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Abstract

This paper contributes to empirical research on the dynamics of the terms of trade. We start by proposing a method for constructing different measures of the terms of trade. This is achieved by estimating a range of substitution elasticities using a panel data approach and highly disaggregated data on trade flows. Next, various measures of the terms of trade and trade margins are related to productivity and demand proxies. We find that domestic demand side movements are positively related to the terms of trade, while domestic productivity gains result in a deterioration of the terms of trade. Our results suggest that higher relative productivity raises the real component of exports relative to imports along the intensive margin inducing a weakening of the terms of trade.

JEL classification: F40; F41

Keywords: Terms of trade; Trade margins; International prices

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1. Introduction

Movements in a country's terms of trade alter the balance of trade in two ways. A deterioration, for instance, reduces the value of exports relative to imports, worsening its international trade position. The same deterioration, however, can change the value of exports by affecting the volume of trade.[1] Accordingly, a deterioration, pricing competitors out of the market, might be an unwelcome development for the rest of the world, particularly in the case of a large swing. Furthermore, developments in the theoretical and empirical literatures have highlighted the importance of distinguishing trade in new goods from trade in existing goods. As the volume and composition of trade is determined by the same set of fundamentals that dictate the dynamics of relative prices, a viable analysis of the terms of trade and trade flows with internally consistent data demands attention. Consequently, understanding the fundamental determinants of the terms of trade is more than just mere academic curiosity and has wide-ranging policy implications.

The purpose of this paper is to contribute empirically to the debate on the terms of trade. First, we discuss three measures of price indices that facilitate construction of the terms of trade: conventional, welfare based, and average. The choice of this index can yield non-negligible differences in price changes over the medium run. The miss-measurement of trade prices, in turn, propagates into miss-measurement of the terms of trade. Second, the creation of average and welfare-based indices requires some knowledge of substitution and transformation elasticities. We estimate these using a panel data approach and 6 digit harmonized classification system data on trade. Third, we decompose trade flows into internally consistent components: price, extensive and intensive margins. Here the focus is on time variation in contrast to Hummels and Klenow (2005) who focus on the roles of the margins in explaining cross-sectional trade differences in international trade. Finally, trade margins and the various measures of the terms of trade are related to supply and demand proxies.

The theoretical literature on the fundamental determinants of the terms of trade is vast. The specialization-by-origin models, for instance, underscore the deterioration of the terms of trade that follow supply-side improvements (Benigno and Thoenissen 2003). On the other hand, monopolistic competition and increasing returns models suggest that an expansion in exports need not be associated with a decline in the terms of trade as the increase in supply will be matched by an increase in demand (Krugman 1989, Corsetti et al. 2007). In a Ricardian trade model Galstyan (2011) shows that higher domestic

[1] This behavior of the trade balance has been dubbed the J-curve.

productivity does not cause major terms of trade deterioration, a result that depends on the size of the non-tradable sector and the dispersion of industry-specific efficiencies. On the other hand, movements in aggregate demand leave a non-negligible impact on the conventional terms of trade as higher demand for domestic goods raises the demand for labor, in turn pushing up relative wages.

With regards to the related empirical literature, the most prominent piece of work in the field is that of Acemoglu and Ventura (2002) where faster capital accumulation fosters a deterioration in the terms of trade. This statement is tested via an instrumental variable regression. The results indicate that countries experiencing faster relative growth face depreciated terms of trade.[2] The second important study is that by Debaere and Lee (2003) where the terms of trade is related to domestically produced export goods relative to foreign import goods (a proxy for supply) and market potential (a proxy for demand). The results of the regressions suggest that relative output has a negative effect while market potential a positive effect on the terms of trade. Gagnon (2005) estimates the terms of trade regressions following the logic of the Acemoglu and Ventura methodology. The main point of the exercise is to show that the growth rate of GDP is not reflected in a deteriorating terms of trade. Putting forward Krugman's argument, the author builds a model where the domestic output share in world output proxies varieties. The empirical results imply that fast-growing countries need not experience secular deterioration in their terms of trade.

We enrich this field along a few dimensions. In relation to substitution elasticities, our findings point to a median of 6.6. These estimates combined with the measure of product turnover suggest that ignoring the extensive margin in the construction of import prices results in an overestimation of the welfare-based price index and an underestimation of the average price index, while disregarding the extensive margin of exports results in an underestimation of the welfare-based price index and overestimation of the average price index. The latter two observations combine into an inaccurate measure of the terms of trade. Meanwhile, the terms of trade improve in response to rising demand, while, in the sample of advance countries, they deteriorate in response to productivity gains. Finally, over the sample period, the main driver of trade flows appears to be the intensive margin. For imports, it is positively related to domestic demand and foreign productivity. On the other hand, domestic productivity gains benefit domestic exports along the intensive margin. We find that, in the sample of developing countries, expansion in the extensive margin of exports is associated with a decline in domestic productivity and an increase

[2]Epifani and Gancia (2009) provide some useful information about terms of trade movements. In comparison to Acemoglu and Ventura (2002), they extend the sample size to the year 2000. The terms of trade regressions follow essentially the logic of Acemoglu and Ventura (2002), and so does the result.

in foreign demand. Our results imply that higher relative productivity simultaneously raises the volume of exports relative to imports along the intensive margin, and calls for a deterioration in the terms of trade, suggesting a negative relation between relative prices and relative intensive margins. Meanwhile, higher relative demand improves the terms of labor raising demand for imports.

The paper is structured as follows. Section 2 presents the empirical strategy on the construction of the terms of trade. Section 3 discusses the methodology for estimating substitution elasticities in a panel framework. In section 4 the data and estimation strategy are highlighted. Section 5 presents the results. Section 6 concludes.

2. Empirical strategy

Measuring movements in the terms of trade requires some measure of export and import price indices. The choice of this index, in turn, can yield non-negligible differences in composite price changes over a medium run. A complication, for instance, arises when the set and quality of goods in question is not constant. In 1994 Feenstra addressed this issue in a classic article. This section revisits his contribution and modifies it to create a measure of the average price index that would capture the "representative price". Then we propose a decomposition strategy of trade flows into extensive and intensive margins, followed by a panel approach to estimating elasticities of substitution.

2.1. Price indices

In an influential article Feenstra (1994) showed that indices which ignore product creation, so called conventional price indices, are upward biased as the price of the new good implicitly declines from infinity to a finite number, suggesting price deflation. Ignoring the latter introduces an upward bias in a conventionally measured composite price index.[3] Derivation of this bias is based on a set of first-order conditions under the assumption of a constant elasticity of substitution (CES) utility function.

2.1.1. Import price index

Let $\theta > 1$ denote the elasticity of substitution between the goods and $C \subset (C_t \cap C_s)$ be the set of goods consumed in two periods s and t respectively, where $C_t \cap C_s \neq \emptyset$ and

[3]Similarly, product destruction creates a downward bias in a conventionally measured composite price index.

