NBER WORKING PAPER SERIES

STICKY BORDERS

Gita Gopinath
Roberto Rigobon

Working Paper 12095
http://www.nber.org/papers/w12095

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
March 2006

We are extremely thankful to the International Price Program of the Bureau of Labor Statistics for providing us with access to the micro data. We especially thank Bill Alterman, Andrew Cohen, Dave Mead, Tien Nguyen, Molly Shannon and Daryl Slusher for all their invaluable help. We are especially grateful to our project coordinator Rozi Ulics for all her help. We also thank Alberto Alesina, Martin Feldstein and the NBER for facilitating the contract with the BLS. We thank Mark Aguiar, Pol Antras, Ariel Burstein, Doireann Fitzgerald, Jordi Gali, workshop participants at MIT (Faculty workshop), the NBER Fall IFM, Harvard, Boston College and the Kennedy School (LIEP), for useful comments. We also thank Tim Schwuchow for excellent research assistance. The views expressed herein are those of the author(s) and do not necessarily reflect the views of the National Bureau of Economic Research.

Sticky Borders
Gita Gopinath and Roberto Rigobon
NBER Working Paper No. 12095
March 2006
JEL No. F30

ABSTRACT

The stickiness of traded goods prices and the currency in which prices are sticky play a central role in international macroeconomics. Despite the existence of a rich theoretical literature, there is very little empirical evidence that directly measures the extent of price stickiness in traded goods prices. To address these questions, we use unpublished micro data on import and export prices at-the-dock for the United States for the period 1994-2005. We present three main results: First, the trade weighted average price duration in dollars is 12.26 months for imports and 13.77 months for exports. This level of stickiness is about twice as high as recent evidence on retail goods prices. The fact that both imports and exports are sticky in dollars suggests that contrary to standard modeling assumptions there is producer currency pricing in U.S. exports and local currency pricing in U.S. imports. Second, there is tremendous heterogeneity in price duration across goods, with differentiated goods adjusting prices far less frequently than homogenous goods. Further, the degree of stickiness does not change dramatically with exchange rate volatility. Third, we document that the degree of stickiness in import prices has been increasing throughout the last 10 years, with very little of this increase explained by a compositional shift from homogenous to differentiated goods.

Gita Gopinath
Department of Economics
Harvard University
1875 Cambridge Street
Littauer Center
Cambridge, MA 02138
and NBER
gopinath@fas.harvard.edu

Roberto Rigobon
Sloan School of Management
MIT, Room E52-431
50 Memorial Drive
Cambridge, MA 02142-1347
and NBER
rigobon@mit.edu

1 Introduction

Sticky prices of traded goods play a central role in international macroeconomics. The Mundell-Fleming models of the nineteen sixties, Dornbusch's overshooting exchange rate hypothesis, and the more recent New Open Economy Macroeconomics literature assign a central role to nominal rigidities. Further, the currency in which prices are sticky and whether there is so called producer currency pricing or local currency pricing, both have important implications for exchange rate pass-through and international spill-over effects of monetary policy. Despite this rich theoretical literature, there is very little empirical evidence that directly measures the extent of price stickiness and the currency of stickiness in import and export prices.

To address these questions, this paper uses a novel data set to present extensive evidence on price stickiness at the border. We use unpublished micro data on import and export prices collected by the Bureau of Labor Statistics for the United States for the period 1994-2005. We present three main results: First, prices are sticky in US dollars for more than a year, both for imports and exports. Second, there is tremendous heterogeneity across goods. Goods that are more homogeneous adjust prices almost every month, while differentiated goods are sticky for over a year. Third, the degree of stickiness in import prices has been increasing throughout the last 10 years.

More specifically, we find that the trade weighted average price duration in dollars is 12.26 months for imports and 13.77 months for exports. If we compare these numbers to the recent evidence by Bils and Klenow (2004) for U.S. retail prices in the consumer price index, the stickiness at the dock is at least twice as high as the stickiness at the retail level. Bils and Klenow (BK, 2004), using micro CPI data show that price changes are far more frequent than earlier studies have found for domestic prices, with half of goods prices fixed for less than 4.3 months. When we match the BK classification of goods with the mostly 4 digit harmonized code classification in our database for imports, we estimate a mean duration of 11.68 months for prices at the dock, while BK estimate a mean duration of 3.93 months for retail prices. In almost all matched categories price stickiness at the border is at least as great and in most cases substantially greater than stickiness at the retail level.

The significant difference in the stickiness between 'at the dock' and retail prices suggests caution in inferring the behavior of prices of actual traded goods from the behavior of so called 'tradable goods' in the CPI. Clearly, there are several reasons why there might be a disconnect between the two. Firstly, most goods entering the CPI could be produced only for local consumption, secondly, most retail prices include a large distribution component that is non-traded (Burstein-Eichenbaum-Rebelo (2004)) and at the dock transactions take place between firms unlike transactions that enter the CPI. While these are perfectly valid reasons there is little empirical work that documents how differently these prices behave. Our evidence suggests an important dimension along which the two differ.

A related finding is with regard to the currency in which prices are sticky. While it might not be surprising that most U.S. imports and exports are invoiced in dollars, it is less obvious that dollar prices should remain unchanged as long as they do for both. This has important implications for theoretical models. It is typically assumed that prices are sticky either in the local currency or in the producers currency and this assumption is symmetric across countries. In the case of the U.S, contrary to this assumption, we find local currency pricing for imports and producer currency pricing for exports. This suggests an asymmetry in terms of which country bears the risk of exchange rate movements. Further, we find that the prices of goods invoiced in a foreign (non-dollar) currency are about as sticky in foreign currency terms as dollar invoiced prices. That is, if we analyze countries for which some goods are invoiced in non-dollar currency, the average duration of stickiness in terms of the non-dollar currency is similar to the stickiness of dollar priced goods in dollars. In a reduced form sense, this is similar to the assumptions we make in our models, where a firm picks a currency to price in and keeps prices stable in that currency. What is different though, is that for the case of the U.S., both imports and exports are priced in and sticky in dollars.

Our second finding is that there is a large amount of heterogeneity in price stickiness across highly disaggregated goods. The mean duration of prices for imports is 12.48 months and the standard deviation is 14.86 months. Similarly, in the case of exports, the mean duration is 13.62 months with a standard deviation of 14.79 months. This dispersion is partly explained by the mix of homogenous and differentiated goods in trade. Using Rauch's (1999) classification, we find that the mean duration of prices is 4.18 months for the organized exchange category, while it is 9.43 months for the reference good category and 13.57 months for the differentiated goods category. The currency in which the price is set also plays an important role, given the stickiness in the currency. The dollar prices of goods priced in a non-dollar currency change almost every other month. Consequently, even within the pool of differentiated goods, there are goods whose prices change very frequently.

One variable that explains very little of this dispersion is the volatility of the exchange rate during the life of the good. Exchange rate volatility weakly effects the duration only at extreme levels of exchange rate movements. This finding is confirmed when we compare the pre and post average probability of price changes during foreign country devaluation episodes and find little difference. Another variable that seems to contribute little to explaining this dispersion, is whether a good is sold 'intra-firm' that is between a parent and an affiliate or to an unrelated party. While we obtain a very precise estimate of the difference, it is quite small. Prices for intra-firm transactions are more sticky by around a month.

Finally, we find that the degree of stickiness has been changing over time in U.S. imports. In particular, the average probability of price change has declined by 10 percentage points from 1994 to 2004. This has important implications for the measurement of pass through at the aggregate level: if stickiness is increasing, then the average pass-through of the exchange rate into U.S. import prices should be declining, all else equal. Indeed, several authors such as Taylor (2000), Marazzi et al (2005) and Campa and Goldberg (2005) have documented the phenomena of declining pass-through at the aggregate level in the 1990s relative to earlier decades. Frankel, Parsley and Wei (2005) also document evidence of declining pass-through using 8 narrowly defined brand commodities. There are several proposed hypothesis for explaining this decline. Some explanations rely on a composition effect- that is the shift from more homogenous goods to differentiated goods, or the shift in country composition towards developing countries such as Mexico and China. When we decompose the increase in price stickiness into composition vs. time varying effects we find that almost all of the decline is explained by within-sector (that is, homogenous and differentiated) and within country time trends and very little by a composition story. The sharpest increase in price stickiness is documented in the differentiated goods sector and within this the decline is across the board in both consumer goods and capital goods. There is no similar evidence of a substantial trend increase in price stickiness in U.S. exports during this period.

To perform the analysis in this paper we have to deal with two econometric challenges: censoring and individual heterogeneity in the data. Censoring takes place for several reasons. First, the life of the goods are relatively short. Items in the data set are supposed to last at least five years, but that is rarely the case. This shorter life is due to the fact that several goods are discontinued after a couple of years, either because the item is upgraded, or simply not sold anymore or there is lack of reporting. This generates censoring at the end of the price series. Second, if the good is not traded or no price is reported there is no information about the price of the item that month, creating missing values in the middle of the price series. These issues together with the fact that prices are sticky roughly for a year makes the problem of censoring severe. Indeed, in our data set, approximately one-third of the items experience no price change at all, in their entire life. The second problem is the heterogeneity at the good level and the consequent aggregation biases that can result from it. To deal with these issues we present several alternative aggregate estimates that take into account heterogeneity and censoring.

The existing literature on international prices that uses micro data has focused mainly on retail prices. Goldberg and Knetter (1997) present a detailed survey of this literature. In more recent work, Crucini, Telmer and Zachariadis (2005) use surveys of retail prices in countries in the European Union to test the law of one price at the retail level. Frankel, Parsley and Wei (2005) use retail price data of 8 narrowly defined brand commodities for a large number of countries to examine theories of pass-through. Since retail prices include local distribution costs, they include a non-traded price component. To analyze the pure trade component we focus on at-the-dock prices. The literature on at-the-dock prices has used mainly aggregate price measures. Knetter (1989 and 1993) used 7 digit industry level unit-value data to measure price discrimination by exporters. Campa and Goldberg (2005) use aggregate import price indices to measure pass-through at the dock. To address the question of price stickiness at the dock, however, we require information on the price of a very precisely defined good over time. For this purpose, unit value data is clearly insufficient. The BLS data provides us with information on the price of close to 100000 extremely detailed U.S. import and export goods. To the best of our knowledge, this data is quite unique in terms of the level of detail of the good being followed over time, the relevant information on the goods and the number of goods covered as compared to other studies of international prices.

The paper is organized as follows: Section 2 describes the data we use. Section 3 documents the degree of price stickiness. Section 4 studies how the degree of stickiness is related to good and transaction characteristics. Section 5 analyses the time trend in price stickiness. Section 6 presents conclusions and directions for future research.

2 Data Description

The data employed in this paper is unpublished data collected by the Bureau of Labor Statistics (BLS) in the International Price Program (IPP) and is the data underlying the construction of import and export price indices for the United States. The primary reason for producing these indices is to deflate the value of U.S. foreign trade. The data made available to us is monthly data that covers the period September 1993 to April 2005. Chapter 15 of the BLS Handbook of Methods (1997) provides a description of the objective, scope and sampling methodology of the IPP. The target universe of the import and export price indexes consist of all goods and services sold by US residents to foreign buyers (exports) and purchased from abroad by US residents (imports).[1]

Price data are collected every month for approximately 20,000 items (including exports and imports). A reporting company is contacted for the transaction price on a monthly basis. Respondents are asked to provide prices for actual transactions that occur as close as possible to the first day of the month. In several cases a company specifies if a price has been contracted and the period for which it is contracted. For these periods the BLS will use the contracted price without contacting the firm directly. However, the BLS will contact a company at least once a year even when the company specifies that it has a longer contract. The price information provided by the company is voluntary and confidential.

