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MT-DP – 2015/32

How do exporters react to the prices of their competitors?

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Abstract

This paper uses firm-product-destination level trade data from Hungary linked to Eurostat data on unit values and quantities in production, imports and exports of products in EU member states to see how firms react following price and exchange rate changes in their export markets. The results show that exchange rate pass-through is similar to that found in other countries, but the elasticity with respect to changes in the market price is only about a precisely estimated 0.02, suggesting that firms adjust their markups very differently following exchange rate and price shocks. In addition, quantity reaction after a change in the market price is quite small, suggesting a very low residual demand elasticity. Regarding heterogeneity, the paper finds that exchange rate pass-through is more incomplete for larger firms, while reaction to price changes is stronger for products which Hungary competes with low price competitors. These results are not easy to explain in a flexible price model, but can be in line with multi-year contracts which handle different shocks differently.

Keywords: F14, F31, F41

JEL classification: exchange rate pass-through, reaction to price changes, trade microdata, Hungary

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Hogyan reagálnak az exportáló vállalatok a versenytársaik áraira?

Muraközy Balázs

Összefoglaló

Ez a tanulmány magyar vállalat-, termék-, célországszintű külkereskedelmi adatokat köt össze az EU-országok termékszintű import-, export- és termelési adataival annak kiderítésére, hogy milyen módon reagálnak a vállalatok az árak és az árfolyam változására. Az árfolyam változására hasonlóan reagálnak a vállalatok, mint ahogy azt más országok esetében kimutatták, de a piaci árváltozásra vonatkozó rugalmasság mindössze – pontosan becsülve – 0.02. Mindez arra utal, hogy a vállalatok eltérő módon változtatják meg haszonkulcsaikat a kétféle (ár- és árfolyam-) sokkot követően. Emellett a piaci árváltozást követő mennyiségváltozás is kicsi, ami rendkívül alacsony reziduális keresleti árrugalmasságra utal. A tanulmány ezekben a rugalmasságokban heterogenitást is kimutat: a nagyobb vállalatok a valutaárfolyam-változás kisebb részét hárítják át és a piaci árra adott árreakció erősebb az olyan termékek esetében, amelyekkel Magyarország inkább alacsony árszintű országokkal versenyez. Ezeket az eredményeket nem könnyű megmagyarázni egy rugalmas árakat feltételező modellben, de összhangban lehetnek olyan hosszú távú szerződésekkel, amelyek eltérő módon kezelik a különböző sokkokat.

Tárgyszavak: árfolyam-átgyűrűzés, árváltozásra adott reakciók, külkereskedelmi mikroadat, Magyarország.

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June 22, 2015

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1 Introduction

How firms react to exogenous shocks and prices of their competitors is a question with much theoretical and policy relevance. It shows how flexibly firms can adjust to shocks in their different markets and whether they have market power to affect prices or market developments in general. It also helps understanding how shocks such as changes in tariffs and exchange rates affect prices and sales on these markets. Such understanding may help in designing beneficial trade and monetary policies in open economies.

In the case of small open economies with firms having small shares on their export markets, different conjectures about market structure have very different predictions for these adjustments. If firms are price-takers, for example, they may either follow the prices of their competitors closely or simply exit whenever a shock is too large to operate profitably in the market. Under the assumptions of monopolistic competition with CES preferences, however, firms have constant markups, hence changes in competitors' prices do not affect their prices. Oligopolistic market structures predict a response between these two extremes.

Studying such reactions also helps in understanding the potential rigidities in firm pricing. Comparing the reactions to different shocks – exchange rate, price, cost – one can infer whether predictions of a flexible price model hold, i.e. whether firms face different types of rigidities when responding to different types of costs. Understanding such rigidities at the micro level may help in understanding macro-level reactions to different shocks.

The aim of this paper is to provide empirical evidence for the strength of the reaction of firms to competitors' prices. For this exercise, it will use data from a small open economy, Hungary, and link detailed trade data with production, import and export data from European countries. I will use the flexible price oligopolistic model of Atkeson and Burstein [2008] as a baseline to guide the empirical exercise and show whether and how pricing behavior deviates from this baseline.

While the novelty of this paper is that it studies reactions of firms to competitors' prices directly, it also focuses in exchange rate pass-through and as a result, it is strongly linked to the literature on this question (see Engel [2001]; Burstein and Gopinath [2013]). In this literature, the important finding that exchange rate pass-through is incomplete motivated a number of explanations ranging from different pricing frictions to models emphasizing variable markups.

In the literature, four main channels have been proposed to explain this phenomenon. The first channel is *local currency pricing*, according to which exporters face price stickiness in local currencies of the destination market (Gopinath and Rigobon [2008]). The second channel results from *local distribution costs* (Burstein et al. [2003]; Goldberg and Campa [2010]), which are denominated in destination country currency. A third channel is proposed and tested by Amiti et al. [2012], who suggest that *imported inputs* may play an important role in incomplete exchange rate pass through.

The baseline framework used here emphasizes a fourth channel: *variable markups and pricing to market*. Recent work on this channel is summarized by

Burstein and Gopinath [2013]. Atkeson and Burstein [2008] develop a quantitative model of variable markups and show that with suitable parametrization it reproduces deviations from purchasing power parity observed in aggregate data. A number of recent studies have shown the importance of pricing to market and variable exchange rates using micro-level data (Gopinath and Itskhoki [2010], Fitzgerald and Haller [2012]).

Pricing-to-market models of exchange rate pass-through emphasize strategic pricing, and exchange rate pass-through is interpreted as a reaction to a cost shock faced by the firm compared to its local competitors. In these models firms posses market power and change their markups following these shocks, which explains incomplete exchange rate pass-through.

Most empirical tests of these models rely on the reaction of prices following a change in the exchange rate when identifying the underlying theoretical parameters. This paper uses additional information from production data from different destination countries to proxy unit values at the product-destination level 'markets'. This provides an opportunity to estimate the parameters of the model more directly and in a transparent way. Also, controlling for competitors' prices together with changes in the cost of imported inputs helps in identifying how much these channels explain from incomplete exchange rate pass-through. Finally, typical pass-through equations ignore the fact that the market price in the destination country can change importantly and heterogeneously across products whenever imports play an important role in the market. The measure in this paper will control for this effect as well.

In addition to the rich data on prices and quantities, such a dataset has further important advantages compared to other approaches. First, similarly to papers using transaction level data (e.g. Amiti et al. [2012]), firm-level information on imports provides an opportunity to control for changes in the firms' costs structure. Second, using information on market shares helps in testing whether firms with different levels of market power price differently. While a few papers have studied this question with respect to exchange rate pass-through (Amiti et al. [2012]; Berman et al. [2012]), this paper provides more direct evidence by relying explicitly on information from competitors' prices. Third, in terms of identification, an important limitation of exchange rate pass-through studies is that there is only one observation for each country-year, hence identification can only be based on differences across countries or years, which precludes the separation of the effect of exchange rate pass-through from that of other country-year level macro shocks. Country-product-year level data, in contrast, provides variation within country-year, hence it helps in separating country-level macro shocks.

The data at hand also has some limitations. First, it is only available for EU countries; hence, price, and especially exchange rate variation may be limited. Second, the calculated unit values may include a significant amount of measurement error, which may lead to downward-biased coefficient estimates. Given the degree of economic integration of European economies, such noise may represent a significant part of the variation in unit values. In the paper I will handle this problem by an instrumental variables approach using the price of the similar products.

The two papers most closely related to this work use detailed trade data linked to firm-level information to investigate the heterogeneity of firms' response following changes in the exchange rate. Berman et al. [2012] show that, following a depreciation, French firms with higher performance increase their markups more and their export quantities less than their less productive counterparts. This is explained by the higher demand elasticities faced by these more productive and larger firms. Amiti et al. [2012] use data from Belgium to demonstrate that import intensity and market share are key determinants of pass-through and interpret it as evidence for the imported inputs channel.

The main conclusions are as follows. First, exchange rate pass-through is similar to that found in other countries, about 0.85 for the sample of all countries but somewhat lower within the EU, where firms may be more likely to price in Euros. Also in line with previous literature, pass-through is more incomplete for more productive firms and firms having larger market shares.