$s < t$. As shown by Feenstra (1994), the welfare-based price index is

$$\frac{P_t}{P_s} = \left(\frac{\lambda_t}{\lambda_s}\right)^{\frac{1}{\theta-1}} \prod_{j \in C} \left(\frac{p_{j,t}}{p_{j,s}}\right)^{w_{j,t}} \tag{1}$$

where $p_{j,t}$ is the price of good j, λ_t captures the expenditure share of goods $j \in C$ in total expenditure at time t and $w_{j,t}$ are weights corresponding to an ideal log-change index[4]

$$w_{j,t} = \left(\frac{\mu_{j,t} - \mu_{j,s}}{\ln \mu_{j,t} - \ln \mu_{j,s}}\right) / \sum_{j \in C} \left(\frac{\mu_{j,t} - \mu_{j,s}}{\ln \mu_{j,t} - \ln \mu_{j,s}}\right) \tag{2}$$

where $\mu_{j,t}$ is the share of good j in total expenditures on goods $j \in C$.[5]

The impact of creation and destruction on the welfare-based price index depends on two parameters: the elasticity of substitution between the goods and the weight of new goods in total expenditures. For a given elasticity, the effect of creation is limited if the share of new goods is negligible. Likewise, the extent of creation is trivial if the elasticity of substitution between the goods is high. Consequently, the larger the elasticity (or the smaller the share of new goods) the smaller the bias, captured by the first term in the equation (1).

To create an index of average prices, let J_t denote the number of goods available for consumption in period t. Then the composite price level can effectively be rewritten as $P_t = J_t^{\frac{1}{1-\theta}} \left(J_t^{-1} \sum_{j \in C_t} p_{j,t}^{1-\theta}\right)^{\frac{1}{1-\theta}}$ where the second expression is the Hölder mean or the average price level at period t.[6] From equation (1)

$$\frac{\tilde{p}_t}{\tilde{p}_s} = \left(\frac{J_t}{J_s}\right)^{\frac{1}{\theta-1}} \left(\frac{\lambda_t}{\lambda_s}\right)^{\frac{1}{\theta-1}} \prod_{j \in C} \left(\frac{p_{j,t}}{p_{j,s}}\right)^{w_{j,t}} \tag{3}$$

where $\tilde{p}_t$ is the average price level. As before, a larger share of new goods tends to reduce the average price index relative to the conventional one. But the number of new goods, in turn, raises the average price index. In the symmetric case $\lambda_t/\lambda_s = J_s/J_t$ and $\tilde{p}_t/\tilde{p}_s = p_t/p_s$. The latter price index is used for the construction of the terms of trade by Krugman (1989) and Corsetti et al (2007).[7]

[4] See Sato (1976) and Feenstra (1994).

[5] Note that as $\mu_{j,t} \to \mu_{j,s}$, the limit of $(\mu_{j,t} - \mu_{j,s})/(\ln \mu_{j,t} - \ln \mu_{j,s})$ is just the expenditure share $\mu_{j,s}$.

[6] The generalized or Hölder mean is defined as $X = (\sum w_i x_i^{\alpha})^{\frac{1}{\alpha}}$, where $\sum w_i = 1$. When (i) $\alpha = 1$ it is a weighted arithmetic average, (ii) $\alpha = 0$ it is a geometric mean, (iii) $\alpha = -1$ it is a harmonic mean, (iv) $\alpha = 2$ it is a quadratic mean.

[7] This price index also coincides with the conventional price index.

2.1.2. Export price index and the terms of trade

To build export prices, we assume that the good is produced using a constant elasticity of transformation production technology. As with imports, the impact of new and disappearing goods on the price index depends on two parameters: the export supply elasticity and the share of new goods. A smaller export supply elasticity increases the weight of new goods, while the importance of new goods is inversely related to the share of existing ones in the value of total production. Accordingly, the exports of new goods increase the welfare-based price index of exports.[8]

Thus, at the level of goods we construct three measures of the price indices: (i) the conventional price index, (ii) the average price index, and (iii) the welfare-based price index. Since it is assumed that the preferences and production technology are given by a two-level aggregator, export and import price indices of individual goods are weighted to create aggregate price indices, which, in turn, are used to construct three measures of the terms of trade.[9]

2.2. A decomposition

An index is ideal if the product of price and quantity components equals the nominal growth rate of the variables in question. As the price and quantity indices proposed by Feenstra (1994) are ideal, it can be shown that at the level of goods, the nominal growth rate of imports is

$$\frac{\sum_{j\in C_t} q_{j,t}p_{gj,t}}{\sum_{j\in C_s} q_{j,s}p_{j,s}} = \left(\frac{\lambda_t}{\lambda_s}\right)^{-1} \prod_{j\in C} \left(\frac{p_{j,t}q_{j,t}}{p_{j,s}q_{j,s}}\right)^{w_{j,t}} \tag{4}$$

The first part on the right hand side captures the contribution of the extensive margin, while the product expression is the nominal growth rate of the intensive margin. At the higher level of aggregation, decomposing the growth rate of nominal imports requires assigning a particular set of weights to equation (4).[10] The nominal growth rate of exports is decomposed in a similar fashion.

2.3. Panel estimation of elasticities

The previous section highlights the importance of substitution and transformation elasticities in the construction of import and export price indices. These elasticities are estimated by extending the Feenstra (1994) methodology to a panel setting.

[8] See Appendix A.
[9] See Appendix A.
[10] See Appendix B.

The demand for imports of variety j for a generic good rewritten in first differences is

$$\Delta \ln s_{j,t} = \phi_t - (\theta - 1)\, \Delta \ln p_{j,t} + \varepsilon_{j,t} \tag{5}$$

where $\phi_t = (\theta - 1)\, \Delta \ln P_t$ is common for all varieties of the good. Meanwhile, the supply curve of variety j is

$$\Delta \ln p_{j,t} = \varpi \Delta \ln x_{j,t} + \xi_{j,t} \tag{6}$$

where $x_{j,t}$ is the volume of imports.[11] Since our data does not report actual prices but unit values, we account for a measurement error by assuming that $\Delta \ln uv_{j,t} = \Delta \ln p_{j,t} + \varkappa_{j,t}$.

It can be shown that equations (5) and (6), combined with their counterpart equations for a reference country k, result in

$$Y_{ij,t} = \eta_i + \eta_1 X^1_{ij,t} + \eta_2 X^2_{ij,t} + \varsigma_{ij,t} \tag{7}$$

where $Y_{ij,t} = \Delta \ln^2 uv_{i,jk,t}$, $X^1_{ij,t} = \Delta \ln^2 s_{i,jk,t}$ and $X^2_{ij,t} = \Delta \ln s_{i,jk,t} \Delta \ln uv_{i,jk,t}$, i indexes countries, j varieties and $\Delta \ln z_{i,jk,t} = \Delta \ln z_{ij,t} - \Delta \ln z_{ik,t}$.[12] The country fixed effect at the level of a good is captured by η_i. Since, by construction, the error terms are correlated with the regressors, equation (7) is estimated using a panel instrumental variables procedure where the instruments are dummy variables across varieties, as proposed by Feentra (1994).

Once estimated, the elasticities are backed out

$$\hat{\theta} = 1 + \left(\frac{2\hat{\rho} - 1}{1 - \hat{\rho}} \right) \frac{1}{\hat{\eta}_2} > 1 \tag{8}$$

where

$$\hat{\rho} = \frac{1}{2} \pm \left(\frac{1}{4} - \frac{1}{4 + \hat{\eta}_2^2 / \hat{\eta}_1} \right)^{1/2} ; \hat{\eta}_2 \gtrless 0 \tag{9}$$

When $\hat{\eta}_1 < 0$ Broda and Weinstein (2006) suggest a grid search procedure over a given parameter space with the final choice being determined by the minimum residual sum of squares. This procedure is repeated continuously for all goods, which in our case are identified by four digit harmonized system 1996 classification (HS1996) categories.

