Sticky Borders*

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Abstract

There is an extensive theoretical literature that places sticky prices of traded goods at the center of international macroeconomics. Despite this rich theoretical literature, there is very little empirical evidence that directly estimates the extent of price stickiness in import and export prices. This paper uses a novel dataset to present extensive evidence on price stickiness at the border, in imports and exports for the U.S. We use unpublished micro data on import and export prices collected by the Bureau of Labor Statistics for the United States for the period 1994-2005.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 find that there is a tremendous amount of dollar price stickiness in both imports and exports. The weighted average price duration is 12.26 months for imports and 14.11 months for exports. These numbers are about three times the Bils-Klenow (2004) estimates for consumer prices. We find little systematic relation between the stickiness of consumer prices of aggregate 'tradeable' sector goods and prices at the dock of 'traded' goods. Goods traded on organized markets and reference priced goods have less sticky prices. However, there is little evidence that the price stickiness of goods traded intra-firm differ from those goods traded at arms-length. Lastly, we explore the relation between exchange rate movements and the probability and size of price change in imports.

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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 (see Lane (2001)) building on the work of Obstfeld and Rogoff (1995) assign a central role to nominal rigidities. Chari, Kehoe and Mcgrattan (2002) demonstrate that the ability of a business cycle model to match the persistence of the real exchange rate in the data is very sensitive to the parameter that is used to calibrate the stickiness of traded goods prices. Despite this rich theoretical literature, there is very little empirical evidence that directly estimates the extent of price stickiness in import and export prices. This paper uses a novel data set to present extensive evidence on price stickiness at the border, in imports and exports for the U.S. We use unpublished micro data on import and export prices collected by the Bureau of Labor Statistics for the United States for the period 1994-2005.

There is a large empirical literature that examines the stickiness of prices for goods produced and sold domestically. This includes prices of consumer goods at the retail level and producer goods sold between firms. Taylor (1999) surveyed this literature and concluded that price stickiness lasts around 1 year. This is the number to which most quantitative international macro models such as Chari et al (2002) calibrate the stickiness parameter for traded goods. In an important recent paper, Bils and Klenow (2004), using micro data that underlies the construction of the consumer price index for the U.S., show that price changes are far more frequent than earlier studies have found. They find that half of goods prices are fixed for less than 4.3 months. Given that a large fraction of goods that enter consumer expenditure are so called tradeable goods, does this imply that actual traded goods also change prices frequently? We find that this is not the case. There is a large amount of dollar price stickiness with (trade weighted) goods prices lasting on average 12.26 months for imports and 14.11 months for exports.

We also find, as in other studies of price stickiness, that there is a tremendous amount of heterogeneity in price stickiness across highly disaggregated goods. The median duration of price change for imports is 13.7 months and the standard deviation is 7.4 months. Similarly, in the case of exports, the median duration is 15.8 months with a standard deviation of 8.3 months. Estimates of stickiness using aggregate data can be very misleading, something we will discuss in detail in the paper.

There is a large literature that measures the extent of pass-through of the exchange rate into import and export prices. There are several differences between the pass-through literature and what we do in this paper. Firstly, clearly, stickiness and pass-through while related are separate concepts. There are numerous reasons why the price at which a good is imported can change, the exchange rate being only one such variable. The currency in which the price is sticky will also have different implications for pass-through rates.[1] Interestingly, for the U.S. we find local currency price stickiness in the case of imports and producer price stickiness in the case of exports. This is unlike the typical model that assumes one extreme or the other.

Secondly, the large majority of papers that examine prices of disaggregated traded goods use retail level prices. See Goldberg and Knetter (1997) for an excellent survey. In an important paper Crucini and Shintani (2004) use micro data on retail prices of 270 goods in European countries to test the law of one price. Retail level prices of a traded good, however, include a large non-traded component such as local distribution costs and the price of other retail services in the final goods price (see Burstein, Eichenbaum and Rebelo 2004), and consequently cannot be directly used to answer the question of price stickiness at the dock. The micro data we employ tracks the monthly at-the-dock price of an extremely detailed item whose unit of sale and other trade factors are unchanged over time. Our study involves the use of 41528 unique items.

To obtain a measure of price stickiness we need to deal with several issues in the data. First, the data is censored; and second, there is large individual or item heterogeneity. Regarding the measurement of price stickiness, goods in the price index have short lives relative to their degree of stickiness, with several goods disappearing from the index well before their scheduled phase out date from the sample. There are numerous reasons why a good is discontinued, including non-reporting or when the good is no longer traded and instead is either replaced by another good or discontinued. Furthermore, there are several goods whose price remains fixed during almost all of their life, meaning that the degree of censoring is substantial. The second issue is with regard to heterogeneity at the item level and the consequent aggregation biases that can result. To deal with these issues we present several alternative aggregate estimates that deal with issues of heterogeneity and censoring. The general result across all the different estimates strongly suggest the existence of large dollar price stickiness in the data.

We next relate the degree of price stickiness to sectoral characteristics of the good. We merge Rauch's (1999) classification of goods into 'homogenous' and 'differentiated' with the sectoral classification in our database. As expected, we find that homogenous goods display far lower price stickiness than differentiated goods. In the case of imports, goods traded on an organized exchange

[1] Engel (2003) has a nice discussion on this.

remain sticky for 3.6 months, reference priced goods for 10.3 months and differentiated goods for 15.8 months. Additionally, we have information on whether a good is sold "intra-firm" that is between a parent and an affiliate or if it is sold to an unrelated party. Interestingly, while we obtain a very precise estimate of the difference, it is quite small. Prices involved in third-party transactions are stickier by around a month. This data, therefore, does not suggest dramatically different price stickiness depending on whether the transaction is intra-firm or not.

Lastly, we merge our classification of imported goods with the Bils-Klenow (2004) classification and generate a match for 106 categories. We then compare the measure of price stickiness at the border with price stickiness of a similar category of goods at the retail level and find that for every single category price stickiness at the border is at least as great (in most cases substantially greater) as stickiness at the retail level. There is a wide disconnect between the stickiness of retail level prices of tradeable goods and the prices at the dock of traded goods. Clearly, there are several reasons why this can be the case. One of the reasons for the disconnect could be that very little of domestic consumption expenditure is actually on imported goods, a point made in Fitzgerald (2005) and Atkeson and Burstein (2005). Another reason could be the fact that most retail prices include a large distribution component that is non-traded (Burstein-Eichenbaum-Rebelo (2004)). 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.

Since the exchange rate is an important component that enters the dollar price of imports, we examine the relation between the exchange rate volatility during the life of the item and the duration of price stickiness. One could argue that the reason prices are unchanging for long periods is because we have numerous items that are imported from countries whose exchange rate is pegged to the dollar. We do not find a sizeable increase in the probability of a price change as exchange rate volatility rises. If we restrict attention to imports from the Euro area, for the period 1999-2004 we obtain a median duration for prices of 9.5 months.

We also find that the degree of stickiness has been changing through the years. In particular, we find that the proportion of items who's prices are fixed has increased since the beginning of the sample. This has important implications for the measurement of the pass through at the aggregate level. If stickiness is increasing, then the average pass through in the US economy should be declining.

