Specific Trade Costs, Quality and Import Prices

Benjamin Bridgman*

Bureau of Economic Analysis

Preliminary

January 2013

Abstract

Quality differences are an essential feature of the recent trade literature. However, statistical agencies rarely adjust for quality in import prices since they lack the data required to make those adjustments. I show that two frequently used techniques used in international price measurement, matched modeling and dropping intermittently traded goods from the sample, may lead to mismeasurement. Specific (per unit) trade costs weaken the link between price and quality, a key assumption of match modeling. Intermittently traded goods are more responsive to shocks, so dropping them understates price movements. Using U.S. import data, I find these effects are quantitatively significant. The impact is strongest on imports from low income countries, which have become increasingly important import sources.

JEL classification: F1.

Keywords: Quality measurement; Import and export price indices; New goods.

*The views expressed in this paper are solely those of the author and not necessarily those of the U.S. Bureau of Economic Analysis or the U.S. Department of Commerce. Address: U.S. Department of Commerce, Bureau of Economic Analysis, Washington, DC 20230. email: Benjamin.Bridgman@bea.gov. Tel. (202) 606-9991. Fax (202) 606-5366.

1 Introduction

Recently, quality differences among internationally traded goods has received significant attention. It is an important feature of the data. For example, differing import quality across markets is a robust empirical finding[1]. Johnson (2011) shows that quality differences account for most firm heterogeneity in trade. Baldwin & Harrigan (2011) argue that trade models must account for such differences to match the data. However, international price indices generally do not make quality adjustments. In the United States, only a few goods (mostly capital goods) are explicitly adjusted for quality (Bureau of Economic Analysis 2011). Correctly accounting for quality difference is important to the measurement of real trade. Mismeasurement of trade filters into other indicators such as real GDP and productivity. (See Houseman (2007), Houseman, Kurz, Lengermann & Mandel (2011) and Feenstra, Reinsdorf & Slaughter (2013).)

While quality measurement is an issue for all price indices, it is a particular challenge for international prices. There has been a significant increase in the number goods that are traded. A large number of goods that are traded are only traded intermittently. The "new goods problem," determining the quality of new goods relative to previously traded ones, is a frequent issue in international prices. A lack of quantifiable characteristics or agency resources often prevent explicit adjustments for quality, such as hedonics.

Statistical agencies have developed techniques to deal with environments with shifting sets of goods. A common way of accounting for the quality of newly measured goods is matched modeling. If an explicit adjustments for quality cannot be done, a good may be matched to a similar good. The price difference is attributed to quality differences.

To avoid having frequent replacement of goods in the sample, sampling techniques drop intermittently traded goods. In the United States, this requirement leads to a majority of goods that are initially selected for inclusion in the sample being dropped (Bureau of Labor Statistics 1997). Price changes of consistently traded goods within a category stand in for all

[1] For example, see Hummels & Skiba (2004), Hallak (2006), Hallak & Schott (2011), Spearot (2011), Irarrazabal, Moxnes & Opromolla (2011), Manova & Zhang (2012) and Martin (2012).

goods in that category.

I examine these techniques in light of recent advances in trade theory. I use a version of the model in Baldwin & Harrigan (2011) to show theoretically that both methods are vulnerable to mismeasurement for goods with quality differences that pay specific (per-unit) trade costs. I then analyze the quantitative impact of these forces using U.S. import data.

I show theoretically that matched modeling will tend to overstate quality differences between goods. Specific trade costs weaken the link between price and quality. Prices are set as mark-up over production and trade costs. Lower quality goods cost less to produce and all goods pay the same specific cost regardless of quality. Therefore, a bigger share of a low quality good's price is due to trade costs. The price difference between goods will be smaller than their quality differences. Using matched modeling will tend to overstate real imports of new goods. Since matched modeling overstates the quality of new goods, it underestimates the (quality adjusted) price.

Dropping intermittently traded goods will tend to underestimate price changes. Specific trade costs make goods that enter and exit systematically different from continuing goods. Lower quality goods are the least profitable, so they are the most sensitive to cost changes. Relatively small cost changes can make a previously profitable market unprofitable, and vice versa. Low quality goods are more likely to be traded intermittently. Prices of these low quality goods are more sensitive to cost shocks.

I show that the quantitative impact of this mismeasurement can be significant. Applying matched modeling leads to significant overstatement of new good quality in some cases. For leather footwear, a major import category, matched modeling understates the quality gap between the highest and lowest quality goods by over 30 percent. The average impact has fallen over this period since transportation costs, which tend to be specific, have fallen.

The impact of dropping intermittently traded goods from the price sample has likely increased. The difference in price responsiveness of a good is proportional to the good's price. The price gap between continuing and newly traded goods have increased. In 2004, the unit value of new goods was half that of continuing goods. The model predicts that new goods are twice as responsive to cost shocks as previously traded ones.

This paper is part of a literature that examines mismeasurement of international prices. Feenstra & Romalis (2012) also examines international prices with specific trade costs. However, their focus is on macro level data, while I analyze the micro level data and the techniques used by statistical agencies. A number of papers have examined difficulties in matched modeling. Reinsdorf & Yuskavage (2011) examine country substitution bias, which arises when imports are sourced from new countries with different price levels. Nakamura & Steinsson (2012) and Gagnon, Mandel & Vigfusson (2012) look at whether the tendency to introduce price changes at product introduction biases import price indices. This paper is complementary to those papers as it looks at a different mechanism. Berman, Martin & Mayer (2012) examine whether entry and exit in response to exchange rates dampen the pass-through of exchange rate fluctuations. The mechanism is similar, though they do not examine its impact on statistical agency methods.