3. Data and econometric specification

[11] Alternatively a similar expression can be derived from the export aggregator. Details available upon request.

[12] Details available upon request.

3.1. Data

In the empirical analysis we rely on the BACI (Base pour l'Analyse du Commerce International) database that is produced by CEPII (Gaulier et al. 2008) and is a finely tuned version of the United Nations COMTRADE database. It provides bilateral export and import data for a wide range of countries at the six-digit level under the harmonized classification system (HS) from 1998 to 2006. In the construction of the BACI database a novel methodology has been applied to overcome such shortcomings of COMTRADE as missing volume information and inconsistency in units of measurement across countries and categories.

HS revisions, however, constitute a more general problem not addressed by BACI. The HS2002 classification, for instance, has gone through a few structural amendments. Creation of longer time series requires that HS2002 be correlated with HS1996 with four consequences: (i) 1:1 correlation, where a set of subheadings is the same in both classifications, (ii) n:1, where some subheadings in HS1996 have been merged together in HS2002, (iii) 1:n, where an HS1996 subheading has been split, and (iv) n:n - a combination of the previous two points. To eliminate re-classification related creation and destruction, we work with data corresponding to the first case only.[13]

The remaining subheadings are categorized as "Manufactures", "Food","Agricultural Raw Materials", "Ores and Metals" and "Fuels". As swings in commodity prices are quite large and mostly exogenous to domestic market conditions, we concentrate on manufactures only in the construction of terms of trade series. Once the terms of trade and the rest of variables are created, countries with less than a 60 percent share of initial manufacturing trade are dropped. The latter threshold leaves a sample of 18 advanced and 24 developing countries.[14]

Finally to build the terms of labor, an alternative and informative measure of movements in relative prices, we use manufacturing wages from KILM (Key Indicators of the Labor Market). Turning to fundamentals, it is pragmatic to treat movements in productivity as capturing shifts in supply. For this reason using total factor productivity growth over 1998-2006 will suffice. Finding a proxy for demand is trickier as demand shift can reflect movements in prices. However, one component of the national accounts could fill

[13]Unfortunately, this elimination not only removes artificial product turnover, but also diminishes the importance of true net creation.

[14]To estimate elasticities we use the original panel with 167 countries. The list of advanced countries is: Australia, Austria, Belgium-Luxembourg, Denmark, Finland, France, Germany, Ireland, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, UK, USA. The list of developing countries is: Argentina, Bulgaria, China, Colombia, Croatia, Czech Republic, Estonia, Guatemala, Hong-Kong, Hungary, India, Israel, Kazakhstan, Korea, Lithuania, Mexico, Peru, Poland, Russia, Singapore, Slovenia, Sri Lanka, Turkey, Ukraine.

the post: government consumption expenditure. A good share of the latter is composed of demand for non-traded goods. As the sample period is long enough to characterize the labor market with inter-sectoral mobility, higher demand for non-traded goods will translate into higher wages in the same sector in turn putting upward pressure on wages in manufacturing. Therefore, increases in government expenditure, via the multiplier effect, will raise aggregate demand for goods and labor, while being insulated from movements in international relative prices.[15] Accordingly, the choice of these regressors is driven by our assumption that medium-run movements in the terms of trade are not reflected in shifts in total factor productivity (from the Groningen Total Economy Database) or government consumption (measured as the change over starting year GDP and taken from UN national accounts), rendering them exogenous.

3.2. Econometric specification

In a Ricardian trade model, Galstyan (2011) shows how terms of trade movements relate to shifts in relative supply and demand. He finds that improving productivity, while raising relative wages, has a marginally negative impact on relative marginal cost. The latter translates into a marginal deterioration of the conventional terms of trade. On the other hand, movements in aggregate demand shift the world-market-equilibrium curve leaving a non-negligible impact on the conventional terms of trade as higher demand for domestic goods raises the demand for labor, in turn pushing up relative wages.

Accordingly, the empirical specification considered is

$$\Delta \ln y_i = \alpha + \beta \Delta \ln rel\_prod_i + \gamma \Delta rel\_demd_i + \varepsilon_i \tag{10}$$

where y_i is the corresponding relative price measure, rel_prod_i is an index of relative total factor productivity and rel_demd_i is a proxy of relative demand. We expect that the terms of trade are declining in relative productivity and increasing in relative demand.

Finally domestic exports are related to domestic productivity and foreign demand,

$$\Delta \ln x_i = \theta + \phi_h \Delta \ln prod_i^h + \varphi_f \Delta demd_i^f + \epsilon_i \tag{11}$$

[15] In general, a collapse in commodity prices will hurt the export sector and the aggregate economy of commodity exporter. In this instance government might step in to fill in the gapping demand (eg. Chilean experience). On the other hand, a sharp increase in relative export prices will reduce domestic competitiveness, forcing the government to adopt expansionary fiscal policy. The first case can be effectively ruled out as commodity exports are dropped. The second scenario is less likely as, to the best of our knowledge, no sharp movements in manufacturing terms of trade have materialized in our sample.

while domestic imports to foreign productivity and domestic demand

$$\Delta \ln m_i = \varpi + \phi_f \Delta \ln prod_i^f + \varphi_h \Delta demd_i^h + u_i \tag{12}$$

where $prod_i^j$ is productivity, $demd_i^j$ captures demand, and $j = h, f$ indexes home and foreign variables respectively.[16] These specifications are considered for both the extensive margin and real component of the intensive margin.

4. Results

4.1. Elasticities, extensive margin and bias

Figure 1 shows the distribution of substitution elasticities at the 4 digit level. There are 814 categories of which a grid search was conducted for 190. The weighted average manufacturing elasticity is 15.1. This is somewhat larger than the non-weighted average elasticity of substitution of 4 estimated by Broda and Weinstein (2006) at the 3 digit SITC level. But a number of factors, such as differences in classification systems, differences in digits that define varieties, and differences in the number of countries involved, complicate direct comparison.

Estimations carried out by Gaulier and Mèjean (2006) are more appropriate for this purpose. These authors use BACI data over a different sample period with estimations performed for a range of countries on an individual basis. The cross-country average elasticity of substitution obtained is 21, which is higher than our estimate. Meanwhile, our estimated median elasticity stands at 6.6, compared to 6 of Gaulier and Mèjean (2006). Even though these authors consider a wider range of categories than just manufacturing, the latter comprises more than half of all trade. Therefore it is instructive to acknowledge some similarity of results.

Table 1 presents a few selected median elasticities at the 2 digit level. Glassware, books and beverages have approximately the same elasticity of 5, suggesting that these goods are, to some extent, differentiated. Toys and sports requisites are more homogenous with an estimated elasticity of 9. The estimates imply a much lower degree of differentiation between cosmetics products, as the elasticity of substitution stands at 15.[17]

[16] One could arguably incorporate domestic demand as a driving force for domestic exports. This effect might be small since we account for domestic supply and foreign demand variables. Given our small sample size, aiming for over-specification will reduce the precision of estimates. Finally, under-specification is not an issue if omitted variables are orthogonal to those that are included.

