Sticker Shocks:
VAT changes and the substitution across expenditure categories*

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Abstract

We take a quasi-experimental approach to estimate the value for the across-sector elasticity of substitution. To that end, we use the effects of changes in value added tax (VAT) rates on long-run movements in relative prices to identify the magnitude of the elasticity of substitution across expenditure categories. Using a standard model of imperfect competition with Cobb-Douglas production and Dixit-Stiglitz preferences both within and across sectors, we show that the long-run response of relative prices to changes in VAT is a simple function of the labor share and the elasticity of substitution across sectors. We construct a novel data set of VAT rate changes by expenditure categories in the European Union matched to their respective inflation rates. Estimates of the effect of VAT rate change on inflation in the long-run suggest that the magnitude of the elasticity of substitution across expenditure categories nears 3.

JEL classification codes: E19, E21, D12

Keywords: demand elasticities, multisector model, heterogeneity, aggregation, VAT rates

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1 Introduction

The economics profession have frequently made use of nested constant-elasticity of substitution (CES) functions to represent consumers' preferences. These functions determine consumers' preferences accounting for different levels of aggregation under which consumers would substitute across varieties, as well as across the categories to which these varieties pertain, with possibly different elasticities of substitution.

In most macro models, the within-sector (or category) elasticity of substitution ultimately determines the markup that firms apply over its marginal costs, and the calibration of this elasticity is guided by the assumptions imposed for the markup. The strategy to calibrate the elasticity of substitution across sectors is not so clear cut. It is intuitive to assume that the latter elasticity is smaller than the within-sector one. However, finding an estimate for the elasticity of substitution across sectors is not a simple task given the absence of high frequency data on consumption expenditure shares by categories. In addition, estimating this elasticity of substitution involves the same endogeneity issues as estimating demand adjustments.

The literature reflects this absence of a clear-cut estimate by resorting to analytically convenient measures for this elasticity, which frequently means choosing the elasticity across categories to be equal their preferred choice for the within-sector elasticity of substitution, or by simply setting it equal to one (which implies Cobb-Douglas preferences). Figure 1 illustrates this point by providing a scatter plot of some alternative calibrations for the elasticities of substitution within and across sectors in the recent literature. The figure shows that the frequent choices for the calibration of the elasticity of substitution across sectors are either one or equal to the authors' choice for the within-sector elasticity.

In this paper, we take a quasi-experimental approach to estimate the value of the across-sector elasticity of substitution. To that end, we use the effects of changes in value added tax (VAT) rates on long-run movements in relative prices to identify the magnitude of the elasticity of substitution across sectors (expenditure categories).

We depart from a standard model of imperfect competition with Cobb-Douglas production function and Dixit-Stiglitz preferences both within and across sectors. Using this commonly applied framework, we show that the elasticity of the long-run response of relative prices to changes in VAT rates is independent from many parameters and assumptions, such as the elasticity of substitution within sector, and the degree of price stickiness. Consequentially, the model yields a very tractable reduced-form equation that allows for the estimation of the elasticity of substitution across sectors under a very broad set of assumptions.

Estimation of this relation requires data on inflation across expenditure categories and their associated changes on VAT rates. We construct a novel data set on VAT rate changes and use it to identify the magnitude of the elasticity of substitution across expenditure categories (or sectors). Because changes in VAT rates are relatively infrequent, we combine data on prices and VAT tax changes for a set of countries in the European Union. In particular, we match existing data on inflation for 39 expenditure categories for 22 countries over the period of January 1996 to June 2013 with our new data on VAT rate changes by expenditure categories for the same countries over the same period.

