0.002%	-0.005%
U.S.	-0.001%	-0.363%	-0.015%	-0.005%	-0.004%	-0.003%	-0.002%	-0.005%

Table 48 Percentage change of goods prices
when trade barriers are reduced in the Machinery industry

	Food	Textile	Wood	Paper	Chem.	Nonmet.	Metals	Mach.
Australia	-0.012%	-0.019%	-0.016%	-0.018%	-0.015%	-0.015%	-0.019%	-0.126%
Austria	-0.009%	-0.036%	-0.011%	-0.015%	-0.010%	-0.010%	-0.012%	-0.085%
Canada	-0.010%	-0.021%	-0.013%	-0.014%	-0.012%	-0.013%	-0.016%	-0.103%
Finland	-0.007%	-0.041%	-0.010%	-0.011%	-0.010%	-0.010%	-0.012%	-0.070%
France	-0.007%	-0.027%	-0.011%	-0.012%	-0.009%	-0.010%	-0.013%	-0.060%
Germany	-0.007%	-0.054%	-0.010%	-0.012%	-0.008%	-0.011%	-0.015%	-0.056%
Greece	**-0.333%**	**-0.226%**	**-0.383%**	**-0.398%**	**-0.392%**	**-0.418%**	**-0.363%**	**-4.841%**
Italy	-0.011%	-0.018%	-0.009%	-0.011%	-0.010%	-0.011%	-0.019%	-0.054%
Japan	-0.004%	-0.013%	-0.006%	-0.005%	-0.005%	-0.005%	-0.010%	-0.030%
Korea	**-0.135%**	**-0.126%**	**-0.171%**	**-0.197%**	**-0.159%**	**-0.172%**	**-0.173%**	**-1.682%**
Mexico	**-0.277%**	**-0.192%**	**-0.085%**	**-0.311%**	**-0.290%**	**-0.357%**	**-0.328%**	**-3.904%**
New Zeal.	-0.013%	-0.019%	-0.018%	-0.019%	-0.017%	-0.017%	-0.026%	-0.146%
Norway	-0.012%	-0.059%	-0.016%	-0.017%	-0.013%	-0.017%	-0.014%	-0.131%
Portugal	**-0.282%**	**-0.052%**	**-0.390%**	**-0.407%**	**-0.311%**	**-0.342%**	**-0.141%**	**-3.936%**
Spain	-0.011%	-0.019%	-0.020%	-0.022%	-0.015%	-0.017%	-0.019%	-0.105%
Sweden	-0.008%	-0.071%	-0.012%	-0.012%	-0.012%	-0.015%	-0.013%	-0.071%
Turkey	**-0.293%**	**-0.291%**	**-0.391%**	**-0.403%**	**-0.357%**	**-0.367%**	**-0.403%**	**-3.507%**
U.K.	-0.009%	-0.032%	-0.015%	-0.014%	-0.011%	-0.012%	-0.016%	-0.082%
U.S.	-0.008%	-0.021%	-0.010%	-0.010%	-0.010%	-0.013%	-0.020%	-0.066%

Tables 49a-c Effects of a 20% increase in the technology parameter of the U.S. Machinery industry

