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Price-Setting and Exchange Rate Pass-Through in the Mexican Economy: Evidence from CPI Micro Data*

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Abstract: As a consequence of the international environment, the currencies of many emerging market economies have experienced important depreciations in a context of high volatility in financial markets. The Mexican peso has not been the exception to the above situation. In this setting, the exchange rate pass-through into consumer prices deserves special attention as it allows us to evaluate the anchoring of inflation expectations in the Mexican economy. To address this issue, in this paper we use non-public micro data from the Mexican Consumer Price Index (CPI) to analyze the relation between exchange rate and price-setting in Mexico for the period between January 2011 and April 2016. Our estimates suggest that the exchange rate pass-through into consumer prices is low.
Keywords: Exchange Rate Pass-Through, Price Micro Data, Nominal Stickiness.
JEL Classification: E31, F31, F41.

Resumen: Como consecuencia del entorno internacional, las monedas de diversas economías emergentes han experimentado importantes depreciaciones en un ambiente de alta volatilidad en los mercados financieros. El peso mexicano no ha sido la excepción a esta situación. En este contexto, el traspaso del tipo de cambio a los precios al consumidor merece una importante atención ya que éste nos permite evaluar el anclaje de las expectativas de inflación en la economía mexicana. Para abordar este tema, en este documento se utilizan micro datos del INPC para analizar la relación del tipo de cambio y la fijación de precios en México para el periodo entre enero de 2011 y abril de 2016. Nuestras estimaciones sugieren que el traspaso del tipo de cambio a los precios al consumidor es bajo.
Palabras Clave: Traspaso del Tipo de Cambio, Micro Datos de Precios, Rigideces Nominales.

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1 Introduction

Since the outbreak of the 2008-2009 global financial crisis, monetary conditions worldwide have been extremely loose. Despite the unprecedented actions taken by most central banks of advanced and emerging economies, the pace of recovery of different economies has been heterogeneous. This implies, on the one hand, a scenario in which economies that have accomplished a higher degree of recovery, such as the U.S., have started to remove extreme levels of monetary accommodation. On the other hand, other economies such as the Euro Area and Japan are likely to continue providing strong monetary stimulus.

One of the consequences of the current state of global monetary conditions and the potential divergence of monetary policy stances of major advanced economies has been the investors' active search for yield process. As it is well known, such a process has implied an exceptional amount of capital flows across economies. The latter, combined with doubts regarding the efficiency of economic policies in China and the recent geopolitical events, has translated into a depreciation pattern of all emerging market economies (EMEs) currencies and has exacerbated their volatility.

The Mexican peso has not been the exception to the above situation. Figure I presents the Mexican peso-USD nominal exchange rate (NER) since January 2008. From the figure, it can be seen that this variable has exhibited considerable fluctuations over the last years, and more recently shows a depreciation pattern from the end of 2014 onwards. In February 2016, after the policies jointly announced by Mexico's Central Bank (*Banco de México*), the Ministry of Finance (*Secretaría de Hacienda y Crédito Público*) and the Foreign Exchange Commission (*Comisión de Cambios*) to strengthen the country's economic fundamentals, the NER somewhat reverted its depreciation trend.[1] Nevertheless, the NER has recently shown

[1]The measures jointly announced by the Mexican authorities were: (1) a 50 basis points increase of the Overnight Interbank interest rate by the Central Bank; (2) a preemptive spending cut in the Federal Public Administration by the Minister of Finance; (3) a suspension of the foreign currency daily auctions and the announcement that, in exceptional cases, the Foreign Exchange Commission may discretionally intervene in the exchange market.

another deterioration. Interestingly, as opposed to the behavior of the NER, during last two years annual headline and core inflation, presented in Figure II, have shown remarkable stability around the Central Bank permanent inflation target of 3 percent.

Given this context, the exchange rate pass-through (ERPT) into consumer prices deserves special attention as it allows us to evaluate the anchoring of inflation expectations, which were achieved through important structural transformations in the Mexican economy over the last two decades, as documented by Aguilar et al. (2014). In this vein, a low pass-through would suggest that the Central Bank has been successful running a credible monetary policy. Because of this, assessing the ERPT into consumer prices becomes a crucial task.

In this paper we address this issue. We use non-public micro data from the Mexican Consumer Price Index (CPI), for the period between January 2011 to April 2016, to estimate the ERPT into consumer prices using a specification that measures the cumulative change of the NER between products' price changes. In line with other estimates based on aggregate variables (Kohlscheen, 2010; Capistrán, Ibarra-Ramírez, and Ramos-Francia, 2012; Cortés, 2013), our results suggest that the ERPT into consumer prices is low. Specifically, for the sample of goods and services analyzed (58.6% of the CPI), we estimate that, on average, when a price changes it only passes through 0.073 percentage points (p.p.) of a 1% change in the NER. Considering the share of the CPI basket studied, and assuming that the ERPT of the goods and services not included is zero, our estimates suggest that a 1% change in the NER has an incidence on aggregate inflation of 0.043%. This result, however, should be interpreted as a lower bound of the ERPT into the aggregate price level.

Besides the baseline estimation for the ERPT into consumer prices, we analyze whether the ERPT varies across different stages of the business cycle. In particular, we estimate to what extent the stage of the business cycle has implications for the magnitude of the ERPT. As expected, we find a positive relation between the ERPT and the business cycle: when the economy operates above its potential the ERPT is around 0.069%, given a 1% change in the NER. Conversely, when economic activity is below its potential the ERPT is non-statistically different from zero. Specifically, when the output gap is positive the ERPT is 0.064 p.p.

larger than when the gap is negative. This difference is statistically significant at 10%.

Finally, we analyze whether the ERPT varies across time. To do so, we present estimations for a time-varying ERPT for the CPI and its main components. In general, we find that the ERPT across time for the complete sample has slight variations through the sample period, however our estimations are in general not statistically significant at a 10%. With respect to the core and non-core components we document that the ERPT in the former is low and with few variations, while for the latter our estimates show a large variance with a lot of periods with a not statistically significant ERPT. Within the core component of the CPI, the pass-through parameter for merchandise shows remarkable stability around zero through the sample period. From this group the result for food, beverages and tobacco stands out, as the ERPT presents an increase starting around July 2015. The other items in the CPI core component are services, for which their time-varying ERPT estimates are more stable and in general not statistically significant. For agricultural goods, which represent the non-core component of the CPI in this sample, the estimated time-varying ERPT is largely volatile and mainly non-statistically different from zero.

This paper is related to the literature that analyzes the ERPT to prices using micro data. For example, Gopinath and Rigobon (2008) use micro data underlying the U.S. import and export price indexes to document different facts about the degree of price stickiness across borders. Additionally, they present an estimation of the ERPT into import prices using this micro data. Other papers have analyzed the relation between the frequency of price change and the ERPT (Gopinath and Itskhoki, 2010) and the relation between the choice of currency of imports and the ERPT (Gopinath, Itskhoki, and Rigobon, 2010). Burstein and Gopinath (2014) present a survey of the empirical and theoretical literature of exchange rate and prices. In this paper, we employ the empirical strategies of this literature to quantify the ERPT into consumer prices for the Mexican economy using price micro data of the CPI. In this vein, there are only few studies for EMEs that attempt to estimate the ERPT using micro data. For a survey about the ERPT in the context of EMEs see Aron, Macdonald, and Muellbauer (2014).

Additionally, this paper is related to the empirical literature that documents the price-setting behavior from price micro data. Leading references of studies that document the price-setting behavior using CPI micro data are Klenow and Kryvtsov (2008), and Nakamura and Steinsson (2008) for the U.S., and Dhyne et al. (2006) for the Euro Area. Klenow and Malin (2011) present a detailed survey of the empirical price-setting literature. These studies have not been limited to advanced economies. As a matter of fact, for Mexico, Gagnon (2009), Cortés, Murillo, and Ramos-Francia (2012) and Kochen (2016) have documented stylized facts of the price-setting behavior using CPI micro data. However, none of them has quantified the ERPT using price micro data.

The paper proceeds as follows. In Section 2 we describe the price micro data used in the paper. We also discuss the empirical strategies that address some relevant features of the CPI micro data. In Section 3 we present some stylized facts about the price-setting dynamics and its relation to the NER in the Mexican economy. Our estimates for the ERPT into consumer prices are presented and discussed in Section 4. Finally, Section 5 concludes.

2 The Data

2.1 Description of the Data

In this section we describe the data set employed in the paper. We use non-public micro data of product-level price quotes underlying the Mexican CPI, the *Índice Nacional de Precios al Consumidor* (INPC). Differently from other CPIs, inflation in Mexico is calculated twice a month from prices collected twice or four times per month in the 46 major cities of the country. The majority of the goods and services in the CPI are quoted on semimonthly basis, while goods with more volatile prices, such as food, are quoted on a weekly basis.

The micro data used in this paper identifies the quoted goods and services, from hereon refereed to as products, at a detailed level. Each price quote has information about the product's brand, a product description, and an outlet unique identification number (e.g. Carbonated drinks, brand Coca-Cola, non-returnable, bottle of 3 liters, sold in outlet 31272 in

Mexico City). In addition, the data set also contains information about the price collection. In particular, it specifies if the product was on sale or was missing when the price was quoted. There is also a product substitution indicator and the reason why it was substituted. Thanks to the detail of the data set we are able to properly address the presence of sales and product substitutions, features that have proved to be relevant for consumer prices micro data (Nakamura and Steinsson, 2008; Kochen, 2016).

CPI's products are classified into three aggregation levels: (1) varieties, (2) city of quotation, and (3) generic item categories. Generic item classifications are broad consumption categories used to group individual products, for example, "Carbonated drinks" or "Haircuts". These categories are analogous to the Entry Level Items of the U.S. CPI. Items' varieties apply for some generic items with further disaggregated classifications. The expenditure weights that are used for inflation measurement are specific to the variety-city-generic level.[2] For this paper we use the current expenditure weights, introduced in April 2013, to calculate weighted aggregate price statistics and for the ERPT estimations.

2.2 Data Coverage

The data set goes from June 2009 to April 2016, however, for the empirical analysis we restrict to a sample starting in January 2011. We restrict to this sample to address left censoring on prices, i.e. when the beginning of the price is not observed, at the initial periods of the data set. Given that, for the price-setting and ERPT analysis, we use the duration of uncensored price spells including prices at the beginning of the sample would over-represent the products that change prices more frequently as they are the ones that will have more uncensored spells at that point of the sample. Because of this, for the empirical analysis we restrict to price changes that took place on or after January 2011. Note that, restricting to this period, the price changes that occurred at the beginning of our sample (January 2011) could have followed from a spell of a maximum duration of 18 months (from July 2009 to December 2010).

