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Estimates of Exchange Rate Pass-through with Product-level Data

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Product-level estimates of exchange rate pass-through: Evidence from Turkey*

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Abstract

We estimate the export and import pass-through rates using product-level data from Turkey. We find that the Turkish lira (TRY) exchange rate changes are mostly passed on to TRY prices of exports and imports–and therefore modestly to their prices in trading partners' currencies. The rate of average pass-through to TRY-prices is 89% for imported goods and 82% for exported goods, with no apparent lags in the impact. Pass-through estimates by sector show variation and are relatively low for food and agricultural products. We argue that the highly-detailed product-level data enable us to estimate the pass-through rates with better reliability and precision than we could by using only aggregated time-series data. We also introduce a pooled equation to estimate the difference between the export and import pass-through rates–a potentially useful statistic–in a way that allows statistical inference.

JEL codes: F14, F31, F41.

Keywords: Exchange rate pass-through, Product-level estimates, Turkish export prices, Turkish import prices.

*The views expressed here are of our own and do not necessarily reflect those of the Central Bank of the Republic of Turkey. All errors are ours.

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Non-Technical Summary

We estimate in this paper the rate of exchange rate pass-through to prices of imports and exports. The rates of pass-through to trade prices are crucial quantities. First, they are an important part of the response of domestic inflation to changes in exchange rates. Central banks often need to disentangle how much of CPI inflation is due to foreign exchange movements and how much is due to other factors such as the output gap, and pass-through to trade prices is the first step in the link from the exchange rate to CPI inflation. Second, pass-through rates are relevant for how much the trade deficit responds to changes in the exchange rate. For example, if, as in the textbook formulations of the Marshall-Lerner condition, export prices in domestic currency do not respond to depreciations while import prices do, a much greater quantity response in exports and imports would be required for the trade balance to improve in response to those depreciations.

While estimating exchange rate pass-through can be difficult, Turkey has a relatively clear-cut pass-through profile. However, the empirical estimates for Turkish pass-through still encompass a very wide range. That literature's estimates range from 9 to 100 percent (or more). One reason for the difficulty to obtain accruate estimates might be that most studies rely on aggregate data. We therefore employ detailed data at the 6-digit product level, and find that we are able to obtain estimates with high precision (i.e., with low standard errors). There are other studies for some other countries that estimate pass-through using similarly detailed data. However, ours is the first that estimates it for Turkey, to the best of our knowledge. Moreover, unlike in the literature, we do a comparison of the performance of micro and macro estimations, by constructing a comparable specification that uses macro data. We show that the use of micro data provides notable improvement in the precision of the estimates.

In addition, we introduce a new approach to estimate the difference in the export and import pass-through rates. That difference can be a useful statistic by itself, and, to the best of our knowledge, has not been estimated in the literature in a way that allows statistical analysis as we do in this paper.

Our estimates for the rate of pass-through is 89% for imported goods and 82% for exported goods prices (when those prices are measured in TL), with no apparent lags in the impact. The standard errors of those estimates are only 3 percentage points, in stark contrast to the wide range of estimates in the literature. Pass-through estimates can vary over sectors and is particularly low for *food and agricultural products*, falling to roughly around two-thirds or less in that group. ■

1 Introduction

Exchange rate pass-through, i.e., the rate at which exchange rate changes are reflected in trade prices, is a crucial macroeconomic parameter for the role that the exchange rate plays in affecting key economic variables–such as inflation and the trade balance–of a country. For example, it is an important parameter in the response of domestic inflation to changes in exchange rates. Pass-through to trade prices is the first step in the link from the exchange rate to CPI inflation. Central banks often need to disentangle how much of the CPI inflation is due to foreign exchange movements and how much is due to other factors such as the output gap, and the pass-through rate is a useful parameter to be informed about for that purpose. Pass-through is also relevant for how much the trade deficit responds to changes in the exchange rate. For example, if, as in the textbook formulations of the Marshall-Lerner condition, export prices in domestic currency do not respond to depreciations while import prices do, a greater quantity response in exports and imports would be required for the trade balance to improve in response to those depreciations–i.e., it would be relatively more difficult to obtain an improvement in the trade balance.

Due to those important roles of the exchange rate pass-through, a sizable literature aims to estimate its magnitude. However, estimating pass-through is not necessarily straightforward. Even for a country for which the pass-through rate is well-examined such as the United States, the literature can still offer fairly different estimates.

The Turkish pass-through behavior is surprisingly clear-cut and offers an interesting case to examine the issues surrounding pass-through estimation. For example, Turkey is one of the three countries that Gopinath (2015) uses to illustrate her main points–along with the United States and Japan–in her multi-country pass-through paper. Nevertheless, despite the relative clarity of Turkey's pass-through behavior, empirical estimates for the Turkish pass-through rates also encompass a wide range.

One reason for the difficulty to obtain accurate pass-through estimates might be that most studies rely on aggregate data. Using the Turkish data, we show that pass-through estimation can be improved notably by the use of highly-detailed data at the 6-digit product level. While there are studies for other countries that use detailed product-level or micro-level data to estimate pass-through rates, they do not compare those estimates to the ones obtained from aggregated data through a detailed examination of a comparable specification, as we do here.[1]

The plan of the paper is as follow. We start with a graphical examination of Turkish pass-through followed by a presentation of the related empirical literature in Section 2. We then provide in Section 3 our estimates using the 6-digit product-level data. In Section 4, we take a closer look at the difference between import and export pass-through rates. Section 5 compares the micro and macro estimates. We present our sector-specific pass-through estimates in Section 6. Section 7 concludes.

2 Exchange rate pass-through in Turkey and the related literature

As we see in Figures (1) and (2), the Turkish pass-through is apparent even visually. The TRY exchange rate movements pass through to TRY trade prices at a high rate and without much of a lag. However, as we see below, the range of estimates in the literature for Turkish pass-through rates is still quite wide.

We first elaborate on the visual pass-through evidence provided in Figures (1) and (2). Those two figures compare the *real* effective exchange rate with the *nominal* (i.e., current TRY) trade prices, as opposed to making a real-to-real or nominal-to-nominal comparison. That helps us remove any potential doubt that could arise on whether or not co-movements might be related to the variation in the overall

[1] See, for example, Gaulier et al. (2008) for a multi-country study and Berner (2011) who employs 8-digit data for Germany. For Turkish pass-through, ours is the first paper, to the best of our knowledge, that employs a large detailed dataset in the estimation.

price level.[2] Such a problem may not be a major concern in practice, because the variation in exchange rates tend to be much larger than the variation in price levels, and, in fact, unless inflation variation is sizable over the examined sample, the empirical pass-through literature tends to justifiably ignore this possible source of bias. Figures (1) and (2) are nevertheless useful as they confirm that the assumption in question is innocuous, which could be a source of doubt when the investigated economy has had periods of high and volatile inflation.

