Welfare gains from imported varieties in Spain, 1988-2006.

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Abstract

This paper investigates the welfare gains due to Spanish imports of new varieties over the period 1988-2006 using the methodology proposed by Feenstra (1994) and Broda and Weinstein (2006). After calculating the elasticities of substitution of Spanish imported products, we estimate that the total welfare gain due to imports of new varieties in Spain is equal to 1.2% of GDP between 1988 and 2006 (a very conservative estimate). By countries, China accounts for about 12% of the total gain, almost the same as the entire EU-15.

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1. Introduction

International good markets allow domestic consumers to access cheaper products as well as more varieties of the same product. Krugman (1979, 1980) was the first to formalize the love-of-variety motif in international trade. Twenty-five years later Broda and Weinstein (2006) estimate the magnitude of the welfare gain from new imported varieties for an entire economy. The authors construct an aggregated price index based on Feenstra´s (1994) exact price index for a good (derived from a CES utility function), which takes into account the import bias resulting from the omission of new and disappearing varieties. Such an import bias measures how much consumers are willing to pay to access a larger set of varieties available at the end of a period. They use highly-detailed product-level U.S. import data and estimate that the import bias in the conventional import price index over the 1972-2001 period was 28% or 1.2 percentage points per year lower. This translates into a cumulative U.S. welfare gain from new imported varieties that is equivalent to roughly 2.6% of U.S. GDP.[1]

Our paper adopts the same approach in order to estimate the welfare gains deriving from the import of new varieties in the case of Spain over the period 1988-2006. As a novelty in the paper we measure the relative importance of geographic areas

[1] The number of papers applying this methodology is still scarce. Mohler and Seitz (2009) calculate the welfare gains for the UE members over the period 1988-2006. Bloningen and Sodersbery (2009) compute the welfare gains from imported varieties of automobiles in the US.

and specific countries in the welfare gain from variety growth of imports. The paper is organised as follows. Section 2 contains the theoretical background and the empirical strategy; Section 3 describes the data; Section 4 presents the results and

2. Theoretical background

Preliminary considerations

In this paper we quantify the benefits from growth in imported varieties in a model of monopolistic competition. For that purpose it is convenient to define first the definition of variety. Here we adopt the Armington (1969) assumption, that is, goods traded internationally are considered differentiated on the basis of the country of origin. So a variety is simply a particular good produced by a particular country. From an empirical point of view we will maintain the number of products constant through the analysis and an increase in the number of supplying countries (i.e. varieties) will constitute the source of welfare gains.

Next we need a simple specification of how consumers value variety. The choice of the constant elasticity of substitution (CES) utility function proves useful: it is very tractable, the derived demand structure is fairly simple and it allows to aggregate price changes across markets. For each good Feenstra (1994) shows that the CES utility form provides an exact price index that is able to accommodate the entry of new goods by adding an extra term that simply adjusts the conventional price index by taking into account that consumers are willing to pay more for new varieties of a type of goods when they perceive that the product is highly differentiated. Broda and Weinstein (2006) generate an aggregated exact price index in order to quantify the total welfare gain for the entire economy due to the variety growth of imports for a given period of time.

Finally the CES utility function and its derived exact price index require knowing the elasticity of substitution across varieties of a particular product. The elasticity of substitution for a particular good tells us how indifferent consumers are with respect to the number of varieties available. From an empirical point of view, estimating the elasticity of substitution at the good level provides some diversification in the degree of substitution of varieties. Whenever the elasticity of substitution for a particular good is high, this implies that consumers tend to be rather indifferent among different varieties; so they do not differentiate in term of country of origin and the potential gains from variety are small. On the other hand, low values of elasticity of substitution indicate that consumers care about the different varieties, so the potential gains from trade are large.

Empirical strategy

Here we describe our empirical strategy very concisely. We complement this section with two technical appendices and refer to Feenstra (1994) and Broda and Weinstein (2006) for more details. We start with a simple CES utility function. A variety is defined as a good *g* imported from a country *c* as in Armington (1969):

$$(1)\ M_{gt} = \left(\sum_{c \in C} d_{gct}^{1/\sigma_g} \left(m_{gct} \right)^{(\sigma_g - 1)/\sigma_g} \right)^{\sigma_g / \sigma_g - 1}$$

where C denotes the set of available countries and hence potentially available varieties in period t. m_{gct} is the sub-utility derived from the imported variety c of good g in period t and d_{gct} > 0 is the corresponding taste parameter. The elasticity of substitution among varieties is given by σ_g >1. The unit-cost functions derived from this utility function can then be used to obtain an exact price index as shown in Sato (1976) show that for the CES utility, this exact price index P_g can be written as

$$(2)\ P_g = \prod_{c \in I_g} \left(\frac{p_{gct}}{p_{gct-1}} \right)^{\omega_{gct}}$$

where ω_{gct} is a log-change ideal weight. So far, the price index in equation (2) only accounts for a fixed set of available varieties I_g, independent of *t*. Feenstra (1994) shows that the inclusion of new and disappearing varieties over time leads to the following expression:

$$(3)\ \Pi_g = P_g \left(\frac{\lambda_{gt}}{\lambda_{gt-1}} \right)^{1/(\sigma_g - 1)}$$

where

$$(4)\ \lambda_{gr} = \frac{\sum_{c \in I_g} p_{gcr} q_{gcr}}{\sum_{c \in I_{gr}} p_{gcr} q_{gcr}}; \quad r = t, t-1$$