The reported price by the company can be quoted in many different price bases. The BLS prefers to collect prices that, in the case of imports, are 'free on board' (fob) at the foreign port of exportation before insurance, freight or duty are added. In the case of exports, the preferred price basis is 'free alongside ship' (fas), the price of the item at the US port of embarkation. The price table in the database provides information on the reported price basis (f.o.b., f.a.s, etc.), the currency in which the price is reported, the unit of sale (one, dozen etc.) and the country of imports/export. The country information is more detailed for the case of imports and less so for exports. There is also information on whether the price is 'linked'. A link is used to correct for changes in trade factors such as when there are changes in the discount size/ class, the unit of sale,

[1]Starting in 1989, IPP divided the import and export merchandise into halves. Samples for one import half and one export half are fielded each year, so both universes are fully re-sampled every 2 years. The sampled products are priced for approximately 5 years until they are replaced by a new sample of the same half-universe.

In our study we exclude services, works of art and antiques (harmonized code 97), articles exported and returned (harmonized code 98) and certain special category goods (harmonized code 99).

quality etc.

The price program tracks the price of a consistent extremely detailed item over time. An example of an item description is "Lot # 12345, Brand X Black Mary Jane, Quick On/Quick Off Mary Jane, for girls, ankle height upper, TPR synthetic outsole, fabric insole, Tricot Lining, PU uppers, Velcro Strap." The table that describes the item includes information on the date on which the item was first sampled and in the event the item was discontinued, the month and year in which it was discontinued. We will define a good as a unique combination of item code, unit of sale and country code. The reason we distinguish by country of origin/destination is so as to relate the behavior of prices to exchange rate movements. The overwhelming number of item codes have an unchanging unit of sale and country code during its life in the index. In the case of imports there are 57494 item codes and 62044 goods. In the case of exports there are 46521 item codes and 49095 goods[2].

The 'net price' that the BLS uses in its price index is the reported price adjusted to reflect any changes in item description and trade factors such as foreign currency, discounts etc. The prices collected are net of duties. The net price is always a dollar price. That is, if the reported price is in a foreign currency the relevant exchange rate is used to convert the price into dollars. It is this net price that we use for our analysis. Almost all U.S. imports and exports have a reported price in dollars. That is, around 90% of import goods and 97% of export goods have a price reported in dollars. The fraction of imports reported in dollars has increased from 87.9% in 1994 to 93.44% in 2004.

2.1 Estimation Issues

The price data is monthly. However there are several months when the item is not traded or simply there is a lack of response from the reporting firm. In this case, the BLS imputes a price for the month and codes the price as being un-usable for the price index. Such prices account for

[2] Starting June 2002 the BLS instituted a new practice of assigning a new item code to the exact same good if it was selected again in the sample rotation (which takes place every 2 years). Unfortunately, there is no easy way to link the two item codes. The BLS assigned a discontinuation code of 7 to such cases. If we count the number of goods with a discontinuation code of 7 past June 2002, this accounts for only 3.6% of all goods and is therefore a minor fraction of our sample. Moreover, given that goods discontinued for other reasons also received a discontinuation code of 7, this 3.6% is an overestimate of the true number of such incidences.

approximately 40% of the observations in the import and export database. Since these un-usable prices do not reflect a true transaction price for an item, in our empirical work we will only use prices that the BLS considers 'usable' for constructing the price index in any given month. We also exclude price observations if the size of the (monthly) price change exceeds 100%. There are however very few such observations in the data.

Since we restrict attention to only usable prices, we have several goods that have only a few observations. In the case of imports, the median (mean) number of observations per good is 12 (18.46). 25% of the good have 4 or less observations. Similarly, in the case of exports, the median (mean) number of observations is 15 (21.56) per item. 25% of the items have 5 or less observations. Secondly, these observations need not be consecutive, because there can be gaps in months when the good is not traded or the reporting company is non-responsive. For instance, if we calculate the usable life of the good as the difference between the last date of a usable price and the first date of a usable price for every good, the median (mean) usable life of the good is 20 (25.05) months for imports. In the case of exports the median (mean) usable life of the good is 25 (28.73) months. Lastly, the goods usable life is shorter than the good's life in the index, calculated as the difference between the date the good was discontinued from the index and the data it was initiated. In the case of imports the median (mean) life of the good is 35 (37.51) months. In the case of exports the median (mean) life of the good is 39 (39.62) months. In sum, there is a problem of censoring in the data.

Goods that have very few usable observations and frequent gaps in their price series make estimation of price duration and hazards problematic. The censoring problem in estimating hazards is magnified when prices remain constant during the life of the good. In the BLS sample, around 30% of goods have their price constant over their entire life, both in the case of imports and exports. A second characteristic of the data is that there is a large amount of heterogeneity across the goods in the behavior of prices. Accordingly, we estimate our price stickiness measure at the good level and then present statistics of the distribution of price stickiness across goods.

Given that several goods have few usable observations, we adopted two approaches in presenting our results. First, we include only those goods that have several consecutive observations. Specifically, we require that there be at least one spell of 12 monthly consecutive usable prices for a good. We then keep all further 12 month usable price spells for the good. The plus to this approach is that we can present simple non-parametric estimates of price stickiness that ignore the issues of censoring and concentrate on the goods heterogeneity aspect of the data alone. A concern with this approach can be that we are excluding goods that get replaced or discontinued more frequently. It may be the case that these goods either have their prices changing very frequently, or have prices that are unchanged for a short duration after which the good is replaced and we might want to treat the replacement of the good as a price change. That is, frequent replacement might be a substitute for price change. Therefore, to capture a larger set of goods, we adopt a second approach where we estimate a constant hazard model and correct for censoring at the good level. For this, we include all goods that have any 6 or more observations (that is, these observations need not be consecutive).[3] If we exclude goods for which there are only 1 or 2 observations, the first approach accounts for 45% and the second approach for 85% of all goods. In the next sections, we will present details about the two approaches.

2.2 Concerns regarding reporting by firms

As mentioned earlier, reporting by the firm is voluntary. The standard procedure involves the firm entering the information on an information sheet provided by the BLS and sending it back to the BLS. The BLS is clearly interested in obtaining accurate information and accordingly in the first step of data collection, a BLS agent negotiates with the company the number of price quotes that the company would be comfortable reporting on so as not to place undue burden on the firm. The average (median) number of price quotes, per reporting firm was 4.6 (4) in 2004. The average (median) number of price quotes, per reporter (some firms can have multiple reporters) was 3.85 (3) in 2004. The small number of price quotes provided by firms alleviates concerns regarding misreporting.

Another interesting piece of evidence relates to the behavior of prices around the period of the terror strikes in 2001.[4] Following the anthrax attacks and disruption of mail to all governmental offices, the BLS could not receive mail in October 2001. Consequently, for this month, a BLS agent contacted the firm by phone and communicated with the company reporter directly to obtain the

[3] In this procedure we are excluding mostly goods that have only 1 or 2 observations. It would be safe to assume that the price series for these goods are not very useful.

[4] We thank Rozi Ulics for bringing this to our attention.

price information. Anecdotal evidence suggests that in this month firms were more responsive and eager to provide information to the BLS. For instance, the BLS received many more updates pertaining to company specific information during this month - such as address and contact information. We accordingly examine if the responses on price change were significantly different for this month. When we calculate the probability of an item having recorded a changed price for this particular month relative to other months in the year, we find no statistical differences.

3 Price Stickiness

The objective of this section is to report the average time that prices are fixed for imports and exports. We first discuss the case of goods that have at least one spell of 12 consecutive observations, and next, the larger BLS sample. Given that the data series for each good has missing prices in the middle and left and right censoring, we present several alternative measures of stickiness. In all our measures we adopt a conservative approach that moves us in the direction of finding shorter durations. The message on price stickiness that we derive is consistent across all these estimates. We find that the trade weighted average price duration (using 2004 weights) in dollars is 12.26 months for imports and 13.77 months for exports.

3.1 Sticky prices: Measures un-corrected for censoring

We first present statistics that are un-corrected for censoring. Given the large amount of heterogeneity in the data, we estimate these statistics at the good level. For this to be a meaningful exercise we need to have a large enough price series for each good. Accordingly, we consider goods that have at least one spell of 12 or more consecutive observations and keep all further 12 months spells. There are 24007 import goods and 18868 export goods that satisfy this criterion.

The measures, or summary statistics, of price stickiness used in the literature are: the probability of change, the inverse of which is the simple average time between changes, and the spell weighted average between changes. Each of these measures is estimated at the good level, i.

Definition 1 *Average probability of price change for good i*

$$\tilde{p}_i = \frac{\sum [\textit{number of price changes for good}_i]}{\textit{total observations of good}_i}$$

Definition 2 *Average time between changes for good i: Each observation is a spell in which prices are fixed*

$$\tilde{t}_i = \frac{\sum [\textit{time between price changes for good}_i]}{\textit{total number of spells for good}_i}$$

This is simply the inverse of the probability of change.

Definition 3 *Spell Weighted average time between changes for good i: Compute the average time between price changes where the observations are weighted by the length of the spell. As before, each observation is a spell in which prices are fixed*

$$\hat{t}_i = \frac{\sum [\textit{time between price changes for good}_i]^2}{\textit{total number of observations}_i}$$

Let us study how these measures perform in an example.

Example 4 *Assume that a good A has prices for* $2T$ *periods. Suppose that in the first* T *periods the price changes every month and in the second* T *periods it changes every 3 months. Further assume that the price series is not censored.*

By construction, good A adjusts prices on average every two months. Assume we compute the probability that prices change next month (Definition 1). If T is big enough, we observe that in T periods there are $T + T/3$ price changes of a total $2T$ observations. In other words, the average probability that a change takes place is 2/3. This statistic implies that on average we observe price changes every month and a half. This measure of duration is biased downwards and accordingly its inverse,the simple average is also biased downwards.

Measure 3 − the spell weighted average of the time between changes[5] − corrects for this problem. In this example, the observations that have one month are weighted by one, and the observations

[5] See Bahard and Eden (2003)

of three months are weighted by 3:

$$\hat{t} = \frac{1 * T * 1 + 3 * T/3 * 3}{T + T/3 * 3} = 2$$

This discussion points to clear advantages of the spell weighted average of the time between changes. Nevertheless, we present results for the probability of change as well.

Probability of Change: We first calculate the average monthly probability of price change at the good level. That is, we calculate the statistic in Definition 1. As mentioned earlier, 30% of items have a price that is unchanging during their life in the sample. For the median item, the probability of price change, λ, is 0.0682 for imports and 0.0556 for exports. The median expected time to price change[6] is then $1/\lambda$, which is 14.66 months for imports and 18 months for exports. There is tremendous amount of dispersion in λ. The mean $\lambda's$ are very different from the median. The mean for imports is 0.21 for imports. There are however only 25% of the items that have a λ that is greater than or equal to 0.21 for imports. Similarly, in the case of exports, the mean is 0.15 and only 23% of exports have a λ that is greater than or equal to the mean.

We also calculate the probability by assuming that the last price is a price change. That is, if a good is observed for 12 months and its price never changes, its probability is estimated to be $\frac{1}{12}$. The simple average of time between changes is 12 months. This clearly is a lower bound on the average price duration. When we make this assumption, the median for imports is 0.11 and the median for exports is 0.095. The median expected time to price change is 9 and 10 months respectively.