The nominal-to-real comparison makes it important to use logarithmic changes (as opposed to percentage changes), because the growth of the nominal series would be inflated by depreciation by more than one-to-one. For example, if the pass-through rate is 100% and the ongoing inflation rate of both CPI and the trade price in question is 60%, then a 20% depreciation in the real exchange rate would result in not a 20 but a 32 percentage point increase (from 60% to 92%) in the nominal trade price inflation (because $1.6 \times 1.2 = 1.92$). That distortion is eliminated when the log changes of the series are compared–for example, in that case complete pass-through would appear as a one-to-one relationship in the graph.

More importantly than the foregoing, employing 12-month changes rather than month-to-month changes turns out to be the key. The monthly noise in the series proves to obscure the relationship substantially in the monthly-change versions of the same figures. In fact, most other versions of those graphs do not show the relationship as clearly.

As noted earlier, despite the visually-evident nature of the Turkish pass-through behavior in Figures (1) and (2), the estimates reported in the related literature cover a wide range. As shown in Table (1), even if we exclude the outlier of 176 percent, the literature's estimates range from 9 to 100 percent. The standard deviation of

[2]There would be an omitted variable bias in a regression version of the proposed relationship. For example, if the figures instead employed a real-to-real comparison, there could be a question as to whether the relationship might be at least in part driven by movements of the overall price level–since a measure of overall prices would have to be used in the denominator of the two variables, variations in that measure could make both variables move in the same direction. A similar issue could be argued to exist if the figures had used a nominal-to-nominal comparison–in that case, a non-existing relationship in real terms could appear to exist in nominal terms due to the movements of the overall price level, because those movements would make the nominal versions of the two variables comove. Neither of those suspicions of a positive bias exists for Figures (1) and (2).

the estimates of import price pass-through is 35 percentage points for the short run and 47 percentage points for the long run, while the standard deviation of the estimates for export prices is 24 percentage points for both the short and the long run. Appendix A presents a more detailed version of Table (1), which presents additional information regarding those studies.

Why do the existing estimates cover such a wide range? As we discussed above, other apparently plausible ways of graphically illustrating the relationship do not always demonstrate the relationship as clearly as in Figures (1) and (2). It could be that, in a similar fashion, many apparently plausible specifications of the relationship perhaps do not produce good estimates for that relationship. In any event, regardless of what its reason is, the fact remains that the literature has produced a wide range of results for a visually apparent relationship. In stark contrast to that wide range, the detailed data that we use in this paper allow us to estimate the pass-through rates quite accurately–i.e., with low standard deviations.

3 Estimating pass-through using product-level trade data

The baseline regression model that we estimate can be expressed as follows:

$$P_{ijt} = \alpha_0 + \sum_{k=0}^{6} \beta_{1,k} E_{t-k} + \sum_{k=1}^{6} \beta_{2,k} GDP_{t-k} + \sum_{k=0}^{6} \beta_{3,k} W_{t-k} + \sum_{k=0}^{6} \beta_{4,k} P_{t-k}^{Energy} + \sum_{k=0}^{6} \beta_{5,k} P_{t-k}^{Ind} + c_j + a_i + y_t + m_t + \epsilon_{ijt}, \quad (1)$$

where i stands for the 6-digit product, j country (trade partner), and t time. The data are in monthly frequency–see the Data Appendix for details. E_t is the log of nominal effective Turkish lira (TRY) exchange rate and the coefficients on E_t are the main parameters of interest, giving us the baseline pass-through rates. We estimate Equation (1) for imports and exports separately; P_{ijt} is log TRY import price in the regression for import pass-through, and log TRY export price in the regression for export pass-through, while the right-hand-side variables are the same in both regressions. We run several specifications of both regressions, all of them with country fixed effects, c_j, product fixed effects, a_i, year fixed effects, y_t, and month fixed effects, m_t. W_t is a measure of foreign price levels, borrowed from Campa and Goldberg (2005).[3] GDP_t controls for economic activity in Turkey and is interpolated to a monthly series from quarterly data using standard time series methods. Energy and industrial commodities price indices (P_t^{Energy} and P_t^{Ind}) are added to control for exogenous commodity price shocks. The regression is estimated with up to 6 lags on the right-hand-side variables.

We call $\beta_{1,0}$ the short-run pass-through parameter and $\sum_0^6 \beta_{1,k}$ the long-run pass-through parameter in the tables. The presence of year fixed effects restricts the feasible limit on the lags to less than 12, and 6 proves to be more than sufficient given that the lags of regressors beyond the first tend to be insignificant.[4] In all regressions, we weight observations by the value of the transaction in dollars. All standard errors are clustered at the 6-digit product level.

3.1 Baseline results

The results of the regression for imports are shown in Table (2) and for exports in Table (3). All three specifications in both tables contain aforementioned fixed effects for products, trade-partners, years, and months of year. Columns 2 and 3 also contain some interaction terms. One of those is the *country*×*product* interaction term, controlling for the cases where a product might be consistently priced more expensively in some countries than in others–for example, cars imported from Germany might tend to be more expensive than those from Hungary even at the detailed product level. Another interaction term is *country*×*year*, controlling for the cases where a trading-partner might have trade prices higher or lower in a given year–for example, a trading-partner might be in a recession or going

[3]More specifically, it is defined as $W_t \equiv NEE_t \cdot CPI_t / REE_t$, and can be interpreted as a trade-weighted average of foreign price levels.

[4]Note that determining the relationship reliably over longer periods such as several years would probably never be possible, because exchange rate changes are themselves often temporary, and can also be endogenous to upcoming long-term changes in trade and/or trade prices. Moreover, the available export and import price data in the Turkish case are unit-value indices (as opposed to price indices), which can have drifts that can grow sizable over long periods of time.

through some other type of macroeconomic fluctuation that affects its trade prices for the whole year. Finally, the *product*$\times$*month* interaction term is only included in specification 3, which controls for the possibly different seasonality of different products–for example, tomatoes, unlike most other products, tend to be much more expensive in December than those in the summer months.

As noted above, we take the first month's response as the short-run and the total of six months' response as the long-run pass-through estimate. In addition to the lags after the first month being often insignificant, the cumulative six-month response is similar to the first-month response in both tables. The differences between the long-run and short-run estimates are statistically insignificant in all cases, and their magnitudes are economically small. This is especially the case in the last specification that will prove to be the preferred specification–the difference between the long- and the short-run estimates is 1 and 2 percentage points in Tables (2) and (3), respectively. Given the fact that lags are generally insignificant and that the difference between the long-run and the short-run estimates tends to be small, we conclude that the short- and the long-run responses can be represented by the same pass-through value, consistent with the visual impression that Figures (1) and (2) give.