The idea of the index Π_g is to correct the conventional price index P_g by multiplying it with an additional term which measures the influence of new and disappearing varieties; this term is called *the lambda ratio*. The numerator of this ratio quantifies the impact of newly available varieties as λ_{gt} captures the ratio of expenditures on varieties available in both periods (i.e. $c \in I_g = \left(I_{gt} \cap I_{gt-1}\right)$), relative to the entire set of varieties available in period t (i.e. $c \in I_{gt}$). Hence, λ_{gt} decreases when new varieties appear. On the other hand, the denominator of the lambda ratio captures the impact of disappearing varieties. These lower λ_{gt-1} and increase the ratio.

The *lambda ratio* also depends on the elasticity of substitution between varieties: If we observe a high elasticity of substitution, the lambda ratio will approach unity and the influence of the lambda ratio on the price index is small. This is intuitive since a change in the varieties of homogeneous goods should not lower the price index.

Following Broda and Weinstein (2006) the price indices (2) and (3) are aggregated into aggregate import price indices. We then take the fraction of the corrected import price index and the conventional import price index. This ratio is called the end-point ratio (EPR):

$$(5)\ EPR = \prod_{g \in G} \left(\frac{\pi_{gt}}{P_{gt}} \right)^{\omega_{gt}} = \prod_{g \in G} \left(\frac{\lambda_{gt}}{\lambda_{gt-1}} \right)^{\omega_{gt}/\left(\sigma_g - 1\right)}$$

where ω_{gt} is again a log-change ideal weight. The endpoint ratio is used to express the upward (or downward) bias resulting from the change of variety over time: If the EPR is smaller than one, it means that the variety change has lowered the conventional import price index. This will be the source of the gains from variety. Finally the welfare gains due to variety growth (as a percentage of GDP) are obtained by raising the inverse of the EPR to the log-change ideal import share over the considered period, where the share represents the fraction of imported goods in total GDP. Appendix A provides a detail description of the empirical strategy.

Estimation method

The entire procedure for obtaining an estimate of the welfare gains due to variety growth can be summarised by the following steps:

1. Define the set of goods G;
2. Obtain estimates of the good-specific elasticity of substitution, σ_g ;
3. Calculate the λ_{gt} ratios which capture the role of new varieties for every good g;
4. By combining estimates of σ_g with the measures of variety growth for each good, obtain an estimate of how much the exact price index for good g moved as a result of the change in varieties (the lambda ratio);
5. Apply the ideal log-change weights (ω_{gt}) to the price movements of each good in order to obtain an estimate of the bias on the exact aggregate price index (the EPR);
6. Calculate the welfare gain or loss from these price movements using the log-change ideal import share in the period.
7. Bootstrap the entire procedure to obtain an estimate of the standard error of the various quantities.

Elasticity of substitution

Here we explain how to calculate the elasticities of substitution for each product (σ_g **)**. Following Feenstra (1994), the underlying import demand equation for each variety of good g can be expressed in terms of shares and changes over time:

(6) $\Delta \ln s_{gct} = \varphi_{gt} - (\sigma_g - 1)\Delta \ln p_{gct} + \varepsilon_{gct}$

where φ_{gt} is a good-time specific random effect as d_{gt} is random and ε_{gct} is driven by the random tastes of consumers across varieties.

Producers compete in monopolistically competitive markets for their varieties such that prices in first differences are,

(7) $\Delta \ln p_{gct} = \psi_{gt} + \frac{\omega_g}{1+\omega_g} \Delta \ln s_{gct} + \delta_{gct}$

where $\omega_g > 0$ is the inverse supply elasticity for each good (identical across varieties of the same good), ψ_{gt} captures the good-time specific shocks to production and δ_{gct} captures technological changes in the production of each variety.

It is evident that the shares and prices are endogenously determined: shocks to either demand ε_{gct} or supply δ_{gct} will both be correlated with share and prices. To control for this endogeneity we estimate these equations simultaneously using the methodology proposed by Feenstra (1994) and extended by Broda and Weinstein (2006). The first step in our estimation is to eliminate φ_{gt} and ψ_{gt} by choosing a reference country k and differencing demand and supply equations, denoted in (6) and (7), relative to country k,

(8) $\Delta^k \ln s_{gct} = -(\sigma_g - 1)\Delta^k \ln p_{gct} + \varepsilon_{gct}^k$

(9) $\Delta^k \ln p_{gct} = \frac{\omega_g}{1+\omega_g} \Delta^k \ln s_{gct} + \delta_{gct}^k$

where $\Delta^k y_{gct} = \Delta y_{gct} - \Delta y_{gkt}$, $\varepsilon_{gct}^k = \varepsilon_{gct} - \varepsilon_{gkt}$, and $\delta_{gct}^k = \delta_{gct} - \delta_{gkt}$.