The paper is organized as follows: Section 2 describes the data we use. Section 3 studies the price stickiness. We discuss the problems with measurement, and present the results. Finally, Section 6 presents conclusions and directions of 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 years 1994-2005. 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).[2]

Price data are collected every month for approximately 20,000 items (include exports and imports). A reporting company is contacted for the transaction price on a monthly basis. The price information provided by the company is entirely voluntary and confidential. Several times 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 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. or c.i.f. etc.), the currency in which the price is reported, the unit of sale (one, dozen etc.), the country of imports/export and 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, quality etc. The price program tracks the price of a consistent extremely detailed item over time.

[2] 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 works of art and antiques (harmonized code 97), articles exported and returned (harmonized code 98) and certain special category goods (harmonized code 99).

An example of an item description is "Lot # 34245, 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 '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. There are approximately 57,000 import items and around 43,000 export items that were in the sample for various periods of time during 1994-2005. Each item is mapped to a 10 digit classification group in the Harmonized system. In several cases, we will report summary statistics by Harmonized group, in most cases at the 4 digit level. This level of aggregation is referred to as the 'Primary Stratum Lower' (PSL) in the BLS tables. Henceforth we shall use the PSL terminology to refer to the strata. 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.

The price data is monthly. However there are several months when the item is not-traded and the company provides no estimated price, 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 approximately 40% of the observations in the import and export database. Since these un-usable prices do not reflect a true 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. These prices in the vast majority of cases reflects a price involved in an actual transaction.

Since we restrict attention to only usable prices, we have several items that have only a few observations. In the case of imports, the median (mean) number of observations per item is 13 (19). 25% of the items have 5 or less observations and 45% have less than 12 observations. Similarly, in the case of exports, the median (mean) number of observations is 17 (22.7) per item. 24% of the items have 5 or less observations and 39% have less than 12 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 life of the item as the difference between the last date of a usable price and the first date of a usable price for every item, the median (mean) life of the item is 22 (25.94) months, for a sample with a median of 13 observations. In the case of exports the median (mean) life of the item is 25 (29.28) months.

Lastly, around 30% of the items have their price constant over their life, both in the case of imports and exports. In the import (export) sample, such items have a median life of 12 (15) months.

Items that have very few usable observations and frequent gaps in their price series make estimation of price duration and hazards extremely problematic. The censoring problem in estimating hazards is magnified, especially since prices remain constant during the life of the item. Accordingly, we adopted the following inclusion criterion for an item. We require that there be at least one spell of 12 monthly consecutive usable prices for an item. We then keep all further 12 month usable price spells for the item. We also excluded price observations if the size of the (monthly) price change exceeded 100%. There are very few such observations in the data. The final size of the sample that we work with in this paper is still very large and includes 22660 items for imports and 18868 items for exports. The number of individual price observations for imports is 718083 and for exports is 643208. As a robustness check for our results, where possible we will extend our sample to include all items with usable prices. We find that our results are unchanged in the full sample.

3 Price Stickiness

The objective of this section is to report the average time that prices are fixed for imports and exports. The data we possess has two important limitations that complicates reporting a single summary statistic to describe the data. First, the data suffers from censoring. Items in the data set remain for relatively short periods of time (roughly two and a half years). If prices are sticky for a year, it means that we observe on average two to three changes in the life of the items, which makes it difficult to estimate the hazard. Second, there is tremendous heterogeneity at the item level, which means that computations of standard hazard models are biased, and calculations of simple probability changes are biased as well. The following section deals with both these issues.

3.1 Sticky prices

As was mentioned above, the items in our sample stay for relatively short periods. According to the sample design each item is to be followed for 5 years, however for the large majority of the items the life of the item in the sample is far shorter. We calculate, in our sample, the average life of an item within each PSL and find that the median across strata is 30 months. When we weight the average lives by the size of the strata (number of observations) the weighted average is 39 months. There is also a large amount of dispersion with average lives ranging from 12.75 months to 140 months.[3] There are several reasons for discontinuation, including "refusal to report", the item being "out-of-scope", and then either "replaced" with another item or simply discontinued. The implication of the short life is that measures of stickiness could be affected by censoring. We present different estimates that will deal with the problem of censoring in alternative ways. The second empirical challenge is dealing with item heterogeneity. In this regard, we compute two measures for price stickiness: (i) weighted average of time between changes, and (ii) proportional hazard functions that correct for censoring and individual heterogeneity. In this section we deal first with the issue of heterogeneity, and then the problem of censoring.

3.1.1 Measures un-corrected for censoring

To understand the significance of the aggregation bias, let us discuss several simple examples and see how the most commonly used measures of stickiness perform. In most of this discussion, we obviate the censoring problem, and concentrate entirely on the bias introduced by aggregation. We will deal with the censoring later.

The measures, or summary statistics, of price stickiness used in the literature are: the probability of change (median or mean), the simple average time between changes, the weighted average between changes, and the median. In the examples below we assume the data is heterogeneous but that the econometrician is pooling the data, or trying to summarize the average behavior. In other words, we assume that the econometrician is trying to find a single measure that describes the properties of the heterogeneous data.

Definition 1 *Average probability of price change: in the pooled data, compute the probability of observing a price change for any given good, the following month. Formally it is given by*

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

Definition 2 *Average time between changes: in the pooled data, compute the average time between*

[3] Note that given our decision to include only items that have at least 12 consecutive observations, the life is bounded below by 12 months.

price changes. In this case, each observation is a spell in which prices are fixed

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

Definition 3 *Weighted average time between changes: in the pooled data, 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*

$$\hat{t} = \frac{\sum [\textit{time between price changes}] * [\textit{time between price changes}]}{\textit{total number of observations}}$$

Let us study how these measures perform in two examples. The objective is to highlight that all measures that include some form of averaging probabilities are biased because the data is censored. This includes, for example, estimations of hazard functions. We show that if individual heterogeneity cannot be accounted directly, the weighted average of time between changes is possibly the best one.

Example 4 *Assume that the economy has only two types of goods: Type A adjusts its price every month, and Type B changes its price every three months. Assume that both goods are equally represented in the data. Assume both prices are observed for T periods.*

By construction, in this economy goods adjust prices on average every two months. In other words, every three months we observe exactly 4 changes of prices.

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. Notice that if we compute the average of the individual probabilities we obtain exactly the same bias downward. The probability of Type A goods changing is 1, while for Type B it is 1/3. The average of these probabilities is again 2/3. It is important to highlight that the mean and the median of the distribution are equally biased.

The second measure computes the average time between changes. As before, in T observations of Type A good, there are T times in which we observe a price change. For Type B, there are $T/3$ observations of 3 months. When we pool all observations we find that there are $T + T/3$ observed spells, T of them last one month, and $T/3$ of them last three months. The simple average is

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

Notice that this implies an average time to change equal to a month and a half. Exactly the same bias computed by using the probabilities. However, observe that if we know that the data is heterogenous and estimate the average stickiness of each price independently (1 and 3) then the simple average of the stickiness produces the correct answer, 2.

Measure 3 − the weighted average of the time between changes[4] − corrects for this problem. In this example, the observations that have one month are weighted by one, and the observations 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 weighted average of the time between changes. Hence, we have decided, in this paper, to concentrate on this measure to summarize the properties of the data. Nevertheless, we present results for the other measures as well.