Second, the elasticity of the prices of Hungarian firms with respect to their competitors' prices is quite low, around 0.02. This shows that markups are variable, but the price reaction is quite weak. The parameters of marginal cost increase and exchange rate pass-through imply much higher markup elasticities and are not very far away from findings for other countries. These facts together imply that firms do not react as strongly to within-EU price changes as to changes in their costs and the exchange rate. This provides evidence that some kind of rigidity is present in their response to this variable. One possibility is that most of these firms export as part of multi-year contracts which may contain provisions on fixing the quantity and modifying the price with respect to easily observable and verifiable variables (i.e. the exchange rate, changes in input prices, changes in the world price of that output) but not to short-term price fluctuations across EU countries. As a result, a within-EU identification may show relatively strong reactions to exchange rate and cost shocks but not to within-EU price differences.

Thirs, studying the reaction of quantity to changes in these variables provides further evidence for this hypothesis. Quantities are weakly effected by price, exchange rate or cost changes, suggesting a very inelastic residual demand function. If the estimated low elasticities follow mainly from such frictions as local currency pricing, menu costs, rational inattention or Calvo-pricing, the resulting mis-pricing should lead to a relatively strong fall in demand. This may not be the case, however, when long-term contracts govern transactions and buyers are willing to smooth such fluctuations.

Third, I study potential heterogeneity in terms of pricing reactions. I find that domestic and foreign firms behave similarly in this respect, the findings do not result from transfer pricing. There is no evidence that larger or more productive firms would react stronger to price changes, but firms exporting products with low unit values relative to other exporter countries react more strongly to market price changes

The structure of the paper is the following. Section 2 discusses the theory of export pricing and the framework which guides the empirical analysis. Section

3 introduces the dataset and the empirical approach. Section 4 shows the main results, while Section 5 studies whether the reactions are heterogeneous. Section 6 discusses why multi-year contracts may provide the best explanation for the findings and Section 7 concludes.

2 Variable markups and export prices

2.1 Theoretical framework

This paper starts from the Atkeson and Burstein [2008] model for its empirical specification, but also builds on the survey by Burstein and Gopinath [2013]. The aim is to derive predictions from this fully flexible price and variable markups model as a baseline.

2.1.1 Supply

The empirical exercise will investigate how firms change their prices after changes in competitors' prices and cost shocks. In order to do this, one can express optimal (log) FOB prices as the sum of (log) marginal costs and markups. Note that everything is measured in destination country currency.

$$\ln p_{in} = \ln \mu_{in} + \ln mc_{in}. \tag{1}$$

Log-differentiating (1) and assuming that returns to scale are constant and wages do not change[1] yields:

$$\Delta \ln p_{in} = -\Gamma_{in}(\Delta \ln p_{in} - \Delta \ln p_n) - \Delta e_{in} + \alpha_{in}\Delta e_{in}, \tag{2}$$

where $\Gamma_{in} \equiv -\frac{\partial \mu_{in}(\cdot)}{\partial(p_{in}-p_n)}$ is the elasticity of the markup with respect to relative price. α_{in} is the partial elasticity of marginal costs (expressed in destination country currency) to the exchange rate (e_{in}). e_{in} shows how much foreign currency is worth in terms of the domestic currency, so a depreciation means an increase in e_{in}. When all of the firm's production costs are in Hungarian Forints, $\alpha_{in} = 0$; when some costs arise in destination country currency, the effect of depreciation is dampened by the change in marginal costs. Hence $\alpha_{in}\Delta e_{in}$ measures the (log) change in marginal costs resulting from the change in cost of imported inputs. Note, this can be measured empirically using import data, and its empirical counterpart will be denoted by $\Delta \ln mc_{it}$. Rearranging yields:

$$\Delta \ln p_{in} = -\frac{1}{1+\Gamma_{in}}\Delta e_{in} + \frac{1}{1+\Gamma_{in}}\alpha_{in}\Delta e_{in} + \frac{\Gamma_{in}}{1+\Gamma_{in}}\Delta \ln p_n. \tag{3}$$

Note that constant markups models are a special case of this equation: when $\Gamma_{in} = 0$, $\Delta \ln p_{in} = \alpha_{in}\Delta e_{in}$. If $\Gamma_{in} > 0$, then pass-through is incomplete: a

[1] These assumptions are not very restrictive, because the Fixed Effects specifications will controll for all such changes.

depreciation of the domestic currency (an increase in Δe_{in}) is associated with a less than proportionally lower price.

2.1.2 Demand

Let the residual elasticity of demand be denoted by ε_{in}. Profit maximization, of course, requires that $\varepsilon_{in} > 1$ in optimum. In this case, the change in quantity is:

$$\Delta \ln q_{in} = -\varepsilon_{in} \left(\Delta \ln p_{in} - \Delta \ln p_n\right) + \Delta \ln q_n, \tag{4}$$

Substituting in (3) yields the following equation:

$$\Delta \ln q_{in} = \frac{\varepsilon_{in}}{1 + \Gamma_{in}} \left(\Delta \ln p_n + \Delta e_{in} - \alpha_{in} \Delta e_{in}\right) + \Delta \ln q_{-in}. \tag{5}$$

2.1.3 Markups

A further important question concerns the magnitude of Γ_{in}, i.e. the elasticity of markup with respect to the relative price. In order to understand how this parameter is determined, let us assume the demand structure in Atkeson and Burstein [2008].

Atkeson and Burstein [2008] distinguish between goods and sectors. The final good is a CES aggregate of the output of a continuum of sectors, with an elasticity of substitution η. Sector output, in turn, is a CES aggregate of a finite number of goods, with an elasticity of substitution θ. Consumers can substitute goods more easily within each sector than across sectors, hence $1 \leq \eta < \theta$. The model assumes that each firm produces one good in a sector and that competes in prices.

Under these conditions, the market share (in terms of value) of firm i in sector n is

$$s_{in} = \exp\left[a_{in} + (1 - \theta)(p_{in} - p_n)\right], \tag{6}$$

where a_{in} is the taste parameter and $p_n = \frac{1}{1-\theta} \ln\left[\sum_i a_{in} + (1 - \theta)(p_{in} - p_n)\right]$. The elasticity of demand for firm i is

$$\varepsilon_{in} = \eta s_{in} + \theta(1 - s_{in}). \tag{7}$$

This expression shows that the elasticity of demand faced by each firm is a weighted average of the product- and sector-level elasticities. The elasticity of demand increases in s_{in}, because the weight of η is increasing in firm size. Larger firms compete with firms from other sectors to a greater extent than smaller ones.

The fact that the demand elasticity depends on market share implies that markups also differ across firms. The optimal markup is given by

$$\mu_{in} = \ln\left[\frac{\eta s_{in} + \theta(1 - s_{in})}{\eta s_{in} + \theta(1 - s_{in}) - 1}\right]. \tag{8}$$

Note that markups increase in s_{in}. From this, one can express Γ_{in}, the elasticity of markups with respect to relative prices:

$$\Gamma_{in} = (\theta - \eta)(\theta - 1)\frac{s_{in}}{[\eta s_{in} + \theta(1 - s_{in})]\,[\eta s_{in} + \theta(1 - s_{in}) - 1]}. \qquad (9)$$

Importantly, Γ_{in} also depends on firm size: the sensitivity of markups is increasing in the market share of each firm.

As we will see, Hungarian firms usually have a quite small markert share. The formula implies that Γ_{in} should be relatively small for such firms.

2.1.4 Restrictions from theory

In this section I will discuss three restrictions from the theory which concern the novel parameter estimated in this paper, that of the market price.

Consider first the price equation. The first hypothesis, H1, is the following: if we have information about the reaction to exchange rate and market price, we can calculate two estimates for Γ_{in}. If the two are different, then firms adjust their markups differently following exchange rate and price shocks. There is a similar restriction w.r.t the parameter of the mc_{in} variable.

The quantity equation also provides a restriction, H2: the coefficient of the market price and exchange rate should be the same while the coefficient of marginal cost change chould be the negative of the other two coefficients.

