The Effects of Pre-announced Consumption Tax Reforms on the Sales and Prices of Consumer Durables

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Abstract

This paper utilizes a unique micro data set on consumer durables to study the effect of consumption tax reforms on the time path of consumption. The dataset reports the monthly sales of individual products and their consumer prices in 22 European countries, which enacted numerous consumption tax reforms in recent years. We implement a reduced form specification for sales that allows us to test theoretical predictions by a standard inter-temporal model of consumer choice under different assumptions about the pass-through of taxes into prices. Our identification strategy exploits the trading of individual products in multiple countries. The results document that changes in baseline consumption tax rates are fully and quickly shifted into consumer prices and exert very strong effects on the time path of consumption. We find that a one percentage point increase in consumption taxes causes an inter-temporal shift in consumption by 3 or more percent. In addition, purchases of durable goods increase temporarily by about 2 percent in the last month before a tax increase.

Key Words: Tax Reform; Fiscal Policy; Consumption Tax; Pass-Through; Tax Incidence; Durable Goods

JEL Classification: D15; D12; H24; H32; E21; E62

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1 Introduction

The consumption tax is a potentially powerful instrument of fiscal policy. Economic theory suggests that, depending on the reform, an upcoming tax-rate change would either incentivize consumers to bring forward or postpone purchases. Since most countries levy broad-based consumption taxes, they could exploit this inter-temporal response and raise or discourage consumption through a pre-announced change of the baseline tax rate. Feldstein (2002), for example, proposes a sequence of pre-announced consumption tax increases in order to stimulate current consumption. Combined with a reduction in income taxes, this would enable fiscal policy to boost consumption without increasing budget deficits. Hall (2011) points out that pre-announced consumption tax increases could be useful to combat the decline in the US demand for consumer durables. Assuming full pass-through of tax changes into consumer prices, Correia, Farhi, Nicolini and Teles (2013) use a New Keynesian model to show that an increasing path of consumption taxes over time could be an essential part of an "unconventional fiscal policy" at the zero lower bound of the nominal interest rate.

There is, however, considerable uncertainty about the degree of consumer responsiveness at the inter-temporal margin (see Attanasio and Weber, 2010), all the more so since consumers might not be fully aware of the consumption tax burden (Chetty, Looney and Kroft, 2009). In addition, conventional assumptions about the pass-through might not hold and the consumer response might deviate from theoretical predictions due to capital market imperfections. In order to make concrete policy recommendations, it is, therefore, important to evaluate empirically the effects of pre-announced tax reforms on consumer behavior.

The existing literature is scarce and the available evidence offers mixed results. One common finding is a high consumer awareness of forthcoming consumption tax changes with significant shifts in sentiment toward expenditure. Crossley, Low, and Sleeman (2014) analyze the effects of a temporary VAT (value-added tax) cut implemented as a fiscal stimulus in the UK in late 2008 and find strong positive effects on consumer sentiment. Exploring the effect of a pre-announced consumption tax increase in Japan in 1997, Cashin and Unayama (2016) also document high consumer awareness of the upcoming reform. D'Acunto, Hoang, and Weber (2016) find that the 2007 consumption tax increase in Germany raised German households' inflation expectations and their willingness to purchase durable goods before the tax reform relative to other European households.

With regard to actual purchases, however, results are mixed. Crossley, Low, and Sleeman (2014) provide some evidence of a positive effect on spending at least when focusing on retail sales in the UK relative to other European countries. But they also document that the tax decrease was only passed through into consumer prices initially with prices starting to increase before the temporary tax cut was reversed. If preferences are non-separable, Ogaki and Reinhardt (1998) emphasize that to obtain unbiased estimates of the inter-temporal consumption response, it is necessary to differentiate between consumer durables and non-durables. Cashin and Unayama (2016) employ detailed household panel data that allow them to distinguish between goods according to their durability and storability. Nevertheless, they find only small intertemporal substitution effects in the case of Japan.

Against this background, we utilize a unique micro-level data set of major domestic appliances at the product level on a monthly basis from 2004 until 2013 in 22 European countries, which underwent numerous VAT reforms in recent years (DeMooij and Keen, 2013). A crucial characteristic of the dataset is the availability of separate information on prices and units sold, which allows us to study the effects of tax reforms on both consumer prices and demand for approximately 30,000 individual products (models). We employ a consistent identification strategy for sales and price effects, which exploits the trading of individual products in multiple countries: The counterfactuals for models in a country experiencing a consumption tax reform are constructed from the contemporaneous sales and prices of the same model in other EU countries. The empirical analysis explicitly takes the timing of reforms' announcement and implementation into account. In addition, we incorporate information on the motivation behind tax reforms following the narrative approach to the analysis of fiscal policy put forward by Romer and Romer (2010).

