The International Elasticity Puzzle Is Worse Than You Think*

Lionel Fontagné (Paris School of Economics – Université Paris I and CEPII)†

Philippe Martin (Sciences-Po and CEPR)‡ Gianluca Orefice (CEPII)§

November 7, 2017

Abstract

We estimate three international price elasticities using exporters data: the elasticity of firm exports to export price, tariff and real exchange rate shocks. In standard models these three elasticities should be equal. We find that this is far from being the case. We use French firm level electricity costs to instrument for export prices and provide a first estimate of the elasticity of firm-level exports to export prices. The elasticity of exports is highest for export prices, around 5, followed by tariffs, around 2, and is lowest for the real exchange rate, around 0.6. The international elasticity puzzle is actually worse than previously thought. Moreover, we show that French exporters absorb one third of tariff changes in their export prices. This implies that estimates of export elasticities that do not take into account the reaction of export prices to tariffs are biased.

Key Words: Elasticity, International Trade and Macroeconomics, Export Price, Firm exports.

JEL Codes: F14, F18, Q56.

*This work benefited from a State aid managed by the National Agency for Research, through the program Investissements d'avenir with the following reference: ANR-10-EQPX-17 (Remote Access to data CASD). Philippe Martin is also grateful to the Banque de France-Sciences Po partnership for its financial support. We thank Thierry Mayer, Sam Kortum, Lorenzo Caliendo, Arnaud Costinot and Thomas Chaney for helpful comments, in addition to participants at seminars at Sciences Po, PSE, Brown University, IMF and UC Berkeley.

†Université Paris I, 106-112 Bd de l'Hôpital, F-75647 Paris Cedex 13. Email: lionel.fontagne@univ-paris1.fr.

‡Sciences-Po, 28 rue des Saints Pere, 75007 Paris. Email: philippe.martin@sciences-po.fr.

§CEPII, 113 rue de Grenelle 75007 Paris. Email: gianluca.orefice@cepii.fr.

Introduction

In many international trade and macroeconomic models, the elasticity of substitution between Home and Foreign varieties, the Armington elasticity, is a crucial parameter. It is one of the fundamental primitives that shape the international transmission of shocks into prices and quantities, and also a key component for analyzing the welfare impacts of trade liberalization (Arkolakis, Costinot & Rodriguez-Clare 2012).[1] However, no consensus has emerged on its value and a tension between the micro and macro views on this elasticity exists. The evidence suggests that the elasticity of export volumes to changes in tariffs is quite large (typically above 2) whereas the elasticity to changes in exchange rates is small (typically around one or lower). This is what Ruhl (2008) has dubbed the international elasticity puzzle. As shown by previous studies, the elasticity puzzle is not only observed with macroeconomic or sectoral data but also with firm level data.

Our paper contributes to this literature by putting firm level export prices explicitly at the center of the analysis of the international elasticity puzzle. The elasticity puzzle literature has focused mainly on the difference in elasticities between tariffs and exchange rates but has not considered the elasticity of firm level export volumes - at the intensive margin - to firm level export prices. This is so even though in standard trade models [2] these three elasticities should be identical. Indeed, if a firm i of country h exports goods to country j, trade models with CES preferences predict the export volume to be:

$$X_{i,h,j} = \left(\frac{p^x_{i_h,j} \tau_{h,j}}{\epsilon_{h,j}} \right)^{-\sigma} P_j^{\sigma-1} Y_j$$

In addition to the destination appropriate price index P_j and income Y_j the firm level export volumes depend on $p^x_{i_h,j}$, $\epsilon_{h,j}$ and $\tau_{h,j}$ the export price in domestic currency, the bilateral exchange rate and the tariff respectively. If the destination price index P_j (which could be affected by individual price, tariff and exchange rate movements) is controlled for, and if the firm does not enter or exit the market, the elasticity of exports to these three variables should be identical and equal to σ. We show this is far from being the case in the data. Moreover, previous empirical studies, by omitting changes in firm level export prices, implicitly assume that these do not react to exchange rate and tariff shocks. We show this assumption is not valid as exporters absorb one third of tariff changes in their prices. This generates a bias in the estimates of the elasticity of firm level exports to tariffs and exchange rates.

An obvious difficulty to estimate the export price elasticity is that export prices and export quantities are endogenous at the firm level. This problem does not occur for exchange rates and tariffs shocks that could be considered exogenous to a single firm. To overcome this difficulty we use a firm level time varying instrumental variable for export prices. To this end, we use an original dataset providing information on a firm specific cost shock, namely firm level electricity prices.

[1] Arkolakis et al. (2012) show that for a larger class of trade models, the welfare gain from trade can be expressed as $\hat{W} = \hat{\lambda}^{1/\varepsilon}$ where $\hat{\lambda}$ is the change in the share of domestic expenditure and ε is the trade elasticity to variable trade costs.

[2] See Krugman (1979),Melitz (2003), Eaton & Kortum (2002) or Atkeson & Burstein (2008)

We argue below that these firm level electricity cost shocks are related to factors exogenous to its export performance (regulation changes, year and length of beginning of contracts, national and local tax changes, location, changes in both market and regulated prices and local weather) and are likely to affect its export performance only through the firm export price. We match this dataset to a data set on French export volumes and values to estimate the firm level export price elasticity. We do this by using French exporters data on the period 1996-2010 and we focus on the intensive margin of trade.

Our results confirm that, when estimated at the firm level, the tariff elasticity is higher (around 2) than the exchange rate elasticity (less than 1). This is the standard international elasticity puzzle. We go further by showing that the export price elasticity is even larger (around 5) than both the tariff and the exchange rate elasticities. From this point of view, our results make the international elasticity puzzle worse.

By introducing explicitly firm level export prices as a determinant of export volumes we also improve on the estimation of the elasticity of exports to exchange rate and tariff shocks. This is because we take into account the reaction of export prices to exchange rate and tariff shocks to estimate the elasticity of exports to those shocks. This would not be important if exporters did not absorb part of the tariff or exchange rate changes in their FOB domestic currency export price. However, we find that French exporters reduce substantially (by 3.5%) their export price when faced with a tariff increase of 10%. This is much less so for exchange rate movements. This implies that in the existing literature, where export prices are not controlled for, the estimated elasticity of export volumes to tariff and exchange rate movements is the addition of the true firm-level elasticity of exports to these shocks and of the export elasticity to the endogenous reaction of export prices to exchange rates and tariffs movements.

Our analysis also uncovers a new stylized fact: exporter prices are countercyclical. Exporters decrease their destination specific prices in years where the GDP of destination is above average. This pricing behavior explains a large share of the increase of exports towards destinations with high demand in addition to the standard direct effect of demand on exports.

Our paper is related to a large literature that has estimated the elasticity of exports to tariffs and exchange rates. An extensive review of the literature estimating trade elasticities is provided by Hillberry & Hummels (2012). Fitzgerald & Haller (2014) and Berman, Martin & Mayer (2012) found that the elasticity of a firm export volumes to an exchange rate movement was below unity and around 0.5 to 0.7. The impact of those shocks on export volumes typically depends on how exporters pass them into export prices, how importers pass them into consumer prices and how final consumers react to change in final goods prices. In addition, Fitzgerald & Haller (2014) find that the elasticity of firm level exports to tariffs is larger than to exchange rate movements, the international elasticity puzzle at the firm level, which we confirm on French data. This elasticity also depends on the extent of strategic complementarities between firms in price setting, an issue analyzed by

Amiti, Itskhoki & Konings (2016) and which we take into account in our analysis. Amiti et al. (2016) also estimate the price response to a firm specific cost shock (proxied with changes in the unit values of the imported intermediate inputs) but do not analyze the response of exports to these cost shocks. As in our paper, Piveteau & Smagghue (2015) use an instrumental strategy to estimate export price elasticities[3]. They use exchange rate rate variations interacted with firm-specific importing shares as instruments and they concentrate their analysis on the estimate of quality of exported goods. We argue that an advantage of using electricity cost shocks as instruments is that they are more likely to affect exports only through their impact on export prices. On the tariff side, Bas, Mayer & Thoenig (2015) show that aggregate and firm-level elasticities to tariffs are shaped by exporter participation and thus vary across destinations. Berthou & Fontagné (2016) estimate a mean elasticity of the product-destination firm-level exports with respect to applied tariffs at about 2.5, which is close to what we find. Using product-level information on trade flows and tariffs, Head & Ries (2001), Romalis (2007) and Caliendo & Parro (2015) estimate aggregate elasticities of 6.9, 8.5 and 4.5 respectively. Also using sector-level data, Costinot, Donaldson & Komunjer (2012) find an elasticity of 6.5[4] as well as by Bussiere, Gaulier & Steingress (2016,). Finally, Anderson and Van Wincoop (2004) survey the evidence on the elasticity of demand for imports at the sectoral level and conclude that this elasticity is likely to be in the range of 5 to 10. Using the methodolgy of Feenstra (1994), Broda & Weinstein (2006) report median import demand elasticities of 3.7 on their most disaggregated samples. Simonovska & Waugh (2014a) estimate the aggregate elasticity to be around 4 and Simonovska & Waugh (2014b) show how to estimate aggregate trade elasticities using price gaps. Our paper differs fundamentally from those using aggregate (sector-level) data in terms of both objective and interpretation. Given that the elasticity to tariffs we estimate is at the firm level, this means its interpretation is different from the elasticity of aggregate trade to tariffs present in models such as Eaton & Kortum (2002) where the aggregate elasticity of trade to tariffs is governed by the heterogeneity across goods in countries relative efficiencies and not the elasticity of substitution between domestic and foreign goods.

