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The Price Setting Behavior in Colombia: Evidence from PPI Micro Data[1]

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Abstract

In this paper we explore the price setting behavior of Colombian producers and importers using a unique database containing the monthly price reports underlying the Colombian PPI from Jun-1999 to Oct-2006. We focus on five particular questions: 1. Are prices sticky or flexible? 2. Is a price increase more likely than a decrease? 3. Are price changes synchronized? 4. Is the pricing rule state or time dependent? 5. Are price changes sizable? Answers to these questions provide some of the micro fundamentals for the design of monetary policy in this country.

Key Words:Price Setting Behavior, Nominal Price Rigidities, Producers Price Index
JEL Codes: E31, E52, E58.

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1. Introduction

For many reasons firms do not adjust the price of their goods and services immediately after a demand or supply innovation. This lack of sensitivity is known as *nominal price rigidity*. Figure 1 shows the price paths of five firms producing a particular good belonging to Colombian PPI. From this figure it can be observed that; 1. The price sequences tend to move together in the long run. Different firms keep their price constant for longer periods of time (*duration*) than others, which implies that the *frequency of* monthly *price changes* is low on average. 3. There is a surprisingly high frequency of price decreases. 4. There is, also, a high frequency of "big" percentage price adjustments, and 5. Price adjustments tend to be non synchronized between firms for this particular good.

The assumption that prices are sticky has become an important factor in the design of monetary policy models. In fact, theoretical studies have shown that the degree of price flexibility has an important effect on the response of key variables to economic innovations[2]. Therefore, Price stickiness is an important source of short to medium term non neutrality in monetary policy models. More precisely, the degree of price flexibility determines the slope of the new Keynesian Phillips curve, which implies that the dynamic behavior of the inflation rate, in response to marginal costs innovations, is highly dependent on the pricing rule used in the model. Thus, price stickiness has an important effect on the degree of inflation (and many other variables) persistence, a key determinant of monetary policy. Thus, price stickiness has also an important effect on

[2] Price stickiness relate to the fact that the price of goods and services do not react immediately to demand or supply innovations.

the design of monetary policies[3]. See Bils and Klenow (2004), Taylor (1980), Rothemberg (1982) and Angeloni et al (2006).

There are several alternative ways to set up pricing rules in monetary policy models. Pricing rules may be "time dependent" or "state dependent". In time dependent rules, prices are kept constant for an exogenously determined random number of periods (Taylor contracts), or, an exogenously determined random fraction of firms is allowed to adjust prices to new information (Calvo rule). In state dependent rules the probability of a price change is endogenous to the state of the economy, but firms face costs related to the price change.

The *lack of synchronization* has been proposed in economic literature as one of the main sources of price stickiness. Producers seem to prefer slow price changes, to avoid large relative price movements, in the face of unsynchronized nominal innovations. In time dependent rules, for instance, price changes are not synchronized, and this lack of synchronization causes price inertia. See Blanchard (1982).

It has also been argued that the cost of price adjustments is an important factor explaining stickiness. If the cost curve is *convex* (increasing) with respect to the price change size, firms will avoid big price changes. In state dependent rules, for instance, the cost of changing prices is one the main sources of stickiness.

Moreover, it has also been proposed that prices are *downward rigid*. Some authors say that the price signals the quality of the good, and thus producers tend to avoid reductions. Others propose that price reductions are rare because consumers do not respond as efficiently to price reductions than to increases. Finally, some others argue

[3] Inflation persistence has to do with the dynamic behavior of the inflation rate (with respect to an "equilibrium"), after the economy has been hit by a shock.

that, in the face of unsynchronized innovations, the strategic behavior of firms lead to downward rigidity. The existence of *strong* downward rigidities relates to big welfare loses associated to monetary policy. However, a *slight* downward rigidity, accompanied by a low (positive) long run inflation target, 'greases the wheels' and allow real (ie relative) prices to fall when necessary for a stable long run inflation target.

Evidence on the price setting behavior comes from quantitative studies on individual price databases and firm's surveys on qualitative features of pricing practices, being more adequate the first ones. Quantitative studies are particularly suited to study the price setting behavior since they contain a huge number of price quotes over a long time span. However, this evidence is usually complemented with surveys on qualitative features that might not be found otherwise[4]. See Alvarez et al (2005a).

There are several reasons to study the price setting behavior at the firm level. First, even though the final goal of the central bank is CPI inflation, several theories on the price setting behavior refer to producers rather than consumers prices. Second, theoretical studies have shown that a monetary policy that does not take into account PPI inflation, or PPI sector shocks, tends to produce larger welfare losses than a policy that targets CPI and PPI inflations (Huang and Liu (2005)). And third, monetary policy channels may differ, and be relatively more important, for producer prices than consumer prices, especially if the retail sector uses simple pricing rules. See Gautier (2006), and Basu (1995).

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[4] Given that firm surveys are performed on a low frequency basis, and in periods of time whose economic conditions rarely repeat in the future, they tend to focus *on* ***qualitative invariant price setting features*** like the type of information used to decide on price changes, the market power of firms, and so on.

Furthermore, producer price setting behavior may differ greatly from that of retailers. Producers have closer links with their costumers, which translate into long term relationships based on explicit contracts. Furthermore the lack of anonymity in producer markets leads to costumer resistance and, depending on the degree of competitiveness in the sector, increases the odds of collusion. In addition, costumer hierarchy is more important in producer markets, and price adjustment costs seem to be of less importance.

In this paper we explore the price setting behavior of Colombian producers. Our database contains the monthly price reports underlying the Colombian PPI from Jun-1999 to Oct-2006. Following our previous discussion, we focus on five particular questions: 1. Are prices sticky or flexible? 2. Is a price increase more likely than a decrease? 3. Are price changes synchronized? 4. Is the pricing rule state dependent or time dependent? 5. Are price changes sizable? **Answers to these questions provide the micro economic foundations for the design of the monetary policy model in this country.**

Being an exploratory work, we include little external information, and consequently, our results are mostly descriptive and unconditional. However, we interpret, as far as possible, our findings in terms of the possible models and macroeconomic implications.

Apart from the introduction the paper is distributed as follows; in section two we describe the definitions we will use along the paper, which are common to price stickiness studies, we describe the dataset and its treatment (as it has a heavy effect on the results), we describe the methodology and the PPI's weighing scheme. By describing the PPI's weights, we propose a ranking according to the manufacture stage of goods, for an aggregated basket, that will be used to interpret the results of section three. In the fourth we conclude.

2. Methodology

2.1. Basic Definitions

A *particular product* is a unique physical item or service that is traded in the economy, which has a clearly defined source (produced-and-consumed or imported), brand, presentation, packaging, unit of measure, and content, among others. A *product category* is a particular product whose price is reported by a clearly identified producer.