Spell Weighted Time Between Price Changes: The next statistic we calculate is Definition 3. We will assume that, for each good, the first price and the last price represents a price change[7]. If there are gaps in the price series, then we assume that the last price before the gap and the first price after the gap represents a new price. By treating the price series as if they are uncensored, if the prices are truly sticky, we are again biasing ourselves downwards in our estimates of the duration for which prices stay unchanged. Despite this, we find that prices stay unchanged for a

[6] This is assuming you can change prices only once a month.
[7] In Section 5 we discuss the evidence on the time variation of probability in the data.

long time. In the case of imports the mean (median) duration is 13.29 (11) months and in the case of exports the mean (median) duration is 14.78 (12.16) months. The standard deviation is 10.88 months for imports and 11.07 months for exports. Note that this standard deviation is not the precision of the estimates, but a measure of the individual dispersion. Figure 1 presents the cummulative distribution of durations in our sample; these are the two schedules identified as the Duration Imports (12 consecutive) and Duration Exports (12 consecutive).

[Figure 1 here]

The evidence we have presented thus far relates to goods that have at least one spell of 12 consecutive observations. We were able to present simple non-parametric statistics of the average duration for which prices remain unchanged. We adopted a conservative procedure of treating the first price and the last price of any unbroken string of usable prices as a price change. To alleviate concerns that our estimates may be affected by our sample selection choices, we examine a broader sample where we consider any good with any 6 observations, even if these observations are not consecutive. The simple probability of price change for the median item is 0.06 and the mean is 0.20 for imports. This is very similar to the numbers we obtained for the smaller sample.

In the following section we describe our specific procedure to estimate the duration of prices. Given the nature of the price data in this larger sample, any procedure will have its limitations. We have adopted a procedure that we expect will bias us downwards in finding shorter price durations. In this sense, we are following a conservative approach.

3.2 Estimation of the Duration for the larger BLS sample

In Figure 2 we depict what a typical price series for a good looks like. There are missing observations, several of the spells are censored, and prices are sticky. This good is in the data for 19 months. The dots represent valid prices, the X's represent missing prices or observations, the empty circle indicates the date on which the item is discontinued. The first spell has three months and it is censored. The next spell is a complete spell of three, followed by another complete spell of two and a censored one of two. The last spell is censored and lasts three months, and we know the item is discontinued three months after that.

[Figure 2 here]

Estimating a hazard model in this data requires several changes to the standard procedure that deals with censoring. First, we will assume that every price initiation is a price change, and that every discontinuation is a price change. This implies that we do not allow censoring before the item is included, nor after the item is discontinued, regardless of the reason for discontinuation. We treat all discontinuations as if the good was retired or replaced after this date. This is not always the case. Around 15% of the goods are discontinued because of failure to report by the firm. Another 25% of the goods are phased out by sample design. Hence, we are overstating price changes.

Second, every price after a censored spell will be considered a price change. For example, in Figure 2, we assume that $p(6)$ and $p(14)$ are price changes, even though $p(6)$ is identical to $p(3)$. These two assumptions imply that our estimates of the hazard are conservative in terms of the measured stickiness.

Third, we have to deal explicitly with censoring that takes place in the middle of the data. These spells have a minimum duration, but also a maximum one. For example, the first spell has a constant price for three months, and it is censored. However, we know that the spell cannot be censored by more than two months, because observations are re-initiated after that. The usual procedure assumes the censoring is unbounded, (or in other words that it is the expected value of any spell greater than or equal to three). We need to change the specification to bound the censoring, and set it to the expected duration for spells larger than 3 months, but smaller than 6.

Lastly, we have to deal with censoring at the end. The last spell has three months fixed, two missing and then the series is discontinued. So again, we assume that the spell is greater than or equal to three, and smaller than 6. The only goods that are censored in the standard sense, and will be treated as such, are those that are still active in the data set, for whom we have no discontinuation date yet.

Formally, assume that D_i is an indicator that takes the value of one when spell i is complete (uncensored), and zero otherwise. Assume the spell durations are indicated by S_i. Finally, assume that M_i is the (strict) maximum of the spell. For instance, for the first spell, $S_1 = 3$, and $M_1 = 6$. We assume that the spells are exponentially distributed with parameter λ. This means that the probability of observing a complete spell of length S_i is $\lambda e^{-\lambda S_i}$. If the spell is censored, then the probability is the accumulation of all the spells greater than or equal to S_i, given by $e^{-\lambda S_i}$. In our case, the upper bound spells are those in which there is always a maximum which implies that the probability of observing the censored spell is $e^{-\lambda S_i} - e^{-\lambda M_i} = e^{-\lambda S_i}(1 - e^{-\lambda(M_i - S_i)})$.

Following the discussion from the previous section we have to take care of the bias that aggregation might introduce if stickiness is not constant through time. As was discussed before, the best alternative is to weight the observations by their length. Therefore, the maximum likelihood is the following:

$$\pounds\left(\lambda\right) = \sum_{i:\{D_i=1\}} S_i \cdot \ln(\lambda) - \sum_i S_i^2 \cdot \lambda + \sum_{i:\{D_i=0\}} S_i \cdot \ln(1 - e^{-\lambda(M_i - S_i)})$$

where the first two terms are the standard terms in constant hazard models with weighting, and the last term is the correction for truncated censoring.

There are several goods that have constant prices through out their lives and all the spells are censored. For those goods, the maximization would estimate an expected life of ∞ ($\lambda \to 0$). Clearly, this is not an interesting case. Hence, we set an upper bound of 60, which is the sampling life of a good in the index. There are only 869 imported goods for which this problem exists. All these goods are indeed currently active, and represent the cases in which the estimation of censoring drives the probability to zero. Importantly, these cases represent less than 2 percent of all goods.

The results of estimating the maximum likelihood item by item produces the following results: The average expected life for imports is 12.48 months with a median of 7.64. For exports the average is 13.62 and the median is 9.15. Notice that these estimates are quite in line with the results presented before. We can estimate the distribution of the expected life across all items. The cumulative distribution of duration for both exports and imports are depicted in Figure 1, refered to as Duration Imports (any 6) and Duration Exports (any 6).

As pointed out earlier, we treat the price before a missing price and the price after a missing price as a price change, even if the latter price is exactly equal to the former price. A typical feature of this data is to have the exact same price separated by missing observations. That is, 30% of the goods have a constant price during their life. However, our procedure will estimate a price duration that equals the life of the good for only 5% of the goods. If we assume that for these 30% goods the missing price equals the constant price, then for imports, the average duration is 14.01 months and the median increases to 8.27 months. As expected, the median is affected more than the average.

Our assumption that every single missing observation represents a price change has to affect the median much more disfavorably than the average, mainly because the shorter spells have a smaller weight in the computation of the average than in the computation of the median. In the consumer price index literature, price movements that involve a temporary price change, as in prices return to their original level following a month or two of change are smoothed over to calculate the price stickiness excluding temporary sales prices. Such a procedure on this data also raises the median significantly.

In a further robustness check we consider only on those goods that have at least one uncensored spell. There are only 27915 goods with at least 6 observations that have at least one uncensored spell. This eliminates all goods whose prices are constant. Despite this, we obtain an average (median) of 10.46 (7.00) months. Finally, the results from this sample and the 12 consecutive price sample are very similar with a large correlation between the two. A simple OLS regressions (in logs) implies an intercept of 0.09, with slope of 0.91, and R^2 of 0.90. (0.14, 0.90, 0.87 for exports, respectively).

Trade Weighted Average: In the previous analysis we gave each good an equal weight in calculating the average across goods. It can be argued that goods with a larger value in trade should be more heavily weighted. While we do not have the goods weight in the index, the BLS was able to provide us with weights at the 10 digit harmonized level, referred to as a classification group. This is the lowest level of aggregation at which the BLS performs its sampling. Each item is mapped to a classification group. The median (mean) number of items in a classification group is 2 (3.5) in our sample for imports[8] and 2 (3.68) for exports. For each group, the BLS provided us with data on the dollar value of imports and dollar value of exports for 5 weight years (1995, 2000-04). We report the trade weighted average for 2004 using the weights from 2002 as is the procedure in the BLS index value calculation. We distribute the dollar value for each classification group evenly across the different items within a group to calculate the item weights. This was done separately for imports and exports. Using the item weights we calculate the weighted time between price changes to be 12.26 months for imports and 13.77 months for exports in the larger sample. In the 12 consecutive observation sample it is 12.26 and 12.82 respectively. In summary, the weighted

[8] 75% of classification groups have less than or equal to 4 items. The largest classification groups has 70 items.

estimates for duration are not very different from the unweighted measures. In the case of imports, crude petrol has the highest weight for 2004 in terms of classification groups in the index and the prices for crude change on a monthly basis. However, the next highest classification group is in the category of cars and the stickiness of these goods is very high.

To summarize, we compute average probabilities of price change and average duration good by good for imports and exports. The message we obtain is consistent. The price stickiness is longer than a year. Finally, it is important to note that the stickiness is in dollars for both imports and exports. While it might not be surprising that both U.S. imports and exports are invoiced in dollars, it is less obvious that the dollar prices should last as long for both. This has important implications for theoretical models, since the typical assumption is to assume either stickiness in local currency (Betts and Devereux (2000) and Devereux and Engel (2003)) or in producer currency (Obstfeld and Rogoff (1995)) and this assumption is symmetric across countries. To the contrary, in the case of the U.S. we find local currency pricing for imports and producer currency pricing for exports. This suggests an asymmetry in terms of which country bears the risk of exchange rate movements.

3.3 Retail and At-the-Dock Prices

The majority of research on the micro prices of traded goods focuses on retail prices. Goldberg and Knetter (1997) provide an excellent survey. In more recent work, there are important papers by Crucini and Shintani (2004), Frankel, Parsley and Wei (2005) among others that examine pass-through at the retail price level. There remains, however, as Engel (1999) pointed out a need to understand "What systematic relation is there between the price of a good at the port and at the consumer outlet?". We take a look at this relationship in this section.

The most comprehensive recent study of the stickiness of retail prices of consumer goods is presented in Bils-Klenow (2004) (henceforth BK). They find that the median duration of prices is around 4 months. In our study of traded goods at the dock we find that the median is at least twice as high. To make a more direct comparison, since a large part of traded goods are producer goods and BK include services which is not in our database, we match the categories in BK with the mostly 4 digit classification in our database for the case of imports. We obtain a match for 106 categories. In the BK subset, the mean (median) is 3.93 (2.85) with a standard deviation of 2.97 months. For the same matched categories we obtain 11.68 (11.40) and a standard deviation of 5.77 months. In Figure 3 we plot log duration from BK and our measures. The two are strongly positively correlated and the duration at the dock measures are in general higher than the retail price measures. This is reflected in the positive and statistically significant constant in the regression. In Table 1, we report the duration numbers for harmonized code categories for which the BLS allows public reporting. As can be seen, in the case of commodities like fuel oil the two measures are very similar, however, for most other categories the stickiness of prices at the dock are much larger. This suggests some important differences between the retail price behavior of tradable goods, and the behavior of actual traded goods. There are, clearly, several reasons why CPI prices can differ from at-the-dock prices. For instance, retail price of tradable goods include local distribution costs (Burstein-Eichenbaum-Rebelo (2004)). Secondly, goods that enter the CPI may be produced mainly for local consumption. Further, at-the-dock prices involve transactions between firms as opposed to the sale of a good to consumers and the contracting relationship in these two cases can be very different. Further research is required to explore these differences.

[Figure 3 here]

[Table 1 here]

4 Price Stickiness and Product Characteristics

There is a large amount of heterogeneity in the level of price stickiness across the goods. The mean duration of a price for imports is 12.48 months and the standard deviation is 14.86 months. Similarly, in the case of exports, the mean duration is 13.62 months with a standard deviation of 14.79 months. To explore some of the factors behind this dispersion in this section we correlate our measures of stickiness with characteristics of the goods, the nature of the transaction depending on whether it is traded intra-firm or not, the currency in which the good is priced and the country of origin/destination. We present the results for the larger sample only, since the results are very similar for the sample of 12 consecutive observations. Before presenting a multivariate regression we summarize the bivariate relationships to ease exposition. In describing the bivariate relationships we concentrate only on the case of imports here, since exports behave very similar.