We multiply these two equations together, and average the resulting equation over time, to obtain the estimating equation:

(10) $\overline{Y}_{gc} = \theta_1 \overline{X}_{1gc} + \theta_2 \overline{X}_{2gc} + \overline{u}_{gc}$

where the over-bar indicates that we are averaging that variable over time, and $Y_{gct} = (\Delta^k \ln p_{gct})^2$, $X_{1gct} = (\Delta^k \ln s_{gct})^2$, $X_{2gct} = (\Delta^k \ln p_{gct} \Delta^k \ln s_{gct})$, and $u_{gct} = (\varepsilon_{gct}^k \delta_{gct}^k)$

The identification strategy relies on the assumption that that demand and supply equation errors at the variety level are uncorrelated; thus, $E[\varepsilon_{gct}\delta_{gct}] = 0$ (i.e. $\overline{u}_{gc} \to 0$ in probability limit as $T \to \infty$). This implies that the error term is therefore uncorrelated with any of the right hand side variables as $T \to \infty$, and we can exploit these moment conditions by running IV on (10). Feenstra (1994) takes advantage of the panel nature of the data to control of endogeneity by using country-specific dummies as instruments and obtain consistent estimates of θ_1 and θ_2. Moreover he shows that that procedure will give consistent estimates of (θ_1, θ_2) provided that the right hand side variables in (10) are not perfectly collinear as $T \to \infty$. This condition will be assured if there is some heteroskedasticity in the error terms across countries, c.

Unfortunately estimates of (θ_1, θ_2) do not always provide economically feasible values for σ_g. In that case we use a grid search over the economically feasible values for σ_g proposed by Broda and Weinstein (2006) to minimise the GMM function objective function implied by the IV estimation (see details on the Appendix B).

Three additional econometric issues must be taken into account when estimation equation (10). First, since we take differences with respect to a country of reference k, each good needs at least one country (i.e. variety) which should always be present in the data set, without any missing year. Second, the use of unit values in place of prices is inherent to import data. Thus prices are surely measured with some error, so are their sample variances. Following Feenstra (1994) we include a constant which will reflect the variance of the measurement error. Third, more efficient estimates can be obtained by running weighted IV on (10). Broda and Weinstein (2006) show that the sample variances are inversely related to the quantity of goods and number of periods.[2]

One feature of the FBW method deserves special mention. FBW did not incorporate any changes in the number of products into their estimation, nor include the domestic economy as a source country in the estimation of the elasticity of substitution for each good. This is correct only under the limited case where the number of home country varieties is constant. However it is likely that the increase in import variety

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[2] Here we follow Broda and Weinstein (2006) and choose the sample variance as $(1/T^3)\left((1/q_{gct}) + (1/q_{gct-1})\right)$.

would result in some reduction in domestic varieties. In that case, the gains from import varieties would be offset by the welfare loss from reduced domestic varieties.

Data

In 1988 the share of imports of goods as percentage of the GDP was 0.19 and twenty years later was 0.28. The rise in imports has been accompanied by a rise in the number of imported varieties. The number of goods is constrained by the classification structure. New goods are initially classified in existing categories, which lead to an underestimation of variety growth as the number of products is limited in each classification. We define a good to be at 6 digit Harmonised System (HS) and a variety is defined as the import of a particular good from a particular country. The definition of "product" is evolving over time creating classification problems due to the 1996 and 2002 revisions. To address this problem we use the "Transposition Codes" from the publication "Update CN Tables" published by Eurostat to ensure that the number of 6 digits HS codes remains constant over the analysed period (1988-2006). Our measurement of variety growth is very conservative since it only occurs when the number of supplying countries rises. Therefore our results provide a lower bound of variety growth and its effects Spanish welfare.

Table 1 presents some descriptive statistics of the database. Notice that the number of 6 digit HS goods is constant over the entire period examined. In 1988 the number of imported varieties was 62,509 (i.e. 4,535 goods from an average of 14 countries) and in 2006 it was 106,238 (i.e. 4,535 goods from an average of 23 countries). It is evident that the number of countries supplying each good almost doubled, which serves as prima facie evidence of a startling increase in the number of varieties. The most plausible explanations for this rise involve some story of the globalization process coupled with an assumption that goods are differentiated by country. For example, reductions of trade costs may have made it cheaper to source new varieties from different countries. Alternatively, the growth of economies like China or India has meant that they now produce more varieties that most developed countries would like to import. But, of course, if these goods are differentiated by country, then this implies that there must be some gain from the increase in variety—a point that we will address in the next section.