[2]The weights used in the Mexican CPI are derived from the Survey of Household's Income and Expenditures, *Encuesta Nacional de Ingreso y Gasto de los Hogares* (ENIGH). This ensures that the CPI generic item categories covers more than 95% of Mexican household's expenditures (INEGI, 2013).

With respect to the CPI coverage, out of the total 283 CPI generic items, we restrict our analysis to 246. The selected items represent 58.6% of the Mexican CPI basket, measured by household expenditure weights. Given that the main purpose of this paper is to quantify ERPT over the Mexican consumer prices we consider the broader group of generic items that could be studied with our empirical strategy. The generic items that had to be excluded from the analysis are now described. First, we had to drop the generic items that have certain characteristics that require particular price collection procedures, and hence, we do not observe the direct price quotes in the data. Out of the 283 items, 20 were excluded for this reason, with a total participation of 30.3% in the CPI. Examples of these items are shelter, private education and telecommunication services.[3] Second, 7 additional items, with a total weight 0.59%, were excluded because of missing data before the December 2010 CPI basket revision.[4] Finally, we follow the practice of excluding the items whose price is regulated since their price dynamics reflect administrative considerations rather than market ones. Overall, a total of 10 items were excluded for the above said reason. These items have a total expenditure weight of 10.6%.

Table I presents the main summary statistics for the selected sample by the CPI main components. The total number of items and expenditure weight for each component are reported in the second and third column of the table. The frequency at which the items are quoted is specified in the fourth one. Overall, the data set considering 246 generic items comprises close to 18.2 million weekly and semimonthly product-level price quotes, of over 250,000 different products, over the period of June 2009 to April 2016. The final columns of the table also report the percentage of prices that are sales or missing values during the sample period.

[3]This type of goods are analogous to the composite-good items of the U.S. CPI. Eichenbaum et al. (2014) show that considering the prices of this type of items could cause a large share of spurious small price changes.

[4]In December 2010 there was a major basket revision that resulted in a reduction of generic categories, from 315 to the current number of 283: 8 generics were open in 20 new generic items, 70 merged in 29 items and 3 were eliminated. For further details of the 2010 basket revision see INEGI (2013). Additionally, we excluded the generic watches, jewelry and costume jewelry, with a CPI weight of 0.06%, because their price variation before the 2010 basket revision was imputed from gold and silver prices.

2.3 Other Aspects of the Data

The micro data used in this paper has some important advantages over the data sets used in previous empirical studies for Mexico. For example, Gagnon (2009) used monthly average prices (of the two or four prices of each month) of the CPI product-level price quotes that are published in the Mexican government's official gazette, the *Diario Oficial de la Federación* (DOF). The use of average prices, instead of the direct price quotes, complicates the inference since the price changes of average prices will be smaller and more frequent generating biases in the price-setting calculations.[5] Additionally, the DOF data set does not report any additional information about the price collection, in particular about the presence of sales or missing values. This novel micro data of the Mexican CPI has only been used in Kochen (2016).

Sale-related price changes, stock-outs and product substitutions are three relevant features of the CPI micro data that have to be addressed when working with CPI micro data. In particular, sales have become relatively more frequent in recent years in Mexico: the monthly percentage of sales, with respect to the total number of price quotes, has almost doubled from 4% in 2009 to a level of 8% in 2016. The empirical literature about price-setting has distinguished between two classes of price changes: (1) posted prices, and (2) regular prices, which filter out sale-related price changes. Given that the main purpose of the paper is to analyze the impact of the nominal exchange rate on consumer prices and on aggregate inflation, we focus on the price-setting of posted prices.[6] However, for the ERPT estimations we are careful to control for the price changes related to sales. We identify sale-related price changes using the sale flag reported in the CPI micro data.[7]

[5]For a further discussion about the implications of the use of average prices for the price-setting analysis see Gagnon (2009). To address the averaging of the prices, a filter is employed in that paper to estimate monthly price statistics with the DOF micro data.

[6]Kochen (2016) documents that sales play an important role in price flexibility as 31.2% of posted price changes are due to sales. Hence, distinguishing between posted and regular prices is relevant when analyzing the price-setting and monetary non-neutrality.

[7]In the Mexican CPI sales are defined as all non-conditional price discounts, either in terms of a minimum

Additionally, to address the presence of stockouts we construct "latent" prices that carry forward the last observed posted price through stockout periods during a maximum of 5 months. If there is no observed posted price after this time period we do not consider these observations. The construction of latent prices is relevant for the ERPT identification strategy used in this paper which calculates the cumulative change of exogenous variables over the course of the price spell that precedes a price change. Hence, left and right censoring in spells due to stockouts, i.e. cases of unobserved beginning or ending of the price, will affect the construction of these variables and hence the use of latent prices, compared to the use of contiguous observations only, considerably reduces the number of censored spells in the data.

To minimize the presence of measurement errors, for example due to uncontrolled quality changes, we discarded price changes related to product substitutions. We identify substitutions using the identification variable reported in the data. Additionally, we address the presence of spurious small price changes.[8] One important source of spurious small price changes in the Mexican CPI micro data is the practice of unit measure prices (e.g. price per kilogram). For 113 out of 246 in-sample generic items, prices are captured in a common unit size. For these items whenever a product has a different size the posted price is converted to the common unit (INEGI, 2013). As a consequence of this reporting practice spurious small price changes are likely to occur. To address for this particular measurement problem we use a conversion factor reported in the data, that was used to calculate the unit size price, to reconstruct posted prices. For further details of these corrections of the CPI micro data see Kochen (2016).

3 Price-Setting in Mexico

The nature of price-setting is relevant for a range of issues in macroeconomics. For example, it has implications for the welfare consequences of business cycles, for monetary policy,

number of products bought or a determined form of payment. This definition excludes all the discounts from the use of coupons or that require a loyalty card (INEGI, 2013).

[8] Eichenbaum et al. (2014) show that spurious small price changes are frequent in the U.S. CPI micro data.

and for exchange rate dynamics (Nakamura and Steinsson, 2008). In this section we briefly characterize the recent price-setting dynamics in the Mexican economy. Additionally, we analyze the relation between price-setting and the NER. We find evidence that the aggregate frequency of price changes responds to large NER movements. With respect to the size of price changes, we find that the magnitude of price adjustments presents some response as well, particularly, around large appreciations.

We follow the price-setting empirical literature (Nakamura and Steinsson, 2008; Gagnon, 2009) and focus on the frequency and the size of price changes. These statistics jointly characterize the price-setting dynamics since they capture how often and for how much prices change. We also report the duration of uncensored price spells, i.e. the spells for which we observe the beginning and ending of the price. All the statistics reported in the paper are at a monthly frequency considering the last quoted, weekly or semimonthly, price of each month. We choose this frequency to make our results comparable to the previous literature. For all our empirical results we aggregate the price statistics using the expenditure weights that are used to calculate inflation. The inflation accounting definitions used to calculate the aggregate price statistics are presented in Appendix A.

3.1 Frequency of Price Change and the Duration of Prices

Table II reports the main statistics that characterize the price-setting behavior of the CPI by its main components. Our results show that, on average, 25.4% of prices change each month, of which 60.1% are increases. The table also shows that there is a considerable heterogeneity in terms of the frequency of price changes across items. This heterogeneity is evident comparing across the CPI main components. For example, only 10.9% of services change their price each month while agricultural goods more than half do. Heterogeneity is also evident in terms of the frequency of price increases relative to all the price changes. For some components, such as services, almost 3/4 of the price changes are increases while for agricultural goods half and half of price changes are increases and decreases, respectively.

Another statistic that is also of interest, as it is a direct measure of the degree of price stickiness, is the duration of price spells. Table II reports the mean weighted duration of non-censored price spells. As it is explained in Appendix A, the duration reported in the table was obtained by first calculating the duration of product-level price spells and then aggregating across spells and time. With this calculation, we obtained that mean weighted duration of price spells is 10.1 months. This statistic is inversely related to the frequency of price adjustments. For example, fruits and vegetables, the component with the higher frequency (69.3%), is the one with shorter duration (2.7 months), while housing services with the lowest frequency (2.8%) is the one with a larger duration (25.5 months). Additional to the average numbers, Figure III presents the distribution of the duration of price spells across products and time. The histogram shows that around 17% of prices last only one month. As a consequence of the right bias present in the duration distribution, the median duration across spells is smaller, 6 months, than the mean duration.

3.2 Size of Price Changes

The size of price changes is the other statistic that characterizes the price-setting behavior. Figure IV presents the distribution of the size of non-zero price changes. The histogram shows that, in the Mexican CPI, the distribution of the magnitude of price changes is bimodal centered at zero with the right side mode having considerably more weight. However, there is also a non-negligible mass of small price changes (close to zero).[9] Additionally, the figure shows that there are some spikes around 10 and 20%, suggesting that prices change at determined magnitudes frequently. As will be discussed below, this type of price changes is commonly related to sales.

Table II presents the calculations for the size of price changes. For the total sample, the average size of price changes is 1.2% while the average of the absolute value is 12.3%.[10] The difference between these statistics suggests the importance of idiosyncratic shocks in the price-setting, as there is a considerable amount of prices that increase while others decrease

[9]For a further discussion about the shape of the distribution of price changes and the frequency of small price changes in the Mexican CPI micro data see Kochen (2016).

[10]Through the paper we refer to log-changes times 100 as percentage changes.

in each period. This stylized fact, that price changes in absolute value are large while on average the magnitude is small, has been consistently documented across different studies (Klenow and Malin, 2011).

With respect to the CPI main components, there are important differences in terms of the average size of price changes as this statistic also reflects the frequency of price increases and decreases across goods. For example, although the absolute value of the size of price changes in merchandise and services are very similar (9.9 and 10.2%, respectively), the average size is 1.4 and 2.8, respectively. This difference is particularly clear for housing services with an average size of 9.2%. Also, fruit and vegetables is the component with the largest magnitude of price changes in absolute value (23.5%) and the one with the smallest average size (0.3%), reflecting that half of the price changes are increases and the other half decreases.

3.3 Price-Setting and the Nominal Exchange Rate

Before proceeding to the formal estimation of the ERPT into consumer prices, in this subsection we briefly analyze the relation between price-setting and the NER. The NER considered in this paper is Mexican pesos per U.S. dollar, hence a positive change in the NER variable is the depreciation of the peso while a negative one is an appreciation. For simplicity, we focus on the Mexican peso-USD exchange rate because this is the most relevant bilateral exchange rate for the Mexican economy in terms of trade.[11] For completeness, in Appendix B we consider a multilateral NER for Mexico's main trade partners, weighted by its share on Mexican imports. Our ERPT results are very similar to the ones we obtained using the bilateral Mexican peso-USD NER.

