Variety Growth and World Welfare

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Economists since Hicks have known that one of the principle means, if not the principle means, through which countries benefit from international trade is by the expansion of varieties.[1] The seminal work of Krugman (1979) brought the study of varieties into sharp focus by presenting a simple general equilibrium model in which countries gain from trade through the import of new varieties. Since then, economists have been hampered in their ability to quantify the impact of new varieties on national welfare by the econometric and data hurdles that need to be surmounted. In this paper, we document some stylized facts about the growth in global varieties which suggest that there may have been substantial welfare gains through the import of new varieties. Moreover, we calculate the impact of increased variety on import prices and find that conventional measures of import price inflation may be dramatically biased upwards.

Classical international trade theory postulates that the elimination of trade barriers improves welfare by reducing the wedge between domestic and import prices as well as the ensuing deadweight loss. An entirely different reason for the gains from trade arises from models of monopolistic competition. If consumers value variety and countries cannot produce all varieties due to a fixed cost in the production of each variety, countries stand to gain from trade because it expands the set of available varieties. In these models, the gains hinge crucially on a number of parameters and variables. The first is the elasticity of substitution among varieties. If varieties are highly substitutable, as might be true for varieties of gasoline, then increasing the number of varieties is unlikely to have much of an effect on prices and welfare. Second, quality variation across varieties may matter. Presumably, most Americans care more

[1] "The extension of trade does not primarily imply more goods… the variety of goods available is (also) increased, with all the widening of life that that entails. There can be little doubt that the main advantage that will accrue to those with whom our merchants are trading is a gain of precisely this kind…. This is a gain which 'quantitative economic history' which works with index numbers of real income, is ill-fitted to measure, or even to describe". John Hicks, A Theory of Economic History (1969).

about having access to French red wine than to Japanese red wine. Finally, import quantities matter as, *ceteris paribus*, one cares more about variety growth in big sectors than in small sectors.

Broda and Weinstein (2004) carefully estimate the impact of increased variety in the US over the period 1972 to 2001. Using the most disaggregated import data available, we document that the number of varieties imported by the US, defined as the number of import categories multiplied by the average number of source countries for each category, quadrupled. About half of this increase was due to increases in the number of categories and half due to a doubling of the number of countries from which the US imported each good. Measuring the impact of this increase on US import prices and welfare is a complex process that we will only discuss briefly here. Essentially, Broda and Weinstein use Feenstra's (1994) methodology to estimate 30,000 elasticities and then construct an aggregate price index that is robust to common changes in quality variation, the arbitrary splitting of categories, the introduction of new goods, and a host of other data problems. After reconstructing the US import price index, Broda and Weinstein find that the price of US imports has been falling at a rate 1.2% per year faster than one would have thought without taking new varieties into account. To get some sense of the enormity of this bias, consider that the impact of quality adjustments on the consumer price index is estimated to be 0.6% per year. Using this adjusted import price index, Broda and Weinstein estimate the impact of new imported varieties on US welfare and find that the value to US consumers from the increase in global varieties is 280 billion dollars or about 3% of US GDP.

Variety Growth by country, 1972-1997

Replicating the results of Broda and Weinstein for a larger set of countries is beyond the scope of this paper. What we want to do here is document that the increase in imported varieties is an important global phenomenon. Moreover, we believe the data suggests that this global growth in imported varieties has significant implications for how globalization has been raising world welfare.

An important limitation that we face as we turn to international data is that we do not have access to highly disaggregated import data for a large cross-section of countries over a long time period. Although Broda and Weinstein use 8- or 10-digit data for their study of the US, consistent international data at the 6-digit Harmonized Tariff System level is only available for a decade or so, and if we want to look at a similar time period as Broda and Weinstein, we are forced to use 4-digit SITC data. As a result, we will be working with only 433 good categories instead of the close to 15,000 categories available in the most disaggregated data.

The major impact of working with more aggregated data is that we are biased against finding large changes in the number of varieties. The reason is simple. Our measure of the change in the number of imported varieties will depend on whether a country that initially did not export a good started to export a good after some point in time. Since whenever a country exports a good in an 8- or 10-digit category, it will export the good in the more aggregated 4-digit category, we will tend to miss a lot of the increase in varieties. A second feature and limitation of the 4-digit data is that the number of categories has declined by 25 over the period from 1972 to 1997 even though the number of product categories in more disaggregated data has risen sharply. On the positive side, this means that we do not need to worry about false increases in variety arising from the splitting of categories into finer units. However, this further biases us against finding increases in varieties arising from the import of entirely new goods.