Table 1. Descriptive statistics

Year	Goods	Number of HS categories	Median number of exporting countries	Average number of exporting countries	Total number of varieties (product-country)	Share in total imports
HS 6 digits concordance 1988-2006						
1988	Common	4535	12	13.8	62509	100%
2006	Common	4535	19	23.4	106238	100%

One can obtain a better sense of the forces that have been driving the increase in variety if we break the data up by exporting country. Table 2 presents data on the numbers of goods exported to Spain by country. The first column ranks them from highest to lowest for 1988, and the following two columns rank them for 1997 and 2006. Not surprisingly, the countries that export the most varieties to Spain tend to be large, high-income, proximate economies. Looking at what has happened to the relative rankings over time, however, reveals a number of interesting stylized facts. First, all countries but two countries, Switzerland and Japan, have increased the number of exported products to Spain. Second, three countries, China, India and Turkey, have risen sharply in the rankings: China moved from being the 15th largest source of varieties to 8th place; India moved from 23rd to 15th place; Turkey moved from 35rd to 16th place. This clearly reflects the "globalisation" effect over the last two decades. Second, the three countries have experienced the largest increase in the number of exported products to Spain over the period. For example, the number of products exported to Spain from Turkey has multiplied by 5, while those from China and India have multiplied by almost 3.

Table 2: Ranking of countries in terms of goods imported by Spain.

Ranking in year	Ratio of goods	Contribution

	1988	1997	2006	2006/1988	import growth 1988-2006
France	1	1	2	1.04	0.4%
Germany	2	2	1	1.07	0.6%
Italy	3	3	3	1.14	1.2%
United Kingdom	4	4	4	1.06	0.5%
USA	5	5	9	1.06	0.4%
Netherlands	6	6	5	1.19	1.3%
Belgium	7	7	6	1.18	1.2%
Switzerland	8	9	10	0.99	-0.2%
Portugal	9	8	7	1.55	2.9%
Japan	10	11	13	0.98	-0.1%
Sweden	11	14	14	1.14	0.6%
Denmark	12	12	12	1.24	1.0%
Austria	13	13	11	1.32	1.3%
Taiwan	14	15	17	1.26	0.9%
China	15	10	8	2.81	4.9%
Korea, Rep	16	16	18	1.60	1.6%
Hong Kong	17	21	25	1.49	1.1%
Finland	18	27	30	1.16	0.4%
Canada	19	19	20	1.72	1.6%
Norway	20	22	29	1.28	0.6%
Ireland	21	18	27	1.42	0.9%
Brazil	22	26	19	1.98	2.0%
India	23	17	15	2.91	3.3%
Israel	24	28	28	1.82	1.3%
Mexico	25	20	21	2.48	2.2%
Turkey	35	24	16	5.01	3.6%

Main results

Estimates of the elasticity of substitution.

Table 3 presents some descriptive statistics of the estimates of the elasticities of substitution for every imported product category (4535 6-digit HS and 2818 3 digit SITC) over the period 1988-2006. The median elasticity is 4.4 and 3.8. The elasticities are of a similar magnitude as in other contributions, for example in Broda et al. (2006) for HS-3 digits for Spain.

Table 3. Estimates of the elasticity of substitution of imported goods.

	N. observ.	Mean	Median	pct 5	pct 95	minimum	maximum
HS 6 digits	4535	6.68	4.43	2.02	14.53	1.27	199.75
SITC 3 digits	2818	6.10	3.86	2.02	13.32	1.16	182.22

Lambda ratio.

Table 4 presents the summary statistics of the lambda ratios of all the 4535 6-digit HS products, as in equation (4). They illustrate the growth or decline in imported variety. For the entire period analyses the median lambda ratio is less than one, indicating that the typical sector saw the number of imported varieties increase. Over the period 1988-2006 the median lambda ratio is 0.92, expressing that a typical product category experienced a positive growth in variety of about 8 percent. As a comparison we also provide a less sophisticated indicator based on counting the new and disappearing varieties. The count data (expressed as the V ratio) is much smaller (0.6<0.92) suggesting the presence of a large number of new varieties with small market shares.

Table 4. Lambda ratio.

	Lambda ratio		Vratio
	Median	[Percentile 5, Percentile 95]	
Period 1988-2006	0.926	[0.237, 1.601]	0.600
Period 1988-1997	0.982	[0.425, 1.598]	0.800
Period 1997-2006	0.975	[0.479, 1.365]	0.765

End-point ratio, import bias and welfare gains

The elasticities and lambda ratios are then used to calculate the corrected import price indices as in equation (3). Aggregating those indices into an aggregate import price index and taking the fraction of the corrected to the conventional import price index, results in the EPR of (5). It is displayed in column 1 of Table 5. If this ratio is lower than 1, it means the change in variety has lowered the conventional import price index.

The percentage in column 2 of table 5 expresses the upward (or downward) bias of the conventional import price index. Column 3 displays the fraction of imports to GDP. Weighting the inverse of column 1 with the import share gives us the gains from variety as a fraction of the GDP in column 4. As an example, Table 5 shows that the EPR in Spain is 0.951 over the period 1988-2006. This accounts to an upward bias in the conventional price index of 4.9% over the whole period. Weighting this bias by the import share of 24%, this translates into a gain from variety of 0.41% of GDP. This gain must be interpreted as follows: Consumers in Spain are willing to spend 1.21% of GDP in 2006 to have access to the larger set of imported varieties of 2006 instead of the set of 1988.