The empirical results document that changes in baseline consumption tax rates are fully and quickly passed into consumer prices and exert very strong effects on the time path of consumer spending. Sales of consumer durables are found to differ substantially before and after a tax-rate change. Specifically, in the month before implementation, sales of durables display a strong temporary change even though at this point about a third of the tax rate change has already been passed into consumer prices. The difference in sales before and after implementation is not merely offsetting the short-run demand effect for durables on the verge of a tax reform, but points to a strong inter-temporal shift in total consumer demand. Quantitatively, our results show that a one percentage point increase in consumption taxes causes an inter-temporal shift in consumption by 3 or more percent. In addition, purchases of durable goods increase temporarily by about 2 percent in the last month before a tax increase.

This paper contributes to different strands of the literature. The empirical analysis is concerned with the developments in sales and prices around tax reforms as in Cashin and Unayama (2016) and D'Acunto, Hoang, and Weber (2016). To derive empirical predictions, we follow Ogaki and Reinhardt (1998) and Cashin and Unayama (2016) and use an inter-temporal model of consumer choice distinguishing between durable and non-durable goods. We show that, depending on the pass-through of taxes, an appropriate specification may need higher-order leads and lags of tax-rate changes to capture pre- and post-reform effects on durables.

We generalize the analysis of pre-announced tax reforms on consumption by studying multiple tax changes, and explore reform heterogeneity along two dimensions: in terms of the length of the implementation lag after announcement as in Mertens and Ravn (2012) and in terms of endogeneity-exogeneity as in Romer and Romer (2010). Only if we incorporate the information on when a policy reform has been announced, our results yield full shifting of consumption tax changes into consumer prices. The shift occurs within a short time period of one or two quarters. Following Gunter *et al.* (2017), we additionally investigate the role of the motivation behind each tax change.focusing solely on reforms that are classified as exogenous with regard to the business cycle, we find that the price pass-through is quicker, the temporary shift in the demand for durables is more pronounced, and the long-term inter-temporal shift in consumption is smaller.

In exploiting regional information within the European Union, our identification strategy is related to the analysis of local sales taxes in the US as in Agarwal, Marwell and McGranahan (2016), who study the consumer response to sales-tax holidays that temporarily exempt specific items. They use household survey data as well data on credit card transactions to identify differences in the tax treatment by households' or merchants' place of residence and find a significant increase in spending that is not offset in the periods before or after the tax holiday. Baker, Johnson and Kueng (2017) use scanner data from the Nielsen Consumer Panel to study consumer responses to state and local sales tax changes at the household and store level and find that consumption spending decreases by 2% after a local sales tax increase. In contrast to state and local sales taxes, the consumption tax effects studied in this paper refer to the baseline tax-rate of a value added, general consumption tax. As this baseline tax-rate is applied to most consumer goods, it is much closer to the type of consumption tax actually discussed in the fiscal policy literature. Since our analysis focuses on EU countries rather than local jurisdictions, cross-border shopping, addressed in the literature on local sales taxes as, for instance, in Agrawal (2015), is arguably less of an issue. We, nevertheless, perform robustness checks to confirm this.

Our analysis provides new evidence on the pass-through of consumption taxes. While it is frequently assumed that pass-through is complete and immediate, some recent empirical papers explore to what extent changes in the baseline consumption tax rate are actually reflected in consumer prices. Carbonnier (2007) studies two major VAT decreases in France and finds that the pass-through is limited, especially for car sales. Carare and Danninger (2008) use monthly price data at a two-digit level to study how the 2007 VAT increase in Germany affected consumer prices. While their results support the view that the tax is fully shifted to the consumer, they find evidence of "inflation smoothing" in the sense that adjustments in prices start before implementation. Using a similar classification as Carare and Danninger (2008), Benedek, deMooij, Keen, Wingender (2015) provide a more comprehensive analysis based on monthly price data for about 17 European countries and 65 distinct VAT reform episodes. For changes in the standard consumption tax rate, they confirm full price pass-through, and for durables they find pre-reform price adjustments. With regard to timing, the authors' estimates show that price adjustments start 7 to 9 months before a reform and continue for 8 months after.[1]

[1] Benedek *et al.* (2015) also note that the pass-through of the baseline consumption tax rate differs for reduced

While we focus on the baseline consumption tax rate, our analysis differs, since instead of statistical information, we use primary data that allows us to focus on the pricing of individual products, and thus provide evidence on tax effects that are not confounded by shifts between products of different quality. Further, unlike previous work, which usually does not take announcements into account, we show that information about the timing of the announcement and the length of the implementation lag after announcement affects the results and should not be ignored when assessing the effect of pre-announced reforms. While we find clear support for full pass-through of the consumption tax, our results also indicate that price adjustment differs depending on the economic background of the reform. If we focus on tax reforms that are not related to GDP shocks, prices for durables are found to display a faster adjustment with pre-reform effects starting only two months before implementation and full pass-through reached in the first month after implementation.