The formula for Γ_{in} yields a further prediction, H3, about the magnitude of the market price coefficient. In the price equation, it can be small, not much different from zero whenever the average market share of firms is small, as in the Hungarian case. However, its coefficient should be larger than 1 in the quantity equation, whenever elasticity is larger than one.

These predictions are testing different rigidities. H1 claims that firms adjust their markups in a similar way following different types of shocks. Whenever it fails, firms do not react in a fully optimal fashion (assuming fully flexible prices). Rejection of this hypothesis may show that firms use sub-optimal rules of thumbs which work differently following different types of shocks. Or, alternativelly, it may mean that firms face adjustment costs, which differ depending on the type of the shock. This may result from menu costs, local currency pricing or may be a consequence of long-term contracts which allow the pass-through of some shocks – for example the exhange rate – but not that of other, less veryfiable shocks, for example the price increase of competitors.

H2 is suitable to distinguish between these two potential explanation to some extent. If 'sub-optimal' prices result from menu costs local, currency prices or other similar rigiditie, customers should react strongly to mis-pricing and reduce their consumption to a large extent. If the mis-pricing is a result of long-term contracts, buyers may not reply by reducing their quantity, because it may be costly to switch to another supplier. Also, if the estimated demand elasticites differ across different types of shocks, that may provide evidence for long-term contracts which handle different shocks in a heterogeneous way.

Third, H3 provides an additional check of whether the magnitude of estimated elasticities are in line with profit maximization. If this is rejected, firms adjust their markups to a degree which is suboptimal in a fully flexible pricing model, providing further evidence for the presence of important rigidities.

3 Data and empirical approach

3.1 Data

This paper uses highly disaggregated trade data linked to balance sheet data from Hungary. Further information about this data is provided in (Halpern et al. [2011], Békés et al. [2011]; Békés and Muraközy [2012]).

The disaggregated trade data are Customs Data from the period between 1996 and 2003, and includes both export/import values and quantities at the 8-digit product-firm-destination-year level. The product classification applied is the Harmonized System. The dataset includes all imports and exports of Hungarian firms. From this, only manufacturing goods are kept. Also, observations with a value less than 5 million HUF (around 25,000 USD) were dropped. For each firm-product destination combination I calculate f.o.b. unit values by dividing export value with export quantity. Observations with a change in log unit value larger than 2 are dropped as outliers.

Another issue is the possibility that firms export products which are not actually produced by them either because they perform carry-along trade (Bernard et al. [2013]) or sell their capital goods or intermediate goods. These products were identified by following Amiti et al. [2012]. First, each product is linked to a (3-digit) NAICS industry by using the concordance provided by Pierce and Schott [2012]. Second, the main NAICS for each firm is identified as the one with the greatest export value in our sample period. Only products belonging to the main NAICS of each firm were included in the analysis.

The Customs Data is linked to firm balance sheet data. This is census data coming from the Tax Authority, and it includes data on firm industry, employment and financial data. This data was cleaned extensively. In the final sample only manufacturing firms are included because heterogeneous firm trade theories can be applied to these firms best. Also, firms with less than 20 employees were left out from the analysis.

These data were merged with the PRODCOM dataset of Eurostat. This includes information on production, exports and imports at the 8-digit product level for EU member states and prospective member states. In parallel with the expansion of the EU, new countries joined continuously to the PRODCOM dataset.[2] An important issue is that the PRODCOM classification differs to some extent from the Harmonized System used for the trade data. Hence,

[2] In particular, data is available for the whole period for Austria, Belgium, Germany, Denmark, Spain, Finland, France, Greece, Ireland, Italy, Netherlands, Norway, Portugal, Sweden, and the UK. It is available from 1998 for Slovakia, from 2000 for Lithuania and Romania and from 2001 for Bulgaria, the Czech Republic, Croatia, Latvia and Slovenia, while it is only available from 2002 for Poland.

Table 1: Number of observations

Year	Firms	Products	Firm-products	Firm-product-destinations
1997	1,214	1,401	4,287	6,828
1998	1,357	1,542	4,995	7,871
1999	1,579	1,658	5,772	8,959
2000	1,650	1,752	5,946	9,437
2001	1,928	2,017	6,959	11,471
2002	1,957	1,986	6,713	11,844
2003	1,817	2,076	6,285	12,000

The table includes the number of firms, products, firm-product and firm-product destination combinations in the estimating sample.

the concordance provided by Eurostat was used to link the two datasets. The concordance includes many cases when codes are not uniquely linked. Hence, I followed a two-step process: first, I linked only those 8-digit HS codes which have a unique PRODCOM pair. Second, I aggregated the PRODCOM database to the 6-digit level, and merged the remaining observations by a concordance at that level. This means that market-level prices are measured at the 8-digit level for some products and at the 6-digit for others. This may introduce additional measurement error.[3]

Sample size in different dimensions is shown in Table 1 - note that these are the observations when two consecutive prices were observed and could be linked to the PRODCOM data. The increase in the number of exporting firms and exported products until 2001 reflects both the strong export-led growth of this period and the increasing availability of data from prospective new member states. The table also shows that many firms export more than one product, but usually only to a few countries.

Our variable of interest is $\Delta \ln uv_{inkt}$, which is a proxy for the price change for firm i, of product n, at destination k. The dataset includes this information in Hungarian Forints which is converted into destination country currency by using yearly average exchange rates provided by the Hungarian National Bank. The quantity variable is simply the revenue at the firm-product-destination level.

The most important independent variable in the empirical analysis is the price of competitors. This is calculated by dividing product-country level value of 'Apparent consumption' with quantity at the same level. Note that this also means converting Euro values to destination country currencies. I also subtract all the Hungarian exports to the country (using PRODCOM) to eliminate endogeneity resulting from the presence of Hungarian firms in the measured import. [4]

[3] Dorpping these observations makes the results less significant, but the point estimates remain similar

[4] Note that the firm-level database use f.o.b. Hungarian export prices, while the PRODCOM includes foreign import proces. Besides the differences in definitions, the two sources may include different measurement errors as well. As a result, subsracting only the given firms'

This variable is calculated in the following way:

$$market\_uv_{nkt} = \frac{production\_v_{nkt} + import\_v_{nkt} - export\_v_{nkt} - HUimport\_v_{nkt}}{production\_q_{nkt} + import\_q_{nkt} - export\_q_{nkt} - HUimport\_q_{nkt}}, \quad (10)$$

where n indexes 8-digit products (the empirical equivalent of sectors), k countries and t years. $production\_v_{nkt}$ and $production\_q_{nkt}$ are the production values and quantities at the country-product-year level, and $import\_v_{nkt}$ and $import\_q_{nkt}$ represent imports at the same level of aggregation. $HUimport\_v_{nkt}$ represent Hungarian exports to country k.[5] I will show in robustness checks that slightly different definitions of this variable do not change the results importantly.

The variable was cleaned in such a way that whenever $market\_uv_{nkt}$ was larger than 1 in absolute value, it was replaced with 1 or -1.[6] Similarly, one can calculate $market\_q_{inkt} = production\_q_{nkt} + import\_q_{nkt} - export\_q_{nkt} - HUimport\_q_{nkt}$. I have also cleaned this variable, with replacing values which were larger than 2 in absolute value with -2 and 2.

Importantly, having information about sales at the country-product level enables me to calculate market shares for each firm-product-country based on the quantity exported relative to all quantity sold in the market. [7] Figure 1 shows the distribution of market shares, calculated as the quantity exported by firm i from the 8-digit product n to market k (from the Customs Data) over $production\_v_{nkt} + import\_v_{nkt} - export\_v_{nkt}$ from the PRODCOM data.