We first analyze whether the frequency of price changes respond to NER movements, differentiating between the frequency of price increases and decreases.[12] As a response to changes in the NER, the prediction would be that the share of price decreases should rise in appreciation episodes, while the share of increases should grow in depreciation ones. For this analysis, we restrict to periods with monthly changes in the NER of 5% or more, in absolute

[11] In January 2011, 79.5% and 50.7% of the Mexican exports and imports were traded with the U.S.

[12] The definitions for the frequency of price increases and decreases are presented in Appendix A.

value, since in the rest of the months there is not enough variation of the NER, in a single time period, to analyze its impact on prices. From the total, around 10% of the months in the sample were identified. Then, considering a window around the selected periods (5 periods before and 5 periods after the NER movement) we obtain the average frequency across episodes. The results of this procedure are presented in panels (a) and (b) of Figure V for appreciation and depreciation episodes, respectively. In these panels time zero indicates the month when the NER movement, of more than 5%, was observed.

On the one hand, panel (a) of Figure V shows that, on average, after appreciation episodes the frequency of decreases rises while the frequency of increases drops in a considerable amount. Hence, after appreciations we find the expected patterns: the number of price increases is reduced while the number of decreases rises. On the other hand, Panel (b) presents the frequencies of increases and decreases around depreciation episodes. In this case we would expect that the share of increases rises and the one of decreases drops. We do observe some of these patterns but in a lower degree. In particular, the frequencies of increases and decreases seem to react slower to the NER shock. Overall, these results show that, in Mexico, the share of adjusting prices seems to respond to this type of aggregate shocks in the NER.

We now analyze the extent to which the magnitude of price adjustments respond to the NER. The previous results for the frequency around NER variations of more than 5%, particularly after depreciations, indicate that prices may respond with some lag to this type of shocks. Hence, this result suggests that analyzing the response of prices to contemporaneous changes in the NER may not be the most adequate identification strategy. To better tackle this issue, previous studies (Gopinath and Rigobon, 2008; Gopinath and Itskhoki, 2010) have proposed to analyze the response of prices conditional on observing a price adjustment. In this paper we follow this strategy. To do this, for each price change we calculate the cumulative change in the Mexican peso-USD NER since the price last adjustment. To exemplify the construction of this variable, which we call $\Delta_c e$, Figure VI presents an hypothetical price trajectory and the NER time series. In this example, the value of $\Delta_c e$ associated to the \$105 to \$115 price change will be the cumulative change of the NER through the 5 months price spell that precedes the adjustment. Note that this calculation requires that the spell preceding the change to be non-censored in order to determine the last time the price was adjusted. This variable is the main explanatory variable used for the ERPT estimations of Section 4.

Figure VII presents the distribution of $\Delta_c e$ across the price spells in our sample. The figure shows that both appreciation (negative change in $\Delta_c e$) and depreciation episodes (positive change in $\Delta_c e$) are common over the sample period. However, the distribution presents a bias towards depreciation episodes. Specifically, 63.5% of the price spells accumulate a NER depreciation, while 36.5% an appreciation. This is mainly explained by the peso depreciation that followed the 2008-2009 global financial crisis and by the depreciation episode that started in August 2014.

To analyze the relation between the size of price adjustments and the NER fluctuations, we associate the sign of this variable to the distribution of the magnitude of price changes. Figure VIII presents the distribution of price changes conditional on observing a positive or negative sign in the NER cumulative change during the price spell that precedes the adjustment. As expected, the figure shows that after NER appreciations the distribution of the size price of price changes presents a larger mass of negative variations, compared to the price changes that followed from NER depreciations. Also, although in a lower degree, there is a larger share of positive price changes following NER depreciations, compared to the distribution following apreciations. Overall, these distributions suggest that price changes do seem to respond to NER variations, however, consistent with the size of price changes average results, idiosyncratic shocks appear to be very relevant in the price-setting.

4 Exchange Rate Pass-Through into Consumer Prices

In this section we estimate the ERPT into consumer prices employing the Mexican CPI micro data. We estimate the ERPT by measuring the response of price changes to the cumulative change in the NER during the price spells that precede the adjustments, which is given by the variable $\Delta_c e$ defined in Subsection 3.3. This specification, which measures the ERPT conditional on an observed price change is suitable to deal with issues of price stickiness in the response of NER movements (Gopinath and Rigobon, 2008). Also, in a similar fashion as for the NER, we estimate the pass-through of other cost push shocks on prices: the price of commodities, the producer price of electricity and wages. As a final control, we include the cumulative change in the 28-days Mexican securities' interest rate.

Additionally, we analyze whether the stage of the business cycle affects the ERPT into prices. In fact, we find evidence that when the economy operates above its potential the ERPT is positive and significant, while when economic activity is below its potential the ERPT is non-statistically different from zero. We then present estimates about heterogeneous ERPT across the main components of the CPI. We find evidence that pass-though, although low, also exists on goods that could be classified as non-tradables, although for most of them a clear connection with some tradable goods can be established. Finally, we analyze possible time-varying ERPT in our sample. We find that, indeed, the ERPT varies across time. Particularly, we identify the CPI components that have experienced a larger increase more recently.

4.1 Exchange Rate Pass-Through

We estimate the ERPT into consumer prices using the following regression for all non-zero price changes:[13]

$$\Delta p_t^s = \beta \Delta_c e_t^s + \gamma' X_t^s + \epsilon_t^s \tag{1}$$

where s denotes the specific product, Δp_t^s is the log price change in product s at time t, $\Delta_c e_t^s$ is the cumulative log change in the Mexican peso-USD NER since product s last price change as defined in Section 3, and X_t^s denotes a vector of control variables. These controls are described below.

The primary interest of the previous specification is the coefficient β, which measures the cumulative ERPT to a product's price when it adjusts. For example, a parameter of 0.05 implies that, on average, given a 1% change in $\Delta_c e$, when a price adjusts it passes through

[13]This specification is what is called in the literature the medium-run pass-through (MRPT). Alternative specifications have also been implemented with price micro data, for example the life-long pass-through (LFPT), also from Gopinath and Itskhoki (2010), that measures the cumulative pass-through over products' entire life.

0.05 p.p. of the NER variation. It is worth mentioning that the pass-through estimated with this empirical strategy is timeless in terms of the time required by prices to reflect the NER variation. The time period in which the prices will respond to the NER shock depends on each individual product price-setting.[14] Particularly, in our sample, as shown in the previous section, prices have an average and median duration of 10.1 and 6 months, respectively. Hence, after 6 months we could expect that half of the prices have already adjusted and have made the pass-though of the NER shock. Also, from Figure III it can be inferred that after 12 months more than 70% of the prices in our sample have changed and reflected variations on the aggregates shocks.

Table III presents the main empirical results from estimating equation (1).[15] The first column presents price changes only as a function of $\Delta_c e$, i.e. without further controls. This estimation suggests a 0.082% ERPT on consumer prices statistically significant at 1% confidence level. The second column introduces controls for sale-related price changes, which increases the ERPT coefficient to 0.094%. It is worth mentioning that the inclusion of these controls significantly increases the adjusted R^2 of the model to 0.2. For this estimation, we introduce three dummy variables for price changes at the beginning, during and after sales. The estimated coefficients for the sale variables have the expected signs: at the beginning of sales there is a price reduction close to 20%; the dummy for price changes during sales is negative, reflecting further reductions around 5%; at the end of sales the average price increases around 15%. These coefficients reveal some of the dynamics of sales in our data where only around 46.5% of the sales return to their previous non-sale price.[16] For the rest of the sales that do not return to their previous level, 33.7% of the total ends at a lower price and 19.8%

[14]For further details about the interpretation of the medium-run pass-through coefficient see Gopinath and Rigobon (2008) or Burstein and Gopinath (2014).

[15]In all our ERPT estimations, separately for each generic item classification, we drop outliers above the 99 percentile of the distribution of the absolute value of price changes. All the regressions were estimated using product-level expenditure weights used to calculate inflation. For all the estimation results we consider robust standard errors clustered at generic item level.

[16]This percentage is smaller compared to the evidence from the U.S. Klenow and Kryvtsov (2008) report that about 60% of sales reported in the U.S. CPI micro data return to their previous regular price.

at a higher one.[17]

The rest of the columns of Table III introduce our baseline controls sequentially. In column (3) and (4) we introduce fixed effects for year and month and for generic item classifications, respectively. Column (4), that considers all the sales and fixed effects controls, presents an ERPT to consumer prices of 0.062% given a 1% increase in the NER. Columns (5) through (8) introduce the cumulative change in the following variables: the international price of commodities, the producer's price of electricity, the daily average of wages in Mexico, and Cetes 28-days Interest Rate.[18] The impact of prices of these shocks have the expected sign. The price of commodities, electricity, and wages have a positive impact on prices while the interest rate has a negative impact. From these the pass-through of electricity and wages stand out, two cost-push shocks that appear to be relevant for the price-setting. Considering the results of column (7) and (8), given a 1% increase in the price of electricity price, the price will increase in 0.072%, while given an increase of that magnitude in wages, prices will rise in 0.175%.

Furthermore, column (8) presents the baseline estimates for the ERPT in the Mexican economy. We estimate that, on average, when prices adjust they pass through only 0.073 p.p. of a 1% cumulative change in the NER. This estimation is statistically significant at 1%. It is worth mentioning that since the data used in the estimation represents 58.6% of all the goods and services of the CPI, assuming that the ERPT of the goods and services not included is zero, then a 1% change in the exchange rate will translate in a 0.043 p.p. change on inflation. For the previous reason, this result should be interpreted as a lower bound of the ERPT into the aggregate price level.

Compared to existing literature, our numbers for the ERPT into consumer prices (around

[17] As shown in Table I, around 7.1% of the prices in our data were reported to be on sale through the sample period.

[18] The price of commodities is the Commodities Price Index published by the International Monetary Fund (IMF). The price of electricity is obtained from INEGI's producer price index. Wages correspond to the Daily Average Base Salary reported to the Mexican Social Security Institute (IMSS). Cetes Rate is the 28-days interest rate of Mexican Government Debt.

0.07%) using a medium-run pass-through (MRPT) specification are considerably smaller than the previous estimates using border prices. Burstein and Gopinath (2014) reported an average MRPT into U.S. import prices of 0.2%, considering a weighted multilateral NER. Additionally, depending on the country of origin, which also relates to the currency of invoice, they document an ERPT varying between 0.24 to 0.41%. This difference was expected, first, because in our analysis we are considering the largest possible CPI basket and hence we are not restricting only to imports. Additionally, even for final imported goods it has been documented that consumer prices are largely affected by local distribution wedges that could generate a low ERPT.[19] Hence, although taking these facts into consideration, our estimations suggest a low pass-through of the exchange rate into consumer prices.