In menu cost models of price stickiness, as in Barro (1972), the cost to not adjusting prices is greater for goods where the elasticity of demand is high. That is, all else equal, we would expect to see lower price stickiness the higher the elasticity of demand for the good. Therefore, we relate our measures of stickiness to the particular nature of the good traded, by using Rauch's (1999) empirical classification of traded goods into homogenous goods and differentiated goods[9]. With this procedure we can classify around 65% of the goods. The homogenous goods category includes goods that are traded on an exchange and those that are reference priced. Reference priced goods are those whose prices are listed in trade publications and the particular brand name does not affect prices much. Therefore, unlike differentiated goods, it is easier to arbitrage price differences across reference priced goods. We would expect that the elasticity of demand is higher for homogenous goods as compared to differentiated goods. When we correlate our measures of stickiness with the Rauch classification we find that goods traded on an organized exchange have the least amount of stickiness. The median (mean) duration of prices is 1.66 (4.18) months for the organized exchange category, it is 4.38 (9.43) months for the reference good category and it is 8.61 (13.57) months for the differentiated goods category.

A second important factor in understanding the dispersion is the currency in which goods are invoiced. The stickiness of prices along with the currency of pricing jointly determine the extent of pass-through of exchange rate changes into local currency prices. As mentioned earlier, an overwhelming number of imports and exports are invoiced in dollars. About 10% of imports and 5% of exports are invoiced in a foreign currency. We find that these foreign invoiced prices are about as sticky in foreign currency terms as dollar invoiced prices. That is, if we analyze countries for which some goods are invoiced in non-dollar currency, the average duration of stickiness in terms of the non-dollar currency is similar to the stickiness of dollar priced goods in dollars. The average stickiness of dollar priced imports in dollars is 13.45 months, while it is 2.10 months for non-dollar priced imports in dollar terms. In a reduced form sense, this is similar to the assumptions we make in our models, where a firm picks a currency to price in and keeps prices stable in that currency.

[9] Rauch (1999) classified enough 5 digit SITCs to cover the majority of trade in each four digit SITC. He then categorized the goods at the 4 digit level according to which of the three categories accounted for the largest share. Each good in our database is mappped to a 10 digit harmonized code. We use the concordance between the 10 digit harmonized code and the SITC2 (Rev 2) codes to classify the goods into the three categories. Since the 10 digit classification is far more detailed than the 4 digit SITC level to which we map the goods, the classification is clearly an approximation. In this sense, it should not be surprising that the number for the organized exchange category exceeds 1.

What is different though, is that for the case of the U.S., both imports and exports are priced in and sticky in dollars.

It is well known that a large fraction of trade takes place between related parties, that is, are intra-firm transactions as opposed to arms-length. In our larger sample, 40% of items are traded intra-firm in the case of imports and 26% in the case of exports. Since the two types of transactions involve different incentives (with a large literature on transfer pricing), we examine if in the case of price stickiness there is a significant difference between the two. We can perform this exercise because the BLS collects information on whether a transaction is a market transaction or not. We find very little difference between the distribution of price stickiness for goods traded intra-firm Vs. those traded at arms length. The mean duration is 13.06 months for intra-firm transactions and 12.06 months goods traded at arms-length. In a regression that controls for 5 digit harmonized code and country fixed effects and all its interactions, intra-firm prices are again more sticky by around a month. This finding is similar to Clausing (2001), who studied intra-firm transfer pricing at the industry level using a shorter period of 1997-99.

Lastly, the data includes producer goods and consumer goods. We use the end-use classification of goods at the 1 digit level and relate it to our measures of stickiness. There are 6 (1 digit) end-use categories. The median (mean) duration for 'consumer goods' is 9 (14.27), for 'capital goods except automotive' it is 8.78 (13.59), for 'automotive vehicles, parts and engines' it is 8.49 (13.31), for 'Food, Feed and Beverages' it is 3.63 (8.88) months, for 'industrial Supplies and materials' it is 4.46 (9.05) and lastly for the 'other' category it is 11.28 (18.25) months. Accordingly, it is not only producer goods but also consumer goods that display a large amount of stickiness.

So far, in our description we have reported on the bivariate relation between price stickiness and the various characteristics of the goods and its transaction. In Table 2 we run a multivariate regression of the log of price duration on all the variables discussed above. In addition we include country fixed effects. As can be seen below, all the main points from the bivariate analysis come through in the multivariate analysis. t-statistics calculated with robust standard errors are reported in parenthesis.

[Table 2 here]

4.1 Price Stickiness and Currency Volatility

Our measures of price stickiness are averages across items imported across a large number of countries with varying levels of exchange rate movements. In this section we correlate our measures of stickiness with exchange rate and inflation volatility in the country of origin. For each country we estimate the dollar value of the foreign consumer price level as the sum of log nominal exchange rate and log of CPI. We then estimate the standard deviation of this sum during the life of the good, for each good. We regress the good's hazard on this measure and find that for very high levels of volatility there is indeed a decline in the duration for which prices stay unchanged. For instance, when the volatility goes up to 20% the duration declines by 1 month. However, for most of the normal range of exchange rate volatility there is very little difference in the duration measures. In fact, when we add this volatility measure to the regression in Table 2, the coefficient on the volatility is significant, but small. When we add the volatility of the dollar value of foreign inflation, instead of the volatility of the nominal exchange rate, then the coefficient becomes insignificant.

[Figure 4 here]

Since there are other idiosyncratic cost and demand shocks that effect a good during its life, the lack of an effect from exchange rate movements might arise from a compounding of different factors. Accordingly, we examine episodes of large foreign currency devaluations in our sample since presumably in those cases the exchange rate movement is the dominant shock. Specifically, we examine episodes when the exchange rate of a foreign currency depreciated by 15% or more in a month and analyze the behavior of import prices from these countries.[10][11] For each good we calculate the simple average probability of price change in a 6 month interval before the devaluation and compare it to the probability within a six month period after the devaluation. In general, the change is negligible. In Figure 5, time zero corresponds to the month in which the exchange rate depreciates. We computed the proportion of items changing prices every month, as well as the probability of price increases, and price declines. The three probabilities are depicted in Figure 5.

[10] We have performed this exercise for alternative large magnitudes and the results are qualitatively the same.

[11] Brazil in our sample had very high and stable inflation of more than 15 percent a month. Therefore movements of nominal exchange rates of 15 percent were common in 1994. For Brazil, we computed the exchange rate adjusted by inflation, and concentrated on the periods in which it moved by 15 percent.

The thick line corresponds to the overall probability of price changes and it is measured on the left axis. The other two lines are measured on the right axis.

[Figure 5 here]

As can be seen, there is a small increase in the probability of price change around the crises - one month after - and then the pattern returns to the normal unconditional probability of change of around 20 percent. When we separate the analysis by price increases and decreases, we find that there is a slight increase in the probability of finding decreasing prices, while there is a decline in the probability of finding price increases. These changes are as expected, but the pattern is surprisingly weak. In summary, even if we restrict attention to periods of significant exchange rate movements, goods tend to exhibit fairly high price stickiness. This is the case even when we restrict attention to only differentiated goods.[12]

5 Price Stickiness and Time Trend

In this section we document that the degree of price stickiness has been increasing significantly in the last ten years in U.S. imports. For imports, the average probability of price change declined by 10 percentage points from 0.29 in 1994 to 0.18 in 2004, that is, there was a 40% decline[13]. We compute the annual average probability of each good by simply dividing the number of price changes by the total number of usable prices in a given year. We then average across goods to calculate the average probability for the year[14]. Figure 6 presents the probability of prices changing computed every year.

[Figure 6 here]

Most of the decline takes place during the 90's, and the trend seems to have stabilized significantly in the 2000's. Two questions immediately arise from this observation: First, what is behind

[12] We concentrated only on imports because the country of destination information is much more limited for exports.

[13] This finding contrasts with the finding in Klenow and Kryvtsov (2004) who find that the fraction of retail goods prices that adjust prices in any given quarter has stayed stable during this period.

[14] Note that the average probabilities are higher than the inverse of the duration numbers we calculate for reasons discussed in Section 3.1.

the increase in stickiness? Second, what are the aggregate implications of the increase in stickiness, especially for pass-through? Indeed, several authors have documented a phenomena of declining pass-through of exchange rate movements into import prices and into retail prices in the 1990s relative to earlier decades. Taylor (2000) surveys the empirical evidence that documents declining pass-through of exchange rate changes into retail prices . Marazzi et al (2005) in a recent paper estimate the pass-through to U.S. import prices using the aggregate import price index and find evidence of declining pass-through even at the dock, with a substantial decline in the 1990's which coincides with our sample period. Campa and Golderg (2004), Frankel, Parsley and Wei (2005) also document evidence of declining pass-through into import prices at the dock.

5.1 Decomposing Price Stickiness

One explanation for the increase in average price stickiness could be the changing composition of goods in the U.S. import basket. Presumably, as the composition of imports shifts from homogenous goods to more differentiated goods where there is more of pricing to market, we should observe an increase in stickiness. Indeed, we find in our regressions in Table 2 that differentiated goods have sizably larger price durations than homogenous goods. Campa and Goldberg (2004) argue that this change in composition might be what is behind the decreasing pass-through. Interestingly though for the sample period that we examine, though there is a substantial decline in the average probability of price change, the composition story explains very little of the decline. The share of homogenous (organized plus reference) goods declined from 25% to 17% of all goods[15]. For each sector- organized, reference and differentiated, we estimate $\lambda_{s,t}$, which is the average monthly probability of price change in sector s in year t. Suppose $n_{s,t}$ is the fraction of goods in sector s at time t relative to the total number of goods at time t. For any t, average probability at time t, $\Lambda_t \equiv \sum_s [n_{s,t}\lambda_{s,t}]$. We then estimate the following measures,

[15] That is, all goods that can be categorized as homogenous or differentiated.

$$
\begin{aligned}
\Lambda_{1t} &\equiv \sum_s [n_{s,1994}\lambda_{s,t}] \\
\Lambda_{2t} &\equiv \sum_s [n_{s,t}\lambda_{s,1994}]
\end{aligned}
$$

The first measure, Λ_{1t}, fixes the sectoral composition at the 1994 level and allows the probability within each category to vary over time. The second measure, Λ_{2t}, fixes the sector probabilities at its 1994 level and allows the composition to vary over time. As the results shown in Table 3 suggests the composition effect is minimal and almost all of the decline is a within sector decline. If we calculate the following ratio, $\Omega = \frac{Var(\Lambda_t - \Lambda_{1t})}{Var(\Lambda_t)}$, the "residual" variance is about 11%.

[Figure 7 here]

[Table 3 here]

In Figure 7 we plot the average probabilities over time within each type of good. For comparison, we normalize the initial probability to 1 for each category. These were estimated by running a regression of probabilities on time fixed effects for each sector. As can be seen, the largest decline in the probability of price change is observed in the differentiated goods sector (40%), followed by a smaller decline in the reference goods sector (20%) and none at all in the organized goods sector. These declines are also very precisely estimated. Within the differentiated goods sector, if we break down by end use we observe increases in price stickiness in consumer goods, capital goods and in the auto sector. The decline accordingly is across the board.