Table 1 presents data on how the number of varieties varies across countries and time for the countries that were the 20 largest importers in 1997. Each element in the first column of Table 1 presents the average number of suppliers of a good imported by a particular country in 1972, and the elements in the second column report the same statistic for 1997. There are basically two stylized facts in the cross-section that we wish to highlight. First, large importers tend to source their imports from more countries than small importers. The US, for example, imported a typical 4-digit SITC good from an average of 31

countries in 1972, whereas the 20th largest importer, Australia, only imported goods from 18 countries. If we look at the 100 largest importers in 1997, we find that the correlation between the amount of aggregate imports and the number of countries supplying each good is 0.79. Countries that import more also tend to import from more countries.[2]

A second element of the cross-sectional variation that is interesting is how varieties change across goods categories. In Table 2, we present the average number of source countries for the twenty largest import categories in 1972. Taken together, these twenty categories accounted for 31 percent of world imports in 1972. One of the striking features of this table is that the goods that importers source from the fewest countries – petroleum oils, other fuel oils, anthracite coal, and unmilled non-durum wheat – are all goods that one would not characterize as specialized by country or firm. Similarly goods that are sourced from the largest number of countries – e.g. medicines, specialized industrial machinery, and motor vehicle parts – are likely to be quite different across countries.

What could be driving this striking difference in the number of suppliers of particular product categories? The most obvious explanation for this phenomenon is one suggested by Davis and Weinstein (2002). Davis and Weinstein contend that importers will tend to source differentiated goods from a wide number of countries. The sourcing, of homogeneous goods, however, can better be modeled by a linear programming process [c.f. Dorfman, Samuelson, and Solow (1954)] that minimizes trade transport costs subject to a constraint that each country's net offer of homogeneous is satisfied. As Dorfman, Samuelson, and Solow (1954) show, the solution to this linear programming problem will involve only a very small number of non-zero bilateral export paths. It is therefore striking that we see the smallest number of bilateral export paths precisely for the goods that are commonly thought to be most homogeneous.

[2] Hummels and Klenow (2003) examine the behavior of *exports* in a large cross-section. They conclude that typically two thirds of the new exports come in the form of new varieties, also indicating the importance of the extensive margin in the case of exports.

So far, we have simply been discussing the cross-sectional variation. The time series variation, however, is even more interesting for our purposes. Returning to Table 1 we see that all of the world's 20 largest importers substantially increased the number of countries from which they source their imports. The average increase for the largest 20 importers rose by 49 percent. This increase almost surely understates what the increase would have been if we had used more disaggregated data. For example, in our study of the US, we found that the number of countries supplying imports rose by 82 percent over this time period. This is almost double the increase that we have in more aggregated 4-digit data. Almost surely this reflects the downward bias arising from the fact that as long as there are some imports from a particular country at the 8-digit level in 1972, we will record no variety growth at the 4-digit level.

Of particular interest is what has happened to individual countries. Countries that liberalized their economies such as China and the former Soviet Union have seen enormous increases in the number of suppliers. China, for example, saw the number of import suppliers of a typical imported commodity grow from 4.9 to 21 – an increase of 425 percent! Similarly, the Soviet Union saw the number of countries supplying a typical importable rise by over 200 percent. It is important to remember that this type of impact from globalization is typically not captured by conventional measures of openness which focus on the aggregate amount of imports rather than the number of sources of those imports.

The increase in the number of import sources highlights an important feature of the time series properties governing the expansion of world trade. In Chart 1, we plot the percentage change in the average number of import suppliers of a country's 4-digit import category against the country's import growth rate. Clearly, as imports of a given country grow, the country tends to source those imports from more countries. This suggests the possibility of a virtuous circle arising from growth – import growth causes an expansion of the number of varieties, which drives down the price index and thereby causes more growth. It also underscores an important source of gains from globalization: as countries import

more, they increase the number of varieties that they import. Reductions in trade costs may be raising welfare not simply by reducing the price of imports but by increasing the available choice set for consumers.

In order to obtain a sense of how important these changes have been for the world economy, we need to put a bit more structure on the data. To do this properly for a country is a major undertaking and the reader is directed to Broda and Weinstein in order to understand how to obtain a careful estimate. Here we will do an extremely simple calibration exercise that should provide some flavor for the magnitude of these global trends.