With respect to the previous estimates for Mexico, our results using price micro data are in line with the previous evidence based on aggregate variables which suggest that, in the Mexican economy, the ERPT into consumer prices has been decreasing in the last decades. For example, Kohlscheen (2010) used a bivariate VAR to estimate the ERPT to consumer prices for a set of EMEs for the period between December 1994 to October 2008. In particular, for Mexico that paper estimates an ERPT of 0.133% after 12 months, given a 1% change in the NER. This number could be particularly high given the large depreciation episode of 1994-1995 that was included in that estimate. Additionally, Capistrán, Ibarra-Ramírez, and Ramos-Francia (2012), using a VAR specification with data from January 1997 to December 2010, estimated an ERPT of close to 0.08% after 12 months. Finally, using a similar approach for the period between June 2001 to August 2012, Cortés (2013) estimated an ERPT of 0.04% after 12 months. This last number is consistent with our estimated pass-through of 0.043% on aggregate inflation, once we take into account the share of the CPI studied.

In the two last columns of Table III we analyze if the ERPT could vary across different economic episodes. In particular, if the stage of the business cycle could influence the magnitude of the ERPT into consumer prices. For that we construct the dummy variable

[19] Berger et al. (2012) identify that for the U.S. there is a large distribution wedge of traded goods that is between 60 to 70% of the total price. This type of distribution wedges could reduce the ERPT considerably.

$PosG_t^s$, which is equal to one if the percentage of months with a positive output gap during the previous price spell is larger than 50%, and zero otherwise.[20] In Column (9) we introduce this variable together with the cumulative change in the IGAE index, a monthly indicator of the quarterly Mexican Gross Domestic Product (GDP). Our estimates show that, on average, the size of price adjustments is 0.07 p.p. higher when the adjustment followed from positive gap episodes, compared to negative ones. Also, given a 1% in the IGAE index, prices will increase in 0.356%.

With these two variables we analyze the relation between the ERPT and the business cycle. To do so we estimate the ERPT with an interaction for the sign of the output gap:

$$\Delta p_t^s = \beta \Delta_c e_t^s + \beta^{PosG} PosG_t^s \times \Delta_c e_t^s + \gamma' X_t^s + \epsilon_t^s \quad (2)$$

The results for this estimation are presented in the tenth column of Table III. As expected, we find that there is a considerable difference in the response of the size of price changes to NER variations across the business cycle. Specifically, we estimate that when the output gap is positive the ERPT given a 1% change in the NER is 0.069%, while when the gap is negative the ERPT is 0.004 and is not statistically different from zero. Moreover, the coefficient of the interaction $PosG_t^s \times \Delta_c e_t^s$, indicates that the ERPT, when the output gap is positive, is 0.064 p.p. larger than when the gap is negative. This difference is statistically significant at 10%. Overall, these results highlight the importance of the business cycle in the determination of the magnitude of the pass-through to prices.

4.2 Heterogeneous Exchange Rate Pass-Through

In this subsection we further characterize the ERPT in Mexico by analyzing it across the main items' groups of the CPI. Table IV reports the results for the baseline estimation of the paper, column (8) of Table III, distinguishing between the CPI main components considered in the sample. We find that, given a 1% change in $\Delta_c e$, the core component of the CPI passes

[20]The output gap was calculated using a Hodrick-Prescott Filter in monthly seasonally adjusted series of the IGAE index from January 1993 to April 2016. The *Indicador Global de Actividad Económica* (IGAE) monthly index is an indicator of the quarterly Mexican Gross Domestic Product (GDP).

through 0.031 p.p. of this change, while the non-core component has a pass-through of 0.201 p.p. Both estimations are statistically significant at 1% level.

Within the core component, on one hand, merchandise present an average ERPT of 0.025%. This result is mainly explained by the pass-through in food, beverage and tobacco merchandise which present an ERPT of 0.086%, given a 1% variation in the NER. The pass-through in non-food merchandise may seem counter intuitive as the estimation shows a negative ERPT. However, when we decompose this component into further subgroups we observe that the negative pass-through is only explained by the behavior of health and personal care goods. Also, within this component, it is worth mentioning the pass-through on household durables at 0.057%, which is statistically significant at 1%. Table C.I in Appendix C reports the ERPT results for the major subgroups within non-food merchandise.

On the other hand, with respect to services, we find that given a 1% in the NER, services have a pass-through of 0.057 p.p. However, notice that, compared to the merchandise estimates, the adjusted R^2 is considerably smaller. Within this component, the result is mainly explained by other services. To further analyze this estimation, in Appendix C we also present results for the subgroups within this CPI component. Table C.II shows that some particular groups such as food, health and transportation services are the ones which exhibit a positive and statistically significant ERPT. For these groups, a clear connection with tradable goods inputs, which are affected by NER fluctuations, can easily be established.

Within the non-core component it is relevant to recall that energy and government approved fares are not part of the sample used in the estimations but do form part of the non-core component of the CPI. Hence the results reported are entirely explained by agricultural items. From these, for fruit and vegetables are noteworthy. We find that given a 1% in the NER, when prices in this component adjust they pass through 0.385 p.p of this change. This estimate is statistically significant at 1%. Finally, with respect to livestock goods, we find a positive pass-through but it is not statistically significant.

4.3 Time-Varying Pass-Through

It is well known that the ERPT may not be constant through time. For example, Berger and Vavra (2015) recently documented that the ERPT over U.S. imports prices varies considerably through the business cycle and through different macroeconomic episodes. In this section we analyze time-varying ERPT in the Mexican economy by estimating the specification presented in the previous section considering a 24-month moving window, indexed by the last observation t:

$$\Delta p_{\tau}^{s} = \beta_t \Delta_c e_{\tau}^{s} + \gamma' X_{\tau}^{s} + \epsilon_{\tau}^{s} \tag{3}$$

where $\tau = t - 23, ..., t$. This specification allows us to estimate time-varying ERPT, which is captured by the coefficient β_t across the sample. For this estimation we consider the same controls used in the main ERPT specification, column (8) of Table III.

In Figure IX we present the estimations for the time-varying ERPT for the CPI and its two main components. Panel (a) presents the results of the estimation of β_t together with its 10% confidence intervals for the CPI total analyzed sample. The figure shows that the ERPT has slight variations through the sample period. Even though this estimation shows a negative pass-through between the last months of 2014 and the beginning of 2015, these estimations are not statistically significant at a 10% level of confidence. But, as we will present in subsequent figures, for some merchandise and services, this estimation is positive and statistically significant. Additionally, on the one hand, panel (b) shows the same calculation of β_t but for the core component of the CPI. As expected given the average ERPT presented in Table IV, the ERPT in the core component is low and with few variations, although our estimates suggest a slight increase at the end of the sample. On the other hand, panel (c) shows this estimation for the non-core component, that, as mentioned, represents the agricultural goods. Unlike the core component, this estimation shows a large variance with a lot of periods with a non-statistically significant ERPT.

Within the core component of CPI, panel (a) of Figure X presents the estimation of β_t for merchandise. For this group the pass-through parameter shows remarkable stability around zero through the sample period, however the estimates show a slight increase at the end of the sample at which we estimate a 0.052% ERPT for the last observation. Additionally, panel (b) of this figure shows that, within the group of food, beverages and tobacco, the ERPT presented an increase starting around July 2015. Although in the last month we estimate a slight decrease, our estimates end at 0.119% pass-through, given over a 1% change in Δe. Finally, for the non-food merchandise, as showed in panel (c) of Figure X, it seems that the ERPT for these products is negative, but, for this category, β_t is not statistically different from zero.

The other items in the CPI core component are services, for which its time-varying ERPT estimates are presented in Figure XI. Panels (a), (b) and (c) suggest that the ERPT has greater variance in this part of the core component, while merchandise pass-through is more stable. Panel (b) shows that the pass-through for housing services fluctuates considerably near zero, and in fact it is not statistically significant at 10%. With respect to other services, presented in panel (c), the ERPT is also low and not statistically significant through most of the sample period.

The last type of items considered are agricultural goods, which represent the non-core component of the CPI in this sample. As we can see in Figure XII, the time-varying ERPT estimated for these items is considerably volatile. Panel (a) of this figure shows that β_t for agricultural goods fluctuates between -0.5 and 0.5%; but this estimate is not statistically significant. This large variation is mainly explained by the ERPT for fruits and vegetables, as it is shown in panel (b), which has a similar behavior (but with a greater variance), and also this estimate is not different from zero. Livestock goods, shown in panel (c), present a more stable ERPT that rises during the first months of 2016. However, the ERPT is not statistically different from zero in the majority of the sample.

5 Conclusions

This paper analyzes the price-setting behavior in the Mexican economy and quantifies the exchange rate pass-through, ERPT, into consumer prices for the period between January 2011 to April 2016, a period of time characterized by high volatility of EMEs' currencies.

Our estimates suggest that the ERPT into consumer prices in Mexico is low. Specifically, for the sample of goods and services analyzed (58.6% of the CPI), we estimate that when a price changes it only passes through 0.073 p.p. of a 1% change in the NER. Moreover, considering the share of the CPI basket studied and assuming the rest of the out-sample items have zero pass-through, the estimated pass-through have an incidence on aggregate inflation of 0.043%.

We also analyze whether the ERPT varies across different economic episodes. In particular, we estimate if the stage of the business cycle has implications for the degree of the ERPT. We find a positive relation between the ERPT and the business cycle: when the economy operates above its potential, the ERPT is around 0.069%, given a 1% change in the NER. Conversely, when economic activity is below its potential, the ERPT is non-statistically different from zero.

Additionally, we present evidence of a heterogeneous pass-through across the CPI main components. We find that, given a 1% in the cumulative NER, on average, goods and services in the core component of the CPI have an ERPT of 0.031 p.p. while goods in the non-core component 0.201 p.p. Within the core component, merchandise presents an average pass-through of 0.025 p.p., result mainly explained by the ERPT in food, beverages and tobacco with a 0.086 p.p. pass-through. With respect to services, we find that given a 1% in the NER, services pass through 0.057 p.p. of that shock. The result for this component is mainly explained by food, health and transportation services. Within the non-core component, formed by agricultural goods, the ERPT into fruit and vegetables is the most relevant with a coefficient of 0.385 p.p, given a 1% in the NER.

We also estimate a time-varying ERPT for the CPI and its main components across the sample period. We find that the ERPT across time for the complete sample has few variations, and these estimations are, in general, not statistically significant at a 10%. With respect to the core and non-core components we document that the ERPT in the former is very low and with few variations, while the latter shows a large variance and generally is non-statistically different from zero. Within the core component of the CPI, the pass-through parameter for merchandise shows remarkable stability around zero. From this group the result for food, beverages and tobacco stands out, for which the ERPT presented an increase starting around July 2015. Services, the group within the CPI core component, presents a more stable and, in general, not statistically significant time-varying ERPT. Finally, for the non-core component, the estimated time-varying ERPT is largely volatile and mainly non-statistically different from zero.