[17] Rauch (1999) classifies industries as differentiated, reference priced, or homogeneous goods. Since almost all of our industries fall into the differentiated goods category, a comparison between average elasticities of differentiated and homogenous goods, as conducted by Broda and Weinstein (2006), becomes

To assess the quantitative effects of the extensive margin on the price indices, the log change of the difference between the welfare-based and the conventional price index is regressed on the log of the extensive margin. A one percentage point increase in the extensive margin of imports is associated with a bias of -0.15 percentage points, while a one percentage point increase in the extensive margin of exports results in a bias of 0.63 percentage points. Thus, a negligible bias over a short period of time may result in a substantial accumulated miss-measurement of welfare-based prices over a longer time period.

4.2. Margins, prices and the terms of trade

Table 2 describes the distribution of changes in trade margins for samples of advanced and developing countries. In the sample of advanced countries, there has been an expansion in the extensive margin of both exports and imports by approximately 1 percent. Though the means are similar, there is a considerable degree of heterogeneity among individual countries, as signified by the wide range and large standard deviation. In the sample of developing economies, the improvement in the extensive margin is more pronounced. The average contribution stands at 2.7 percent for exports and 2.3 for imports. The degree of heterogeneity is more apparent in this sample compared to that of the advanced countries, as the range and standard deviation are much larger. Looking at imports, a similar pattern emerges, though the dispersion is larger for exports than for imports.

For the group of advanced countries over the period 1998-2006 the volume of exports along the intensive margin has increased by an average of 4.5 percentage points, compared to the 6.4 percent increase in the sample of developing countries. Advanced countries have also experienced a marked increase in imports along the intensive margin of trade: the average growth rate in volume stands at 4.5 percent. As for developing countries, the table suggests a significant expansion in import volume along the intensive margin with an average growth rate of 7.7 percent. Range and standard deviation statistics highlight considerable heterogeneity along the intensive margin as well, with developing countries characterized by greater dispersion than advanced countries.

Figure 2 shows a scatter plot of the corrected (vertical line) versus conventional (horizontal line) import price index for the sample of advanced countries. A striking feature of the graph is the under-estimation of import price inflation by the conventional price index compared to the average price index. On the other hand, the conventional price

impossible.

index overestimates the welfare-based change in price levels. Figure 3 plots the corrected versus conventional export price index. The graph suggests that the conventionally measured price index has been over-estimating changes in export prices when compared to the average price index and under-estimating the extent of export price changes when compared to the welfare-based measure.

The miss-measurement of trade prices propagates into miss-measurement of international relative prices in Figure 4 which charts the corrected and conventional terms of trade. The conventional terms of trade tends to understate movements of the welfare-based measure while overstating movements of the terms of trade based on average prices. Even though the correlation between different measures is high, the matter of importance is the degree of miss-measurement. If interest lies with the welfare-based index, then the annual order of underestimation is of 0.7 percent. If, on the other hand, the average-price-based index is considered, an overestimation of the terms of trade by 1.3 percent is realized. These graphs indicate that the choice of index might have a non-negligible impact on the magnitude of movements in international relative prices.

4.3. Regressions

In this subsection we turn to a cross-sectional analysis of the determinants of the terms of trade and margins of international trade flows. The results for the terms of trade are presented in Table 3. The regressions are run for a variety of country groups. In addition to the full sample, a distinction is made between advanced and developing countries. The differentiation is important as movements in the terms of trade for the latter category can be exogenous.

Column (1) of panel A shows the estimates for the full sample. The results suggest a positive relation between relative productivity and the terms of labor: a 1 percentage point increase in relative productivity is associated with a 0.64 percent rise in relative wages. Meanwhile an increase in relative demand by 1 percentage point calls for an improvement in the terms of labor by 0.3 percent.[18] The pattern seems consistent with the theoretical predictions discussed in the previous subsection with a possible interpretation that domestic productivity gains are translated into a higher marginal product of labor improving the terms of labor. Meanwhile, higher domestic demand raises the demand for labor, in turn pushing up relative wages. Columns (2) and (3) show the results for split samples. The demand factor carries over the qualitative (and quantitative)

[18]Since the regressors are proxies to actual variables, there is a proxy component that adds to both the estimated elasticity and the variance due to the measurement error. Thus, estimated elasticities can miss-state the true magnitude of movements particularly for demand.

results from the full sample. Relative productivity, however, ceases to be statistically significant.[19]

Columns (4) to (6) describe results for the conventional measure of the terms of trade. In the full sample, higher productivity is associated with improving terms of trade. This positive relation is driven by developments in emerging markets. One possible explanation is exogeneity of the terms of trade in this group, while the other is endogeneity of TFP.[20] In the sample of advanced countries, however, higher productivity engenders a deterioration in the terms of trade: a 1 percentage point increase in relative productivity is associated with a 1 percent decline in the terms of trade. Meanwhile higher relative demand, although marginally insignificant, is still associated with improving terms of trade.[21] Galstyan (2011) suggests that as productivity improves, the marginal product of labor, the numerator in the pricing equation, rises. The latter increase is not strong enough to combat gains in productivity, the denominator in the pricing equation. Consequently, a deterioration in the terms of trade with an improvement in the terms of labor is warranted. On the other hand, higher domestic demand raises the demand for labor, pushing relative wages up. The latter development, in turn, puts upward pressure on the terms of trade for any given level of productivity.

Panels A and B provide a similar story for alternative measures of the terms of trade. The size of the standard errors suggests a low likelihood of rejecting coefficient equality between different measures. The main distinction between the panels, however, is captured by the constant. The negative intercept in columns (1)-(3) of panel B suggests that movements in the terms of trade based on average prices tend to be 2 percentage points smaller than movements in the conventional terms of trade after controlling for productivity and demand. Conversely, the positive constant in columns (4) and (6) of panel B captures a higher growth rate in the welfare-based terms of trade by 2 percentage points.

Estimates for the trade margins are shown in Table 4. As expected, higher domestic demand and higher foreign productivity expand the real volume of imports along the intensive margin. Neither determinant of the extensive margin of imports is significant though. In the total sample higher productivity raises the real component of exports along the intensive margin. The statistical significance disappears once the sample

[19] In the sample of industrial countries this result is driven by Australia. Meanwhile exclusion of Kazakhstan, Turkey and Russia from the developing sample reduces the spread around the regression line restoring statistical significance.

[20] For a hypothetical country, a higher price of exports raises export value expanding GDP. Extracting TFP as a residual generates a positive correlation between the latter and the price of exports. This effect could be particularly important for countries (a) with exogenous terms of trade and (b) with GDP growth driven by exports.

[21] Exclusion of Finland, which looks off-charts, from the sample of advanced countries improves statistical significance.

is split. Interestingly, higher domestic productivity is negatively related to the extensive margin of exports. This relation is statistically significant in the sample of developing countries. One possible explanation could be that higher productivity, requiring resources in production of exportables along the intensive margin, calls for resource reallocation, reducing the supply of exportables along the extensive margin. Improvements in exports along the extensive margin, on the other hand, are associated with increasing foreign demand for domestic goods.

In summary, our results suggest that higher relative productivity simultaneously raises the volume of exports relative to imports along the intensive margin, and calls for a deterioration in the terms of trade, suggesting a negative relation between relative prices and relative intensive margins. Meanwhile, higher relative demand improves the terms of labor raising demand for imports.

