

Disaggregated Evidence for Exchange Rate and Import Price Pass-through in the Light of Identification Issues, Aggregation Bias and Heterogeneity

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Disaggregated Evidence for Exchange Rate and Import Price Pass-through in the Light of Identification Issues, Aggregation Bias and Heterogeneity*

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Abstract

For emerging market economies, changes in import prices and exchange rate are among the major determinants of inflation. In general, studies analyzing the pass-through of foreign prices into inflation consider the headline inflation. However, such an approach may suffer from aggregation bias and may not reveal the differences in pass-through due to heterogeneous nature of the CPI. In this paper, we try to investigate the impact of such issues on the pass-through analysis for Turkey over the sample period of 2005-2015. We propose a disaggregated approach and run an extended VAR model for each of 152 subcomponents of the CPI separately. Then, we aggregate the individual impulse-responses of those components with significantly positive response to exchange rate and import prices. Our results reveal a significant heterogeneity in pass-through coefficients across subcomponents of the CPI. We show that the foreign price pass-through is also sizeable in food and services, as well as in core goods and energy. Our findings further point to a clear aggregation bias. Once the disaggregated approach is used, we report a higher pass-through from the exchange rate to the headline inflation.

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1. Introduction

For emerging market economies, changes in the import prices and the exchange rate are among the major determinants of inflation, especially in the short run. Moreover, rapid and sizeable change in import prices and exchange rates at times, increases the importance of such factors. Turkey also belongs to the list of countries that are highly prone to international price changes. Furthermore, given the volatile nature of capital flows to emerging markets, exchange rate changes can also be strong. Hence, for a good understanding of inflation dynamics, it is of great importance to understand the impact of such foreign prices on inflation.

The widely used framework for analyzing the pass-through of foreign prices on inflation is the VAR impulse-response analysis. In a simple setting, a VAR model with exchange rate, import prices, output gap and inflation would be sufficient to analyze the impact. However, such an approach may suffer from various biases of different sort. In this paper, we try to analyze the sources and implications of such biases on the pass-through analysis using Turkey as a benchmark, over the sample period of 2005-2015.

First one is the identification bias. A simple VAR framework as outlined above may not reveal the real nature of the relationship. The domestic output gap and the course of the exchange rate are highly dependent on the course of global demand and of global capital movements. In this respect, if foreign output gap and global risk appetite are not controlled for, the results of the impulse responses have a great chance of being misleading. Second bias is related to aggregation. Given that the Consumer Price Index (CPI) is composed of various heterogeneous subcomponents, looking at the aggregate figure may not be informative enough. Indeed, we propose a disaggregated approach and run an extended VAR model for each of 152 subcomponents of the CPI separately. Then, we aggregate the individual impulse responses of those components with significantly positive response to exchange rate and import prices. Our findings reveal a clear aggregation bias. Once disaggregated approach is used, we report a higher pass-through coefficient for exchange rate to inflation.

Third point is the heterogeneity in pass-through coefficients. We show that in Turkey, the exchange rate and the import price pass-through are strong not only in core goods and energy, but also in food items. Services prices are also found to be sensitive

to exchange rates. Additional sources of heterogeneity are inherited in the choice of import prices. Fourth finding relates to the import price pass-through. When component-wise analyzed, we find that the pass-through of final consumption good import prices to inflation is higher than the pass-through of raw material import prices. Finally, our analysis reveals that the pass-through of import prices has lowered after 2013. The tremendous fall in oil prices have resulted in asymmetric effects. The pass-through of falling international energy prices has been much lower than the pass-through of increasing oil prices.

Overall, our disaggregated approach provides a very rich environment to analyze many aspects of foreign price pass-through in emerging markets. The rest of the study is organized as follows: Next section gives a brief overview of the literature; third section presents the data and methodology; fourth section discusses the findings while the last section concludes the study.

2. Overview of Literature

2.1. Exchange rate pass-through

Exchange rate pass-through (ERPT) is a popular issue discussed in the literature. Firstly, the focus was on the degree of pass-through of exchange rate to import prices based on the law of one price theory (Irandoost, 2000; Campa and Goldberg, 2005). Besides, other studies analyzed the pass-through of exchange rate on consumer and producer prices (McCarthy, 2007; Hahn, 2003). Furthermore, the dynamics of pass-through gained importance (e.g, McCarthy, 2007; Taylor, 2000; Choudhri and Hakura, 2006; Burstein *et al.*, 2002; Saiki, 2004). These studies show that the volatility and persistence of the shocks, distribution chain structure, size of the economy, inflationary environment and implementation of inflation targeting regime have significant effects on the degree and speed of the exchange rate pass-through.

For many emerging countries, the decrease in pass-through into domestic prices is a common phenomenon, due to changes in policies. Saiki (2004) claims that after inflation targeting implementation, pass-through coefficient declines. Mihaljek and Klau (2008) show that the exchange rate pass-through into inflation decreased due to changes in policy implementation.

Ca' Zorzi *et al.* (2007) examine the degree of exchange rate pass-through to prices in 12 emerging and developing markets in Asia, Latin America, and Central and Eastern Europe. Constructing upon VAR modelling, they show that exchange rate pass-through into both import and consumer prices are higher in emerging than in developing countries.

This strand of literature analyzes the extent of the pass-through into aggregate import prices and consumer prices. On the other hand, some studies examine the exchange rate pass-through using micro-data, i.e. sub-components of aggregate price indices. Analysis pertaining to the US and Euro Area show the effect of commodity prices on sub-components of price indices. Examples of studies examining exchange rate pass-through into sub-components of consumer prices are Rigobon, 2007; Parsley, 2012 and Aron *et al.* 2014(a).

Aron *et al.* (2014(b)) present a detailed survey of exchange rate pass-through in emerging markets focusing on the previous literature, methods, estimation techniques and challenges. They also summarize the key findings from the micro-level studies on ERPT and argue that studies focusing on EPRT heterogeneity on industry, firm or product level may provide useful insights into underlying structural price adjustments.

2.2. Prior studies in Turkey

Most of the literature on Turkish data investigates the exchange rate pass-through into consumer prices in Turkey. Leigh and Rossi (2002), Arbatlı (2003), Kara and Öğünç (2005), Kara *et al.* (2007) are some of the studies conducted on exchange rate pass-through into consumer prices. Mostly, the early literature on Turkish data considers the pre-2001 crisis period. For that reason, their findings provide evidence from a period of different monetary policy implementation than recent period. Furthermore, some studies divide the whole period into two sub-periods as before and after the flexible exchange rate regime. The results show that under fixed exchange rate regime, exchange rate pass-through was much higher.

More recent studies mostly analyze the period after 2002. Kara and Öğünç (2008) estimate the 'imported inflation' pass-through into consumer prices before and after the inflation targeting period. Their findings indicate that exchange rate pass-through into consumer prices was high and rapid before the inflation targeting period.

They claim that low inflation pass-through is a result of central bank credibility and exchange rate unpredictability. Damar (2010) analyses the exchange rate pass-through both into consumer price index (CPI) and core CPI for two periods, before and after the floating exchange rate regime. The results show that pass-through effect declines through production chain and after the floating exchange rate implementation. Gündoğdu (2013) states similar results, and claims that pass-through effect is lower after the 2008 global crisis.