The paper proceeds as follows. The next section provides a theoretical analysis of intertemporal consumption in a model with durable and non-durable goods which is used to derive the empirical specification for sales. Section 3 describes the dataset, while Section 4 provides descriptive evidence of the effect of consumption tax increases on the sales and prices of white goods in Germany and Spain. Section 5 outlines our empirical methodology. The regression results for sales and prices are presented in Section 6, including various robustness checks. Section 7 concludes.

rates, for which they find limited pass-through. The latter is confirmed by Kosonen (2015), who also documents asymmetries in the pass-through of tax increases and decreases in reduced rates (see also Benzarti, Carloni, Harju, Kosonen, 2017).

2 Theoretical Framework

This section develops a framework for the analysis of the consumption decisions of a representative household facing a pre-announced general consumption tax increase. We follow Ogaki and Reinhart (1998) and assume that the household derives utility from the service flow of the stock of durables, k_s, and the consumption of non-durable goods, x_s, in period s. The utility from consumption in this period has constant elasticity of substitution ϵ such that

$$u_s = \left[x_s^{\frac{\epsilon-1}{\epsilon}} + b k_s^{\frac{\epsilon-1}{\epsilon}} \right]^{\frac{\epsilon}{\epsilon-1}}.$$

Since the model focuses on pre-announced changes in the tax rate, the consumer's choice is analyzed in an intertemporal setting with certainty. The present value of the instantaneous utility in all periods is

$$\sum_{s=t} \beta^{s-t} \frac{\sigma}{\sigma-1} u_s^{1-\frac{1}{\sigma}},$$

where $\beta < 1$ is a discount factor reflecting the household's time preference, and σ is the intertemporal elasticity of substitution. Note that this function is additively separable over time. Let i_s designate purchases of durables in period s and δ be the rate of depreciation. Then the stock of consumer durables evolves according to

$$k_s - k_{s-1} = i_s - \delta k_{s-1}. \tag{1}$$

Normalizing the producer price of non-durables to unity and denoting the producer price of the durable good by q_s, consumer prices for durable and non-durable goods are $p_s = (1 + \tau_s) q_s$ and

$(1+\tau_s)$, respectively. The evolution of (financial) wealth is determined by total income, which consists of labor income, w_s, and interest income net of current purchases of non-durable consumption goods and current investment in durables

$$a_{s+1} - a_s = w_s + ra_s - (1+\tau_s)\, x_s - p_s i_s, \tag{2}$$

with a_s being the stock of wealth at the beginning of period s, and r the interest rate.

2.1 Demand for Consumer-Durables

In each period s the household chooses consumption of non-durables, x_s, and investment in durables, i_s, to maximize its expected discounted utility subject to constraints (1) and (2). Eliminating i_s by plugging (1) into (2), the consumer's problem is equivalent to choosing x_s and k_s.

As shown in the appendix (see Appendix A.1), assuming that $\beta\,(1+r) = 1$, the optimum consumption structure requires that

$$k_s = b^{\epsilon} Q_s^{-\epsilon} x_s, \tag{3}$$

where Q_s is the user cost of the service flow of the durable good (Ogaki and Reinhart, 1998). Formally,

$$Q_s = \left[1 - \rho\,(1-\delta)\left(\frac{p_{s+1}}{p_s}\right)\right] \frac{p_s}{1+\tau_s}, \tag{4}$$

where $\rho = \frac{1}{1+r}$. Note that the user cost in period s depends on the change in the consumer price in period $s+1$.

In order to derive implications for the demand of durable goods, we consider the optimal stock of durables in period $s+1$ relative to period s. From equation (3), the optimal path of the stock of durables is given by

$$\frac{k_{s+1}}{k_s} = \left(\frac{Q_{s+1}}{Q_s}\right)^{-\epsilon} \frac{x_{s+1}}{x_s}, \tag{5}$$

and, as shown in the appendix, the optimal path of non-durables is

$$\frac{x_{s+1}}{x_s} = \left(\frac{1+\tau_{s+1}}{1+\tau_s}\right)^{-\sigma} \left(\frac{F_{s+1}}{F_s}\right)^{\frac{\sigma-\epsilon}{\epsilon-1}}, \tag{6}$$

where

$$F_s = 1 + b^{\epsilon} Q_s^{1-\epsilon} \tag{7}$$

captures the utility effect of changes in the optimum consumption structure as determined by (3). In the case of a Cobb-Douglas function ($\epsilon = 1$), this term does not vary with the user cost, and F_s is a constant parameter. Equations (5), (6) and (7) determine the time path of the optimal stock of durables as a function of the time paths of the user cost and the tax rate.