Theory suggests that an important channel of incomplete exchange rate pass-through is the change in the cost of imported inputs. To control for this, I follow Amiti et al. [2012] by proxying this effect with the approximate increase in variable costs resulting from the change in the price of imported inputs relying on detailed import data. In particular, I first calculate the share of imported intermediate goods[8] in variable costs, which is approximated with the sum of total personal and material costs: $imp\_share_{it} = \frac{\sum_j imp\_v_{ijt}}{personal\_exp_{it} + material\_exp_{it}}$, where imp_v_{ijt} shows the import value of firm i from product j in year t. Second, I calculate a weighted average change of import unit values: $\Delta \ln imp\_uv_{it} = \sum_j \frac{\frac{imp\_v_{ijt}}{\sum_j imp\_v_{ijt}} + \frac{imp\_v_{ijt-1}}{\sum_j imp\_v_{ijt-1}}}{2} \Delta \ln uv_{ijt}$. The approximate proportional change in marginal costs is the product of the import share and weighted change in unit values: $\Delta \ln mc_{it} = imp\_share_{it} * \Delta \ln imp\_uv_{it}$.

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exiport price from the destination country imports may introduce important endogeneity

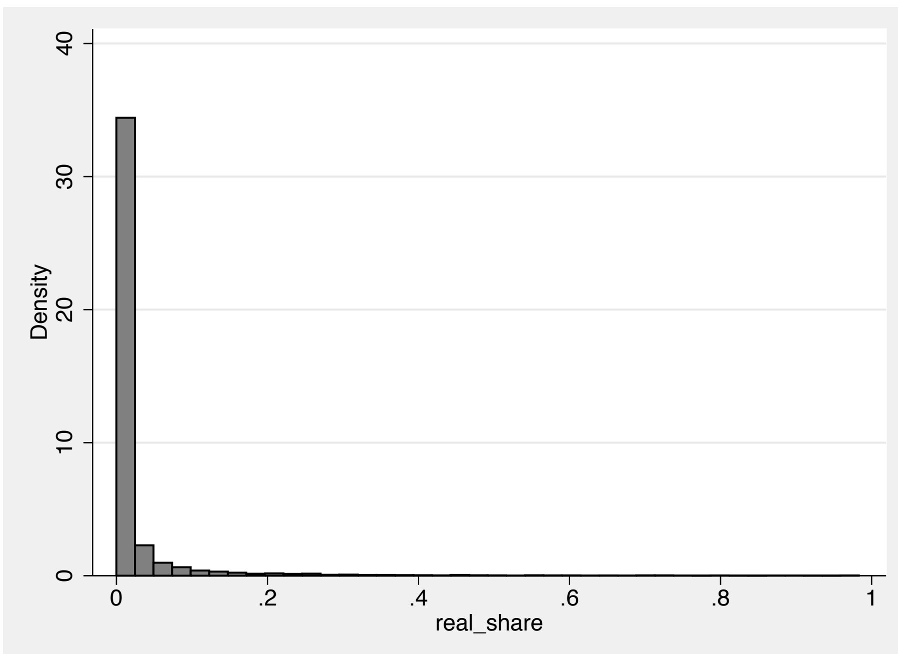
[5]Theoretically it would be probably better only to substract the exports of the given firm, but it is likely to lead to measurement error as the firm-level data source is different from the PRODCOM.

[6]Dropping these observations or using different thresholds does not change the results importantly.

[7]Note that the different definitions in the two datasets are less important with respect to quantities than for prices

[8]We identify intermediate goods from the import data by relying on the Broad Economic Categories classification.

Figure 1: Distribution of market shares in 2003



Note that this measure is defined at the firm-year level, and as such does not reflect that the proportional change in fixed costs may differ across products in multi-product firms. An alternative of this measure is to use firm-product-year fixed effects.

3.2 Main specification

The main specification is the empirical counterpart of Equation (3):

$$\begin{aligned}\Delta \ln uv_{inkt} \quad = \quad & \beta_p \Delta \ln market\_uv_{nkt} + \beta_e \Delta \ln e_{kt} + \beta_{mc} \Delta \ln mc_{it} + \\ & \beta_q \Delta \ln market\_q_{nkt} + \eta_k + \zeta_{in} + \varepsilon_{inkt}. \qquad (11)\end{aligned}$$

In this specification, β_p shows the elasticity of the firm's price with respect to the price of its competitors. In theoretical terms, this is an estimate for $\frac{\Gamma_{in}}{1+\Gamma_{in}} \geq 0$. Testing whether it is significant is a test whether Hungarian firms have variable markups.

$\Delta \ln e_{kt}$ is the change in the exchange rate. It is expressed as how many Hungarian Forints can be exchanged for a unit of foreign currency, hence a positive value of this variable shows a depreciation of the Hungarian currency. According to Equation (3), its coefficient should be $\beta_e = -\frac{1}{1+\Gamma_{in}}$. If $\beta_e = 0$, then there is no exchange rate pass-through into export prices, and this also implies constant markups. $\beta_e = -1$, on the other hand, implies full pass-through.

As was discussed in the previous section, I also control for the impact of the exchange rate on the cost of imported inputs, ($\alpha_{in} \Delta e_{in}$, with its proxy, $\Delta \ln mc_{it}$. Its coefficient, β_{mc}, is equivalent to the theoretical $\frac{1}{1+\Gamma_{in}} > 0$. I also include $\Delta \ln market\_q_{nkt}$ in order to control for the change in demand on the market.

In the simplest specification two sets of fixed effects are included: country fixed effects to capture differing price trends at the country level and 4-digit product-year fixed effects to control for changes in demand for similar products. This specification exploits both within- and across-country differences across different 8-digit products within a 4-digit category for identification. In a second specification, country-year fixed effects are included to control for the macro-level shocks. Here, identification comes from within-country differences across 8-digit products within a 4-digit category. Note that in this case the effect of the exchange rate is not identified, but, as prices vary within countries across products, one can estimate the other parameters. The third specification uses firm-product-year fixed effects instead of the marginal cost proxy to make sure that firm-product level differences in intermediate import use do not bias the results. However, as Table 1 suggests, firms usually export their products only to a few markets, hence there is much less identifying variation when this specification is used than in the previous ones.

The change in quantities is modeled in a symmetric framework:

$$\Delta \ln q_{inkt} = \gamma_p \Delta \ln market\_uv_{nkt} + \gamma_{mc} \Delta \ln mc_{it} + \gamma_q \Delta \ln market\_q_{nkt} + \gamma_e \Delta \ln e_{kt} + \eta_k + \zeta_{in} + \varepsilon_{inkt}. \quad (12)$$

Standard errors are clustered at the country-product-year level, because the main explanatory variables are measured on this level.

3.3 Measurement error

When estimating Equations (11) and (12), one potential problem is the measurement error in market-level prices and quantities. Given the strong integration of European economies, a significant part of the variation in the changes of these unit values may come simply from measurement error in the PRODCOM database. This can have many sources. It may arise from the difference between product classifications and relevant markets for each product. In addition, these prices are measured over a one-year long period, and quantities may only reflect partial adjustment.

Another source of measurement error may arise from the fact that the export of firm i is included in the market-level unit value measure, which may lead to positive bias. While this may be a small problem thanks to the small market share of Hungarian firms, it still warrants investigation.

If measurement error is a serious issue, it may lead to downward bias in parameter estimates. I will handle both of these with IV estimation.

Endogeneity may also be an issue, if product-country level taste shocks may affect market prices and firm-level prices and/or quantities simultaneously. Such problems are handled to a great extent with using different sets of dummies to check the robustness of the estimates. For example, firm-product-year fixed effects control for product-level shocks while country-year fixed effects handle country-year level shocks. Given that results are similar in these specifications, one may be relatively confident that this type of endogeneity may not lead to serious bias. Still, instrumental variables estimation provides and important check whether this is the case.

In order to handle these problems, I estimate Equations (11) and (12) by using instrumental variables for $\ln market\_uv_{inkt}$. The instrument is the unit value change of similar products in the same country. In particular, I calculate the unit value of all products within the same 4-digit category excluding the product in question:

$$similar\_uv_{nkt} = \frac{\sum_{j \in N, j \neq n} (production\_v_{jkt} + import\_v_{jkt} - export\_v_{nkt} - HUimport\_v_{nkt})}{\sum_{j \in N, j \neq n} (production\_q_{nkt} + import\_q_{nkt} - export\_q_{nkt} - HUimport\_q_{nkt})},$$

where N denotes the 4-digit category into which product n belongs.[9] The

[9] For the products where the merge between the production and export classifications was only possible at the 6-digit level, I use the set of products within the same 4-digit category to calculate the instrument.

instrument is the change in this variable. Another instrument is the denominator of this variable, the change in quantity of similar products.

