Prices, Productivity, and Innovation

David E. Weinstein and Christian Broda

Economists have long known the importance of focusing on "real" as opposed to "nominal" variables in order to understand a wide range of economic outcomes such as growth, productivity, and welfare. While the distinction between real and nominal variables is simple in theory, in practice it is very difficult for statistical agencies to measure prices accurately. One of the main difficulties stems from the fact that the set of goods in the economy is constantly changing because of the creation of new goods and quality upgrading. How does one measure price changes when the set of goods consumed in two periods is different? Much of our research over the last few years has been focused on estimating the impact that new goods has on our understanding of the US and world economies.

A hallmark of our approach has been to combine micro data with a rich framework that allows the biases in the price measurement of individual goods to be aggregated over large sectors of the economy. This research agenda has produced a series of papers that have emphasized the macro implications of these micro biases. The principle macro implications of our work are the following:

- Because trade provides consumers with new goods, over the last few decades we have underestimated the gains from globalization around the world.[1]
- We estimate the aggregate CPI bias for a large set of goods to be close to 1 percentage points per year and to have a strong pro-cyclical component. The cyclicality of the bias suggests that business cycles are more pronounced than is typically reported in official statistics.[2]
- Incorporating the effect of new goods into the measurement of prices suggests that real wages for the typical worker in the US have risen substantially over the last 30 years. It also suggests that poverty rates based on our corrected CPI measurements have fallen sharply relative to their official counterparts since the late 1960s.[3]

New Goods and Inflation

The starting point for thinking about how new goods and higher quality goods affect price measurement is to understand how prices are currently measured. Virtually all price indexes that are used by economists are essentially "common goods" price indexes. In other words, most price indexes compare the prices of a common set of goods sampled in two periods and then take a weighted average of these prices to obtain a single inflation estimate. In the case of the US Consumer Price Index (CPI), a small subsample of the prices are adjusted for quality changes (e.g. computers), but in general no adjustments are made for the appearance of new goods.

The problem with this methodology stems from the fact that appearance of new goods has price implications for consumers. To understand this, one needs to think about how a new good affects a consumer. As John Hicks argued decades ago, the appearance of a new good can be thought of as a drop in the price of the good from its reservation price – that is, the price at which demand equals to zero – to the observed market price. Since official price indexes do not record these implied price drops, they overstate inflation.

Although this problem with conventional indexes is well-known, prior work had only been able to address it for a handful of products. The Boskin commission, for instance, extrapolated the findings of a few studies to estimate the bias for the entire CPI, but this extrapolation was based on a few studies that covered at most 10 percent of the CPI. Moreover, these studies were not comprised of a representative sample of goods. One of the main differences between our work and that of prior researchers is that we examine a unique dataset that covers the universe of products with barcodes – approximately 700,000 goods in a typical quarter covering around 40 percent of all expenditures of goods in the CPI. Because manufacturers almost never change a barcode unless they make some modification and never make an important modification to a good without changing the barcode, our data enables us to observe virtually all changes in quality or in the set of goods in this sample.

The data reveals several important facts for understanding pricing. First, over 90 percent of product creation and destruction happens within firm product lines and because of firm entry and exit. To put this in perspective, we find four times more entry and exit in product markets than that found in establishment and labor market data. In a typical year, 40 percent of household's expenditures are in goods that were created in the last 4 years, and 20 percent of expenditures are in goods that disappear in the next 4 years. This implies that price indexes that do not adjust for the important role played by new goods are likely to be highly susceptible to new goods or quality biases.

Second we find that net creation is strongly pro-cyclical, with more products being introduced in expansions and in product categories that are booming. Destruction of goods is counter-cycle, although its magnitude is quantitatively less important. This is suggestive of models where firms have an incentive to defer implementation of the product until aggregate demand is relatively high.

Finally, we develop a methodology that enables us to estimate the aggregate importance of the price drops for consumers. We show that since most product creation and destruction is unobserved by the Bureau of Labor Statistics, there remains a substantial bias arising from new and higher quality goods in the CPI. This upward bias averages 0.6 – 0.9 percent per year depending on the aggregation methodology. The bias is also strongly pro-cyclical, which suggests that business cycles are more pronounced than is typically reported in official statistics.

International Price Implications of Product Heterogeneity

Barcode data can also help us to understand many of the puzzles in international economics.[4] Consider two key results about international price deviations: borders give rise to flagrant violations of the law of one price and convergence rates back to purchasing power parity (PPP) are inconsistent with the evidence of micro studies on nominal price stickiness. A major problem with these studies is the comparison of goods that are not identical. For example, if we look at product categories similar to those in the CPI – e.g. like fresh eggs and milk – we see that the disaggregate price indexes across cities within the U.S. are comprised of samples of goods with little to no overlap across locations. This fact implies that using these price indexes as the basis of studies of the law of one price has clear limitations.

Moreover, since Canada and the US use the same barcode system, we can directly compare the similarity of consumption bundles in the two countries. In the typical bilateral city/region comparison between the US and Canada only 7.5 percent of the goods are common. This is less than one third the common set of goods available between city pairs of equal distance within the US. In other words, a random sample of goods sold in the US is likely to differ

substantially with the composition of a sample of goods sold in Canada. By the same token, we find more proximate locations have more similar consumption bundles than distant locations.