If we assume that all consumers use a constant elasticity of substitution (CES) utility function that places equal weights on imports from every country, prices of all imports are identical, and there are no differences in quality or substitution elasticities across goods, then we can write the exact import price index that takes variety growth into account, P_c^V, as

$$(1) \quad P_c^V = P_c \times \prod_g \left(\frac{n_{gc72}}{n_{gc97}} \right)^{\frac{1}{\sigma-1}}$$

where P_c is the conventional price index, n_{gc72} is the number of varieties of good g imported by country c in the year 1972, and σ is the elasticity of substitution. In this case increasing the number of source countries for a given good will reduce the ration n_{gc72}/n_{gc97} and hence the exact price index. An unfortunate feature of the 4-digit data is that the number of import categories in 1997 is thirty less than the number in 1972. If we were implementing the Broda and Weinstein methodology this would not be a problem, but it is a problem when one uses count data as a measure of varieties since it would result in a spurious decline in the number of goods. In order to deal with this problem, we take as our measure of n_t average number of countries supplying 4-digit categories that did not change definition over the sample.

In columns 4 and 5, of Table 1 we calculate the implied changes in import prices due to the increases in varieties under a number of assumptions regarding the elasticity of substitution. The fourth column reports the implied price movements using an elasticity of substitution of 2. This elasticity of substitution is lower than the one typically estimated, but we include it because it generates a price movement for the US which is approximately equal to the estimate in Broda and Weinstein. Presumably the reason for this is that the low elasticity offsets the upward bias in the adjusted import price index arising from the more aggregated data. Another way of saying this is that the first column calibrates the elasticity so that it provides an estimate of the gains from variety for the US that is essentially the same as in Broda and Weinstein. An alternative way of picking an elasticity is to chose a number that is similar to elasticity estimates from other papers. We do this in the next column.

The results from this exercise suggest that there are very large import price declines arising from increases in variety. Indeed, most countries appear to have experienced larger increases in the number of import suppliers than the US in the period 1972-1997. For example, the dramatic increase in varieties for South Korea implies a drop in the import price index of 70 percent in the last 25 years. What is even more striking is how prices have moved for countries that liberalized their economies. China, Mexico, and the former Soviet Union saw the number of source countries for their goods rise by 326, 89, and 214 percent resulting in implied import price indices declining by 83, 50, and 75 percent respectively assuming an elasticity of 2. The price declines are significantly smaller with the higher elasticity, but these price declines are almost surely biased towards zero because of the more aggregated 4-digit data.

Turning to welfare, our estimates imply substantial gains for these countries. If we multiply the changes in the price index by the import share for each country,[3] we obtain an estimate of how much real income in that country rose as a result of increases in varieties. If we focus on the first column of welfare

[3] We assume that all imports are consumed rather than re-exported. This is clearly a simplification for the case of many East Asian countries that have GDP shares of imports over 50 percent.

results, we see that if we calibrate sigma to replicate the Broda and Weinstein results, the growth in varieties implies enormous welfare gains for many countries. Indeed, by using US data, Broda and Weinstein picked the country for which variety gains were the smallest. Our calibration exercise suggests that many countries saw their welfare rise by 10 percent or more as a result of new varieties. For many developing and emerging economies the impacts are even larger. We calculate that China, the former Soviet Union, and Mexico saw their welfare rise by 27, 32, and 25 percent as a result of increased import varieties. The magnitudes are so large that they suggest that increases in varieties may be one of the principle means through which liberalizing countries benefit from trade. Even if we focus on the last column, which uses the higher elasticity and therefore underestimates the gains for the US, we see welfare gains on the order of 7 to 10 percent for these countries.[4]

Conclusion

Over the last twenty-five years, international trade has undergone a revolution in terms of our understanding of what drives the gains from trade. Although monopolistic competition theory rests on the notion that a major source of the gains from trade stems from increases in product varieties, empirical analysis lags far behind. In prior work, we conducted the first econometric estimate of how much increases in imported variety mattered for the welfare of the United States. Our estimates suggested that US welfare is 3 percent higher due to the increase in imported varieties.