An even more conservative instrument is to calculate the price and quantity change of similar products in other countries:

$$similar\_uv\_other_{nkt} = \sum_{j \in K, j \neq k} similar\_uv_{nkt}.$$

3.4 Testing for heterogeneity

Recent research emphasized heterogeneity in exchange rate pass-through across firms with different size and/or productivity. Here it is also possible to test whether firms are heterogeneous in their reactions to competitors' prices. In this paper I conduct a number of such tests.

The first set of such tests will look for heterogeneity across different types of firms.

First, I will check whether reactions differ across firms with different labor productivity. More productive firms tend to have larger market shares and, thus, react more strongly to the prices of competitors and have a lower exchange rate pass-through. I will also test heterogeneity by the number of employees and market share (firms quantity/market quantity) and expect similar patterns. Note that the market share variable varies at firm-product-country level, hence it is much less noisy than firm or firm-product-level variables used mainly in the previous literature. Motivated by Amiti et al. [2012], I will also test whether importers differ from non-importers.

The second set of checks will investigate whether reactions to exchange rates and pass-through differ across different products.

First, it is possible that PRODCOM product codes include different segments: a lower segment with intensive price competition and a higher segment where products are more differentiated. The elasticities may differ across these two types of segments. In order to check this, I calculate the distribution of import unit values, including its 10th and 90th percentile from different countries to each destination country-product pair. I calculate the place of Hungarian average export unit value in this interval (so 0.5 shows that Hungarian average unit value is at the middle of the interval between the 10th and 90th percentily) and interact this with the variables of interest. Similarly, I calculate the average import prices from developed and calculate the place of Hungarian average unit value in this range. The expectation in both cases is that the price elasticity will be larger for products for which Hungary competes in the lower segment.

Second, price reactions may also differ across products with different elasticities: firms are more likely to follow the reactions of their competitors when the product is more homogenous. This can be seen from combining Equations (9) and (3). To check whether this prediction is valid, I classify products according to the elasticities estimated by Broda and Weinstein [2006], and include an interaction with larger than median elasticity.

4 Results

4.1 Exchange rate pass-through in full sample

The market unit value variable comes from the PRODCOM database, which is only available for EU member states, hence includes only a limited number of currencies. To make this study more comparable to other studies on exchange rate pass-through, I first run the basic pass-through regression for the full sample of countries. This is also useful because it will enable me to check whether exchange rate pass-through is different within the EU from the whole sample.

Table 2 shows the result of this exercise. In columns (1)-(4) the dependent variable is (ln) price while in columns (5)-(8) quantity is modelled. The different columns show results with different sets of fixed effects: columns (1) and (5) include only country and year fixed effects; columns (2) and (6) include country and 2-digit product-year fixed effects to control for potentially heterogeneous price evolution of different product groups; columns (3) and (7) include 4-digit product year and country-year fixed effects, which control for idiosyncratic country-year shocks (but its not possible to estimate the exchange rate pass-through) while columns (4) and (8) represent the most demanding specification with country and firm-product year fixed effects to control for all firm-product level shocks.

The coefficient of the exchange rate is quite stable across specifications with values between 82 and 88 percent. This is much in line with the findings of other authors: values of around 80-85 percent were found both by Berman et al. [2012] and Amiti et al. [2012] for France and Belgium, respectively.

The coefficient of the marginal cost variable is around 0.4-0.5, again not very far away from the values around 0.5 found by Amiti et al. [2012]. These findings show that the pass-through observed in the Hungarian data in the sample of all countries is quite similar to the findings in other European countries.

The quantity reaction to exchange rate changes is between 0.63-0.73. This is somewhat smaller (in absolute value) than the coefficient in the price equation, suggesting an elasticity of demand below 1, which is not in line with profit maximization.

4.2 Baseline results

Figure 2 shows the descriptive relationship between the change in market prices and firm level prices.[10] There is a positive relationship between the two variables. The fitted line is not very steep, however, suggesting that 10 percent increase in market prices is associated with about 0.6 percent increase in prices of Hungarian firms. The figure also suggest a linear relationship.

Table 3 shows the baseline results for Equation (11).

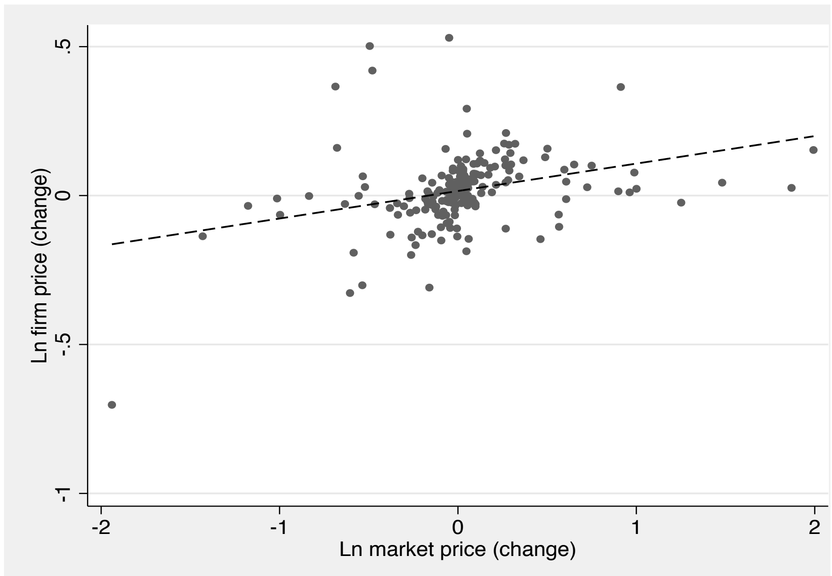
[10] To make the figure more transparent, we made 200 quantiles from the obervations based on changes in market price and the figure shows the avarage firm-price change in each of these quantiles.

Table 2: Results for all countries

dependent:	(1) uv(d)	(2) uv(d)	(3) uv(d)	(4) uv(d)	(5) q(d)	(6) q(d)	(7) q(d)	(8) q(d)
exchange rate (d)	-0.818***	-0.874***		-0.888***	0.640***	0.634***		0.729***
	(0.035)	(0.040)		(0.042)	(0.095)	(0.100)		(0.118)
mc (d)	0.524***	0.408***	0.402***		0.316*	0.279	0.291	
	(0.072)	(0.075)	(0.075)		(0.168)	(0.197)	(0.197)	
year FE	yes	no	no	no	yes	no	no	no
country FE	yes	yes	no	yes	yes	yes	no	yes
product(4d)-year FE	no	yes	yes	no	no	yes	yes	no
country-year FE	no	no	yes	no	no	no	yes	no
firm-product(8d)-year FE	no	no	no	yes	no	no	no	yes
Observations	110,207	110,207	110,207	110,207	110,207	110,207	110,207	110,207
R-squared	0.030	0.151	0.153	0.654	0.004	0.077	0.080	0.584

One observation is one firm-product year combination, and the table includes data from all countries. Dependent variable is the log change in unit value (measured in destination country currency) and the log change in quantity (in natural units of measurement). Exchange rate is the log change in exchange rate while mc is the estimated change in variable costs resulting from the change in imported input prices. Standard errors are clustered at the country-product year level.

Figure 2: Descriptive relationship between market- and individual unit values: median firm unit values for a 100 bins of market unit value distribution



First, let me compare the results for the previous ones on all countries. Exchange rate pass-through seems to be significantly weaker than in the previous exercise, it is around 0.6 in all specifications, suggesting that firms behave differently within Europe than outside it. This may be because of their larger market share or because they simply price in Euros on all European markets. The quantity reaction is somehat larger than the price reaction, in line with a residual elasticity of demand somewhat above 1.

The coefficient of mc_in in the price equation is quite similar to the previous result. Quantity reaction with respect to this variable is small, insignificant but so imprecisell estimated, that no firm conclusions can be drawn from it.

Let me discuss the variable of main interest, the market unit value. Its coefficient in the price equation is quite small, between 0.019 and 0.035. It is also highly significant and remarkably precisely estimated. This shows that Hungarian firms do not apply constant markups, but they change their markups only to a very limited extent.