Probability of Change We first calculate the average monthly probability of price change at the item level. That is, we calculate the statistic in Definition 1 at the item level. We find that 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[5] is then $1/\lambda$, which is 14.66 months for imports and 18 months for exports. This statistic[6] is the closest to the Bils-Klenow (2004) statistic where they estimate λ to be a much higher number of around 0.2. Therefore, our estimate of price stickiness implies that prices last more than 3 times as long at the border.

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.

[4] See Bahard and Eden (2003)

[5] This is assuming you can change prices only once a month.

[6] Bils and Klenow (2004) calculate the statistic at a slightly more aggregated level since the data they use is at the level of 4-5 items per category. They also weight by the goods weight in the index, a calculation we perform later.

Figures 1 and 2 present the cumulative distribution for the probability of change for imports and exports respectively.

Time Between Price Changes The next statistic we calculate is the time between price changes. Here we concentrate on Definition 3. Since we start observing the price of the item only when it is sampled, and most of the lives of the items are short, we have left and right censoring of the time between price changes that biases our results towards finding shorter durations than the true measures. The censoring issue is particularly severe in our sample because of the large number of items that never change price during their life. In this section we calculate the statistic by assuming that the first observation is a new price and the last observation is also a new price. By doing this we are biasing ourselves in the direction of finding shorter durations.[7] In the case of imports the median (mean) duration is 11 (13.29) months and in the case of exports the median (mean) duration is 12.16 (14.78) months. The standard deviation is 10.88 months for imports and 11.07 months for exports. Remember that this standard deviation is not the precision of the estimates, but a measure of the individual dispersion.

After calculating $\hat{t}$ for each item, we calculate the average for each PSL by weighting the items $\hat{t}$ with the number of observations for the item. In the case of imports the mean and median across the PSL's is estimated to be 13.87 and 13.71 respectively. The standard deviation is 7.4 months. In the case of exports the mean and medians are slightly longer at 15.07 and 15.15 months respectively. The standard deviation is 8.32 months. That is, despite being biased downward, we find that prices last a long time.

Figures 3 and 4 present the distribution of durations in our sample.

[7] In the case when there are missing observations during the life of the item, we truncate the spell and treat the last price observation before the missing month as a price change and the price following a missing month as a new price. Here again, we are biasing ourselves in the direction of finding low numbers for duration.

3.1.2 Hazard Functions: Measures corrected for censoring

In this section we estimate duration models of price stickiness to correct for the censoring[8]. Given the large amount of heterogeneity in the data, we estimate them at the Item level.

Since a large number of items never change their price in their entire life, estimating the duration model is problematic. In particular, the estimation of a standard duration model will assign infinite duration to all the goods whose prices never change. This clearly is not an interesting estimate. Therefore, for those cases when the prices do not change we take two approaches: We assume that the goods is exponentially distributed, and that the observed spell is the average of such a distribution. This implies that the expected stickiness for those prices is twice the observed spell. The second alternative is to simply not correct for censoring in those cases. So, we use the observed spell as the duration.

	Imports	Exports
No Censoring		
Average	12.48	14.01
Median	9.50	11.25
Std Deviation	11.67	12.03
Censoring		
Average	23.79	26.70
Median	15.00	18.00
Std Deviation	27.04	30.50
Censoring (no adjustment for constant)		
Average	16.55	18.97
Median	13.00	15.00
Std Deviation	18.42	22.81

Table 1: Estimated average stickiness for each Item. Export and Import items

As can be seen, at the item level, there is tremendous stickiness in prices. When the data is not adjusted for censoring, the average stickiness is 12.48 months, while the median is 9.50. This is very much in line with our previous estimates. We also report the standard deviation of the individual estimates to highlight the very high heterogeneity in the data. When we adjust for censoring these estimates increase significantly: average of 23.79 and median of 15.00 months. If we

[8] Just to clarify, we estimate constant hazard models, and the log likelihood function for each item is

$$L_i = \sum [d_i \ln \lambda_i - t_i \lambda_i]$$

where d_i indicates the observations that are not censored, t_i are the elapsed times of price changes, and λ_i is the hazard we are estimating.

leave uncorrected the hazard for items whose price never changes, then the average in the sample is 16.55 and the median is 13.0 months. The pattern for exports is very similar.

The main conclusion derived from this analysis is that the average or median price stickiness is more than a year for imports and exports.

3.1.3 Weighted averages

In the previous analysis we gave each item an equal weight. It can be argued that the items we really care about are the ones with the larger weight in the index. To perform this calculation we would require the weight of the item in the index. While we do not have the specific item weight, the BLS was able to provide us with weights at the 10 digit harmonized level, referred to as a classification group, which is the lowest level of aggregation at which the BLS performs its sampling. Each item is mapped to a classification group. The median and mean number of items in a classification group is 2 and 5 in our sample[9]. 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 calculated the average dollar value across the years for each group and then distributed this dollar value 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 14.11 months for exports. When we weight the corrected for censoring measures of hazard we arrive at 21.64 months for imports and 25.62 months for exports. The other weighted estimates are presented in Table 3. As can be seen, the weighted estimates for the hazard model are not very different from the unweighted measures. In the case of imports, crude petrol has the highest weight 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.

3.1.4 Using the Full BLS sample

As described earlier, given that several items have very few observations and numerous gaps in their price series, we had to exclude these items from our estimation. As a robustness check we calculated

[9] 75% of classif_groups have less than or equal to 5 items. The largest classif_group has 166 items.

	Imports	Exports
Average Duration	12.25726	14.12302
Duration model		
No Censoring	11.27991	13.45918
Censoring	21.61291	25.60442
Censoring (no constants)	15.09442	17.62047

Table 2: Weighted average stickiness using a measure of item weights in the index

the probability of price change for every item in the original sample. The probability of price change for the median item is 0.047 for imports and 0.036 for exports. The invers of these numbers imply very high durations of price stickiness. Since there are numerous gaps in available price even within the life of each item the censoring problem is quite severe. When we estimate the hazard model corrected for censoring (without correcting for items whose price never changes), the median is 8 months and the average is 15.62 months for the case of imports and a median of 7 months and average of 15.32 months for exports. The median in this case is biased downwards because there are numerous items with only 1 or 2 price observations whose price remains unchanged.

3.1.5 Concerns Regarding Reporting by the firm

A concern that one might have is that since the reporting is voluntary, a reporting company might prefer to simply state that the price has not changed. The standard procedure involves the firm entering the information on an information sheet provided by the BLS and mailing it back. To determine if the reporting would have been any different if the company reporter had to convey the information directly to a BLS agent, we use an interesting experiment that took place around the period of the terror strikes in 2001.[10] Following the anthrax attacks and disruption of mail, in October 2001, prices for that month were collected by BLS agents directly contacting the reporting company. Anecdotal evidence suggests that in this month firms were more responsive in providing information. 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 almost no difference in the median and mean probability of price change for that year. In this sense, the hypothesis that prices are sticky because firms find it convenient to misreport seems less likely.