The next key fact to realize is that there is considerable heterogeneity even in goods categories that sound homogeneous like bottled water: Perrier can sell at an enormous premium over Poland Springs. Again, these differences are not random. In particular, households that have higher incomes tend to buy more expensive varieties of the same class of good. For example, a household that spends twice as much as another household per capita tends to pay 6 percent more for the items in a product group. Approximately 85 percent of this price difference is due to richer households purchasing more expensive varieties within a product group. These results hold even for seemingly homogeneous goods like eggs, milk, and sodas, which establishes that tests of price convergence using aggregate data that is collected across countries or regions with different per capita incomes are likely to falsely reject purchasing price parity because the quality of the goods will vary systematically with income.

Taken together, these facts suggest that a major problem in examining PPP across borders is that the set of goods consumed in different countries varies substantially and that even seemingly substitutable goods, like eggs, sell at very different prices even within the same store.[5] Thus, finding that egg prices do not move together across borders may be in part due to the fact that consumers in different locations purchase similar goods that differ substantially in quality. Moreover, since there is substantial heterogeneity in the prices charged for the same barcode in different locations even within the US, the simple fact that international prices differ is not informative of the incremental border barrier.

Indeed, we find that if one restricts the analysis to the set of common goods consumed in the US and Canada, the border introduces only a small distortion to relative prices, and rates of convergence to PPP are relatively fast. However, if one runs the same analysis on product groups – e.g. milk – the border looms much larger because the prices of different goods do not always move together.

New Goods, Variety, and Growth

We next turn our attention to the implications of the increases in the set of available goods for economic growth. Earlier work had demonstrated an important fact for the US. If we defined a "variety" as an HS-10 good exported by a particular country, e.g. French red wine, we saw that there was a dramatic increase in the number of goods imported by the US between 1972 and 2001. This analysis indicated that there were substantial gains to the US economy arising from the increased availability of foreign varieties in our markets.

In Broda, Greenfield, and Weinstein (2006), we reexamined this from a global perspective.[6] A key feature of endogenous growth models is that the introduction of new varieties drives productivity growth. Analyzing 6-digit bilateral trade flows over the period 1994-2003, we document that the reason that trade-to-GDP ratios have been rising in virtually all countries is due to the fact that countries are importing new varieties, not because they imported more of existing varieties. In the typical developing country, virtually all of the growth in imports to GDP came from the import of new varieties.

These models also imply that these new varieties should affect the growth rate of productivity. The wider access to imported intermediate goods means that R&D labor is more productive, which reduces the cost of generating new blueprints for intermediate products. We find evidence that the effect of varieties on the growth rate of an economy is relatively small, temporary, but persistent. Given this persistence, however, the impact on the level of long-run

growth is large. Our results indicate that the increase in varieties we observed is likely to increase the presented discounted value of the income by 17 percent. Of this, only 1.3 percentage points are due to the static gains from trade and the remainder is due to the impact that new goods has on the incentive to perform research and development and invest. In other words, semi-endogenous growth models suggest that there are very powerful growth effects due to trade liberalization that are ignored by conventional static analyses.

Political Economy Issues

The previous work has focused on the positive gains from new varieties, but it is legitimate to ask, "if new varieties are so good, why do countries restrict trade?". We have focused on two key theories of trade barriers.[7] First is the standard, but controversial, "optimal tariffs argument," i.e. countries set tariffs to exploit their market power in international markets. Second, we examine more conventional political economy arguments.

In doing so, we make three contributions. First, we estimate elasticities of export supply faced by fifteen importer countries at a highly disaggregated level. Second, we use these elasticities to provide evidence that prior to constraints imposed by the World Trade Organization (WTO) these countries systematically set higher import tariffs on goods in which they have market power. Finally, we estimate similar elasticities for the U.S. and find that its trade restrictions that are not constrained by the WTO are significantly higher in goods where the U.S. has more market power. The results are robust to the inclusion of political economy variables and a variety of model specifications. The effect is statistically and economically significant both relative to other explanations and to the average tariff in the typical country. In short, we find strong evidence that countries have market power in imports and exploit it in setting their trade policy.

Conclusion and Directions for Future Research

The use of barcode and other forms of highly disaggregated data has opened up a number of new ways that we can peer inside the black box of firms to see how innovations occur for broad sectors of the economy. These datasets are likely to provide researchers to obtain a better understanding of how macro theories match up with micro behavior of consumers when they make individual purchases. We hope this will serve to further integrate micro and macro economics.

[1] C. Broda and D. E. Weinstein, "Globalization and the Gains from Variety", Quarterly Journal of Economics, Vol. 121, Issue 2 - May 2006..

[2] C. Broda and D. E. Weinstein. "Product Creation and Destruction: Evidence and Price Implications," with Christian Broda, NBER Working Paper #13041, April 2007. The American Economic Review forthcoming.

[3] Broda, Christian and David E. Weinstein. Prices, Poverty, and Inequality, 2008, Washington: AEI Press.

[4] Broda, Christian and David E. Weinstein. "Understanding International Price Differences Using Barcode Data," with Christian Broda, NBER Working Paper #14017, May 2008.

[5] Broda, Christian and David E. Weinstein. "Getting Real about Real Wages," Columbia University mimeo, 2008.

[6] C. Broda, J. Greenfield, and D. E. Weinstein. "From Groundnuts to Globalization: A Structural Estimate of Trade and Growth," NBER Working Paper 12512, September 2006.

[7] Broda, Christian and David E. Weinstein. "Optimal Tariffs and Market Power: The Evidence," with Christian Broda and Nuno Limao, NBER Working Paper 12033, February 2006. *The American Economic Review* forthcoming.