This result may be much in line with Hungarian firms having small market shares and market power, which may be much in line with the the theoretical structure.

Two predictions of model are violated, though. First, the Γs estimated from the exchange rate and the price coefficients differ significantly. An exchange rate pass-through coefficient of 0.6 is associated with $\Gamma = 0.66$ while a market price coefficient of 0.03 is associated with $\Gamma = 0.032$. This discrepancy suggests that firms change their markups more strongly following an exchange rate shock than following a market price shock.

Second, this very weak price reaction should lead to a significant relative price change following the change in the market price, hence, it should lead to a strong quantity reaction. We cannot observe this, however: a 10 percent change in the market price is associated with a quantity change between 0.2 and 0.8 %. This is also relatively precisely estimated, with the higher end of the confidence interval between 0.6 and 1.4 percent in the different specifications. The results reflect small changes both in prices and quantities following a change in the market price.

The discrepancy between the reactions with respect to exchange rate and market price suggests that firms do not optimize fully either because of not maximizing or because of some rigidities. If the difference would come from rules of thumb, menu costs or Calvo pricing, one would expect customers to change their demanded quantity strongly following changes in market prices. The weak quantity reaction following a change in the market price is more in line with another type of rigidity: long term contracts which regulate both prices and quantities, and only allowing changes in the price when the exchange rate moves.

As the results do not differ across specifications, the preferred specification will be the one in column (2) with product-year and country fixed effects, which includes variation for the identification of all coefficients. To conserve space, in what follows I will mainly report results using this specification, but they are in general robust to including the extra sets of fixed effects in columns (3) and (4).

4.3 Robustness

I conduct three kinds of robustness checks. First, I will restrict the sample to domestic-owned firms to see whether the results are an artifact of transfer pricing. Second, I will check the differences between Eurozone and non-Eurozone countries. Third, I will check whether different measures of market price yield different results.

4.3.1 Domestic firms

One potential concern with the above analysis is that the results may be driven by transfer pricing of multinationals. To see whether this is the case, I restrict the sample to only domestic-owned firms in Table 4.

In general, the results are very similar, though sometimes less significant than for the whole sample. The only (not significant) difference is the lower exchange rate pass-through coefficient. This is somewhat surprising as domestic firms are usually smaller than multinationals, hence the theory would predict a larger pass-through for these firms.

Table 3: Baseline regression

dependent	(1) uv(d)	(2) uv(d)	(3) uv(d)	(4) uv(d)	(5) q(d)	(6) q(d)	(7) q(d)	(8) q(d)
market uv (d)	0.035***	0.028***	0.032***	0.019*	0.014	0.027	0.054*	0.083*
	(0.008)	(0.006)	(0.007)	(0.011)	(0.027)	(0.028)	(0.030)	(0.046)
market q (d)	0.001	0.004**	0.004**	0.001	0.036***	0.035**	0.055***	0.030
	(0.002)	(0.002)	(0.002)	(0.004)	(0.010)	(0.014)	(0.014)	(0.022)
exchange rate (d)	-0.558***	-0.594***		-0.603***	0.692**	0.673**		1.073**
	(0.091)	(0.086)		(0.122)	(0.276)	(0.267)		(0.428)
mc (d)	0.459***	0.361***	0.356***		0.188	0.073	0.079	
	(0.080)	(0.085)	(0.085)		(0.287)	(0.349)	(0.351)	
year FE	yes	no	no	no	yes	no	no	no
country FE	yes	yes	no	yes	yes	yes	no	yes
product(4d)-year FE	no	yes	yes	no	no	yes	yes	no
country-year FE	no	no	yes	no	no	no	yes	no
firm-product(8d)-year FE	no	no	no	yes	no	no	no	yes
Observations	59,828	59,828	59,828	59,828	59,828	59,828	59,828	59,828
R-squared	0.027	0.114	0.117	0.750	0.003	0.086	0.088	0.689

One observation is one firm-product year combination, and the table includes export to EU countries covered by the PRODCOM database. Dependent variable is the log change in unit value (measured in destination country currency) and the log change in quantity (in natural units of measurement). Exchange rate is the log change in exchange rate while mc is the estimated change in variable costs resulting from the change in imported input prices, market UV is the log change in the unit value of the apparent consumption (minus imports from Hungary) of the product in the destination country , while market q is the log change in the quantity of the apperant consumption of the product in the destination country. Standard errors are clustered at the country-product year level.

Table 4: Baseline regression for domestic firms

dependent	(1) uv(d)	(2) uv(d)	(3) uv(d)	(4) uv(d)	(5) q(d)	(6) q(d)	(7) q(d)	(8) q(d)
market uv (d)	0.027***	0.026***	0.028***	0.027	0.038	0.031	0.049	0.089
	(0.009)	(0.008)	(0.010)	(0.019)	(0.037)	(0.034)	(0.047)	(0.088)
market q (d)	0.000	0.006**	0.005	0.007	0.039***	0.036***	0.055***	0.022
	(0.002)	(0.002)	(0.004)	(0.008)	(0.008)	(0.012)	(0.015)	(0.036)
exchange rate (d)	-0.481***	-0.544***		-0.587***	0.460	0.404		1.078
	(0.106)	(0.115)		(0.210)	(0.487)	(0.509)		(0.835)
mc (d)	0.736***	0.743***	0.723***		0.222	0.273	0.224	
	(0.122)	(0.149)	(0.149)		(0.628)	(0.756)	(0.754)	
year FE	yes	no	no	no	yes	no	no	no
country FE	yes	yes	no	yes	yes	yes	no	yes
product(4d)-year FE	no	yes	yes	no	no	yes	yes	no
country-year FE	no	no	yes	no	no	no	yes	no
firm-product(8d)-year FE	no	no	no	yes	no	no	no	yes
Observations	27,845	27,845	27,845	28,450	27,844	27,844	27,844	28,449
R-squared	0.028	0.136	0.141	0.777	0.004	0.110	0.113	0.740

One observation is one firm-product year combination, and the table includes export of domestically owned firms to EU countries covered by the PRODCOM database. Dependent variable is the log change in unit value (measured in destination country currency) and the . Exchange rate is the log change in exchange rate while mc is the estimated change in variable costs resulting from the change in imported input prices, market UV is the log change in the unit value of the apparent consumption (minus imports from Hungary) of the product in the destination country, while market q is the log change in the quantity of the apperant consumption of the product in the destination country. Standard errors are clustered at the country-product year level.

4.3.2 Eurozone vs. non-Eurozone

An interesting problem with the identification strategy of this paper is that exchange rates do not change within the Eurozone (when year fixed effects are included), so the exchange rate coefficient is generally identified from data outside the Eurozone. Prices may vary within the Eurozone, but firms may still use one price in the Eurozone and different prices outside it. So it is interesting to split the sample to the Eurozone and non-Eurozone, which is shown in Table 5.

The table shows that the majority of observations are from the Eurozone, but the exchange rate pass-through, naturally, is estimated mainly from non-Eurozone countries. The estimated market price coefficient is very similar in the Eurozone to the full sample. Outside the Eurozone, it is not significant, but relativelly precisely estimated, suggesting that it is not much different within and outside the Eurozone.

Table 5: Results for Eurozone and non-Eurozone countries

	(1)	(2)	(3)	(4)
	EZ	EZ	non-EZ	non-EZ
dependent	uv(d)	uv(d)	uv(d)	uv(d)
market uv (d)	0.039***	0.031***	0.012	0.008
	(0.011)	(0.009)	(0.012)	(0.015)
market q (d)	-0.001	0.004*	0.000	-0.009
	(0.002)	(0.002)	(0.005)	(0.011)
exchange rate (d)			-0.566***	-0.643***
			(0.098)	(0.124)
mc (d)	0.457***	0.368***	0.072	-0.329
	(0.090)	(0.094)	(0.191)	(0.305)
year FE	yes	no	yes	no
country FE	yes	yes	yes	yes
product(4d)-year FE	no	yes	no	yes
Observations	47,340	47,340	4,532	4,532
R-squared	0.005	0.100	0.026	0.357

One observation is one firm-product year combination, and the table includes exports to EU countries covered by the PRODCOM database. Columns (1) and (2) restrict the sample to Eurozone countries while columns (3) and (4) to non-Eurozone countries. Dependent variable is the log change in unit value (measured in destination country currency). Exchange rate is the log change in exchange rate while mc is the estimated change in variable costs resulting from the change in imported input prices, market UV is the log change in the unit value of the apparent consumption (minus imports from Hungary) of the product in the destination country, while market q is the log change in the quantity of the apperant consumption of the product in the destination country. Standard errors are clustered at the country-product year level.