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

3.2 Discussion

In summary, we compute average probabilities of price changes, average durations, and hazard functions item by item for imports and exports. The message we obtain is consistent. The price stickiness is longer than a year. Also, it is important to note that the stickiness is in dollars for both imports and exports. This may be related to the fact that over 80% of US imports and exports are invoiced in dollars, though clearly there is no obvious reason why invoicing in a particular currency should make prices sticky in that currency. The stickiness of imports and exports in dollars implies a phenomenon of local currency pricing for imports and producer currency pricing for exports in the U.S. In typical models of price stickiness usually one or the other is assumed.

3.3 Sticky Prices, Homogenous goods, and Intra-Firm Transactions

In this section, we relate our measures of stickiness to whether the good is traded in organized markets, and if the transaction takes place intra-firm or involves unrelated parties. We also compare our results with those of Bils and Klenow (2004).

3.3.1 Sticky Prices and Homogenous goods

Jim Rauch (1999) classified traded goods, empirically, into homogenous goods and differentiated goods. The former 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 price goods. An example is "Polymerization and Co-Polymerization products". We merge our PSL classification with Rauch's classification using the concordance between harmonized codes and SITC2 codes. We obtain a match of 181 classification codes for imports and 160 classification codes for exports. We will present the results using Rauch's conservative classification, but the results are almost identical for the liberal classification.

We regress the various measures of stickiness on a dummy variable for reference priced goods and a dummy for differentiated goods. As we would expect, the more homogenous the good the lower the price stickiness. In the case of imports, price stickiness, as measured by the time between price changes, is 3.6 months for goods traded on an organized exchange. It is 10.3 months for reference priced goods and 15.8 months for differentiated goods. In the case of exports the numbers are 4.5

months, 7.8 months and 18.2 months respectively. (t-stats are reported in parenthesis). A very similar relation between price stickiness and homogeneity is obtained when we use the measures from Section 3.1.1 on the probability of price changes and the hazard estimates. This is reported in Table 3.

	Imports		
	Months Between Price changes	Probability of Price Change	Hazard
Constant (Homogenous)	3.60 (2.06)	0.83 (11.49)	6.29 (1.69)
Reference Priced	6.73 (3.22)	-0.62 (-7.52)	6.54 (1.52)
Differentiated	12.16 (6.64)	-0.72 (-9.67)	19.31 (3.85)
No. of Observations	181	181	181
R^2	0.25	0.47	0.22
	Exports		
	Months Between Price changes	Probability of Price Change	Hazard
Constant (Homogenous)	4.48 (3.58)	0.72 (8.83)	6.43 (3.11)
Reference Priced	3.32 (1.83)	-0.27 (-2.66)	4.93 (1.65)
Differentiated	13.84 (9.55)	-0.66 (-8.08)	22.39 (9.48)
No. of Observations	160	160	160
R^2	0.35	0.60	0.36

Table 3: Price Stickiness and Homogeneity

Notice that for homogeneous goods the probability of price changes the next month is 0.83 for imports and 0.72 for exports; For reference priced goods the probability of price changes is 0.21 for imports and it is 0.45 for exports; and finally for differentiated goods, the probability of price changes is 0.11 for imports and 0.06 for exports. We estimated simple linear probability models and all these estimates are highly statistically significant. Observe that the pattern of probabilities is exactly the same as the one derived from the time between changes.

3.3.2 Sticky Prices and Intra-Firm Transactions

It is well known that a large fraction of trade takes place between related parties, that is, are intra-firm transactions. In our sample, 44.9% of items are traded intra-firm in the case of imports and 24% in the case of exports. While there is no clear prediction from theory on how prices of intra-firm transactions should differ from unrelated party transactions, there are several reasons to think that the persistence measures could differ (for instance, transfer pricing). We find very little difference between the stickiness of prices of items traded intra-firm and those that are not traded intra-firm and are coded as market transactions in the database. As Table 4 shows, intra-firm transactions involve prices that are less sticky by approximately 1 month in the case of imports and 2 months in the case of exports. Although the probabilities are statistically different, these differences are not large - economically speaking. This is very similar to Clausing (2001), who looks at the BLS price data for the period 1997-99. Clausing (2001) found that intra-firm prices are marginally more sticky and the overall pattern of behavior of these prices is similar to prices involved in market transactions.

	Imports		
	Months Between Price changes	Probability of Price Change	Hazard
Constant (Market Transaction)	13.59 (138.37)	0.21 (78.36)	22.28 (90.73)
Intra-Firm Transaction	-0.89 (-5.86)	0.003 (0.81)	-2.56 (-6.59)
PSL Fixed Effects	Y	Y	Y
No. of Observations	23999	24007	23667
R^2	0.14	0.25	0.11
	Exports		
	Months Between Price changes	Probability of Price Change	Hazard
Constant (Market Transaction)	15.26 (169.62)	0.14 (92.70)	27.83 (105.84)
Intra-Firm Transaction	-2.04 (-11.27)	0.023 (6.32)	-4.21 (-8.50)
PSL Fixed Effects	Y	Y	Y
No. of Observations	19931	19942	19705
R^2	0.17	0.39	0.10

Table 4: Price Stickiness and Intra-Firm Transactions

3.3.3 Tradeable Vs. Traded Goods

Engel (1999) concluded from his study of U.S. real exchange rates that an overwhelming fraction of the movement in the real exchange rate is accounted for by movements in the relative price of traded goods. Traded goods price indices are typically calculated using measures of price indices of tradeable sectors. Engel (1999) for instance used several different measures using the prices of tradeable sectors in the consumer price index, in output prices and in the producer price index. The idea is to associate goods with being tradable and services with being non-tradable. The large volatility of the relative price of tradeable goods comes through in all the different measures. However, as Engel (1999) pointed out we still need to understand "What systematic relation is there between the price of a good at the port and at the consumer outlet"? to understand the behavior of the real exchange rate. We take a look at this relationship in this section and find that at least in the dimension of price stickiness, there is very little systematic relation between the consumer prices of tradeable goods and prices at the dock of actual traded goods.

To make our comparison we match the categories in Bils-Klenow (2004) with the PSL in our database for the case of imports. The idea is that the BK measure will capture the behavior of tradeable goods at the consumer outlet and our measure will capture the behavior at the dock. We obtain a match for 106 categories. Since a large number of traded goods are intermediate producer goods they do not have a match in the consumer price index. The matching is clearly not perfect and only suggestive. Figure 5 plots the comparison. The solid line is the measure of price stickiness for traded goods at the dock where we have ordered the categories in terms of increasing stickiness. The dashed line is the measure of stickiness of tradeable goods at consumer outlets, as calculated by Bils-Klenow (2004) . As is evident, with the exception of categories such as petrol, price stickiness is much higher at the dock. There also doesn't appear to be a very systematic relation between the two measures.

4 Relation between Price Stickiness and Exchange Rate Movements

One of the variables that in theory should move the dollar price of imports is the exchange rate. The exchange rate is only one form of costs that should effect the dollar price of U.S. imports, which is why we found it useful to first look at the stickiness without relating it to exchange rate movements. Our measures of price stickiness is an average 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 volatility. Since we have information on the counrty from which the good is imported, we can relate our measures of stickiness to exchange rate movements. One calculation we do is to group items by the level of exchange rate volatility in the life of the item. That is, for each item we calculate the exchange rate volatility during its life and the average time duration during which its price remains fixed during its life. We can then calculate the price stickiness of the median item within each volatility class. Here the volatility class x is defined as having an exchange rate volatility that is greater than or equal to a certain x percent. This is plotted in Figure 6 where the x-axis refers to the exchange rate volatility class x.[11]

[11] We have also performed this calculation defining intervals of exchange rate volatility (such as greater than 1% and less than 5% etc.) and find very similar patterns.