2.2 Sales Effects of a Tax Rate Change

While the above theoretical model abstracts from possibly important aspects of the consumer demand such as adjustment costs or limited access to the capital market, it can be used to derive some basic empirical predictions about the inter-temporal effects of a tax-rate change. To explore the effect on the path of consumer durables of a change in the tax rate set to occur in period t and already anticipated in period $t-1$, we take logs and substitute eq. (6) into eq. (5). The resulting expression shows that growth in the stock of durables, $\log\left(\frac{k_t}{k_{t-1}}\right)$, is a linear function of the growth in the user cost, $\log\left(\frac{Q_t}{Q_{t-1}}\right)$, the change in the tax rate, $\log\left(\frac{1+\tau_t}{1+\tau_{t-1}}\right)$, and the growth in the intra-temporal substitution term, $\log\left(\frac{F_t}{F_{t-1}}\right)$. Recall that the latter term drops out when the intra-temporal substitution elasticity is unity ($\epsilon = 1$), or, as noted by Cashin and Unayama (2016), when the utility function is separable in the consumption of durables and non-durables ($\sigma = \epsilon$). In order to address the more general case where $\epsilon \neq 1$ and $\sigma \neq \epsilon$, $\log F_t$, $\log F_{t-1}$, Q_t and Q_{t-1} are approximated linearly around the steady-state value of $Q = [1 - \rho(1-\delta)]\, q$ to obtain

$$\Delta \log F_t = (1-\epsilon)\left(\frac{b^{\epsilon} Q^{1-\epsilon}}{1 + b^{\epsilon} Q^{1-\epsilon}}\right) \Delta \log Q_t.$$

Hence, the growth in the optimum stock of durables can be expressed solely in terms of the change in the tax rate and the growth rate of the user cost

$$\Delta \log k_t = -\sigma \Delta \tau_t - \varphi \Delta \log Q_t, \tag{8}$$

where $\varphi = \epsilon + (\sigma - \epsilon)\left(\frac{b^{\epsilon} Q^{1-\epsilon}}{1+b^{\epsilon} Q^{1-\epsilon}}\right) > 0$ and $\log\left(\frac{1+\tau_t}{1+\tau_{t-1}}\right)$ is approximated by $\Delta \tau_t$.

Equation (8) shows that an anticipated change in the consumption tax has basically two separate effects on the optimal stock of durable goods. Consider a tax increase in period t. As the tax rises, the stock of durables declines due to intertemporal substitution. The strength of this decline depends on the magnitude of the tax increase and on the elasticity of intertemporal substitution σ. A second effect emerges from changes in the user cost. From eq. (4), if consumer prices are bound to be higher in t, the user cost in period t is higher than in period $t-1$ before the tax increase. In fact, under the assumption of constant producer prices, *i.e.* with complete and instantaneous pass-through of the consumption tax change, the change in the consumer price is proportional to the tax rate change $\Delta \log Q_t = \log \frac{Q_t}{Q_{t-1}} = -\log \left(1 - \alpha \left(\frac{\tau_t - \tau_{t-1}}{1+\tau_{t-1}}\right)\right) > 0$. Depending on the magnitude of φ, this will contribute to a decline in sales in period t. However, in period $t-1$ we have $\Delta \log Q_{t-1} = \log \frac{Q_{t-1}}{Q_t} = \log \left(1 - \alpha \left(\frac{\tau_t - \tau_{t-1}}{1+\tau_{t-1}}\right)\right) < 0$. This causes a temporary increase in sales in $t-1$ before the reform. The strength of the response hinges on various parameters, and in particular on the intra-temporal elasticity of substitution ϵ. Intuitively, the larger the degree of substitutability between durables and non-durables, the larger this transitory effect on the sales of durables.

Supposing a full and immediate pass-through of the tax rate change into consumer prices assumes away any price movements in anticipation of the consumption tax reform, and in particular, producer price effects in the form of an early pass-through. However, high demand prior to a tax increase might induce producers to change their prices in $t-1$, triggering adjustments in Q_{t-1}. Similarly, a drop in demand in t might push producers to lower prices, and as a consequence, the user cost in period t might be below the long-term steady state. Hence, further demand effects could take place in $t+1$.