Focusing on the results for imports in Table 2, the short-run pass-through estimates start with 0.92 in the first specification (which has no interaction terms) and fall slightly to 0.89 and 0.88 in the last two specifications. The standard errors also decrease in the later specifications, consistent with the intended purpose of the controls, falling roughly from 0.05 to 0.03. The tests for the difference from unity (i.e., from 100%) are not shown separately but that difference is not significant in the first specification while it is so in the last two. The long-run import pass-through estimates vary in a narrow range and are all significantly lower than unity. Based on these results (especially the preferred specifications 2 and 3, the ones that control for interactions), we conclude that import pass-through is "incomplete," although a pass-through rate of 89% may not be too different economically from the "complete" pass-through value of 100%. The standard errors of the long-run estimates again fall from the first to the third specification, roughly from 0.04 to 0.03. By the third specification, the short-run and long-run estimates produce very similar results, both in terms of the point estimate and its standard error.

Before going on to Table (3) (the export pass-through results), a clarification would perhaps be useful. The definition of pass-through can be a source of confusion. For both imports and exports, pass-through is conventionally defined as the degree to which producers pass on the exchange rate changes to their customers' prices.[5] notes. The convention could have been something else, but it is not: the pass-through rate must tell how much prices change as measured in customers' (i.e., importers') currency. By that usual definition, the values in Table (3) technically do not correspond to the export pass-through rate but rather to $(100 -$ the export pass-through rate$)$.[6] We chose here to report in Table (3) simply the pass-through rate from the 'TRY exchange rate' to the 'TRY export prices'.[7]

Going back to the results for exports in Table (3), the estimates of pass-through from the TRY exchange rate to export prices measured in TRY are all similar in all specifications for both the short and the long run. However, as in Table (2), the standard errors become smaller as we go from specification 1 toward specification 3 and as we move from short run to long run. Thus, the long-term regression from the specification 3, which has the most controls and the smallest standard errors, becomes our preferred specification.

To summarize, the baseline estimates for the rate of pass-through from the TRY exchange rate to TRY trade prices is 0.89 for imports and 0.82 for exports (for both the short and the long run).[8]

[5] It is essentially equivalent to the degree to which producers pass on the changes in their *costs* to their customers, as Feenstra (2015)

[6] This definitional problem does not apply to import pass-through. The values reported for imports in the previous table (in Table 2) are the import pass-through estimates.

[7] Complete pass-through would correspond to a value of 0 by that measure, ignoring the presence of imported inputs. However, Turkish exports have significant imported content, which means that production costs are not fixed in TRY. Even in a perfectly competitive environment, we would not have expected export pass-through to approximate the "complete" value.

[8] The estimates in Table (3) are greater than any reasonable estimates of the Turkish exports' import content. Given

3.2 Estimating pass-through using bilateral exchange rates

We explore whether controlling for the bilateral variation in exchange rates makes a difference in results. We find that it does not. More specifically, we estimate:

$$
\begin{aligned}
P_{ijt} = \alpha_0 + \sum_{k=0}^{6} \beta_{1,k} E_{t-k} + \sum_{k=1}^{6} \beta_{2,k} GDP_{t-k} + \sum_{k=0}^{6} \beta_{3,k} W_{t-k} \\
+ \sum_{k=0}^{6} \beta_{4,k} P_{t-k}^{Energy} + \sum_{k=0}^{6} \beta_{5,k} P_{t-k}^{Ind} + \\
\sum_{k=0}^{6} \beta_{6,k} CPI_{j,t-k} + \sum_{k=0}^{6} \beta_{7,k} E_{j,t-k} + c_j + a_i + y_t + m_t + \epsilon_{ijt}, \quad (2)
\end{aligned}
$$

where $E_{j,t-k}$ is the k^{th} lag of the trade partner j's log nominal exchange rate. Note that the trade partner's CPI 's also included in the regression in order to control for the possible variation in the bilateral trade partner's price level, which could cause variation in $E_{j,t-k}$ with no effect on P_{ijt}, biasing the pass-through estimate toward zero.

The results are shown in Tables (4) and (5). The point estimates are similar to those in Tables (2) and (3). The change in point estimates from the baseline is about one percentage point or less in Specifications 2 and 3. However, there is no improvement in standard errors. To the contrary, they are slightly larger, leaving us little reason for favoring Equation (2) over Equation (1). In short, controlling for the trade partners' exchange rates does not improve the precision of the estimates, although it provides a reliable robustness check.

4 The difference between the export and import pass-through rates

The difference between the two pass-through rates is also a statistic that can be useful. That difference, if estimated with sufficient accuracy, can be combined with

the small standard errors of those estimates, one can conclude that these export estimates indicate a very "imperfect" (or incomplete) pass-through behavior.

estimates of trade elasticities (i.e., the elasticities of trade volumes with respect to the exchange rate) to produce estimates of the response of the current account to the exchange rate. The difference between the two pass-through rates can, of course, be computed from Tables (2) and (3) by simply taking their difference (in this case 0.89-0.82=0.07), but to be able to calculate the standard error of that difference one would need to know the correlation rate of the two pass-through rates. We do not know that correlation because the equations are estimated by two separate regressions. To be able to determine that correlation, the two pass-through rates need to be estimated simultaneously. The following regression equation is therefore estimated by pooling all the export and import data:

$$P_{ijt} = \alpha_0 + \sum_{k=0}^{6} \beta_{1,k}^{X} E_{t-k} X_{ijt} + \sum_{k=0}^{6} \beta_{1,k}^{M} E_{t-k}(1 - X_{ijt}) + \sum_{k=1}^{6} \beta_{2,k} GDP_{t-k} + \sum_{k=0}^{6} \beta_{3,k} W_{t-k} + \sum_{k=0}^{6} \beta_{4,k} P_{t-k}^{Energy} + \sum_{k=0}^{6} \beta_{5,k} P_{t-k}^{Ind} + c_j + a_i + y_t + m_t + \epsilon_{ijt}, \quad (3)$$

where X_{ijt} is an indicator variable that takes the value of 0 if the observation in question is for imports and 1 for exports.

The estimates for the difference of the import and export pass-through rates obtained from this pooled-data regression, Equation (3), are shown in Table (6). This equation also produces estimates of the import and export pass-through rates, but those are very similar (both in terms of the point estimates and their standard errors) to the corresponding estimates shown earlier in Tables (2) and (3); therefore, they are not repeated in this table. Note that those new pass-through estimates are not expected to be (and are not) *exactly* identical to those in the earlier tables, because pooling the data for this joint regression results in the omission of some observations. Table (6) shows that the standard errors of the difference estimates are not large per se, but the difference estimates are themselves small, rendering those estimates statistically insignificant, with the exception of the long-run estimate from specification 3. The standard error of that difference estimate is 0.0352.

Remembering that the point estimates from our preferred specification are 0.89 and 0.82 for the two pass-through rates, their difference, which equals 0.08 after rounding, could be interpreted as having a ± 2 sigma range of roughly [0.01, 0.15].