A *product class* is a basket or group of individual products. There are several ways to aggregate individual products in PPI databases. For the Colombian case, product classes or baskets refer to interactions, at different levels, of the source (produced-and-consumed or imported), the nine digits local adaptation of the CIIU code, and the destination (intermediate consumption, final consumption, capital goods and construction materials) of goods. Moreover, according to BANCO DE LA REPUBLICA (1999), the PPI can be obtained according to many other alternative baskets.

The workhorse of price stickiness studies is the *duration*; the length of time the price of a product category remains constant. We also define a *price sequence* as an uninterrupted sequence of price reports belonging to a particular product category.

A particular product category might be associated to more than one price sequence due to the eventual appearance of *missing values*. Missing values may arise due to several reasons like the temporary unavailability of the informant, or the product category in a particular informant. In this case, PPI administrators follow very strict rules to *impute* missing values, like *carrying over* the last observed price or price change. On the other hand, when the informant or product unavailability is permanent, we refer to product or sample *attrition*.

A *price spell* is an uninterrupted sequence of constant price reports associated with a unique product category.

In most cases the beginning of the price sequence does not match the date a particular product category appears for the first time in the economy, thus the first spell is usually *censored*. In a similar way, the end of the last spell in a particular sequence might not match the disappearance of the particular product category, and therefore might be *truncated*. Truncation may arise because of involuntary product or informant *attrition* or voluntary *attrition* due to sample maintenance. See Baudri et al (2004).

For a particular product category and price spell, s, price stickiness can be studied through the *duration* of the spell, T_s, or the *frequency of price changes*, F_s. The frequency of price changes is the fraction of the basket weight, belonging to a particular product class that changes their prices on a given period of time.

The duration (a time series measure) and frequency of price changes (a cross section measure), computed for the whole sample, relate to each other according to the formula

$$T = \frac{1}{F}$$

from which an indirect non parametric duration estimate may be obtained.

Direct non parametric duration estimates rely on very few assumptions but require that all price spells to be non-censored**.** Indirect non parametric estimates, those derived from the frequency of price changes, can handle censored spells at the cost of assuming a constant hazard rate function[5].

In Taylor contracts, for instance, the implied hazard function is generally increasing, depending on the duration distribution assumed. In state dependent rules the hazard function depends on the distribution of the innovations, and is usually increasing. A constant hazard function, like that implied in a deterministic Calvo pricing, is hard to justify in practice.

2.2. *The Data Set*

Our data set consists of 540,069 monthly list price reports collected from June 1999 to October 2006 in order to compute the Colombian PPI, excluding exports. On average there were 6,178 reports each month, which corresponds to the number of different product categories surveyed. The sampling and PPI computation methodology is described in BANCO DE LA REPUBLICA (1999).

The Colombian PPI database has some similarities and differences in comparison to those studied in the individual country studies in the IPN. Our sample is bigger only than the Italian one, which has just 71,000 records, and its time coverage is similar to ours, six years. Moreover, the German, Portuguese and Spanish, like our, covers the whole PPI basket, unlike the Italian and French that include just 44% and 92% respectively of this basket.

[5] The *hazard function* describes the probability of a price change conditional on no price change during the last k periods, as a function of k. The *survival function* is analogous to the hazard and determines the probability that a price spell lasts more than k periods.

A unique feature of our database is that price reports are requested and recorded, "ex-post", when the reporter is temporarily unavailable. Certainly, these reports can not be used for PPI computation. Whenever "ex-post" prices are observed, they replace the corresponding missing or imputed values in our analysis. Imputation is performed and recorded in the database only for three months, when the sample attrition is recorded.

Imputation is performed by carrying over the last observed price in its currency, and the currency value is updated at every period of time. The original sample contains 32,693 reports imputed by the PPI administrator, 6.10% of the original sample. However, there were still 1,750 missing values disconnecting some of the price sequences identified. These missing values were imputed, which gives a total of 34,443 imputed reports, 6.43% of the original sample.

Regarding imputation we follow the lead of the IPN individual country studies where all but the French and German studies report the use some kind of imputation. See Table 1.

Our database contains indicator variables for the following events: sales, promotions, rebates, sale of defective products and sale of products by companies in the liquidation process. These reports were excluded from both our analysis and the PPI computation[6]. Altogether there were 3,768 reports deleted because of these events, 0.74% of the sample.

As far as taxes go, according to Banco de la República (1999), PPI prices are requested before taxes.

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[6] Deleting the records corresponding to sales and rebates is a normal practice in price duration studies since they might reveal end of season, liquidating or other events not related to normal price strategies. However, their deletion might cause an upward duration bias since the related spells tend to be shorter than average. Since in our study these records are a very small percentage of the total sample its effect is expected to be negligible.

Finally, for most product categories prices are reported on a monthly basis. However, some informants schedule price changes at lower frequencies like quarters, semesters or years. Under these circumstances, the PPI survey is performed at the requested frequency, and the questionnaire continuously asks for frequency updates. Frequency changes are recorded in the database and the survey frequency is updated accordingly.

2.3. Weighing

The Colombian PPI has two levels of operating weights. At the highest disaggregation levels, such as the minimal classes and product categories, there is a flexible weighing scheme, which applies mostly to agricultural products. From there, CIIU7 and up, a fixed weighing scheme applies. For our estimates we use average weights when required.

We hypothesize that the pricing behavior of firms differ according to the source of goods (imports or produced-consumed), and its manufacture stage. The first is explained by both, the effect of exchange rate variations on the price of imports, and the type of innovations an importer is subject to, in comparison to a producer of locally consumed goods. The second relates to the fact that whenever unsynchronized innovations occur, firms prefer slow price adjustments, in order to avoid large relative price movements. See Blanchard (1982) and Clark (1999).

Table 5 shows the weight allocation, within each destination, according to the source – one digit CIIU code interaction. The organization of the Table aims to emphasize both, the link between the destination of goods and their manufacture stage, proxied by the CIIU code within each source, and the difference between imported and produced-consumed goods.

In the upper panel of Table 5, destination weight shares add up 100% regardless of the source of goods, and in the lower panel destination share weights add up 100% for each source[7].

The upper panel of Table 5 reveals that construction materials, intermediate and final consumption goods have an important share of produced-consumed goods. In fact, the shares of produced-consumed goods are 81.5%, 78% and 85.6% respectively and just 27.8% for capital goods. In addition, it should be noticed that imports, 24% of the basket, are basically manufactures with a very small share of agriculture and mining.

The lower panel of Table 5 reveals a more interesting picture. Destination, for produced-consumed goods at least, may be ranked according to their manufacture stage by comparing the share of agricultural (lowest manufacture level) and manufactures (highest manufacture level) between them. In fact, for produced-consumed goods, the lowest share of manufactures, 56%, and the highest of agriculture, 41%, corresponds to intermediate-consumption goods, setting this destination in the lowest manufacture stage level. The third is final-consumption with 83% and 17% respectively. The second is capital-goods with 94% and 6% respectively, and the first is construction-goods, 91% manufactures and 9% mining and quarry, since the later have a higher manufacture stage than agricultural products.