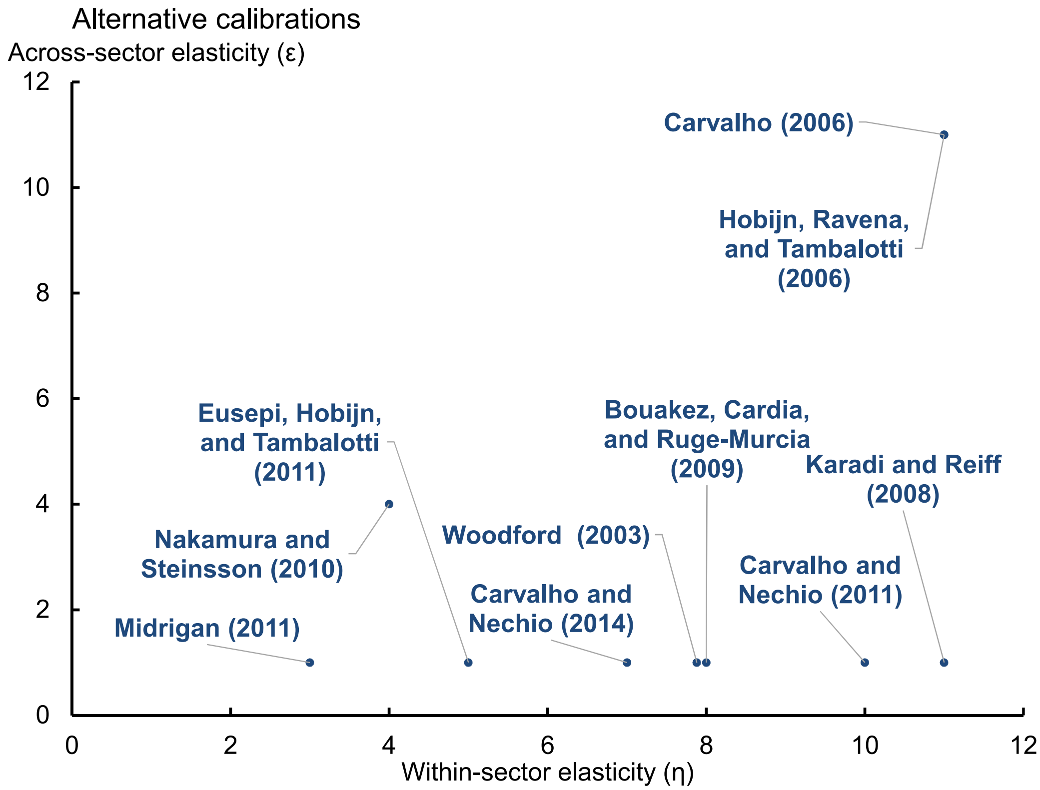

Figure 1: Identification strategy

To estimate long-term effects of VAT tax changes on relative inflation, we resort to the local projection method as described in Jordà (2005). Our reduced-form long-term relation is a simple application of such method, for which we pool all countries and expenditure categories and, after controlling for countries' and categories' fixed effects, as well as seasonal and time trends, we estimate the average effect of changes in VAT rates on relative prices over different horizons.

Our benchmark results indicate that the across-sector elasticity of substitution is around 3 with a standard error of 0.6. In addition, despite the substantial heterogeneity across countries and expenditure categories, our estimate of 3 is relatively robust. Estimates that allow for heterogeneity across countries or across expenditure categories show that the distributions of implied elasticities are very similar. Both distributions are bimodal with peaks that imply an elasticity of 3 and at a negative value. The shape of these two distributions, relative to our preferred pooled-estimate distribution, indicates the considerable noise cleaned away when the data is polled and controlled for fixed effects.

There are two key features of our empirical approach. First, we do not incur into the usual endogeneity problems that arise when estimating demand elasticities. Endogeneity problems can arise in the estimation of aggregate demand functions when price determination involves an interplay between supply and demand jeopardizing the estimation results (see Berry 1994, and Berry et al. 2004 for a thorough discussion). Our empirical approach does not resort to quantities to estimate elasticities but instead only considers the long-term (or equilibrium) price change in response to tax changes. Second, our reduced-form regressions do not require assumption about monetary policy nor consumers' utility function yielding a clear mapping to a standard model under a very broad set of assumptions.

This paper is related to a vast literature that makes use of heterogeneity in theoretical models in trying to match the dynamics of aggregate variables. This literature includes Aoki (2001), Bouakez et al. (2009), Carvalho (2006), Carvalho and Nechio (2011 and 2014), Midrigan (2011), Nakamura and Steinsson (2010), Woodford (2003), among other, who calibrated elasticities across and within sectors in models that studied the effects of sectoral heterogeneity of frequency of price adjustment on aggregate macroeconomic variables. It also relates to other papers that calibrated multisector models that considered other sources of heterogeneity to study other macroeconomic questions, such as Eusepi et al. (2011) and Hobijn et al. (2006).

In addition, our data set is close to those used on papers that tries to estimate the (short-term) effects of VAT tax changes inflation, such as Karadi and Reiff (2008), Gabriel and Reiff (2008), Gautier and Lalliard (2013), Carare and Danninger (2008), among others. Differently from our approach, in addition to using VAT changes to answer a different question, these papers implemented a country-specific analysis instead of our multicountry approach.

Finally, our paper also speaks to the microeconomics and the behavioral literatures that study consumer preferences and tries to estimate price demand elasticities for different goods and industries. This literature includes Deaton and Muellbauer (1980), Hausman et al. (1994), Berry et al. (2004), among others.

The paper proceeds as follows. Section 2 described the model and presents our main reduced-form long-run relation to be estimated. Section 3 describes how the data is constructed and Section 4 discusses our econometric approach. Sections **??** and 6 present our empirical results, and the implications for the measure of the across-sector elasticity. The last section concludes.

2 Model

We consider a partial equilibrium model that features a multisector economy. Demand for goods produced in each sector depends on aggregate conditions, which are assumed to be exogenous, and are characterized by a balanced growth path. Each sector is populated by a continuum of firms that produce varieties with a decreasing returns to scale production function that features labor as its only input.

More specifically, aggregate output Y_t and aggregate price P_t aggregate across all sectors and are assumed to follow:

$$Y_t = (1+g)\, Y_{t-1} \tag{1}$$

$$P_t = (1+\pi)\, P_{t-1} \tag{2}$$

where g is real growth and π is inflation.

A firm i in each sector j faces a demand function given by:

$$Y_{ijt} = \left(\frac{P_{ijt}}{P_{jt}}\right)^{-\eta} \left(\frac{P_{jt}}{P_t}\right)^{-\varepsilon} Y_t,$$

where P_{ijt} is the post-tax price by a firm i in sector j at time t and Y_{ijt} is the demand for good i in sector j at time t. $\varepsilon > 0$ is the elasticity of substitution across sectors, and $\eta > 1$ is the elasticity of substitution across varieties in each sector obtained from CES preferences that generate these demand functions. P_{jt} and P_t are, hence, price indices are given by:

$$P_{jt} = \left[\int_0^1 \left(\frac{1}{P_{ijt}}\right)^{\eta-1} di\right]^{\frac{1}{1-\eta}}$$

$$P_t = \left[\sum_{j=1}^{J} f_j \left(\frac{1}{P_{jt}}\right)^{\varepsilon-1}\right]^{\frac{1}{1-\varepsilon}}$$

where $f_j > 0$ is sector-j weight, and $\sum_{j=1}^{J} f_j = 1$.