5. Conclusions

This paper contributes to empirical research on the dynamics of the terms of trade and margins of trade flows using internally consistent data. First, the paper proposes a method for constructing various measures of the terms of trade. This is accomplished in a few steps. Initially, using a panel data approach and highly disaggregated data on trade flows, we estimate a range of substitution elasticities. The median elasticity that we estimate stands at 6.6. These estimates are then used to create import and export price indices. We find that ignoring the extensive margin in the construction of welfare based price indices results in an overestimation of import prices by 0.15 percentage points and an underestimation of export prices by 0.63 percentage points.

The miss-measurement of trade prices propagates itself into miss-measurement of international relative prices. We find that the conventional terms of trade tends to understate movements in the welfare-based measure while overstating movements in the average-price-based terms of trade. In the case of the welfare-based measure, the annual underestimation is of a 0.7 percent magnitude. If, on the other hand, the average-price-based index is considered, an overestimation of the terms of trade by 1.3 percent is realized.

Finally, trade margins and various measures of the terms of trade are related to productivity and demand proxies. We find that domestic demand side movements are positively related to the terms of trade, while, in the sample of advanced countries, domestic productivity gains result in a terms of trade deterioration. Over the sample period, the main driver of trade flows is the intensive margin. Our results suggest that the intensive

margin of imports is positively related to domestic demand and foreign productivity while domestic productivity gains are associated with an expansion of domestic exports along the intensive margin. In the sample of developing countries, improvements in the extensive margin of exports are caused by a decline in domestic productivity and an increase in foreign demand. Our findings reveal that higher relative productivity simultaneously raises the volume of exports relative to imports along the intensive margin, and calls for a deterioration in the terms of trade, suggesting a negative relation between relative prices and relative intensive margins.

As demand-side effects are arguably non-negligible, further research on fundamentals with a finer level of trade data disaggregation would shed more light on the importance of demand in explaining movements in the terms of trade over the medium run.

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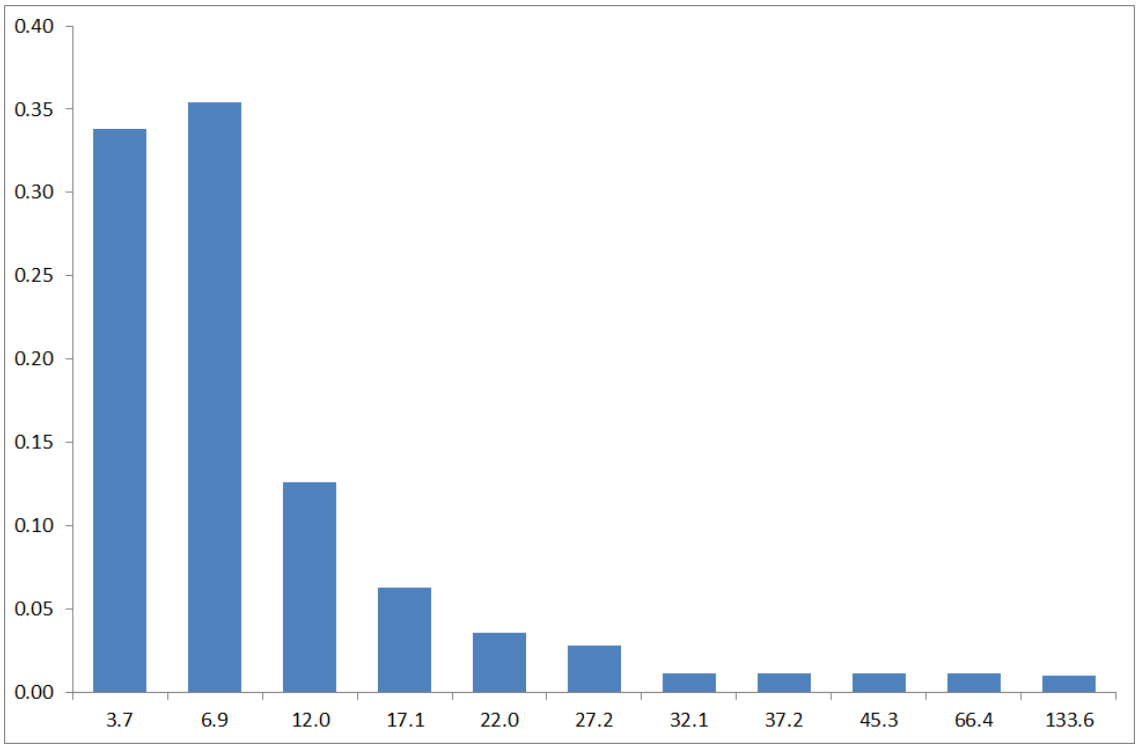
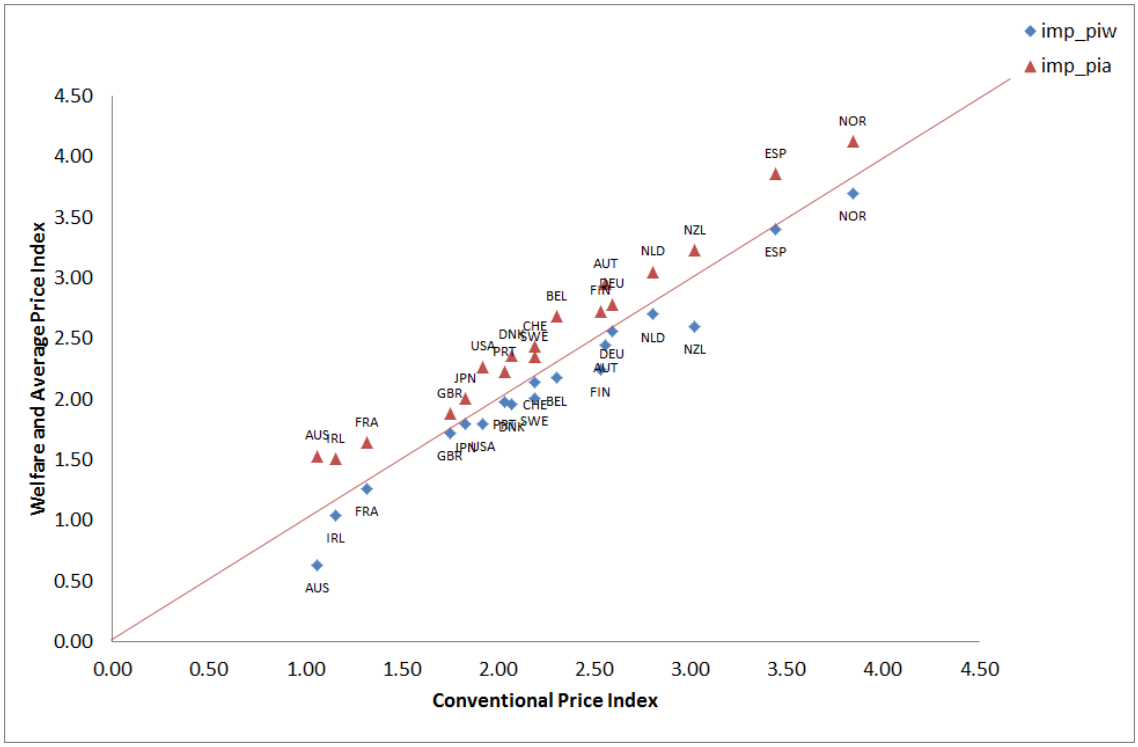
Figure 1: Elasticities