Table 5. Import price Index Bias and Gains from variety.

	End-point ratio	Import bias	Import share	Gain from variety (% GDP)
1988-2006	0.951	4.90	0.24	1.21
	[0.929,0.957]			[1.04,1.66]
1988-1997	0.985	1.50	0.22	0.33
	[0.981,0.988]			[0.25,0.40]
1997-2006	0.974	2.60	0.27	0.71
	[0.963,0.978]			[0.58,0.99]

Welfare gains country-by-country

So far we have calculate the welfare gain generated from importing more varieties, without taking into account the source country. In this section we calculate the share of welfare gains that directly comes from a specific country. We calculate the contribution of a country for each good and then sum over all the goods to obtain the total gains from that particular country. First we calculate the simple weights for each country and each good based on the cost shares in the last year of the period analysed. The cost share of a “country of interest” is calculated as follows:

$$s_{g,ref,t} = \frac{\sum_{ref \notin Ig} p_{g,ref,t} q_{g,ref,t}}{\sum_{c \notin I_g} p_{gc,t} q_{gc,t}}$$

where I_g is the set of common varieties between the starting and the final year of the period, $I_{cou,t}$ is the set of varieties from the country of interest and t in this case is 2006. The weight for the country of interest is then simply their cost share divided by the sum of total cost shares (all countries). The lambda ratio of each good is now raised to its log-change ideal weight times the "country of interest" weight.

Table 6 shows the geographic distribution of the gains from imported varieties. The continent with the largest contribution to the gain over the entire period is Asia (35%), followed by Rest of Europe (17.4%), Western Europe (14.6%) and Africa(14%).

Table 6. Contribution of geographic areas to total gains from variety. Period 1988-2006.

Groups of countries	% on gains
Western Europe	14.6
Rest of Europe	17.3
Africa	14.3
Asia	35.2
Latin America	11.1
Rest of America	1.8
Former USSR	5.5

Table 7 shows the contribution of a number of countries to the welfare gain due to variety growth over the entire period. China is the country that contributes the most with 11.8% of the total welfare gain (i.e. 0.14% of GDP). The contribution of China is big considering that Chinese imports represent 5% of the total increase in imports between 1988 and 2006. Other six countries, Indonesia, Egypt, Turkey, Brazil, India and Russia, account for another 19% of the total gain from new varieties. Central European countries also have made a significant contribution: Czech Republic, Poland, Hungary account for 11% of the total gain from new varieties. Finally three EU countries, Portugal, Netherlands and Ireland, contribute each with 2%. All the EU-15 represents 13.6% of the total gain in varieties.

Table 7. Contribution of a selection of exporting countries to total gains from variety in Spain. Period: 1988-2006.

Country	% on gains	Country	% on gains	Country	% on gains
Portugal	2.4	China	11.8	Czech Republic	4.4
Netherlands	2.3	Indonesia	4.4	Poland	3.2
Ireland	2.2	Egypt	4.2	Hungary	3.2
France	1.0	Turkey	3.5	Slovakia	1.6
Luxembourg	0.9	Brazil	2.6	Romania	1.2
Austria	0.9	India	2.3	Bulgaria	0.9
United Kingdom	0.7	Russia	2.2	Slovenia	0.7
EU15	13.6	BRIC	18.9	PECO	15.2

Conclusions

The present study applies the same approach of Feenstra (1994) and Broda and Weinstein (2006) and to investigate the effects of variety growth in Spain over the period 1988-2006. Globalization leads to an expansion in the number of varieties purchased by countries. The effect of new varieties on the increase of welfare is equal to 1.2% of the GDP between 1988 and 2006, which corresponds to a lower bound due to the methodology implemented.

By countries, China emerges as the country with the largest contribution to the welfare gain from consumption of new varieties (12%). Indonesia, Egypt, Turkey, Czech Republic, Poland and Hungary contribute more than 3% each to the welfare gain. Finally the EU-15 has a modest contribution (13,6%), with Portugal, Netherlands and Ireland contributing 2% each to the welfare gain.

Another contribution of the paper is the estimates of the elasticity of substitution of imports for different product and industry classifications.

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Appendix

Appendix A. Theory

Here we describe briefly the methodology developed by Feenstra (1994) and Broda and Weinstein (2006), to account for product variety change in price indexes which can then be translated into welfare changes for an economy. The utility function is a nested CES with three tiers of consumption. The upper level of the nested CES utility function aggregates the composite domestic good, D_t , and the composite imported good, M_t , and is given by:

$$\text{(A1) } U_t = \left(D_t^{(\kappa-1)/\kappa} + M_t^{(\kappa-1)/\kappa}\right)^{\kappa/\kappa-1}$$

where $\kappa(>1)$ is the elasticity of substitution between the two goods.