Despite the effort to quantify the ERPT for the Mexican economy, further research needs to be done in order to have a micro founded explanation of the levels of ERPT and their determinants. Exploring the price-setting behavior of importing firms and the role of multianual contracts in the price-setting seem relevant topics to explore.

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TABLE I
SAMPLE DESCRIPTIVE STATISTICS BY CPI MAIN COMPONENTS

	Items	Weight (%)	Quoting Frequency	N	Sales (%)	Missing (%)	Products
CPI	246	58.6	Weekly and Semimonthly	18,188,114	7.1	6.7	256,568
Core	206	50.2	Weekly and Semimonthly	12,812,792	6.7	7.4	229,941
Merchandise	176	33.9	Weekly and Semimonthly	11,446,757	7.3	7.9	213,547
Food, Beverages and Tobacco	67	14.7	Weekly	5,293,984	8.2	4.7	40,737
Non-Food Merchandise	109	19.2	Semimonthly	6,152,773	6.6	10.7	172,810
Services	30	16.4	Weekly and Semimonthly	1,366,035	1.5	2.8	16,394
Housing	2	2.0	Semimonthly	120,120	0.1	3.7	1,686
Other Services	28	14.4	Weekly and Semimonthly	1,245,915	1.6	2.7	14,708
Non-Core	40	8.4	Weekly and Semimonthly	5,375,322	8.0	5.2	26,627
Agriculture	40	8.4	Weekly	5,375,322	8.0	5.2	26,627
Fruit and Vegetables	32	3.6	Weekly	3,843,792	7.9	5.6	18,039
Livestock	8	4.9	Weekly	1,531,530	8.3	4.2	8,588

SOURCE: Banco de México and INEGI.
NOTES: Weight denotes the current CPI expenditure weights. Weekly Quoting Frequency refers to the items that are quoted 4 times a month and Semimonthly 2 times a month. Price Quotes refer to the total number of price quotes, weekly or semimonthly depending on the group. Sales and Missing refers to the percentage of weekly or semimonthly observations that are on sale and missing, respectively.

TABLE II

MONTHLY PRICE STATISTICS BY CPI MAIN COMPONENTS

	Weight (%)	fr	fr^+/fr	dur	dp	$\lvert dp\rvert$	$\lvert dp^+\rvert$	$\lvert dp^-\rvert$
CPI	58.6	25.4	60.1	10.1	1.2	12.3	11.2	13.8
Core	50.2	20.3	62.2	11.4	1.4	10.0	9.2	11.3
Merchandise	33.9	24.9	59.8	9.3	1.1	9.9	9.3	10.9
Food, Beverages and Tobacco	14.7	22.1	61.4	11.1	1.6	9.2	8.9	9.8
Non-Food Merchandise	19.2	27.0	58.7	7.9	0.8	10.4	9.6	11.6
Services	16.4	10.9	73.8	16.6	2.8	10.2	8.8	13.6
Housing	2.0	2.8	92.7	25.5	9.2	10.5	10.9	9.7
Other Services	14.4	12.0	73.2	16.0	2.6	10.2	8.8	13.7
Non-Core	8.4	55.4	55.5	4.1	0.7	17.3	16.2	18.4
Agriculture	8.4	55.4	55.5	4.1	0.7	17.3	16.2	18.4
Fruit and Vegetables	3.6	69.3	51.6	2.7	0.3	23.5	22.7	23.4
Livestock	4.9	45.2	59.8	5.1	1.2	10.4	9.8	11.2

SOURCE: Banco de México and INEGI.

NOTES: All the frequency price statistics are reported in percentage per month. fr denotes the weighted mean frequency of price changes across generic items. fr^+/fr denotes percentage of price changes that are price increases calculated as the mean frequency of increases over the mean frequency of price changes. dur is the average duration of price spells in months. All the statistics for the size of price changes are calculated as the log size times 100. dp denotes the average size of price changes. $|dp|$ is the absolute value. $|dp^+|$, and $|dp^-|$ is the average size of price increases and decreases, respectively.

TABLE III
EXCHANGE RATE PASS-THROUGH

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$\Delta_c e$	0.082***	0.094***	0.101***	0.062***	0.084***	0.079***	0.071***	0.073***	0.056***	0.004
$\Delta_c e$ + PosG † $\times \Delta_c e$										0.069***
PosG † $\times \Delta_c e$										0.064*
PosG †									0.007**	0.007**
Beginning of Sale †		-0.195***	-0.195***	-0.198***	-0.198***	-0.198***	-0.197***	-0.197***	-0.197***	-0.197***
During Sale †		-0.046***	-0.047***	-0.048***	-0.048***	-0.048***	-0.047***	-0.047***	-0.047***	-0.047***
End of Sale †		0.147***	0.147***	0.143***	0.143***	0.143***	0.144***	0.145***	0.145***	0.145***
Δ_c Commodities					0.017	0.005	0.007	0.009	0.008	-0.005
Δ_c Electricity						0.078***	0.072***	0.069**	0.043	0.036
Δ_c Avg. Wage							0.184***	0.174***	0.044	0.058
Δ_c Cetes Rate								-0.009	-0.012	-0.011
Δ_c IGAE									0.356***	0.371***
Impact on Inflation	0.048	0.055	0.059	0.036	0.049	0.046	0.042	0.043	0.033	0.040
Year and Month FE	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Item FE	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R^2	0.0006	0.2231	0.2255	0.2304	0.2304	0.2307	0.2310	0.2311	0.2315	0.2315
N	1,214,718									

SOURCE: Banco de México, IMF and INEGI.
NOTES: Column 1 to 8 present different estimations for equation (1). Column 9 and 10 present the estimation including (2). The dependent variable is the size of product level price changes Δp_t^s. The superscripts ***, **, and * denote statistical significance at the 1%, 5% and 10% levels, considering robust standard errors clustered at generic item level. † denotes a dummy variable. FE denotes fixed effects controls.

TABLE IV
EXCHANGE RATE PASS-THROUGH BY CPI MAIN COMPONENTS

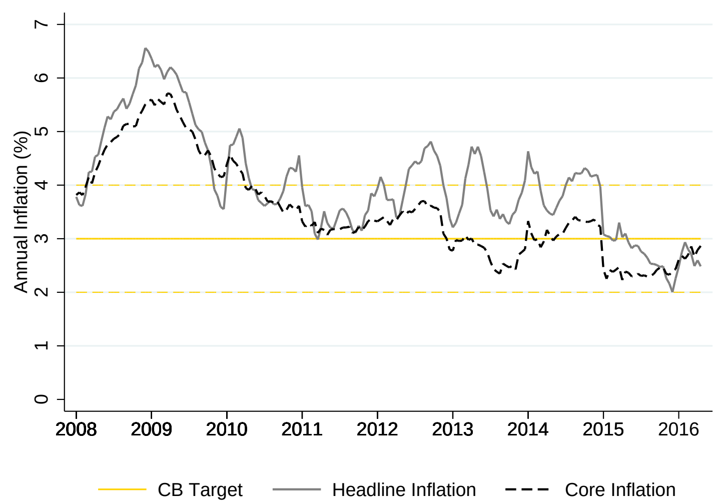
	Weight (%)	$\Delta_c e$	Adj. R^2	N
CPI	58.6	0.073***	0.2311	1,214,718
Core	50.2	0.031***	0.3784	622,916
Merchandise	33.9	0.025**	0.4421	580,695
Food, Beverages and Tobacco	14.7	0.086***	0.3789	250,137
Non-Food Merchandise	19.2	-0.024**	0.4795	330,558
Services	16.4	0.057**	0.1450	42,221
Housing	2.0	0.053	0.2051	781
Other Services	14.4	0.058**	0.1436	41,440
Non-Core	8.4	0.201***	0.1475	591,802
Agriculture	8.4	0.201***	0.1475	591,802
Fruit and Vegetables	3.6	0.385***	0.1355	476,339
Livestock	4.9	0.029	0.3223	115,463

SOURCE: Banco de México, IMF and INEGI.
NOTES: $\Delta_c e$ denotes the estimated coefficient for the exchange rate pass-through (1). All the regressions control for the variables included in column (8) of Table III. The superscripts ***, **, and * denote statistical significance at the 1%, 5% and 10% levels.

FIGURE I
PESO-USD NOMINAL EXCHANGE RATE

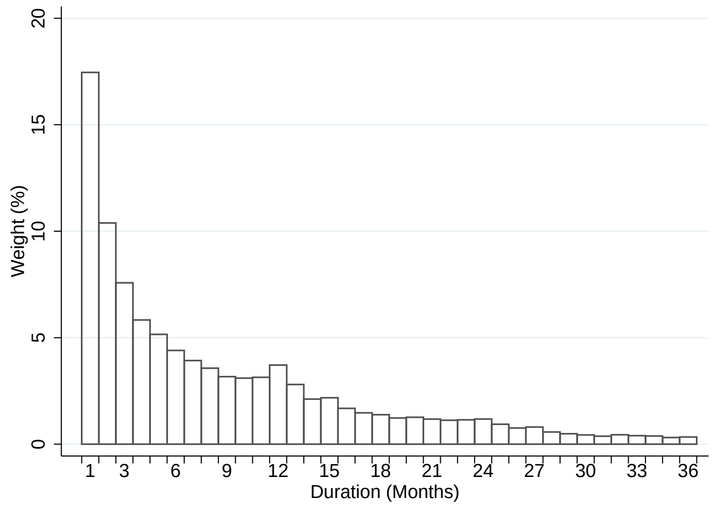
SOURCE: Banco de México.
NOTES: FIX daily nominal exchange rate from January 1, 2008 to May 30, 2016.

FIGURE II
HEADLINE AND CORE INFLATION RATE



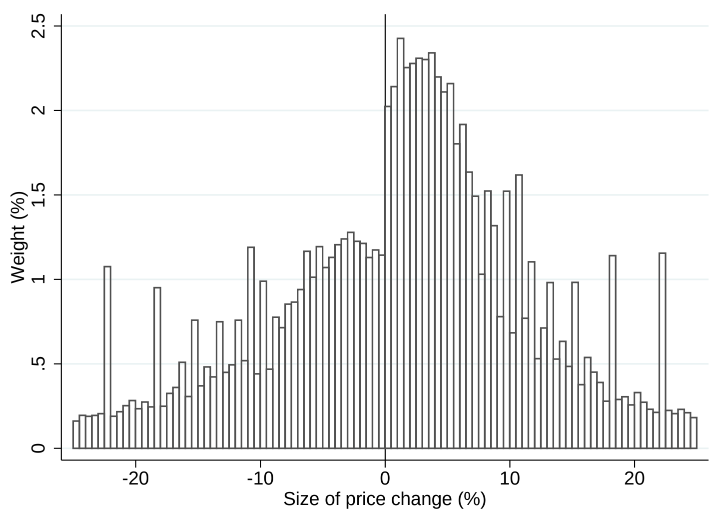
SOURCE: Banco de México and INEGI.
NOTES: Semimonthly headline and core annual inflation rate from January 2008 to April 2016.