Ca' Zorzi *et al.* (2007) also report that for Turkey, at the end of one year, the exchange rate pass-through to consumer prices is 9%, in a panel study of 12 developing countries. However, they claim that Turkey is one of the outlier countries and stands out with low pass-through on consumer prices compared to other emerging countries. Dedeoğlu and Kaya (2015) examine the exchange rate pass-through via VAR framework and use Bayesian model averaging method to deal with model uncertainty. They report a low pass-through of exchange rate to CPI, of 7.5%, in Turkey. The studies focusing on aggregate CPI suffer from aggregation bias as will be discussed in the following sections.

Yüncüler (2011), on the other hand, examines pass-through of both import prices and exchange rate into consumer prices and manufacturing industry prices. The results show that as the distribution chain theory suggests, pass-through into producer prices is higher than pass-through into consumer prices. Furthermore, after the inflation targeting regime, pass-through is effectively lower.

Overall, studies on Turkey have extensively focused on aggregate price indicators, an approach that inevitably fails to thoroughly examine the nature of the pass-through on distinct subcomponents of the CPI. Also a few studies explicitly analyze exchange rate and import prices separately.

2.3. Motivation and our approach: need for disaggregation

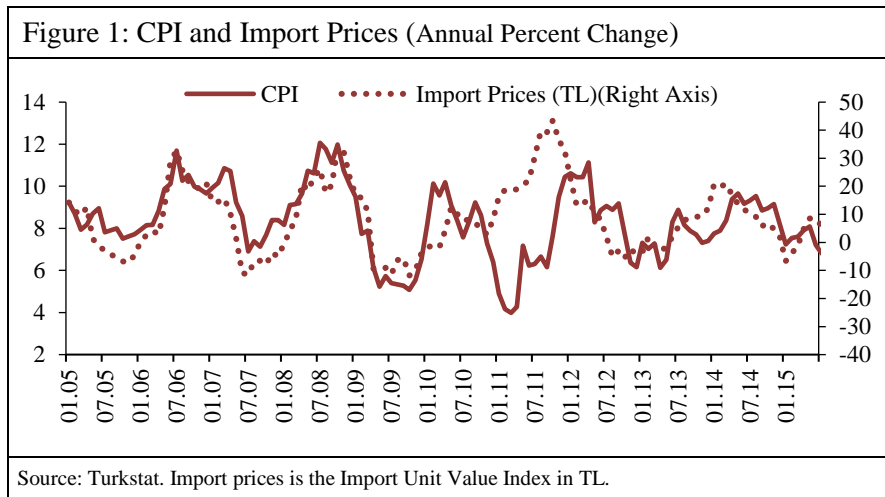
The previous studies in the literature focus on aggregate price series, CPI or some sort of core inflation measure, to study the impact of exchange rate and import prices on inflation in the VAR framework. Although quite appealing, dealing with the aggregate price index may hide important information as the aggregate index contains a great deal of heterogeneity. Indeed, it is already documented that the CPI consists of sub groups

with very distinct pricing behavior in terms of determinants and frequency of price changes (Özmen and Sevinç, 2016). For instance, some energy prices, i.e. motor fuels, are determined by import prices (oil) and the exchange rate. Meanwhile, services prices are less sensitive to import prices, as most of them are non-tradable, and they mostly depend on domestic costs (Başer *et al.* 2015).

In this regard, our analysis departs from the literature on the grounds that we consider highly disaggregated price indices (152 sub components of the CPI) to detect pass-through evidence. This approach serves several purposes: first, one can document differing pass-through coefficients for major sub groups (i.e. food, energy); second, one can rank individual items in terms of the size of the pass-through; third, one can discuss the nature of heterogeneity and aggregation bias; fourth, one can use this information to generate more robust core inflation measures, among others.

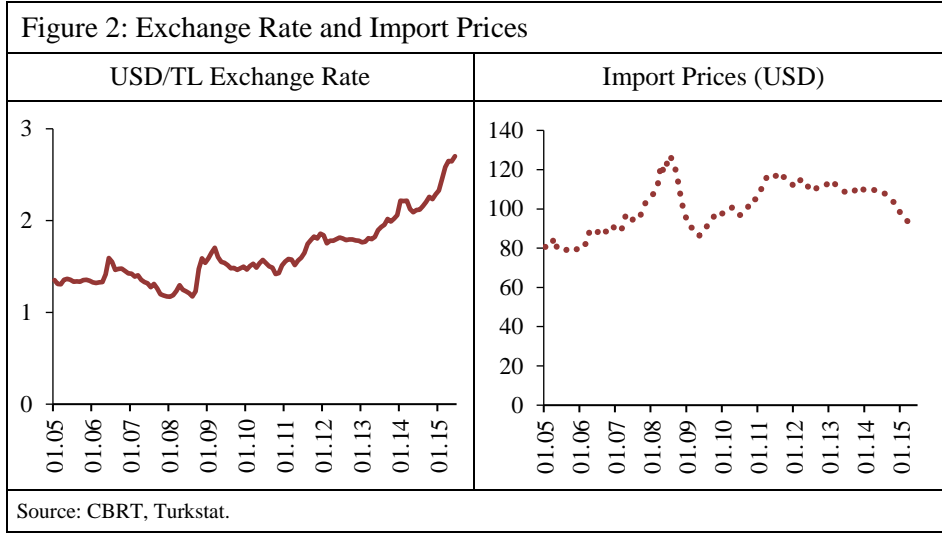
3. Data and Methodology

Import prices in domestic currency and CPI moves coherently in Turkey (Figure 1). Thus, imported cost items are important determinants of the headline inflation.¹



However, import prices in TL has also two components, import prices in USD and USD/TL exchange rate, which may exhibit distinctive movements at times (Figure 2). For that reason, we analyze the pass-through from import prices and exchange rate separately.

¹ In a recent study, Özmen and Sarıkaya (2017) report that the percentage of CPI items affected from import prices in domestic currency is around 60 percent.



As it is widely used in empirical pass-through analysis, we rely on the VAR framework. In this study, following Ögünç, Özmen and Sarıkaya (2017), we construct an extensive 5-variable VAR model incorporating import prices, exchange rate, output gap, inflation and wages as endogenous variables. We also include several exogenous variables to control for global growth and global risk appetite, and for domestic supply shocks in food prices along with taxes excised on energy items.

The VAR specification is applied to each of 152 sub components of the CPI. For each VAR specification, we consider three alternative import price definitions:² the aggregate import price index (IMP), import prices of raw materials (IMP-Raw) and import prices of consumption goods (IMP-Cons), all in USD terms; the exchange rate basket (Basket); the output gap; and the non-farm real unit wage. In the VAR specification, the stationary forms of the variables are used. The definition and the sources of data are presented in Table 1. All the variables apart from output gaps are in quarterly change form.³ The descriptive statistics of the variables are given in Table 2.