A theoretical literature examines how to accommodate new goods in international price measurement. Feenstra (1994) derives a method of calculating the ideal price index with new goods. This paper focusses on statistical agency practice and does not deal with welfare.

2 Model

The model adapted from that found in Bridgman (2013). This model is the based on the Quality Heterogeneous Firm Trade (QHFT) model developed Baldwin & Harrigan (2011) and similar to that of Gervais (2008).

2.1 Households

There are J countries. The preferences of the representative household in each country is given by:

$$U = \left(\sum_{i \in \Omega_j} (c_j(i)q(i))^{1-\frac{1}{\sigma}}\right)^{\frac{1}{1-\frac{1}{\sigma}}} \tag{2.1}$$

where $c_j(i)$ is units consumed of variety i in country j and Ω_j is the set of available varieties. The preference parameters $q(i)$ are the quality of the variety and $\sigma > 1$. The household is endowed with L units of labor.

2.2 Production

Consumption goods are produced using labor. The wage in country j is w_j. There is a constant set of firms each endowed with a technology to produce a variety. Output of a variety is $y(i) = \frac{L(i)}{a(i)}$. Higher cost firms produce higher quality goods. A firm with unit cost a produces a good of quality q according to:

$$q(i) = a(i)^{1+\theta} \tag{2.2}$$

where $\theta > 0$. The assumption that $\theta > 0$ implies the consumer's valuation of quality increases faster than marginal cost, so profit increases in marginal cost. Baldwin & Harrigan (2011) argue that the data support this assumption. Following Eaton, Kortum & Sotelo (2012), profits are spent outside the economy.

2.3 Trade

There are three costs to export a variety. There is a market entry fixed cost of $F_{od}^f(i)$ units of labor to export variety i from origin country o to destination country d. There is a specific (per unit) cost with unit labor requirement $F_{od}^s(i)$. Finally, there is an *ad valorem* charge $\tau_{od}(i)$. Given a mill price $p_{od}(i)$, consumers pay delivered price $p_d(i) = p_{od}(i)(1 + \tau_{od}(i)) + w_o F_{od}^s(i)$.

2.4 Solution

This section characterizes the solution but does not fully solve it. A full solution to the model would require specifying a distribution of unit costs. Since the results do not require a distribution, I do not fully close the model.

Each representative household chooses $c_j(i)$ for $i \in \Omega_j$ to maximize Equation 2.1 subject to $\sum_{i\in\Omega_j} p_j(i)c_j(i) \leq Lw_j$. For varieties that are available in a market, expenditure in destination country d is given by:

$$p_d(i)c_d(i) = [\frac{q(i)}{p_d(i)}]^{\sigma-1}B_d \tag{2.3}$$

where $B_d = \frac{w_d L_d}{P_d^{1-\sigma}}$ and

$$P_d = [\sum_i (\frac{p_d(i)}{q(i)})^{1-\sigma}]^{\frac{1}{1-\sigma}} \tag{2.4}$$

is the quality adjusted price index of destination country d. The demand function in terms of the mill price $p_{od}(i)$ in origin country o for a good exported to destination country d is $c_d(p_{od}(i)) = [q(i)]^{\sigma-1}[p_{od}(i)(1+\tau_{od}(i)) + w_o F^s_{od}(i)]^{-\sigma}B_d$.

Firms are monopolistic competitors that set prices to maximize profits. They can set different prices for each market. As a simplifying assumption, the firm takes the price index P as given[2]. The optimal mill price $p_{od}(i)$ is the solution to:

$$\max_{p_{od}(i)} p_{od}(i)c_d(p_{od}(i)) - w_o a(i)c_d(p_{od}(i)) - F^f_{od}(i)w_o \tag{2.5}$$

The mill price solution is $p_{od}(i) = \frac{w_o}{\sigma-1}[a(i)\sigma + \frac{F^s_{od}(i)}{1+\tau_{od}(i)}]$ which generates the delivered price $p_d(i) = \frac{w_o\sigma}{\sigma-1}[a(i)(1+\tau_{od}(i)) + F^s_{od}(i)]$.

The firm will only export if profits are non-negative. The goods that are available are determined by whether it is profitable to sell to the market. A variety i will be exported from origin country o to destination country d if

$$(\frac{a(i)^{1+\theta}}{a(i)+F^s_{od}(i)})^{\sigma-1}(\frac{\sigma-1}{w_o})^{\sigma-1}\frac{B_d}{(1+\tau_{od}(i))\sigma^\sigma} \geq F^f_{od}(i)w_o. \tag{2.6}$$

[2]This assumption provides closed form solutions for prices. As shown in Bridgman (2013), the impact of this assumption is small as long as there are a large number of varieties sold.

3 Results

This section examines the theoretical difficulties in adjusting for quality. I examine two methods used by statistical agencies that may be vulnerable to mismeasurement due to quality differences: Matched modeling and dropping intermittently traded goods from the sample. I show that specific trade costs interfere with the assumptions that support the use of these methods.