This ordering will play an important role for the interpretation of results. However, for imports it is not possible to establish a similar ordering since the behavior of import prices is highly influenced by the import frequency.

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[7] The whole weighing structure may be recovered from Table 5 by noticing that 38.8% of the PPI excluding exports corresponds to final consumption, 43.0% to intermediate consumption, 10.2% to capital goods and the remaining 8.0 % to construction goods.

2.4. Methodology

Direct estimation of the mean duration at any level of aggregation is based on non censored spells, that is, discarding the first and last spells of each price sequence. However, indirect duration estimates, derived from the frequency of price changes, include censored spells and thus might be more efficient and unbiased.

Indirect non parametric estimates, those derived from the frequency of price changes, can handle censored spells at the cost of assuming a constant hazard rate function[8].

In Taylor contracts, for instance, the implied hazard function is generally increasing, depending on the duration distribution assumed. In state dependent rules the hazard function depends on the distribution of the innovations, and is usually increasing. A constant hazard function, like that implied in a deterministic Calvo pricing, is hard to justify in practice.

After discarding the first and last spells of every price sequence, there were 159,090 price spells remaining in the database, an average of 14.5 spells per sequence.

Since our price sequences are not interrupted, each of them may be uniquely identified as a sequence of price reports P_{mjkt}, where $t = 1, 2, 3, \ldots, T$, is the time, $k = 1, 2, 3, \ldots, K_{mj}$ identifies the product category reported by the $j = 1, 2, 3, \ldots, J_m$ informant belonging to the $m = 1, 2, 3, \ldots, M$ minimal class. The triplet (m, j, k) identifies a price sequence uniquely.

[8] The *hazard function* describes the probability of a price change conditional on no price change during the last k periods, as a function of k. The *survival function* is analogous to the hazard and determines the probability that a price spell lasts more than k periods.

Let $i = 1,2,3,\ldots,N_{mjk}$ be the identifier of the $i-th$ price spell in the (m,j,k) sequence, and let T_{mjki} be the $i-th$ price spell duration. All the information regarding the $i-th$ price spell can be summarized in the triplet (m,j,k) , the price level, the spell's starting date and duration.

We can estimate the mean duration for the (m,j,k) product category as

$$\overline{T}_{mjk} = \frac{1}{N_{mjk}} \sum_{i=1}^{N_{mjk}} T_{mjki}$$

Since our database does not distinguish particular products, we can not compute any statistics at this level. Instead, we compute the average weighted duration for each minimal product class as

$$\overline{T}_m = \frac{1}{\sum_{j=1}^{J_m} \sum_{k=1}^{K_{mj}} \alpha_{jk}} \sum_{j=1}^{J_m} \sum_{k=1}^{K_{mj}} \alpha_{jk} \overline{T}_{mjk}$$

where α_{jk} is the average weight for each product category in the minimal product class.

Once we have estimated the average duration for each minimal product class, we can estimate the duration for wider aggregations by computing weighted averages using the corresponding average or fixed PPI weights.

$$\overline{T}_n = \frac{1}{\sum_{m=1}^{Mn} \alpha_m} \sum_{m=1}^{Mn} \alpha_m \overline{T}_m$$

where α_m is the PPI weight associated with the m-th minimal product class.

Given that we are unable to identify individual products, our aggregation starts with the minimal classes rather than individual products. This procedure affects the interpretation of our estimates at the minimal class level since these are, for the majority of the sample, unweighed averages of the product categories belonging to the minimal classes. However, no aggregation bias is expected to happen since the duration of price spells are computed for uniquely determined sequences.

Following the same procedure we can compute any statistic to characterize the distribution of durations. We focus on the median, the quartiles and standard deviation.

Indirect mean duration estimates may be obtained from the estimated mean frequency of price changes, FPC. The mean FPC is the average percentage of the basket changing its prices on a given period of time, and thus it is a cross sectional measure[9].

Indirect duration estimates require the computation of the frequency of price changes for each product category, thus, we define a binary variable indicating a price change

$$I_{m,j,k,t} = \begin{cases} 1 \;\; if \quad p_{m,j,k,t} \neq p_{m,j,k,t-1} \\ 0 \qquad\qquad otherwise \end{cases}$$

and then, the estimated FPC for the m-th minimal class at time t can be computed as

$$F_{mt} = \frac{1}{\sum_{j=1}^{j_m} \sum_{k=1}^{k_{mj}} W_{mjki}} \sum_{j=1}^{j_m} \sum_{k=1}^{K_{mj}} W_{mjk} I_{mjkt}$$

and

$$\overline{F}_{mt} = \frac{1}{T} \sum_{t=1}^{T} F_{mt}$$

Following the same procedure we compute the frequency of price increases an decreases.

[9] Non parametric indirect duration estimates derived from FPC's assume the existence of a constant hazard function.

3. How do Colombian Producer's Change Their Prices?

3.1. Are Prices Sticky or Flexible?

To answer this question, the estimated duration and frequency of price changes, FPC, distributions are studied for increasingly disaggregated baskets up to the minimal classes. Distributions according to the destination and source of goods are also studied. The results are shown in Tables 7 and 8 as well as in Figures 2a and 2b. Further breakdowns are available from the authors.

Findings about this issue summarize in the following points.

- *The average weighed duration of producer's prices is 5.52 months, 20.2% of the basket change it prices each month, but there is a sizable degree of duration heterogeneity between and within product classes.* The weighed standard deviation of durations is 4.16 months. See Table 7.
- *Heterogeneity might be explained in part by the source of goods.* Because of COP/USD exchange rate variation, not only there is a sharp difference in average duration, 3.84 months for imported and 6.03 for produced-and-consumed, but there are also homogeneity gains within imported goods as its weighed standard deviation reduces to 3.41 months, and the coefficient of variation for produced-and-consumed reduces with respect to that of the total basket. See Table 7.
- *Price duration heterogeneity might also be explained by the manufacture stage of goods.* For produced-and-consumed goods, duration ranking is similar to the one obtained by analyzing the PPI weighing structure in section 2.3. Construction materials have the largest duration, 7.73 months, intermediate consumption the lowest, 5.29 and final consumption and capital goods are in the middle, 6.43 and

6.46 months respectively. There are also clear homogeneity gains as the intermediate consumption and construction materials standard deviation, 3.92 and 2.78 months respectively, are smaller than those of the total produced-and-consumed basket, 4.23 months. Surprisingly, the coefficient of variation of construction materials reduces to 2.78 showing a striking heterogeneity reduction for this basket. See Tables 7 and 8.