To allow for producer price effects, we decompose the change in the user cost in producer price and tax effects by means of a linear approximation

$$\Delta \log Q_t = -\alpha \Delta \log q_{t+1} + (1+\alpha) \Delta \log q_t - \alpha \left(\Delta \tau_{t+1} - \Delta \tau_t\right), \tag{9}$$

where $\alpha = \frac{\rho(1-\delta)}{1-\rho(1-\delta)} > 0$. With a linear approximation for $\log i_t$, the change in sales is[2]

$$\Delta \log i_t = \frac{1}{\delta} \left(\Delta \log k_t - (1-\delta) \Delta \log k_{t-1} \right). \tag{10}$$

Assuming a constant price elasticity of supply, the change in the producer price is proportional to the change in sales. Hence, the producer price is related to current and lagged changes in the stock of durable goods, such that:

$$\Delta \log q_t = \eta \left(\Delta \log k_t - (1-\delta) \Delta \log k_{t-1} \right),$$

where η is inversely related to the price elasticity of supply. Replacing the producer price in eq. (9), inserting for $\Delta \log Q_t$ in eq. (8) and introducing L and F as lag and forward operators, respectively, gives:

$$\left(1 - \gamma_3 \mathsf{F} - \gamma_4 \mathsf{L}\right) \Delta \log k_t = \gamma_1 \Delta\tau_{t+1} - \gamma_2 \Delta\tau_t, \text{ where} \tag{11}$$

$$\gamma_1 = \frac{\varphi\alpha}{1+\varphi\eta\left(\alpha\left(1-\delta\right)+\left(1+\alpha\right)\right)}, \qquad \gamma_2 = \frac{\sigma+\varphi\alpha}{1+\varphi\eta\left(\alpha\left(1-\delta\right)+\left(1+\alpha\right)\right)},$$
$$\gamma_3 = \frac{\varphi\alpha\eta}{1+\varphi\eta\left(\alpha\left(1-\delta\right)+\left(1+\alpha\right)\right)}, \qquad \gamma_4 = \frac{\varphi\left(1+\alpha\right)\eta\left(1-\delta\right)}{1+\varphi\eta\left(\alpha\left(1-\delta\right)+\left(1+\alpha\right)\right)}.$$

Solving for $\Delta \log k_t$, the change in the optimal capital stock is determined by distributed leads and lags of the change in the tax rate. Inserting into eq. (10) yields a prediction for the change in investment

$$\Delta \log i_t = \sum_{s=1}^{p} a_s \mathsf{F}^s \Delta\tau_t + b\Delta\tau_t + \sum_{s=1}^{q} d_s \mathsf{L}^s \Delta\tau_t \tag{12}$$

where $q \geq 1$ and $p \geq 1$ determine the number of lags and leads of the tax rate change.

[2]Note that $\log i_t$ can be approximated around k_{t-1} by $\log i_t \simeq \log\delta + \log k_{t-1} + \frac{1}{\delta}\Delta \log k_t$.

In the absence of producer price effects ($\eta = 0$), there is full and immediate pass-through of taxes into consumer prices. Hence, $\gamma_3 = \gamma_4 = 0$ and $p, q = 1$, and eq. (12) simplifies to

$$\Delta \log i_t = a_1 \mathsf{F} \Delta \tau_t + b \Delta \tau_t + d_1 \mathsf{L} \Delta \tau_t.$$

In this case, only three parameters, a_1, b and d_1, characterize the sales path and we are able to make predictions on their sign. The coefficient related to the upcoming change in the tax rate should be positive ($a_1 = \frac{\varphi\alpha}{\delta} > 0$), which suggests that the demand for durables changes in the period before the tax reform. More specifically, in case of a tax increase, sales of durables rise. A second effect on the sales path occurs in the period when the tax rate change is implemented. With a tax increase, the model predicts an unambiguous decline in sales ($b = -\frac{1}{\delta}\left(\sigma + \varphi\alpha\right) - \left(1 - \delta\right)\frac{\varphi\alpha}{\delta} < 0$). This partly reflects the reversal of the temporary pre-reform increase in sales, and partly the inter-temporal substitution effect that works towards a decline in demand. In the subsequent month, the model predicts a recovery of sales ($d_1 = \frac{1-\delta}{\delta}\left(\sigma + \varphi\alpha\right) > 0$). The sum of the three coefficients identifies the intertemporal substitution elasticity:

$$\sigma = -\left(a_1 + b + d_1\right).$$

In the presence of producer price effects, the model predicts that sales effects are not necessarily limited to the periods directly before and after a tax-reform. As a consequence, p and q would be larger than unity, and the empirical parameters $a_1, ...a_p, b, d_1, ...d_p$ would be a combination of consumer and producer responses.

3 Data Description

The dataset is provided by the market research company Gesellschaft für Konsumforschung (GfK) Retail and Technology GmbH and consists of monthly panel data at the model level on unit sales and scanner prices of durable "white goods" for all countries of the European Union (EU), except Bulgaria, Croatia, Cyprus, Ireland, Luxembourg and Malta. The white goods comprise of eight major categories: Cookers, refrigerators (coolers), dishwashers, freezers, cooktops (hobs), hoods, tumble driers and washing machines. Each individual model has a unique identification number (id), which is the same over time and across countries, in case a model is traded in more than one Member State. Table 1 summarizes the coverage of the data by country and category.