In what follows, I will focuss on how statistical agencies measure international price change. The U.S. Bureau of Labor Statistics uses a Laspeyres index for its import prices indices (Bureau of Labor Statistics 1997). The expression for the index measuring a price change from period 0 to period t is:

$$P_t = \sum_i \frac{\omega_t(i)}{\sum_i \omega_t(i)} \frac{p_{od,t}(i)}{p_{od,0}(i)} \tag{3.1}$$

where $\omega_t(i) = p_{od,t}(i)c_{d,t}(i)$.

This measure is distinct from the theoretical price index that measures the welfare effects of price change. Bureau of Labor Statistics (1997) states explicitly that the purpose of the international price indices is not to measure welfare.

To isolate the differential impact of costs on price across goods of different qualities, I assume throughout this section that trade costs are the same for all varieties.

3.1 Matched Modeling

Matched modeling works off the assumption that if two similar goods are available in the market at different prices, the price gap reflects differences in quality. We can recover the quality gap between an existing and new good by examining the price gap. In this section, I show that specific costs weaken the link between price and quality.

Without specific costs ($F^s = 0$), prices closely reflect quality. The relationship between unit cost $a(i)$ and quality $q(i)$ can be written as $a(i) = q(i)^{\frac{1}{1+\theta}}$. The relative price of two goods

i and i' that only differ in quality is:

$$\frac{p_{od}(i)}{p_{od}(i')} = \frac{\frac{q(i)^{\frac{1}{1+\theta}}\sigma w_o}{\sigma-1}}{\frac{q(i')^{\frac{1}{1+\theta}}\sigma w_o}{\sigma-1}} = [\frac{q(i)}{q(i')}]^{\frac{1}{1+\theta}} \tag{3.2}$$

In this case, matched modeling works well. As long as wages faced by the producers of the two products is the same, the price difference reflects only quality differences. If a comparison good from a producer with similar input costs can be found (for example, from the same country), matched modeling is a practical method for dealing with the new good problem[3].

This clear relationship between price and quality breaks down with specific costs. The relative price is now:

$$\frac{p_{od}(i)}{p_{od}(i')} = \frac{q(i)^{\frac{1}{1+\theta}}\sigma + \frac{F^s_{od}}{1+\tau_{od}}}{q(i')^{\frac{1}{1+\theta}}\sigma + \frac{F^s_{od}}{1+\tau_{od}}} \tag{3.3}$$

As the specific cost term increases, prices are determined more by trade costs than quality. Breaking the relationship between price and quality makes matched modeling more difficult. In matched modeling, the price gap between an old and new good is attributed to quality. As Proposition 3.1 shows, this method underestimates the quality gap.

Proposition 3.1. *Suppose* $a_L < a_H$*. Then* $\frac{p_o(L)}{p_o(H)} > \frac{q_L}{q_H}$.

Proof. From the solution to the model, $\frac{p_o(L)}{p_o(H)} > \frac{q_L}{q_H}$ if

$$\frac{\frac{w_o}{\sigma-1}[a(L)\sigma + \frac{F^s_{od}}{1+\tau_{od}}]}{\frac{w_o}{\sigma-1}[a(H)\sigma + \frac{F^s_{od}}{1+\tau_{od}}]} > [\frac{a(L)}{a(H)}]^{1+\theta} \tag{3.4}$$

This condition holds if $a(H)\sigma[(\frac{a(H)}{a(L)})^\theta - 1] + \frac{F^s_{od}}{1+\tau_{od}}[(\frac{a(H)}{a(L)})^\theta - 1] > 0$. This condition is always true since $\frac{a(H)}{a(L)} > 1$ and $\theta > 0$ by assumption.

□

[3]There are other issues with match modeling. If there are menu costs, firms may use the introduction of new models as an opportunity to change prices (Nakamura & Steinsson 2012). That concern does not arise in this model since prices are fully flexible and there is no strategic or informational reasons for not adjusting prices. Therefore, that literature is complimentary to this paper.

The specific cost F^s_{od} has more influence on the price of low quality goods. Therefore, the price difference will be smaller than quality differences. New goods are of lower quality than prices indicate. This force will tend to overstate the imports of new goods.

3.2 Sampling

Statistical agencies cannot collect price data for all goods that are traded. They must use a sub-sample to stand in for non-sampled goods. Since statistical agencies want to track changes in prices over time, they do not collect prices for intermittently traded goods. The BLS drops a majority of its sample since most categories "do not contain items that are traded frequently enough to be consistently priced over time." Only 40 percent of the sample yields a usable price series (Bureau of Labor Statistics 1997).

As long as the non-sampled prices move in the same way as the sampled goods, this method gives accurate price measures. However, specific trade costs can introduce differences. Newly and intermittently traded goods are likely to have systematically lower quality than continuing goods. These lower quality goods react to trade cost changes differently, so deflating these goods by prices of high quality goods can lead to mismeasurement.

3.2.1 Quality of New Goods

Newly traded goods tend to be of lower quality than continuing goods. Since lower quality goods are the least profitable, they are the most sensitive to cost changes. High quality goods exporters will serve even high trade cost markets since they have high margins. Low quality good, low margin exporters are much closer the zero profit cutoff. Relatively small cost increases can make a market unprofitable, so they are the most likely to exit.