5 Comparison of micro and macro estimates

Motivated by the apparent time series relationship in Figures (1) and (2), we estimate the pass-through rates using those plotted aggregate time series data in order to see if we can obtain similar point estimates, and to find out if and how much the accuracy of the new estimates differs from the accuracy in the micro regressions presented above. For comparability of the new estimates, we aim a specification that is similar to the one represented by Equation (1).

A difficulty in constructing a time-series version of the same estimate is that a time series regression cannot have the same year and month fixed effects employed in the microeconometric estimates. That creates an additional issue because, in Equation (1), P_t and E_t are integrated variables, and using them in levels in a time-series regression would introduce a “spurious regression" problem.[9] We therefore have to use a differenced version of Equation (1) to eliminate the unit roots. However, we use 12-month log differences of those variables (denoted by “ˆ” hats), as in Figures (1) and (2), rather than monthly differences. As noted earlier, monthly changes tend to be too noisy–the relationship is not as clear in versions of Figure (1) or (2) that use monthly changes. By employing 12-month changes, we aim to make the regression parallel to Figures (1) and (2), with the intention of making the regression more likely to capture the evident pass-through relationships in those figures. In contrast, using monthly changes essentially introduces substantial noise on both sides of the equation, meaning that the estimates would be biased toward zero.

Another difference from the micro regressions related to being unable to use

[9] In a regression of an I(1) variable over other I(1) variables, long-term drifts in the left- and right-hand side of the variables cause large and random deviations in the estimated coefficients from their true means.

the year and month fixed effects is that we now need to use real versions of the exchange rates and trade prices. The reason is that inflation is not negligible in the sample and it makes all nominal quantities move in tandem. Therefore, we replace P and E by their real versions, p and e.[10] The control variables and the lag lengths are the same as in the micro estimation. Consequently, the estimated time series equation becomes:

$$\hat{p}_t = \alpha_0 + \sum_{k=0}^{6} \beta_{1,k}\hat{e}_{t-k} + \sum_{k=1}^{6} \beta_{2,k}G\hat{D}P_{t-k} + \sum_{k=0}^{6} \beta_{3,k}\hat{W}_{t-k} + \sum_{k=0}^{6} \beta_{4,k}\hat{P}^{Energy}_{t-k} + \sum_{k=0}^{6} \beta_{5,k}\hat{P}^{Ind}_{t-k} + \epsilon_t, \quad (4)$$

where, as in the panel estimation, p_t is import price in the import pass-through regression and export price in the export pass-through regression.[11] Note that using 12-month changes creates an auto-correlation problem in the error term of this time-series regression, which we address in the estimation.[12]

Table (7) shows the results obtained by estimating Equation (4) under the column "Macro," next to the results taken from the earlier tables summarizing the results of the panel regressions (but displayed with fewer digits) for easier comparison. The long-run macro estimates are not noticeably different from those obtained by the panel regressions, which is a positive outcome that confirms the earlier estimates. In contrast, the short-run macro estimates are different from those obtained by the panel regressions by 6 to 10 percentage points (respectively in exports and imports).

Those differences are notable, but are fairly small compared to the variation we see in the literature's estimates (Table 1). Note that the short-run micro estimates

[10]More precisely, p_t is real import prices ($P_{M,t}/CPI_t$) in the import pass-through regression and is real export prices ($P_{X,t}/CPI_t$) in the export pass-trough regression, where $P_{M,t}$ and $P_{X,t}$ are import and export price series published by TurkStat in dollars multiplied by the \$/TRY exchange rate published by the CBRT, while e_t is the real effective TRY exchange rate index published by the BIS.

[11]Note that it could be argued the W terms (which proxy for foreign CPIs) can now be dropped from the specification in Equation (4), because this specification uses the real versions of both the trade price and the exchange rate, removing the theoretical necessity for the W terms, making those terms arguably redundant. But removing the W terms does not make an important difference in results, so we report the estimates including those terms to preserve the parallel to the micro regressions.

[12]We correct for heteroskedasticity and auto-correlation.

are still within the confidence bands one would have obtained from the macro estimates, but the converse is not true–the panel regressions would reject the point estimates from the macro regression at 5% significance level for imports and at close to 10% for exports. The more important message from Table (7) is about the standard errors. The preferred panel specifications (columns 2 and 3), especially specification 3, estimate the pass-through rates with substantially smaller standard errors than the macro estimates. It should be noted that this comparison might be understating the advantages of a micro econometric approach: the wide range of estimates in Table (1) establishes that pass-through estimation can go quite wrong with aggregate data, depending on the presumed specification.

6 Sectoral results

While we estimate a relatively large exchange rate pass-through for Turkey on average, pass-through can vary across sectors and it could be much lower in some sectors. We group the 2-digit product codes into five groups as follows: *food and agricultural products*, *chemicals and plastic*, *leathers and textiles*, *unprocessed materials* and *processed/manufactured goods*.[13] We then estimate the export and import pass-through rates for each category separately using Specification 4.

The results are presented in Tables 8 and 9. The estimates of pass-through rates now have a much wider range–from 0.53 to 0.98–and often have much larger standard errors than the estimates for aggregate exports and imports. We focus on the short-term and long-term estimates rather than the details of the lag structure, as before. Unlike before, the long-term pass-through estimates are sometimes different from the short-term estimates, although a reason for that finding is that the standard errors of the point estimates are larger. In sectors other than *food and agri-*

[13] The details are as follows. 1. *Food and agricultural products*: Live animals and animal products, vegetable products, animal and vegetable fats and oils, prepared foodstuffs, beverages and tobacco. 2. *Chemicals and plastic*: Chemical products and plastic. 3. *Leathers and textiles*: Leather, textiles, clothing accessories. 4. *Unprocessed materials*: Minerals, wood, paper, glass and stones, semi-precious stones, base metals. 5. *Processed/manufactured goods*: Machinery, electronics, vehicles and aircraft, optical and medical gear, arms and ammunition. We leave out sectors 20 and 21 (other miscellaneous manufactured goods, works of art).

cultural products, pass-through to TL prices is in the range of 84-96% in imports and 80-90% in exports. In contrast, *food and agricultural products* have much lower pass-through rates for both imports and exports, which are estimated at around 70% in the short-run, and at 53% and 71% in the long-run, respectively, for imports and exports. Reasons for the weaker pass-through in *food and agriculture* might include greater ability to substitute domestic products in the case of imports, and greater competition from other domestic producers in the case of exports. The pass-through rates for imports and exports differ the most in the *processed goods* category–the long-run estimate is 96% for imports and 80% for exports.

7 Conclusion

Using highly-detailed (6-digit product-level) bilateral monthly import and export data, we estimate that the exchange rate pass-through rates in Turkey from the TRY exchange rate to TRY-denominated import and export prices are 89% and 82%, respectively. There are no apparent lags in that pass-through behavior. Those estimates are from a baseline specification that uses the TRY effective exchange rate. Bilateral data actually allow us to use bilateral exchange rates in the specification, but using them does not provide an improvement–it produces nearly identical pass-through point estimates but with larger standard errors. We therefore consider the specification with bilateral exchange rates as providing a robustness check rather than making it our preferred baseline.