The data covers around 110,000 different models with 62.4 million units sold per year, and an annual market size of 26.1 billion Euro. On average, the data accounts for 49% of the annual final household consumption expenditure on household appliances (COICOP category P053) for the countries in question. The time period generally extends from January 2004 until September 2013, although data coverage for some countries usually starts at a later date. GfK collects price and quantity data retailer by retailer. The final units sold for a model in a given country in a specific month are the sum of all sales of this model across all retailers in the country in the respective month. The corresponding price is a monthly sales-weighted average of all prices for this model across retailers. Prices are inclusive of consumption taxes and reflect all discounts, special offers and other promotions received by consumers.[3]

[3]According to GfK's panel methodology, GfK Retail and Technology generate the data in the following way: First, distribution channels are defined, which are relevant for a respective product group. Examples of distribution channels are hypermarkets, technical superstores, department stores, *etc.* An address database is established for all outlets in a given country belonging to a certain distribution channel with the goal of determining its corresponding universe. This is achieved through census data and special questionnaires to dealers/retailers. Once the universe is

Table 1: DATA COVERAGE

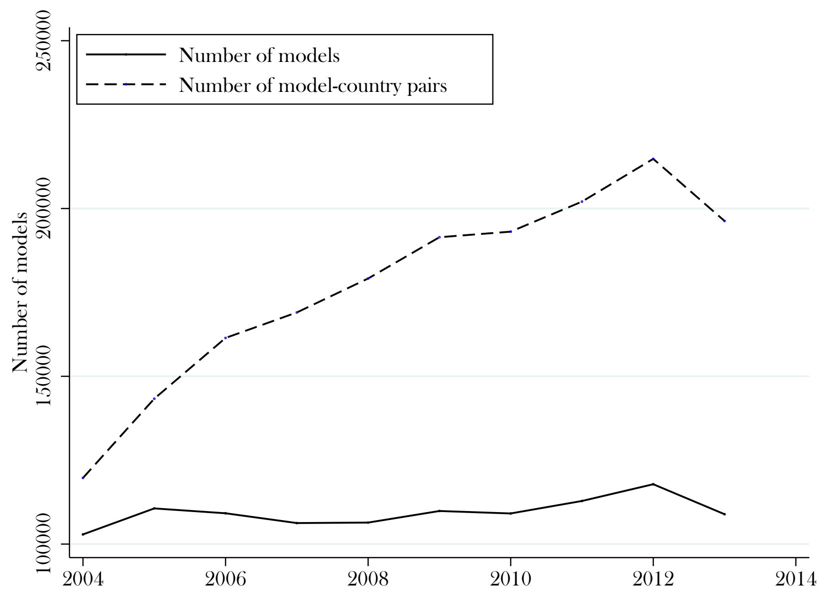
Country	Coverage
AT, BE, CZ, DE, ES, FR, IT, NL, PL, PT, SE, UK	Jan. 2004 - Sept. 2013 for all categories of white goods.
DK	Jan. 2004 - Sept. 2013 WM, TD, CO, RG; Jan. 2007 - Sept. 2013 FRZ; Jan. 2008 - Sept. 2013 HB; HD not covered.
EE, LV, LT	Jan. 2006 - Sept. 2013 for WM, CO, RG; Jan. 2008 - Sept. 2013 for HB, DW; HD,TD, FRZ are not covered.
GR	Jan. 2005 - Sept. 2013 for all product categories except TD, which is covered from Jan. 2007 - Sept. 2013.
FI	Jan. 2005 - Sept. 2013 for all product categories, except HD, which is not covered.
HU	Jan. 2004 - Sept. 2013 for all product categories except HD, which is covered from Oct. 2006 - Sept. 2013.
RO	Jan. 2009 - Sept. 2013 for all product categories except HD, which is covered from Jan. 2012 onwards.
SI	Jan. 2005 - Sept. 2013 for all product categories except HD, which is covered from Jan. 2009 - Sept. 2013.
SK	Jan. 2006 - Sept. 2013 for all product categories.

Notes: CO=Cooker; DW=Dishwasher; FRZ= Freezer; HB=Hob/Cooktop; HD=Hood; RG= Refrigerator; TD=Tumble dryer; WM=Washing machine. AT=Austria; BE=Belgium; CZ=the Czech Republic; DE=Germany; DK=Denmark; EE=Estonia; ES=Spain; FI=Finland; FR=France; GR=Greece; HU=Hungary; IT=Italy; LV=Latvia; LT=Lithuania; NL=the Netherlands; PL=Poland; PT=Portugal; RO=Romania; SE=Sweden; SI=Slovenia; SK=Slovakia.