In this paper we extend those results in a number of important dimensions. First we document that even at higher levels of aggregation, there has been an unmistakable global pattern of variety growth. On average large importing countries source imports from 50 percent more countries than they did twenty-five years ago. Using a simple calibration exercise we calculate the bias in conventional price indices due

[4] Given the severe downward bias arising from evaluating variety change at too high a level of aggregation we decided to use the count data to measure variety growth rather than the measure used in Broda and Weinstein. In this case, welfare effects are substantially lower but for a number of countries they are still in excess of 6 percent of national income. Unfortunately, we could not report these results due to space limitations.

to omitting changes in imported varieties. Our calculations suggest a pervasive and potentially large upward bias in import prices particularly for liberalizing countries. These results also imply that conventional measures of the gains from trade may be far lower than those implied by new trade theory. Obviously more work needs to be done, but our preliminary calculations suggest that increasing global varieties has exerted a large and positive impact on world welfare.

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TABLE 1: THE IMPACT OF VARIETY ON WORLD PRICES AND WELFARE

Country	Average Number of Exporters per			Aggregate Bias in Import Price between 1972 and 1997		Percent Change in Real Income between 1972 and 1997	
	1972	1997	*Percent*	Sigma = 2	Sigma = 5	Sigma = 2	Sigma = 5
USA	31.4	42.7	*36.1*	0.72	0.91	3.0	0.9
GERMAN	29.1	38.2	*31.2*	0.76	0.93	8.9	2.3
JAPAN	20.6	28.8	*39.9*	0.68	0.91	3.3	0.8
UNITED	30.4	38.4	*26.5*	0.79	0.94	5.6	1.4
FRANCE	26.3	35.2	*34.2*	0.75	0.93	5.3	1.4
ITALY	23.9	33.5	*40.0*	0.72	0.92	14.2	3.8
CANADA	17.8	25.2	*41.3*	0.68	0.91	19.4	5.3
NETHERLAND	23.6	31.5	*33.1*	0.77	0.94	7.1	1.8
CHINA	4.9	20.7	*326.1*	0.17	0.64	26.9	7.5
BELGIUM-	20.8	27.6	*32.8*	0.77	0.94	14.8	3.9
HONG	15.0	23.7	*57.9*	0.60	0.88	18.0	4.9
SPAIN	16.6	21.8	*31.6*	0.72	0.92	6.2	1.6
MEXICO	9.1	17.3	*89.3*	0.50	0.84	32.2	9.3
SINGAPOR	14.7	23.2	*57.6*	0.62	0.89	45.6	14.1
FM	8.7	27.3	*213.7*	0.25	0.71	25.4	7.1
KOREA RP	5.9	16.8	*185.3*	0.30	0.74	30.8	8.8
SWITZERLAN	18.7	24.2	*28.9*	0.81	0.95	6.7	1.7
TAIWAN	7.7	17.4	*126.9*	0.40	0.79	36.9	10.9
SWEDEN	18.8	22.8	*21.5*	0.87	0.97	3.9	1.0
BRAZIL	11.5	19.7	*70.7*	0.56	0.86	26.8	7.5