A second conjectured hypothesis that we can examine is whether the decline is due to changing country composition in the import basket. That is, the share of China and Mexico in U.S. import trade has grown significantly over the past decade. Since both these countries have fairly stable exchange rates against the dollar one might argue that longer average duration can be explained by a changing country mix. We find very little support for this. For instance, for the differentiated goods sector we can estimate the time varying country probability and a time varying country composition similar to the procedure we followed for the sectoral decomposition. The "residual" variance that is unexplained by time varying country probability is 15%. Therefore, an explanation for the decline in average probabilities for the period 1994-2004 needs to be one that is not based on changing country or sector composition but one that can explain a general trend decline in probability within each country and particularly among differentiated goods.

A possible reason for the increase in stickiness could be due to the change in the currency of invoicing over time since we find that non-dollar priced imports have their dollar prices changing on a monthly basis. As mentioned earlier, the fraction of imports reported in dollars has increased from 87.9% in 1994 to 93.44% in 2004. Figure 8 plots a decomposition of the decline in the probability of price change based on the currency of invoicing. The line "Time varying currency composition" plots the yearly probability of price change assuming that probabilities within dollar invoiced and non-dollar invoiced categories stay unchanged at their level in 1994 and allowing only the fraction of goods invoiced in each category to change. The line "Time varying currency stickiness" plots the yearly probability of price change assuming that the fraction of goods invoiced in each currency stays unchanged at the level in 1994 and allowing only the average probability within each category to change. As the plots depict, the time varying currency composition can explain a significant decline in average probability especially in the later years. The Time varying currency stickiness also plays an important role particulary in the earlier years.

[Figure 8 here]

Figure 9 shows the probability of observing a price change for both imports and exports, as well as the proportion of items that are not changing at all in that year. The dashed thick line represents the probability of price change in imports and it is measured on the left axis. This is identical to Figure 6. The thin dashed line is the probability of observing price changes in exports. Notice that in this case the decline is much smaller, and the probability at the end of the sample is not much different from the one at the beginning. The continuous thick line is the percentage of items whose prices never change in a particular year, and it is measured on the right axis. As can be seen, this fraction was close to 45 percent in 1994, and it has increasing sharply to 60 percent in 2004. The thin continuous line is the same measure for exports.

[Figure 9 here]

5.2 Pass-Through and Time Trend

In this section we present a preliminary look - a reduced form view - at pass through and its relationship with the degree of price stickiness. Given the documented decline in probability of change in the previous sub-section in imports, the first step is to study how the conditional average price change per year has evolved. For each good we calculate the average absolute price change conditional on changing prices. For the period 1994-2005, for imports, the average across goods is 7.9% (median is 4.9%). Around 23% of the changes are 10% or higher and around 8% are greater that 20%. For differentiated goods only, the average is 7.2% (4.4%) and 20% exceed a 10% change. In a simple regression of the conditional absolute price change of a good on the log price duration of the good calculated previously, the slope coefficient is 0.020 (t stat of 32.56) for the sample as a whole and 0.022 (t stat of 29.03) for the differentiated goods sector. That is, as would be expected, goods with longer periods between price adjustments adjust prices by a large absolute magnitude when they do.

There is very little change over time in this average conditional absolute magnitude of price change as can be seen in Figure 10. The measure increased from an average of 6 percent to almost 8 percent. Although it is possible to reject the hypothesis that the average is the same across the sample, the fluctuation is economically small in comparison to the change in the frequency of change.

[Figure 10 here]

What remains to be answered is if prices, conditional on changing, are more or less responsive to exchange rate and inflation fluctuations. In order to estimate this for each good, we compute the change in the price and exchange rate between the months in which a price change is observed. Clearly, for the majority of the goods, the months are not consecutive. This procedure however tries to eliminate the time aggregation bias common in regressions when one of the variables is sticky. See Caballero and Engle (2004). We run a simple OLS regression of the change in price (conditional on changing) on the cumulated change in the nominal exchange rate and inflation over the period of the change in rolling windows of a year. Figure 11 shows the coefficient together with the confidence interval for each estimate.

[Figure 11 here]

As can be seen, the time pattern in the goods price response to an exchange rate movement, conditional on changing prices, while moving around does not display the monotonic declining trend that is observed in price stickiness. This conditional pass-through behavior is only preliminary evidence and further research should be devoted to fully understand these patterns.

6 Conclusions

Price stickiness plays a central role in our understanding of monetary policy, and it is an important ingredient in theoretical models in closed and open economy macroeconomics. To understand the price behavior of actual traded goods, we have used unpublished data from the BLS to measure the degree of price stickiness for imports and exports. These prices represent at-the-dock prices and therefore do not include local distribution costs that enter into retail prices. We have three main findings: prices are sticky, and in dollars for both U.S. imports and exports; there is a large degree of heterogeneity at the good level; and the degree of stickiness has been trending upwards in recent years for imports.

Our first finding is that prices are indeed very sticky at the dock for the U.S. The trade weighted average price duration in dollars is 12.26 months for imports and 13.77 months for exports. These results are robust to different measures of stickiness that deal with heterogeneity and censoring present in the data. This degree of stickiness is much larger than the ones estimated using similar micro data at the retail level for the U.S. However, our estimates are closer to the averages found in recent studies performed at the retail level using CPI data for the Euro Area.[16] Second, we find that there is a large amount of heterogeneity across goods that can be partly explained by the type of good - that is if it is homogenous or differentiated and the currency in which the good is invoiced. Since prices are sticky in the currency in which they are invoiced in, foreign currency invoiced goods display dollar price changes on a monthly basis. The variables that explain surprisingly little of the dispersion is whether the good is traded intra-firm or not and the exchange rate volatility and inflation volatility during the life of the good. Lastly, we studied the time trend in the degree of

[16] See Alvarez et. al. (2005) for an extensive summary on this work.

stickiness and documented a sizeable decrease in the probability of observing price changes in the sample in imports. This pattern is particularly pronounced in differentiated goods imports. Such a strong trend does not exist for exports.

These results have important implications for models in international economics. Firstly, the finding that prices are far more sticky in traded goods prices at-the-dock than prices of goods in the CPI for the U.S. suggests some concern about using prices of so-called tradable goods in the CPI to understand the price behavior of actual traded goods. The reasons for the differences need to be further explored both empirically and theoretically. The differences in contracting relationship for prices at the dock which involves transactions between firms Vs. retail prices where the sale is to a final consumer is one avenue that needs to be further explored theoretically. Secondly, the fact that U.S. imports and exports are sticky in dollars suggests that unlike the standard modeling assumption that all countries have either local currency or producer currency pricing the U.S. has both. This has implications for which country bears the risk of exchange rate movements and the impact of exchange rate movements on the trade balance. Lastly, the finding that price stickiness has increased over time has implications for aggregate measures of pass-through in the data. We find that the time trend is not due to a compositional shift towards differentiated goods or a simple change in country composition. The decline is across the board both in consumer goods and capital goods. This evidence can shed light on alternative theories for the decline in pass-through in recent decades documented in the literature.

References

[1] Alvarez, L. J, E. Dhyne, M. Hoeberichts, C. Kwapil, H. Le Bihan, P. Lunnemann, F. Martins, R. Sabbatini, H. Stahl, P. Vermeulen and J. Vilumen (2005), "Sticky Price in the Euro Area: A Summary of New Micro Evidence", working paper.

[2] Atkeson, Andrew and Ariel Burstein (2005), "Trade Costs, Pricing to Market and International Relative Prices", working paper.

[3] Bils, Mark and Peter J. Klenow (2004), "Some Evidence on the Importance of Sticky Prices", *Journal of Political Economy* 102, October 2004, 947-985

[4] Baharad, Eyal and Benjamin Eden (2003), "Price Rigidity and Price Dispersion: Evidence from Micro Data", *Working paper no. 03-W21.*

[5] Barro, Robert (1972), "A Theory of Monopolistic Price Adjustment", *Review of Economic Studies*, Vol. 39 (1), 17-26.

[6] Betts, Caroline and Michael Devereux (2000), "Exchange Rate Dynamics in a Model of Pricing to Market", *Journal of International Economics,* 50, 1, 215-244.

[7] BLS Staff (1997), BLS Handbook of Methods, Chapter 15. Available online at http://www.bls.gov/opub/hom/homch15_a.htm.

[8] Burstein, Ariel, Martin Eichenbaum, and Sergio Rebelo (2004), "Large Devaluations and the Real Exchange Rate", *Journal of Political Economy*, forthcoming.

[9] Caballero Ricardo and Eduardo M.R.A Engel (2004), "Adjustment is Much Slower Than you Think", working paper.

[10] Campa, Jose and Linda Goldberg (2005), "Exchange Rate Passthrough into Import Prices", *Review of Economics and Statistics*, forthcoming.

[11] Clausing, Kimberly (2001), "The Behavior of Intra-Firm trade prices in U.S. International Price Data", *Bureau of Labor Statistics Research papers, No. 333.*

[12] Crucini, Marios, Chris I. Telmer and Marios Zachariadis (2005), "Understanding European Real Exchange Rates", *American Economic Review*, Vol. 95, No. 23, 724-738.

[13] Devereux, Michael and Charles Engel (2003), "Monetary Policy in the Open Economy Revisited: Price Setting and Exchange Rate Flexibility", *Review of Economic Studies*, 70, 765-84.

[14] Engel, Charles (1999), "Accounting for US Real Exchange Rate Changes", *Journal of Political Economy*, Vol. 107, No. 3.

[15] Frankel, Jeffrey A, David C. Parsley and Shang-Jin Wei (2005), Slow Passthrough Around the World: A New Import for Developing Countries? NBER Working Paper No. 11199.

[16] Goldberg, Pinelopi K and Michael M. Knetter (1997), "Goods Prices and Exchange Rates: What Have We Learned?, *Journal of Economic Literature*, Vol. 35, No. 3. 1243-1272.

[17] Klenow, Peter and Oleksiy Krystov (2005), "State Dependent or Time Dependent Pricing: Does it Matter for U.S. Inflation? ", working paper.

[18] Knetter, Michael (1989), "Price Discrimination by U.S. and German Exporters", *American Economic Review*, Vol. 79, No. 1, 198-210.

[19] Knetter, Michael (1993), "International Comparisons of Pricing-to-Market Behavior", *American Economic Review*, Vol. 83, No. 3, 473-486.

[20] Lane, Philip (2001), "New Open Economy Macroeconomics: A Survey", *Journal of International Economics*, 54, 235-266, August.

[21] Lancaster, Tony (1990) “The Econometrics Analysis of Transition Data", Cambridge University Press.

[22] Marazzi, M, N. Sheets, R. Vigfusson, J. Faust, J. Gagnon, J. Marquez, R. Martin, T. Reeve and J. Rogers (2005), "Exchange Rate Pass-Through to U.S. import prices: Some new evidence", International Finance Discussion Papers, Number 833.

[23] Obstfeld, Maurice and Kenneth Rogoff (1995), "Exchange Rate Dynamics Redux", *Journal of Political Economy*, 103, 624-60.

[24] Rauch, James E. (1999), "Networks versus markets in International Trade", *Journal of International Economics*, Vol. 48, 7-35.

[25] Reiersol, Olav (1950) "Identifiability of a Linear Relation between Variables Which Are Subject to Error" *Econometrica*, Vol. 18, No. 4. (October), pp. 375-389.

[26] Taylor, John (2000), "Low Inflation, pass through, and the Pricing Power of Firms", *European Economic Review*, June volume 44 issue 7 pp. 1389-1408.

[27] van den Berg, G. J. (2001) "Duration Models: Specification, Identification, and Multiple Durations" Handbook of Econometrics, Vol. 5, Chapter 55.