We also estimate separately the difference between the import and export pass-through rates. That difference is important–the larger it is, the more difficult it is for the trade balance to improve in response to depreciation for given values of trade elasticities.[14] Central to the Marshall-Lerner condition is the assumption that the difference in question is unity (i.e., 100 percentage points), which proves to be very inaccurate in the Turkish case, as our estimates are in the range of only

[14]Trade elasticities are the elasticity of export and import quantities in response to the exchange rate.

5 to 9 percentage points, with the baseline preferred value of 8 percentage points. Those difference estimates are not themselves significantly different from zero in a robust way–their standard errors are 4 to 6 percentage points–but it is clear that the difference is small and dramatically below the value of 100 percentage points assumed in the Marshall-Lerner condition. We are not aware of a similar statistical inference exercise carried out in the literature (for Turkey or otherwise) for the difference in export and import pass-through rates, for which we provide a practical approach in this paper.

We find that our detailed data enable us to estimate the pass-through rates with better reliability and precision than we could by aggregate time-series data. Inspecting the literature for the Turkish case, the wide range of pass-through estimates (which are all obtained by aggregate time-series data and methods) show that pass-through estimates that rely on aggregate data can be quite misleading, depending on the specification. The pass-through estimates from our own carefully constructed macro specification are not economically too different from those we obtain in our preferred micro specification, but the standard errors of the estimates from that macro specification are notably larger, making the estimation with our micro specification much more preferable.

We also analyze the sectoral variation in pass-through. We find that the pass-through rates are substantially lower in the *food and agricultural products* category, for both imports and exports, which are estimated at around 70% in the short-run and around 60% or less in the long-run. Pass-through rates are the highest in the *processed goods* and *leathers and textiles* categories for both imports and exports, staying above 90% in the short-run and above 80% in the long-run.

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Figure 1: Changes in the real TRY exchange rate and **import** prices in current TRY

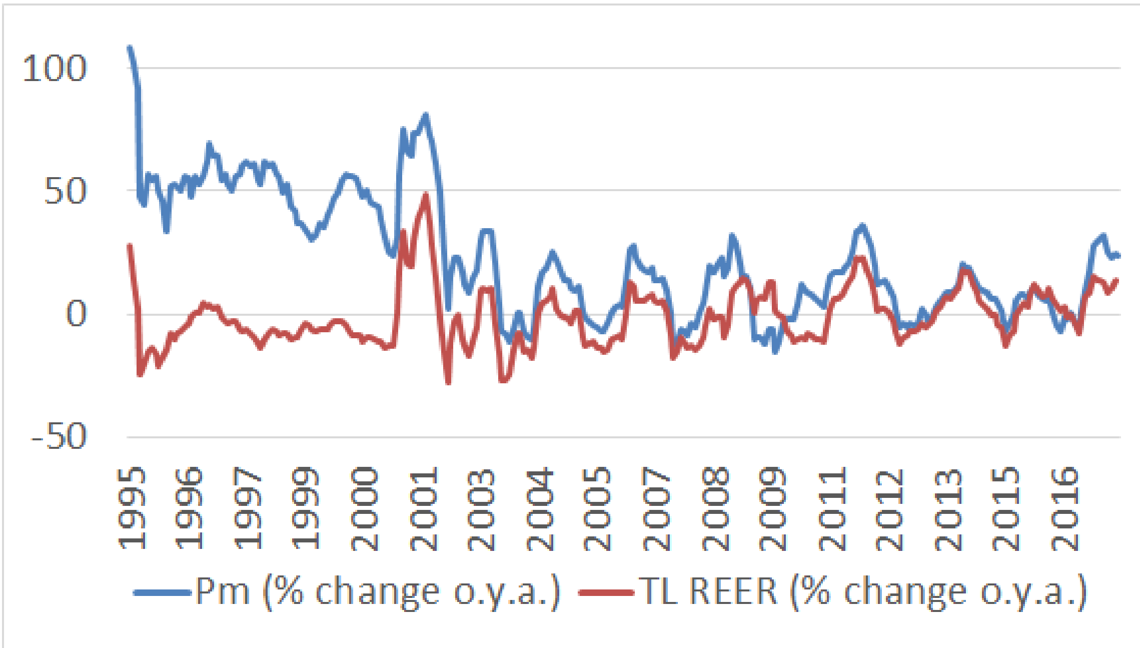

Figure 2: Changes in the real TRY exchange rate and **export** prices in current TRY

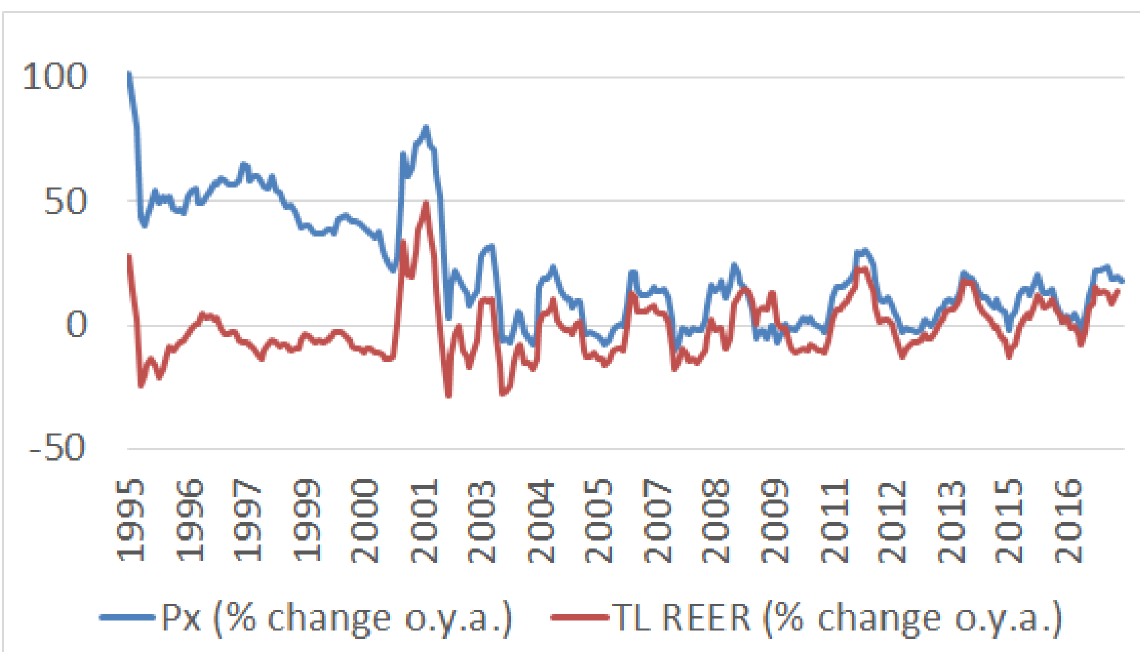

Table 1: Estimates of exchange rate pass-through in Turkey (%)