In what follows, I will vary a cost and hold all other quantities constant. That is, if an exercise changes specific trade cost $F^s_{od,t+1} \neq F^s_{od,t}$, all other trade costs and wages are held constant: $F^f_{od,t+1} = F^f_{od,t}$, $\tau_{od,t+1} = \tau_{od,t}$ and $w_{o,t+1} = w_{o,t}$.

Define cutoff quality $\overline{q}_{od}$ as the quality level that sets Equation 2.6 at equality. Changes in trade costs or input prices will change this cutoff. Lemma 3.2 shows that falling wages and trade costs (holding the other quantities constant) will lead to entry of low quality goods.

Lemma 3.2. *Holding all other quantities constant, if any of the following conditions hold:*

1. $F^s_{od,t+1} < F^s_{od,t}$,
2. $F^f_{od,t+1} < F^f_{od,t}$,
3. $\tau_{od,t+1} < \tau_{od,t}$
4. $w_{o,t+1} < w_{o,t}$

then $\overline{q}_{od,t+1} < \overline{q}_{od,t}$.

Proof. For proofs of the first three conditions, see Lemmas 3.3, 3.5 and 3.7 in Bridgman (2013). For the final condition, rearranging the cut-off condition (Equation 2.6) gives us:

$$(\frac{a(i)^{1+\theta}(\sigma-1)}{a(i)+F^s_{od}(i)})^{\sigma-1}\frac{B_d}{(1+\tau_{od}(i))\sigma^\sigma} \geq F^f_{od}(i)w^\sigma_o. \tag{3.5}$$

If $w_{o,t+1} < w_{o,t}$, the RHS of the condition falls. This decline is equivalent to the fixed cost $F^f_{od,t}$ falling. Following the proof of Lemma 3.5 in Bridgman (2013), this implies that $\overline{q}_{od,t+1} < \overline{q}_{od,t}$. □

3.2.2 Quality and Price Changes

The fact that new and intermittently traded goods are lower quality would not be a problem for sampling if the prices of low and high quality goods were the same. However, low quality goods react more to cost changes more than high quality goods. Since more of the price of low quality goods reflects trade costs, they are more sensitive to changes in these costs. Low quality goods prices fall (rise) more when specific trade costs fall (rise) than higher for higher quality goods. I show this formally in Proposition 3.3.

Proposition 3.3. *If* $a(H) > a(L)$ *and either*

1. $F^s_{od,t+1} \neq F^s_{od,t}$ *or*

2. $\tau_{od,t+1} \neq \tau_{od,t}$

then $\left|\frac{p_{t+1}(L)-p_t(L)}{p_t(L)}\right| > \left|\frac{p_{t+1}(H)-p_t(H)}{p_t(H)}\right|$.

Proof. Define $\Delta p(i)$ by $p_{t+1}(i) = p_t(i)+\Delta p(i)$. For the condition $\left|\frac{p_{t+1}(L)-p_t(L)}{p_t(L)}\right| > \left|\frac{p_{t+1}(H)-p_t(H)}{p_t(H)}\right|$ to hold, we have $\left|\frac{\Delta p(L)}{p_t(L)}\right| > \left|\frac{\Delta p(H)}{p_t(H)}\right|$. If either trade cost ($F^s_{od,t}$ or $\tau_{od,t}$) change, $\Delta p(L) = \Delta p(L)$. Formally, if $F^s_{od,t+1} \neq F^s_{od,t}$ then $\Delta p(L) = \Delta p(H) = \frac{F^s_{od,t+1}-F^s_{od,t}}{1+\tau}$ and if $\tau_{od,t+1} \neq \tau_{od,t}$, then $\Delta p(L) = \Delta p(H) = \frac{F^s_{od}}{1+\tau_{od,t+1}} - \frac{F^s_{od}}{1+\tau_{od,t}}$. The condition holds if $\frac{1}{p_t(L)} > \frac{1}{p_t(H)}$. Since $a(H) > a(L)$, $p(H) > p(L)$ and the condition holds. □

Since they show more price volatility, dropping low quality goods will tend to underestimate price changes. To see this more concretely, consider the case where both a high and low quality good ($c(H)$ and $c(L)$ respectively) are traded in a category but only the high quality good is included in the sample. Suppose the specific cost falls ($F^s_t < F^s_{t-1}$). The measured price change for the category is $P^M_t = \frac{[\omega_t(H)+\omega_t(L)]}{\sum_i \omega_t(i)} \frac{p_t(H)}{p_{t-1}(H)}$. The price change should be $P_t = \frac{\omega_t(H)}{\sum_i \omega_t(i)} \frac{p_t(H)}{p_{t-1}(H)} + \frac{\omega_t(L)}{\sum_i \omega_t(i)} \frac{p_t(L)}{p_{t-1}(L)}$. By Proposition 3.3, $\frac{p_{t+1}(L)}{p_t(L)} > \frac{p_{t+1}(H)}{p_t(H)}$. That implies that

$$\frac{\omega_t(H)}{\sum_i \omega_t(i)} \frac{p_t(H)}{p_{t-1}(H)} + \frac{\omega_t(L)}{\sum_i \omega_t(i)} \frac{p_t(H)}{p_{t-1}(H)} > \frac{\omega_t(H)}{\sum_i \omega_t(i)} \frac{p_t(H)}{p_{t-1}(H)} + \frac{\omega_t(L)}{\sum_i \omega_t(i)} \frac{p_t(L)}{p_{t-1}(L)} \tag{3.6}$$

Therefore, $P^M_t > P_t$ so the measured price change underestimates the price fall.