PSL	HTS Code Description	BK LI Description	BK	GR
2710	Processed petrol	Fuel oil	1.3	1.0
2711	Natural and petrol gases	Bottled or tank gas	2.6	2.1
0306	Crustaceans	Shellfish (excl canned)	2.2	2.3
07	Edible vegatables	Other fresh vegetables	1.3	4.5
91	Watches and clocks	Watches	4.8	7.4
20	Vegatable and fruit products	Other processed vegetables	3.5	8.4
8471	Automatic data processing machines	Personal computers and peripheral equip.	2.1	10.1
8523	Prepared unrecorded media audiovisual	Records and tapes, prerecorded and blank	8.2	11.4
8528	Reception apparatus broadcast video media	Televisions	2.7	11.4
9405	Lamps and light fixtures	Lamps and lighting fixtures	4.6	11.6
6403	Footwear w/composite material	Girls /Men's /Boys /Women's Footwear	3.4	11.7
4011	New pneumatic tires	Tires	2.7	11.9
8521	Video recording equipment	Video cassette rec., disc players, cameras	2.7	12.2
70	Glass and glassware	Glassware	4.9	12.3
8708	Parts and accessories for vehicles	Vehicle parts and equipment other than tires	5.8	12.3
4202	Leather cases, bags, luggage	Luggage	2.6	13.2
38	Miscellaneous chemical products	Coolant, brake fluid, hydraulic fluid, additives	7	13.4
8516	Electric portable heaters house items	Portable cool/heat equip small appliances	4.8	13.5
8704	Motor vehicles for transport of goods	New trucks	2.1	13.9
6110	Knit/Crochet sweatshirts, pullovers, sweaters	Men's sweaters	1.7	13.9
9401	Seats and parts	Sofas	3.6	14.2
30	Pharmaceuticals	Prescription drugs and medical supplies	5.4	14.3
7113	Articles of jewelry containing precious metal	Jewelry	3.7	14.3
6203	Men's/boys' suits, ensembles, pants	Men's suits	3.3	14.9
6204	Women's/Girl's suits, pants, dresses	Women's suits	1.6	15.6
3926	Other plastics	Plastic dinnerware	9.3	16.1
6402	Partially waterproof footwear	Girls /Men's /Boys /Women's Footwear	3.4	16.1
63	Other textile articles	Kitchen and dining room linens	8.4	16.8
6205	Men's/boys' shirts	Men's shirts	2.5	17.7
8703	Passenger vehicles, capacity<10	New cars	2	18.7
37	Photographic and cinemegraphic goods	Photographic and darkroom supplies	18.4	18.7
9403	Other furniture and parts	Occasional furniture	4.3	19.3
2208	Undenatured ethyl alcohol w<80% concent	Distilled spirits at home (excl whiskey)	6.5	19.9
9018	Medical devices	Medical equipment for general use	9.7	22.5

Table 1: Comparison between the Bils-Klenow measures of stickiness of retail prices (BK) and this papers estimates for stickiness at-the-dock (GR), reported for only those harmonized code categories for which the BLS allows public reporting. Sectors are matched based on their descriptions.

	Imports	Exports	Imports	Exports
Constant	0.98 (29.81)	1.00 (36.21)	1.07 (30.72)	1.08 (28.22)
Reference	0.73 (21.13)	0.53 (12.95)	0.67 (18.67)	0.32 (7.38)
Differentiated	0.99 (26.18)	0.89 (26.37)	0.96 (24.40)	0.77 (17.47)
Intra-Firm	0.13 (9.51)	0.12 (8.19)	0.11 (7.74)	0.11 (6.58)
Nondollar	-1.79 (-95.87)	-1.79 (-49.29)	-1.82 (-93.27)	-1.82 (0.04)
Industrial Supplies	-0.08 (-3.07)	0.14 (4.92)	-0.08 (-2.96)	0.23 (0.03)
Capital goods excl auto	0.28 (9.23)	0.49 (16.36)	0.26 (8.20)	0.54 (0.04)
Auto parts engines	0.27 (8.27)	0.34 (10.34)	0.26 (7.43)	0.39 (9.39)
Consumer goods	0.25 (8.65)	0.49 (16.44)	0.22 (7.48)	0.51 (13.13)
Other enduse	0.55 (9.38)	0.51 (11.12)	0.54 (9.20)	0.49 (8.22)
Standard Deviation of Exchange Rate			-0.005 (6.47)	0.001 (1.08)
Country Fixed Effects	Y	Y	Y	Y
No, of observations	27636	23862	24916	13038
Adjusted R2	0.29	0.22	0.29	0.25

Table 2: Duration and product characteristics. The dependent variable is log duration. t-stats calculated using robust standard errors are reported in parenthesis. The standard deviation of exchange rate refers to the standard deviation of the nominal exchange rate in percentage terms.

Year	Monthly Probability	Time Varying Sectoral Probability	Time Varying Sectoral Composition
1994	0.29	0.29	0.29
1995	0.28	0.28	0.29
1996	0.26	0.26	0.29
1997	0.25	0.25	0.28
1998	0.24	0.25	0.28
1999	0.21	0.22	0.28
2000	0.19	0.20	0.28
2001	0.18	0.20	0.28
2002	0.18	0.19	0.28
2003	0.18	0.19	0.28
2004	0.18	0.20	0.28

Table 3: Decomposing the Time Trend in Price Stickiness. The annual average probability of price change is calculated for each good by dividing the number of price changes by the total number of usable prices in a given year. The average probability for the year, reported in column 2 is calculated by averaging across goods.

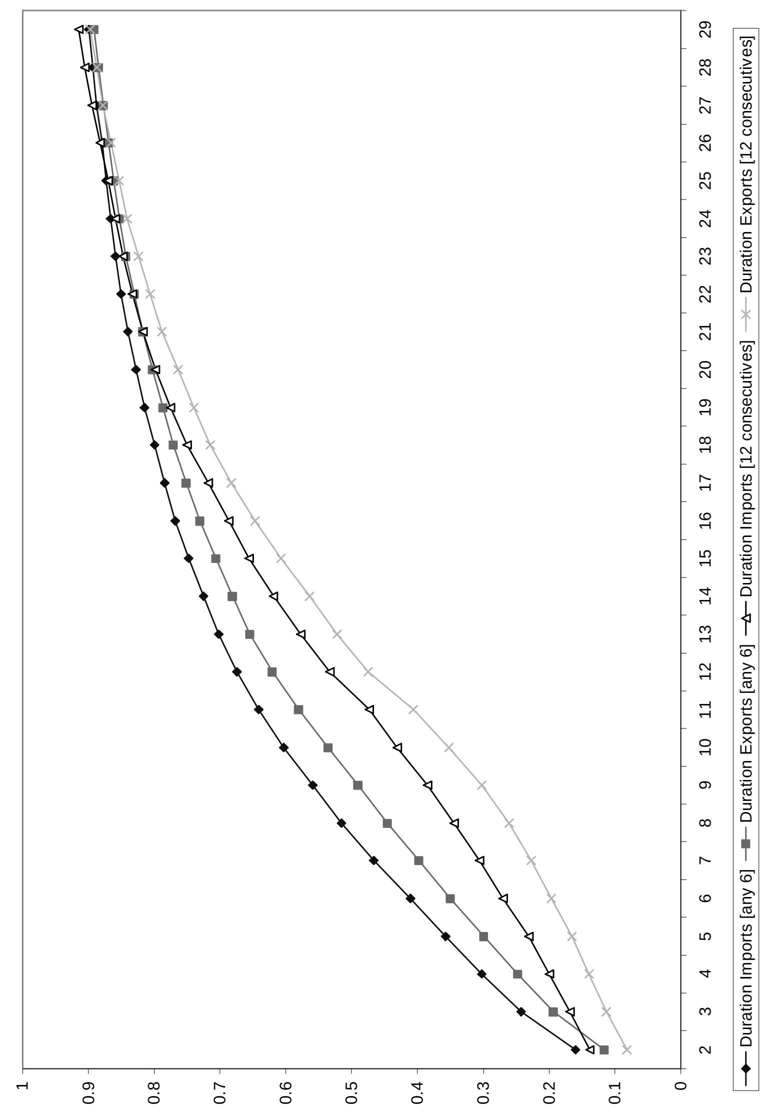

Figure 1: Cumulative distribution of price duration for imports and exports. The number of months are plotted on the x-axis and the fraction of goods with average duration less than or equal to a certain number of months is plotted on the y-axis. Duration Imports (12 consecutive) refers to the measures when we restrict the sample to goods that have at least one spell of 12 consecutive observations. Duration Imports (any 6) refers to the measures using the larger sample of all goods that have any 6 observations that need not be consecutive.

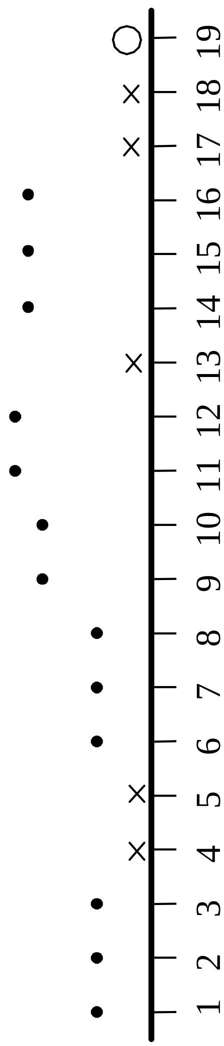

Figure 2: Depiction of a typical price series for a good. Dots represent usable prices, the X's represent missing prices and the empty circle indicates the date on which the good was discontinued.

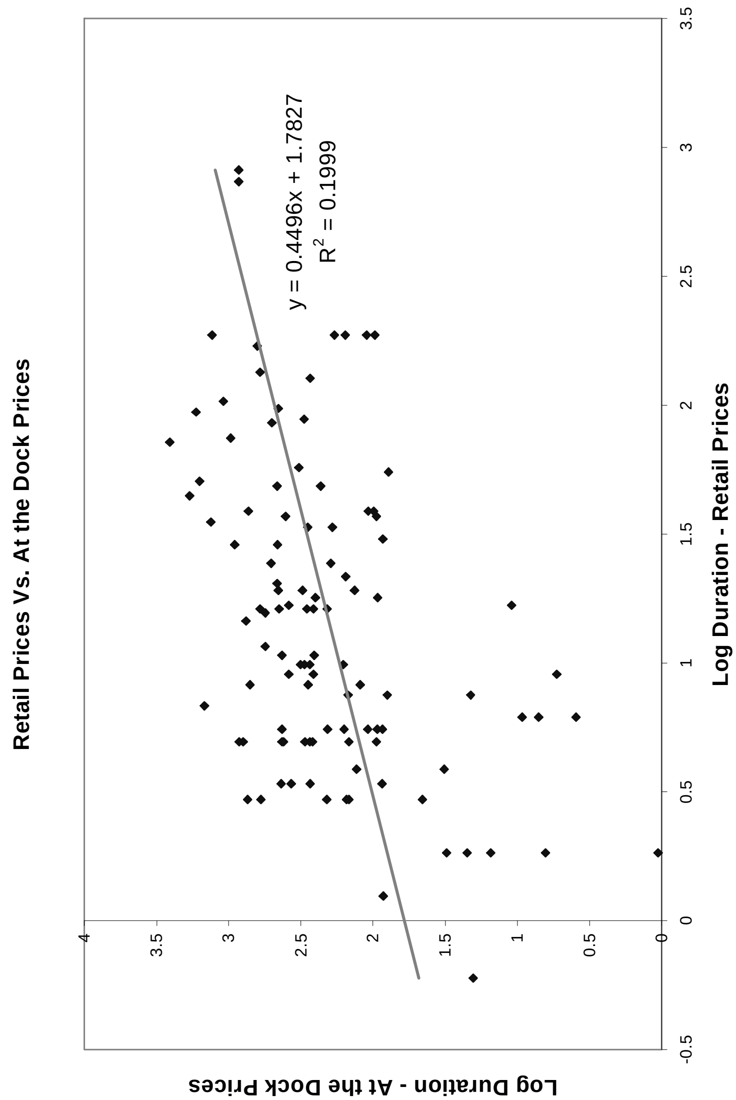

Figure 3: Relation between the log of the duration measures estimated in this paper for goods at-the-dock and the Bils-Klenow (2004) measures of duration for retail prices. The matching with the BK categories was done based on description of the category. Each observation for at-the-dock prices is the average duration within, in most cases, a 4 digit harmonized code in our sample.