	Import prices		Export prices	
	Short-run	Long-run	Short-run	Long-run
Türkcan (2005)	95	98		
Pain et al. (2005)	69	100	78	57
Ca'Zorzi et al. (2007)	91	176		
Bussière and Peltonen (2008)	15	24	28	45
Tekin and Yazgan (2009)	60	45	68	29
María-Dolores (2010)	09	10		
Toraganli (2010)				60
Brun-Aguerre et al. (2012)	100	97		
Bussière et al. (2014)	99	99	60	28
Ülke (2015)*		73		
Choudhri and Hakura (2015)	96	94	91	91
Gopinath (2015)	93	100		
mean	73	83	65	52
median	92	97	68	51
standard deviation	35	45	24	24

Note: Authors' summary from the listed papers. See Appendix A table for greater detail. The rate presented for Ülke (2015) is his estimate for the period between January 2003 and December 2013–his estimate for before 2002 is not included to avoid another line for the same study.

Table 2: Baseline import pass-through estimates

		1	2	3
Exchange rate	t	0.9227***	0.8947***	0.8811***
		(0.0495)	(0.0378)	(0.0322)
	t-1	-0.0094	0.0125	0.0519
		(0.0877)	(0.0596)	(0.0387)
	t-2	0.0134	-0.0243	-0.0335
		(0.0941)	(0.0633)	(0.0437)
	t-3	0.1104	0.0819	0.0620
		(0.1066)	(0.0705)	(0.0490)
	t-4	-0.1281	-0.0885	-0.0630
		(0.0838)	(0.0555)	(0.0444)
	t-5	0.0592	0.0471	0.0316
		(0.0750)	(0.0517)	(0.0472)
	t-6	-0.0993	-0.0668	-0.0368
		(0.0670)	(0.0465)	(0.0369)
Country x Product		-	+	+
Country x Year		-	+	+
Product x Month		-	-	+
N		6,857,012	6,804,688	6,802,054
Summary	Short-run	0.9227***	0.8947***	0.8811***
		(0.0495)	(0.0378)	(0.0322)
	Long-run	0.8688***	0.8565***	0.8933***
		(0.0397)	(0.0306)	(0.0280)
	Difference	-0.0539	-0.0381	0.0122
	(Long−Short-run)	(0.0730)	(0.0529)	(0.0422)

*** p<0.01, ** p<0.05, * p<0.1. The standard errors are clustered at the product level. Dependent variable: log import price level in TRY. Exchange rate is the log of nominal effective TRY exchange rate (higher exchange rate corresponds to less valuable TRY). All regressions include controls for prices of oil and of industrial commodities, and fixed effects for products, years, months of the year and countries.

Table 3: Baseline export pass-through estimates

		1	2	3
Exchange rate	t	0.8083***	0.8289***	0.8371***
		(0.0532)	(0.0417)	(0.0392)
	t-1	0.047	0.006	0.0084
		(0.0508)	(0.0531)	(0.0447)
	t-2	-0.0524	-0.0472	-0.0508
		(0.0829)	(0.0725)	(0.0703)
	t-3	0.0077	0.0123	0.0208
		(0.0580)	(0.0464)	(0.0497)
	t-4	0.0098	0.0482	0.0636**
		(0.0587)	(0.0312)	(0.0272)
	t-5	0.0722	-0.0008	-0.0303
		(0.0732)	(0.0427)	(0.0342)
	t-6	-0.0641	-0.0381	-0.0329*
		(0.0404)	(0.0237)	(0.0194)
Country x Product		-	+	+
Country x Year		-	+	+
Product x Month		-	-	+
N		11,711,860	11,629,066	11,625,377
Summary	Short-run	0.8083***	0.8289***	0.8371***
		(0.0532)	(0.0417)	(0.0392)
	Long-run	0.8283***	0.8093***	0.8160***
		(0.0464)	(0.0303)	(0.0279)
	Difference	0.0200	-0.0196	-0.0212
	(Long−Short-run)	(0.0664)	(0.0437)	(0.0416)

*** $p<0.01$, ** $p<0.05$, * $p<0.1$. The standard errors are clustered at the good level. Dependent variable: log export price level in TRY. Exchange rate is the log of nominal effective TRY exchange rate (higher exchange rate corresponds to less valuable TRY). All regressions include controls for prices of oil and of industrial commodities, and fixed effects for products, years, months of the year and countries. Note that this table shows the response of Turkish export prices as measured in TRY. The conventional definition of pass-through would look at the response of prices measured in importers' currency, which would correspond to 100 minus the values shown in this table.

Table 4: Import pass-through estimates using bilateral exchange rates

		1	2	3
Exchange rate$_t$	t	0.9037***	0.8956***	0.8783***
		(0.0572)	(0.0411)	(0.0347)
	t-1	-0.0109	-0.0079	0.0345
		(0.0984)	(0.0657)	(0.0407)
	t-2	0.0247	-0.0004	-0.0018
		(0.1029)	(0.0703)	(0.0473)
	t-3	0.1017	0.0719	0.0416
		(0.1173)	(0.0781)	(0.0522)
	t-4	-0.0876	-0.0846	-0.0527
		(0.0859)	(0.0596)	(0.0465)
	t-5	0.0563	0.0587	0.0396
		(0.0789)	(0.0548)	(0.0488)
	t-6	-0.1080	-0.0674	-0.0356
		(0.0714)	(0.0493)	(0.0382)
Exchange rate$_{j,t}$	t	-0.4763***	-0.2514***	-0.2477***
		(0.0761)	(0.0567)	(0.0554)
	t-1	0.0580	0.0859	0.0544
		(0.0785)	(0.0703)	(0.0674)
	t-2	0.0426	0.1015	0.1301
		(0.1234)	(0.1083)	(0.1049)
	t-3	-0.0525	-0.1238	-0.1006
		(0.1484)	(0.1036)	(0.0985)
	t-4	-0.0393	-0.0290	-0.0527
		(0.0576)	(0.0470)	(0.0582)
	t-5	0.0250	0.1364**	0.1201*
		(0.0707)	(0.0683)	(0.0717)
	t-6	0.0215	-0.1211**	-0.0774**
		(0.0770)	(0.0494)	(0.0372)
Country x Product		-	+	+
Country x Year		-	+	+
Product x Month		-	-	+
Exchange rate$_t$	ST	0.9037	0.8956	0.8783
	LT	0.8799	0.8659	0.9039
Exchange rate$_{j,t}$	ST	-0.4763	-0.2514	-0.2477
	LT	-0.4210	-0.2015	-0.1738
N		6,222,699	6,190,900	6,188,171