4 Empirical Evidence

The previous section showed theoretically that specific trade costs can lead to mismeasurement. In this section, I examine how important this mismeasurement is empirically.

This section only performs an initial assessment of the empirical scope of the theoretical mechanisms. It does not “fix” the import price index. While I find that these mechanisms appear to have a quantitative impact in some cases, doing a full adjustment of the data will require additional work.

4.1 Data

The basic data I use in the data analysis is U.S. goods import data from the Census Bureau, as collected by Hummels (2007). These data give trade valued on a customs value (FOB), tariffs, freight charges and weight of shipments from 1974 to 2004. A "good" is a SITC revision 2/country of origin pair.

There are a couple of caveats to using these data. They are *not* the data that are used by statistical agencies to calculate import price indices. The price concept I use is unit value (value per weight) rather than a price per product. A product is much more aggregated compared to the prices used by statistical agencies, so will likely underestimate the real impact of specific costs. Further, the analysis does not cover all trade. Weight data only cover shipments brought in by water or air. Therefore, the portion of trade with Mexico and Canada shipped by rail or truck is excluded. Further, not all goods report a weight.

Despite the limitations of the data, they do have advantages that lead me to use them. Most importantly, they are publicly available unlike the microdata. Quality variation across exporters and locations is a robust finding. For example, see Hummels & Klenow (2005), Choi, Hummels & Xiang (2009) and Bastos & Silva (2010). Therefore, country level variation generates sufficient quality differences to get a first pass impact of quality difference on price measurement.

In what follows, I assume that tariffs are all *ad valorem* charges and freight rates are all specific costs. That is, $\tau_{od}(i)$ is the tariff rate and $w_o F^s_{od}(i)$ is freight charge per kilogram. Price $p_{od}(i)$ is unit value. Hummels & Skiba (2004) among many others, find that freight rates are charged on a specific basis. Tariffs in the postwar era are typically charged on an *ad valorem* basis.

4.2 Matched Modeling

As documented in Proposition 3.1, specific trade costs change the relationship between quality and price compared to the case without such costs. To get an empirical measure of this impact, I compare the model's estimates of the cost parameter $a(i)$ with and without specific costs. Since we know that specific costs are present, I will assume that the specific trade cost model is the "true" model. I will use the ratio of the "true" $a(i)$ and the estimate without these costs, as is usually assumed, as my indicator of quality mismeasurement.

The mill price is given by $p_{od}(i) = \frac{w_o}{\sigma-1}[a(i)\sigma + \frac{F^s_{od}(i)}{1+\tau_{od}(i)}]$. We can rewrite this equation:

$$a(i)w_o = \frac{1}{\sigma}[p_{od}(i)(\sigma-1) - \frac{w_o F^s_{od}(i)}{1+\tau_{od}(i)}] \tag{4.1}$$

Neglecting the impact of specific costs (setting $F^s = 0$) will give an estimate of $\hat{a}(i)$:

$$\hat{a}(i)w_o = \frac{p_{od}(i)(\sigma-1)}{\sigma} \tag{4.2}$$

Taking the ratio gives us a measure of the overstatement of quality differences from assuming only *ad valorem* costs[4].

$$\frac{a(i)}{\hat{a}(i)} = 1 - \frac{w_o F^s_{od}(i)}{p_{od}(i)(1+\tau_{od}(i))(\sigma-1)} \tag{4.3}$$

Specific trade costs are more likely to be an issue when one or more of the following are true.

1. High specific cost goods (high F^s)

2. Low quality goods (low $a(i)$)

3. Inelastically demanded goods (low σ)

[4]Quality is actually a function of this cost $q(i) = a(i)^{1+\theta}$. By only examining the ratio of the $a(i)$, we do not have assign a value for θ. This ratio shows the impact of specific trade costs on quality measurement, but we would need a value of θ to assess the impact on welfare measurement.

4.2.1 Micro Analysis

I begin the empirical analysis by examining one good, leather footwear, in detail. I selected this good for a number of reasons. It is one of the ten largest import categories in the period examined. A wide variety of countries export this good to the United States, with the potential for significant quality differences. In addition, there are few observable attributes that can be used for hedonic quality adjustment. Therefore, there may be room for alternative methods such as the one proposed in this paper.

Table 1: Leather Footwear $a(i)$ Ratios

	Switzerland 1974	Sri Lanka 1974	Switzerland 2004	Sri Lanka 2004
P_o	15.41	2.97	30.97	13.01
$F^s w_o$	0.70	0.93	1.49	0.80
τ	0.08	0.13	0.08	0.11
$\frac{\hat{a}(i)}{a(i)}$	1.043	1.373	1.046	1.057

I need a value of σ to estimate the mismeasurement. I use a value of 2.02, taken from Broda & Weinstein (2006)[5]. Table 1 reports the estimated $a(i)$ ratio for Switzerland and Sri Lanka at the beginning and end of the sample period. I use these two counties since they represent the high and low ends of unit value, with Swiss exporters charging nearly four times the price of their Sri Lankan counterparts in 1974. This spread reflects the fact the richer countries tend to export higher quality goods (Fajgelbaum, Grossman & Helpman 2011).