FIGURE III
DISTRIBUTION OF THE DURATION OF PRICE SPELLS



SOURCE: Banco de México and INEGI.
NOTES: Weighted histogram of the duration of price spells across time and product-level items. The figure plots the price spells of less than 36 months only. Bin size is 1 month.

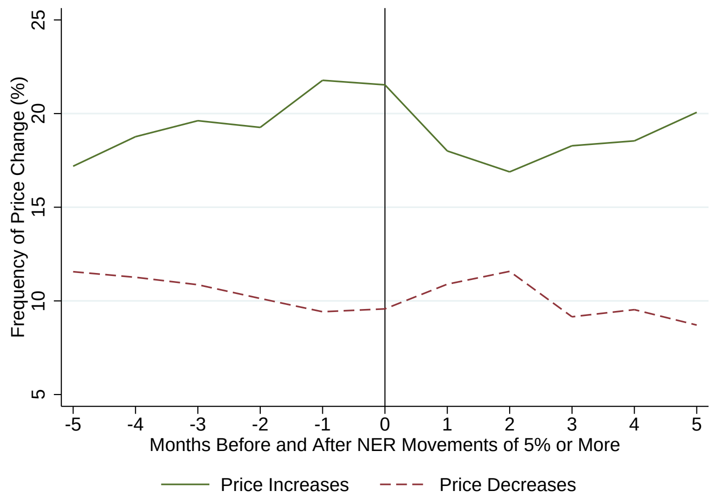
FIGURE IV
DISTRIBUTION OF THE SIZE OF PRICE CHANGES



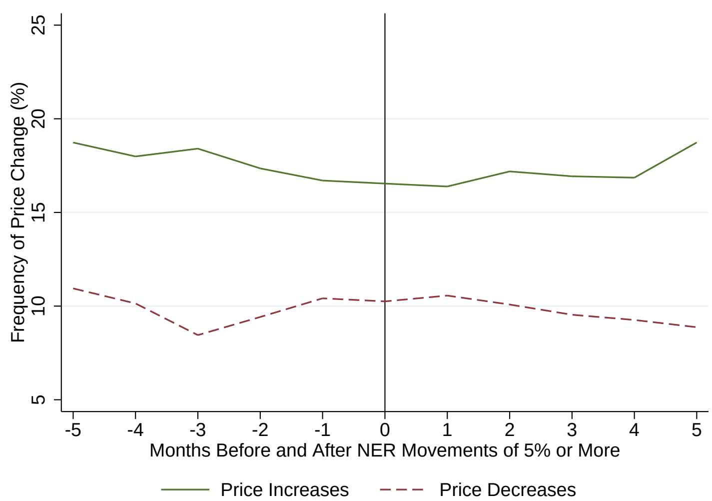
SOURCE: Banco de México and INEGI.
NOTES: Weighted histogram of the size of non-zero price changes across time and products. The size of price changes is the log size times 100. The figure plots the price changes distribution in the $|25\%|$ range only. Bin size is 0.5%.

FIGURE V
FREQUENCY OF PRICE CHANGE AROUND NER MOVEMENTS OF 5% OR MORE

(a) Appreciations

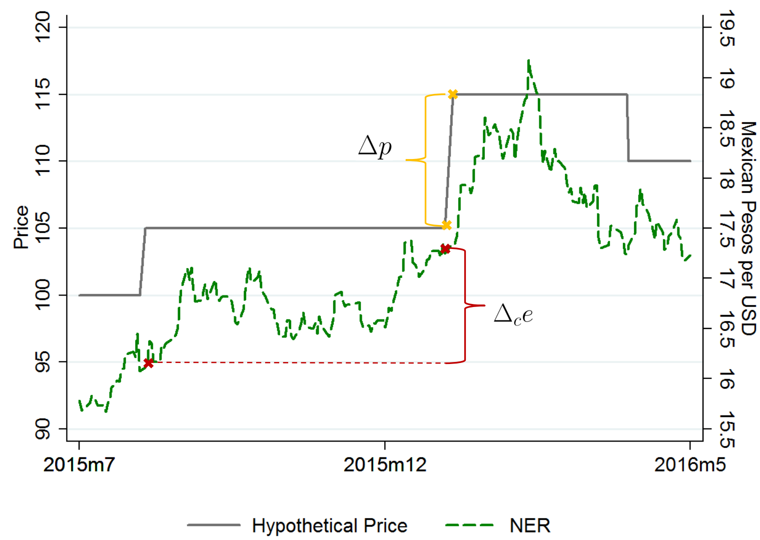


(b) Depreciations



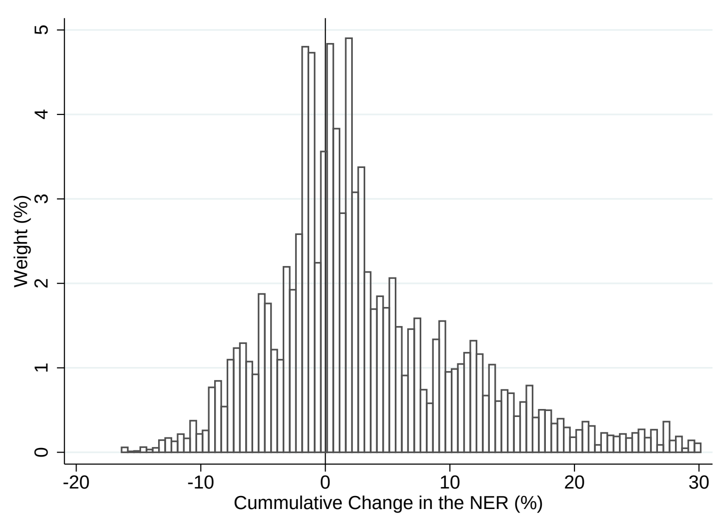
SOURCE: Banco de México and INEGI.
NOTES: Average frequency of price increases and decreases around nominal exchange rate appreciation and depreciation episodes of more than 5% monthly change.

FIGURE VI
NER CUMULATIVE CHANGE CONSTRUCTION



SOURCE: Banco de México.
NOTES: Hypothetical price trajectory and the daily Mexican Peso-USD NER during a 10 months period. Δp denotes the magnitude of the price change. $\Delta_c e$ denotes the NER cumulative change through the price spell that precedes the considered price change.

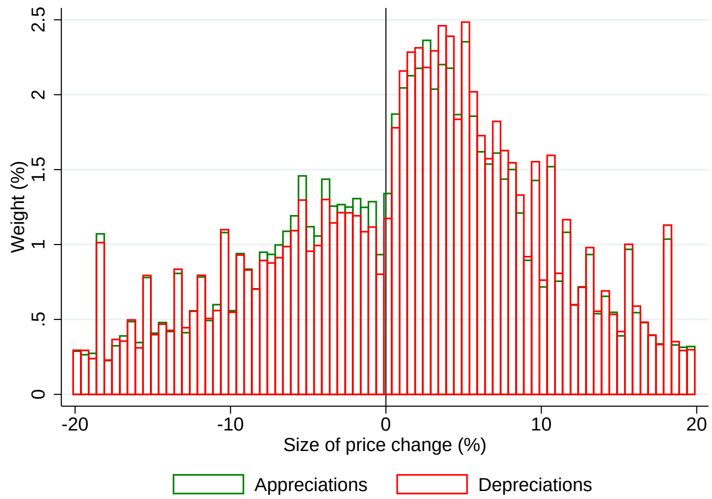
FIGURE VII
DISTRIBUTION OF THE NER CUMULATIVE CHANGE



SOURCE: Banco de México and INEGI.
NOTES: Weighted histogram of the cumulative change of the nominal exchange rate ($\Delta_c e$) across price spells and time. The cumulative change is the log change in the nominal exchange rate times 100. The figure plots the distribution in the $|20\%|$ range only. Bin size is 0.5%.

FIGURE VIII

DISTRIBUTION OF THE SIZE OF PRICE CHANGES AND THE NER

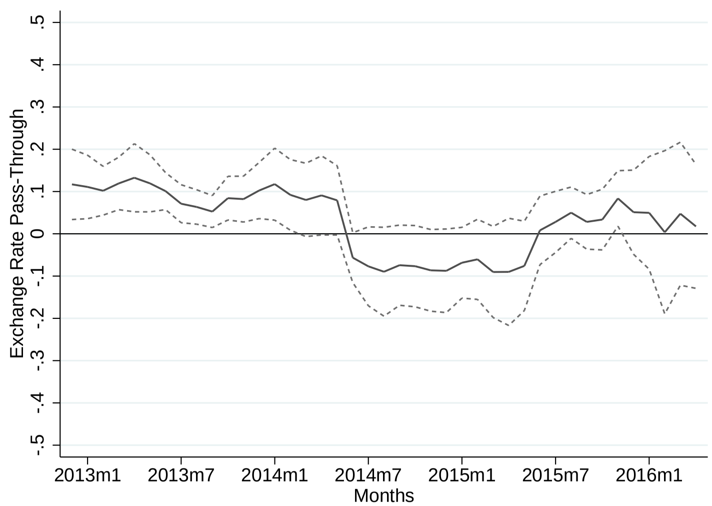


SOURCE: Banco de México and INEGI.
NOTES: Weighted histogram of the size of non-zero price changes across time and products conditional on the value of $\Delta_c e$. The size of price changes is the log size times 100. The figure plots the price changes distribution in the $|25\%|$ range only. Bin size is 0.5%.