Labor is the only input used in the production of varieties by each sector. The production function features a technology shock and decreasing returns to scale:

$$Y_{ijt} = A_t L_{ijt}^{1-\alpha},$$

where L_{ijt} is labor supplied to firm i in sector j at time t, $1-\alpha$ is returns to labor. The productivity A_t grows at rate ρ:

$$A_t = (1+\rho)\, A_{t-1},$$

where $\rho \in [0, 1)$.

We assume that firms face a stochastic cost ζ to adjust their prices. Hence, at each period, a firm's cost of price adjustment is drawn independently from a distribution with cdf $F(\zeta)$ to be specified below.

Let V^*_{ijt} denote the value function of a firm i in sector j that adjusts its prices at time t.

$$V^*_{ijt} = \max_{P^*_{ijt}} \left\{ \Pi\left(P^*_{ijt}\right) + \frac{1}{1+r} V_{t+1}\left(P^*_{ijt}\right) - Z_t \zeta_t \right\},$$

where P^*_{ijt} is the price chosen when the firm adjusts, and r is a nominal interest rate assumed to be constant.

Hence, the firm's decision problem is such that it chooses between adjusting its price (and paying the adjustment cost) or charging the same price as in the previous period:

$$V_t\left(P_{ijt}\right) = \max\left\{ V^*_{ijt}, \Pi\left(P_{ijt}\right) + \frac{1}{1+r} V_{t+1}\left(P_{ijt}\right) \right\},$$

subject to:

$$\begin{aligned}
\Pi\left(P_{ijt}\right) &= \frac{P_{ijt}}{1+\tau_j} Y_{ijt} - W_t L_{ijt}, \\
Y_{ijt} &= \left(\frac{P_{ijt}}{P_{jt}}\right)^{-\eta} Y_{jt}, \\
Y_{jt} &= \left(\frac{P_{jt}}{P_t}\right)^{-\varepsilon} Y_t, \\
P_{jt} &= \left[\int_0^1 \left(\frac{1}{P_{ijt}}\right)^{\eta} di\right]^{\frac{1}{1-\eta}}, \\
Y_{ijt} &= A_t L_{ijt}^{1-\alpha},
\end{aligned}$$

where $\frac{P_{ijt}}{1+\tau_j}$ is the pre-tax price, τ_j are VAT rates faced by sector j, and W_t is nominal wage.

Firms will adjust their prices when:

$$V^*_t \geq \Pi\left(P_{ijt}\right) + \frac{1}{1+r} V_{t+1}\left(P_{ijt}\right).$$

That is:

$$\begin{aligned}
\zeta_t &\leq \frac{1}{Z_t}\left\{ \Pi\left(P^*_{ijt}\right) + \frac{1}{1+r} V_{t+1}\left(P^*_{ijt}\right) \right\} - \frac{1}{Z_t}\left\{ \Pi\left(P_{ijt}\right) + \frac{1}{1+r} V_{t+1}\left(P_{ijt}\right) \right\} \\
&= \bar{\zeta}\left(P_{ijt}; Z_t\right)
\end{aligned}$$

Hence, the probability the firm will adjust its price is $F\left(\bar{\zeta}\left(P_{ijt}; Z_t\right)\right)$.

For simplicity, assume firms set their prices as in Calvo (1983). $F\left(\bar{\zeta}\left(P_{ijt};Z_t\right)\right)$ implies that:

$$F\left(\zeta\right)=\begin{cases}\phi & if \quad \zeta\epsilon[0,\infty)\\ 1 & if \quad \zeta\rightarrow\infty,\end{cases}$$

where ϕ is each firm's exogenous one-period probability of price adjustment.

The model solution must satisfy:

$$\begin{aligned}\frac{\partial V_t}{\partial P_{ijt}} &= (1-\phi)\left\{\frac{\partial \Pi_t\left(P_{ijt}\right)}{\partial P_{ijt}}+\frac{1}{1+r}V'_{t+1}\left(P_{ijt}\right)\right\}\\ 0 &= \Pi'_t\left(P^*_{ijt}\right)+\frac{1}{1+r}V'_{t+1}\left(P^*_{ijt}\right)\end{aligned}$$

The solution yields the reset price P^*_{ijt} equals:

$$P^*_{ijt}=\left[\frac{\frac{\eta}{1-\alpha}\sum_{s=0}^{\infty}\left(\frac{1-\phi}{1+r}\right)^s W_{t+s}P_{jt+s}^{\frac{\eta_j}{1-\alpha}}\left(\frac{Y_{jt+s}}{A_{t+s}}\right)^{\frac{1}{1-\alpha}}}{\frac{(\eta-1)}{1+\tau}\sum_{s=0}^{\infty}\left(\frac{1-\phi}{1+r}\right)^s P_{jt+s}^{\eta_j}Y_{jt+s}}\right]^{\frac{1}{1+\frac{\alpha\eta_j}{1-\alpha}}}.$$

2.1 Long-run equilibrium

Under a balanced growth path, the model implies that nominal wages grows at rate γ, where:

$$(1+\gamma)=\frac{(1+\pi)(1+\rho)^{\frac{1}{1-\alpha}}}{(1+g)^{\frac{\alpha}{1-\alpha}}}.$$