	a. Manuf. consumption price level				b. Capital good price			
	No int'l investment		With int'l investment		No int'l investment		With int'l investment	
	Impact	S.S.	Impact	S.S.	Impact	S.S.	Impact	S.S.
Australia	-0.48%	-0.56%	-0.44%	-0.52%	-0.50%	-0.56%	-0.47%	-0.54%
Austria	-0.39%	-0.46%	-0.32%	-0.40%	-0.36%	-0.41%	-0.31%	-0.37%
Canada	-0.81%	-0.92%	-0.86%	-0.94%	-0.88%	-0.96%	-0.93%	-0.99%
Finland	-0.38%	-0.45%	-0.32%	-0.40%	-0.38%	-0.43%	-0.33%	-0.40%
France	-0.39%	-0.46%	-0.32%	-0.41%	-0.36%	-0.41%	-0.31%	-0.38%
Germany	-0.43%	-0.49%	-0.35%	-0.44%	-0.38%	-0.44%	-0.34%	-0.40%
Greece	-0.31%	-0.38%	-0.24%	-0.33%	-0.35%	-0.40%	-0.30%	-0.37%
Italy	-0.35%	-0.42%	-0.27%	-0.36%	-0.33%	-0.38%	-0.28%	-0.35%
Japan	-0.48%	-0.55%	-0.40%	-0.49%	-0.41%	-0.46%	-0.35%	-0.42%
Korea	-0.44%	-0.51%	-0.39%	-0.48%	-0.45%	-0.51%	-0.42%	-0.49%
Mexico	-0.63%	-0.74%	-0.70%	-0.79%	-0.90%	-0.99%	-0.96%	-1.03%
N.Z.	-0.44%	-0.51%	-0.40%	-0.48%	-0.46%	-0.52%	-0.43%	-0.50%
Norway	-0.45%	-0.52%	-0.39%	-0.48%	-0.42%	-0.47%	-0.38%	-0.44%
Portugal	-0.34%	-0.40%	-0.27%	-0.35%	-0.35%	-0.41%	-0.31%	-0.37%
Spain	-0.33%	-0.40%	-0.26%	-0.35%	-0.34%	-0.39%	-0.29%	-0.35%
Sweden	-0.47%	-0.54%	-0.41%	-0.49%	-0.44%	-0.49%	-0.40%	-0.46%
Turkey	-0.25%	-0.31%	-0.18%	-0.27%	-0.33%	-0.38%	-0.29%	-0.35%
U.K.	-0.45%	-0.52%	-0.39%	-0.47%	-0.43%	-0.48%	-0.39%	-0.45%
U.S.	-0.64%	-0.77%	-0.77%	-0.86%	-1.27%	-1.36%	-1.34%	-1.41%

c. Price changes in the steady state of the basic model

	Food	Textile	Wood	Paper	Chem.	Nonmet.	Metals	Mach.
Australia	-0.28%	-0.47%	-0.41%	-0.44%	-0.30%	-0.43%	-0.44%	-0.83%
Austria	-0.26%	-0.48%	-0.41%	-0.46%	-0.34%	-0.42%	-0.42%	-0.61%
Canada	-0.34%	-0.49%	-0.42%	-0.44%	-0.31%	-0.42%	-0.28%	-1.45%
Finland	-0.25%	-0.46%	-0.39%	-0.44%	-0.33%	-0.40%	-0.41%	-0.64%
France	-0.26%	-0.46%	-0.40%	-0.45%	-0.33%	-0.41%	-0.40%	-0.61%
Germany	-0.29%	-0.48%	-0.44%	-0.49%	-0.37%	-0.46%	-0.44%	-0.65%
Greece	-0.21%	-0.40%	-0.32%	-0.37%	-0.28%	-0.32%	-0.35%	-0.60%
Italy	-0.24%	-0.44%	-0.36%	-0.42%	-0.32%	-0.39%	-0.38%	-0.56%
Japan	-0.31%	-0.60%	-0.44%	-0.56%	-0.42%	-0.53%	-0.51%	-0.68%
Korea	-0.25%	-0.49%	-0.27%	-0.39%	-0.33%	-0.44%	-0.44%	-0.76%
Mexico	-0.21%	-0.14%	0.20%	-0.09%	-0.17%	-0.36%	-0.23%	-1.50%
N.Z.	-0.24%	-0.41%	-0.36%	-0.39%	-0.26%	-0.37%	-0.43%	-0.77%
Norway	-0.27%	-0.46%	-0.42%	-0.46%	-0.34%	-0.42%	-0.43%	-0.70%
Portugal	-0.19%	-0.46%	-0.33%	-0.37%	-0.29%	-0.34%	-0.39%	-0.60%
Spain	-0.22%	-0.41%	-0.34%	-0.39%	-0.29%	-0.36%	-0.36%	-0.58%
Sweden	-0.31%	-0.46%	-0.47%	-0.53%	-0.37%	-0.47%	-0.45%	-0.73%
Turkey	-0.16%	-0.31%	-0.26%	-0.30%	-0.23%	-0.28%	-0.29%	-0.57%
U.K.	-0.29%	-0.49%	-0.44%	-0.49%	-0.36%	-0.46%	-0.42%	-0.72%
U.S.	0.27%	0.46%	0.39%	0.55%	0.33%	0.39%	0.24%	-2.08%