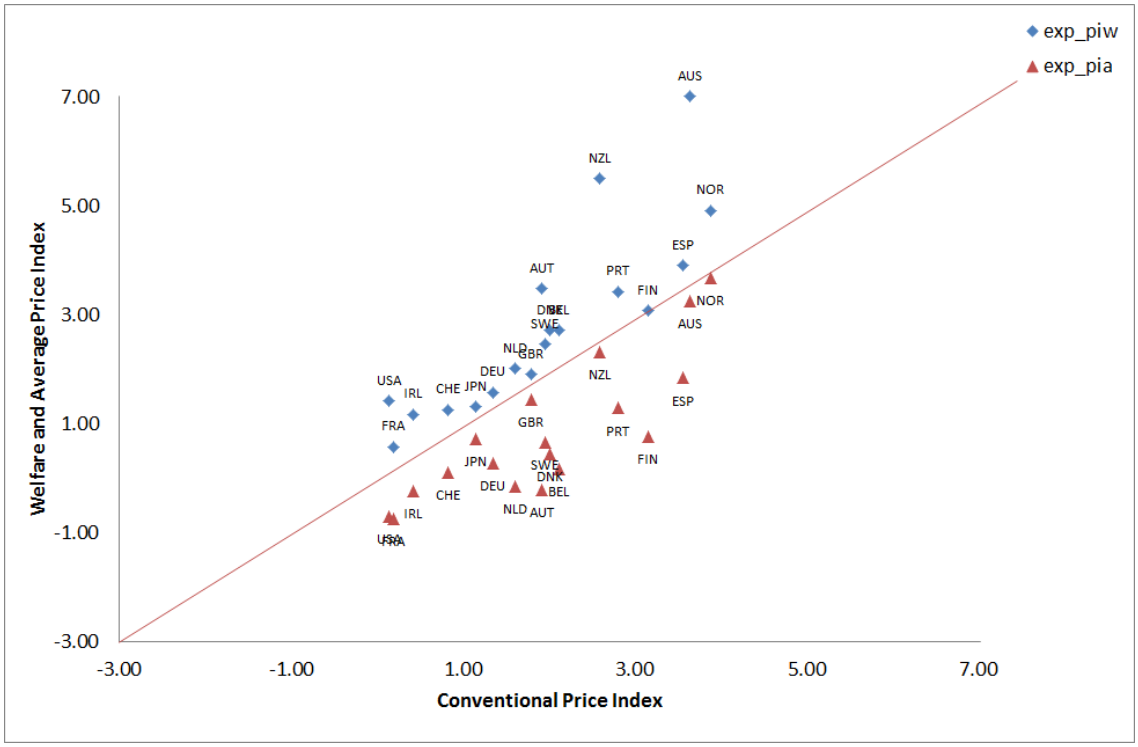
Notes: The histogram shows the distribution of substitution elasticities at the 4 digit HS1996 level over 814 manufacturing categories. The elasticities are estimated using a panel instrumental variables procedure where the instruments are dummy variables across varieties. The estimation is conducted for a panel of 167 countries with trade data from BACI (Base pour l'Analyse du Commerce International).

Figure 2: Import prices



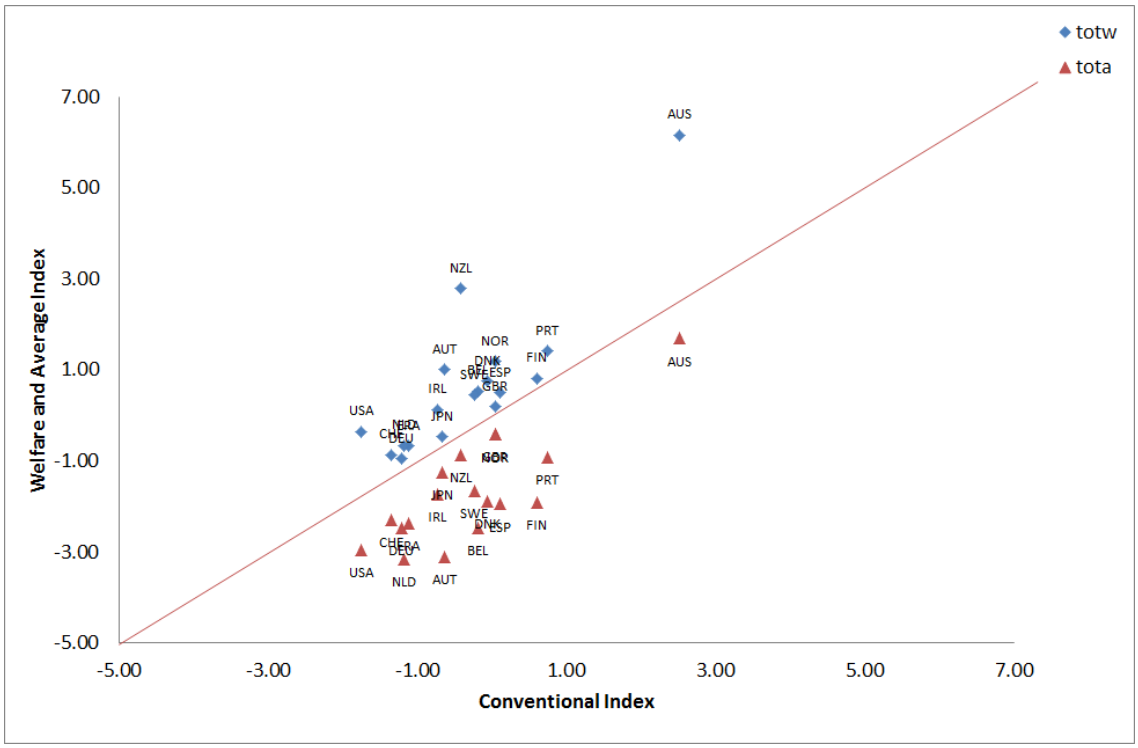
Notes: Price index of manufacturing imports. The conventional price index ignores product turnover. The welfare-based price index adjusts for product turnover by incorporating the weight of new varieties, while the average price index takes into account not only the weight but also the quantity of new varieties. Authors calculations based on BACI (Base pour l'Analyse du Commerce International).

Figure 3: Export prices



Notes: Price index of manufacturing exports. The conventional price index ignores product turnover. The welfare-based price index adjusts for product turnover by incorporating the weight of new varieties, while the average price index takes into account not only the weight but also the quantity of new varieties. Authors calculations based on BACI (Base pour l'Analyse du Commerce International).

Figure 4: Terms of trade



Notes: Manufacturing terms of trade measured by the ratio of export to import price indices. The conventional price index ignores product turnover. The welfare-based price index adjusts for product turnover by incorporating the weight of new varieties, while the average price index takes into account not only the weight but also the quantity of new varieties. Authors calculations based on BACI (Base pour l'Analyse du Commerce International).