The solution to this model implies that, in equilibrium, the relative price $\frac{P_{jt}}{P_t}$ follows:

$$\frac{P_{jt}}{P_t}=(F_j)^{\frac{1+\frac{a}{1-\alpha}\varepsilon}{1+\frac{\alpha}{1-\alpha}\eta}}(s_j)^{\frac{1}{1+\frac{\alpha}{1-\alpha}\varepsilon}}(1+\tau_j)^{\frac{1}{1+\frac{\alpha}{1-\alpha}\varepsilon}}\left\{Y_t^{\frac{\alpha}{1-\alpha}}\left(\frac{1}{A_t}\right)^{\frac{1}{1-\alpha}}\frac{W_t}{P_t}\right\}^{\frac{1}{1+\frac{\alpha}{1-\alpha}\varepsilon}}, \qquad (3)$$

where:

$$\begin{aligned}\frac{1}{F_j} &= \left(\frac{\phi_j}{1-\left(1-\phi_j\right)(1+\pi)^{\eta_j-1}}\right)^{\frac{1}{1-\eta_j}}\\ s_j &= \frac{\eta_j}{\left(\eta_j-1\right)}\frac{1}{1-\alpha}\left(\frac{1-\left(\frac{1+\phi_j}{1+r}\right)(1+\pi)^{\eta_j}(1+g)}{1-\left(\frac{1+\phi_j}{1+r}\right)(1+\pi)^{\frac{\eta_j}{1-\alpha}}\left(\frac{1+g}{1+\rho}\right)^{\frac{1}{1-\alpha}}(1+\gamma)}\right).\end{aligned}$$

The long-run equilibrium of relative prices implied by equation (3) yields some properties. In the long run, VAT rate acts like a marginal-cost shifter, and the elasticity of relative price changes to VAT rate changes does not depend on price stickiness, nor on the within-sector substitution. In the long run, changes in relative price of a sector j in response to VAT rate changes are function of sector-j characteristics and some aggregate dynamics. This elasticity is independent of sector-j characteristics, such as sectoral markup, and other aggregate dynamics.

Note that including some other sources of heterogeneity such as heterogeneity in frequency of price adjustment by assuming ϕ_j is different across sectors (as in Carvalho 2006), or in markups by assuming η_j varies across sectors (as in Eusepi et al. 2011) does not affect the elasticity of relative prices with respect to VAT rate changes.[1] Adding sectoral heterogeneity in the labor share $(1-\alpha)$ would complicate the model a bit, and while it would affect the price elasticity of relative to prices to tax changes, we opt to abstract from this additional source of differentiation across sectors. We justify this choice based on the results of Eusepi et al. (2005), that shows that the across-sector heterogeneity of labor share is not too large.

3 Data

The estimation of equation (3) requires data on disaggregated prices and their associated changes in VAT rates. Because changes of VAT rates are relatively infrequent, it is useful to combine these data across countries.

To measure inflation, we collect harmonized consumer price indices (HICP) by consumer expenditure category (COICOP) for a set of countries within the European Union. The set of countries and COICOPs for which we collect data is dictated by our data on VAT rate changes.

VAT rates are obtained from European Commission (2013), an annual report containing VAT levels and their changes by country and expenditure category.[2] Countries within the European Union (EU) are subject to four classifications of VAT rates: super reduced, reduced, standard, and parking rate. Given that EU law only requires that the standard VAT rate must be at least 15% and the reduced rate at least 5%, actual rates applied vary across countries, and across certain types of products.[3] For example, goods facing a standard rate in the United Kingdom are charged with a 20% VAT rate, while in Luxembourg the standard rate is 15%. In addition, these four categories can also include a range of levels of VAT rates, and the level applied to a certain category may change over time. For example, in 2010, France applied two different super reduced VAT rates, 2.1% and 5.5%. In 2012, a third 7% super reduced rate was introduced. Finally, same categories may face different VAT rates in different countries. For example, Spain charged 10% VAT rate on hotel accommodation services while Portugal charges a 6% rate. Restaurants face a 7% rate in France and a 19% rate in Germany.

[1] Note that an alternative model with flexible prices ($\phi \to 1$) also yields that the elasticity of relative prices in response to VAT rate changes is equal to $\frac{1}{1+\frac{\alpha}{1-\alpha}\varepsilon}$.

[2] The report is available at http://ec.europa.eu/taxation_customs/resources/documents/taxation/vat/how_vat_works/rates/vat_ra

[3] These simple rules are however complicated by a multitude of derogations granted to certain European Union Member States, in some instances a majority of Member States.

Each expenditure category included on the VAT rates report is matched with its respective HICP series. Our time sample is monthly and runs from January 1996 to June 2013. It includes a total of 1092 VAT rate changes across 22 countries. Since the labeling of expenditures categories is harmonized across different European Union reports and data sets, the matching between VAT rates and expenditure categories requires a limited number of judgement calls. A data appendix provides additional details on the data set.

4 Econometric model

To estimate long-run shifts in relative prices in response to changes in VAT rates we use a local projection method introduced in Jordà (2005). The method consists of estimating local projections at each period of interest without the need of specifying nor estimating the underlying multivariate dynamic system.