- *Price stickiness increases as the inflation rate decreases.* Figure 2b show a clear upward duration trend with a higher slope during 1999 and 2000, as expected from the rapid inflation adjustment after the 1998 crises. Afterwards the trend is small but steady, consistent with the steady small downward trend the inflation rate has followed since 2000. Moreover, setting aside basket differences, our findings are consistent with Colombian CPI results. Jaramillo and Cerquera (1999) concluded that, on average, consumer prices remained constant for two months during a period of moderately high average CPI inflation of 28%. Espinosa, Jaramillo and Caicedo (2001) found a mean duration of four months during a period when the average CPI inflation rate was 25%, and our results show an estimated mean duration of 5.5 months in a period when the producers price inflation is 7%[10].
- *The analysis of the FPC distribution leads to similar results.*

Colombian outcomes are analogous to those of the IPN. The weighted average FPC for the whole Euro-Area is 21%. The highest flexibility is found for France, where 25% of producer prices change each month, and the highest stickiness for Italy, where 15% of producer prices change every month, on average. Colombian results, 20% each month,

[10] More recently Hofstetrer (2007) studied the prices stickiness of newspapers in Colombia, less than 2.5% of the CPI basket, which limits his results.

lie in a middle range. These results imply that, if expectations are similarly anchored in both places and prices indexation is also similar, the welfare cost of a reduction of the same size is about the same both in the EU and Colombia[11]. See Vermeullen et al (2007).

More interestingly, individual country studies, as well as the EU summaries, report a high degree of duration heterogeneity within and between product classes. Vermeullen et al (2007), reports that individual country data bases in the EU consistently point to a direct relationship between duration of producer price spells and the amount of transformation required to produce the particular items.

These results, Colombian as well IPN, agree with Blanchard (1982), who proposes that price setting must be influenced by the number of manufacturing stages. This author argues that "Desynchronization implies snake effects, i.e. movements in factor prices slowly transmitted to intermediate and final good prices". Therefore, goods lower in the manufacture stage scale have higher price and profit variability than those high up in this scale.

3.2. Is a price increase more likely than a decrease?

In order to answer this question, we compute the average frequency of price increases and decreases according to the source, destination and CIIU1 classification code of goods. Results are presented in Table 9 and the corresponding findings summarize in the following points:

[11] However, if we take into account that the inflation rate during the sample for the countries of the IPN was lower than 2.5% and the Colombian was 7%, and if it the stickiness in Colombia continues to increase as the inflation reduces, under particular circumstances this evidence might suggest that Colombian prices would be stickier than those of the IPN when we reach the long run inflation target, 3%.

- *Price increases are slightly more likely to happen than decreases.* In fact, only in one case, mining imports destined to intermediate consumption, the frequency of price increases is lower than that of decreases, 10% and 10.8% respectively. See Table 9.
- *The ratio between the frequency of price increases and decreases is higher for produced-and-consumed goods in comparison to imported ones.* In just one case, agricultural products destined to final consumption, it is higher for imports. Thus, there is a clear difference in the behavior of price increases over decreases between sources of goods. See Table 9.
- *The ratio between the frequency of price increases and decreases relates to the manufacture stage of goods too.* Within produced-consumed goods, the average ratio is highest for manufactures, middle for mining and lowest for agriculture. A similar order is observed for imports if we take into account that agricultural imports in Colombia correspond chiefly to highly processed foods. See Table 9.
- *There is a surprisingly high frequency of price decreases.*

Finding a slight downward nominal rigidity in producer prices is not surprising, given that a positive inflation of moderate size was observed in the sample span for Colombia. Moreover, this slight downward rigidity justifies the choice of a 3% long run inflation target in Colombia, since it permits that real (relative) prices reduce when required to maintain the long term objective. Moreover, the finding of no **strong** downward rigidities, in comparison to the six IPN countries, indicates that the welfare costs of bringing the inflation rate to the long run target are not "excessive" at least with respect to the EU.

3.3. Are price changes synchronized within minimal classes?

In order to determine the degree of synchronization of product changes, we compute a synchronization measure proposed by Fisher and Konieczni (2000). Under the assumption of perfect synchronization, these authors propose to use the ratio between the standard deviation of the monthly frequencies of price changes at the minimal class level, and the theoretical standard deviation implied by the average frequency of price changes computed at the minimal class level that would be observed under the assumption of perfect synchronization. This ratio is one in the case of perfect synchronization and zero with perfect staggering[12]. See also Aucremane and Dhyne (2004) and Diaz (2004).

The results are presented in Figures 2 and 3 and the main finding comprise in the following point.

- *Colombian producers do not tend to synchronize price changes, but there seems to be some seasonal synchronization.* Figure 3 displays the frequency of minimal product classes (bars measured on left scale), for each level of synchronization ratio (x axis), and the cumulative weight (line measured on right scale), for minimal product classes. The distribution of the synchronization ratio is highly skewed with a

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[12]For a given minimal class let p_t be the mean FPC at t. The synchronization index proposed by Fisher and Konieczni may be computed as $FK = \sqrt{\frac{1}{T}\frac{\sum_{t=1}^{T}(p_t-\overline{p})^2}{\overline{p}(1-\overline{p})}} = \frac{\sqrt{s_{p_t}^2}}{\sqrt{\overline{p}(1-\overline{p})}}$ where $\overline{p} = \frac{\sum_{t=1}^{T} p_t}{T}$ and $s_{p_t}^2$ are the sample mean and variance of p_t respectively. If synchronization is perfect, either all firms change its prices at the given period of time or none of them do. Hence p_t is a dummy variable and $s_{p_t}^2 = \overline{p}(1-\overline{p})$, leading to $FK = 1$. Now, if $p_t = \overline{p} \ \ \forall t$, that is, under uniform staggering with a fixed percentage of firms p_t changing

unique mode around 0.175, where the cumulative weight reaches about 80% of the total PPI basket. Moreover, more than 98% of the PPI weight has a synchronization ratio below 0.3, but only 0.15% of the products have a synchronization ratio between 0.95 and 1. However, Figure 2 suggests the existence of seasonal synchronization at very aggregate levels.

This finding is consistent with the view that the lack of synchronization is an important factor explaining price stickiness. Italian researchers find strong evidence of staggering (in agreement with its high stickiness), and German researchers find evidence of a high degree of synchronization in particular industrial sectors (which agrees with its low stickiness). Therefore, the Colombian price stickiness seems to be related to a low synchronization level.

3.4. Is the pricing rule "state dependent" or "time dependent"?

In order to answer this question, we present two types of evidence; a conditional logistic model and the Klenow and Krivtsov (2003) inflation variance decomposition[13]. The first helps determine the factors affecting the choice of changing or not producer prices. The second helps asses the importance of time dependence and state dependence

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its prices each period, $FK = 0$. Therefore, given $\overline{p}$, FK measures the proximity of $s^2_{p_t}$ to its upper bound.

[13]According to Klenow and Krivtsov the inflation rate might be decomposed as the product of the FPC and the percentage price change as $\pi_t = FPC_t D(P_t)$ where P_t is the price level and D is the difference operator. The volatility of the first term figures prominently in many state dependent models, and the volatility of the second is the only source of fluctuations in time dependent pricing models. By writing $\pi_t = FPC_t\overline{D(P_t)} + \overline{FPC_t}D(P_t) + (FPC_t - \overline{FPC_t})(D(P_t) - \overline{D(P_t)}) - \overline{FPC_t}\overline{D(P_t)}$ an exact variance decomposition is found, $V(\pi_t) = FPC_t^2 V(D(P_t)) + V(FPC_t\overline{D(P_t)} + (FPC_t - \overline{FPC_t})(D(P_t) - \overline{D(P_t)})) + 2Cov_t$ where $Cov_t = Cov(\overline{FPC_t}D(P_t), FPC_t\overline{D(P_t)} + (FPC_t - \overline{FPC_t})(D(P_t) - \overline{D(P_t)}))$. In the variance decomposition equation the first term is time dependent and the remaining two are the state dependent ones.

in producer's pricings rules.