In 1974, the impact of specific costs on mismeasurement is much stronger for Sri Lanka than it is for Switzerland. Price overstates quality by nearly 40 percent for Sri Lanka, whereas it is only 4 percent for Switzerland. FOB prices are selected as a mark-up over production

[5] This value is the 1974-1988 value for SITC revision 2 code 85102 taken from the working paper version (Broda & Weinstein 2004). The published version reports elasticities for the more aggregated three digit SITC level, while the working paper reports at the five digit level.

cost, which is correlated with quality, and specific cost, which is not. For Switzerland, trade costs are low relative to price. Therefore most of the price reflects production cost, which reflects quality. Specific costs relative to unit value are much higher for Sri Lanka, so more of the charged price is a mark-up over trade costs. In 2004, Sri Lanka's mismeasurement falls significantly. Specific costs relative to unit value are much lower. Switzerland and Sri Lanka are much more similar in cost structure, so prices are more reflective of quality.

If each good was mismeasured by the same amount, there would be no impact on matched modeling. As shown above, specific costs affect low quality goods more so we would not expect the impact to be the same. To measure the impact on measurement, we need to compare goods across producers. An issue with the trade data is that the producers are different countries, so input costs are unlikely to be the same. The price levels of wealthier countries tend to be higher, the "Penn effect". (See Jaime Marquez & Land (2012) for a recent empirical confirmation of this effect.) Certainly, wages in Switzerland and Sri Lanka are different.

We can use the model to eliminate the wages from our estimates. If good k is produced by countries i and j, the price ratio without specific costs is $\frac{p_i(k)}{p_j(k)} = \frac{w_i \hat{a}_i(k)}{w_j \hat{a}_j(k)}$. The equivalent ratio with the true $a(i)$ ratio is:

$$\frac{w_i a_i(k)}{w_j a_j(k)} = \frac{w_i \hat{a}_i(k)}{w_j \hat{a}_j(k)} * \frac{a_i(k)}{\hat{a}_i(k)} * \frac{\hat{a}_j(k)}{a_j(k)} \tag{4.4}$$

The degree to which matched modeling underestimates quality gaps is:

$$\frac{w_i a_i(k)}{w_j a_j(k)} * \frac{w_j \hat{a}_j(k)}{w_i \hat{a}_i(k)} = \frac{a_i(k)}{\hat{a}_i(k)} * \frac{\hat{a}_j(k)}{a_j(k)} \tag{4.5}$$

In 1974, the unadjusted price ratio overstate the quality difference by 32 percent. The unadjusted price ratio ($\frac{w_i \hat{a}_i(k)}{w_j \hat{a}_j(k)}$) is 5.19 while the adjusted ratio ($\frac{w_i a_i(k)}{w_j a_j(k)}$) is 6.83. In 2004, the overstatement falls to 1 percent. Since Swiss and Sri Lankan costs are more similar, so is the degree of mismeasurement. Therefore, the data better reflect the assumptions of matched modeling.

Overstating the quality of new goods will overstate imports. The effect is strongest for low quality goods. Therefore, this effect will tend to overstate the U.S. trade deficit.

American producers tend to produce higher quality goods since the U.S. is a high income country. U.S. imports have begun to shift to lower income countries, for whom the effect is stronger. Therefore, imports are more likely to be overstated than exports.

The size of the mismeasurement is sensitive to the elasticity used. For example, the $a(i)$ ratio for Sri Lanka in 1974 drops from 1.37 to 1.10 if σ is increased from 2.02 to 4. On the other hand, the ratio jumps up to 2.24 if σ falls to 1.5. The elasticity governs the degree to which price is mark-up over cost. For low values of σ (inelastic goods), there are high mark-ups that magnify the impact of specific costs.

4.2.2 Aggregate Analysis

I now turn to the aggregate effect on quality measurement. I use $\sigma = 4$ for all goods. This is the value that Simonovska & Waugh (2011) settle on a consensus value using U.S. data and is within the usual range use in the literature. This will tend to underestimate the impact, since more differentiated goods tend to have lower value of σ.

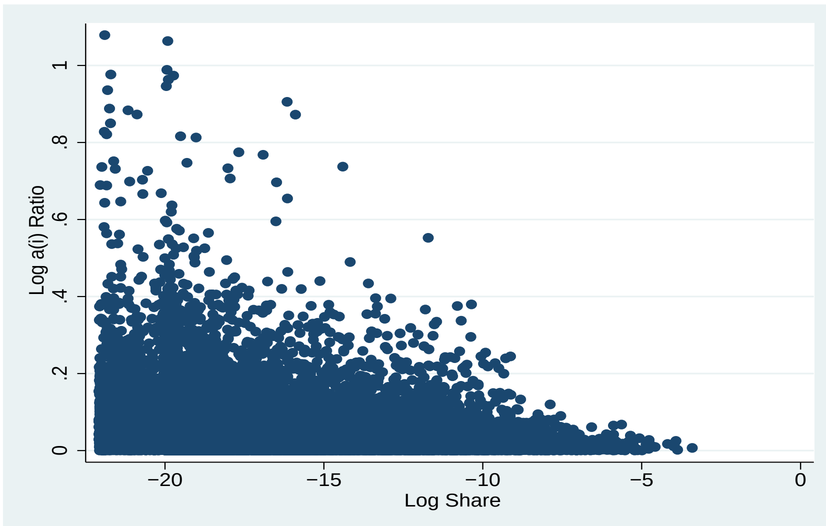
The impact of specific costs is heterogeneous. The range is large, from a ratio of 1 (no distortion) to 3 (200 percent overstatement). The average $\frac{\hat{a}(i)}{a(i)}$ ratio over the sample is 1.039, with a standard deviation of 0.067.