Our paper is also related to Feenstra, Luck, Obstfeld & Russ (2014) who distinguish between the elasticity governing the substitution between home and foreign goods (which they call macro and estimate to be below 1) and the elasticity governing the substitution between varieties of foreign goods (which they call micro and estimate around 4.4). Our approach is different as: (i) we do not make this distinction; (ii) we use exporters level data rather than sectoral data on imports and (iii) we rely on an instrumentation method (firm level electricity cost shocks) rather than a GMM estimator that rests on the assumption that demand and supply costs are unrelated. This assumption may be an issue if higher costs of production are correlated with higher quality.[5]

[3] Erkel-Rousse & Mirza (2002) also use instruments for aggregate import prices (exchange rates, wage rates and production and exporter fixed effects) to estimate trade elasticities and find that they vary between -4 and -15.

[4] In Costinot et al. (2012) this is the producer price export elasticity. Aggregate elasticities are also estimated by Imbs & Mejean (2015) and Imbs & Mejean (2016).

[5] See Feenstra & Romalis (2014) for how taking into account the issue of endogenous quality alters the estimation of international price elasticities.

A further advantage of our instrument is that it bypasses the problem of quality that may affect both demand and supply costs. Indeed, an electricity price change in one year is plausibly uncorrelated with a quality change on the exported product in that year.

Finally our paper is related to the pass-trough literature (see Burstein & Gopinath (2014) for a survey as well as Bussiere et al. (2016,)) because our first stage shows that French export prices absorb much more tariff than exchange rate shocks.

The remaining of the paper is structured as follows. We present data and our instrumental variable for export prices in Section 1. Our results on the estimate of the elasticity of export volumes to (instrumented) export prices are given in section 2. We then estimate jointly and compare the elasticities of exports to export prices, tariffs and exchange rates in section 3 and present robustness checks in section 4. The last section concludes and attempts to provide an interpretation of our results in particular relating trade elasticities to the volatility of shocks.

1 Data and instrumental variable description

1.1 Data

We use three confidential firm level datasets: (i) *Douanes* database on French firms exports, (ii) $Ficus/Fare$ on French firms balance sheet information and (iii) $EACEI$ data on energy consumption and purchase of French firms .[6] Macro level control variables come from standard sources (World Bank, CEPII and Penn World Table).

The *Douanes* database is provided by French customs for the period 1995-2010 on import and export flows of French firms by destination country, product (HS 6-digit classification) and year. This database contains all trade flows by firm-product-destination that are above 1,000 euros for extra EU trade and 39,000 euros for intra-EU trade, so it can be considered an exhaustive sample of all French exporting firms.[7] Based on export values and quantity (reported in kilos) we compute the Trade Unit Values (TUV) for a specific firm-product (HS 6-digit)-destination-year cell (here used as proxy for the export price). The potential amount of observations is thus very large: there are almost 100,000 exporting firms per year and 200 destination markets. For this reason (and also because our main instrumental variable does not vary with product dimension - see below), we collapse the French customs data at firm-destination-year level. Hence, the resulting TUV is the weighted average across exported products of a given firm-destination-year cell.[8] Doing so, we lose the HS exported product dimension; but when needed, we still have the information of the main *industry* (NAF700 classification) in which the firm operates (as coded by the INSEE).[9]

[6] All firm level confidential dataset have been used at CEPII.
[7] Reporting of firms having trade values below such thresholds is discretionary but many firms below the bar are in the dataset.
[8] We use export quantities as weights.
[9] Notice that each firm is assigned to a unique industry of activity by INSEE. There are 615 industries in the NAF700 classification.

The weighted average of TUVs can suffer from a composition bias (due to the aggregation of several products exported within a firm-destination-year cell).[10] Hence, in a robustness check, we retain the export product dimension of the dataset by restraining the analysis to the core product exported by the firm in a given market. For each firm-destination we keep the HS-6 code that represents the maximum (average across years) exported value for the firm-destination. For the core product of the firm, TUVs do not suffer from a composition bias. Thus, in all the core product estimations we refer to a specific *sector* rather than to a more general industry dimension (as done in the baseline dataset described above).

The second firm level database is $Ficus/Fare$ which contains balance sheet information for all French firms. From this database we use employment level of each French manufacturing firm as a control variable in our main regressions. From $Ficus/Fare$ we also keep the labor cost and the purchase of intermediate inputs and raw materials used to compute the share of electricity over the total cost reported below.

The information on firm level electricity price (used as instrumental variable for the export price, see section 2) is provided by the $EACEI$ survey on energy purchase and consumption by around 11.000 French firms in the period 1996-2010.[11] For each plant-year combination we have information about the use of different types of energy such as electricity, steam, coke and gas. For consistency with the French custom data, the $EACEI$ database has been aggregated at firm level by summing electricity bill and consumption across plants within the same firm.[12] The price of electricity has been computed as the ratio between electricity bill (in €) and purchased quantity of electricity (in kWh). The final electricity price for the firm is thus expressed in €/kWh. When we merge the three firm level databases we are left with around 8,500 exporters per year.

Finally we merge firm level data with other macro datasets: (i) OECD.stat for the GDP of destination countries, (ii) CEPII MacMap HS-4 and HS-6 data for tariffs and (iii) Penn World Table for nominal exchange rates and consumer price indices (used to calculate the real exchange rate). The MacMap database on tariffs records ad-valorem *applied* tariff for each country pair-sector (HS-4 and HS-6 digit) observed in four years: 2001, 2004, 2007 and 2010 (see Bouet, Decreux, Fontagné, Jean & Laborde (2008) and Guimbard, Jean, Mimouni & Pichot (2012) for more details on MacMap).[13] Since French exporters do not face tariff in EU, we simply set to zero intra-EU tariffs. As described above, for our baseline regressions we use a firm-destination-year specific dataset. So we follow Fitzgerald & Haller (2014) and use the weighted average tariff faced by a firm into a given destination-year (average across exported products).[14] In the core product estimations, since we keep the core exported product of each firm, we can use the (core) product level tariff. In the main regressions, we use HS-4

[10] This is not a big problem in our case since the majority of firm-destination cells (60%) involve export shipments within a unique HS 4-digit heading. Since products within a HS 4-digit heading are mostly homogeneous, the composition bias concern here is reduced.

[11] The survey has been conducted on firms with more than 20 employees.

[12] We use the French firm identifier *siren* to merge with the Custom database.

[13] We use tariff in 2001 for the years preceding 2001. Tariffs in 2001 were also used for the period 2001-2003. Then tariffs in 2004 have been used for the period 2004-2007. Finally, tariffs in 2007 were used for tariffs in the period 2007-2010.

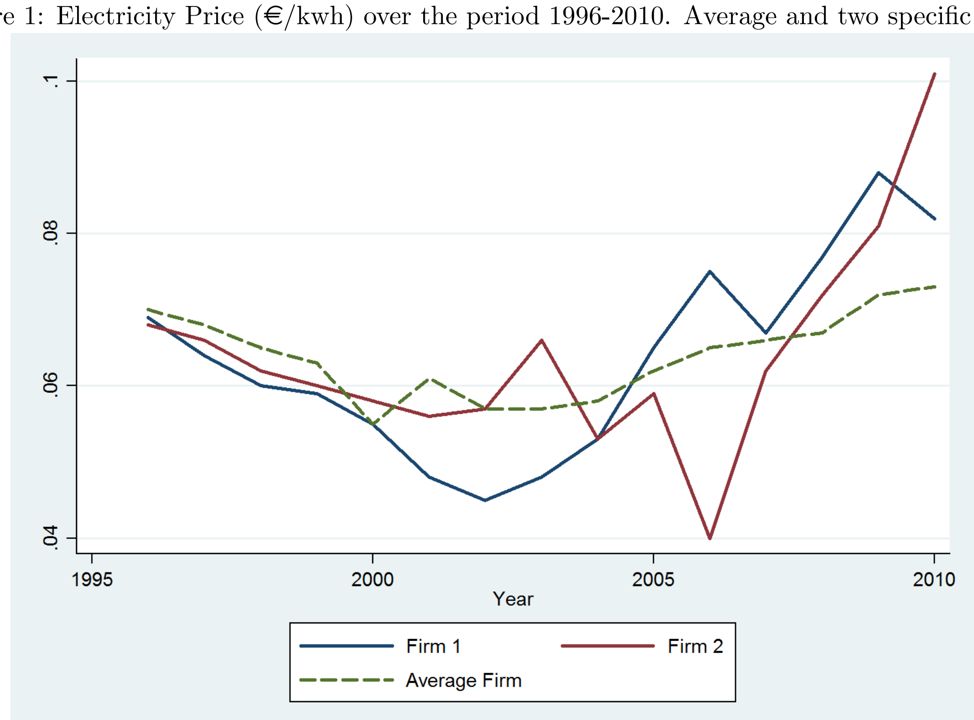
[14] We follow Berthou & Fontagné (2016) and use the product share over total exports as a weight.

digit tariffs. This has the advantage that it reduces the concern that tariffs may be increased on some French firms which experience high export growth and therefore that tariffs may not be fully endogenous at the firm level. In a robustness check, we use tariffs at the HS-6 digit.