The second level of the nested CES utility function, which aggregates over all the goods and pins down the composite imported good, M_t , is similarly defined, together with the corresponding unit cost requirement, as follows:

$$\text{(A2) } M_t = \left(\sum_{g\in G} M_{gt}^{(\gamma-1)/\gamma}\right)^{\gamma/(\gamma-1)}$$

$$\text{(A3) } \phi_t^M = \left(\sum_{g\in G}\left(\phi_{gt}^M\left(I_{gt},\mathbf{d}_{gt}\right)\right)^{1-\gamma}\right)^{1/1-\gamma}$$

where M_{gt} is the consumption of imported good g at time t, $\gamma(>1)$ is the elasticity of substitution among imported goods, and $\mathbf{d}_{gt}$ is the vector of taste parameters for each country.

The last sub-utility is obtained from the consumption of a single good and is derived together with the corresponding minimum expenditure to obtain one unit of utility as follows:

$$\text{(A4) } M_{gt} = \left(\sum_{c\in C} d_{gct}^{1/\sigma_g}\left(m_{gct}\right)^{(\sigma_g-1)/\sigma_g}\right)^{\sigma_g/\sigma_g-1}$$

$$\text{(A5) } \phi_{gt}^M\left(I_{gt},\mathbf{d}_{gt}\right) = \left(\sum_{c\in I_{gt}} d_{gct}\left(p_{gct}\right)^{1-\sigma_g}\right)^{1/1-\sigma_g}$$

where m_{gct} is the particular variety of good g imported from country c at time t; $\sigma_g(>1)$ is the elasticity of substitution among varieties of good g; d_{gct} is the taste parameter; p_{gct} is the price of variety c of good g in period t. C is the set of all countries and $I_{gt}\subset C$ is the subset of all varieties of good g consumed in period t.

The following two propositions allow calculating the welfare gains stemming from variety growth, derived from the works of Feenstra (1994) and Broda and Weinstein (2006).

Proposition 1*. (Feenstra, 1994) For $g \in G$, if $d_{gct} = d_{gct-1}$ for $c \in I_g = \left(I_{gt} \cap I_{gt-1}\right)$, $I_g \neq \varnothing$, then the exact import price index for good g with unit change in varieties is given by:*

(A6)

$$\pi_g^M\left(p_{gt}, p_{gt-1}, q_{gt}, q_{gt-1}, \mathbf{I}_g\right) = \frac{\phi_{gt}^M\left(I_{gt}, \mathbf{d}_{gt}\right)}{\phi_{gt-1}^M\left(I_{gt-1}, \mathbf{d}_{gt-1}\right)} = P_g^M\left(p_{gt}, p_{gt-1}, q_{gt}, q_{gt-1}, \mathbf{I}_g\right)\left(\frac{\lambda_{gt}}{\lambda_{gt-1}}\right)^{1/(\sigma_g - 1)}$$

where $\lambda_{gr} = \sum_{c \in I_g} p_{gcr} q_{gcr} \Big/ \sum_{c \in I_{gr}} p_{gcr} q_{gcr}$, for $r = t, t-1$ and P_g^M is the conventional import price index for good g over a constant set of varieties. By Sato (1976) and Vartia (1976),

$$\text{(A7)} \quad P_g^M\left(p_{gt}, p_{gt-1}, q_{gt}, q_{gt-1}, I_g\right) \equiv \prod_{c \in I_g} \left(\frac{p_{gct}}{p_{gct-1}}\right)^{\omega_{gct}}$$

is the geometric mean of particular variety price changes, where the ideal log-change weights are

$$\text{(A8)} \quad \omega_{gct} = \frac{\left(s_{gct} - s_{gct-1}\right) / \left(\ln s_{gct} - \ln s_{gct-1}\right)}{\sum_{c \in I_g} \left(\left(s_{gct} - s_{gct-1}\right) / \left(\ln s_{gct} - \ln s_{gct-1}\right)\right)}$$

which is the harmonic mean of the variety cost shares,

$$\text{(A9)} \quad s_{gcr} = \frac{p_{gcr} q_{gcr}}{\sum_{c \in I_g} p_{gcr} q_{gcr}} \quad \textit{for } r = t, t-1.$$

[Footnote: The Sato-Vartia formula gives very similar results using other weights, such as $\frac{1}{2}\left(s_{gct} + s_{gct-1}\right)$, as used for the Törnqvist price index.]