The goods with the largest ratios are those shipped by air. The mismeasurement is larger for goods with high specific trade costs. Since air charges are much larger than by water, goods shipped mostly or exclusively by air are more subject to this distortion.

So far, I have treated each good equally. To get a sense of the overall impact, Figure 2 plots the $a(i)$ ratio against its share in total imports within the sample for 2004[6] The most distorted goods tend to be a smaller share of imports. However, there are a number of goods that are relatively important with significant distortion.

[6] I log both variables to make the figure easier to see. I use 2004, the final year of the sample, since it has the most observations.

Figure 1: Log $a(i)$ Ratio vs. Log Share 2004 ($\sigma = 4$)



As a measure of the aggregate impact, I calculate a trade weighted ratio of all goods.

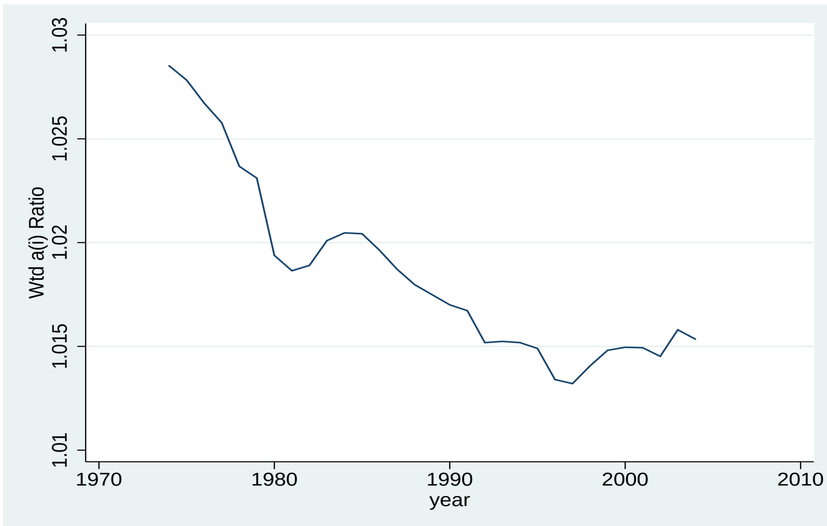
$$\sum_i s_i \frac{w_i \hat{a}(i)}{w_i a(i)} \tag{4.6}$$

where $s_i = \frac{p_o(i)c(i)}{\sum_i p_o(i)c(i)}$.

Figure 3 shows the weighted ratio. It declined from 1.029 to 1.015. This decline follows the fall in freight rates documented in Hummels (2007). Of course, what matters for matched modeling is the relative mismeasurement within a category. As shown above with Sri Lankan shoes, the decline in specific costs will reduce the scope of this source of mismeasurement. Since the typical good's price reflects its quality more over time, the typical relative mismeasurement will likely decline as well.

The matched modeling issue may be important for at least some goods. There is reason to believe that this calculation underestimates the degree of mismeasurement. The data may understate actual specific costs. They do not include any other specific costs that accrue due to internal transportation, wholesale and retail trade. Rousslang & To (1993) find that internal

Figure 2: Weighted $a(i)$ Ratio ($\sigma = 4$)



trade barriers are significant. Internal transportation costs are 37 percent of international rates. If any of these costs are specific, these estimates will be too low. Using Norwegian data, Irarrazabal et al. (2011) estimate that the median specific trade cost is 34 percent of a good's value.

Using the same σ for all goods understates the impact on some differentiated goods whose demands that are less elastic than $\sigma = 4$. If we set $\sigma = 2$, the magnitude of the average mismeasurement increases to 9.9 percent in 1974 and 5.4 percent in 2004.

Even if the impact for the average good is small, there are some goods for which it is likely to matter. Lower income countries, which tend to produce lower quality goods, have become more important in U.S. imports. The shift to air transportation, which has much higher freight rates, increased the specific cost for some goods.

4.3 Sampling

The model predicts that new and intermittently traded goods are of lower quality than continuing goods. Goods that were not traded in the previous year have lower unit values. This set of goods includes both completely new goods and intermittently traded goods that are imported again. Figure 4 shows that newly traded goods enter at lower quality[7]. Trade costs are similar across the two sets of goods.

This evidence provides support to the prediction that non-sampled goods are lower quality than continuing goods. These data do not allow us to assess the quantitative impact of sampling since we cannot identify which goods are excluded from the sample.

However, we can do a back of the envelope calculation to get a sense of quantitative impact. I examine the impact of trade cost changes for low and high quality goods. Specifically, I compare what the theory predicts the new prices would be if F^s changed to $F^{s,\prime}$. To parameterize the exercise, I use new and old goods in 2004 as reported in Figure 4. I identify old and new goods as high and low quality goods respectively. Their prices are $p_o(H)$ and $p_o(L)$. (H and L for high and low.)