1.2 Firm level electricity prices as instruments for export prices

In our empirical strategy, we use the firm specific electricity price as an instrumental variable for the export price [15]. The average electricity price in our dataset (reported in table 1) is in line with the publicly available average prices for the manufacturing sector. Importantly, our dataset exhibits variance across firms and within a firm over time. We also observe annual variations in prices that are not synchronized across firms. In figure 1 the dotted line is the average price of electricity paid by French firms between 1996 and 2010. We also show the price paid by two anonymous firms chosen here to have a mean price and a standard deviation similar to the mean and the standard deviation of the overall sample. Although the overall trend is similar (first downward then upward), we see that these firms experience yearly shocks that are very different.

Figure 1: Electricity Price (€/kwh) over the period 1996-2010. Average and two specific firms.



Note: The dashed line refers to the average firm, obtained by collapsing the dataset by year. Firm 1 and 2 are specific (anonymous) firms having mean and std dev electricity price similar to sample mean and std dev. Source: Authors based on EACEI dataset.

We now explain what is behind the firm specific component of electricity prices in the French manufacturing

[15] Ganapati, Shapiro & Walker (2016) use energy cost shocks as instruments for marginal cost shocks. Their aim, very different from ours, is to estimate the pass-through of those shocks into domestic prices. A major difference with our paper is that they use the interaction between national fuel prices for electricity generation and 5-year lagged electricity generation shares at the state level. We use firm level data for electricity prices.

sector. In particular we argue how the specificities of the French electricity market enable us to use firm level electricity prices as an instrument for export prices. Note that our regressions will include firm fixed effects so that any time invariant characteristic of the firm electricity price will be controlled for and that the source of variation we will use is across years for a given firm. A characteristic of the French electricity market is that many contracts co-exist with both regulated and market driven prices. Regulated prices are offered only by EDF (the main historical operator) and unregulated prices are offered by all operators to all firms (Alterna, Direct Energie, EDF, Enercoop, GDF Suez, Poweo...). Firms can also have several contracts with several producers and some produce their own electricity.

Another characteristic is that many firms had to renegotiate long-term contracts that ended during the period. These long term contracts allowed firms to have lower prices and their expiration means that firms may experience an increase in price in different years depending on the year the contract was initially signed and its length. Importantly for us there has also been many changes in regulations during the period 2001-2010. Under the pressure of the European Commission the market has been partially deregulated and opened with an increasing role of both imports and exports. Large firms were the first to be able to opt out from regulated prices in 2000 and this possibility was open progressively to all firms in the 2000s. However, in the same period many different electricity tariffs co-existed and were affected by several changes. For example, in 2006 there was a large increase in electricity prices for firms that had opted (in the preceding years) for contracts with deregulated market prices. The government decided in 2007 to allow those firms to go back to a transitory regulated tariff (TarTAM tariff) calculated on the basis of the regulated tariff plus a surcharge depending on the firm of 10%, 20% or 23%. Not all firms chose to do so as it depended on the difference between the firm specific previous contracted price and the (firm specific) TarTAM (transitory regulated tariff). This choice depended itself on the date the previous contract was signed. This possibility was then stopped in particular because it was deemed to be a sectoral subsidy by the European Commission and this meant another change in price for some but not all firms. There are also different regulated tariffs for firms. The Blue tariff (small electricity users) allows a fixed price (for a year) with possibility to have lower prices during the night. Yellow and Green tariffs (intermediate and large electricity users) may also benefit from a fixed price with lower average prices during the year if they accept to pay higher prices possibly on a maximum 22 days in the year (very cold days in winter when household demand is high). Depending on the location of the firm in France these price increases may differ. Also, some firms benefit from low prices because they are close to hydroelectric facilities. Finally, the electricity price also depends on several taxes especially the so-called TURPE (to pay for distribution and transport in particular) since 2000 which was created after the European Commission obliged France to separate the production and the distribution of electricity. The tax is itself quite complex, firm specific (in particular it is reduced if the firm has experienced a power outage of more than 6 hours in the year) and changes every year. It can constitute up to

40% of the final electricity cost. Another tax (CSPE to finance renewable costs) also varies every year. Finally there are additional taxes at the city and department level that can vary both across locations and years.

This description of the electricity market in France shows that electricity prices vary at the firm level for reasons that are both endogenous to the firm activity (in particular its *average* electricity use, which is then captured by firm fixed effects in our empirical strategy) and more importantly exogenous to the firm export activity (regulation changes, year and length of beginning of contract, tax changes both at the national and local levels, location, changes in both market and regulated tariffs, local weather).[16] We take into account some of the impact of firm characteristics on electricity prices by including a firm fixed effect as well as a time varying measure of its activity (employment). Using firm specific electricity price changes as an instrument for export prices in the regression to estimate the price elasticity of exports is also valid because we believe that electricity price changes at the firm level affect export volumes only through their effect on export prices (the exclusion restriction). This would not be the case for other types of costs (wages or intermediate inputs) that may alter export volumes if an increase in these costs is caused by an increase in the quality of the good (see Piveteau & Smagghue 2015 on this). An alternative instrument for marginal cost shocks is exchange rate shocks for intermediate imported inputs as in Piveteau & Smagghue (2015) and Loecker & Biesebroeck (2016). One potential issue with using the exchange rate variations (even if interacted with firm-specific importing shares) as an instrument is that they may affect directly the exports of the firm other than through its export price.

Our first stage regression that we detail in the next section resembles a pass-through equation where export prices depend in particular on electricity prices. In a standard framework where a firm i uses several inputs (electricity among others) which are imperfect substitutes and minimizes costs, the path-through of a firm level electricity cost shock p_{ei} to export prices p_i is given by:

$$\frac{dp_i}{dp_{ei}} \frac{p_{ei}}{p_i} = \frac{p_{ei}e_i}{p_{ei}e_i + \sum_{m=1}^{M} p_m x_{mi}} \tag{1}$$

where M is the number of inputs (other than electricity) and $p_m x_{mi}$ the expenditures on those inputs. Hence, the passthrough of electricity cost shocks to export prices is simply the share of electricity costs in the total costs of the firm. For each firm we have labor costs, energy costs and intermediate goods costs but not capital costs. In our data set which is restricted to the manufacturing sector this ratio is around 2.7% (see table 1)[17] so we should expect that in our first stage regressions the pass-through of a firm level electricity price shock to

[16] One may be concerned that the electricity price of French firms is correlated with the international price of energy which itself affects world demand for French exports. International price for gas and oil are indeed correlated with the French electricity price (the correlation is around 0.5 on the period). However, we include year fixed effects in all our regressions (either as year fixed effects alone or as destination-year fixed effects). This fully controls for the business cycle and world energy prices that might drive both the electricity prices in France and aggregate exports. Given the presence of firm and year fixed effects, this means our IV uses the part of firm level electricity prices which is not common to all French firms and which deviates from the average over the period for this firm.

[17] The observed distribution of the electricity cost share among French manufacturing exporters is shown in appendix figure A1 and suggests that although heterogenous this cost share is concentrated around its mean

export prices is around the same number. An alternative instrument for the firm specific export price, consistent with equation 1, would be the interaction between the firm-year specific price of electricity and the firm specific share of electricity over total costs. For this cost share we tried either the average share for the firm on the whole period or the share for the sector to reduce endogeneity. The advantage of this instrument is that it uses an information specific to the firm or the sector which describes its electricity intensity. The disadvantage is that total costs (including labor costs and intermediates) may be endogenous to exports of the firm and may affect exports in particular its mix of produced (and then exported) goods. We use this alternative instrument in robustness checks in section 4 and find similar results.

Table 1: In-sample descriptive statistics on firm-year level dataset.

	Mean	Std Dev	Min	Max	Std Dev Between	Std Dev Within
Electricity Price (€/kwh)	0.064	0.016	0.033	0.139	0.016	0.009
Electricity cost share	0.027	0.059	0.000	0.999	0.059	0.043
Trade Unit Value (ln)	2.256	1.673	-1.660	7.982	1.667	0.479

Source: Author's calculation on Ficus/Fare sample and Douane data.

The share of electricity over the total cost (as reported in table 1) is computed as the ratio between the electricity bill and the total production costs of the firms available in the Ficus/Fare dataset (i.e. labor cost, purchase of intermediate inputs, raw materials and electricity). Table 2 reports the summary statistics for the sample of firms we use in our baseline regressions, so the number of firms and the other statistics reported in the table refer to a sample of exporting firms for which we also have balance sheet and electricity bill data. The average size of the firm over the period 1996-2010 is large but this is not surprising since these are exporting firms only.[18] There is also some variation in the electricity cost share over time: from 1.9% in 2005 up to 3.6% in 2002 and back to 2.5 % in 2010 (the average over the period is 2.7%).

Our empirical strategy proceeds in two steps. First, we estimate the elasticity of export volumes to prices by using an instrumental variable approach to solve the endogeneity problem of prices i.e. Trade Unit Values. Then, we analyze the international elasticity puzzle in our data set by including in the same regression export price (instrumented), real exchange rate and firm specific tariffs.

2 Export Volumes Elasticity to Export Prices

To estimate the elasticity of export volumes to export prices we use the instrumental strategy described in the previous section. To highlight the robustness of our price elasticity estimation, we show results with several combinations of fixed effects and controls. The second stage regression has the following econometric specification

[18] Moreover, remember that EACEI survey is conducted on firms with more than 20 employees.