More specifically, equation (3) shows that in the long run, changes in relative price in response to VAT rate changes are function of sector-specific characteristics and some aggregate dynamics. Hence, the mapping between the model predictions and the estimation suggests that to estimate the effects of VAT rate changes on relative prices, we need to control for expenditure categories characteristics, as well as seasonal and time effects. Since our data includes many countries, we also control for country-specific effects. Therefore, our benchmark estimation method involves polling all countries and expenditure categories (COICOPs) to estimate:

$$
\begin{aligned}
\Delta_h p_{ijt+h} &= \beta_h \Delta_l \tau_{ijt+l} + \delta_h \Delta p_{ijt} + \alpha_{ijm} + \gamma_{it} + \varepsilon_{ijt}, \qquad (4a)\\
\text{where} &: \\
\Delta_h p_{ijt+h} &= \ln p_{ijt+h} - \ln p_{ijt} \\
\Delta_l \tau_{ijt+l} &= \tau_{ijt+l} - \tau_{ijt} \\
\Delta p_{ijt} &= \ln p_{ijt} - \ln p_{ijt-1}.
\end{aligned}
$$

The dependent variable $\Delta_h p_{ijt+h}$ corresponds to the accumulated logarithmic (log) change of the price index of the expenditure category j in country i between times t and $t+h$. The regressors include $\Delta_l \tau_{t+l}$, the accumulated change in VAT rates of the expenditure category j in country i between times t and $t+l$, and Δp_{ijt}, the one-period log-change in the price index of expenditure category j in country i between times t and $t-1$. α_{ijm} are country-coicop-season fixed effects, and γ_{it} are a country-time fixed effects. ε_{ijt} is the regression residual. The dummy variables α_{ijm} control for country-, category-, and seasonal-specific trends in relative prices, while γ_{it} control for country-time specific effects.

Note that since we are interested in estimating long-run effects of VAT changes in relative prices, h should be large as possible. In addition, we consider the cumulated change in VAT rates between t and $t+l$, $l < h$, so that rates changes that were reversed between these two time periods are not taken into account.

Figure 2 helps illustrate our identification strategy. We explore the country-coicop dimension while implicitly assuming that any tax change between $t+l$ and $t+h$ is uncorrelated with tax changes between t and $t+l$.

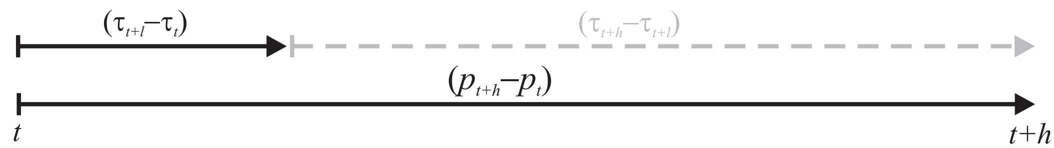

Figure 2: Identification strategy

Alternatively, we also estimate an unrestricted model in which we allow for the elasticity β_h to vary over time, and we include all one-period changes in VAT rates between t and $t+l$. More specifically:

$$\begin{aligned} \Delta_h p_{ijt+h} &= \sum_{m=1}^{l} \beta_{hl} \Delta\tau_{ijt+m} + \delta_h \Delta p_{ijt} + \alpha_{ijm} + \gamma_{it} + \varepsilon_{ijt}, \\ \text{where} &: \\ \Delta\tau_{ijt+m} &= \tau_{ijt+m} - \tau_{ijt+m-1} \end{aligned} \tag{5a}$$

where $\Delta_h p_{ijt+h}$, Δp_{ijt}, α_{ijm}, and γ_{it} are as previously defined, and $\Delta\tau_{ijt+m}$ is the one-period change in VAT rates.

Other alternative estimation specifications are discussed in the robustness section.

5 Empirical results

Table 1 provides a summary of the results from the estimation of equation (4a). It shows the estimates of $\hat{\beta}_h$ and $\hat{\delta}_h$ along with the associated standard errors for $h = 48$ and $l = 12$.

Figure 3 complements by showing the evolution of $\hat{\beta}_h$ as h goes from 12 to 48 along with their 95% confidence intervals. The results show that there is some variation in $\hat{\beta}_h$ in the shorter term, but as h increases, $\hat{\beta}_h$ stabilizes around 0.4.

Figure 4 compares the evolution over time of the estimated accumulated effect of changes in VAT rates, $\left(\hat{\beta}_h\right)$, as reported in Table 1 with the results of the unconstrained estimation of $\hat{\beta}_{hl}$ for $h \in [12, 48]$ and $l \in [1, 12]$ as in equation (5a). The figure shows that, as in the restricted benchmark model, the unrestricted results show that for all lags of l (from 1 to 12), as h increases, $\hat{\beta}_{hl}$ stabilizes around 0.4.

Table 1: Benchmark regression results – long-term estimates

	(1)
VAT rates (β_h)	0.44
	(0.11)
Inflation (δ_h)	-0.32
	(0.02)
Number of obs.	96,237
Degrees of freedom	84,570
R^2	0.72