Equation 4.1 gives us $a(i)w_o$. Using the price equation, we can calculate $p_o'(i)$ for $i \in \{H, L\}$, the predicted price when F^s changes to $F^{s,\prime}$ and all other quantities are held constant.

If trade costs F^s and τ are the same for high and low quality goods, which is the case for new and old goods in 2004, the relative growth rate of prices is:

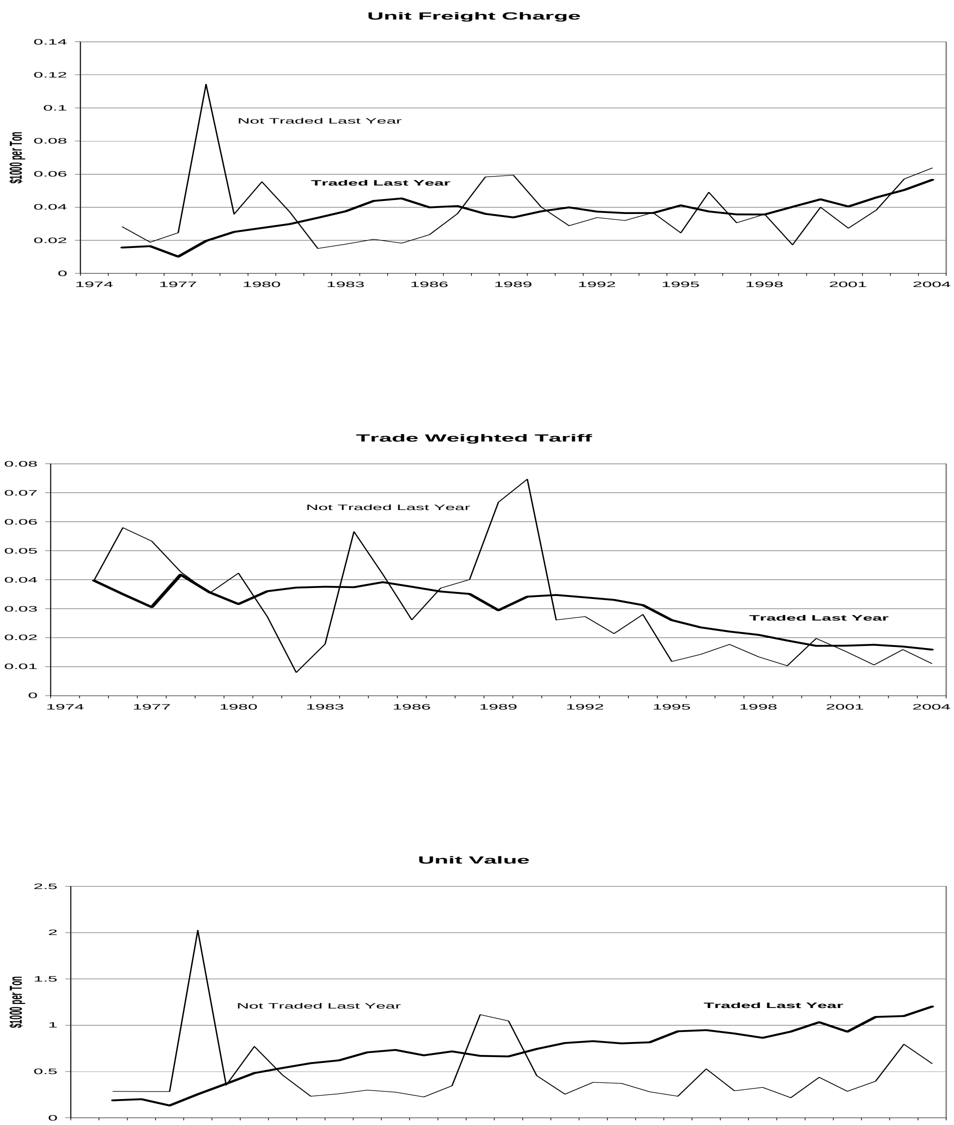
$$\left(\frac{p_o'(H)}{p_o(H)} - 1\right)/\left(\frac{p_o'(L)}{p_o(L)} - 1\right) = \frac{p_o(L)}{p_o(H)} \tag{4.7}$$

In 2004, we have $\frac{p_o(L)}{p_o(H)} = \frac{0.59}{1.20} = 0.49$. Therefore, high quality goods are half as responsive to a change in specific trade costs.

While this example is quite stylized, it indicates that there can be significant differences in price responsiveness among goods of different quality. Using only high quality goods will

[7]This information was presented in Figure 2 from Bridgman (2013).

Figure 3: Trade Weighted Import Costs of New and Old Goods 1975-2004



tend to underestimate price changes. The price gap between new and old goods has been increasing, suggesting that this source of mismeasurement may be becoming more important.

5 Conclusion

This paper shows that two frequently used techniques used in international price measurement, matched modeling and dropping intermittently traded goods from the sample, will mismeasure prices when there are quality differentiated goods and specific trade costs. Specific costs weaken the link between a good's quality and its price. This effect causes matched modeling to overstate the quality of low quality goods. Intermittently traded goods are typically low quality goods, those whose prices are most sensitive to shocks. Removing them from the sample will understate price movements. These effects may lead us to overstate the amount of trade from new, low income exporters, since they tend to produce lower quality goods. Determining the extent of this overstatement will require additional work using more granular data. However, initial data work indicates that these effects are quantitatively important.

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