A state dependent pricing model of price adjustment would predict that large exchange rate movements would increase the probability of the prices adjusting. As the figure suggests, for a large range of exchange rate volatility, the median duration of prices does not change by much. When volatility is closer to and exceeds 40%, we do observe a decline of about 2 months. This decline could simply reflect the higher exchange rate volatility of countries that tend to export more homogenous goods. So this is a characteristic of the good being exported and not of the volatility of the exchange rate. Accordingly, we perform a second calculation.

We examine episodes of large devaluations relative to the dollar. For each country that experienced a large devaluation, that we define here as a 10% or more decline in a month (we have also done this for the case when the decline was 20% or more) in the value of the countries currency relative to the dollar, we calculate the probability of items changing prices in a 6 month period after the devaluation and compare it to the average probability of price change in the 6 month period before the devaluation. The difference by country is plotted in Figure 7. Here again, there is a mixed result. While clearly for some countries there is an increase in the fraction of items that change prices, there are other countries for which the change in probability is close to zero.

Figure 8 plots the change in the average size of the price change (conditional on changing prices) pre and post devaluation. We would expect that the dollar price should be adjusted downwards on average. For most of the countries we do find that conditional on adjusting prices they adjust the price downwards and in some cases this adjustment is substantial.

We also examine the episode of the euro movements against the dollar from Jan 1999 to december 2004. During this period, the dollar both appreciated and depreciated considerably against the euro. During this period the median price duration was 9.5 months and the median fraction changing prices is 0.07. This is not much lower than the average for all imports. Also, the median fraction changing prices each year did not change much during this period and the average actually declined by a few percentage points from 1999 to 2004.

The main conclusion from this section is that even if we restrict attention to periods of significant exchange rate movements, items tend to exhibit fairly high price stickiness. Clearly, we have not ruled out the case that the composition of goods being imported changed post large devaluations and this needs to be explored further.

5 Import Price Index Decomposition

(to be completed)

6 Conclusions

Price stickiness is one of the most important features for the understanding of monetary policy. It is a crucial ingredient for theoretical models, and it is indispensable information for the design of policy. In this paper we have used unpublished data from the BLS to measure the degree of price stickiness for imports and exports items. We find large degrees of stickiness; imports and exports are sticky for, 12.26 months for imports and 14.11 months for imports. These results are robust to different measures of stickiness that deal with heterogeneity and the 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. Our estimates are closer to the averages found in recent studies performed at the retail level using CPI data for the Euro Area. See Alvarez et. al. (2005) for an extensive summary on this work. We do observe an interesting dimension of stickiness in our data, namely, dollar price stickineness.

We find that there are important patterns regarding the stickiness of prices. Firstly, homogenous goods display far higher probabilities of price change. There is little evidence that intra-firm transactions display very different price stickiness patterns relative to arms-length transactions. We also study the relation between price adjustments and exchange rate movements as this is an important cost push factor for the price of imports. We examine the probability of price changes after large devaluations and find that the evidence does not overwhelmingly suggest a large increase in the probability of adjustment as suggested by state dependent pricing models. Across different sizes of exchange rate volatility, the median duration of price changes remains unchanged and declines by a couple of months for very large levels of volatility. Future research has to deepen our understanding of these results. Here we have simply shown that the US has *Sticky Borders*.

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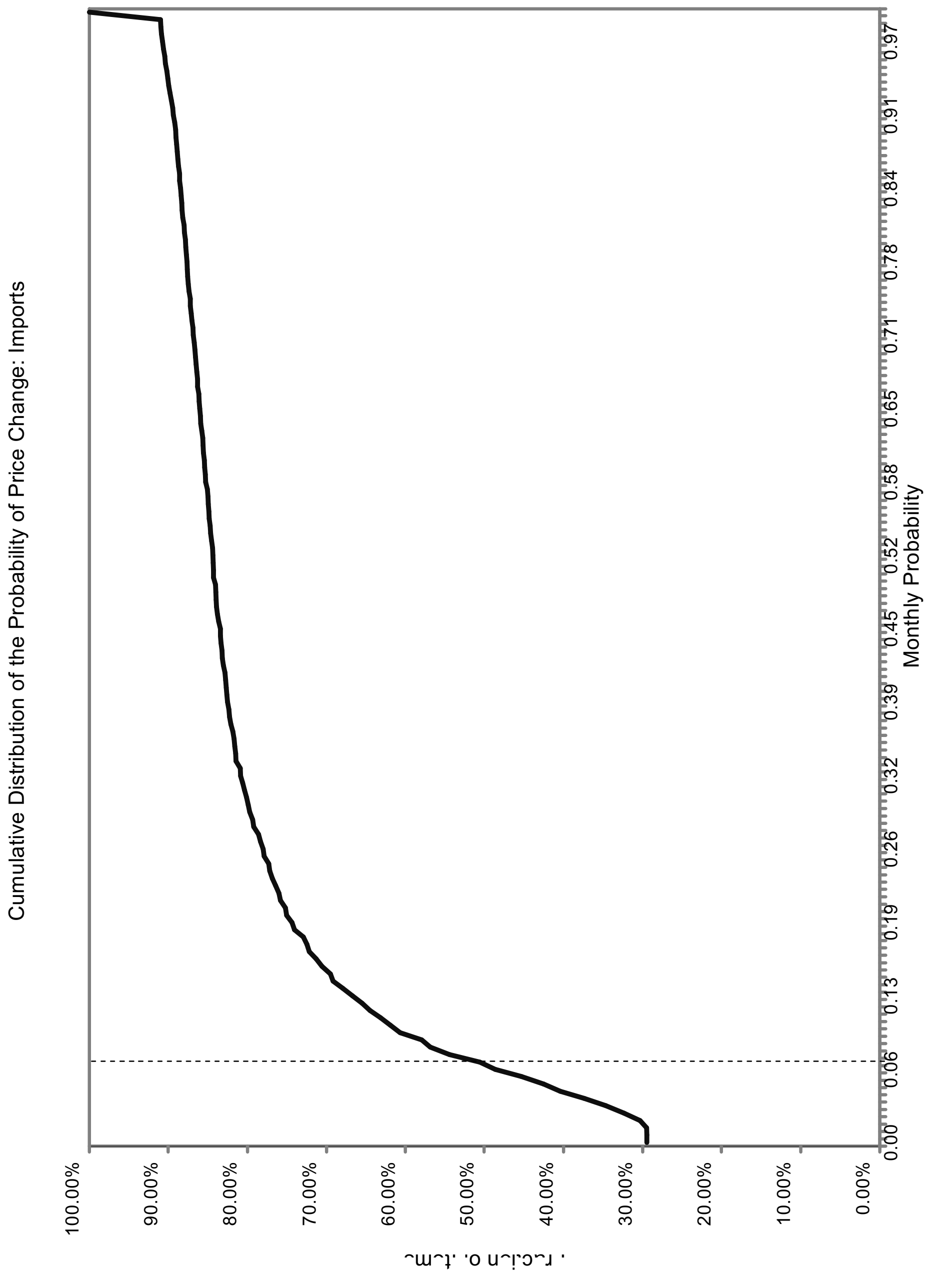


Figure 1: Fraction of Price Changes per Item for imports.