Table 1: Estimated elasticities

2 digit description	**Elasticity**
Umbrellas, walking-sticks, seat-sticks, whips, etc	3.1
Manufactures of plaiting material, basketwork, etc.	3.5
Fertilizers	3.9
Ceramic products	4.4
Glass and glassware	4.5
Stone, plaster, cement, asbestos, mica, etc articles	4.6
Wood and articles of wood, wood charcoal	4.8
Articles of iron or steel	4.9
Printed books, newspapers, pictures etc	4.9
Ships, boats and other floating structures	4.9
Soaps, lubricants, waxes, candles, modeling pastes	5.0
Beverages, spirits and vinegar	5.1
Milling products, malt, starches, inulin, wheat gluten	5.2
Paper and paperboard, articles of pulp, paper and board	5.2
Cork and articles of cork	5.4
Carpets and other textile floor coverings	5.4
Impregnated, coated or laminated textile fabric	5.4
Musical instruments, parts and accessories	6.6
Furniture, lighting, signs, prefabricated buildings	6.8
Railway, tramway locomotives, rolling stock, equipment	7.3
Vehicles other than railway, tramway	7.3
Organic chemicals	7.6
Bird skin, feathers, artificial flowers, human hair	7.9
Tools, implements, cutlery, etc of base metal	8.4
Photographic or cinematographic goods	8.5
Toys, games, sports requisites	9.0
Optical, photo, technical, medical, etc apparatus	10.6
Furskins and artificial fur, manufactures thereof	11.1
Cotton	11.2
Silk	11.3
Nuclear reactors, boilers, machinery, etc	12.2
Articles of apparel, accessories, knit or crochet	13.9
Electrical, electronic equipment	14.8
Special woven or tufted fabric, lace, tapestry etc	15.0
Essential oils, perfumes, cosmetics, toileteries	15.2
Articles of apparel, accessories, not knit or crochet	18.8
Knitted or crocheted fabric	23.3

Notes: 4 digit elasticities are estimated using a panel instrumental variables procedure where the instruments are dummy variables across varieties. The estimation is conducted for a panel of 167 countries with trade data from BACI (Base pour l'Analyse du Commerce International). The elasticities above are medians for a given 2 digit HS1996 category.

Table 2: Distribution of margins

Panel A: Advanced	**Imp. Int. (1)**	**Exp.Int. (2)**	**Imp.Ext. (3)**	**Exp.Ext. (4)**
Min	1.5	0.5	0.1	-0.1
Max	8.8	12.7	2.9	4.4
Mean	4.5	4.5	1.0	1.3
Median	4.5	4.4	0.8	0.8
St.Dev.	1.7	2.6	0.9	1.3
Panel B: Developing	**Imp. Int. (1)**	**Exp.Int. (2)**	**Imp.Ext. (3)**	**Exp.Ext. (4)**
Min	-1.7	-3.3	0.6	-1.2
Max	15.4	12.3	6.6	8.5
Mean	7.7	6.4	2.3	2.7
Median	7.4	7.0	1.6	2.3
St.Dev.	4.5	3.5	1.7	2.0

Notes: Growth rates of trade margins over the 1998-2006 period. Imp stands for imports, while Exp for exports. Int is the quantity or real component of the intensive margin, while Ext represents the extensive margin.

Table 3: Terms of trade: relative factors

Panel A	**Rel. Wage**			**TOT Conventional**		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Rel. Productivity	0.64	-0.01	0.57	0.47	-0.99	0.54
	(0.32)**	(0.60)	(0.50)	(0.19)**	(0.37)**	(0.29)*
Rel. Demand	0.30	0.22	0.32	0.04	0.04	0.03
	(0.05)***	(0.05)***	(0.08)***	(0.03)	(0.03)	(0.04)
Constant	-0.00	-0.01	0.00	0.00	-0.01	0.00
	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)***	(0.00)
R^2	0.58	0.54	0.57	0.23	0.41	0.23
Observations	42	18	24	42	18	24
Sample	All	Adv	Dev	All	Adv	Dev
Panel B	**TOT Average**			**TOT Feenstra**		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Rel. Productivity	0.42	-1.04	0.80	0.53	-1.45	0.45
	(0.23)*	(0.47)**	(0.33)**	(0.27)*	(0.64)**	(0.35)
Rel. Demand	0.00	0.06	-0.03	0.01	0.09	-0.03
	(0.04)	(0.04)	(0.05)	(0.04)	(0.06)	(0.05)
Constant	-0.02	-0.02	-0.02	0.02	-0.00	0.03
	(0.00)***	(0.00)***	(0.01)***	(0.00)***	(0.00)	(0.01)***
R^2	0.09	0.35	0.22	0.11	0.37	0.07
Observations	42	18	24	42	18	24
Sample	All	Adv	Dev	All	Adv	Dev

Note: Rel.Wage is the relative wage rate in manufacturing; TOT conventional is the conventional terms of trade; TOT average is the terms of trade based on average price indices; TOT Welfare is the terms of trade based on welfare price indices; Rel. Productivity is the log of the relative total factor productivity index over the 1998-2006 period; Rel. Demand is the change in government consumption over the 1998-2006 period as a share of GDP in 1998 relative to the weighted average of trading partners. Standard errors in parenthesis.
Asterisks ***,**,* indicate significance at 1%, 5% and 10%, respectively.

Table 4: Margins

Panel A	**Imp.Int.**			**Imp.Ext.**		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Productivity ROW	2.86	0.11	2.07	0.56	0.36	0.28
	(0.76)***	(1.20)	(1.13)*	(0.42)	(0.64)	(0.61)
Demand	0.16	-0.02	0.20	-0.02	0.04	-0.03
	(0.05)***	(0.06)	(0.07)**	(0.03)	(0.03)	(0.04)
Constant	0.00	0.04	0.01	0.01	-0.00	0.02
	(0.01)	(0.02)**	(0.01)	(0.01)**	(0.01)	(0.01)***
R^2	0.54	0.01	0.55	0.04	0.10	0.04
Observations	42	18	24	42	18	24
Sample	All	Adv	Dev	All	Adv	Dev
Panel B	**Exp.Int.**			**Exp.Ext.**		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Productivity	0.75	0.79	0.44	-0.05	-0.39	-0.63
	(0.32)**	(0.65)	(0.52)	(0.21)	(0.48)	(0.27)**
Demand ROW	-0.18	0.23	-0.11	0.08	-0.25	0.30
	(0.17)	(0.28)	(0.25)	(0.11)	(0.21)	(0.13)**
Constant	0.07	0.01	0.07	0.01	0.05	-0.00
	(0.02)***	(0.04)	(0.03)**	(0.01)	(0.03)	(0.02)
R^2	0.14	0.19	0.04	0.01	0.19	0.23
Observations	42	18	24	42	18	24
Sample	All	Adv	Dev	All	Adv	Dev

Note: Imp stands for imports, while Exp for exports; Int is the quantity or real component of the intensive margin, while Ext represents the extensive margin; Productivity is the log of the total factor productivity index over the 1998-2006 period; Productivity ROW is the log of the weighted total factor productivity index of trading partners over the 1998-2006 period; Demand is the change in government consumption over the 1998-2006 period as a share of GDP in 1998; Demand ROW is the weighted change in government consumption over the 1998-2006 period as a share of GDP in 1998. Standard errors in parenthesis.
Asterisks ***,**,* indicate significance at 1%, 5% and 10%, respectively.