The conditional logistic model explains the probability of no price change at the product category level. The explanatory variables, according to the previous discussions, are the source code, SOURCE, the CIIU1 code, the year and month of the price report, the monthly devaluation rate, the inflation rate and the output gap. Since our logistic analysis involves some categorical factors, SOURCE, CIIU1, the year and month of the report, the overall factor significance is studied through the type III analysis of variance. Table 10 contains this analysis for the model including all the regressors (upper panel), and the factors remaining after a STEPWISE factor selection procedure in the lower panel.

The results are presented in tables 10 to 12, and the findings summarize in the following points:

- *There is clear presence of time and state dependence in producer's pricing rules, but time dependence dominate.* In fact, time related variables like the month and year of the report explain a higher share of the variation in the decision of changing prices, than variables related to the state of the economy, in the conditional logistic model. Moreover, due to the correlation between the inflation rate and the output gap, only the inflation rate enters into the model (see Table 10 bottom panel). However, after removing the inflation rate, the output gap significance improves greatly. These findings are confirmed in Table 11, where the final model estimates are presented, and in Table 12, where the Klenow and Krivtsov decomposition is shown. From Table 12 it can be observed that consistently the time dependency contribution to the inflation variance is substantially bigger, in all categories and classifications, than the state contribution.

In addition, it should be noted that, in agreement with our previous discussion, the source and manufacture state of goods (CIIU1), as well as their interaction, are the most important factors explaining the decision of changing prices.

- *For produced-and-consumed goods state dependency seems to relate to the manufacture stage of goods.* In fact, the state dependence contribution is higher, between 16.5% and 34%, for produced-consumed manufactures regardless of their destination. See Table 12.

International studies also find evidence of strong time dependency in producer prices with a small but significant contribution of state dependency. In France, for instance, the average time dependence contribution is 92.2%. Strong time dependency in producer prices may arise because of the higher reliance on explicit contracts and costumer resistance.

3.5. Are Price Changes Sizable?

In order to answer this question, the weighed median percentage price increase and decrease were computed. The results are contained in Table 13 and the findings summarize in the following points.

- *Median percentage price increases and decreases are not sizably different from the average inflation level during the sample span.* They are explainable lower for imports than produced-and-consumed goods. See Table 13.
- *However, this evidence implies that a big amount of the basket changing its prices*

above the inflation, in absolute value. This is particularly true for produced-and-consumed goods, which weight about 75% of the PPI basket. This evidence suggests that costs are not convex. See Table 13.

- *Median percentage price increase and decrease heterogeneity has to do with the source of goods and its manufacture stage.* Percentage price increases and decreases are uniformly lower for imported goods than produced-consumed goods. For produced-consumed goods, the average ratio of increases over decreases is smallest for agriculture, 125.4%, second for mining, 147.7% and highest for manufactures, 159.4%. A similar ordering is found for imports.

International evidence on the existence of convex costs agrees with our findings. See Vermeullen et al (2007).

4. Conclusion

Colombian producers and importers change their prices as frequently as a set of six countries of the EU, 20% of the PPI basket each month, which implies that in Colombia prices remain constant on a weighed average of 5.5.months. These results imply that, if expectations are similarly anchored in both places and prices indexation is also similar, the welfare cost of a reduction of the same size is about the same both in the EU and Colombia[14]. See Vermeullen et al (2007).

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[14] However, if we take into account that the inflation rate during the sample for the countries of the IPN was lower than 2.5% and the Colombian was 7%, and if it the stickiness in Colombia continues to increase as the inflation reduces, under particular circumstances this evidence might suggest that Colombian prices would be stickier than those of the IPN when we reach the long run inflation target, 3%.

An important factor explaining this level of stickiness is the lack of synchronization. However, we found some evidence of seasonal synchronization that may be related to the minimum wage increase schedule.

Moreover, the costs of price changes do not seem to be convex. Therefore, the costs of price change do not seem to matter much when firms decide on a price update. This result might imply that a fully state dependent rule might not be appropriate to model Colombian producers and importers price adjustment rules. Moreover, according to the previous results on synchronization, a time dependent rule might be a good approximation to the way producer prices are set in Colombia.

A slight nominal downward rigidity was also found. However, no evidence of *strong* downward rigidities was found. A slight downward rigidity relate to the efficiency of the price system, as it permits to set long run inflation target of 3%. However, no signs of strong nominal downward rigidities were found. Therefore, the welfare costs of monetary policy related to strong nominal rigidities, at least in comparison to the countries in the IPN, are ruled out for Colombia.

Nevertheless, a surprisingly high frequency of price decreases of moderate size was found given the level of PPI inflation prevailing during the sample.

Moreover, we found that the decision to change prices is determined by both, state and time dependent factors, dominated by the later. However, the contribution of state dependency increases for produced-and-consumed manufactures. Thus, PPI price adjustment rules are sector dependent with varying degrees of state dependency among sectors.

There are strong sectoral differences in the price setting behavior of firms related to the source and manufacture stage of goods. In fact, import prices are more flexible, both in absolute and downward terms, than produced-and-consumed ones. Moreover, produced-and-consumed goods are stickier, both in absolute and downward terms, as their manufacture stage increases. In addition, the “state dependence” component is higher for produced-and-consumed goods than for the rest of the basket. Consequently, imports and low manufactured goods respond quicker to monetary policy than those higher up in the manufacture stage scale.

Finally, price rigidity increased with the reduction of the inflation rate, which implies that inflation persistence relates directly to the level of inflation. Therefore, the end of the 1990’s inflation decline reduced the pricing power of firms since their expectations on future costs were anchored to decrease. This fact, in turn, contributed to maintain the downward inflation trend. However, these benefits (decreasing inflation and increasing GDP), may disappear easily if the stance of the monetary policy or agents expectations change. See Angeloni et al (2006) and Taylor (2000).