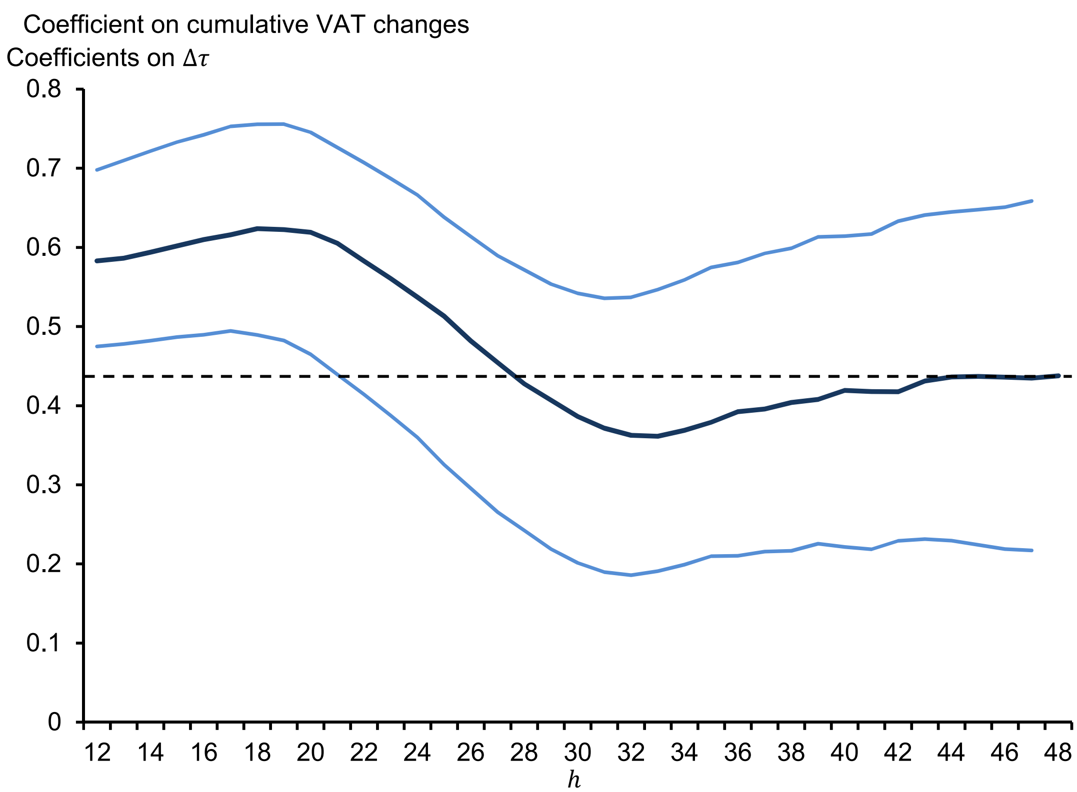

Figure 3: Long run effect of VAT changes on relative prices

5.1 Robustness

The regression results reported in Section **??** do not allow for neither country' or expenditure category' heterogeneity in the estimated elasticities. As a robustness check to our results, we reestimate equation (3) while allowing for country- or category- specific cumulated effects of VAT rate changes. More

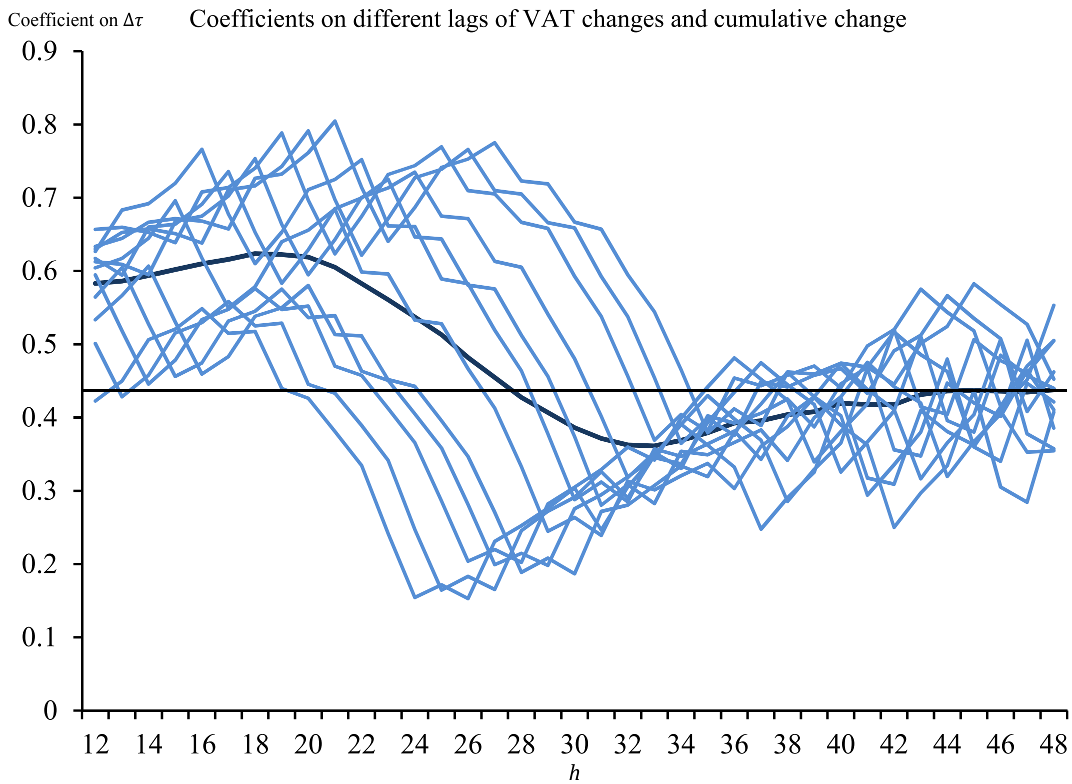

Figure 4: Long run effect of VAT changes on relative prices

specifically, we (separately) estimate:

$$\Delta_h p_{ijt+h} = \sum_{i=1}^{I} \beta_{hi} \Delta_l \tau_{ijt+l} + \delta_h \Delta p_{ijt} + \alpha_{ijm} + \gamma_{it} + \varepsilon_{ijt}, \tag{6}$$

and

$$\Delta_h p_{ijt+h} = \sum_{j=1}^{J} \beta_{hj} \Delta_l \tau_{ijt+l} + \delta_h \Delta p_{ijt} + \alpha_{ijm} + \gamma_{it} + \varepsilon_{ijt}, \tag{7}$$

where equation (6) allows β_h to vary across countries, and equation (7) allows for β to vary across expenditure categories. All other variables are as previously defined. As in our benchmark specification, we set l equal to 12 and h runs from 12 to 48.