² As a proxy of import prices, we use import unit value indices as they are readily available. This is a caveat for the analysis as, in practice, unit values may alter with quantity as well.

³ The VAR specification is a system of linear equations with constant parameters, which may be inappropriate if non-linearity is present, if the series are subject to structural breaks, or if there are major policy changes. Although the use of VAR may be considered as a caveat, considering that the inflation had stable course over the sample period we argue that such issues may not be very relevant in this case.

Table 1: Data Definitions

<i>Variable</i>	<i>Description</i>	<i>Source</i>
Inflation	Quarterly percent change of seasonally adjusted price indices (152 sub-indices)	COICOP 5-digit CPI (2003=100) sub-indices, Turkstat
Output gap	Percent deviation of the GDP from its potential level	Turkstat and Alp, Ögünç and Sarıkaya (2012)
Import prices	Quarterly percent change of the import price index, in USD	Import Unit Value Index (in USD) (2010=100), Turkstat
Import prices of Consumption goods	Quarterly percent change of the import price index of consumption goods, in USD	Import Unit Value Index (in USD) (2010=100), Turkstat
Import prices of Raw materials	Quarterly percent change of the import price index of raw materials, in USD	Import Unit Value Index (in USD) (2010=100), Turkstat
Exchange rate (Basket)	Quarterly percent change of the exchange rate basket (0.5*USD+0.5*Euro)	CBRT
Wages	Quarterly percent change of the non-farm real unit wage	Turkstat, Authors' calculations
EMBIG	Quarterly percent change in EMBI Global index	Bloomberg
Global output gap	Percent deviation of the global GDP (a weighted sum of the growth of trading partners of Turkey) from its HP-filtered trend	Bloomberg, Authors' calculations
Unprocessed food excluding fresh fruits and vegetables	Quarterly percent change of the unprocessed food price index (excluding fresh fruits and vegetables)	Turkstat, CBRT
Energy tax	Quarterly percent change in the ad-valorem special consumption tax excised on energy items	Turkstat, Authors' calculations

Table 2: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.
Import prices (quartely percent change)	41	0.46	5.02
Import prices-raw materials (quartely percent change)	41	0.64	6.05
Import prices-consumption goods (quartely percent change)	41	0.18	3.21
Exchange rate basket (quartely percent change)	41	1.61	5.21
Output gap (level)	41	0.75	3.54
Wages (quartely percent change)	41	0.46	2.36
Foreign output gap (level)	41	0.16	1.19
EMBIG (quartely percent change)	41	1.98	22.10
Energy tax (quartely percent change)	41	1.21	3.65
Unprocessed food prices (quartely percent change)	41	2.75	2.62

Sample period is 2005q2-2015q2. Variables are in the form they enter the VARs. Unprocessed food prices exclude fresh fruits and vegetables.

We also include global risk premium (EMBIG), global output gap, unprocessed food price index (excl. fresh fruits and vegetables) and taxes in energy items as external control variables in the each VAR. As discussed by Ögünç *et al.* (2017), these control variables enable better identification of the impact of cost shocks (import prices and exchange rate on inflation). Global output gap and risk appetite measures control for global growth channel. In the last decade, what we observe in the data is that periods of global growth and periods of hike in international commodity prices coincide. Also in these periods, increased risk appetite induces more capital inflows into emerging economies. Thus, an increase in import prices (a cost shock by itself) seems to increase domestic growth and to appreciate the local currency. Thus, if global growth and risk appetite is not controlled for, the identification of import price shocks will be problematic. In the same manner, indicators that capture domestic supply shocks in food market along with indicators that capture tax adjustments in energy items also needs to be controlled for in order to reveal the plausible impact of exchange rate and import prices on domestic prices.

Due to data length issues and considering the number of variables, the VAR models are estimated with one lag.⁴ For identification, we rely on Cholesky decomposition as widely employed in VAR analysis. The following order is employed in the study: quarterly change in import prices; quarterly change in exchange rates; output gap; quarterly inflation (in each sub-group, respectively); quarterly change in wages.⁵ EMBIG, foreign output gap, unprocessed food (exc. fresh fruits and vegetables) price inflation and changes in energy taxes are included as exogenous control variables in each VAR. In addition, for food items, international food prices (percent change in FAO price index) and for energy items, international oil price (quarterly percent change) are used as additional control variables to check the robustness of the findings. The extended sample period considered in the study covers 2005q2-2015q2 period.

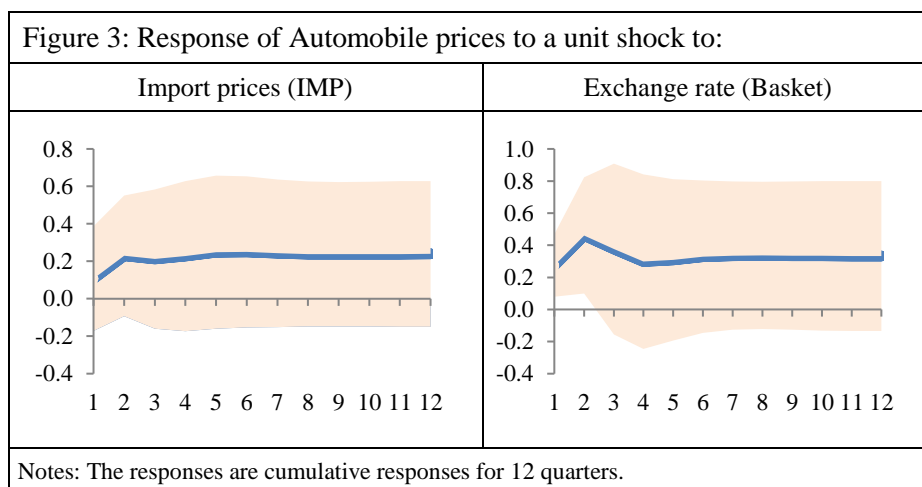
⁴ When optimal lag length selection criteria are employed, one lag is chosen to be the optimal lag for all but a few items. Selecting a low lag length may result in under-estimated pass-through of slow-adjusting series such as the wages.

⁵ We are aware of the fact that the estimation results may be sensitive to selection of the ordering of the variables. However, due to computational difficulties, we prefer to work with one set of variable ordering. The motivation behind this ordering is that, import prices are mostly global market prices, then, incorporating financial flows exchange rates are determined; then the exchange rate affects the output gap; exchange rate and output gap affects inflation, and by indexation behavior wages are altered.

However, we also work with a shorter period of 2005q2-2013q2 in order to analyze whether the pass-through coefficients has changed recently.

Once the models are constructed, the response of inflation to shocks to exchange rate and import prices are analyzed through impulse-response functions. Visual inspection of impulse-response functions gives a broad idea of whether a price index is significantly affected by exchange rate of import prices. Given that the sample period is relatively short, we use aggregated import price series and there may be additional factors to be controlled for each price index, the confidence intervals around the estimated impulse-response may not always point to a clear indication.

To put the idea on concrete terms, consider the responses of automobile prices, for instance, to import price and exchange rate shock over the sample period (Figure 3). A very high proportion of the automobiles sold in Turkey are imported. Therefore, domestic prices are highly dependent on the course of import prices and the exchange rate. In practice, we observe that both cost shocks are transmitted into domestic prices of automobiles.