Proposition 2*.(Broda and Weinstein, 2006) If $d_{gct} = d_{gct-1}$ for $c \in I_g \neq \varnothing \ \forall g \in G$, then the exact* ***aggregate*** *import price index with variety changes is given by:*

(A10) $\Pi_g^M\left(p_{gt}, p_{gt-1}, q_{gt}, q_{gt-1}, I_g\right) = \dfrac{\phi_t^M\left(I_t, \mathbf{d}_t\right)}{\phi_{t-1}^M\left(I_{t-1}, \mathbf{d}_t\right)} = \prod_{g \in G} \widetilde{P}_g^M\left(I_g\right)\left(\dfrac{\lambda_{gt}}{\lambda_{gt-1}}\right)^{\omega_{gt}/(\sigma_g - 1)}$

where $\widetilde{P}_g^M$ *is the aggregate conventional import price index and* ω_{gt} *are log-change ideal weights at the goods level,*

(A11) $\omega_{gt} = \dfrac{\left(s_{gt} - s_{gt-1}\right) / \left(\ln s_{gt} - \ln s_{gt-1}\right)}{\sum_{g \in G} \left(s_{gt} - s_{gt-1}\right) / \left(\ln s_{gt} - \ln s_{gt-1}\right)}$

which is the harmonic mean of the cost shares at goods level

(A12) $s_{gr} = \dfrac{\sum_{c \in I_{gr}} p_{gcr} q_{gcr}}{\sum_{g \in G} \sum_{c \in I_g} p_{gct} q_{gcr}}$ *for* $r = t, t-1$,

where G is the set of all goods which remains constant over the whole period, I_g *is the set of common varieties between the starting and the final year of the period, and* $p_{gcr} q_{gcr}$ *is the trade value of a particular variety in year r.*

The main goal of the analysis is to compute the value of the lambda ratio for each good; this is the deviation of the exact price index with change in varieties from the conventional price index. The lambda ratio defines the importance of new varieties; the higher the expenditure share of new varieties, the low is λ_{gt} and the smaller is π_g with respect to the conventional price index P_g^M .The lambda ratio depends on σ_g, which is the estimated elasticity of substitution for a particular good g. When the elasticity of substitution is big the lambda ratio tends to one so the difference between the two price indices is small. This implies that the new varieties are close substitutes to the existing ones, the exact price index does not differ much from the conventional price index and the gains from variety growth are small because consumers do not care much about the new varieties. Hence the growth in varieties is not simply given by the number of varieties but it takes into account taste or quality differences that affect the share of expenditures among different varieties. This correct the so-called "quality bias". Moreover, allowing for good-specific values of the elasticity of substitution, it is also possible to correct for the "symmetry bias" among available goods.

The second proposition shows that the difference between the exact aggregate price index and the conventional aggregate price index is simply calculated as the geometric weighted average of the lambda ratios. This term is referred as “import bias”. The weights are ideal log-change weights, which are a function of prices and quantities for all varieties of a particular good.

Finally the welfare gains due to variety growth are obtained by raising the import bias to the ideal import share over the considered period; the share represents the fraction of imported goods in total GDP.

(A13) $\Pi = \left(\Pi_g^M\right)^{\omega_t^M}$

where the log-change ideal weights, ω_t^M, which correspond to the ideal import share used to calculate the welfare gains over the considered periods, are defined as follows:

(A14) $\omega_t^M = \left(s_{Mt} - s_{Mt-1}\right) / \left(\ln s_{Mt} - \ln s_{Mt-1}\right)$

where

(A15) $s_{Mt} = \dfrac{\sum_{g \in G} \sum_{c \in I_g} p_{gct} q_{gct}}{GDP_t}$; the numerator of s_{Mt} represents the total goods imports in year t and the denominator is the Gross Domestic Product, both in current US$.

Notice that the import bias is defined over the period into consideration; therefore in Proposition 1 and 2 one should read the starting and final year of the period instead of t-1 and t.

Appendix B. Estimation of the Elasticity of Substitution.

The estimation strategy follows Feenstra (1994). The import demand equation for each variety of good g is defined as follows:

(B1) $q_{gt} = \dfrac{d_{gct}\left(p_{gct}\right)^{-\sigma_g} Y}{\sum_{c \in I_{gt}} d_{gct}\left(p_{gct}\right)^{1-\sigma_g}}$

From quantities, the cost shares are obtained as follows:

(B2) $s_{gct} = \frac{p_{gct}q_{gct}}{\sum_{c\in I_g} p_{gct}q_{gct}} = \frac{d_{gct}\left(p_{gct}\right)^{1-\sigma_g}}{\sum_{c\in I_g} d_{gct}\left(p_{gct}\right)^{1-\sigma_g}} = \frac{\phi_{gt}^{M}\left(\mathbf{d}_{gct}\right)^{\sigma_g -1} d_{gct}}{\left(p_{gct}\right)^{\sigma_g -1}}$

where $\mathbf{d}_{gct}$ is the vector of taste parameters for each country and $I_g = \left(I_{gt} \cap I_{gt-1}\right)$. So the import demand equation for each variety of good g can be expressed in terms of shares and changes over time:

(B3) $\Delta \ln s_{gct} = \varphi_{gt} - \left(\sigma_g - 1\right)\Delta \ln p_{gct} + \varepsilon_{gct}$

where

$\varphi_{gt} = \left(\sigma_g - 1\right)\ln\left[\Phi_{gt}^{M}(d_{gt}) / \Phi_{gt-1}^{M}(d_{gt-1})\right]$ is a random effect as d_{gt} is random and $\varepsilon_{gct} = \Delta \ln d_{gct}$.