Table 2: In-sample summary statistics

Year	N. Firms	Employees	Elec. Price	Elec. Share
1996	9,000	227	0.070	0.029
1997	9,492	217	0.068	0.029
1998	9,746	215	0.065	0.028
1999	9,702	213	0.063	0.028
2000	5,561	289	0.055	0.020
2001	8,744	223	0.061	0.025
2002	5,895	344	0.057	0.036
2003	5,715	353	0.058	0.036
2004	6,054	316	0.059	0.035
2005	4,613	241	0.062	0.019
2006	6,198	205	0.065	0.020
2007	6,464	201	0.067	0.022
2008	5,413	223	0.068	0.021
2009	5,437	194	0.073	0.033
2010	5,721	183	0.075	0.025

Notes: statistics on the sample of firms used in the baseline estimations.
Source: Authors' calculations on EACEI and Douane dataset.

depending on the set of fixed effects included:

$$ln(exp_{i,j,t}) = \theta_i + \theta_{jt} + \sigma ln\left(TUV_{i,j,t}\right) + \beta_1 \left(X_{i,t}\right) + \varepsilon_{i,j,t} \tag{2}$$

$$ln(exp_{i,j,t}) = \theta_i + \theta_{jst} + \sigma ln\left(TUV_{i,j,t}\right) + \beta_1 \left(X_{i,t}\right) + \varepsilon_{i,j,t} \tag{3}$$

$$ln(exp_{i,j,t}) = \theta_{ij} + \theta_t + \sigma ln\left(TUV_{i,j,t}\right) + \beta_1 \left(X_{i,t}\right) + \beta_2 \left(Z_{j,t}\right) + \varepsilon_{i,j,t} \tag{4}$$

while the first stage regression is the following respectively with the electricity price ($Elect.Price_{i,t}$) as instrument variable:

$$ln(TUV_{i,j,t}) = \theta_i + \theta_{jt} + \gamma_1 ln\left(Elect.Price_{i,t}\right) + \gamma_2 \left(X_{i,t}\right) + \eta_{i,j,t} \tag{5}$$

$$ln(TUV_{i,j,t}) = \theta_i + \theta_{jst} + \gamma_1 ln\left(Elect.Price_{i,t}\right) + \gamma_2 \left(X_{i,t}\right) + \eta_{i,j,t} \tag{6}$$

$$ln(TUV_{i,j,t}) = \theta_{ij} + \theta_t + \gamma_1 ln\left(Elect.Price_{i,t}\right) + \gamma_2 \left(X_{i,t}\right) + \gamma_3 \left(Z_{j,t}\right) + \eta_{i,j,t} \tag{7}$$

where subscripts i,j, s and t stand respectively for firm, destination market, sector and year. The dependent variable in equations (2), (3) and (4) $ln(exp_{i,j,t})$ is the log of the exported volume by firm i in a specific country j and year t. In standard models of international trade, that generate gravity-type equations, firm level export volumes depend on the firm-destination specific price - $ln(TUV_{i,j,t})$ - the destination country aggregate income and price index. Our main focus here is the instrumented log of the export price (i.e. trade unit value) - $ln(TUV_{i,j,t})$ - and we expect a negative coefficient for σ. As explained in the data section we use two main regression samples: (i) exported volumes and average TUV across products within firm-destination-year (*baseline full dataset*), (ii) exported volumes and TUV of the HS-6 specific core product of the firm for a given destination (*core product dataset*). The subscript s refers to sector (NAF700 classification) and sector (HS classification) respectively for baseline and core product dataset (see section 1 for further details).

Table 3: Baseline 2SLS regressions on full dataset.

	(1)	(2)	(3)	(4)	(5)	(6)
Dep Var:	Export Volumes (ln)		Export Volumes (ln)		Export Volumes (ln)	
TUV (ln)	-4.203***	-3.916***	-5.692***	-5.366***	-5.544***	-5.131***
	(0.729)	(0.671)	(1.197)	(1.125)	(0.982)	(0.900)
Employment (ln)		0.159***		0.132***		0.205***
		(0.012)		(0.017)		(0.015)
GDP (ln)					0.784***	0.831***
					(0.167)	(0.153)
Effective RER (ln)					-0.067***	-0.067***
					(0.017)	(0.016)
Firm FE	yes	yes	yes	yes	no	no
Destination-Year FE	yes	yes	no	no	no	no
Firm-Destination FE	no	no	no	no	yes	yes
Year FE	no	no	no	no	yes	yes
Destination-Sector-Year FE	no	no	yes	yes	no	no
First Stage						
Electricity Price	0.049***	0.050***	0.040***	0.040***	0.046***	0.046***
Employment (ln)		0.002		-0.002		-0.001
F-stat	23.25	23.47	15.83	15.60	22.83	22.67
Observations	1630856	1630856	1630856	1630856	1488954	1488954

Standard errors are clustered within firm-year in all estimations. When Destination-Sector-Year FE are included, the sector is the main NAF700 sector of the firm. More details on the first stage results are reported in table A5
*** $p < 0,01; **p < 0,05; *p < 0,1$.

We want to compare our estimates of the price elasticity with various fixed effect combinations. In equations (2) and (5), we include firm fixed effects (θ_i) and destination-year fixed effects (θ_{jt}). This enables to control for any time invariant characteristic of the firm and for any destination specific time varying impact on the firm demand, as well as components of the global cycle that may affect electricity prices and French exports. Firm fixed effects control for the time invariant part of the firm characteristics (e.g quality) that may affect its exported volumes. Destination year-fixed effects control for the effect of the macroeconomic cycle in the destination country (aggregate demand) as well as the destination price index (see Anderson & van Wincoop (2003) and Head & Mayer (2014)). This set of fixed effects is standard in the trade literature. In equation (3) and (6) the specification is more demanding as it replaces destination-year fixed effects (θ_{jt}) by destination-sector-year fixed effects (θ_{jst}). In the core product estimations, when s represents the sector of firm's export, the θ_{jst} fixed effects should better control for both the aggregate demand for the sector and the price index at destination as it takes into account differences across sectors in a same destination-year cell. Moreover, θ_{jst}

fixed effects control for sector specific shock in each destination.[19] In equations (4) and (7) we include firm-destination (θ_{ij}) and year (θ_t) fixed effects.[20] These fixed effects properly control for any time shock (common to all destinations) and for any firm-destination specific characteristics affecting the export volumes of French firms. Because the specification in equation (4) does not control for the destination time varrying aggregate demand and price index through the proper fixed effects, we add a set of country-year specific variables Z_{jt} including GDP (in ln) and effective real exchange rate as a proxy for the destination price index (the real exchange rate has been computed as in Berman et al. (2012)).

Table 3 shows the results of the IV regression with the three different sets of fixed effects and the first stage results at the bottom of the table. The coefficient on electricity prices is always positive and significant, and the F-stat is always above 15. Note in particular that the first stage estimates of the impact of electricity cost shocks on export prices are very stable as they vary between 0.04 and 0.05[21]. As discussed before, a simple model predicts that this elasticity should be close to the share of electricity costs in total costs. The average observed share in our sample is around 3% so not very different from our estimated pass-through.

Table 3 provides a first estimate of the export price elasticity that varies (in absolute value) between 3.9 and 5.7[22]. In the specification reported in columns 1 of table 3, firm fixed effects and destination year fixed effects are included but there is no control for the time varying activity of the firm that may affect electricity prices, export prices and export volumes. This is are added in column 2 where we control for employment (in ln). We have also tried with firm turnover which generates similar results but prefer employment as turnover includes export sales. Note, that our first stage estimation is not much affected by this control. Then, in columns 3 and 4, the destination-year fixed effect is replaced by a more demanding destination-sector-year fixed effect. [23] Finally specifications 5 and 6 have a firm-destination fixed effect and a year fixed effect. Results are very similar. [24]

All in all, we conclude that the estimate of the export price elasticity is robust across different specifications (i.e. fixed effects) and around 5.

2.1 Robustness checks using core product dataset.

In table 4, we perform several robustness checks on the sample. First, we restrict the sample to the core product of the firm (for each firm we keep the product line having the maximum average exports over the period 1996-

[19] Destination-sector-year fixed effects in the baseline sample estimations use the NAF700 classification of each firm, i.e. the sector to which the firm belongs to, so they are poorer proxy for the price index relevant for the firm.

[20] We use high-dimensional instrumental variable estimations procedure developed in Bahar (2014) - **ivreg2hdfe** in Stata.

[21] The full first stage regression results are shown in the appendix in table A5.

[22] We report the OLS estimation in the appendix in table A2. Not surprisingly the demand elasticity is lower in absolute value, just above 1, when we do not instrument the export price. An obvious reason is that in this case price movements are not exogenous and affected by demand shocks to the firm.

[23] Industries are defined using the NAF700 4-digit classification of the French statistical institute INSEE for each firm. There are 615 NAF700 industries in the French economy.

[24] Another possible specification is to run the regression in first difference. The coefficient on TUV in the second stage is estimated at -5.176 and significant. However, the instrument in the first stage although significant is weak with an F-stat less than 4.

