Trade, product variety and welfare: a quantitative assessment for mainland China

Michael Funke* and Ralf Ruhwedel

Department of Economics, Hamburg University, Hamburg, Germany

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We calculate a variety of welfare gains for Mainland China, following the approach of Romer (1994), who emphasized that proper modelling of the impact of trade restrictions on the number of available product varieties is crucial for quantifying the welfare impact of trade liberalization. The empirical work presented relies on direct measures of product variety calculated from highly disaggregated trade data. The emerging conclusion is that freer trade has indeed boosted welfare.

Keywords: trade liberalization; product variety; welfare; China

1. Introduction

We consider here a very old question: what are the welfare gains accruing to a country that opens up its borders to international trade? Estimating the size and extent of such welfare gains is no easy task as trade can affect an economy in many ways. Economists measure the welfare gains of integration in terms of growth rates or static efficiency. There is a preponderance of empirical cross-country evidence that trade liberalization and openness to trade increases the growth rate of income and output. In addition, numerous individual country studies over the past three decades suggest that trade causes growth.1 A country’s trade policy is the key link in the transmission of price signals from the world market to the national economy. Undistorted price signals from world markets allow a resource allocation consistent with comparative advantage, thereby increasing productivity. An open trade and investment regime, in turn, encourages integration into the global trading environment and the import of diverse and modern technologies that are important for productivity improvements.

Traditional estimates of static efficiency gains from trade liberalization, in contrast, have been rather small. Most studies find the cost of protection for various countries in different years to be no more than 1% of GDP.2 One inherent weakness of this conventional analysis of protection is the assumption that the set of goods is both fixed and complete. Prices may change, but the list of goods that are traded at a certain price, in a certain quantity, does not change. Romer (1994) loosened this assumption and emphasized that proper modelling of the impact of trade protection on the change in the number of available varieties is crucial to quantifying the welfare impact of trade liberalization. He incorporated this idea into a simple model with a single final good produced using labour and differentiated inputs imported from abroad, which incur some fixed cost. The larger the number of inputs, the lower the cost of production.

*Corresponding author. Email: funke@econ.uni-hamburg.de
After more than two decades of market-oriented reforms, China has become increasingly integrated into the world economy and has redrawn the lines of international trade. Mainland China has emerged as an international production hub which combines a vast supply of cheap labour with an economy that is very open by international standards. In that sense, China’s impact upon the world economy is a substantial supply shock. World trade patterns and production structures in the rest of the world are adjusting to accommodate China’s emergence as a global economic player.

The highly dynamic and diversified Chinese trade has been amply documented and discussed in Rodrik (2006) and Schott (2006). Both authors have examined the relative sophistication of China’s exports compared with OECD countries. Schott (2006) finds that China exports more products in common with OECD countries than would be expected given its level of development. On the other hand, the prices China receives for its exports have been declining over time. Rodrik (2006) has compiled sophistication indices for products based on the weighted averages of per capita GDP of the countries that export them, and finds that China’s export bundle is more sophisticated than would be expected from its level of development, and has become more sophisticated over time. Building upon Rodrik’s (2006) work, Cui and Syed (2007) have also calculated the sophistication index of China’s imports. The comparison of the sophistication level between exports and imports indicates that imported goods are more sophisticated. The increase in trade also came from re-tooled capacities and a finer division of labour based on production sharing. New technologies facilitated this fragmentation of production processes, i.e. the division of the value chain into smaller functions that could be contracted out to suppliers located in different countries. The result of these developments is – to borrow a phrase from Feenstra (1998) – integration of trade and disintegration of production in the global economy.

Controlling for other potential determinants, Brambilla (2006) has recently demonstrated, using firm-level data for the Chinese manufacturing sector during 1998–2000, that foreign-owned firms introduce twice as many new varieties as domestic firms. Finally, Feenstra and Kee (2007) have measured the variety of Chinese exports to the US over the period 1990–2001 and have demonstrated that export variety has increased on average by 3.7% per year.