4.3.3 Different measures

Our measure of market price involves a number of corrections, and it is important to see whether any of them drives the results.

First, it is 'apparent consumption', i.e. production+imports-exports. One may argue that substracting exports may lead to problems. Conceptually, it is possible that exports also exert a competitive pressure on the market, so it should not be omitted. Also, sometimes exports are larger than production and imports.

Second, I correct with Hungarian exports to the market to reduce endogeneity. This is done by substracting all Eurostat imports from Hungary both from the numerator and the denominator. This procedure may also introduce some bias if there is a measurement error.

As a result, I check whether any of these corrections affect the results. Table 6 shows the results of two other measures. Columns (1) and (2) show the simplest measure, in which export is not substracted and there is no correction for Hungarian export to the market. Columns (3) and (4) show results when exports are substracted but there is no correction for Hungarian exports. The differences are not very important, though in the second case the market price coefficient becomes smaller and not significant. This still shows a weak reaction, but shows that correcting for Hungarian exports may be important.

4.4 Instrumental variables

One of the concerns regarding this analysis is the potential measurement error which may bias the market price coefficient towards zero. This is handled by instrumental variables estimation. The results are shown in Table 7 Columns (1) and (4) show OLS results for comparison, columns (2) and (5) show the results when price and quantity changes of similar products are used as instruments, while (3) and (6) show results when the price and quantity changes of similar products in other countries are the instruments.

The point estimate of the coefficient for market unit value remains similar but it becomes insignificant. The confidence interval, however, remains quite tight, with an upper end around 0.12. This suggests that the true coefficient is unlikely to be biased downwards to a large degree, hence the previous conclusions seem to be valid. The other coefficients are also very similar to previous results.

4.5 Heterogeneity

4.5.1 Firm heterogeneity

This section tests whether the estimated parameters differ across heterogeneous firms. I introduce interactions both with the exchange rate and market price variables. The results are presented in Table 8.

Column (1) shows the interaction between productivity and the key variables. In line with the theory and the results of Berman et al. [2012], more

Table 6: Results with different measures of the market unit value

	(1)	(2)	(3)	(4)
	Production+ import	Production+ import	Apparent consumption, no correction for HU	Apparent consumption, no correction for HU
dependent	uv(d)	uv(d)	uv(d)	uv(d)
market uv (d)	0.041***	0.028***	0.004	0.003
	(0.008)	(0.007)	(0.003)	(0.003)
market q (d)	0.002	0.005***	-0.003	0.001
	(0.002)	(0.002)	(0.002)	(0.002)
exchange rate (d)	-0.539***	-0.560***	-0.553***	-0.570***
	(0.082)	(0.068)	(0.083)	(0.069)
mc (d)	0.463***	0.342***	0.463***	0.340***
	(0.075)	(0.080)	(0.076)	(0.080)
year FE	yes	no	yes	no
country FE	yes	yes	yes	yes
product(4d)-year FE	no	yes	no	yes
country-year FE	no	no	no	no
firm-product(8d)-year FE	no	no	no	no
Observations	67,549	67,549	67,548	67,548
R-squared	0.028	0.120	0.027	0.119

One observation is one firm-product year combination, and the table includes exports to EU countries covered by the PRODCOM database. Dependent variable is the log change in unit value (measured in destination country currency). In columns (1) and (2) market uv is the unit value of production and imports while columns (3) and (4) it is the apperant consumption, not corrected by Hungarian exports to the market. Exchange rate is the log change in exchange rate while mc is the estimated change in variable costs resulting from the change in imported input prices, while market q is the log change in the quantity of the apperant consumption of the product in the destination country. Standard errors are clustered at the country-product year level.

Table 7: Instrumental variables estimation

		(1)	(2)	(3)	(5)	(6)	(7)
dependent		uv(d)	uv(d)	uv(d)	q(d)	q(d)	q(d)
IV:	product country	OLS	similar same	similar other	OLS	similar same	similar other
market uv (d)		0.034***	-0.005	-0.001	0.010	0.178	0.301**
		(0.005)	(0.025)	(0.028)	(0.025)	(0.127)	(0.146)
market q (d)		0.001	-0.006	-0.005	0.031***	0.058***	0.079***
		(0.002)	(0.004)	(0.005)	(0.008)	(0.022)	(0.025)
exchange rate (d)		-0.561***	-0.579***	-0.577***	0.703**	0.781***	0.839***
		(0.057)	(0.058)	(0.058)	(0.292)	(0.298)	(0.300)
mc (d)		0.463***	0.464***	0.464***	0.157	0.152	0.148
		(0.045)	(0.045)	(0.045)	(0.231)	(0.231)	(0.231)
year FE		yes	yes	yes	yes	yes	yes
country FE		yes	yes	yes	yes	yes	yes
product(2d) FE		yes	yes	yes	yes	yes	yes
Observations		59,828	59,828	59,828	59,828	59,828	59,828
R-squared		0.029	0.028	0.028	0.005	0.004	0.003

One observation is one firm-product year combination, and the table includes exports to EU countries covered by the PRODCOM database. Dependent variable is the log change in unit value (measured in destination country currency) and the log change in quantity. In columns (2) and (5) market uv is instrumented by the change in the unit value and quantity of the apperant consumption of other products in the 6-digit category in the same country, while in columns (3) and (6) it is instrumented by the same variable in other countries. Exchange rate is the log change in exchange rate while mc is the estimated change in variable costs resulting from the change in imported input prices, while market q is the log change in the quantity of the apperant consumption of the product in the destination country. The table uses somewhat less demanding set of fixed effects that the baseline specification, and OLS results are rported for comparability.

productive firms show smaller exchange rate pass-through, supposedly because they are more likely to adjust their markups. The results also show that more productive firms react more strongly to market price shocks. While this is a new empirical result, it is in line with theory, because this is also in line with a larger Γ for more productive firms.

Columns (2) and (3) show heterogeneity for two alternative measures of firm size. Column (2) shows the interactions with employment, but these are only marginally significant. The interaction of market share and exchange rate is, however, significant at 5%, suggesting again that firms with a larger market share exhibit weaker exchange rate pass-through. Note that this result utilizes firm-product-country-level variation in market shares. Interestingly, firms with higher market share do not seem to react more strongly to the market price.

Finally, following Amiti et al. [2012] I also test for heterogenity with respect to import share. Here, I find no significant effect.

To sum up, these tests of firm-level heterogeneity show some evidence for lower pass-through for more productive firms with a larger market share, and they provide weak evidence for stronger reaction of more productive firms to their competitors' prices.

4.5.2 Product heterogeneity

Table 9 shows how the elasticities differ across products.

Columns (1) and (2) investigate heterogeneity based on the average Hungarian export unit value relative to the range determined by the 10th and 90th percentile of export prices to the given market from the given product. The hypothesis is that the lower the Hungarian price relative to competitors, the more likely it is that Hungarian firms compete in prices, hence one would expect a stronger price reaction; the interaction between 'high average Hungarian unit value' dummy and the market price should be negative. This is supported by the data: when Hungarian exports are at the lower end of the spectrum, reaction to competitors' prices is stronger. Interestingly, there is no evidence for heterogeneity in the exchange rate pass-through in this dimension. These results are reinforced by columns (3) and (4) which compares Hungarian unit value to the range determined by the average unit value of developing and developed countries.

Columns (5) and (6) classify products according to their Broda-Weinstein elasticities. I find no evidence for heterogeneity along this dimension.

5 Interpretation

One can derive the following conclusions from this analysis.