Unfortunately it might well be that both $\Delta \ln s_{gct}$ and $\Delta \ln p_{gct}$ are correlated with the error term due to simultaneous determination of import price and quantities. So the equation (B3) cannot be directly estimated and some assumptions on the supply side of the economy have to be made. Simultaneous bias is corrected by allowing the supply of variety c to vary with the amount of exports, $\Delta \ln p_{gct} = \omega_g \Delta \ln q_{gct} + \Delta \ln v_{gct}$, where ω_g is the inverse of the supply elasticity (assumed to be the same across countries). Since $q_{gct} p_{gct} = s_{gct} E_{gt}$ where E_{gt} is total expenditures on good g, the export supply equation is defined as follows:

(B4) $\Delta \ln p_{gct} = \psi_{gt} + \frac{\omega_g}{1+\omega_g} \Delta \ln s_{gct} + \delta_{gct}$

where

$\psi_{gt} = \frac{\omega_g}{1+\omega_g} \Delta \ln E_{gt}$ and $\delta_{gct} = \frac{1}{1+\omega_g} \Delta \ln v_{gct}$.

The identification strategy relies on the following assumption $E\left[\varepsilon_{gct}\delta_{gct}\right] = 0$. This implies that demand and supply equation errors at the variety level are uncorrelated.

It is convenient to eliminate φ_{gt} and ψ_{gt} by choosing a reference country k and differencing demand and supply equations, denoted in (B3) and (B4), relative to country k.

(B5) $\Delta^k \ln s_{gct} = -(\sigma_g - 1)\Delta^k \ln p_{gct} + \varepsilon_{gct}^k$

(B6) $\Delta^k \ln p_{gct} = \dfrac{\omega_g}{1+\omega_g}\Delta^k \ln s_{gct} + \delta_{gct}^k$

where $\Delta^k y_{gct} = \Delta y_{gct} - \Delta y_{gkt}$, $\varepsilon_{gct}^k = \varepsilon_{gct} - \varepsilon_{gkt}$, and $\delta_{gct}^k = \delta_{gct} - \delta_{gkt}$.

Equation (B6) can be re-written as follows:

(A7) $(1-\rho_g)\Delta^k \ln p_{gct} = \dfrac{\rho_g}{\sigma_g - 1}\Delta^k \ln s_{gct} + \delta_{gct}^k$

where

$\rho_g = \dfrac{\omega_g(\sigma_g - 1)}{1+\omega_g \sigma_g}$ and it satisfies $0 \le \rho_g \le \dfrac{\sigma_g - 1}{\sigma_g} < 1$.

In order to take advantage of the identification strategy (A5) and (A7) are then multiplied together to obtain:

(B8) $\left(\Delta^k \ln p_{gct}\right)^2 = \theta_1\left(\Delta^k \ln s_{gct}\right)^2 + \theta_2\left(\Delta^k \ln p_{gct}\Delta^k \ln s_{gct}\right) + u_{gct}$

where

$\theta_1 = \dfrac{\rho_g}{(1-\rho_g)(\sigma_g - 1)^2}$, $\theta_2 = \dfrac{(2\rho_g - 1)}{(1-\rho_g)(\sigma_g - 1)}$ and $u_{gct} = \dfrac{\varepsilon_{gct}^k \delta_{gct}^k}{(1-\rho_g)(\sigma_g - 1)}$

Endogeneity is apparent, as the error term in our estimating equation is comprised of the error terms of the regressands. Feenstra (1994) demonstrates that by taking advantage of the panel nature of the data one can control of this endogeneity by using country-specific dummies as instruments and obtain consistent estimates of θ_1 and θ_2. So long as $\theta_1 > 0$ then ρ_g and σ_g are defined as follows:

$$\rho_g = \frac{1}{2} + \left(\frac{1}{4} - \frac{1}{4+\left(\theta_2^2/\theta_1\right)}\right)^{1/2} \quad if \quad \theta_2 > 0$$

$$\rho_g = \frac{1}{2} - \left(\frac{1}{4} - \frac{1}{4+\left(\theta_2^2/\theta_1\right)}\right)^{1/2} \quad if \quad \theta_2 < 0$$

$$\sigma_g = 1 + \left(\frac{2\rho_g - 1}{1-\rho_g}\right)\frac{1}{\theta_2}$$

If $\theta_1 < 0$ and $\theta_2 < 0$, it is not possible to obtain economically feasible values for σ_g and ρ_g. In that case we use a grid search over the economically feasible values for σ_g and ρ_g proposed by Broda and Weinstein (2006) to minimise the GMM function objective function implied by the IV estimation. Explicitly, we choose values $\sigma_g \in (1.05,100.05)$ at equally spaced intervals of 0.05 and $\rho_g \in \lfloor 0, \sigma_g - 1/\sigma_g \rfloor$ split into 100 equal intervals to minimize $G^*(\rho_g, \sigma_g)' W G^*(\rho_g, \sigma_g)$ where $G^*(\rho_g, \sigma_g)$ is the sample analog of the moment condition $G(\rho_g, \sigma_g) = E\lfloor u_{gct} \rfloor = 0, \forall c$.