The remainder of the paper is structured as follows: In Section 2, we briefly discuss the welfare gains arising from a wider diversity of imports. In Section 3, we map out the method for measuring variety growth, describe the dataset, and present empirical results for Mainland China. Section 4 concludes.

2. Trade restrictions and product variety

To keep things simple and frame the main message, we offer the following diagram. Assume a small economy, where all agents take world prices as exogenously given. Figure 1 shows a simple demand line for a hypothetical imported good with price plotted on the vertical axis and quantity on the horizontal axis. The graph shows a point of equilibrium at a price $P_1$ and a quantity of $X_1$. The corresponding consumer surplus is given by the triangle $A+B+C$.

Now suppose that the government has imposed a tariff on the import good. The price rises by the amount of the tariff, from $P_1$ to $P_2$; the quantity demanded falls from $X_1$ to $X_2$. Further, the consumer surplus shrinks. This dwindling of consumer surplus consists of two parts. The larger part, shown by area $B$, is the tariff revenue collected by the government. The foregone surplus – the triangle marked $C$ – is the deadweight loss. Conventional estimates of the cost of protection are based upon the size of $C$. Romer (1994), however, argues that such calculations may substantially underestimate the costs of protection arising from trade restrictions, taxes, corruption, or bureaucratic red tape, because the set of goods that are traded is not fixed in the real world.
Suppose that introducing a new good to a market incurs a fixed cost, such as the cost of advertising or the establishment of a servicing and parts supply network. The introduction of increasing-returns-to-scale technologies is, however, not inconsequential for the potential gains from variety with a tariff reduction. Because of fixed selling costs, some amount of revenue is required for a good to be sold at all. Therefore, even a small tariff may prevent a good from ever appearing in that country’s market. In other words, if a tariff (tariff removal) leads to the withdrawal (appearance) of a (new) good, then the corresponding loss (welfare gain) is not the $C$-triangle, but the entire social surplus, $A+B+C$. The reason is that foreign producers will be forced out of business and variety will disappear from the market, i.e. the tariff has a ‘market-size’ effect. To illustrate, Romer (1994) calibrates a model with intermediate varieties in an Ethier–Dixit–Stiglitz framework. With fixed costs, tariffs reduce the variety of capital goods available. In a conventional world with a fixed list of capital inputs, a tariff of 10% reduces GDP by 1%. However, in the opposite case of changing product variety, the welfare cost is hefty – about 20% of GDP.

While the appearance of new goods is a fundamental feature of the modern economy and has been the subject of analysis in trade and growth models, quantitative papers tackling the gains-from-variety effect do not abound. Accordingly, our empirical analysis of the welfare gains from the introduction of new goods in Section 3 below is offered as a step toward redressing this deficiency in the literature.

### 3. Empirical estimates of variety gains in Mainland China

The product differentiation view of trade suggests a different empirical framework for assessing the impacts of trade liberalization. In the traditional world of comparative advantage, gains from trade would be evaluated in terms of increases in allocative efficiency arising from the relocation of resources across industries and firms. In the variety framework, gains from trade would be reflected in a wider range of available varieties after trade liberalization. In addition there is a price effect associated with trade liberalization and increasing competition, which lowers the price for each variety, thereby increasing consumers’ and producers’ access to new varieties.

Our empirical work builds on Feenstra (1992, 1994) and Hummels and Klenow (2005), who have mapped out a procedure for calculating welfare gains arising from product variety.³ Letting $m_i$ denote the imports of country $i$ and $m_W$ the corresponding world imports, we decompose each
country’s share of world imports \((m_i/m_W)\) into the product of an extensive and intensive import margin, such that

\[
\frac{m_i}{m_W} = (\text{Intensive Import Margin}) \cdot (\text{Extensive Import Margin})
\]  

(1)

The intensive and extensive import margins in equation (1) can be written as

\[
\text{Intensive Import Margin} = \sum_{j \neq i} \sum_{s \in M_{ijs}} \frac{m_{Wjs}}{m_{Wjs}}
\]  

(2)

and

\[
\text{Extensive Import Margin} = \frac{\sum_{j \neq i} \sum_{s \in M_{ijs}} m_{Wjs}}{m_W}
\]  