Figure 5 reports the distributions of long-term (β_h when $h = 48$) coefficients of country-specific, category-specific, and the pooled (benchmark) estimates. More specifically, the figure reports the asymptotic distribution of $\hat{\beta}_{48}$ from the pooled estimation in equation (4a) along with the kernel densities obtained from the estimated country-specific ($\hat{\beta}_{hi}, \forall i$ and $h = 48$), and category-specific ($\hat{\beta}_{hj}, \forall j$ and $h = 48$) long-term coefficients of equations (6) and (7), respectively. Figure 5 shows that the distribution of the pooled estimate is concentrated around 0.4. The distributions of coefficients across countries and across categories are quite similar. Both distributions are bimodal with peaks

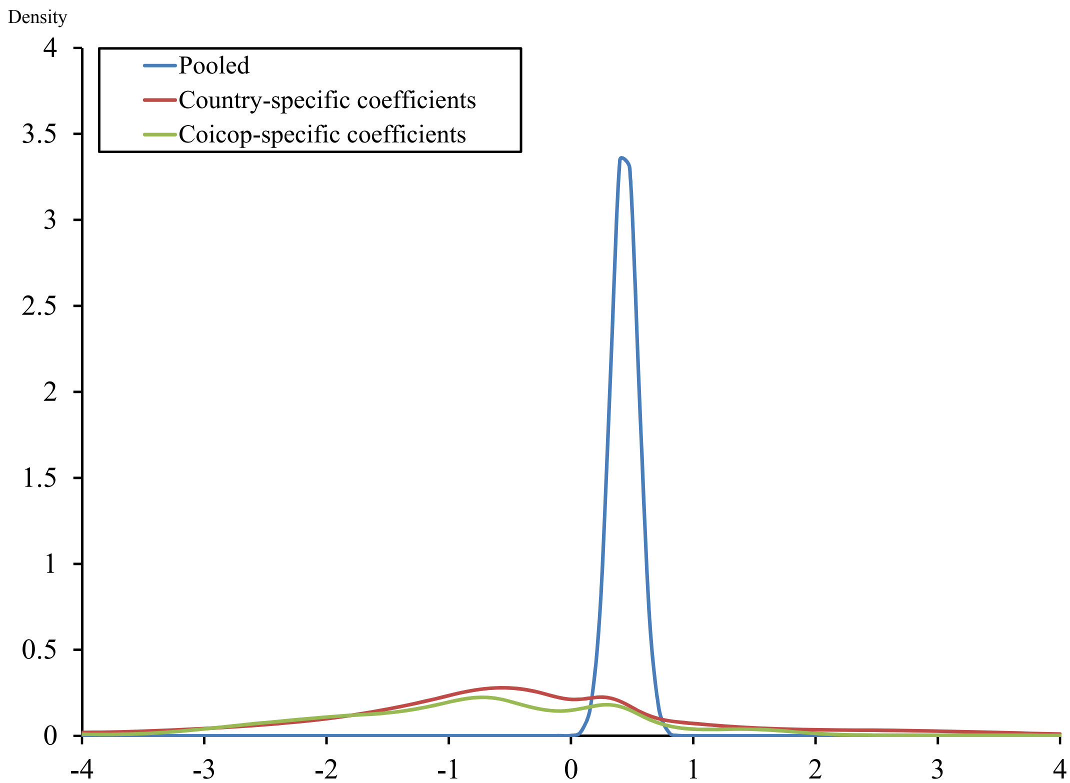

Figure 5: Distributions of pooled and non-pooled coefficients

at 0.4 and at -0.5. The shape of these two distributions, relative to our preferred pooled-estimate distribution, indicates the considerable noise cleaned away when the data is polled and controlled for fixed effects.

6 Implied estimate for the elasticity ε

Our findings suggest that the long-term response of prices to changes in VAT rates nears 0.4 with a standard error of 0.01. The mapping between our model of Section 2 and our empirical approach imply a simple relation between the estimated response of prices and the across-sector elasticity of substitution ε.

Recall that the long-run relation between relative prices and VAT rates from equation (3) equals $\frac{1}{1+\frac{\alpha}{1-\alpha}\varepsilon}$, where $1-\alpha$ is the labor share of output and ε is the elasticity of interest. Therefore, the mapping between our model and the estimation results is such that $\frac{1}{1+\frac{\alpha}{1-\alpha}\varepsilon}$ equals the estimated price elasticity of 0.4.

Hence, we are left with the calibration of the labor share to determine the value of the implied elasticity of substitution across expenditure categories. The macroeconomics literature has commonly assumed $1-\alpha$ at 2/3. Under this calibration, our estimation results and model imply that ε equals

3 with a standard error of 0.6.

This choice for the labor share is common in the literature and maps well into the labor compensation share of output for many countries. European data on GDP and labor compensation suggests that despite some variability across countries, the European Union average labor share nears 2/3.[4]

7 Conclusion

In this paper, we take a quasi-experimental approach to estimate the value of the across-sector elasticity of substitution. To that end, we use the effects of changes in value added tax (VAT) rates on long-run movements in relative prices to identify the magnitude of the elasticity of substitution across sectors (expenditure categories).

We depart from a standard model of imperfect competition with Cobb-Douglas production function and Dixit-Stiglitz preferences both within and across sectors. Using this commonly applied framework, we show that the price elasticity of the long-run response of relative prices to changes in VAT rates is independent from many parameters and assumptions, such as the elasticity of substitution within sector, and the degree of price stickiness. Consequentially, the model yields a very tractable reduced-form equation that allows for the estimation of the elasticity of substitution across sectors under a very broad set of assumptions. To estimated this relation, we construct a novel data set on VAT rate changes and map it to inflation across expenditure categories for a set of countries.