Appendix A: Definitions of prices

Import prices

As in Broda and Weinstein (2006), preferences are given by a two-level utility function. The aggregate volume of imports in period t is determined by a CES aggregator over a set of goods g with an elasticity of substitution $\gamma > 1$. At the lower level of aggregation, preferences of the importing country are approximated by a CES aggregator over a set of varieties for a given good g with a $\theta_g > 1$ substitution elasticity.

The aggregate welfare-based import price index is a geometric average of the price indices of imported goods

$$\frac{P^w_{m,t}}{P^w_{m,s}} = \prod_{g \in M} \left(\left(\frac{\lambda^m_{g,t}}{\lambda^m_{g,s}} \right)^{\frac{1}{\theta_g - 1}} \prod_{j \in C} \left(\frac{p^m_{gj,t}}{p^m_{gj,s}} \right)^{w^m_{gj,t}} \right)^{w^m_{g,t}}$$

where M is the set of all imported goods and the $w^m_{gj,t}$ correspond to the log-change weights of good g in aggregate imports.

The conventional aggregate import price index is

$$\frac{P^c_{m,t}}{P^c_{m,s}} = \prod_{g \in M} \left(\prod_{j \in C} \left(\frac{p^m_{gj,t}}{p^m_{gj,s}} \right)^{w^m_{gj,t}} \right)^{w^m_{g,t}}$$

while the average aggregate import price is

$$\frac{P^a_{m,t}}{P^a_{m,s}} = \prod_{g \in M} \left(\left(\frac{J^m_{g,t}}{J^m_{g,s}} \right)^{\frac{1}{\theta_g - 1}} \left(\frac{\lambda^m_{g,t}}{\lambda^m_{g,s}} \right)^{\frac{1}{\theta_g - 1}} \prod_{j \in C} \left(\frac{p^m_{gj,t}}{p^m_{gj,s}} \right)^{w^m_{gj,t}} \right)^{w^m_{g,t}}$$

Export prices

To derive prices for exports, we assume that the production technology for aggregate exports is also given by a two-level aggregator. The aggregate export good is produced by $X_t = \left(\sum_{g \in X} X^{(\sigma+1)/\sigma}_{g,t} \right)^{\sigma/(\sigma+1)}$, where $X_{g,t}$ is the volume of exports of good g, $\sigma > 0$ is the elasticity of transformation between the goods and X is the set of all exported goods. At the lower level of aggregation, the production function for export good g is given by a similar CES aggregator with an elasticity of transformation $\psi_g > 0$.

The aggregate export price index is constructed as

$$\frac{P^w_{x,t}}{P^w_{x,s}} = \prod_{g \in X} \left(\left(\frac{\lambda^x_{g,t}}{\lambda^x_{g,s}} \right)^{-\frac{1}{\psi_g + 1}} \prod_{j \in EX_g} \left(\frac{p^x_{gj,t}}{p^x_{gj,s}} \right)^{w^x_{gj,t}} \right)^{w^x_{g,t}}$$

where X is the set of all exported goods and the $w^x_{gj,t}$ correspond to the log-change weights of good g in aggregate exports. The conventional aggregate export price index is

$$\frac{P^c_{x,t}}{P^c_{x,s}} = \prod_{g \in X} \left(\prod_{j \in EX_g} \left(\frac{p^x_{gj,t}}{p^x_{gj,s}} \right)^{w^x_{gj,t}} \right)^{w^x_{g,t}}$$

while the average aggregate export price is

$$\frac{P^w_{x,t}}{P^w_{x,s}} = \prod_{g \in X} \left(\left(\frac{J^x_{g,t}}{J^x_{g,s}} \right)^{-\frac{1}{\psi_g + 1}} \left(\frac{\lambda^x_{g,t}}{\lambda^x_{g,s}} \right)^{-\frac{1}{\psi_g + 1}} \prod_{j \in EX_g} \left(\frac{p^x_{gj,t}}{p^x_{gj,s}} \right)^{w^x_{gj,t}} \right)^{w^x_{g,t}}$$

Terms of trade

The welfare-based terms of trade is defined as

$$\tau^w = \frac{P^w_{x,t}}{P^w_{x,s}} \Big/ \frac{P^w_{m,t}}{P^w_{m,s}}$$

the conventional terms of trade is

$$\tau^c = \frac{P^c_{x,t}}{P^c_{x,s}} \Big/ \frac{P^c_{m,t}}{P^c_{m,s}}$$

while the average terms of trade is

$$\tau^a = \frac{P^a_{x,t}}{P^a_{x,s}} \Big/ \frac{P^a_{m,t}}{P^a_{m,s}}$$

Appendix B: A decomposition

The nominal growth rate of aggregate imports can then be written as a product of extensive and intensive margins

$$\frac{\sum q^m_{gj,t} p^m_{gj,t}}{\sum q^m_{gj,s} p^m_{gj,s}} = \underbrace{\prod_{g \in M} \left(\frac{\lambda^m_{g,t}}{\lambda^m_{g,s}} \right)^{-w^m_{g,t}}}_{\textit{Extensive margin}} \underbrace{\prod_{g \in M} \left(\prod_{j \in IM_g} \left(\frac{p^m_{gj,t} q^m_{gj,t}}{p^m_{gj,s} q^m_{gj,s}} \right)^{w^m_{gj,t}} \right)^{w^m_{g,t}}}_{\textit{Intensive margin}}$$

where the intensive margin is itself captured by the product of quantity and price components

$$\underbrace{\prod_{g \in M} \left(\prod_{j \in IM_g} \left(\frac{p^m_{gj,t}}{p^m_{gj,s}} \right)^{w^m_{gj,t}} \right)^{w^m_{g,t}}}_{\textit{Price component}} \underbrace{\prod_{g \in M} \left(\prod_{j \in IM_g} \left(\frac{q^m_{gj,t}}{q^m_{gj,s}} \right)^{w^m_{gj,t}} \right)^{w^m_{g,t}}}_{\textit{Quantity component}}$$

The latter coincides with the conventional aggregate price index.

Similar to the growth rate of imports, we can write the nominal growth rate of aggregate exports as a product of extensive and intensive margins

$$\frac{\sum q^x_{gj,t} p^x_{gj,t}}{\sum q^x_{gj,s} p^x_{gj,s}} = \underbrace{\prod_{g \in X} \left(\frac{\lambda^x_{g,t}}{\lambda^x_{g,s}} \right)^{-w^x_{g,t}}}_{\textit{Extensive margin}} \underbrace{\prod_{g \in X} \left(\prod_{j \in EX_g} \left(\frac{p^x_{gj,t} q^x_{gj,t}}{p^x_{gj,s} q^x_{gj,s}} \right)^{w^x_{gj,t}} \right)^{w^x_{g,t}}}_{\textit{Intensive margin}}$$

The intensive margin itself is given by the product of price and quantity components:

$$\underbrace{\prod_{g \in X} \left(\prod_{j \in EX_g} \left(\frac{p^x_{gj,t}}{p^x_{gj,s}} \right)^{w^x_{gj,t}} \right)^{w^x_{g,t}}}_{\textit{Price component}} \underbrace{\prod_{g \in X} \left(\prod_{j \in EX_g} \left(\frac{q^x_{gj,t}}{q^x_{gj,s}} \right)^{w^x_{gj,t}} \right)^{w^x_{g,t}}}_{\textit{Quantity component}}$$

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