*** p<0.01, ** p<0.05, * p<0.1. The standard errors are clustered at the good level.

Table 5: Export pass-through estimates using bilateral exchange rates

		1	2	3
Exchange rate$_t$	t	0.8478***	0.8378***	0.8484***
		(0.0504)	(0.0489)	(0.0453)
	t-1	0.0214	-0.0015	0.0169
		(0.0544)	(0.0603)	(0.0502)
	t-2	-0.0473	-0.0367	-0.0602
		(0.0751)	(0.0772)	(0.0747)
	t-3	0.0008	-0.003	0.0107
		(0.0548)	(0.0499)	(0.0535)
	t-4	0.0224	0.0456	0.0738**
		(0.0615)	(0.0362)	(0.0356)
	t-5	0.0818	0.0168	-0.0253
		(0.0733)	(0.0489)	(0.0396)
	t-6	-0.0855*	-0.0463*	-0.0377
		(0.0494)	(0.0280)	(0.0237)
Exchange rate$_{j,t}$	t	-0.2735***	-0.1993***	-0.3009***
		(0.0562)	(0.0416)	(0.0916)
	t-1	0.2076*	0.0838	0.3088*
		(0.1216)	(0.0772)	(0.1855)
	t-2	-0.1068	-0.0261	-0.1989
		(0.1579)	(0.0677)	(0.1409)
	t-3	-0.0847	0.1568*	0.2677**
		(0.0960)	(0.0830)	(0.1043)
	t-4	0.2446	-0.1408*	-0.2304**
		(0.2042)	(0.0804)	(0.0998)
	t-5	0.0075	0.1612*	0.1811*
		(0.0976)	(0.0847)	(0.1045)
	t-6	-0.0118	-0.0601	-0.0398
		(0.0762)	(0.0460)	(0.0508)
Country x Product		-	+	+
Country x Year		-	+	+
Product x Month		-	-	+
Exchange rate$_t$	ST	0.8478	0.8378	0.8484
	LT	0.8414	0.8127	0.8266
Exchange rate$_{j,t}$	ST	-0.2735	-0.1993	-0.3009
	LT	-0.0171	-0.0245	-0.0124
N		7,414,677	7,373,725	7,369,410

*** $p<0.01$, ** $p<0.05$, * $p<0.1$. The standard errors are clustered at the good level. Note that this table shows the response of Turkish export prices as measured in TRY. The conventional definition of pass-through would look at the response of prices measured in importers' currency, which would correspond to 100 minus the values shown in this table.

Table 6: Estimation of the difference between import pass-through and export pass-through rates

A. Short-term			
	1	2	3
Separate estimations	0.1144	0.0658	0.0440
	(na)	(na)	(na)
Joint estimation	0.1180	0.0728	0.0527
	(0.0772)	(0.0569)	(0.0481)

B. Long-term			
	1	2	3
Separate estimations	0.0404	0.0473	0.0774
	(na)	(na)	(na)
Joint estimation	0.0463	0.0540	0.0851**
	(0.0600)	(0.0393)	(0.0352)

** $p<0.05$. The standard errors are clustered at the good level and shown in parenthesis. No standard errors are shown for the separate estimations because the covariance of the estimates from independently run regressions is not known. The specifications 1-3 are as in Tables 2-5 (see Table 2 for their differences). To clarify the meaning of "difference," this table shows the difference in the exchange rate elasticity of Turkish import and export prices when both prices are measured in the same currency.

Table 7: Comparison of pass-through estimates from micro and macro estimations

		1	2	3	Macro
Import pass-through	ST	0.92	0.89	0.88	0.98
		(0.050)	(0.038)	(0.032)	(0.073)
	LT	0.87	0.86	0.89	0.90
		(0.040)	(0.031)	(0.028)	(0.050)
Export pass-through	ST	0.81	0.83	0.84	0.90
		(0.053)	(0.042)	(0.039)	(0.060)
	LT	0.83	0.81	0.82	0.82
		(0.046)	(0.030)	(0.028)	(0.044)

The standard errors are in parenthesis. They are clustered at the good level for the micro estimates and obtained by HAC for the macro estimates. The specifications 1-3 are as in Tables 2-5 (see Table 2 for their differences). All the estimates are significantly different from zero with $p<1\%$. Note that this table shows the response of Turkish export and import prices as measured in TRY. The conventional definition of pass-through would look at the response of prices measured in importers' currency, which, for exports (in the bottom half of the table), would correspond to 100 minus the shown value.

Table 8: Import pass through estimates by sector

		Food and agricultural products	Chemicals and plastic	Leathers and textiles	Unprocessed materials	Processed goods
Exchange rate	t	0.6932***	0.8921***	0.9425***	0.8443***	0.9793***
		(0.0441)	(0.0449)	(0.0236)	(0.0640)	(0.0474)
	t-1	0.0721	0.0366	-0.0161	-0.0359	0.1005
		(0.0680)	(0.0560)	(0.0287)	(0.0466)	(0.0854)
	t-2	-0.0568	0.0144	-0.0294	-0.0089	-0.0354
		(0.0733)	(0.0514)	(0.0243)	(0.0384)	(0.0949)
	t-3	0.0324	0.0567	0.0196	0.0614	0.0130
		(0.0481)	(0.0680)	(0.0315)	(0.0659)	(0.1028)
	t-4	0.1117*	-0.1406*	-0.0433**	-0.0086	-0.1008
		(0.0589)	(0.0839)	(0.0220)	(0.0413)	(0.1032)
	t-5	-0.2056**	-0.0944	0.0430	-0.0361	0.1667**
		(0.0806)	(0.0724)	(0.0309)	(0.0744)	(0.0831)
	t-6	-0.0250	0.0871	-0.0765***	0.0548	-0.1605**
		(0.0604)	(0.0672)	(0.0254)	(0.0508)	(0.0701)
Short-run		0.6932***	0.8921***	0.9425***	0.8443***	0.9793***
		(0.0441)	(0.0449)	(0.0236)	(0.0640)	(0.0474)
Long-run		0.6220***	0.8519***	0.8398***	0.8710***	0.9628***
		(0.0706)	(0.0291)	(0.0536)	(0.0386)	(0.0434)
N		242,100	1,381,780	1,255,156	1,439,841	2,219,190

*** p<0.01, ** p<0.05, * p<0.1. The standard errors are clustered at the good level. For this table only specification 3 is used (the specification with the country-good country-year and good-month interactions).