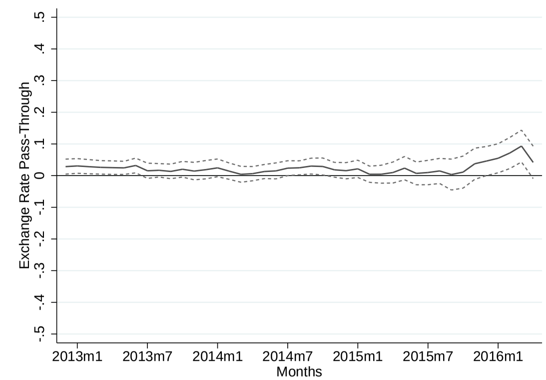
FIGURE IX

TIME-VARYING EXCHANGE RATE PASS-THROUGH (24-MONTH ROLLING WINDOW) BY CPI MAIN COMPONENTS

(a) **CPI**



(b) **Core**



(c) **Non-Core**

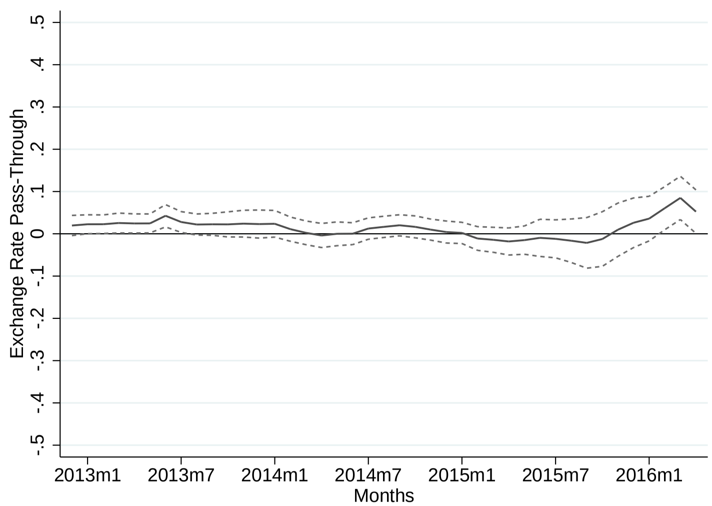
SOURCE: Banco de México and INEGI.

NOTES: Time-varying exchange rate pass-through estimation using a 24-month moving window, as specified in equation (3). All the regressions control for the variables included in column (8) of Table III. The dashed lines represent the 90% confidence intervals.

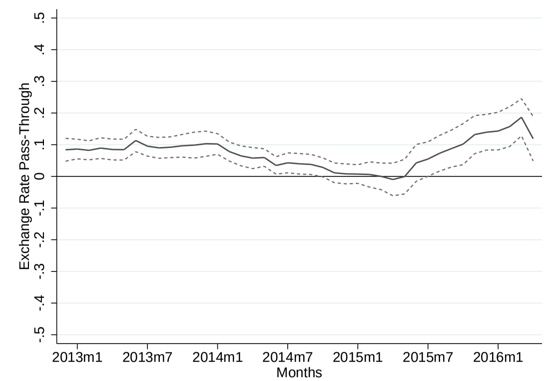
Figure X

Time-Varying Exchange Rate Pass-Through (24-month Rolling Window) by CPI Main Components

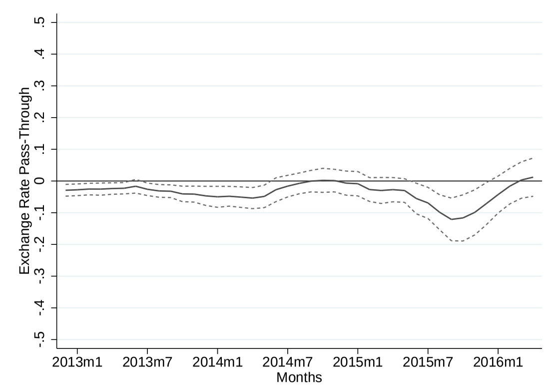
(a) **Merchandise**



(b) Food, Beverages and Tobacco



(c) Non-Food Merchandise

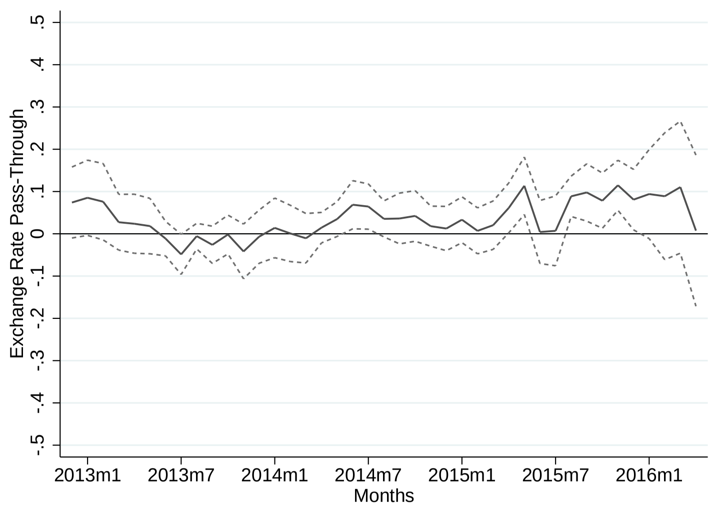


Source: Banco de México and INEGI.
Notes: Time-varying exchange rate pass-through estimation using a 24-month moving window, as specified in equation (3). All the regressions control for the variables included in column (8) of Table III. The dashed lines represent the 90% confidence intervals.

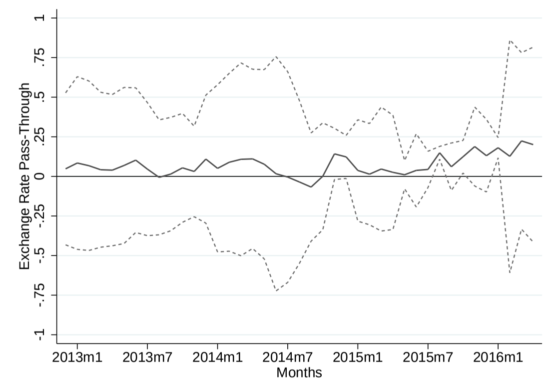
FIGURE XI

TIME-VARYING EXCHANGE RATE PASS-THROUGH (24-MONTH ROLLING WINDOW) BY CPI MAIN COMPONENTS

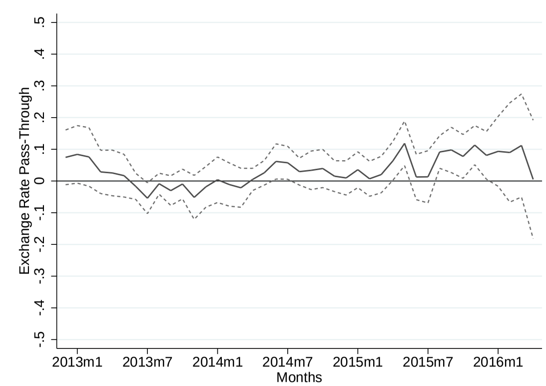
(a) **Services**



(b) Housing



(c) Other Services

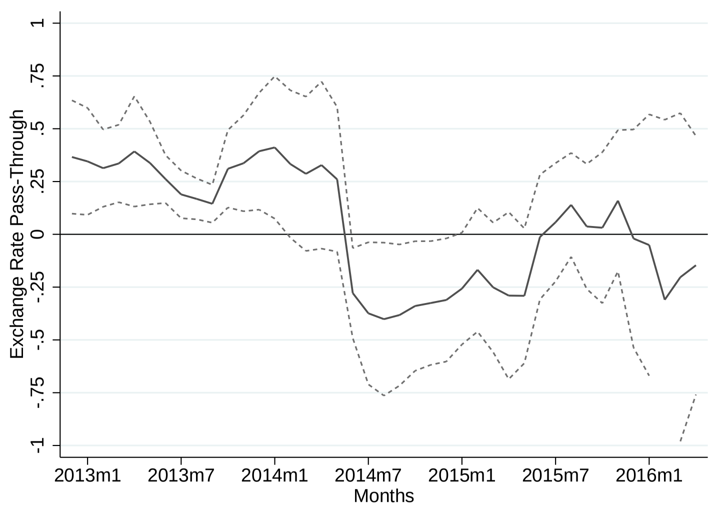


SOURCE: Banco de México and INEGI.
NOTES: Time-varying exchange rate pass-through estimation using a 24-month moving window, as specified in equation (3). All the regressions control for the variables included in column (8) of Table III. The dashed lines represent the 90% confidence intervals.

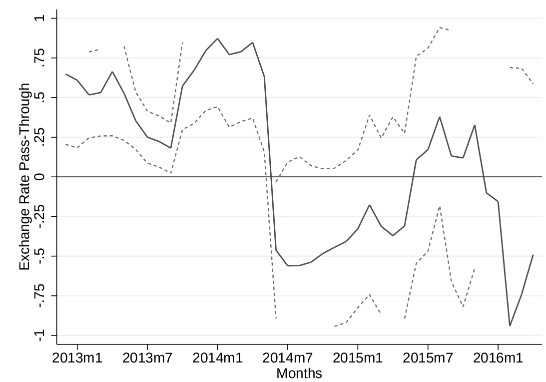
FIGURE XII

TIME-VARYING EXCHANGE RATE PASS-THROUGH (24-MONTH ROLLING WINDOW) BY CPI MAIN COMPONENTS

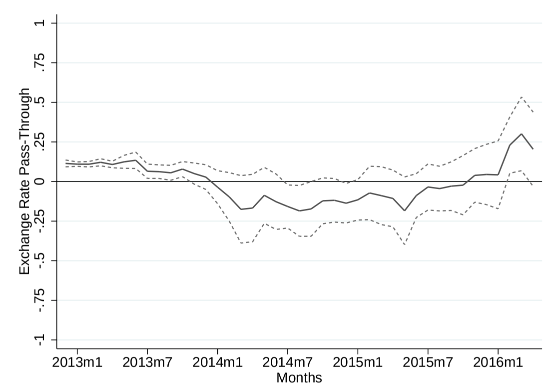
(a) **Agriculture**



(b) Fruits and Vegetables



(c) Livestock



SOURCE: Banco de México and INEGI.

NOTES: Time-varying exchange rate pass-through estimation using a 24-month moving window, as specified in equation (3). All the regressions controls for the variables included in column (8) of Table III. The dashed lines represent the 90% confidence intervals.

A Inflation Accounting and Price Statistics Definitions

In this appendix we present the definitions of the price statistics used to characterize the price-setting dynamics in the Mexican economy. The appendix follows closely Kochen (2016). For the following definitions, let s denote the specific product, v the item's variety, c the city of quotation, and g the generic item.

A.1 Inflation Accounting Principles

We follow the price-setting empirical literature (Klenow and Kryvtsov, 2008; Gagnon, 2009) and define aggregate inflation (π_t) as the weighted sum of the log price changes of individual products:[21]

$$\pi_t = \sum_g \omega^g \sum_c \omega^{c,g} \sum_v \omega^{v,c,g} \left(\frac{1}{\#\Upsilon_t^{v,c,g}} \sum_{s \in \Upsilon_t^{v,c,g}} \Delta p_t^s \right) \tag{4}$$

where ω^g are generic item level weights that sum to 1 across all generic items, $\omega^{c,g}$ are city weights that sum to 1 across all cities for each generic, and $\omega^{v,c,g}$ are variety weights that sum to 1 for each city and generic item. $\Upsilon_t^{v,c,g}$ is the set of all individual products at the (v, c, g) aggregation level that are considered for the price-setting calculations at time t. This set could change over time in function of the treatment of sales, missing values and item substitutions considered.[22] $\Delta p_t^s = p_t^s - p_{t-1}^s$, where p_t^s is the price in logs of the items in $\Upsilon_t^{v,c,g}$.