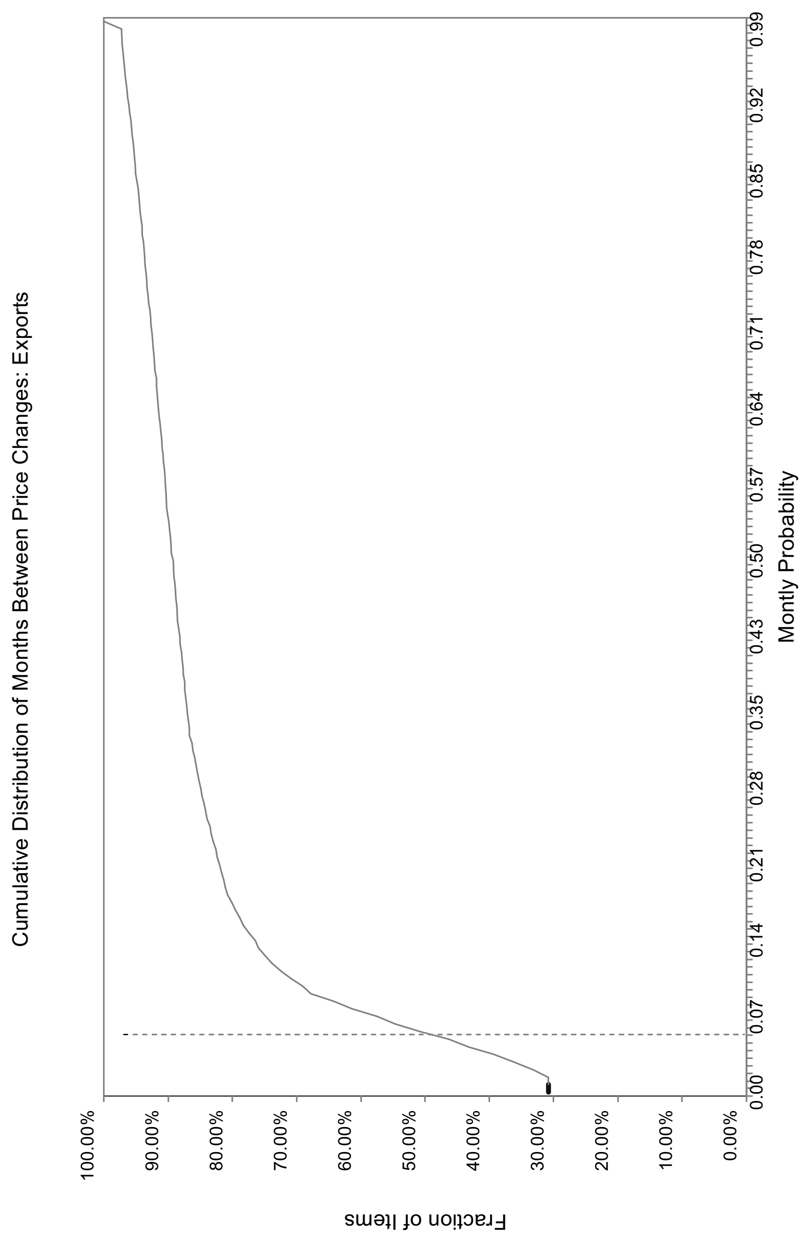


Figure 2: Fraction of Price Changes per Item for exports.