2010). This solves the potential aggregation bias concern when firms export more than one product to a given destination. In this case, changes in unit values and quantities may reflect changes in the product mix instead of real price changes. One may also be concerned that an electricity price increase may push firms to concentrate on the high quality exported goods and therefore to change its mix of exported products. To eliminate these problems, we restrict the sample to a set of observations for which the firm exports only one product over our time frame which we take as the core product. Second, we restrict the sample to firms exporting to a given destination over the entire period. This is the simplest way to deal with the selection bias (entry/exit dynamics of the firm) - see Fitzgerald & Haller (2014). Results reported in columns 1-2 in table 4 show an estimated elasticity a bit higher (in absolute value) than that obtained on the full sample (when we do not restrict to the core product). This may indeed suggest that firms faced with a cost shock tilt a bit their product mix towards higher quality, lower elasticity products. The F-stat of the first stage regressions decrease and are slightly lower than 10. This suggests a moderate weak instrument issue that might be due to the reduced number of observations in presence of clustered standard errors with demanding sets of fixed effects. In column 2 and 4 of table 4 we report regressions with destination-sector-year fixed effects and obtain similar results. In those regressions, because we use the core product of the firm we can use the HS classification for the sector fixed effect. We use the 4 digit level of HS because defining the sector fixed effect at the 6 digit level is too demanding for the regressions. In columns 3-4 in table 4, we report a further robustness check by using the core product of the firm for a sub-sample of firms exporting at least five years over the period 1996-2010. This robustness check aims at reducing the problem of churning without sticking on pure continuous exporting firms. The estimated elasticities are a bit higher in the range of 4.6 to 6.5 with a joint F-stat above 10.

2.2 Robustness checks controlling for strategic complementarity.

A final issue we want to address is strategic complementarity that has been emphasized recently by Amiti et al. (2016) in international pricing. The concern is that in the first stage regression, the electricity cost shock that generates the export price increase could also lead close competitors to increase their own price. In turn, this may alter the estimate of the impact of the export price increase on its export sales. If such a strategic complementarity exists, for example of the kind analyzed by Atkeson & Burstein (2008), the perceived elasticity of demand is different (smaller) from the elasticity of substitution across products. A complete analysis of this issue is beyond the scope of our paper but we can take advantage of our dataset to check whether our estimates are robust to a crude measure of these strategic complementarities. Note that they should be already taken into account when we include destination-sector-year fixed effects as in columns 3 and 4 of table 3, and/or destination-sector-year fixed effects as in table 4. The reason is that in a model such as Atkeson & Burstein (2008), the firms are large enough to affect the sectoral price index. A destination-sector-year fixed effect should

Table 4: Core product robustness checks.

	(1)	(2)	(3)	(4)
Dep Var:	Export Volumes (ln)		Export Volumes (ln)	
TUV (ln)	-5,296***	-3,325***	-5,991***	-5.495***
	(1.667)	(0.818)	(1.426)	(1.216)
Employment (ln)	0.201***	0.172***	0.196***	0.150***
	(0.027)	(0.020)	(0.023)	(0.028)
Sample	Core product and balanced database		Core product exporting more than 5 years	
Firm FE	yes	yes	yes	yes
Destination-Year FE	yes	no	yes	no
Destination-Sector-Year FE	no	yes	no	yes
First Stage				
Electricity Price	0.043***	0.063***	0.042***	0.045***
Employment (ln)	-0.002	-0.006	-0.004	-0.015***
F-stat	8.75	7.70	14.26	10.18
Observations	173827	173827	643567	643567

When Destination-Sector-Year FE are included, the sector is the HS 4-digit chapter of the core HS 6-digit product.
Standard errors are clustered within firm-year in all estimations.
*** $p < 0,01; **p < 0,05; *p < 0,1$.

control for the sector price index and therefore for the strategic complementarity effects. One interpretation of the larger (in absolute term) coefficient that we obtain in columns 3-4 compared to columns 1-2 in table 3 is therefore that when we do not include destination-sector year fixed effects, the estimated elasticity is the perceived elasticity of demand (around 3 to 4) whereas when do, the estimated elasticity is the elasticity of substitution between home and foreign products within a sector (around 4 to 6). However, one could argue that the NAF4 digit sectors that we use for these fixed effects are not necessarily the valid ones to capture these strategic complementarities. However, destination-HS4-year fixed effects as in table 4 are a more compelling way of controlling for strategic complementarity and results hold. Moreover, as a further robustness test, we use the core product dataset and control for the prices of other French exporters to the same destination and in the same HS6 sector.

We follow a similar empirical strategy as in Amiti et al. (2016) although we depart from them because we use a different instrumental variable and we analyze the strategic complementarity on export prices while they analyze it on domestic prices. We proceed in two steps. First we control for strategic complementarity of French exporters only and then we control for strategic complementarity of non French exporters to the destination. In order to define the relevant set of competitors, we need the specific HS 6-digit in which the firm operates. So, for this estimations we rely on the core product based sample of firms (as in table 4). For firm i exporting to a given HS6-Destination combination, we define the French competitors trade unit value (TUV) as the average TUV of French firms exporting to that HS6-Destination combination. We exclude from this average the TUV of firm i. We also exclude from the sample HS6-destination combinations with less than two competitors. Finally, we define foreign competitors TUV as the average import price (TUV) of non-French exporters to a given HS6-destination where the French firm i is exporting (using BACI dataset). In table 5 we show results based on core product dataset (firms exporting more than 5 years) controlling for the average price of French competitors - columns 1 and 2 - and for both domestic and foreign competitors TUV - column 3. The results are intuitive as firm export prices increase with both domestic and foreign competitors prices (in the first stage) suggesting the presence of strategic complementarity. The price of competitors also have a positive impact on export volumes. However, the main result is that the estimated elasticity is not much affected.

As a robustness check in columns 2 of table 5 we replace the French competitors prices by an exogenous shock to these prices, i.e. the average electricity cost for these French competitors. Its effect on export volumes is positive and significant in column 2 but again the estimate of the export price elasticity is not much affected. All in all, from this first set of evidence we conclude that our estimate of the firm level export price elasticity is precisely estimated and relatively high at around 5.

Table 5: Strategic complementarity robustness checks

	(1)	(2)	(3)
Dep Var:	Export Volumes (ln)		
TUV (ln)	-6.232***	-6.381***	-5.770***
	(1.699)	(1.758)	(1.527)
Employment (ln)	0.160***	0.153***	0.162***
	(0.043)	(0.045)	(0.041)
TUV competitors (ln)	0.622***		0.517***
	(0.216)		(0.181)
TUV importing country (ln)			0.208***
			(0.059)
Electricity Price competitors (ln)		0.216**	
		(0.096)	
Sample	Core product, exporting more than 5 years		
Firm FE	yes	yes	yes
Destination-Year FE	yes	yes	yes
First Stage			
Electricity Price	0.046***	0.045***	0.048***
Employment (ln)	-0.017***	-0.017***	-0.018***
TUV competitors (ln)	0.127***		0.118***
TUV importing country (ln)			0.038***
Electricity Price competitors (ln)		0.002	
F-stat	11.62	11.32	12.40
Observations	301795	301795	298431

Standard errors are clustered within firm-year in all estimations.

*** $p < 0,01; **p < 0,05; *p < 0,1$.

2.3 Other robustness checks

In A3, in the appendix, we report the estimate of the export price elasticity when dropping the top-5% and bottom-5% TUV firms within each HS6. Dropping these extreme values helps alleviate the concern that TUVs are highly volatile and subject to measurement errors, for this reason. Results hold. As discussed in section 1.2, the electricity market in France was deregulated in 2000. As a robustness check in table A4 we provide a robustness check using the post-2000 period only, and our results hold.

3 Export Elasticity to Prices, Tariffs and Real Exchange Rates

In this section we compare the elasticity to the firm specific export price with two other trade elasticities often estimated in the existing literature: the elasticity (i) to tariff and (iii) to real exchange rate. The previous literature highlighted the presence of the so called international elasticity puzzle as trade volumes react more elastically to tariffs than to real exchange rate movements. Importantly, we take into account that exporters can partly absorb tariff and exchange rate shocks in their export prices to improve on the estimation of these elasticities.

Our estimation strategy is the same as in equation (4) but we add firm-destination-year specific tariffs ($ln(tariff_{ijt}+1)$) and bilateral real exchange rate (RER_{jt}) as follows:[25]

$$ln(exp_{i,j,t}) = \theta_{ij} + \theta_t + \sigma_1 ln\left(TUV_{i,j,t}\right) + \sigma_2 ln\left(RER_{j,t}\right) + \sigma_3 ln\left(tariff_{i,j,t}+1\right) + \alpha_4\left(X_{i,t}\right) + \alpha_5\left(Z_{j,t}\right) + \varepsilon_{i,j,t} \quad (8)$$

while the first stage regression is:

$$ln(TUV_{i,j,t}) = \theta_{ij} + \theta_t + \gamma_1 ln\left(Elect.Price_{i,t}\right) + \gamma_2 ln\left(RER_{j,t}\right) + \gamma_3 ln\left(tariff_{i,j,t}+1\right) + \gamma_4\left(X_{i,t}\right) + \gamma_5\left(Z_{j,t}\right) + \eta_{i,j,t} \quad (9)$$

All variables have the same meaning as before. In contrast to the specifications we tested in the previous section, we can only include firm-destination (θ_{ij}) and year (θ_t) fixed effects since destination-year fixed effects would be perfectly collinear with real exchange rates.[26] As before we include a set of destination-year specific control variables Z_{jt} containing the GDP (in log) of destination countries to control for import demand and the real *effective* exchange rate to control for the degree of competition in the destination country and the price index of the importing country.

Note that controlling for the instrumented export prices in our estimate of the elasticities of trade to tariffs

[25] $ln(tariff_{ijt}+1)$ is the weighted average tariff faced by a given firm into a given destination across exported products. We use the product share of firm's exports as a weight.