This definition for the aggregate inflation implies that each specific product s is weighted by dividing the total expenditure share of the aggregation level (v, c, g), to which product s belong, over the total number of products in that aggregation level considered to calculate the price statistics at time t. Hence, defining product-level weights as $\omega_t^s = \omega^g\, \omega^{c,g}\, \omega^{v,c,g} / \#\Upsilon_t^{v,c,g}$, aggregate inflation can be calculated as:

$$\pi_t = \sum_{s \in \Upsilon_t} \omega_t^s \Delta p_t^s$$

[21] This methodology to compute inflation differs from the official methodology that calculates inflation as the percentage change of Laspeyres indexes. However, we follow the empirical literature standards to make our results comparable to previous studies. For further details about the inflation measurement in Mexico, see INEGI (2013).

[22] In the periods where no product is observed at some of aggregation levels, the variety-city-generic weights are re-weighted, such that in each time period and aggregation level the weights sum up to 1.

where Υ_t is the union of the sets $\Upsilon_t^{v,c,g}$ across aggregation levels (v, c, g) at time t.

With this definition, aggregate inflation can be decomposed as the product of two price statistics, the fraction of prices that change their price and the average size of those price changes:

$$\pi_t = \underbrace{\left(\sum_{s\in\Upsilon_t} \omega_t^s I_t^s\right)}_{fr_t} \underbrace{\left(\frac{\sum_{s\in\Upsilon_t} \omega_t^s \Delta p_t^s}{\sum_{s\in\Upsilon_t} \omega_t^s I_t^s}\right)}_{dp_t} \tag{5}$$

where I_t^s is an indicator variable equal to 1 if a price change has occurred and zero otherwise. The term fr_t is henceforth referred to as the aggregate frequency of price change, and dp_t is the aggregate size of non-zero price changes at time t. These statistics jointly characterize the inflation dynamics since they capture how often and for how much do prices change. The statistics without the time subindex, e.g. fr and dp, are the average of these statistics across time.

An additional decomposition, that is also informative for the relationship between inflation and the distribution of price changes, is to separate the frequency and the size between price increases and decreases:

$$\pi_t = \underbrace{\left(\sum_{s\in\Upsilon_t} \omega_t^s I_t^{s+}\right)}_{fr_t^+} \underbrace{\left(\frac{\sum_{s\in\Upsilon_t} \omega_t^s I_t^{s+} \Delta p_t^s}{\sum_{s\in\Upsilon_t} \omega_t^s I_t^{s+}}\right)}_{dp_t^+} + \underbrace{\left(\sum_{s\in\Upsilon_t} \omega_t^s I_t^{s-}\right)}_{fr_t^-} \underbrace{\left(\frac{\sum_{s\in\Upsilon_t} \omega_t^s I_t^{s-} \Delta p_t^s}{\sum_{s\in\Upsilon_t} \omega_t^s I_t^{s-}}\right)}_{dp_t^-} \tag{6}$$

where I_t^{s+} (I_t^{s-}) is an indicator variable equal to 1 if a price increase (decrease) has occurred and zero otherwise. The terms fr_t^+ and dp_t^+ (fr_t^- and dp_t^-) are the frequency and the size of price increases (decreases).

A.2 Duration of Price Spells

Additional to the frequency and the size of the price change, the duration of price spells is of interest since it is a direct measure of the degree of price stickiness. In this paper we use the empirical strategy to measure the duration of prices presented in Kochen (2016). Specifically, we calculate the aggregate duration (dur) of all the non-censored price spells by aggregating the duration across spells and products weighting each spell with the sum of the corresponding time-varying weights (w_t^s) along the duration of the spell:

$$dur = \frac{1}{T - \omega_{cens}} \sum_s \sum_\tau \left(\sum_{t_0^{\tau,s} \leq t \leq t_T^{\tau,s}} \omega_t^s \right) dur^{\tau,s} \tag{7}$$

where τ denotes the price spells of specific product s, $t_0^{\tau,s}$ and $t_T^{\tau,s}$ are the beginning and ending period of the spell τ, and $dur^{\tau,s}$ is the duration. The term $1/(T - \omega_{cens})$ corrects for the total sum of weights of non-censored price spells, where T is the total number of time periods and ω_{cens} is the total weight of the censored price spells across time.

B Multilateral Exchange Rate

Besides the main estimations of the paper, that use the peso-USD nominal exchange rate, in this appendix we present the results considering a multilateral exchange rate for Mexico's main trade partners. To do so we construct a multilateral NER weighted by each country, or monetary union, share in Mexican imports. For this exercise we focus on the trade partners with a share of more than 1% in total Mexican imports: Brazil (1.4%), Canada (2.4%), China (14.5%), Korea (4.0%), US (50.7%), Japan (4.6%), Malaysia (1.6%), Taiwan (1.8%), and the European Union (10.7%). Altogether, these 9 trade partners represent 91.7% of Mexican imports.[23]

We construct a multilateral NER weighting each country, or monetary union, bilateral NER with the Mexican peso by its share in the selected basket of imports. The ERPT estimations considering these NER are presented in Table B.I. This table is presented the same way Table III was constructed. Column (1) of Table B.I estimates price changes just as a function of $\Delta_c e^{IM}$, the cumulative change across price spells for the multilateral NER weighted by imports. The table shows that, given a 1% change in this variable, prices will pass through 0.091 p.p. of this change (significant at a 1% confidence level). This number is slightly larger than the one presented in Table III. Column (2) introduces the controls for sale-related variables while columns (3) and (4) introduce the time and generic item fixed effects.

Columns (5) to (8) of this table introduce the rest of the control variables: the cumulative change in the price of commodities, electricity, wages and Cetes interest rate. Column (8) presents the main result of this appendix. The coefficient related to $\Delta_c e^{IM}$ suggests, on average, when a price changes it passes through 0.072 p.p. of a 1% change in the multilateral NER. Taking into account the share of the sample studied (58.6%) and assuming the rest of the items have zero pass-through, this estimation implies an incidence on aggregate inflation of 0.042%. Hence, once we control for the main covariates or results with the bilateral peso-USD and multilateral NER are almost identical.

[23]These numbers correspond to Mexican imports on January 2011.

Finally, columns (9) and (10) introduce the variables related with the business cycle. In the model estimated in column (9), we add a dummy variable ($PosG_t$, that is equal to one if the percentage of months with positive output gap during the previous price spell is larger than 50%), and the cumulative change in the IGAE index. In column (10) we add an interaction between $\Delta_c e^{IM}$ and $PosG_t$. Considering this last specification, the results shows that when the output gap is positive the ERPT into consumer prices is 0.072 p.p. larger than when the gap is negative, however in this case, this difference is not statistically significant.

TABLE B.I
MULTILATERAL EXCHANGE RATE PASS-THROUGH

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$\Delta_c e$	0.091***	0.105***	0.114***	0.070***	0.082***	0.074***	0.070***	0.072***	0.052**	-0.005
$\Delta_c e + \text{PosG} \dagger \times \Delta_c e$										0.067
PosG † $\times \Delta_c e$										0.072
PosG †									0.007**	0.007*
Beginning of Sale †		-0.195***	-0.195***	-0.198***	-0.198***	-0.198***	-0.197***	-0.197***	-0.197***	-0.197***
During Sale †		-0.046***	-0.047***	-0.048***	-0.048***	-0.048***	-0.047***	-0.047***	-0.047***	-0.047***
End of Sale †		0.147***	0.147***	0.143***	0.143***	0.143***	0.144***	0.145***	0.145***	0.145***
Δ_c Commodities					0.009	-0.003	0	0.002	0.002	-0.008
Δ_c Electricity						0.078***	0.071***	0.069**	0.043	0.036
Δ_c Avg. Wage							0.189***	0.180***	0.048	0.058
Δ_c Cetes Rate								-0.009	-0.011	-0.011
Δ_c IGAE									0.361***	0.376***
Impact on Inflation	0.053	0.062	0.067	0.041	0.048	0.043	0.041	0.042	0.030	0.039
Year and Month FE	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Item FE	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R^2	0.0005	0.2230	0.2255	0.2303	0.2303	0.2307	0.2310	0.2310	0.2315	0.2315
N					1,214,718					

SOURCE: Banco de México, IMF and INEGI.
NOTES: Column 1 to 8 present different estimations for equation (1). Column 9 and 10 present the estimation including (2). The dependent variable is the size of product level price changes Δp_t^s. The superscripts ***, **, and * denote statistical significance at the 1%, 5% and 10% levels, considering robust standard errors clustered at generic item level. † denotes a dummy variable. FE denotes fixed effects controls.

C Exchange Rate Pass-Through Within CPI Major Components

TABLE C.I
EXCHANGE RATE PASS-THROUGH WITHIN NON-FOOD MERCHANDISE

	Weight (%)	$\Delta_c e$	Adj. R^2	N
Non-Food Merchandise	19.2	-0.024**	0.4795	330,558
Household Goods	2.4	0.019	0.4667	50,242
Household Goods	1.7	0.057***	0.4892	52,426
Apparel	5.3	-0.02	0.6039	88,959
Transportation Goods	3.4	-0.008	0.238	15,433
Recreation Goods	1.2	0.038	0.4284	16,998
Health and P. Care Goods	5.3	-0.042***	0.4955	106,500

SOURCE: Banco de México, IMF and INEGI.
NOTES: $\Delta_c e$ denotes the estimated coefficient for the exchange rate pass-through (1). All the regressions control for the variables included in column (8) of Table III. The superscripts ***, **, and * denote statistical significance at the 1%, 5% and 10% levels.

TABLE C.II
EXCHANGE RATE PASS-THROUGH WITHIN OTHER SERVICES

	Weight (%)	$\Delta_c e$	Adj. R^2	N
Other Services	14.4	0.058**	0.1436	41,440
Food Services	7.3	0.056*	0.2209	5,688
Recreational Services	3.3	0.006	0.1352	15,757
Mixed Services ‡	0.6	0.008	0.6463	1,895
Health Services	1.9	0.074**	0.4377	5,045
Transportation Services	1.2	0.146***	0.0897	13,055

SOURCE: Banco de México, IMF and INEGI.
NOTES: $\Delta_c e$ denotes the estimated coefficient for the exchange rate pass-through (1). All the regressions control for the variables included in column (8) of Table III. The superscripts ***, **, and * denote statistical significance at the 1%, 5% and 10% levels. ‡ The services within the group Mixed Services are: professional services, funeral services, laundry services and and cleaning services.