(3)

where \(m_{Wjs}\) are the world imports from country \(j\) in product variety \(s\), and \(M_{ijs}\) are all those product varieties \((i,j)\) for which the imports by country \(i\) from country \(j\) in product variety \(s\) is positive \((m_{ijs} > 0)\). The interpretation of both margins is straightforward. The intensive import margin in equation (2) measures a country’s share of world imports in those product varieties in which it imports. Conversely, the extensive import margin for country \(i\) in equation (3) measures the fraction of world imports that occur in those product varieties in which country \(i\) imports. Other things being equal, if a country concentrates all of its imports in a small number of product varieties, it will have a higher intensive import margin and a lower extensive margin. If that country spreads its imports thinly over many product varieties, it will have a lower intensive import margin and a higher extensive margin. Romer’s (1994) model sketched above is consistent with economies importing mostly on the extensive import margin because of the fixed costs of importing each variety.

Welfare changes are notoriously difficult to measure; indirect routes must typically be used. To translate a changing extensive margin for imports into welfare, we adopt Feenstra’s (1994) methodology for estimating welfare gains from import variety growth. Feenstra (1994) and Hummels and Klenow (2005) have shown that the GDP-equivalent of the welfare gains \((VG)\) from import variety can be expressed as

\[
VG = \left( \frac{m_i}{y_i} \right)^{\text{(Extensive Import Margin)}}^{1/(\sigma-1)}
\]  

(4)

where \((m_i/y_i)\) is the import share and \(\sigma\) is the elasticity of substitution between import varieties.4

To sum up, our goal in computing welfare gains is to gauge how well different economies are performing in terms of import variety growth. Since this is an important idea, let us explain the logic by way of the textbook example depicted in Table 1. The table shows the quantities of
the three product categories (1, 2 and 3) initially imported by three hypothetical economies (A, B and C).

From these data and equations (2) and (3), we can derive the initial intensive and extensive import margins, respectively. The results are summarized in Table 2.

Table 2 shows that if an economy like country A concentrates all of its imports in a small number of product categories, it has a higher intensive import margin and a lower extensive import margin. Other things being equal, if an economy like country C spreads its imports over many product categories, it has a lower intensive import margin and a higher extensive import margin.

In Romer’s (1994) model sketched above, lowering trade barriers enhances demand for foreign varieties. To measure the welfare gains of a greater variety of import goods, we suppose that the import flows after trade liberalization are as shown in Table 3.

The corresponding extensive import margin is given in Table 4. The table also gives $VG$ using $\sigma = 2$ and an import share equal to 20% (pre-liberalization) and 25% (post-liberalization), respectively.

Table 4 has a simple interpretation: countries that import more varieties after trade liberalization (such as countries A and B) enjoy greater welfare gains. Obviously, we have described an extremely simple situation. In reality, we have thousands of different products. The calculations then become messier and much more cumbersome, but the essential idea of the procedure is the same.

The benefits of trade integration look potentially vast for countries who embrace international trade, both in scope and in speed. China has established itself as pivotal to the further economic

Table 1. Initial imports of three goods by three countries.

<table>
<thead>
<tr>
<th></th>
<th>Country A</th>
<th>Country B</th>
<th>Country C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product 1</td>
<td>0 / 100 / 100</td>
<td>50 / 0 / 50</td>
<td>33 / 33 / 0</td>
</tr>
<tr>
<td>Product 2</td>
<td>0 / 0 / 0</td>
<td>50 / 0 / 50</td>
<td>33 / 33 / 0</td>
</tr>
<tr>
<td>Product 3</td>
<td>0 / 0 / 0</td>
<td>0 / 0 / 0</td>
<td>34 / 34 / 0</td>
</tr>
<tr>
<td>$m_i$</td>
<td>200</td>
<td>200</td>
<td>200</td>
</tr>
</tbody>
</table>

Note: The matrix element 0/100/100, for example, indicates that imports of product 1 by country A from country B and country C are equal to 100, respectively.

Table 2. Initial intensive and extensive import margins.