[26] In a robustness check reported in table 7 we exclude RER from the sample of covariates and run a specification including destination-tear fixed effects.

and exchange rates changes means our estimate is different from OLS estimates that do not include this control. The OLS estimate elasticity, for example of tariffs, is the sum of two effects: the direct impact of tariffs on trade and the indirect impact through the change in export prices that absorb part of the tariff change. Hence, using 8 and 9 the OLS elasticity is $\sigma_3 + \gamma_3\sigma_1 < \sigma_3$ if $\gamma_3 < 0$. We will indeed show that the OLS elasticity is biased downwards.

The results are shown in table 6. Column (1) is the most general and therefore our preferred regression. The first stage regression can be interpreted as a pass-though equation and is interesting to comment. Our instrument, the firm level electricty price, remains significant. We find also that tariffs and real exchange rates shocks are partly absorbed by exporters in their export prices. Only a small part of the exchange rate change is absorbed (less than 3 percent). The pricing to market behavior is more relevant for core product sample estimations reported in table 7), where around 10 percent of the exchange rate shock is absorbed in the export price. This result is consistent with the evidence in Berman et al. (2012). Note that most of the evidence on pricing to market following exchange rate movements is on import prices and not export goods prices so this result may suggest that importers and retailers at destination do absorb exchange rate movements. We also note that Bussiere et al. (2016,) find (on disaggregated bilateral trade flows) that the pass-through of exchange rate into export prices is in general larger for industrialized countries than for emerging prices. Our results on French exporters is consistent with this.

The most interesting result is for tariffs for which, to our knowledge, we are the first to report that exporters absorb a large part of tariff changes in their export prices: they indeed increase export prices by 3.5 percent following a 10 percent decrease in tariff. Note that this result can either be interpreted as showing that exporters increase their markup or that production costs (except for electricity prices which we control) increase following a tariff reduction.

We now comment the second stage results. Table 6 shows that the inclusion of tariffs and real exchange rates does not alter the estimate of the instrumented export price elasticity that remains close to 5. In regression (1), we report our main result on the ranking of the three elasticities: the export price elasticity is much larger than the elasticity for the tariff which itself is larger that the elasticity for the real exchange rate. The tariff elasticity is around 1.8 and the exchange rate elasticity is around 0.6.

In regressions (2), (3) and (4) we analyze the difference between exports towards OECD, non OECD and extra-EU countries. We first note that the absorption of both exchange rates and tariffs in export tariffs in export prices is more prevalant towards OECD countries. We also note that the coefficients in the second stage are relatively similar across destinations although lower towards non OECD countries. This may suggest that French goods are less substitutable with non-OECD produced goods

One important advantage of including the (instrumented) price in the export volume equation is that it

Table 6: 2SLS regressions on full baseline dataset.

	Dep Var: Export Volumes (ln)				Export Volumes (ln)	Export Values (ln)
	(1)	(2)	(3)	(4)	(5)	(6)
TUV	-5.171***	-5.434***	-4.681***	-5.504***	-	-
	(0.911)	(1.001)	(1.200)	(1.104)		
RER (ln)	0.659***	0.831***	0.566***	0.636***	0.524***	0.550***
	(0.040)	(0.086)	(0.037)	(0.038)	(0.019)	(0.016)
Ln(tariff+1)	-1.771***	-2.508***	-1.534***	-1.891***	0.028	-0.320***
	(0.175)	(0.628)	(0.405)	(0.406)	(0.057)	(0.047)
Effective RER (ln)	0.121***	0.026	0.117***	0.089***	0.074***	0.083***
	(0.019)	(0.051)	(0.019)	(0.019)	(0.010)	(0.009)
Employment (ln)	0.205***	0.248***	0.144***	0.173***	0.217***	0.215***
	(0.015)	(0.017)	(0.021)	(0.018)	(0.009)	(0.008)
GDP (ln)	0.624***	0.530**	0.817***	0.702***	1.556***	1.376***
	(0.175)	(0.260)	(0.168)	(0.169)	(0.030)	(0.026)
Estimator	2SLS	2SLS	2SLS	2SLS	OLS	OLS
Sample	All countries	OECD	non-OECD	extra-EU	All countries	All countries
Firm-Destination FE	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes
First Stage						
Electricity Price	0.046***	0.049***	0.042***	0.045***	-	-
RER (ln)	0.026***	0.061***	0.006	0.009	-	-
Ln(tariff+1)	-0.348***	-0.498***	-0.327***	-0.353***	-	-
Effective RER (ln)	0.009*	-0.009	0.007	0.001	-	-
Employment (ln)	-0.00184	0.003	-0.009	-0.006	-	-
GDP (ln)	-0.181***	-0.235***	-0.131***	-0.142***	-	-
F-stat	22.47	16.38	9.10	16.53	-	-
Observations	1488954	863035	625919	1022174	1488954	1488954

Standard errors are clustered within firm-year in all estimations.

More details on the first stage results for specification in column 1 is reported in table A5.

*** $p < 0,01; **p < 0,05; *p < 0,1$.

enables to take into account that exporters absorb part of a change in tariff and exchange rate in their FOB export price in exporter's currency. In the existing literature based on firm level data (see Fitzgerald & Haller (2014) and Berman et al. (2012)) where TUVs are absent, the estimates of the international elasticity of tariffs and exchange rates are actually a mix of two elasticities: the elasticity through the change in export prices and the "true" elasticity of exports to tariffs or exchange rates. To see this in our data we run the standard OLS equation that does not include the instrumented export price. This is done in column (5) in table 6 that can be compared to colimn (1). In this case, the exchange rate elasticity is reduced from 0.66 to 0.52 and the tariff elasticity is reduced (in absolute value) from 1.77 to 0.03 (and not significant). The difference is much larger for tariffs because we saw that in the first stage exporters absorb a large part of the tariff in their export price but a smaller part of an exchange rate change.

To see the importance of controlling for the export price we can decompose the impact of a tariff through its direct impact and through the impact of export prices. The OLS estimate is the sum of the two. An increase in tariffs affects export volumes via the elasticity of substitution effect (measured here as -1.77) and via the impact it has on export price which themselves affect export volumes (-0.35*-5.17=1.81). The two effects in our data approximately cancel each other which we see in the OLS regression (5) in the coefficient on tariffs (0.03). But it would be clearly wrong to conclude from the OLS regression that tariffs do not affect firm level exports.

Another way to see the importance of taking into account export prices in the estimation of international elasticities is to compare the estimation for export values and export volumes in the OLS regression. If the inclusion of export prices in the estimation is not an important issue, then the elasticity to tariff and exchange rate shocks should be identical for export values or volumes. We see in regressions (5) and (6) that, especially for tariffs, this is clearly not the case. Note that neither regression (5) or (6) provides an estimate close to ours in the case of tariff shocks. The fact that the difference is much smaller for exchange rates comes from the fact that French exporters do not absorb much exchange rate movements in their export price. However, as shown by Bussiere et al. (2016,) on bilateral trade flows, this is not true for many countries especially emerging markets that set their export prices in dollar. Hence, even though the bias we identify in the estimates of export elasticities that do not control for export prices is much larger for tariffs than for exchange rates, this may not be true for other countries than France that price in dollar.

Another interesting result of table 6 is the impact of cyclical demand in the destination country. French exporters *decrease* their export prices towards destinations where GDP is higher than average. Because we have country and year fixed effects, this does not mean that exporters have lower prices in richer countries but that they lower prices in a specific country in years where GDP is higher than average.The impact is substantial: a 1% above average growth rate in destination leads French exporters to decrease their price to that destination by 0.18% (regression 1). This also means that the elasticity of exports to destination demand is the sum of two components: the direct and standard effect of final demand on exports (0.62 in the full sample) on the one hand and the effect of the fall in export prices (-0.18*-5.2=0.94). The OLS coefficient on GDP in regression (5) is the sum of these two effects (1.56). Hence more than half (0.94/1.56) of the increase in exports following an increase in GDP in the destination country is due to the pricing strategy of firms rather than the standard direct effect. To our knowledge, our paper is the first to document this pricing behavior which cannot be directly reconciled with existing models. Although Atkeson & Burstein (2008) may be a good candidate, we leave to future research the aim to rationalize this stylized fact.[27]

4 Robustness checks

In table 7 we perform a series of robustness tests. In column (1), we replace firm year fixed effects by destination-year fixed effects. In this case, the exchange rate variable is absorbed by the fixed effect but the impact of the tariff which is firm-destination specific can still be estimated. The destination-year fixed effect enables to better control for the impact of changes in tariffs on the destination price index. The estimated elasticity for the TUV and the tariff remain similar to our preferred specification in Table 6. In column (2), we restrict the sample to pre-crisis years (1996-2007) and the results are robust. In column 3, we run the regression in first difference. The estimated coefficients on the three elasticities are similar. However, our instrument is not very strong in this case as shown by the F-stat below 4.

An empirical concern is the selection bias in the export status if firms select endogenously in different destinations (firm-level zeros). In heterogeneous firm trade models, only high-productivity firms are able to serve more distant and more costly markets and low productivity firms are not present. In our framework, low productivity firms will exit destinations with higher tariff or depreciated exchange rates and this selection effect may bias our elasticity downwards. To address this problem, we follow Fitzgerald & Haller (2014) and Mulligan & Rubinstein (2008) and run robustness checks using a subsample of top exporting firms, i.e. firms with exports above 75^{th} and 90^{th} percentile of destination-sector specific distribution of exports. Results, reported in columns (4) and (5) of table 7 suggest that the selection bias is not a big problem in our data.