Table 9: Export pass through estimates by sector

		Food and agricultural products	Chemicals and plastic	Leathers and textiles	Unprocessed materials	Processed goods
Exchange rate	t	0.7119***	0.8257***	0.9450***	0.7738***	0.9178***
		(0.0508)	(0.0376)	(0.0158)	(0.0658)	(0.0822)
	t-1	0.0414	0.0942**	-0.0345***	-0.0756	0.0637
		(0.0435)	(0.0406)	(0.0126)	(0.0471)	(0.1474)
	t-2	-0.1449***	-0.0266	-0.0012	0.1102*	-0.1573
		(0.0465)	(0.0538)	(0.0188)	(0.0582)	(0.1993)
	t-3	-0.1192	-0.0035	-0.0211	0.0342	0.0379
		(0.0724)	(0.0556)	(0.0162)	(0.0510)	(0.1236)
	t-4	0.1669***	-0.0217	0.0314*	0.0666	0.0360
		(0.0475)	(0.0535)	(0.0164)	(0.0412)	(0.0531)
	t-5	-0.2584***	-0.0557	-0.0607***	0.0428	0.0543
		(0.0422)	(0.0467)	(0.0178)	(0.0781)	(0.0610)
	t-6	0.1362***	0.0156	-0.0515***	-0.0420	-0.1481**
		(0.0432)	(0.0342)	(0.0151)	(0.0464)	(0.0606)
Short-run		0.7119***	0.8257***	0.9450***	0.7738***	0.9178***
		(0.0508)	(0.0376)	(0.0158)	(0.0658)	(0.0822)
Long-run		0.5339***	0.8280***	0.8074***	0.9100***	0.8043***
		(0.0716)	(0.0292)	(0.0159)	(0.0434)	(0.0476)
N		896,766	1,674,631	3,055,835	2,641,773	3,032,064

*** p<0.01, ** p<0.05, * p<0.1. The standard errors are clustered at the good level. For this table only specification 3 is used (the specification with the country-good country-year and good-month interactions). Note that this table shows the response of Turkish export prices as measured in TRY. The conventional definition of pass-through would look at the response of prices measured in importers' currency, which would correspond to 100 minus the values shown in this table.

Appendix A. Summary of the empirical literature on exchange rate pass-through in Turkey

	PASS-THROUGH ESTIMATES				Variable of Elasticity	Period	Indicators of significance				Horizon Lengths (ST:Short-term ; LT:Long-term)	Method	Number of Explanatory Variables
	Short Run		Long Run				Short Run		Long Run				
	Import Prices	Export Prices	Import Prices	Export Prices			Import Prices	Export Prices	Import Prices	Export Prices			
Turkcan (2005)	95%		98%		Export and import unit values in TL	1989Q1-1996Q4	Not significantly different from zero or one at 5% significance level		Not significantly different from zero or one at 5% significance level		ST: Current period; LT: 1 year	Dynamic OLS	4 variables
Pain et al.(2005)	69%	78%	100%	57%	Export and import price indices in domestic currency	1982-2002 Quarterly	t-ratio: 49.6	t-ratio:17	Complete pass-through is imposed in the equation	t-ratio:17	ST: 1 qrtr. ; LT: Cointegration	Cointegration, ECM and non-linear least squares.	4 for LT eqn, 7 for ST eqn
Ca'Zorzi et. al. (2007)	91%		176%		Import price index in domestic currency	1975:1 to 2004:1					ST: 4 qrtrs.; LT: 8 qrtrs (see Notes)	VAR	6 variables
Bussiere and Peltonen (2008)	15%	28%	24%	45%	Import and Export prices in domestic currency	1980Q1-2006Q2	Not statistically significant from zero at 10%	Not statistically significant from zero at 10%	Not statistically significant from zero at 10%	Not statistically significant from zero at 10%	ST: Current period ; LT: 3 months	Dynamic OLS	4 variables
Tekin and Yazgan (2009)	60%	45%	68%	29%	Export unit values in foreign currency; Import unit values in local currency	1988Q1-2004Q3	p-value:0	p-value:0	asymptotic standard error of 0.1231	asymptotic standard error: 0.15	ST: 3 months; LT: Cointegration	VEC and ECM Model	3 variables
Maria-Dolores (2010)	9%		10%		Import unit values in domestic currency	2000:1-2006:12	Statistically different from one		Statistically different from one		ST: Current Period ; LT: 4 months	Dynamic OLS and cointegration	10 variables
Toraganlı (2010)				60%	Export unit values in domestic currency	1995-2007				z-score above 2	LT: See Notes	See Notes	3 variables
Brun-Aguerre et al. (2012)	100%		97%		Import price in local currency	1997Q1-2009Q3	Significant at 1%		Significant at 1%		ST: 3 months ; LT: Cointegration	Error Correction Model	3 variables
Bussiere et al. (2014)	99%	60%	99%	28%	Export and import prices in domestic currency	1990Q1-2011Q2	t-statistic:6.17	t-statistic:7.75	standard error: 0.16	standard error: 0.31	ST: 1 quarter ; LT: Cointegration	Dynamic OLS	3 variables
Ulke (2015)			73% ; 100%		Import unit value index denominated in TL	2003:1-2013:12 1998:1-2002:12					ST: Current period; LT: 4 months	IVAR	4 variables
Choudhri and Hakura (2015)	96%	91%	94%	91%	Import and export prices in home currency	1979-2010 Quarterly	Standard error: 0.055	Standard error: 0.024	Standard error: 0.069	Standard error: 0.046	ST: Current period ; LT: 1 year	DSGE & OLS& VAR	9 variables
Gopinath (2015)	93%		100%		Import price in local currency	1995-2015 Quarterly	N/A for aggregate imports. For the manufacturing sub-sample, s.e is 0.06		N/A for aggregate imports. For the manufacturing sub-sample, s.e is 0.08		ST: 3 months ; LT: 24 months	Dynamic OLS	2 variables

Notes: The significance levels are for the difference of the coefficient from the null of zero, unless stated otherwise. The significance levels in some cases are not reported clearly (especially in multi-country studies); in those cases the corresponding cells in the significance columns are left blank. Choudhri and Hakura (2012) study is not included given that their 2015 paper is already in the list. Abalı (2004) is also not listed, as she focues on pass-through in broad 3-digit manufacturing sectors rather than all of manufacturing. (Abalı's pass-through results vary from "no pass-through" to "complete pass-through" across the eight manufacturing sectors she considers.) The Ca'Zorzi et al study does not specify any horizons as short or long term, but report results for 4 and 8 quarters. Toraganlı obtains results by jointly estimating a set of equations derived from a firm profit maximization problem.

Appendix B. Data

Monthly import and export quantities as well as import and export prices are obtained from TurkStat at 6-digit industry detail. The dataset covers 5565 different 6-digit sectors, and details Turkey's bilateral trade with more than 200 countries at monthly frequency. These data are not published by Turkstat but are available from Turkstat through a standardized request procedure. Original data are in US dollars, which we convert to TRY by the monthly exchange rate data published by the Central Bank of Turkey. The effective exchange rates are from the BIS. Oil price and industrial commodity price indices that we use as controls in the regressions are from the IMF. Bilateral foreign exchange rate data are taken from the IMF and the World Bank. GDP data are also from TurkStat.

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