The solid line in Figure 1 displays the evolution of the total number of models of white goods from 2004 to 2013, irrespective of their sales location. The dashed line shows the number of unique model-country pairs over the same time period, so that model X sold in country A is treated as different from model X sold in country B. Compared to 2004-2006, the general trend is that models are traded in an increasing number of countries over time. This can explain the changing composition of the volume of sales disaggregated by number of countries in which products are marketed, as depicted in Figure A-1 in the Appendix. While one-country models generated 67% of the total volume of sales in 2004, their share dropped to 35% in 2012, with sales of models available in two to five

known in its structure, the sample is drawn through disproportional quota sampling, taking into account three key factors – region, distribution channel, and turnover class. The aim is to make sure that the data provides an equally good representation of developments for each model. The basic data is received retailer by retailer in a heterogenous form. Incoming data from different sources referring to the same model is translated into one single definite GfK product code. Once checked, the basic data is extrapolated for each distribution channel.

Figure 1: CROSS-COUNTRY MARKETING



Note: The figure depicts the number of unique models per year (solid line), and the number of models when one particular model is treated as separate models when sold in a different country (dashed line). For example, in 2008 there are 106,414 unique white good models. Some of these are marketed in more than one country, so that the unique country-model pairs in 2008 are 179,141.

countries steadily taking over. This particular feature of the data means that the consumption tax rate varies not only across countries over time, but for those models sold simultaneously in multiple markets, the tax rate also varies within each cell of observations comprising the sales of an individual model in a specific time-period. It is precisely this characteristic of the data that we exploit in our identification strategy as explained in Section 3.

Table 2 shows descriptive statistics on the average annual number of models, units sold, value of sales, the average monthly price and quantity per model and other variables. Descriptive statistics disaggregated by model category are presented in Table A-1 in the Appendix. In terms of number and value of sales, refrigerators and washing machines constitute the two biggest categories.

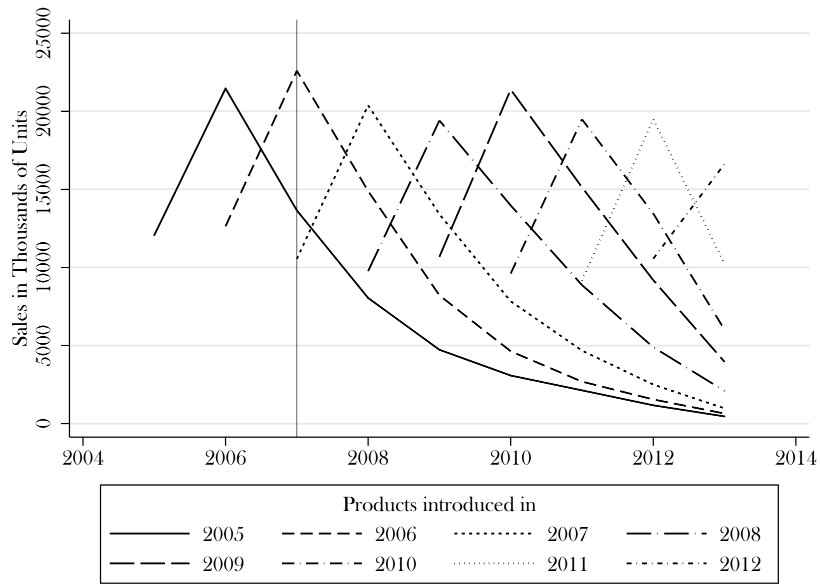
While the annual number of models is stable at around 110,000 (Fig. 1), the composition changes

Table 2: DESCRIPTIVE STATISTICS

	Mean	Std. Dev.	Min	Max
	All Models (Full Sample)			
Average № of Models per Year	109,848	3,889	102,879	117,842
Average № Units Sold per Year (Thousands)	65,405	5,079	47,081	65,708
Average Value of Sales per Year (Millions Euro)	26,119	2,206	19,531	27,992
Average № Units Sold per Model per Month	50	184	-262	24,965
Average Price per Model (Euro)	488	398	-1,968	29,826
Average Months Model Sold	30.46	23.22	1	117
Average Market Age (Months)	26.87	22.27	1	117
Rank	892	797	1	5,364
R5 (min(rank) $\in [1, 50]$)	0.101	0.301	0	1
R10 (min(rank) $\in [1, 100]$)	0.182	0.386	0	1
	Models Sold in at Least Two Countries (Estimation Sample)			
Average № of Models per Year	18,507	5,200	2,695	23,299
Average № Units Sold per Year (Thousands)	24,334	4,966	6,377	28,449
Average Value of Sales per Year (Millions Euro)	11,101	2,184	3,047	12,849
Average № Units Sold per Model per Month	47	156	-21	17,032
Average Price per Model (Euro)	531	404	-1,454	13,284
Average Months Model Sold	34.13	22.72	1	117
Average Market Age (Months)	28.34	21.09	1	117
Rank	683	666	1	5,364
R5 (min(rank) $\in [1, 50]$)	0.137	0.344	0	1
R10 (min(rank) $\in [1, 100]$)	0.241	0.427	0	1
Standard VAT rate	.201	.023	.15	.27
Unemployment rate	8.85	4.10	3.1	27.8