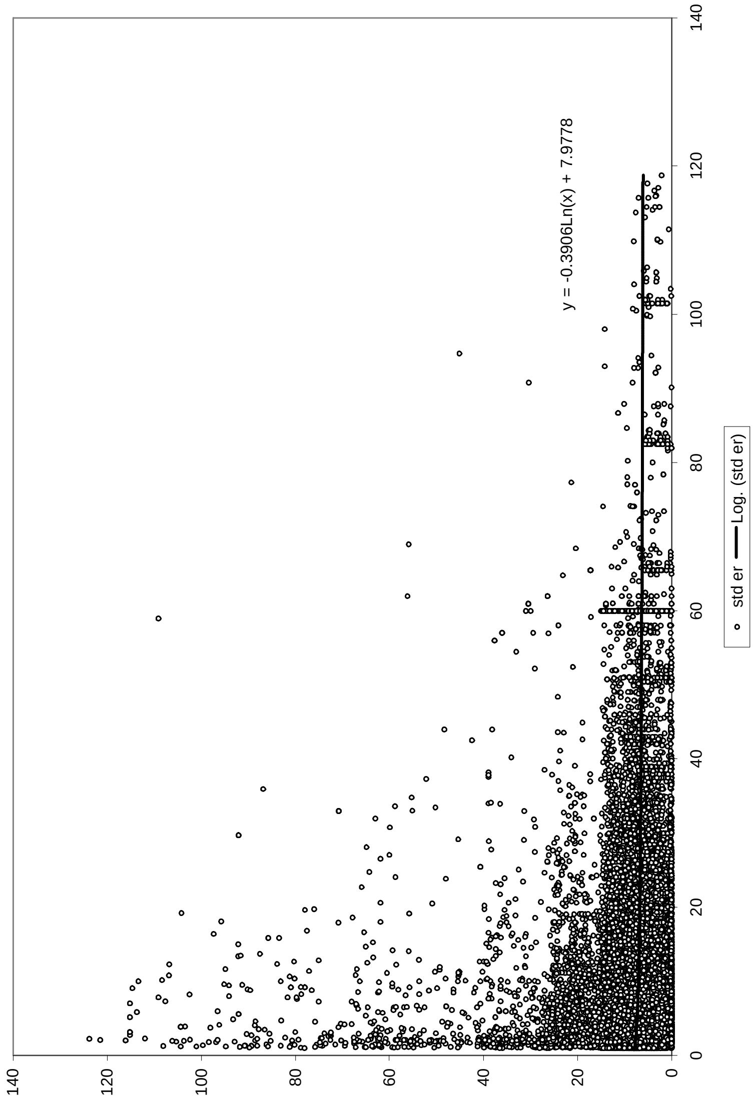

Figure 4: Duration and Nominal Exchange Rate volatility. Duration is measured on the y-axis and the standard deviation of the nominal exchange rate (in percentage terms) is measured on the x-axis. Each point plots the price duration for a good and the exchange rate volatility during the life of the good.

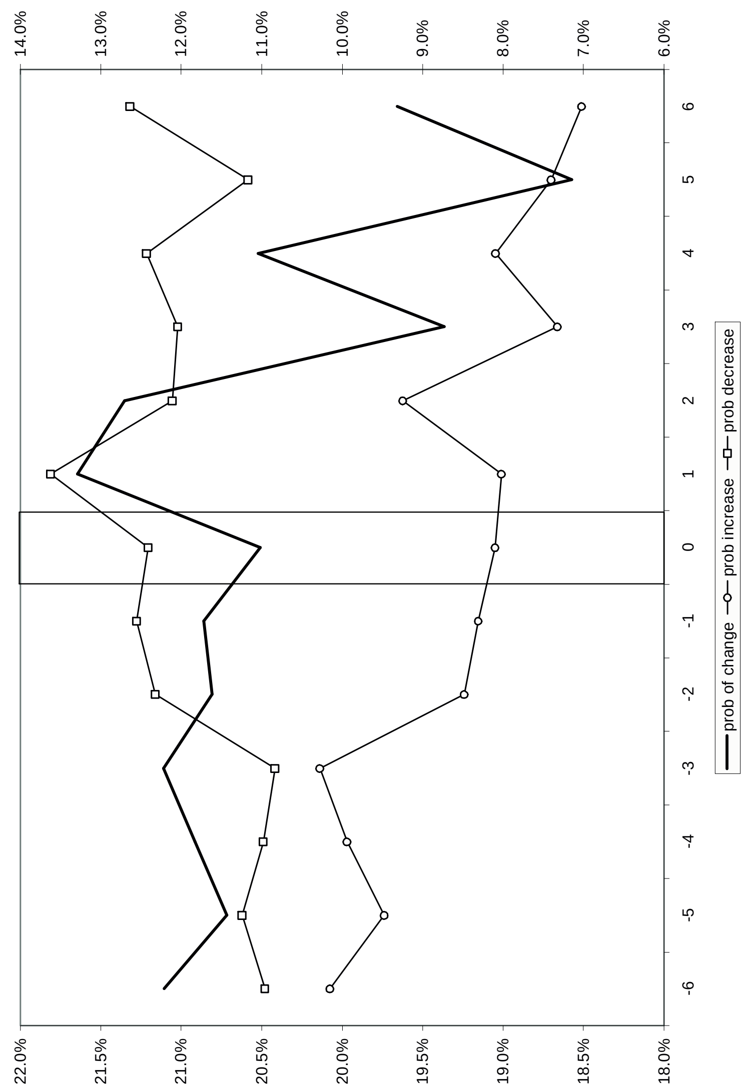

Figure 5: Probability of Price change around large devaluations. Large devaluations are defined as exchange rate depreciations of 15 percent or more in a single month. The plot covers the period 6 months before and 6 months after the depreciation. 'Prob increase (decrease)' refers to the probability of price change conditional on the price change being a price increase (decrease).

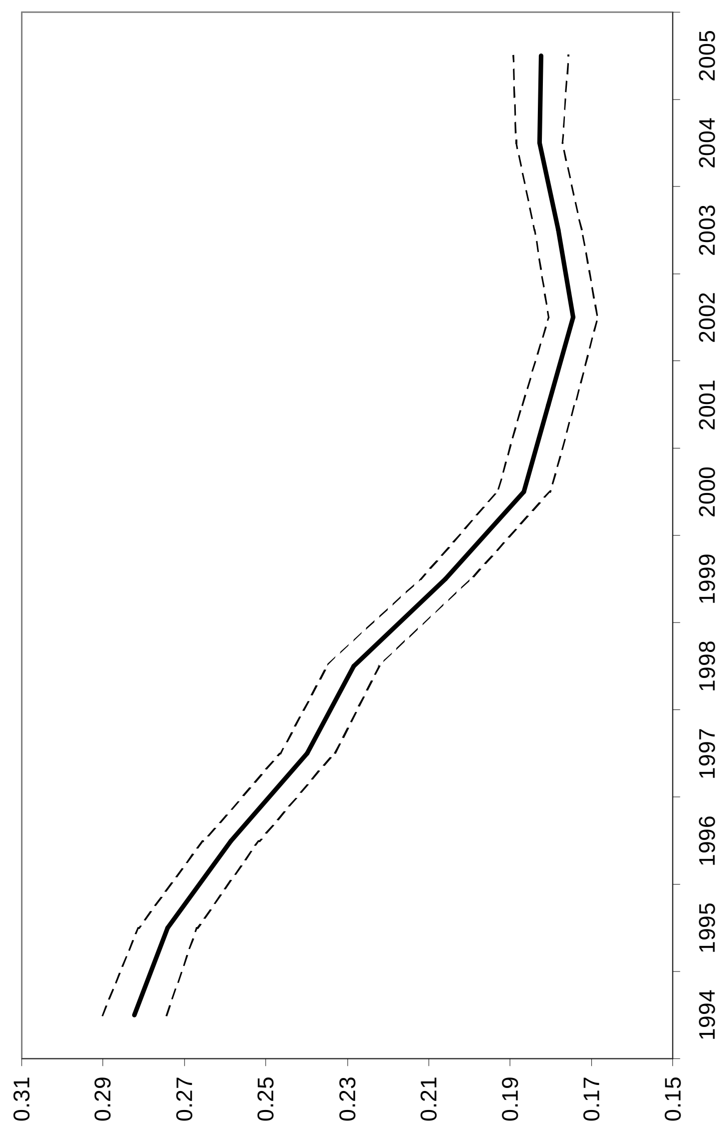

Figure 6: Time Trend in the Probability of Price change. The annual average probability of price change is calculated for each good by dividing the number of price changes by the total number of usable prices in a given year. The average probability for the year, reported in column 2 is calculated by averaging across goods. The bands represent 95% confidence intervals.

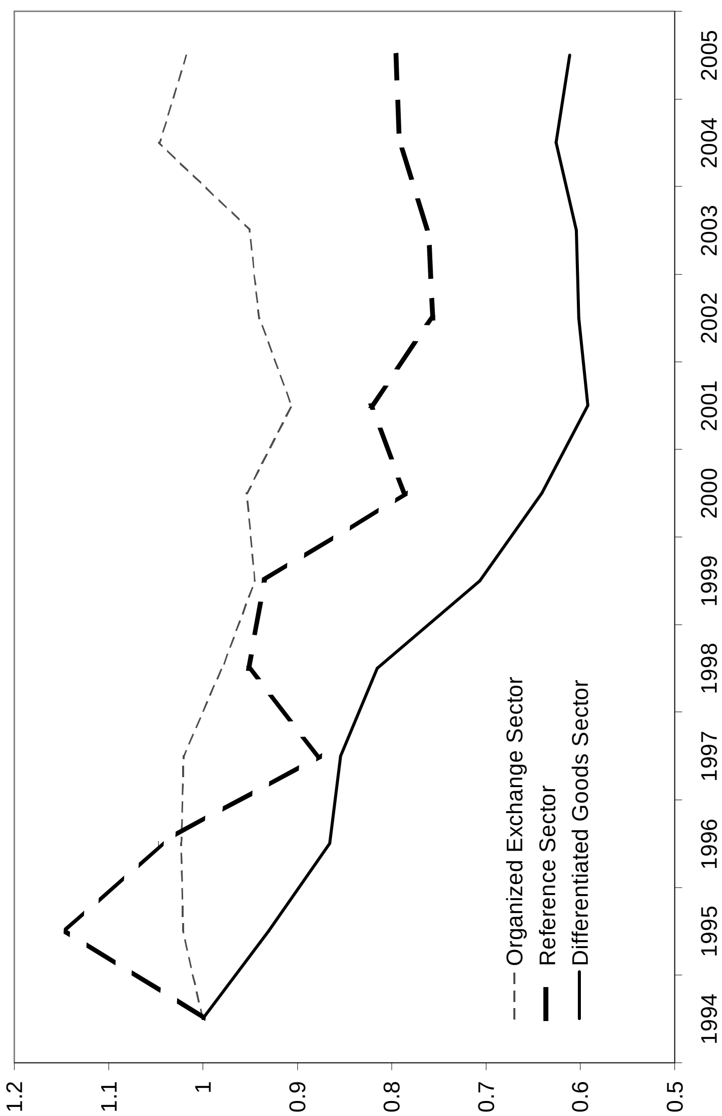

Figure 7: Time trend in Probability of Price change across organized, reference and differentiated categories. The initial point is normalized to 1 for all categories.