However, in Figure 3, we see that the confidence interval around the response does not lie entirely in the positive territory. Even for a price which undoubtedly depends on exchange rate and import prices, the impulse-responses may still assign some probability to the case of pass-through being negative. This outcome is contrary to economic intuition and what is observed in the data. Therefore, looking at the impulse-responses, it will be unfair to conclude that automobile prices are not significantly affected by exchange rate and import prices. Two possible reasons may be cited for

such a case. First, the sample period may not long enough to identify the relations with a reasonable precision. Second, due to data constraint and with an aim to produce comparable results with aggregate studies, we consider a generic import price index for all the items. In this respect, an alternative approach has to be exercised.

With this discussion in mind, we propose a methodology to determine the CPI sub components which are affected by exchange rate and import prices. That is, if 75% of the confidence interval of the response lies in the positive territory, we will declare that price index as being affected by cost measures. That is, for instance, following Figure 3, given that the large enough proportion of the cumulative response of automobile prices to import prices and exchange rate is on the positive side (at least 75%), we conclude that domestic automobile prices respond to cost shocks to exchange rate and import prices.

Once each 152 price index are modeled with a VAR specification, we determine the indices that positively respond to exchange rate and import price shock. Then, we aggregate the pass-through responses with respective weights of each component in order to calculate the aggregate group pass-through values. For instance, if 5 energy items are found to be responding to import price shock, we aggregate the responses of these 5 items to calculate the “import price pass-through in energy”.⁶

4. Findings

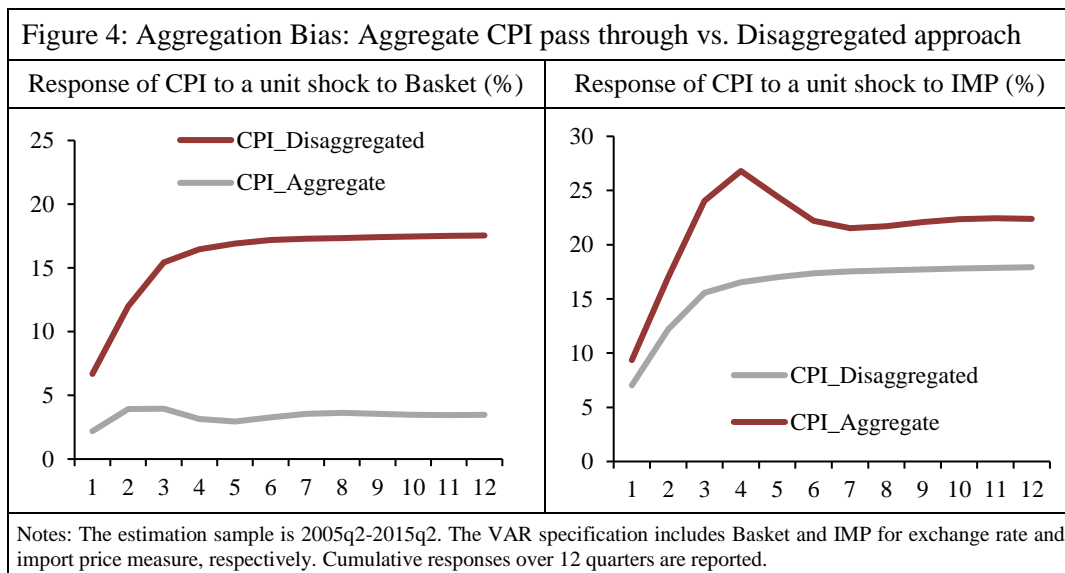
We discuss our findings on the onset of aggregation bias, heterogeneity on various grounds and recent periods.

4.1. Aggregation Bias

One aim of this study is to show that due to heterogeneity and identification, pass-through to headline CPI (aggregate) differs from the pass-through to CPI calculated from subgroups (disaggregated). As mentioned, we choose the subgroups which have “meaningfully positive” pass-through, then aggregate them to calculate the pass-through to aggregate series. Then, we compare the pass-through results for CPI to exchange rate

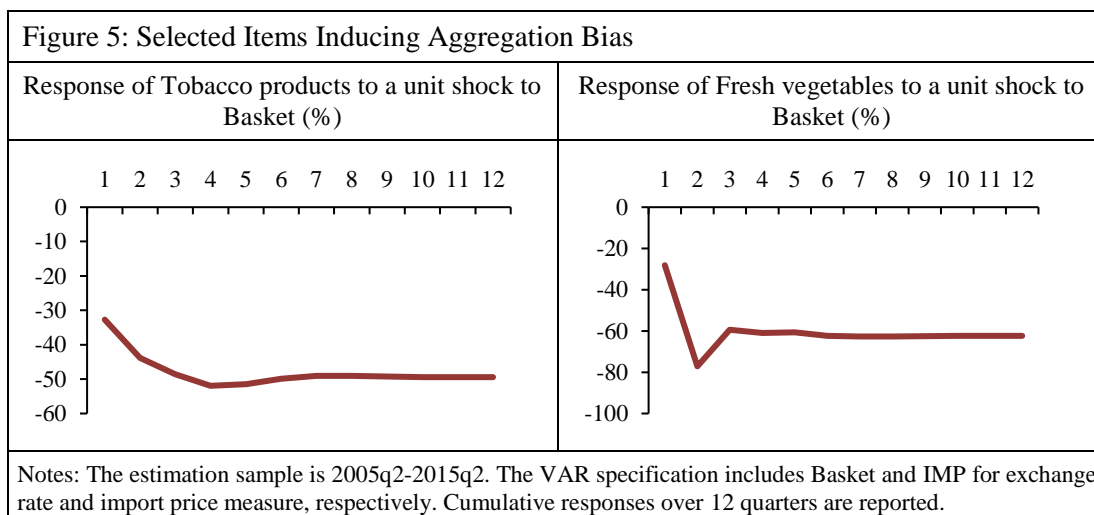
⁶ In section 4.5, we further discuss the relevance of our selection criteria. Also, we consider 66% and 80% as different thresholds for the share of the confidence interval lying above the zero-line. The results shown in the Appendix A, reveal that the 75% threshold gives a relatively good measure.

and import price shocks for two cases: Aggregate and Disaggregated. Aggregate approach refers to the impulse-response results of a VAR specification that uses the aggregate CPI only. Meanwhile, the disaggregated approach refers to the aggregation of individual pass-through paths of items selected according to the discussed methodology. Figure 4 shows the cumulative response of CPI to exchange rate and import prices.



The results points to a clear aggregation bias when the pass-through is calculated only with the headline index. The bias is more severe when the exchange rate basket is considered. The aggregate approach yields a much lower exchange rate pass-through, thus it is downward biased. On the other hand, there is an upward bias for import price pass-through in the aggregate analysis.