<table>
<thead>
<tr>
<th></th>
<th>Country A</th>
<th>Country B</th>
<th>Country C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intensive Import Margin</td>
<td>200/166 = 1.21</td>
<td>200/332 = 0.60</td>
<td>200/400 = 0.50</td>
</tr>
<tr>
<td>Extensive Import Margin</td>
<td>166/600 = 0.28</td>
<td>332/600 = 0.55</td>
<td>400/600 = 0.67</td>
</tr>
</tbody>
</table>

Table 3. Import flows after trade liberalization.

<table>
<thead>
<tr>
<th></th>
<th>Country A</th>
<th>Country B</th>
<th>Country C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product 1</td>
<td>0 / 100 / 100</td>
<td>50 / 0 / 50</td>
<td>66 / 66 / 0</td>
</tr>
<tr>
<td>Product 2</td>
<td>0 / 50 / 50</td>
<td>50 / 0 / 50</td>
<td>66 / 66 / 0</td>
</tr>
<tr>
<td>Product 3</td>
<td>0 / 50 / 50</td>
<td>100 / 0 / 100</td>
<td>68 / 68 / 0</td>
</tr>
<tr>
<td>$m_i$</td>
<td>400</td>
<td>400</td>
<td>400</td>
</tr>
</tbody>
</table>
development of economies right around the world due to its phenomenal economic growth and transformation. China’s highly dynamic participation in international trade has been an important feature of this ‘success story’. Figure 2 indicates that the average Chinese tariff rate on non-agricultural and non-fuel imports has been reduced from 34.5% in 1994 to 9.55% in 2004. These developments offer a unique opportunity to analyze variety welfare gains.

The next task therefore is to make the procedure above operational for Mainland China and to reconcile theory with facts. Our in-depth analysis uses highly disaggregated product-level trade data to/from worldwide from the PC-TAS database, which is based on the United Nations Statistics Division trade database and which covers over 90% of world trade (see http://www.intracen.org/mas/pctas.htm). The trade data are broken down into 5113 six-digit Harmonized System (HS) products for the years 1993 to 2003. The most important advantage of these data is that the classification of goods is consistent across countries and time.

Table 4. Extensive import margins and import variety gains.

<table>
<thead>
<tr>
<th>Country</th>
<th>Extensive Import Margin $\frac{800}{1200} = 0.67$</th>
<th>Country B</th>
<th>Country C</th>
</tr>
</thead>
<tbody>
<tr>
<td>$VG_0$</td>
<td></td>
<td>5.6%</td>
<td>11.0%</td>
</tr>
<tr>
<td>$VG_1$</td>
<td></td>
<td>16.8%</td>
<td>16.8%</td>
</tr>
</tbody>
</table>

Notes: $VG_0$ gives the pre-reform variety gains for the initial extensive import margin [for example, $VG_{A,0} = 0.20 \cdot (0.28)^{1.0} = 0.056$]; $VG_1$ gives the variety gains for the post-reform extensive import margin [$VG_{A,1} = VG_{B,1} = VG_{C,1} = 0.25 \cdot (0.67)^{1.0} = 0.168$].

Figure 3 reports the range of Chinese imports over time. In the 1990s, the number of imported product categories increased from 4579 in 1995 to 4807 in the year 2000. Afterwards, however, the trend reversed as the number of imported varieties declined to 4729 in 2003. Further research on this structural break is warranted. The above remarks about the time-varying number of six-digit HS product categories should be taken into account when interpreting the empirical results below, where the link between the number of product categories and varieties will not always be explicit, although it will still be useful in explaining the general results.

The Chinese trade pattern leads to the extensive and intensive import margins in Table 5. The results in Table 5 indicate that Mainland China is characterized by low (high) intensive (extensive) import margins. This feature is consistent with Romer’s (1994) model sketched above. In other words, the results tell us that greater imports mostly take the form of more product categories rather than the form of more imports per product category. Over the nine-year window from 1995 to 2003, the intensive (extensive) import margin has increased (decreased). This is consistent with the bulk of international trade models in which a tariff reduction leads to increasing trade on the intensive margin. On the other hand, it is contrary to Debaere and

![Figure 3. Number of six-digit HS product categories imported by China from the worldwide 1995–2003.](image)

Notes: The data has been calculated using the PC-TAS database (http://www.intracen.org/mas/pctas.htm). The trade data is broken down into 5,113 6-digit Harmonized System (HS) products.