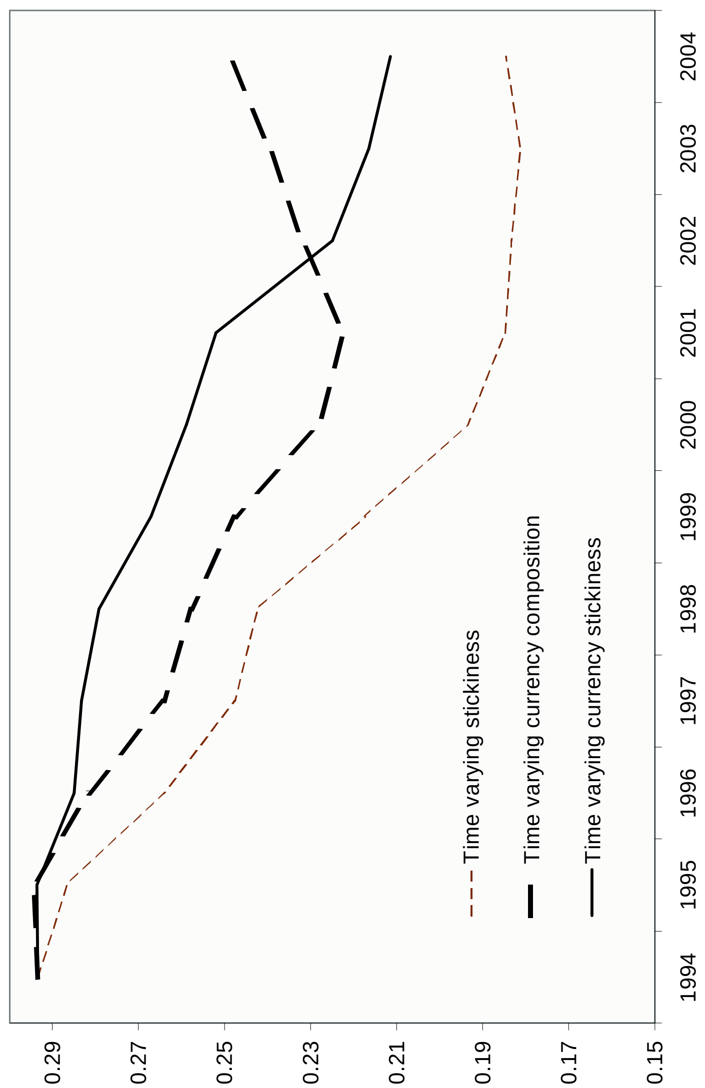

Figure 8: Decomposition of the Time trend in Probability of Price change across goods invoiced in dollars and those invoiced in a non-dollar currency. The line 'Time varying stickiness' plots the average probability of price change by year. 'Time varying currency composition' plots the yearly probability of price change assuming that probabilities within dollar invoiced and non-dollar invoiced categories stay unchanged at their level in 1994. 'Time varying currency stickiness' plots the yearly probability of price change assuming that the fraction of goods invoiced in each currency stays unchanged at the level in 1994.

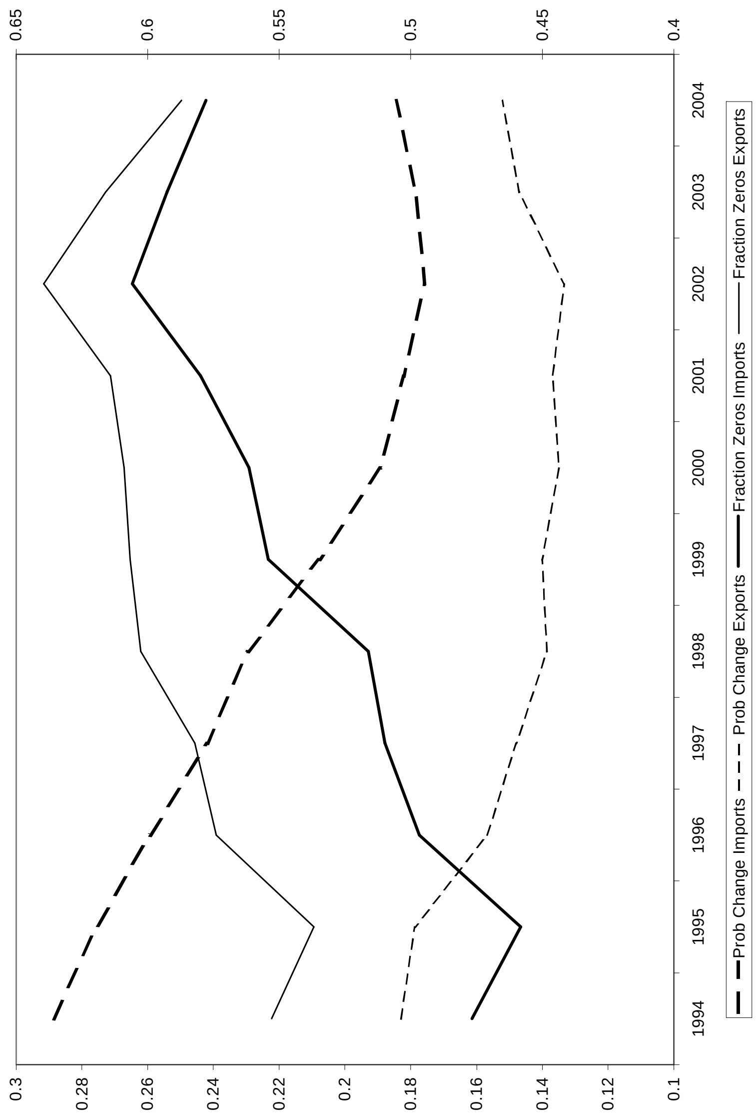

Figure 9: Time trend in the probability of price change and the fraction of items with a probability of zero in a given year.

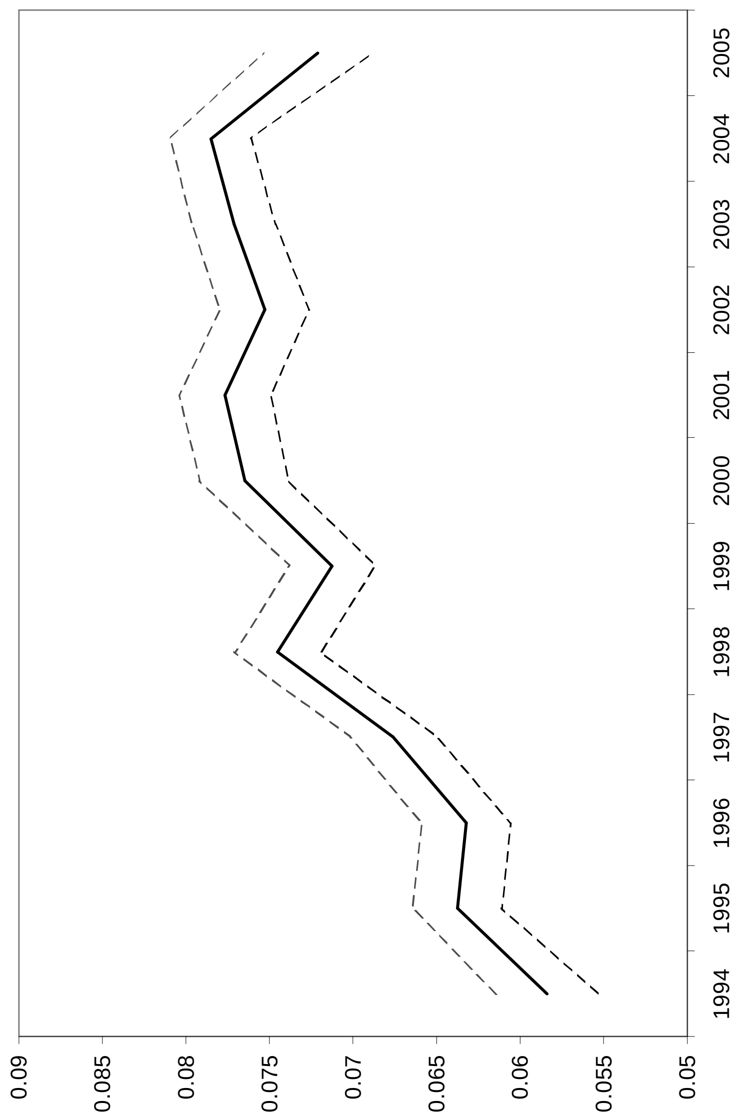

Figure 10: Time trend in the magnitude of absolute price change. For each good we calculate the average absolute price change conditional on changing prices in a given year, and then report the average across goods for each year. The bands represent 95 percent confidence intervals.

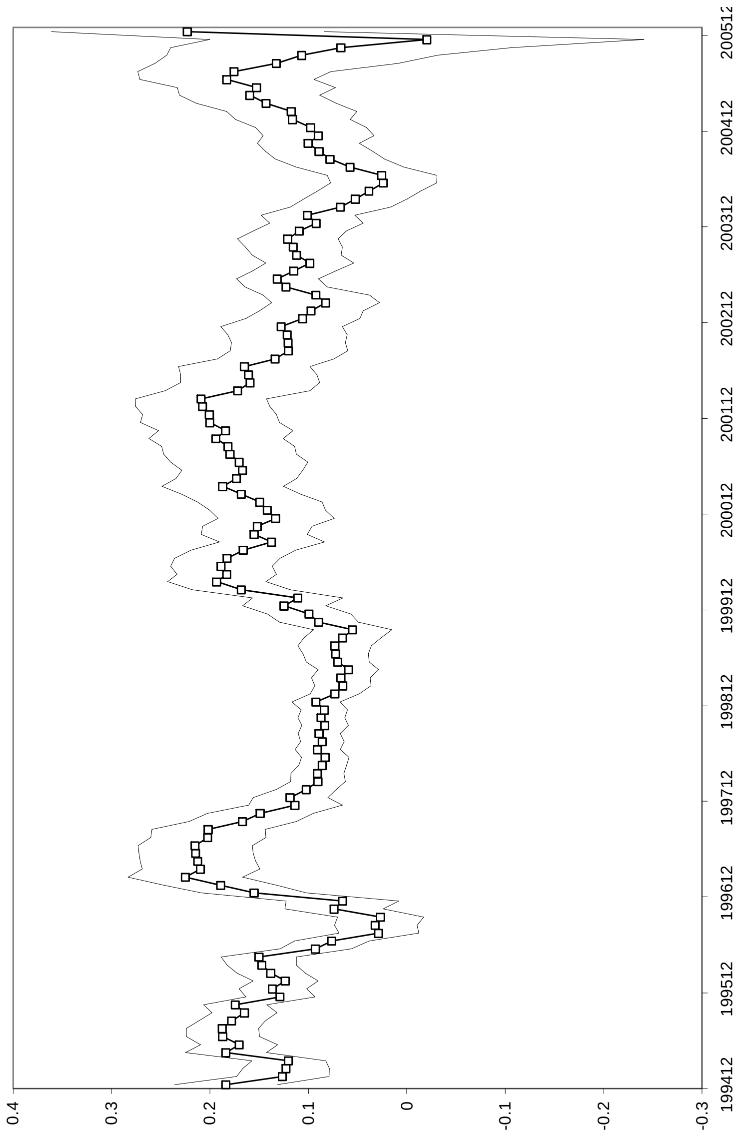

Figure 11: Pass through of exchange rates to prices conditional on observing a price change. To calculate the pass-through we used 12 month rolling windows. 95 percent confidence bands also shown.