The source of aggregation bias for the exchange rate pass-through can clearly be identified with the help of the disaggregated approach. We see that the VAR models predict negative pass-through coefficient of very high magnitudes for several items with sizeable weights in the CPI. The major items of this sort are tobacco products, fresh vegetables, and natural gas among others. Figure 5 shows the cumulative response of the prices of tobacco products and fresh vegetables to a shock to exchange rates. The estimated pass-through coefficients are not economically justifiable and are contrary to intuition. Nonetheless, these two items constitute almost 8% of the total CPI. Thus, such components with very high weights and with very high negative pass-through coefficients are the major source of the aggregation bias. Our disaggregated approach, which discards such items, produces more reliable estimates of pass-through.

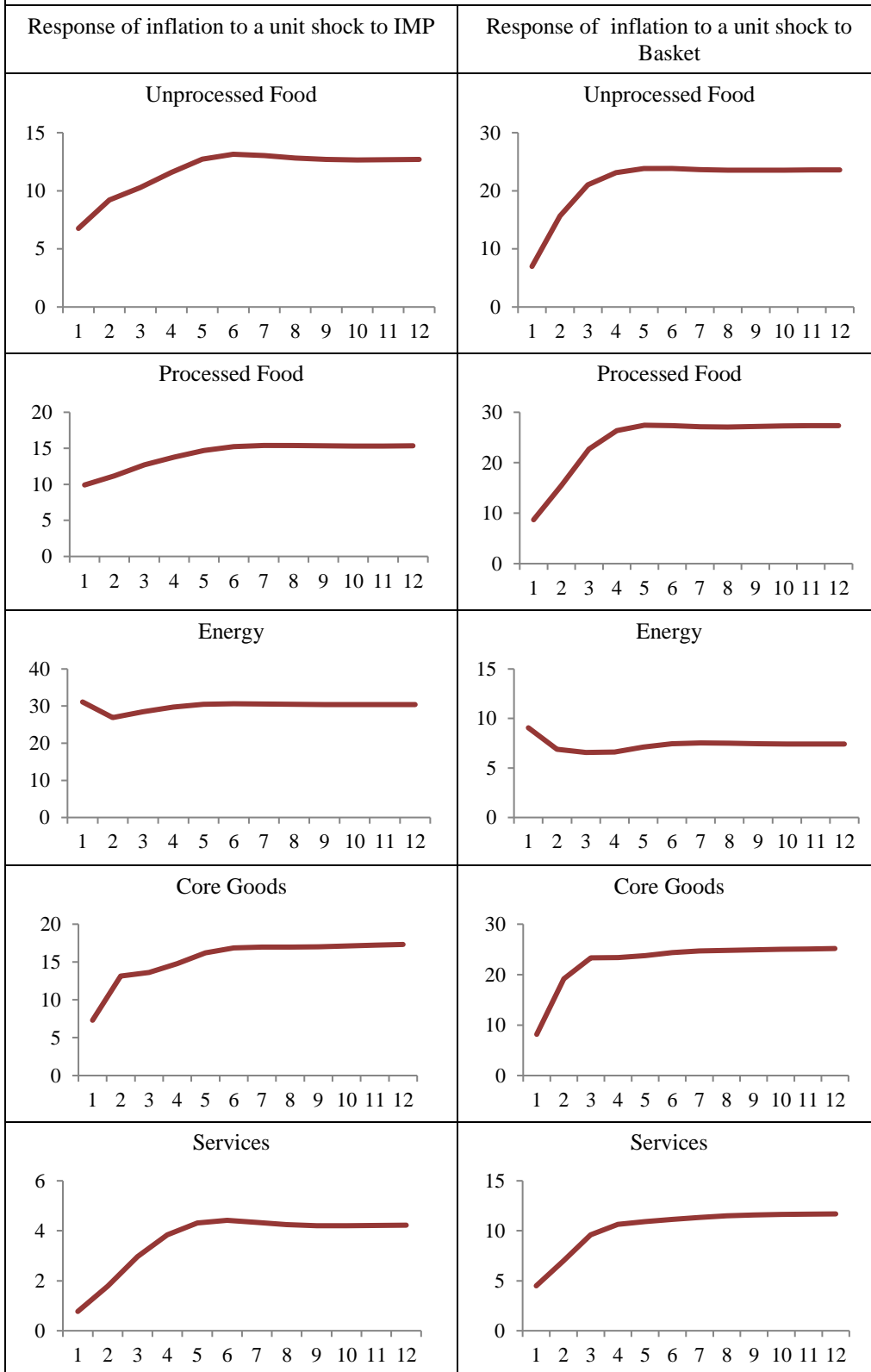


Our selection methodology, although subjective to some extent, produces plausible pass-through coefficients. If one were to stick to the information in the impulse-responses and consider only the items with entire confidence band in the positive territory, would end up with around 6 percent of pass-through both from import prices and exchange rate over the 2005-2015 sample. However, these numbers are way below then what is observed. The reason is that, only 27 out of 152 items are responding to exchange rate and only 11 out of 152 items are responding to import prices in a statistically significant way. Thus, such a strict approach will be very restrictive and yield misleading results. In fact, using a wide range of single equation models, Özmen and Sarıkaya (2017) show that roughly 2/3rd of the CPI are significantly affected by import prices in Turkish lira which combines import prices and exchange rate.

4.2. Heterogeneity across Major Components of CPI

As discussed in the introduction, the CPI is composed of heterogeneous items with different pricing behavior. Here, we analyze the pass-through to major components of the CPI: core goods, services, energy, unprocessed food and processed food. Figure 6 reports the cumulative percent response of each component to a unit shock to exchange rate and import prices in the general model for the entire sample of 2005q2-2015q2, where the exchange rate is the Basket and import prices is IMP. Our results point to very different exchange rate and import price pass-through in terms of magnitude and speed across major groups. The detailed figures are reported in the Appendix, Table B1.

Figure 6: Exchange Rate and Import Price Pass-through to Major CPI Components



Notes: The estimation sample is 2005q2-2015q2. The VAR specification includes Basket and IMP for exchange rate and import price measure, respectively. Cumulative responses over 12 quarters are reported.

The results reveal important points. First of all, the core goods are significantly affected by both the exchange rate and the import prices. This finding is not surprising as majority of the core goods, i.e., automobiles, are imported. The import price pass-through to core goods price is around 17% and it is almost completed in about 6 quarters. On the other hand, the exchange rate pass-through to core goods prices is around 25% and it is completed much faster compared to import prices, in about 3-4 quarters. Another major group with strong import price pass-through is energy. This is also in line with a priori expectations as Turkey is an energy importer. The import price pass-through to energy is around 30% and it is completed fairly quickly. For energy items, the models estimate a relatively lower exchange rate pass-through while a relatively higher import price pass-through. However, overall, if we consider exchange rate and import prices together, there is a sizeable pass-through in terms of changes in import prices in Turkish lira. In the context of our analysis, the differences in pass-through of exchange rate and import price may well be due to the ordering of the variables in the VAR setting, which includes import prices before the exchange rate. Also, another point to note is that the prices of a major part of the energy items, i.e. electricity and natural gas, are administered. Therefore, although they are affected by the changes in the imported cost items, the fact that they are not adjusted periodically prevents the models from estimating a significant pass-through. Thus, in our context, the impact comes from fuel-oils and liquefied hydrocarbons. For these items, the pass-through of cost items to prices is not perfect as indirect taxes constitute a major portion of the consumer prices.