Our benchmark results indicate that the across-sector elasticity of substitution is around 3 with a standard error of 0.6. This estimate is robust to different regression specifications and data partitions.

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A Data appendix

We measure inflation from the harmonized consumer price indices (HICP) by consumer expenditure category (COICOP). VAT rates are obtained from European Commission (2013), an annual report containing VAT levels and their changes by country and expenditure category.

Table 2 lists all countries included in the sample along with the number of coicops with VAT rate changes in each country, and and the number of VAT changes for that country. Table 3 provides analogous information by COICOP. Figure 6 reports the time series of VAT rate changes.

Table 2: Summary statistics by country

	Number of coicops with VAT changes	Number of VAT changes
Countries:		
Bulgaria	34	408
Cyprus	16	702
Czech Republic	32	1164
Germany	17	408
Estonia	31	368
Greece	29	920
Spain	20	440
Finland	29	681
France	15	180
Hungary	19	662
Ireland	13	516
Italy	14	336
Lithuania	31	744
Latvia	30	1080
Malta	13	156
Netherlands	10	210
Poland	20	240
Portugal	19	864
Romania	28	336
Slovenia	33	396
Slovakia	20	708
United Kingdom	13	420
Total	486	11,939

Table 3: Summary statistics by expenditure category

	Number of countries with VAT changes	Number of VAT changes
Expenditure Categories:		
Bread and cereals	9	211
Meat	9	211
Fish and seafood	9	211
Milk, cheese and eggs	9	211
Oils and fats	9	211
Fruit	9	211
Vegetables	9	211
Sugar, jam, honey, chocolate and confectionery	9	211
Food products n.e.c.	9	211
Coffee, tea and cocoa	9	211
Mineral waters, soft drinks, fruit and vegetable juices	16	437
Spirits	22	579
Wine	22	543
Beer	22	579
Tobacco	22	579
Garments	20	483
Other articles of clothing and clothing accessories	20	483
Cleaning, repair and hire of clothing	20	516
Footwear including repair	16	422
Maintenance and repair of the dwelling	16	348
Electricity	18	453
Gas	17	435
Liquid fuels	14	284
Major and small household appliances whether electric or not	22	579
Pharmaceutical products	9	204
Medical services; paramedical services	1	12
Hospital services	1	12
Motor cars	22	579
Passenger transport by railway	2	56
Passenger transport by road	4	80
Telephone and telefax equipment	17	427
Telephone and telefax services	17	427
Recreational and sporting services	10	252
Cultural services	8	192
Books	1	12
Newspapers and periodicals	10	244
Restaurants, cafés and the like	10	232
Accommodation services	17	380
Total	486	11,939

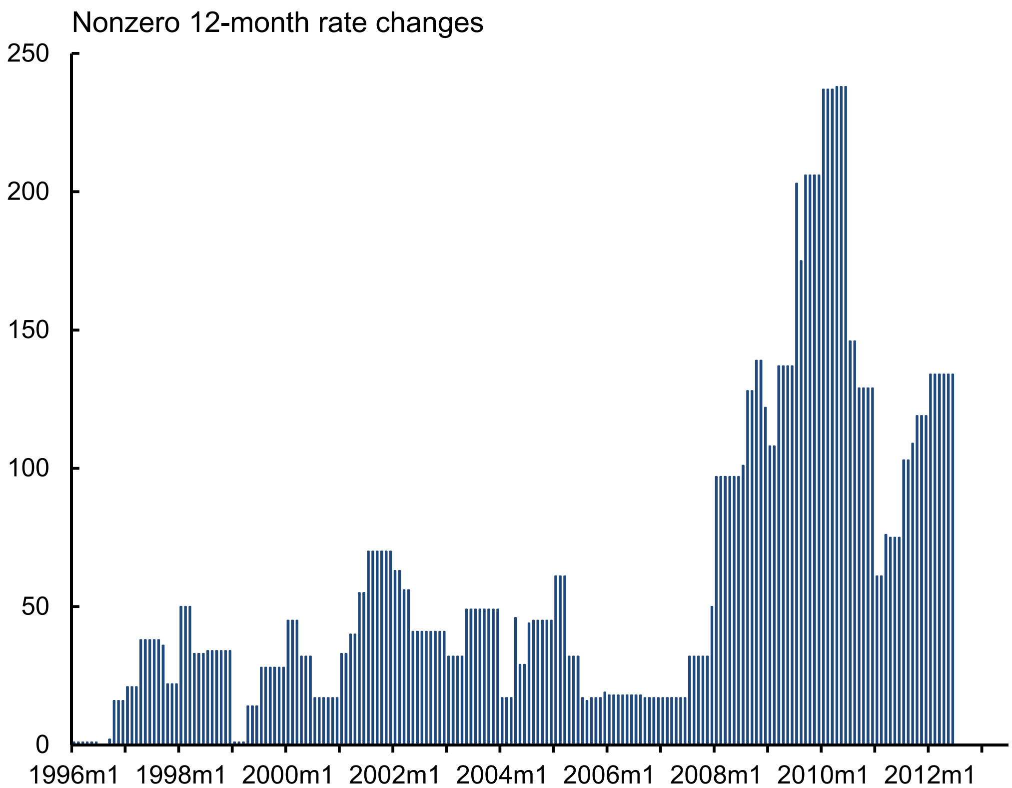

Figure 6: VAT rate changes over time