Appendix A: TABLES

Table 1. International Research: Methodological Issues

Country	Prices	Basket (% PPI)	Time	N Reports	Imput	Censor	Estim
France	Transac	92.0	Jan94-Jun05	1500000	No	Yes	Dur/Fre
Italy	Transac	44.0	Jan97-Dec02	71000	Yes	Yes	Dur/Fre/Surv
Germany	Transac	100.0	Jan80-Nov01	1300000	No	Yes	Dur/Fre/Surv
Spain	Transac	99.4	Nov-91-Feb99	1650000	Yes	Yes	Dur/Fre
Portugal	Transac	100.0	Jan95-Aug02	1000000	Yes	Yes	Dur/Fre/Sur/ Hazard

Table 2. International Research: Results

Country	FCP (%)	Duration Months	Heterogeneity	Downward Rigid	Sync	State/Time	Convex Costs
France	25	7	Manuf Stage	Yes	N/A	S/T	No
Italy	15	6	Manuf Stage	No	Low	N/A	No
Germany	17	8	Manuf Stage	Yes	High	S/T	No
Spain	21	12	Cost Str / Comp	Slight	N/A	S/T	No
Portugal	23	N/A	Manuf Stage	Slight	Yes	N/A	No

Table 3. Initial Sample Composition, Number of Price Reports

	PRODUCED CONSUMED	IMPORTED	TOTAL
AGRICULTURE CATTLE HUNTING FORESTRY FISHING	62905	11032	73937
MINING QUARRY	6108	1131	7239
MANUFACTURE INDUSTRY	295706	163187	458893
TOTAL	364719	175350	540069

Table 4. Price Sequence Composition, Final Sample

	PRODUCED CONSUMED	**IMPORTED**	**TOTAL**
AGRICULTURE CATTLE HUNTING FORESTRY FISHING	967	190	1157
MINING QUARRY	98	18	116
MANUFACTURE INDUSTRY	5767	3876	9643
TOTAL	6832	4084	10916

Table 5. Weight Composition.

SOURCE	CIIU1	INTERM. CONSUMP.	FINAL CONSUMP.	CAPITAL GOODS	CONST. GOODS
PRODUCED CONSUMED	AGRICULTURE CATTLE HUNTING FORESTRY FISHING	31.9%	14.2%	1.6%	0.0%
	MINING QUARRY	2.8%	0.7%	0.0%	7.3%
	MANUFACTURE INDUSTRY	43.8%	70.7%	26.2%	74.2%
IMPORTED	AGRICULTURE CATTLE HUNTING FORESTRY FISHING	2.0%	0.5%	0.0%	0.0%
	MINING QUARRY	0.1%	0.0%	0.0%	0.0%
	MANUFACTURE INDUSTRY	19.4%	13.9%	72.1%	18.5%
	TOTAL	100.0%	100.0%	100.0%	100.0%

SOURCE	CIIU1	INTERM. CONSUMP.	FINAL CONSUMP.	CAPITAL GOODS	CONST. GOODS
PRODUCED CONSUMED	AGRICULTURE CATTLE HUNTING FORESTRY FISHING	40.6%	16.6%	5.8%	0.0%
	MINING QUARRY	3.6%	0.9%	0.0%	9.0%
	MANUFACTURE INDUSTRY	55.8%	82.6%	94.2%	91.0%
SUBTOTAL		100.0%	100.0%	100.0%	100.0%
IMPORTED	AGRICULTURE CATTLE HUNTING FORESTRY FISHING	9.2%	3.3%	0.0%	0.0%
	MINING QUARRY	0.5%	0.0%	0.0%	0.0%
	MANUFACTURE INDUSTRY	90.3%	96.7%	100.0%	100.0%
SUBTOTAL		100.0%	100.0%	100.0%	100.0%

Table 6. Spell Distribution.

	IMPORTS	PRODUCED CONSUMED	TOTAL
AGRICULTURE CATTLE HUNTING FORESTRY FISHING	6007	45828	51835
MANUFACTURE INDUSTRY	70443	34647	105090
MINING QUARRY	937	1228	2165
TOTAL	77387	81703	159090

Table 7. Duration and FPC Distributions for the Whole Basket and by Source (months)

SOURCE	MEAN	STD	Q1	MED	Q3
PRODUCED CONSUMED	6.03	4.23	2.34	5.37	8.77
IMPORTED	3.84	3.41	1.67	2.88	4.94
ALL	5.52	4.16	1.82	4.83	8.13
(% of PPI Basket)					
SOURCE	**MEAN**	**STD**	**Q1**	**MED**	**Q3**
PRODUCED CONSUMED	17.26	13.82	5.23	12.95	29.48
IMPORTED	29.76	13.76	18.99	30.21	41.27
ALL	20.22	14.79	5.95	15.52	32.70

Table 8. Duration Distributions by Destination and Source

DESTINATION	SOURCE	MEAN	STD	Q1	MED	Q3
INTERMEDIATE CONSUMPTION	PRODUCED CONSUMED	5.29	3.92	1.52	4.85	7.61
	IMPORTED	3.47	2.79	1.67	2.40	4.67
FINAL CONSUMPTION	PRODUCED CONSUMED	6.43	4.51	2.44	6.50	9.63
	IMPORTED	4.71	4.32	2.53	4.05	6.01
CAPITAL GOODS	PRODUCED CONSUMED	6.46	5.27	2.63	5.89	8.60
	IMPORTED	3.39	3.11	1.00	2.22	4.05
CONSTRUCTION MATERIALS	PRODUCED CONSUMED	7.73	2.78	5.96	6.97	9.12
	IMPORTED	5.12	3.59	2.58	4.80	6.88

Table 9. Frequency of Price Increases and Decreases by Source, CIIU1 and Destination

		PRODUCED CONSUMED			IMPORTS		
DESTINATION	**CHANGE**	AGRIC	MANUF	MINING	AGRIC	MANUF	MINING
INTERMEDIATE CONSUMPTION	INCREASE	8.3%	4.2%	11.9%	9.8%	8.0%	10.0%
	DECREASE	6.0%	1.8%	6.6%	9.2%	7.2%	10.8%
FINAL CONSUMPTION	INCREASE	9.8%	4.1%	10.3%	7.7%	6.1%	
	DECREASE	8.8%	2.0%	8.9%	6.7%	5.3%	
CAPITAL GOODS	INCREASE	10.7%	4.7%			8.4%	
	DECREASE	7.4%	1.1%			8.3%	
CONSTRUCTION MATERIALS	INCREASE		3.3%	1.7%		6.6%	
	DECREASE		1.0%	0.7%		5.9%	
AVERAGE RATIO INCR/DECR		131%	299%	180%	111%	110%	93%

Table 10. Type III Analysis of Variance for Logistic Regression For Decision of not Changing Prices

EFFECT	DF	Chi-Sq	Pr>Chi-Sq
SOURCE	1	1,662.38	<.0001
CIIU1	2	14,203.74	<.0001
SOURCE*CIIU1	2	9,022.33	<.0001
YEAR	7	1,367.82	<.0001
MONTH	11	374.90	<.0001
PPI_INFL	1	136.04	<.0001
DEV_RATE	1	3.71	0.05
OUTP_GAP	1	0.69	0.41
CIIU1	2	14,203.43	<.0001
SOURCE*CIIU1	2	9,022.46	<.0001
SOURCE	1	1,662.32	<.0001
YEAR	7	1,452.64	<.0001
MONTH	11	412.69	<.0001
PPI_INFL	1	191.24	<.0001