The major findings which are novel to this study are related to services and food prices. For services sector, which is mostly non-tradable and subject to domestic cost pressures, we observe a non-negligible amount of exchange rate pass-through of around 12%. Meanwhile, as expected the import price pass-through is lower, around 4%. When it comes to food prices, on the other hand, we see a considerable amount of exchange rate and import price pass-through both for processed and unprocessed food prices. The import price pass-through is on the range of 12-15%, while the exchange rate pass-through is on the range of 23-27%. This finding is quite unique. Food prices, which have been considered as being subject to domestic supply shocks, are actually found to responding to foreign price shocks to a large extent as well. Similar to other sub

components, the import price pass-through takes a longer time to complete, compared to the exchange rate. The heterogeneity across major components of the CPI is also depicted in Table 3, which summarizes the exchange rate and import price pass-through at the end of two years.⁷

Table 3: Cumulative response of CPI components to Exchange rate and Import prices

	CPI	Unprocessed Food	Processed Food	Energy	Core Goods	Services	CPIX	CPI*
Exchange rate shock	17.4	23.5	27.1	7.5	24.8	11.5	17.5	19.1
Import price shock	14.0	12.8	15.4	30.5	17.0	4.2	14.8	15.3

Notes: The estimation sample is 2005q2-2015q2. The VAR specification includes Basket and IMP for exchange rate and import price measure, respectively. Cumulative responses over 8 quarters are reported. CPIX: CPI excluding unprocessed food and alcohol-tobacco. CPI*: CPI excluding fresh fruits and vegetables, alcohol-tobacco.

In analyzing and forecasting inflation, generally, some items of exogenous nature are excluded from the CPI. The CPIX, which excludes unprocessed food and alcohol-tobacco is widely used in Turkey.⁸ One main argument for such exclusion of items is that the prices of these items are not affected by the major determinants of inflation. Our disaggregated analysis, however, reveals that some unprocessed food items actually respond to import prices and exchange rates. In this respect, excluding all unprocessed items may hide some useful information for inflation analysis.⁹

4.3. Heterogeneity across different components of import prices

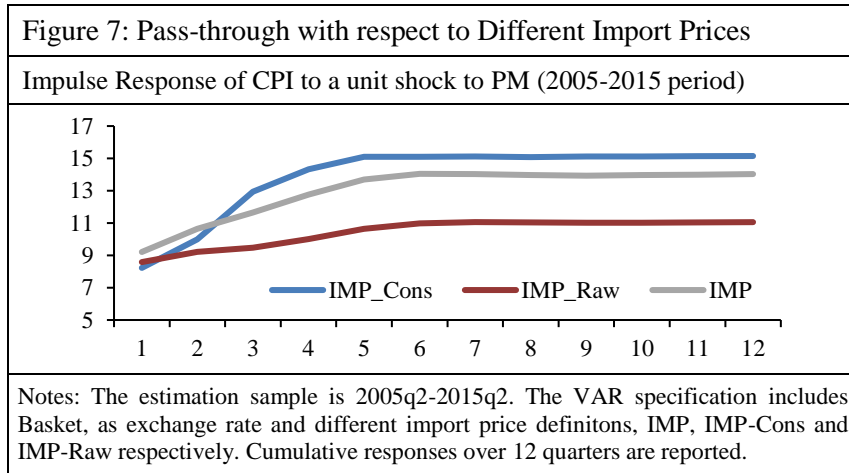
The results presented above consider the baseline VAR including the exchange rate basket (Basket) and overall import prices (IMP). The general import prices include different components related to different sectors of the domestic economy. The major components include the consumption good import prices (IMP-Cons) and raw material import prices (IMP-Raw). These two import price definitions actually point to two different transmission channels on inflation. The imported consumption goods affect the inflation directly. Meanwhile, imported raw materials enter into production process and their impact is indirectly observed on consumer inflation. That is, the pass-through these

⁷ The aggregation of pass-through coefficients are realized by the use of most current CPI weights in the estimation sample (2015). If the current weights, 2017, were to be used, the aggregate exchange rate pass-through at the end of two years would be 17.3, while that of energy would be 9.2 instead.

⁸ For instance, the CPIX is explicitly discussed in each Inflation Report of the CBRT.

⁹ Thus, we argue that another definition, CPI*, which excludes only fresh fruits and vegetables, along with alcohol-tobacco, may provide a series with a wider coverage for inflation analysis.

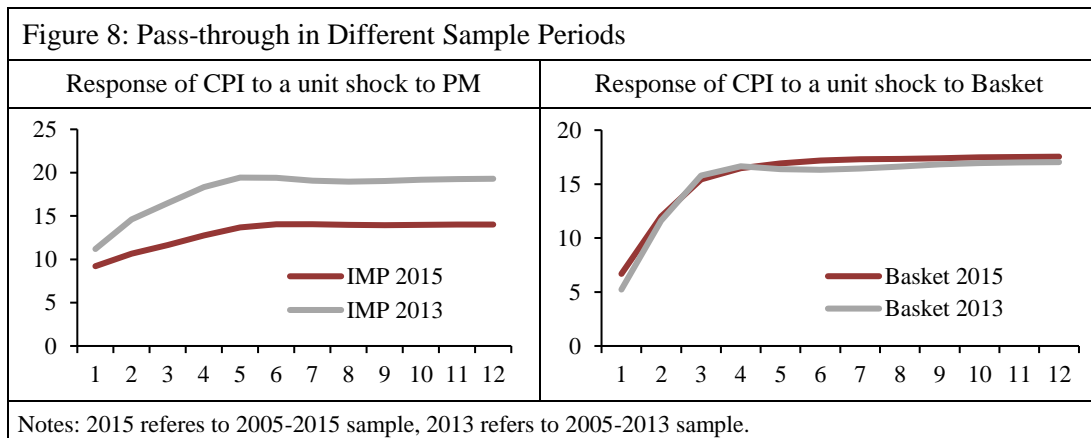
import prices to inflation may differ both in terms of magnitude and in terms of speed. Figure 7 shows the response of consumer prices to unit shock in different import prices.