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</tr>
</thead>
<tbody>
<tr>
<td><strong>IIM</strong></td>
<td>0.04</td>
<td>0.04</td>
<td>0.04</td>
<td>0.04</td>
<td>0.04</td>
<td>0.05</td>
<td>0.06</td>
<td>0.07</td>
<td>0.09</td>
</tr>
<tr>
<td><strong>EIM</strong></td>
<td>0.62</td>
<td>0.63</td>
<td>0.63</td>
<td>0.64</td>
<td>0.61</td>
<td>0.58</td>
<td>0.58</td>
<td>0.57</td>
<td>0.56</td>
</tr>
<tr>
<td><strong>VG_t</strong></td>
<td>10.66%</td>
<td>9.91%</td>
<td>8.88%</td>
<td>8.41%</td>
<td>9.35%</td>
<td>10.68%</td>
<td>10.61%</td>
<td>11.57%</td>
<td>14.09%</td>
</tr>
<tr>
<td><strong>VG_{1995}</strong></td>
<td>10.66%</td>
<td>10.84%</td>
<td>10.76%</td>
<td>10.87%</td>
<td>10.01%</td>
<td>10.01%</td>
<td>10.61%</td>
<td>10.52%</td>
<td>9.66%</td>
</tr>
</tbody>
</table>

Notes: *IIM* = intensive import margin; *EIM* = extensive import margin; *VG* = welfare gain for *s* = 2 and the current import share; *VG_{1995} = welfare gain for *s* = 2 and the import share of 1995. The Chinese import share (*m/y*) is calculated from the *World Development Indicators* database (http://publications.worldbank.org/WDI/).
Mostashari (2005) and Kehoe and Ruhl (2003) who have found evidence that tariff changes have significantly influenced the extensive margin of international trade. With extensive and intensive import margin estimates obtained, Table 5 also provides the corresponding variety welfare gains ($VG$) à la Romer (1994) based upon equation (4) for the years 1995–2003 for $\sigma = 2$ (a mark-up of 100%). Several observations can be drawn from the data tabulated in Table 5. The most important observation is that trade liberalization has boosted welfare in the range predicted by the Romer (1994) model. This supports the paradigm that trade liberalization can lead to significantly higher real incomes, and the results are consistent with estimated gains of trade liberalization from cross-country growth regressions.10

4. Conclusions

It is often said that if there is one thing that all economists agree on, it is the merits of free trade. This belief is supported by an extensive corpus of international trade theory that demonstrates how gains from trade can emerge through a variety of channels.11 Classical trade theory focuses on the gains from exchange and specialization. Other channels, such as preference heterogeneity and imperfect competition, have become prominent relatively recently. According to the theory, gains from trade can be realized when markets are imperfectly competitive, because opening up to trade increases competition between domestic and foreign firms and thus enforces market discipline. Gains from trade are also realized when consumers have heterogeneous preferences, because trade increases the number of product varieties available. The underlying premise is that there may be fixed costs to importing a variety, and that tariffs limit variety by shrinking the market for each good. In other words, increasing-returns-to-scale technologies have the potential to deliver large welfare gains from trade liberalization.

Despite the theory’s strong predictions, empirical evidence on the magnitude of variety gains from trade is limited. In this paper, we have therefore tried to confirm or rebuff this suspicion by analyzing an exceptional case: the evolution of trade in Mainland China since 1995. At a time when the debate on the merits and perils of globalization is heating up, it is important to be able to draw lessons from specific episodes in trade liberalization. Using the most disaggregated trade data available, our estimates indicate that trade integration has helped to increase welfare significantly, and, therefore, freer trade has been a blessing. Since the increase in traded varieties is a global phenomenon, we believe the data suggests that variety growth has important implications for how globalization has increased world welfare.