Table 11. Parameter Estimates Logistic Regression for Frequency of Price Changes

PARAMETER	DF	ESTIMATE	STD ERR	WALD	PR > CHI SQ
Intercept	1	-0.36	0.02	370.91	<.0001
SOURCE_IMPORTED	1	-0.71	0.02	1662.32	<.0001
SOURCE_PROD_CONS	1	-0.71	0.02	1425.56	<.0001
CIIU1_AGRIC	1	0.89	0.02	2562.79	<.0001
SOURCE*CIIU1 AGRIC	1	1.00	0.02	2786.88	<.0001
SOURCE*CIIU1_MANUF	1	-0.28	0.02	261.15	<.0001
YEAR1999	1	-0.40	0.02	422.80	<.0001
YEAR2000	1	0.09	0.01	68.04	<.0001
YEAR2001	1	0.14	0.01	204.38	<.0001
YEAR2002	1	0.22	0.01	492.88	<.0001
YEAR2003	1	0.14	0.01	206.69	<.0001
YEAR2004	1	0.11	0.01	107.95	<.0001
YEAR2005	1	0.03	0.01	7.54	0.01
MONTH1	1	-0.08	0.01	30.20	<.0001
MONTH2	1	-0.20	0.01	204.52	<.0001
MONTH3	1	-0.01	0.01	0.58	0.45
MONTH4	1	0.06	0.01	18.36	<.0001
MONTH5	1	0.05	0.01	12.76	0.00
MONTH6	1	0.00	0.01	0.01	0.92
MONTH7	1	0.00	0.01	0.00	0.99
MONTH8	1	-0.09	0.01	48.56	<.0001
MONTH9	1	0.04	0.01	11.00	0.00
MONTH10	1	0.03	0.01	3.43	0.06
MONTH11	1	0.05	0.01	11.55	0.00
PPI_INFL	1	-12.52	0.91	191.24	<.0001

Table 12. Klenow–Kryvtsov Inflation Variance Decomposition

		PRODUCED CONSUMED			IMPORTS		
DESTINATION	**RULE**	AGRIC	MANUF	MINING	AGRIC	MANUF	MINING
INTERMEDIATE CONSUMPTION	TIME DEP	98.1%	78.2%	94.3%	99.0%	99.6%	99.1%
	STATE DEP	1.9%	21.8%	5.7%	1.0%	0.4%	0.9%
FINAL CONSUMPTION	TIME DEP	97.8%	75.8%	93.4%	97.9%	98.9%	
	STATE DEP	2.2%	24.2%	6.6%	2.1%	1.1%	
CAPITAL GOODS	TIME DEP	96.3%	65.9%			98.1%	
	STATE DEP	3.7%	34.1%			1.9%	
CONSTRUCTION MATERIALS	TIME DEP		83.5%	64.5%		95.2%	
	STATE DEP		16.5%	35.5%		4.8%	

Table 13. Median Percentage Price Increase and Decrease

		IMPORTED			PRODUCED CONSUMED		
DESTINATION	**CHANGE**	AGRIC	MANUF	MINING	AGRIC	MANUF	MINING
CAPITAL GOODS	INCREASE		3.05%		4.44%	4.93%	
	DECREASE		1.84%		3.58%	3.34%	
FINAL CONSUMPTION	INCREASE	8.23%	4.32%		13.09%	7.16%	6.55%
	DECREASE	7.02%	1.98%		9.88%	4.18%	3.13%
INTERMEDIATE CONSUMPTION	INCREASE	4.79%	4.68%	3.74%	5.65%	7.56%	9.48%
	DECREASE	3.09%	2.44%	3.01%	4.72%	4.71%	7.64%
CONSTRUCTION MATERIALS	INCREASE		4.52%			7.45%	9.28%
	DECREASE		2.55%			4.71%	8.46%
AVERAGE RATIO INCR/DECR		136.16%	188.40%	123.91%	125.41%	159.35%	147.73%

Table 14. List of variables in Data set

Prices	The price in its original currency.
	The price in Colombian Pesos, COP
Product category identification	The source code, which identifies if the product is imported or produced-and-consumed.
	A 9 digit minimal product class code, which is a local adaptation of the CIIU code revision 3
	A quote code (unique within informants), that identifies reports on particular product categories.
Informant identification	City in which the reporter is located.
	An informant code that is unique within each city.
Indicator variables that record the occurrence of the following events:	Promotions and rebates.
	Sale of defective products
	Changes in sales units, name, brand, internal reference code or report currency.
	The inclusion or exclusion of a product category.
	The inclusion or exclusion of an informant.
	Change in report frequency.
	Temporary unavailability of the reporter
	Price report imputation and the method used
	A code that indicates whether the record was used for the actual computation of the PPI or not.

Appendix B: FIGURES

Figure 1. Five price sequences belonging to a particular good

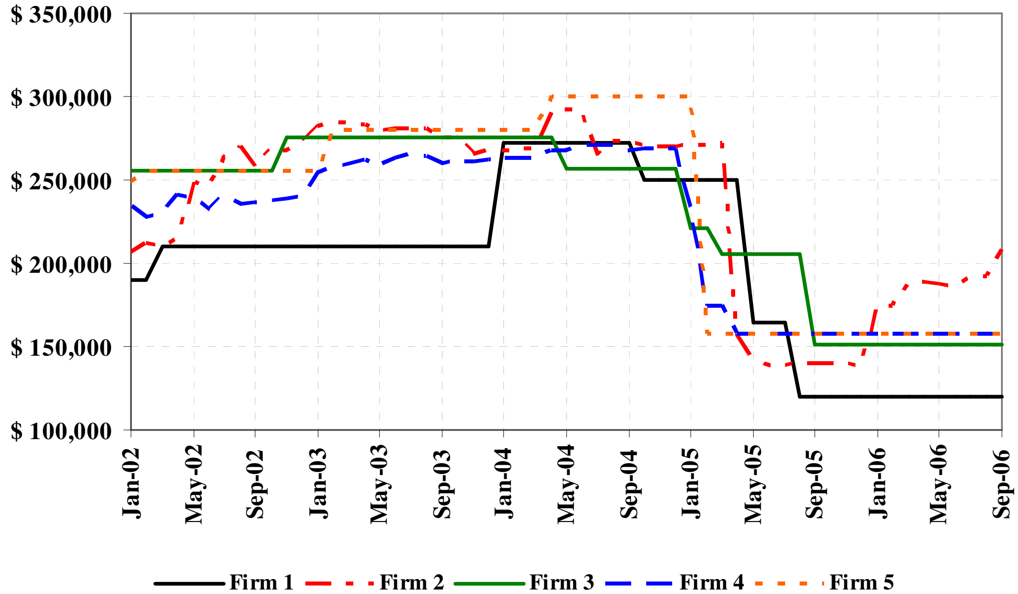


Figure 2a. Estimated Mean Frequency of Price Changes Across Time Whole Basket and for Each Destination