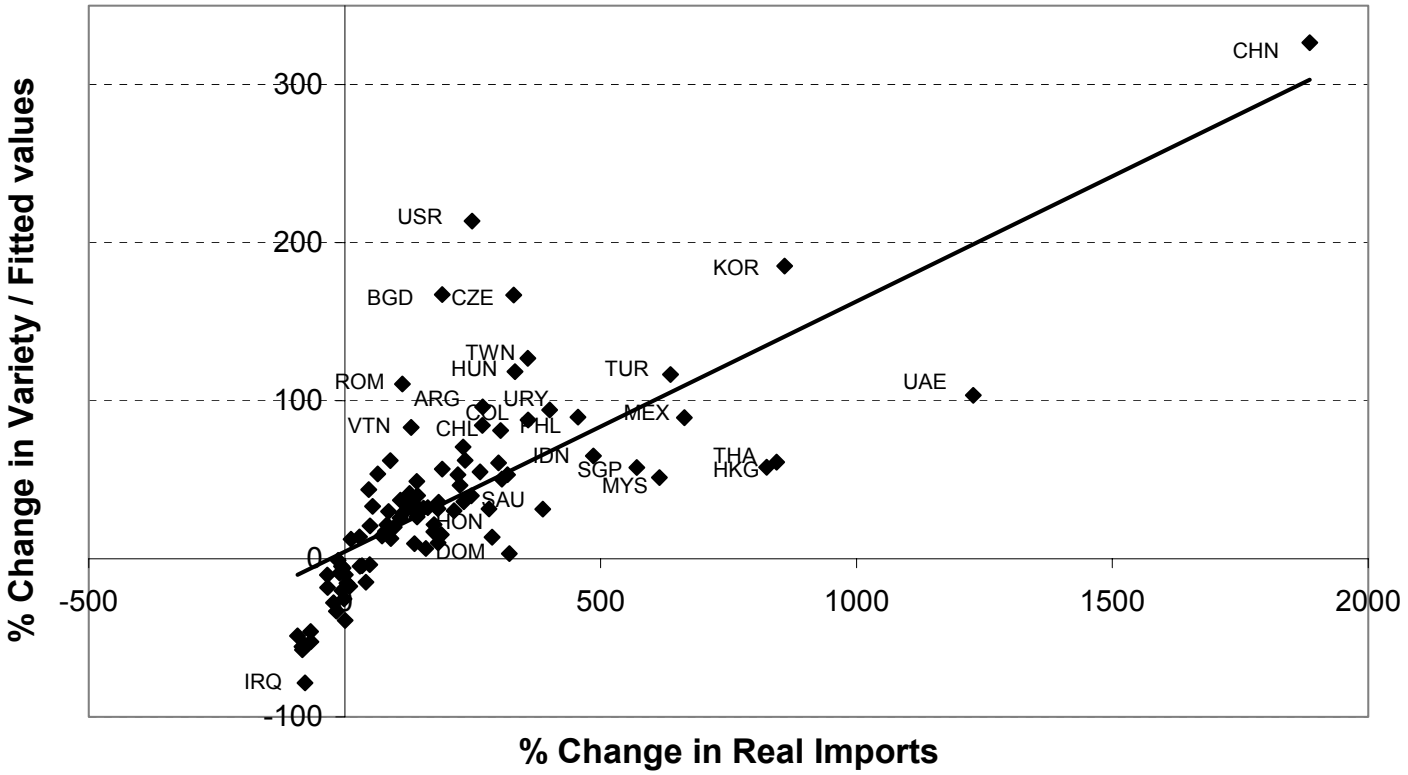
Source: Feenstra (2000) and authors' calculation. (*) Geometric average of n-ratios (see equation (1) in text).

TABLE 2: VARIETY IN THE TOP 20 GOODS(*)

SITC #	Goods Name	Average Number of Importing Sources across Countries	
		1972	1997
3330	PETROL.OILS & CRUDE OILS OBT.FROM BITUMIN.MINERALS	4.7	6.4
7810	PASSENGER MOTOR CARS,FOR TRANSPORT OF PASS.& GOOD	16.1	20.2
7849	OTHER PARTS & ACCESSORIES OF MOTOR VEHICLES	17.4	24.8
3343	GAS OILS	8.2	7.0
7821	MOTOR VEHICLES FOR TRANSPORT OF GOODS/MATERIALS	9.9	16.5
7139	PARTS OF INT.COMB.PISTON ENGINES OF 713.2-/713.8-	16.5	21.9
6821	COPPER AND COPPER ALLOYS,REFINED OR NOT,UNWROUGHT	5.6	9.1
7284	MACH.& APPLIANCES FOR SPEZIALIZED PARTICULAR IND.	18.7	26.8
711	COFFEE,WHETHER OR NOT ROASTED OR FREED OF CAFFEINE	9.5	13.7
412	OTHER WHEAT (INCLUDING SPELT) AND MESLIN,UNMILLED	3.2	4.4
6672	DIAMONDS,UNWORK.CUT/OTHERWISE WORK.NOT MOUNTED/S	5.2	7.5
7247	MACH.FOR WASHING,CLEANING,DRYING,BLEACHING TEXT.	16.4	17.5
111	MEAT OF BOVINE ANIMALS, FRESH, CHILLED OR FROZEN	6.2	7.9
2482	WOOD OF CONIFEROUS SPECIES,SAWN,PLANED,TONGUED ET	10.1	10.1
8510	FOOTWEAR	16.6	22.0
3344	FUEL OILS,N.E.S	5.0	7.1
3221	ANTHRACITE,WHETHER/NOT PULVERIZED,NOT AGGLOMERATE	3.1	5.1
7442	LIFTING,HANDLING,LOADING MACH.CONVEYORS	15.7	21.6
7361	METAL CUTTING MACHINE-TOOLS	14.3	18.1
5417	MEDICAMENTS(INCLUDING VETERINARY MEDICAMENTS)	21.7	25.1

Source: Feenstra (2000). (*) In terms of 1972 imported values.

Chart 1: Variety Growth 1972-1997



Note: Fitted Regression y = 0.15x + 4.6 ; R2=0.56 and nobs=100