Our results are also robust on the estimate of the export price elasticity to using the core-product for firms exporting more than five years as on a balanced panel as shown in columns (6) and (7). This solves the aggregation bias discussed above. However, in this case, the instrument is weaker and the estimate on the tariff

[27] Atkeson & Burstein (2008) indeed show in their model of imperfect competition and variable markups that because firms market shares determine the price elasticity of demand, firms decrease their markups and prices when they loose market share. If a destination GDP boom attracts new firms and products (domestic and foreign) and therefore reduces the French exporters market share, this would increase the elasticity of demand and provide an incentive to reduce their export price. A related but different mechanism is introduced by Jaravel (2016) who shows that increasing market size causes the introduction of more products and, through increased competitive pressure and decreasing markups, lower prices. This is also coherent with a Melitz & Ottaviano (2008) type of model where, departing from CES assumptions, competition is tougher (markups lower) in larger markets accommodating more firms.

elasticity lower.

In columns (8) and (9), we use alternative data sets for tariffs, respectively HS-6 classification and WITS data set (HS4). The estimate of the tariff elasticity is robust in HS-6 but lower with WITS.

Finally, in table A6 in appendix, we test the robustness of our results to the use of an alternative instrument for the firm specific export price. Consistent with equation 1, we use the interaction between the firm-year specific electricity price and the electricity costs share over total firm's costs. For this cost share we use either the average share for the firm on the whole period or the share for the sector to reduce endogeneity. The advantage of this instrument is that it uses a specific information about the firm or sector specific electricity intensity (as in equation 1). The drawback of this approach is the likely endogeneity bias. Indeed, the total cost of the firms (in particular labor costs and intermediates) may be endogenous to the export performance of the firm and may affect exports through other channels than the export price. In particular, the mix of exported goods might be affected by labor and/or intermediates cost if such products are labor or intermediate goods intensive. Hence, we think this instrument may be more reliable when used in the core product sample. The results are shown in table A6. The instrument works well in the sense that in the first stage the elasticity of export price to the instrument is between 0.8 and 0.9 (regressions 1 and 2) in the full sample. This elasticity should be around unity if there was full pass-through of costs to prices but we do not expect full pass-through given that this is not the case for exchange rates or tariffs. In addition, we do not have information on capital costs so we should also expect the elasticity to be below unity. The international elasticities are similar to those estimated with our main instrument except that they are smaller especially for tariffs and export prices. As explained above however, we believe that this instrument is more reliable for the core product sample which is shown in regressions (3) and (4). In this case the first stage is weak. The estimated elasticities are very similar to those estimated with our main instrument (see table 6) for the export price and the exchange rate but lower for the tariff.

Table 7: Robustness checks

	Dep Var: Export Volumes (ln)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
TUV	-5.065***	-5.260***	-5.306**	-5.195***	-3.605***	-6.751***	-5.497***	-5.166***	-5.128***
	(0.864)	(1.070)	(2.390)	(0.1064)	(0.903)	(1.711)	(1.804)	(0.909)	(0.905)
RER (ln)	-	0.791***	0.552***	1.010***	1.148***	1.101***	1.060***	0.658***	0.653***
		(0.054)	(0.120)	(0.067)	(0.078)	(0.149)	(0.205)	(0.041)	(0.039)
Ln(tariff+1)	-2.116***	-2.000***	-2.070*	-1.509***	-1.629	-0.256	-0.716***	-1.605***	-0.395***
	(0.475)	(0.457)	(1.100)	(0.294)	(0.351)	(0.169)	(0.177)	(0.308)	(0.082)
Effective RER (ln)		0.151***	-0.027	0.150***	0.173***	0.099***	0.130**	0.121***	0.130***
		(0.024)	(0.033)	(0.035)	(0.038)	(0.031)	(0.050)	(0.020)	(0.020)
Employment (ln)	0.207***	0.176***	0.111***	0.297***	0.352***	0.106***	0.194***	0.205***	0.206***
	(0.014)	(0.016)	(0.022)	(0.036)	(0.041)	(0.026)	(0.028)	(0.015)	(0.015)
GDP (ln)		0.897***	1.239***	1.543***	1.824***	0.709***	1.119***	0.634***	0.723***
		(0.165)	(0.306)	(0.134)	(0.145)	(0.238)	(0.174)	(0.173)	(0.157)
Estimator	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS
Sample	Full	Full	Full	Full	Full	Core	Core	Full	Full
		1996-2007	First Diff.	Top-25	Top-10	more 5 years	balanced	Tariff HS6	Tariff WITS
Firm-Destination FE	yes	yes	no	yes	yes	yes	yes	yes	yes
Year FE	no	yes	yes	yes	yes	yes	yes	yes	yes
Destination-Year FE	yes	no	no	no	no	no	no	no	no
First Stage									
Electricity Price	0.052***	0.044***	0.015*	0.074***	0.094***	0.037***	0.041***	0.046***	0.047***
RER (ln)		0.035***	0.045***	0.033**	0.051**	0.082***	0.105***	0.026***	0.024***
Ln(tariff+1)	-0.228***	-0.409***	-0.453***	-0.168***	-0.244***	0.038	0.006	-0.318***	-0.040**
Effective RER (ln)		0.013**	0.004	0.013	0.017	0.002	-0.001	0.009*	0.011**
Employment (ln)	0.001	-0.001	0.006*	-0.017**	-0.026**	-0.006	-0.003	-0.002	-0.001
GDP (ln)		-0.139***	-0.116***	-0.094***	-0.111***	-0.130***	-0.069***	-0.179***	-0.161***
F-stat	24.04	16.87	3.6	15.20	10.49	12.77	8.13	22.52	22.44
Observations	1496270	1218470	1003361	403196	167273	640447	172918	1488954	1459931

Standard errors are clustered within firm-year in all estimations.

*** $p < 0,01; **p < 0,05; *p < 0,1$.

5 Concluding remarks

The main contribution of this paper is to offer an estimate of the firm level price elasticity of exports using an original instrumental variable strategy. Our results point robustly to an estimate around 5. The second contribution is to show that this elasticity is much higher in absolute value than both the exchange rate (around 0.6) and the tariff (around 2) elasticities. We also show the importance of the absorption of exchange rate and tariff changes by exporters in their export prices. This implies that an estimate of elasticities of exports to exchange rates and tariffs that does not take into account the endogenous reaction of export prices is a mix of two opposite effects: the elasticity of substitution between home and foreign goods and the elasticity of exports to the endogenous reaction of export prices to the exchange rate or tariff shock. These two effects have opposite signs: an increase in tariff generates a substitution away from French exports but the endogenous fall in French exporters prices counteracts this. Because the elasticity of exports to exporters prices is much larger than to exchange rates and tariffs, this mechanism is quantitatively important.

Our results show that the international elasticity puzzle is well alive and actually worse than previously thought.

Our results can be viewed as stylized facts in search of theory. We now briefly present two interpretations that are consistent with our data. One interpretation of our results, which we cannot test in our data, is that importers and wholesalers in the destination country absorb differently in their prices these three shocks or that they switch to alternative producers differently depending on the source of the shock. If these intermediaries pass export price shocks to retail prices more than tariff and exchange rate shocks this could explain the ranking we observe. This could in turn be due to differences in the perceived persistence and volatility of those shocks. Consistent with the model of Drozd & Nosal (2012), importers and retailers absorb more volatile and less persistent shocks because they need to explicitly build market shares by matching with their customers. If this process is costly and time consuming, it may be that they will do it only when shocks are not too volatile and persistent enough. We cannot not test this mechanism in particular because we do not observe import and consumer prices of the exported French goods. However, we can compare the ranking of our elasticities and the ranking of volatilities and persistence for the three shocks. We calculated in our sample the coefficients of variation for the three shocks. To be consistent with the dimension of our estimation, we calculated it for each firm-destination and then computed the average. For export prices, we want the estimate of the volatility that comes from our specific cost shock. Hence, we take the predicted value from the first stage of regression (1) in Table 6 but exclude tariffs and exchange rate. For persistence, we estimated the coefficient on an AR(1) process.

As shown in Table 8, a larger volatility and lower persistence are associated with a lower elasticity. Although only suggestive this comparison points to an interpretation of differences of the international elasticity to the

Table 8: Ranking of elasticities and volatilities

	exchange rate	tariff	export TUV
Trade elasticity	0.6	2	5
Coeff. var. (firm-destination)	7.8%	0.9%	0.5%
Persistence (firm-destination)	67%	88%	95%

three shocks as being linked to their differences in their respective volatility and persistence.

Another avenue to interpret our results, in particular on the difference in the elasticity of trade with respect to tariffs or exchange rates on the one hand and to export prices on the other hand is that the first two affect all Eurozone exporters (for tariffs all EU exporters) whereas a change in export price is firm specific. In the first case, following a tariff reduction or a euro depreciation, the demand for transport, distribution and marketing services in the destination will increase (see Arkolakis (2010) for example on market penetration) which may push up costs in the destination. Importers, wholesalers and retailers experiencing an increase in costs following an expansion on French exports, may pass-through these costs to consumers so that the fall in consumer prices maybe much smaller than the decrease in tariffs or the euro depreciation. This would not (or at a much lower extent) be the case with a single French firm export expansion following a decrease of its export price (due to a firm specific fall in electricity costs). The pass-through to consumer prices would therefore be smaller in the case of a shock that affects all French exporters than in the case of a firm specific cost shock. In turn, this implies a lower trade elasticity for a tariff, or exchange rate shock than for a firm specific shock. Our results are consistent with such a mechanism that is based on differences in pass-through of the shocks to consumer prices. We leave to further research to explore this possible explanation of the international elasticity puzzle.