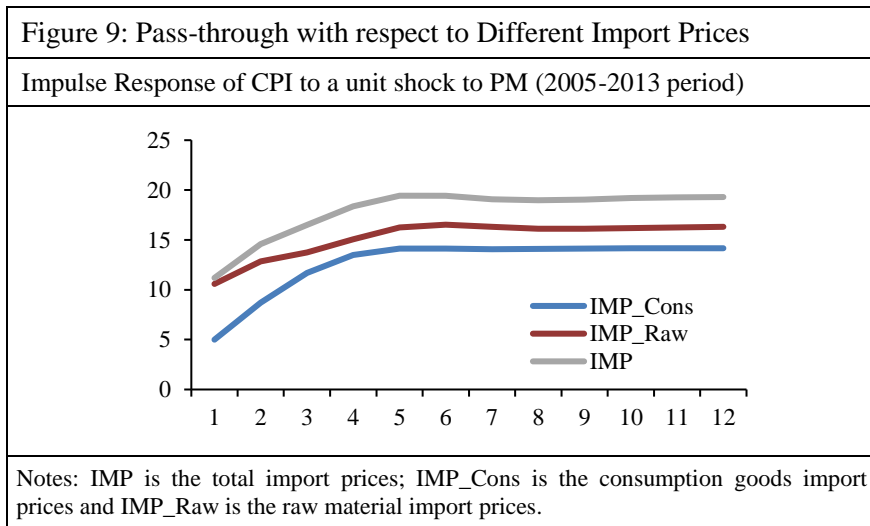
Two observations stand out. First, over the sample period, the pass-through of consumption goods import prices is higher than that of raw material import prices (around 15% vs. 11%). Second, the pass-through of raw materials import prices is completed more slowly. The detailed figures are reported in the Appendix, Table B2.

4.4. Recent change in pass-through

In this section, we analyze whether the pass-through rates has changed recently. We compare the results of the baseline model for two different samples in Figure 8: 2005q2-2015q2 (our full sample, labeled as 2015) and 2005q2-2013q2 (labeled as 2013 in figure). We see that there is no change in the pass-through of the exchange rate on inflation in two different samples. However, there is a considerable drop in the pass-through of import prices in the full sample (Figure 8). With the addition of two years of observations, the pass-through of import prices came down from 19% to around 14%.



The reason behind this fall is visible in Figure 9. We see that the pass-through of raw material import prices has significantly come down from 17% to 11% in the full sample (see section 4.3). This finding may be related to the unresponsiveness of several items in the CPI to the significant fall in import prices induced by oil prices. Mainly, energy prices, apart from motor fuel, remained constant over the last years of the sample period. This caused a remarkable reduction in the pass-through of imported raw material into domestic inflation given the significant share of oil in raw material imports. Given that the overall energy cost in production (mainly electricity) did not reflect the changes in import prices, the link between the import prices and consumer prices weakened over this period. Meanwhile, the pass-through of consumption goods import prices has even gone up slightly.



4.5. Further discussion and caveats

We may further discuss the drawbacks of the current study. One major drawback is the fitting of a common VAR specification to all sub-group price indices. Such an investigation may amplify identification issues as each inflation series may be subject to idiosyncratic shocks. This is, however, a choice made on the basis of two concerns. First, the general VAR specification includes output gap, wages and import prices for the whole economy, which are not available for detailed price indices. Thus, we rely on the analysis of aggregate variables for modelling each inflation series. Second, each goods and services may require additional control variables when modelling inflation.

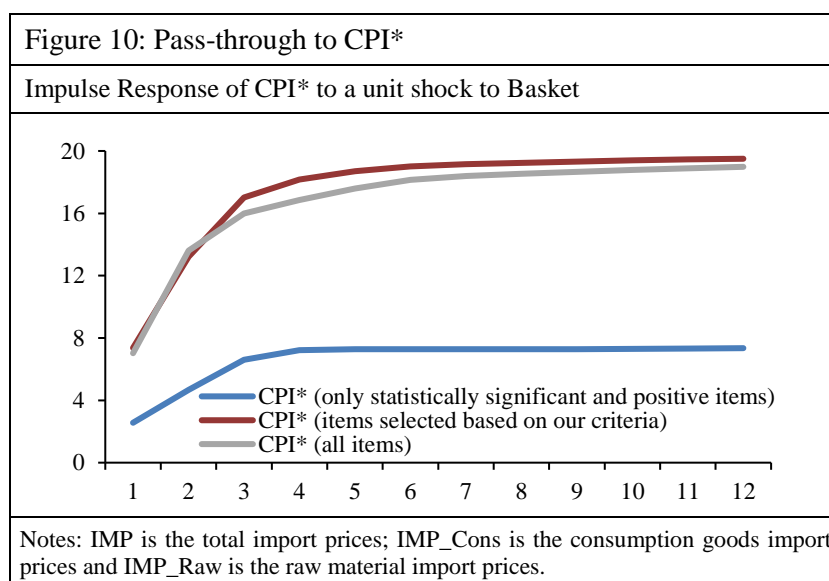
For instance, tax adjustments in durable goods may have an effect on the inflation of cars and white goods; or introduction of trade restrictions may affect the inflation of traded foods items. In that sense, modelling each inflation series in a more detailed way requires a more directed attention, which is out of the scope of the current study.

The second drawback of the study is the use of a subjective selection criterion, rather than totally relying on statistical significance of the impulse-responses, for determining items that are responsive to exchange rate and import prices. This is also an inevitable choice to be made. As the confidence bands around the impulse-responses cover a wide range, due to either short data or not-perfectly-fit models, many goods and services known to be affected by exchange rate and import prices do not exhibit a statistically significant response. A third drawback of the analysis is that it does not allow for across item price interactions. That is, this system discards any impact of changes in relative prices on inflation of individual sub-group items.

Overall, using disaggregated data comes with its own trade-off of providing more detailed information at the expense of utilizing a generic specification for all items. What this study aims at is to decompose an aggregate pass-through parameter to each individual item and to come with aggregate coefficients for major sub-groups of the CPI by using the general framework applied to aggregate CPI. In that sense the above drawbacks, which may be subject of further studies, are currently not addressed in this study.

Our selection criteria, based on threshold detection for confidence intervals of the impulse-responses, may be cross validated by revisiting the findings related to two aggregate series. First, as discussed previously, the aggregation bias is very low for CPIX which excludes unprocessed food and alcohol-tobacco from the headline index. The reported 17.5 percent exchange rate pass-through at the end of two years, in our context is, then comparable with studies that treat the CPIX. For instance, Kara and Ögünç (2012) and Ögünç *et al.* (2017) report around 17 and 18 percent exchange rate pass-through, respectively, for CPIX after two years. Thus, our selection criteria ex-post produces a similar amount of pass-through.

Second, as discussed previously, the main source of the aggregation bias is the presence of several items with both high relative weights in the CPI and coincidentally high negative pass-through coefficients, especially fresh vegetables and tobacco products. In this perspective, removing these items already solves a bulk of the aggregation bias. Thus, our proposed aggregate price index to be used in modelling analysis, CPI* (that excludes only fresh fruits and vegetables, and alcohol-tobacco), serves as another benchmark. As we see from Figure 10, the exchange rate pass-through to CPI* with our selection criteria is very similar to the aggregate pass-through coefficient if all the individual items' pass-through coefficients were aggregated regardless of statistical significance and sign of the pass-through. In a nutshell, the aggregation of the pass-through coefficients of 79 items realized with our selection criteria, matches the aggregation of the pass-through coefficients of all 144 items constituting CPI*. Thus, our selection procedure, although seems arbitrary, does a good job of producing reliable pass-through coefficients.