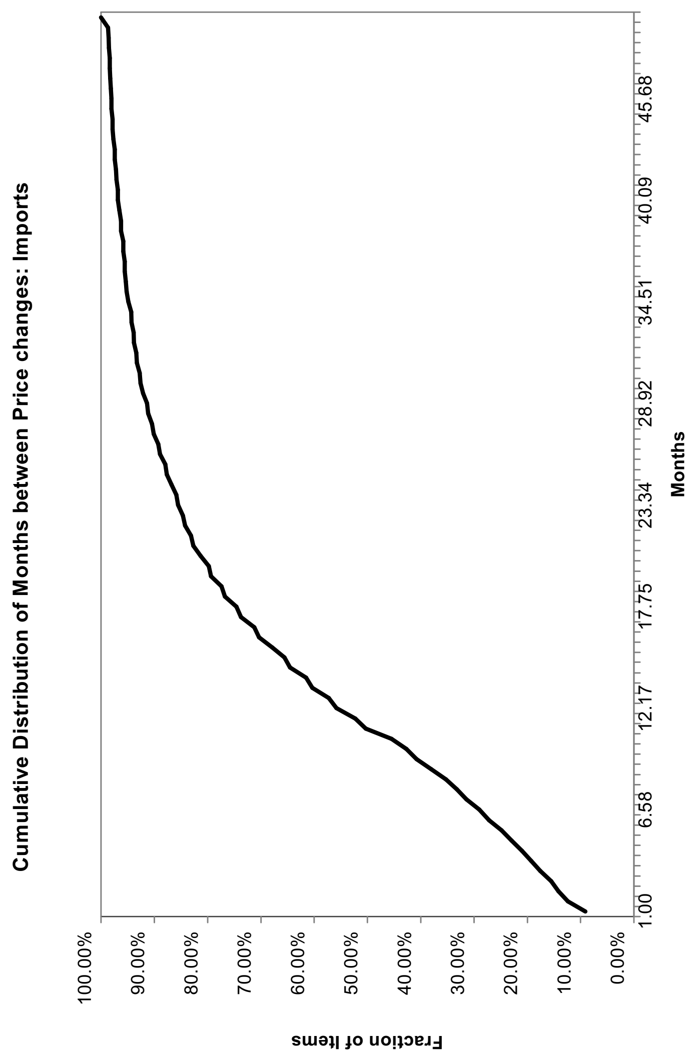


Figure 3: Montly Duration of Price Changes for Imports

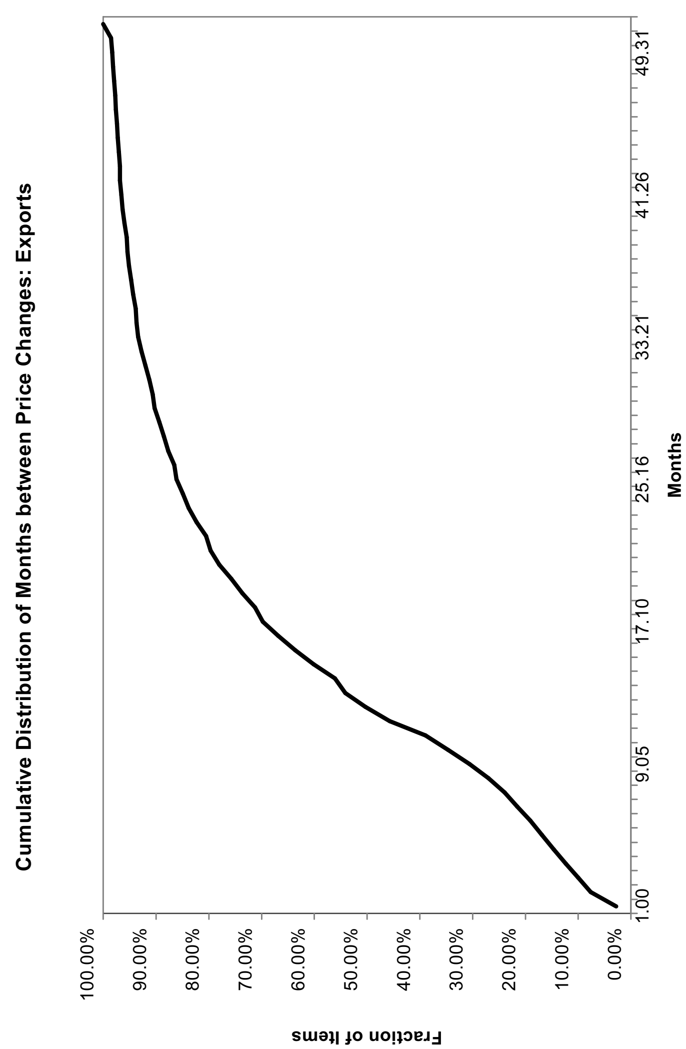
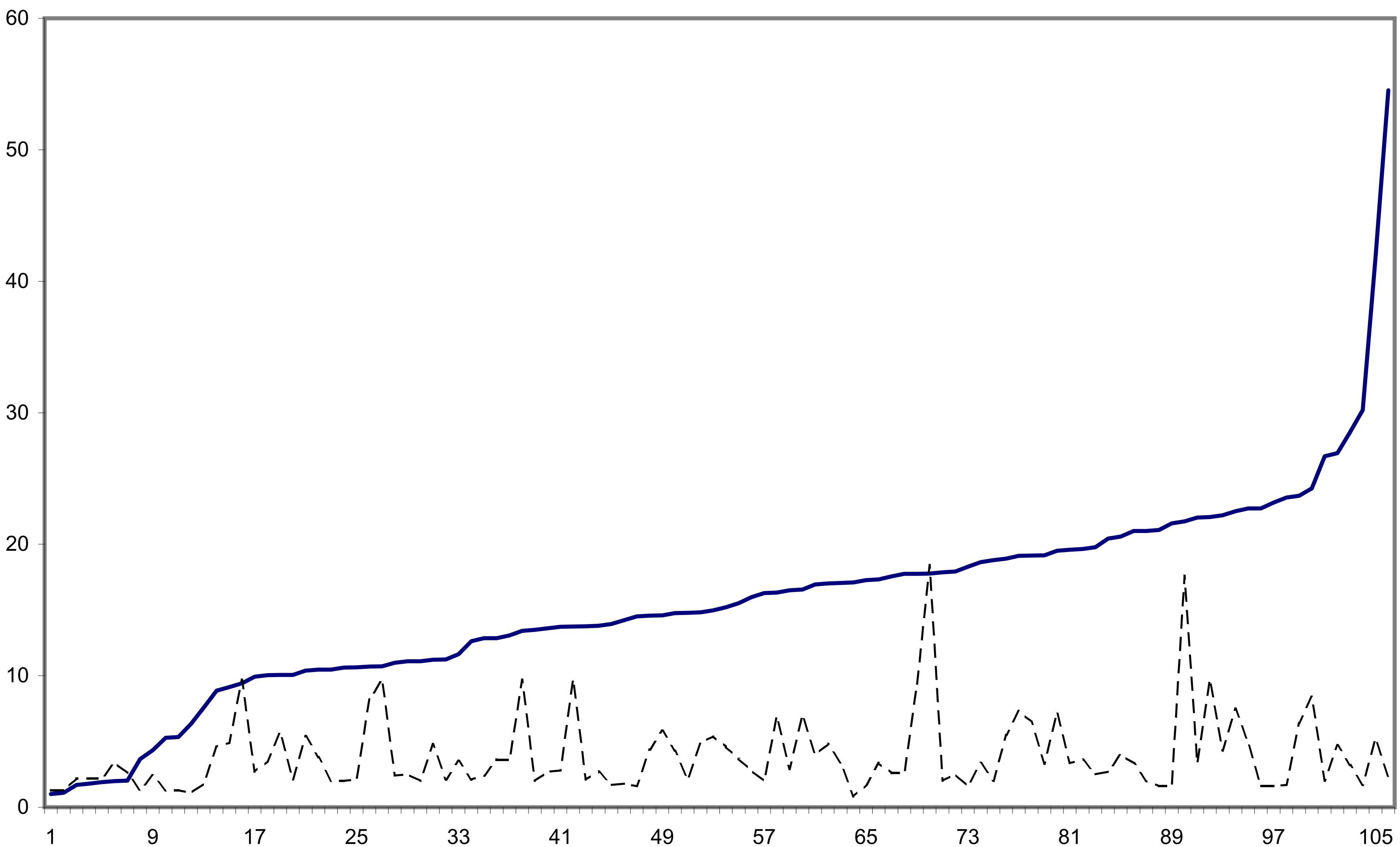


Figure 4: Monthly Duration of Price Changes for Exports

Price Stickiness in Imports Vs Consumer Prices: Comparison with Bils-Klenow (2004)