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A Appendix

Figure A1: Histogram of electricity cost shares

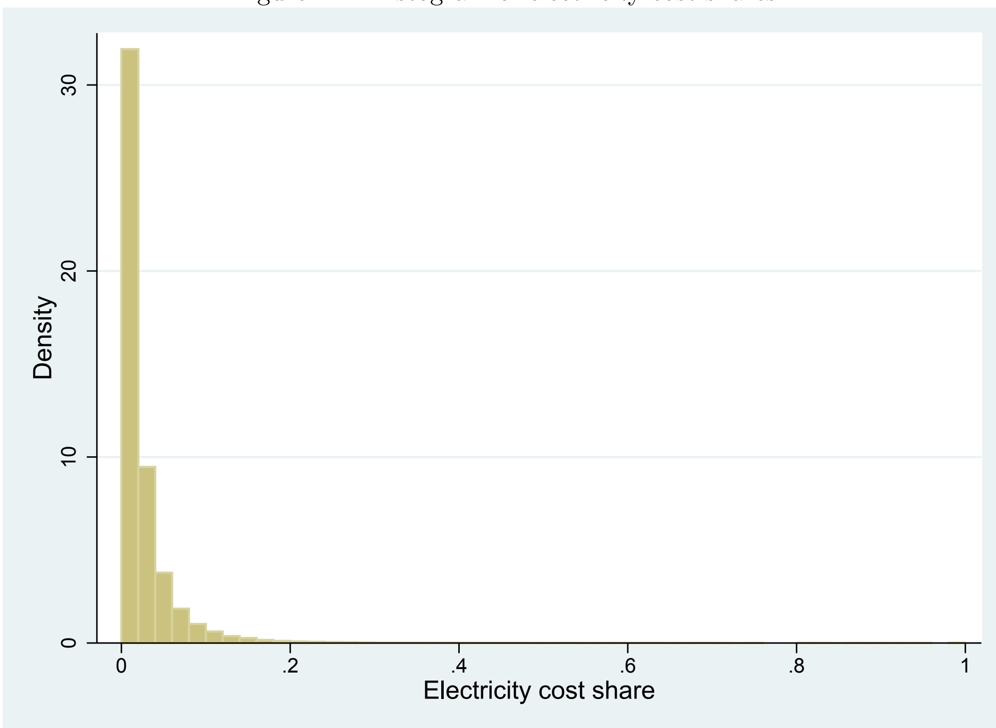

Table A1: In-sample descriptive statistics before the firm-year aggregation.

	Observations	Mean	Std Dev	Min	Max
Electricity Price (€/kwh)	1630856	0.062	0.015	0.033	0.139
Exported Quantity (ln)	1630856	8.378	3.187	-0.693	20.702
TUV (ln)	1630856	2.608	1.813	-1.66	8.005
Employment (ln)	1630856	5.372	1.068	0.693	8.869
Turnover (ln)	1630856	10.407	1.471	-1.881	17.23
Ln (tariff+1)	1630856	0.042	0.084	0	2.397
RER (ln)	1630856	0.106	0.191	-2.005	1.162
GDP (ln)	1630856	26.05	1.925	18.3	30.24
Effective RER (ln)	1630856	1.179	1.967	-2.09	9.499

Table A2: OLS regressions on full baseline dataset.

Dep Var:	Export Volumes (ln)	
	(1)	(2)
TUV (ln)	-1.268***	-1.143***
	(0.003)	(0.002)
Employment (ln)	0.153***	0.215***
	(0.007)	(0.008)
GDP (ln)		1.457***
		(0.027)
Effective RER (ln)		-0.080***
		(0.008)
Firm FE	yes	no
Destination-Year FE	yes	no
Firm-Destination FE	no	yes
Year FE	no	yes
Observations	1366037	1624300
R-squared	0.621	0.873

Standard errors are clustered within firm-year in all estimations.

*** $p < 0,01; **p < 0,05; *p < 0,1$.

Table A3: Robustness check dropping top-5 and bottom-5 TUV firms within HS6.

	(1)	(2)
	Dep Var: Export Volumes (ln)	
TUV (ln)	-4.143***	-5.733***
	(0.737)	(1.145)
Employment (ln)	0.154***	0.202***
	(0.021)	(0.016)
GDP (ln)		0.895***
		(0.163)
Effective RER (ln)		-0.041**
		(0.018)
Sample	Drop Top-5 and Bottom-5 TUV firms within HS6	
Firm FE	yes	no
Destination-Year FE	yes	no
Firm-Destination FE	no	yes
Year FE	no	yes
First Stage		
Electricity Price	0.047***	0.040***
Employment (ln)	0.000	-0.002
GDP (ln)		-0.131***
Effective RER (ln)		0.007*
F-stat	21.95	17.75
Observations	1554061	1424017

Standard errors are clustered within firm-year in all estimations.

*** $p < 0,01; **p < 0,05; *p < 0,1$.

Table A4: Robustness check using post-2000 period.

	(1)	(2)
	Dep Var: Export Volumes (ln)	
TUV (ln)	-2.842***	-4.328***
	(0.586)	(1.086)
Employment (ln)	0.122***	0.185***
	(0.015)	(0.020)
GDP (ln)		0.792***
		(0.233)
Effective RER (ln)		-0.079***
		(0.233)
Sample	Period 2001-2007	
Firm FE	yes	no
Destination-Year FE	yes	no
Destination-Year FE	no	yes
Year FE	no	yes
First Stage		
Electricity Price	0.052***	0.039***
Employment (ln)	0.017***	0.011**
GDP (ln)		-0.203***
Effective RER (ln)		-0.002
F-stat	18.09	11.48
Observations	996115	881787

Standard errors are clustered within firm-year in all estimations.

*** $p < 0,01; **p < 0,05; *p < 0,1$.

Table A5: First stage regression results on full baseline dataset.

Dep Var:	TUV (ln)		TUV (ln)		TUV (ln)		TUV (ln)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Electricity Price (ln)	0.049***	0.050***	0.040***	0.040***	0.046***	0.046***	0.046***
	(0.011)	(0.010)	(0.010)	(0.010)	(0.010)	(0.011)	(0.010)
RER (ln)							0.026***
							(0.008)
Ln(tariff+1)							-0.348***
							(0.029)
Employment (ln)		0.002		-0.002		-0.001	-0.002
		(0.004)		(0.004)		(0.004)	(0.004)
GDP (ln)					-0.158***	-0.158***	-0.181***
					(0.013)	(0.013)	(0.004)
Effective RER (ln)					0.003	0.003	0.009*
					(0.004)	(0.004)	(0.004)
Firm FE	yes	yes	yes	yes	no	no	no
Destination-Year FE	yes	yes	no	no	no	no	no
Firm-Destination FE	no	no	no	no	yes	yes	yes
Year FE	no	no	no	no	yes	yes	yes
Destination-Sector-Year FE	no	no	yes	yes	no	no	no
Observations	1630856	1630856	1630856	1630856	1485547	1488954	1488954
R-squared	0.770	0.770	0.779	0.779	0.883	0.883	0.883
F-stat	23.25	23.47	15.83	15.60	22.83	22.67	22.47

Standard errors are clustered within firm-year in all estimations. When Destination-Sector-Year FE are included, the sector is the main NAF700 sector of the firm.

*** $p < 0,01; **p < 0,05; *p < 0,1$.

Table A6: Robustness Check using alternative Instrumental Variables.

	Dep Var: TUV (ln)			
	(1)	(2)	(3)	(4)
TUV (ln)	-2.378***	-1.297***	-7.262*	-5.656***
	(0.473)	(0.441)	(3.984)	(1.688)
RER (ln)	0.586***	0.557***	1.246***	1.077***
	(0.021)	(0.018)	(0.431)	(0.195)
Ln(tariff+1)	-0.799***	-0.423***	-0.708***	-0.715***
	(0.172)	(0.159)	(0.232)	(0.182)
Effective RER (ln)	0.095***	0.086***	0.129*	0.130***
	(0.011)	(0.008)	(0.067)	(0.052)
Employment (ln)	0.211***	0.214***	0.190***	0.194***
	(0.008)	(0.007)	(0.038)	(0.028)
GDP (ln)	1.127***	1.322***	0.999***	1.108***
	(0.089)	(0.082)	(0.312)	(0.166)
Sample	Full Sample		Balanced Core Products	
Firm-Destination FE	yes	yes	yes	yes
Year FE	yes	yes	yes	yes
First Stage				
Electricity Price*Avg. Elec Dependency	0.868***		0.631**	
Electricity Price*Sector Elec Dependency		0.806***		0.924***
RER (in log)	0.026***	0.026***	0.105***	0.105***
Ln(tariff+1)	-0.348***	-0.348***	0.004	0.007
Effective RER (ln)	0.009*	0.009*	-0.000	-0.000
Employment (ln)	0.002	0.002	-0.002	-0.002
GDP (ln)	-0.179***	-0.179***	-0.067***	-0.067***
F-stat	18.99	21.20	3.13	10.43
Observations	1488954	1488954	172918	172918

Standard errors are clustered within firm-year in all estimations.

*** $p < 0,01; **p < 0,05; *p < 0,1$.