5. Conclusion

In this study, we show that the analysis of the foreign price pass-through to inflation with aggregate price series, such as the CPI, may hide a considerable amount of heterogeneity and may thus lead to wrong conclusions. Instead, using a disaggregated approach, by considering each 152 sub component of the CPI separately, presents a very fruitful domain to analysis and to discuss very different aspects of heterogeneity. Such an approach also provides a platform with many policy implications.

We first show that there is an aggregation bias. For the case of exchange rate, considering the CPI itself may underestimate the pass-through to a large extent. Following that, we document that the sub components of the CPI respond very differently exchange rate and import prices. Moreover, we also note that the pass-through rates also differ with the selection of the import price measures. Our analysis also sheds light on the recent changes in the pass-through of import prices to inflation. A complete understanding of the exchange rate and import price pass-through is very crucial for a better reading of the inflationary process and for formulating policy responses. In that sense, we propose that a disaggregated approach is needed.

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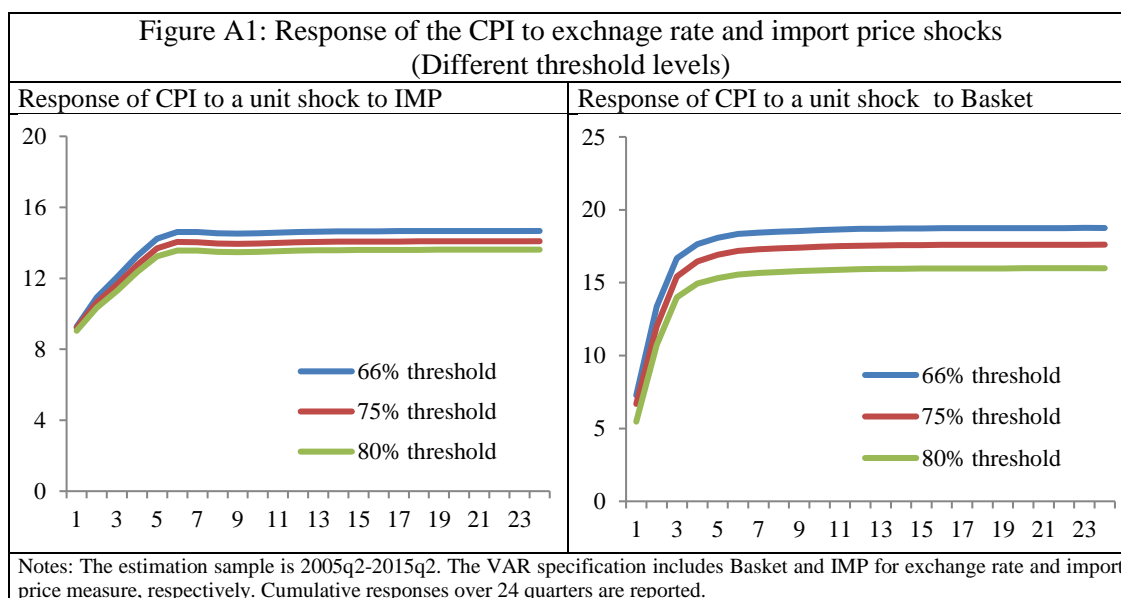
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Appendix

A: Robustness of threshold selection

In this study, as discussed in section 2, our methodology necessitated a threshold selection for the determination of items whose impulse responses mostly remain in the positive territory. Here, to facilitate a comparison between our findings and those of studies focusing on aggregate data, we selected the 75% threshold as the benchmark. In Figure A1, we carry out further robustness checks of this threshold. Along with the 75%, we consider 66% (more relaxed) and 80% (stricter) thresholds for the selection of items responding to exchange rate and import prices in CPI. These can also be considered as certain upper and lower limits as well.



For the import price pass-through to CPI, the benchmark analysis points to 14 percent at the end of 2 years. The 66% and 80% thresholds on the other hand point to 14.5 and 13.5 respectively. There is a relatively low level of variation between these figures. For the exchange rate pass-through to CPI, the benchmark analysis points to 17.4 percent at the end of 2 years. The 66% and 80% thresholds on the other hand point to 18.5 and 15.7 respectively. The pass-through of exchange rate is slightly more dispersed compared import prices. In this respect, the benchmark analysis provides a reasonable outcome.

B. Additional Tables

Table B1: Cumulative response of CPI components to:								
A Unit Shock to Exchange rate basket								
	CPI	Unprocessed Food	Processed Food	Energy	Core Goods	Services	CPIX	CPI*
Q1	7	7	9	9	8	4	7	7
Q2	12	16	15	7	19	7	12	13
Q3	15	21	23	7	23	10	16	17
Q4	16	23	26	7	23	11	17	18
Q5	17	24	27	7	24	11	17	19
Q6	17	24	27	7	25	11	17	19
Q7	17	24	27	8	25	11	18	19
Q8	17	24	27	7	25	11	18	19
A Unit Shock to Import Prices								
	CPI	Unprocessed Food	Processed Food	Energy	Core Goods	Services	CPIX	CPI*
Q1	9	7	10	31	7	1	10	10
Q2	11	9	11	27	13	2	11	12
Q3	12	10	13	28	14	3	12	13
Q4	13	12	14	30	15	4	14	14
Q5	14	13	15	30	16	4	15	15
Q6	14	13	15	31	17	4	15	15
Q7	14	13	15	31	17	4	15	15
Q8	14	13	15	30	17	4	15	15

Notes: The estimation sample is 2005q2-2015q2. The VAR specification includes Basket and IMP for exchange rate and import price measure, respectively. Cumulative responses over 8 quarters are reported. CPIX: CPI excluding unprocessed food and alcohol-tobacco. CPI*: CPI excluding fresh fruits and vegetables, alcohol-tobacco.

Table B2: Cumulative response of CPI components to:								
A Unit Shock to Consumption Goods Import Prices								
	CPI	Unprocessed Food	Processed Food	Energy	Core Goods	Services	CPIX	CPI*
Q1	8	24	4	29	4	1	7	6
Q2	10	16	10	29	9	2	10	10
Q3	13	22	14	32	13	3	12	13
Q4	14	22	17	32	16	3	14	15
Q5	15	24	18	33	18	3	15	15
Q6	15	24	18	32	18	3	15	15
Q7	15	24	18	32	18	3	15	15
Q8	15	24	18	32	18	3	15	15
A Unit Shock to Raw Material Goods Import Prices								
	CPI	Unprocessed Food	Processed Food	Energy	Core Goods	Services	CPIX	CPI*
Q1	9	6	9	29	7	1	9	9
Q2	9	8	9	23	12	2	10	10
Q3	9	8	10	23	11	3	10	10
Q4	10	9	11	24	11	3	11	11
Q5	11	9	11	25	12	4	11	12
Q6	11	10	12	25	13	4	12	12
Q7	11	10	12	25	13	4	12	12
Q8	11	10	12	25	13	4	12	12

Notes: The estimation sample is 2005q2-2015q2. The VAR specification includes Basket and IMP for exchange rate and import price measure, respectively. Cumulative responses over 8 quarters are reported. CPIX: CPI excluding unprocessed food and alcohol-tobacco. CPI*: CPI excluding fresh fruits and vegetables, alcohol-tobacco.

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