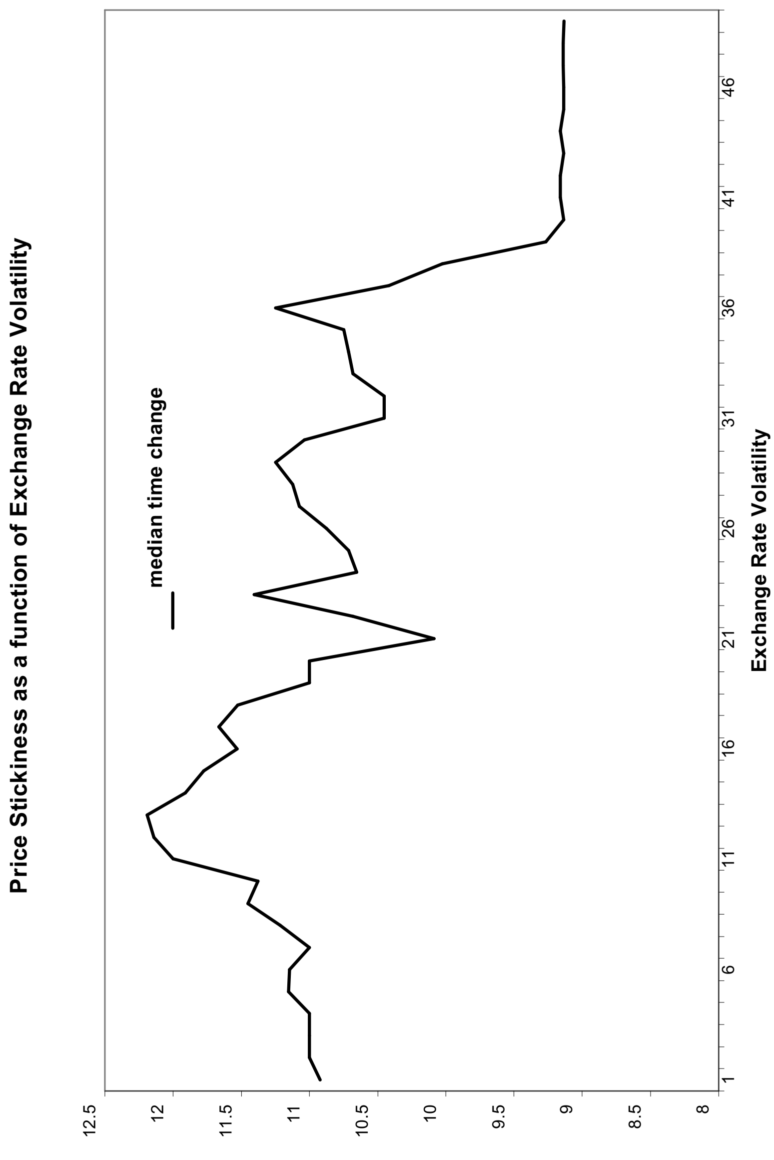


Figure 6: Relation between Exchange Rate Volatility and Price Stickiness

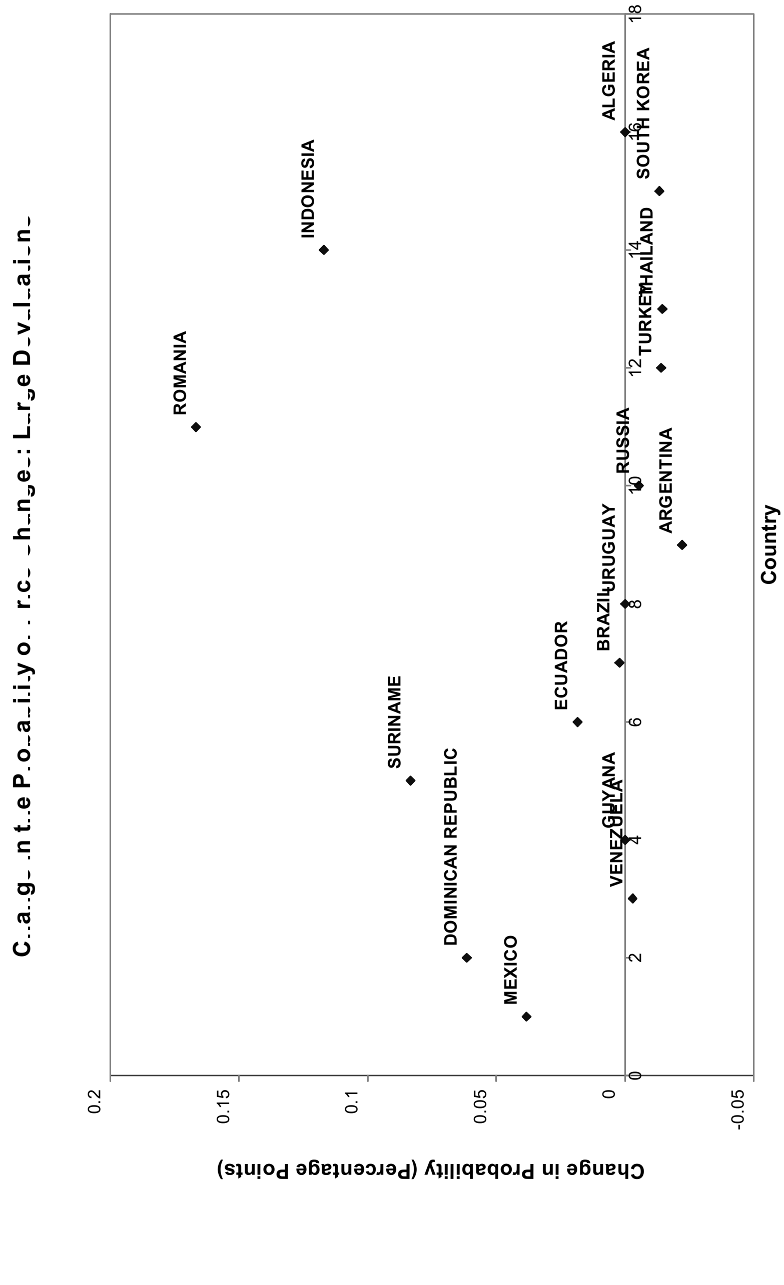


Figure 7: Monthly Devaluation of 10% or more: Change in the Probability of Price Change, by Country

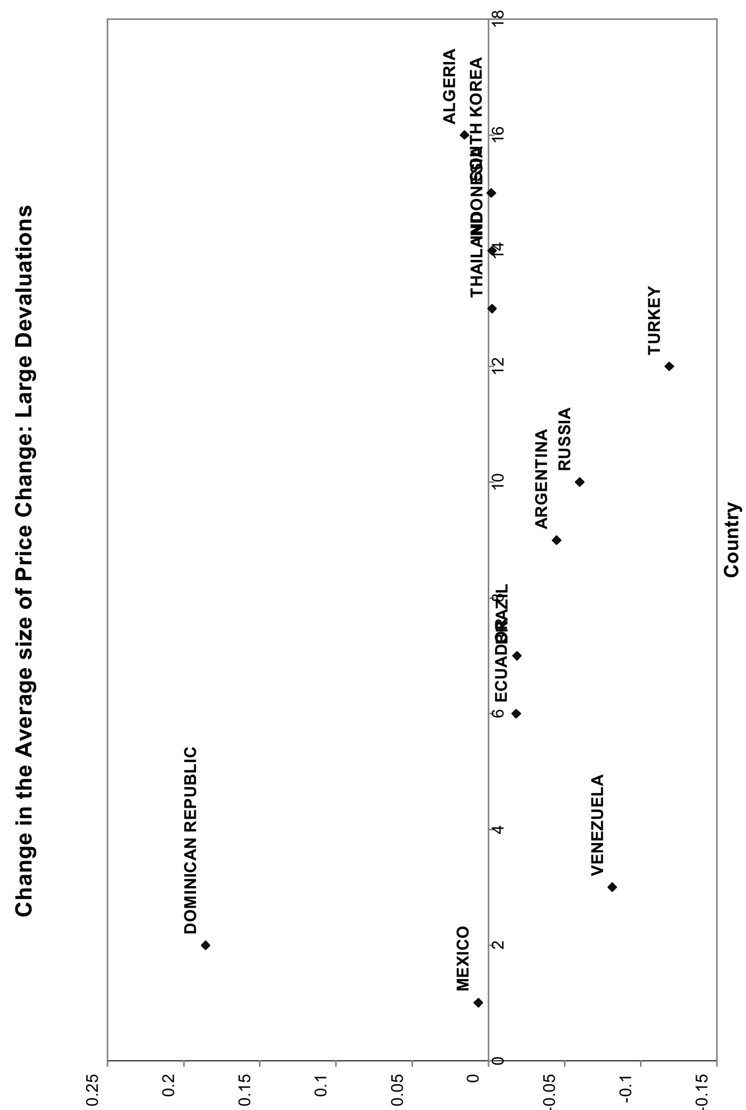


Figure 8: Monthly Devaluation of 10% or more: Change in Average Change in Price, by country.