Acknowledgements

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Notes

1. For example, Sachs and Warner (1995) estimated that open economies average higher growth of about 2.45% compared to closed economies. The differences between open and closed economies were found to be even greater among developing countries. Frankel and Romer (1999) further demonstrated that adjusting for the endogeneity bias in cross-country regression studies such as Sachs and Warner (1995) does not reduce the estimated impact of openness on growth.
2. Various studies using static computable general equilibrium models generated similar numbers for the triangular losses. See, for example, Harris (1984).
3. An alternative approach has been used by Broda and Weinstein (2004, 2006). They have calculated the American import price index with and without dealing with varieties. Note that a reduction in the import price index is, ceteris paribus, a welfare gain. They find that the variety adjusted unit price of
imports fell approximately 30% faster than the unadjusted index between 1972 and 2001. This amounts to 3% of GDP, which suggests that the love-of-variety effect is an important contribution to economic welfare.

4. The specific form of the ‘variety effect multiplier’ arises when utility is determined by the love-of-variety CES-utility function \( U = \left( \sum_{i=1}^{n} m_i^{\sigma} \right)^{1/\sigma} = \left( \frac{m^\sigma}{n^{1-\sigma}} \right)^{1/\sigma} = n^{1-\sigma} m = n^{1/(\sigma-1)} m \). The multiplier increases with the number of differentiated imports \( m_i \) and increases as \( \sigma \) decreases toward 1 (\( \sigma > 1 \)). Because trade will increase the number of varieties available to each consumer, trade will increase every consumer’s welfare. Of course, this is based on the assumption that every consumer prefers more varieties to fewer.

5. While China was accepted into the WTO in 2000, it had implemented unilateral tariff reductions of its own before that time and benefiting from low tariffs abroad.

6. While models with product variety are now common, empirical applications lag far behind. This deficiency is serious because ‘showing that something can be true in a model does not make it so’ (Romer 1994, 35).

7. The HS was introduced in 1988, and since then it has become an internationally accepted method of classification wherever products are traded. The HS classification is ‘harmonized’ in relation to the classifications of the United Nations and the European Communities. The HS, a revision of the CCCN (Customs Cooperation Council Nomenclature) 1974 classification system, includes a six-digit subheading that was introduced for more precise tagging of products. At present this system contains 21 sections, 97 chapters and 1241 headings at the four-digit level, 930 of which are further divided in sub headings. HS-1996 (revision 1) represented a total of 5113 separate categories of goods identified by a six-digit code. The use of pre-established product categories makes it impossible to measure gains in product variety within any specific category and beyond the number of pre-established product categories. In other words, we cannot see new products arriving within an existing category and one cannot see the invention of truly new categories, because there is a de facto fixed frontier in observable product variety. Therefore, our estimates miss a potential source of variety gains.

8. Most of the empirical studies on trade in varieties use the growth in the number of HS lines with positive trade as an indicator of increases in variety. Mangani (2007) is an exception to this. They employed the World Intellectual Property Office cross-country trademark registration statistics to measure the recent trends in global trade in variety.

9. Among the manufactured goods, Feenstra (1994, 1995) has estimated import elasticities of substitution in the range of \( 1.5 < \sigma < 3.5 \). Broda et al. (2006) have estimated a median \( \sigma \) of 2.3 for the US economy.

10. A policy-induced change in welfare of such magnitude is quite plausible. To put these numbers into perspective, Rutherford and Tarr (1998) show that a welfare gain of between 10 and 35% corresponds to an increase in the steady state growth rate of between 0.4 and 1%. The benefits of product differentiation for economic growth are analysed empirically in Feenstra et al. (1999) and Funke and Ruhwedel (2001, 2005). Recently, Koren and Tenreyro (2005) have proposed an endogenous growth model with technological diversification. Technological progress increases the number of varieties, and the expansion in the number of varieties provides diversification benefits against variety-specific shocks and hence lowers the volatility of output.

11. Searching in Google under the keywords ‘trade & welfare’ yields more than 3.5 million hits – ample proof that both interest and research abound.

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