Tables 49d-f Effects of a 20% increase in the technology parameters of the U.S. Machinery industry

d. Real manufacturing income

	No int'l investment		With int'l investment	
	Impact	S.S.	Impact	S.S.
Australia	-0.37%	-0.33%	-0.61%	-0.52%
Austria	-0.43%	-0.43%	-0.72%	-0.63%
Canada	-0.31%	-0.22%	-0.54%	-0.45%
Finland	-0.38%	-0.38%	-0.65%	-0.57%
France	-0.43%	-0.43%	-0.71%	-0.62%
Germany	-0.55%	-0.56%	-0.88%	-0.79%
Greece	-0.20%	-0.19%	-0.38%	-0.30%
Italy	-0.40%	-0.40%	-0.68%	-0.60%
Japan	-0.65%	-0.67%	-1.03%	-0.94%
Korea	-0.44%	-0.45%	-0.80%	-0.71%
Mexico	-0.15%	-0.04%	-0.25%	-0.17%
New Zealand	-0.22%	-0.20%	-0.43%	-0.34%
Norway	-0.34%	-0.33%	-0.60%	-0.51%
Portugal	-0.24%	-0.23%	-0.45%	-0.36%
Spain	-0.33%	-0.33%	-0.56%	-0.48%
Sweden	-0.55%	-0.55%	-0.88%	-0.79%
Turkey	-0.21%	-0.20%	-0.38%	-0.29%
United Kingdom	-0.50%	-0.49%	-0.79%	-0.71%
United States	2.70%	2.98%	3.37%	3.46%

	e. Real wage				f. Interest rate			
	No int'l investment		With int'l investment		No int'l investment		With int'l investment	
	Impact	S.S.	Impact	S.S.	Impact	S.S.	Impact	S.S.
Australia	-0.41%	-0.37%	-0.65%	-0.56%	-0.31%	-0.72%	0.62%	0.02%
Austria	-0.46%	-0.46%	-0.74%	-0.66%	-0.44%	-0.72%	0.62%	0.02%
Canada	-0.51%	-0.41%	-0.72%	-0.64%	0.10%	-0.58%	0.62%	0.02%
Finland	-0.41%	-0.41%	-0.68%	-0.59%	-0.36%	-0.66%	0.62%	0.02%
France	-0.47%	-0.46%	-0.74%	-0.65%	-0.41%	-0.70%	0.62%	0.02%
Germany	-0.60%	-0.61%	-0.92%	-0.84%	-0.52%	-0.78%	0.62%	0.02%
Greece	-0.21%	-0.20%	-0.40%	-0.31%	-0.18%	-0.48%	0.62%	0.02%
Italy	-0.41%	-0.41%	-0.70%	-0.61%	-0.42%	-0.70%	0.62%	0.02%
Japan	-0.69%	-0.70%	-1.07%	-0.98%	-0.67%	-0.93%	0.62%	0.02%
Korea	-0.42%	-0.44%	-0.79%	-0.70%	-0.49%	-0.77%	0.62%	0.02%
Mexico	-0.42%	-0.30%	-0.51%	-0.42%	0.56%	-0.22%	0.62%	0.02%
N.Z.	-0.28%	-0.25%	-0.47%	-0.39%	-0.13%	-0.52%	0.62%	0.02%
Norway	-0.39%	-0.37%	-0.64%	-0.55%	-0.33%	-0.67%	0.62%	0.02%
Portugal	-0.25%	-0.24%	-0.46%	-0.38%	-0.22%	-0.51%	0.62%	0.02%
Spain	-0.36%	-0.36%	-0.59%	-0.50%	-0.30%	-0.58%	0.62%	0.02%
Sweden	-0.60%	-0.60%	-0.93%	-0.85%	-0.50%	-0.83%	0.62%	0.02%
Turkey	-0.23%	-0.22%	-0.41%	-0.32%	-0.11%	-0.40%	0.62%	0.02%
U.K.	-0.55%	-0.54%	-0.85%	-0.76%	-0.45%	-0.76%	0.62%	0.02%
U.S.	2.80%	3.08%	3.47%	3.56%	2.98%	1.70%	0.62%	0.02%