- The estimated Γs suggest that firms react differently to different shocks: firms adjust their markups much more strongly following a change in the exchange rate than after a change in the market price.

Table 8: Firm-level heterogeneity

dependent	(1) uv(d)	(2) uv(d)	(3) uv(d)	(4) uv(d)
market uv (d)	0.021***	0.025***	0.021	0.019**
	(0.007)	(0.007)	(0.015)	(0.008)
market q (d)	0.004**	0.004**	-0.000	0.004**
	(0.002)	(0.002)	(0.002)	(0.002)
exchange rate (d)	-0.635***	-0.628***	-0.429***	-0.568***
	(0.096)	(0.087)	(0.103)	(0.095)
mc (d)	0.367***	0.361***	0.361***	0.370***
	(0.084)	(0.085)	(0.086)	(0.087)
labor prod.	-0.001***			
	(0.000)			
labor prod x market uv	0.002**			
	(0.001)			
labor prod x exchange rate	0.008***			
	(0.003)			
employees		0.000		
		(0.000)		
emp x market uv		0.000		
		(0.000)		
emp x exchange rate		0.000*		
		(0.000)		
market share (ln)			-0.011***	
			(0.001)	
market share x market uv			-0.001	
			(0.002)	
market share x exchange rate			0.022**	
			(0.009)	
import share				-0.006
				(0.017)
import share x market uv				0.033
				(0.021)
import share x exchange rate				-0.087
				(0.127)
country FE	yes	yes	yes	yes
product(4d)-year FE	yes	yes	yes	yes
Observations	59,653	59,828	59,699	59,828
R-squared	0.115	0.115	0.120	0.114

One observation is one firm-product year combination, and the table includes export to EU countries covered by the PRODCOM database. Dependent variable is the log change in unit value (measured in destination country currency). Exchange rate is the log change in exchange rate while mc is the estimated change in variable costs resulting from the change in imported input prices, market UV is the log change in the unit value of the apparent consumption (minus imports from Hungary) of the product in the destination country , while market q is the log change in the quantity of the apperant consumption of the product in the destination country. The variables of interest are interacted with labor productivity (value added/employees), the number of employees, the share of the firm-product relative to the apparent consumption at the destination-product and the share of imported inputs relative to material cost. Standard errors are clustered at the country-product year level.

Table 9: Product-level heterogeneity

dependent	(1) uv(d)	(2) uv(d)	(3) uv(d)	(4) uv(d)	(5) uv(d)	(6) uv(d)
market uv (d)	0.048***	0.037***	0.049***	0.040***	0.029***	0.023***
	(0.009)	(0.008)	(0.009)	(0.008)	(0.009)	(0.008)
market q (d)	0.000	0.004**	0.001	0.004**	0.002	0.004**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
exchange rate (d)	-0.548***	-0.618***	-0.564***	-0.612***	-0.542***	-0.573***
	(0.093)	(0.087)	(0.093)	(0.088)	(0.085)	(0.083)
mc (d)	0.457***	0.360***	0.458***	0.360***	0.485***	0.382***
	(0.079)	(0.085)	(0.079)	(0.085)	(0.077)	(0.079)
HU price in p10-p90 x market uv	-0.025***	-0.017*				
	(0.008)	(0.009)				
HU price in p10-p90 x exchange rate	-0.016	0.061				
	(0.042)	(0.053)				
HU price in developed-developing x market uv			-0.028***	-0.024***		
			(0.010)	(0.009)		
HU price in developed-developing x exchange rate			0.011	0.036		
			(0.032)	(0.029)		
High elasticity x market uv					0.035	0.003
					(0.040)	(0.042)
High elasticity x exchange rate					-0.022	0.008
					(0.041)	(0.043)
year FE	yes	no	yes	no	yes	no
country FE	yes	yes	yes	yes	yes	yes
product(4d)-year FE	no	yes	no	yes	no	yes
Observations	59,828	59,828	59,828	59,828	56,388	56,388
R-squared	0.027	0.114	0.027	0.115	0.026	0.114

One observation is one firm-product year combination, and the table includes export to EU countries covered by the PRODCOM database. Dependent variable is the log change in unit value (measured in destination country currency). Exchange rate is the log change in exchange rate while mc is the estimated change in variable costs resulting from the change in imported input prices, market UV is the log change in the unit value of the apparent consumption (minus imports from Hungary) of the product in the destination country, while market q is the log change in the quantity of the apperant consumption of the product in the destination country. The variables of interest are interacted with the following dummies. In columns (1) and (2) I calculate the 10th and 90th percentile of the import price dsitribution for each product and place the Hungarian average export unit value in this interval. The dummy shows whether this measure is high (lager than median) relative to other products. In columns (3) and (4) I use the interval between developing and developed country average instead to the percentiles. Finally, in columns (5) and (6) the dummy shows whether the product is more elastic than the median according to the Broda-Weinstein elasticities. Standard errors are clustered at the country-product year level.

- There is a weak demand reaction following the change in Hungarian firms' relative prices when the market price changes.
- Hungarian firms react more strongly when they are at the low end of the unit value distribution.

These observations together suggest that these firms face some kind of rigidity in their international prices. However, many standard models of such rigidities can hardly explain the observed patterns.

As already described, menu cost, rational inattention or Calvo pricing models cannot easily explain these facts for two reasons. First, the observed asymmetry between the reaction to market price and the other variables is not in line with frameworks where firms only change their prices infrequently. In such a framework firms either react to all the variables optimally when they adjust their prices or they do not change the price. Second, in such a framework one would expect strong quantity reactions when prices deviate from their short-term optimal values, which contradicts the very small estimated demand elasticities.

Multi-year contracting, however, may provide a satisfying explanation for the observed stylized facts. Let us imagine a large manufacturer or retailer proposing multi-year contracts for these manufacturing firms. It may be optimal to write the contract in such a way that determines the quantities supplied in each year. The contract may include provisions about the price but these may focus on easily verifiable and observable aspects, like the world price, the exchange rate and cost shock faced by the producer. Country-level prices may not be easily observable and verifiable and they may also deviate only temporarily from the EU-wide price in a few years thanks to the integrated EU market. Such a setting would explain the asymmetry between the different explanatory variables and also the unresponsiveness of the quantity following shocks.

6 Conclusions

This paper has investigated how Hungarian firms react to changes in the market prices in their export markets. The paper has used a model of flexible prices, heterogeneous firms and endogeneous markups as a benchmark and used Hungarian trade and balance sheet data linked to Eurostat data on production, exports and imports at the country-product level for European countries.

While the results about the effect of exchange rate are much in line with previous findings, the results about the effect of the market price contradict the restrictions derived from the flexible price model. First, firms seem to react differently to changes in the exchange rate and market price: while they adjust their markup to a considerable extent when the exchange rate moves, they hardly adjust it following changes in the market price. Second, such weak reaction should mean that following changes in the market price, Hungarian firms' relative prices should change considerably, hence quantity should fall strongly. Empirically this is not the case: the estimated elasticity of demand is indeed significantly smaller than 1.

These findings suggest that these firms - and their consumers - face some rigidities which may differ with respect to different shocks. One possible explanation is the presence of long-term contracts which largely fix prices and quantities and only allow for price changes following changes in easily verifiable variables, e.g. exchange rates.

The results proved to be robust for many robustness checks. Importantly, the main findings are true when restricting the sample to domestic firms, when splitting it to Eurozone and non-Eurozone, and when instrumenting change in market unit values.

Studying potential heterogeneity confirmed some of the findings in the literature with respect to exchange rate pass-through: pass-through is smaller for more productive firms and firms with larger market shares. The reaction to market price does not seem to be heterogeneous along these dimensions but it is stronger when Hungarian firms seem to compete with low-price competitors.

The findings of this paper shows that fully-flexible pricing models do not fully explain the reaction of firms to their competitors' prices on international markets, and the weak demand reaction also contradicts many models of rigidities. Long-term and relational contracts may play an important role in price determination, which may be built into such models.

The price rigidities shown in this paper may have policy relevance as well. The heterogeneous adjustment to different shocks may affect the mechanism of monetary policy or currency devaluations. Also, the possible presence of long-term and inflexible contracts may be important when designing export-promotion policies.

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