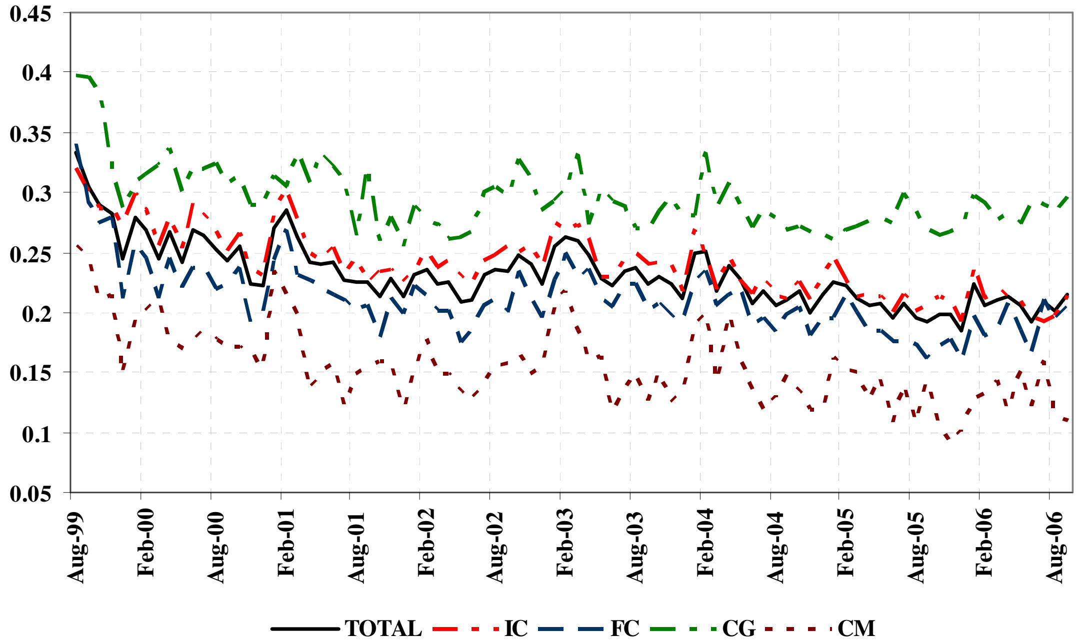


Figure 2b. Estimated Mean Duration Across Time Whole Basket and for Each Destination

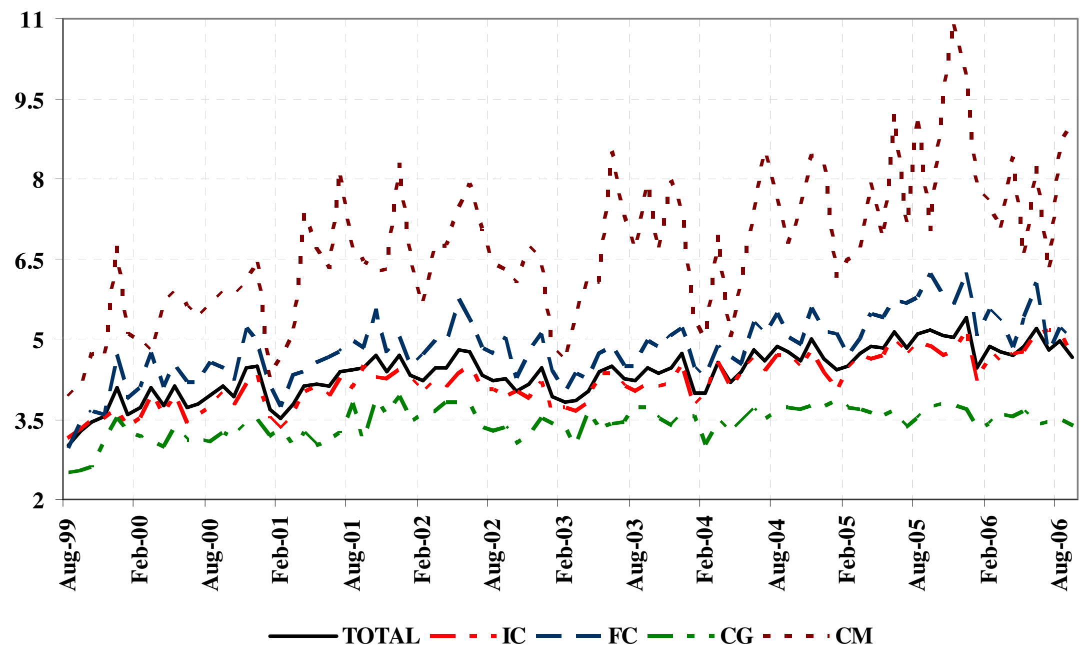
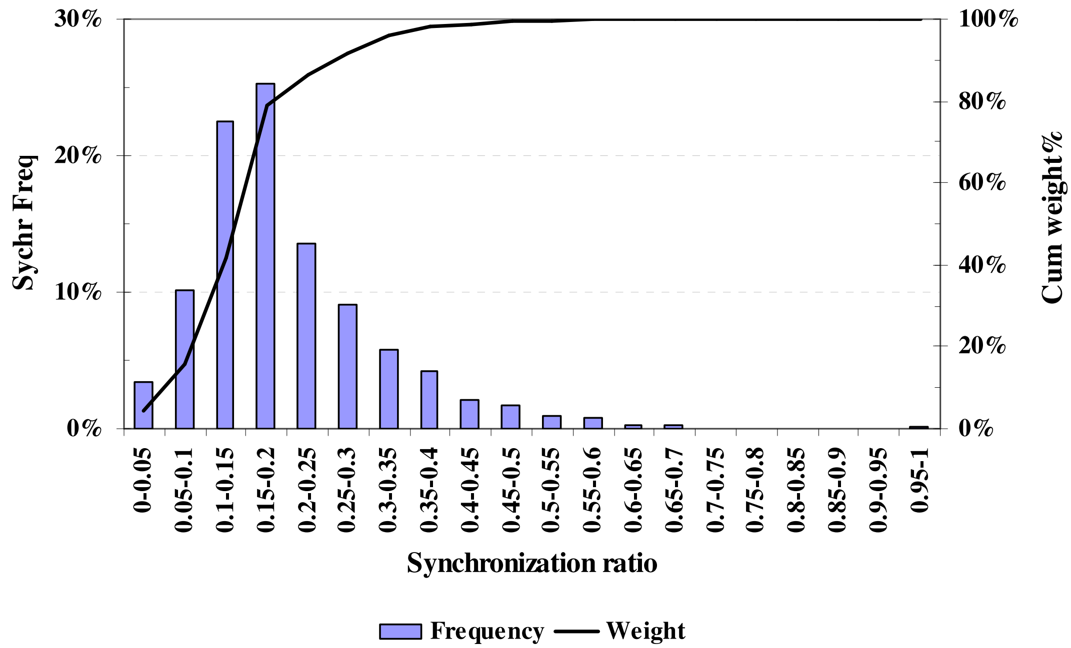


Figure 3. Synchronization Ratio



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