Tables 49g-h Effects of a 20% increase in the technology parameters of the U.S. Machinery industry

	g. Capital stock				h. Foreign investment into U.S. in the steady state as		
	No int'l investment		With int'l investment				
	Impact	S.S.	Impact	S.S.		U.S. investme	Foreign investme
Australia	0.04%	0.48%	-1.10%	-0.44%	Australia	0.04%	1.90%
Austria	0.03%	0.29%	-1.28%	-0.63%	Austria	0.02%	1.12%
Canada	0.07%	0.83%	-0.68%	-0.02%	Canada	0.09%	4.51%
Finland	0.03%	0.32%	-1.19%	-0.53%	Finland	0.02%	0.96%
France	0.03%	0.30%	-1.25%	-0.59%	France	0.16%	8.23%
Germany	0.02%	0.26%	-1.41%	-0.75%	Germany	0.29%	14.84%
Greece	0.03%	0.35%	-0.90%	-0.24%	Greece	0.00%	0.24%
Italy	0.02%	0.30%	-1.26%	-0.60%	Italy	0.12%	6.04%
Japan	0.02%	0.25%	-1.61%	-0.96%	Japan	0.86%	43.35%
Korea	0.02%	0.28%	-1.41%	-0.75%	Korea	0.07%	3.73%
Mexico	0.09%	0.95%	-0.10%	0.56%	Mexico	0.01%	0.41%
New Zeal.	0.04%	0.44%	-0.90%	-0.24%	New Zeal.	0.01%	0.25%
Norway	0.03%	0.38%	-1.14%	-0.48%	Norway	0.01%	0.65%
Portugal	0.03%	0.32%	-0.98%	-0.32%	Portugal	0.01%	0.29%
Spain	0.03%	0.30%	-1.08%	-0.43%	Spain	0.05%	2.58%
Sweden	0.03%	0.36%	-1.38%	-0.73%	Sweden	0.04%	1.94%
Turkey	0.03%	0.32%	-0.83%	-0.18%	Turkey	0.01%	0.48%
U.K.	0.03%	0.35%	-1.29%	-0.64%	U.K.	0.17%	8.48%
U.S.	0.15%	1.65%	3.12%	3.80%	Total	1.98%	100.00%

Tables 49i-j Effects of a 20% increase in the technology parameters
of the U.S. Machinery industry

i. Total factor productivity change in the steady state, no international investment

	Food	Textile	Wood	Paper	Chem.	Nonmet.	Metals	Mach.
Australia	-0.008	-0.005	-0.006	-0.006	-0.008	-0.006	-0.006	-0.002
Austria	-0.007	-0.005	-0.006	-0.005	-0.007	-0.006	-0.006	-0.004
Canada	-0.011	-0.009	-0.010	-0.010	-0.011	-0.010	-0.011	0.001
Finland	-0.007	-0.005	-0.005	-0.005	-0.006	-0.005	-0.005	-0.003
France	-0.007	-0.005	-0.006	-0.005	-0.007	-0.006	-0.006	-0.004
Germany	-0.009	-0.006	-0.007	-0.006	-0.008	-0.007	-0.007	-0.005
Greece	-0.005	-0.002	-0.003	-0.003	-0.004	-0.004	-0.003	-0.001
Italy	-0.007	-0.004	-0.005	-0.005	-0.006	-0.005	-0.005	-0.003
Japan	-0.010	-0.007	-0.009	-0.007	-0.009	-0.008	-0.008	-0.006
Korea	-0.008	-0.005	-0.008	-0.007	-0.008	-0.006	-0.006	-0.003
Mexico	-0.009	-0.009	-0.013	-0.010	-0.009	-0.007	-0.009	0.004
New Zeal.	-0.006	-0.004	-0.005	-0.005	-0.006	-0.005	-0.004	-0.001
Norway	-0.007	-0.005	-0.005	-0.005	-0.007	-0.006	-0.006	-0.003
Portugal	-0.006	-0.002	-0.004	-0.004	-0.005	-0.004	-0.004	-0.001
Spain	-0.006	-0.004	-0.005	-0.004	-0.006	-0.005	-0.005	-0.002
Sweden	-0.009	-0.007	-0.007	-0.007	-0.008	-0.007	-0.008	-0.005
Turkey	-0.005	-0.003	-0.003	-0.003	-0.004	-0.003	-0.003	0.000
U.K.	-0.008	-0.006	-0.007	-0.006	-0.008	-0.007	-0.007	-0.004
U.S.	0.013	0.014	0.014	0.011	0.011	0.012	0.013	0.038

j. World effects

	No int'l investment		With int'l investment	
	Impact	S.S.	Impact	S.S.
Capital stock	0.07%	0.77%	0.17%	0.84%
Real manufacturing inc	0.63%	0.72%	0.66%	0.75%
Interest rate	N/A	N/A	0.62%	0.02%