Note: The market age is the number of months a model is sold in a specific country as opposed to the total number of months a model appears in the data irrespective of the location of sales (Average Months Model Sold). Min(rank) is the minimum rank achieved by a model in a given country across all years, *i.e.* it captures the highest rank of a model in its best-selling year. $R5$ is a dummy variable equal to 1 if a model reaches a rank between 1 and 50 throughout its life-cycle; $R10$ is a dummy variable equal to 1 if min(rank) is between 1 and 100. After first checks of the data, the following where eliminated: Observations without an id; observations for models for which all units/price variables are missing across all years; observations in years for a model for which all units/prices are missing. This resulted in the loss of only 15,174 observations, or 0.07% of all available data points. Across all categories, there are a very limited number of observations with negative units sold and prices. We treat these as returned items and leave the data as it is. The largest negative number for units sold is -262 in the case of cookers. Outliers in prices were also removed. In particular, we calculated percentage changes of prices of a specific model within a country and replaced prices exhibiting increases greater than 200% (929 prices) and price decreases greater than 50% (97,353 prices) with missing observations. Out of the 97,353 prices that fell by more than 50%, only 6,617 were real price changes, and the rest were driven by zero prices (percentage change of -1.) More detailed descriptive statistics disaggregated by model category are presented in Table A-1 in the Appendix.

Figure 2: PRODUCT LIFECYCLE BY YEAR OF INTRODUCTION



Note: The figure depicts the annual evolution of unit sales by year of introduction. It also shows the composition of sales based on models' year of introduction. For example, in 2007, models introduced in 2005 constituted 21% of total sales, models launched in 2006 – 34%, and new models (launched 2007) –16%. The remaining 29% were models first appearing in the data in 2004 and not shown in the figure.

periodically, with new models entering the market and older ones exiting. The life cycle, *i.e.* the change in the volume of sales over time for models introduced in a particular year is depicted in Figure 2.[4] Clearly, sales are inversely proportional to a model's age. The sales of new models account for, on average, 20-25% of the total units sold in the first year they are introduced, peak in the second year, and peter out afterwards. This pattern does not vary substantially across individual product categories. About 80% of new entries drop out of the market in 5 to 6 years.

Table 2 reports two statistics on the age of models: The age of a model, with the relevant date of introduction being the first time it appears in any country, and the market age, which reports the

[4]Models' years of introduction are based on the assumption that the first year a product appears in the data (in any country), is the year, in which it was introduced. GfK provided us with a sample plot with exit and entry of fridges based on actual dates of introduction and exit, which was closely mirrored by a model's appearance and disappearance from the data.

number of months a model has been sold in a specific market (country).[5] The table also provides statistics on the rank of a product. All models in the data are ranked according to their sales. The rank variable is category-, country-, and year-specific, but does not vary within a year. Thus, the best selling refrigerator in Germany in a given year has a rank one, and so do the best-sellers in the other categories, but the same model may not be a market leader in France, for example. $R5$ and $R10$ are binary indicators for top-selling models. They equal unity if a model is part of the top 50 or 100 best-selling products within its respective category at least once during its life cycle. In the estimation sample, $R5 = 1$ for 27% of all models, and $R10 = 1$ for 42%.[6]

The second panel of Table 2 describes the reduced sample of models sold in a minimum of two countries. Even though models marketed in multiple countries constitute on average only 17% of all models within a year, they comprise 37% of all units sold, and generate 42% of sales.

The GfK data is merged with data on the consumption taxes in the 22 countries under consideration. The baseline VAT rate is the relevant tax rate for white goods in these countries as they are not subject to reduced VAT, zero rating or exemptions.[7] While from 2004 until 2013 the VAT rates in Austria, Belgium, France, Sweden and Denmark remained unchanged, the other 17 EU countries altered the standard rate 33 times, which provides time and within country/within model variation.

[5] The longest-lived categories are the ones typically sold as part of kitchens – hoods, cooktops, and cookers, and the shortest-lived are washing machines but differences are small.

[6] Together, the top 50 products in each of the eight categories of white goods in each country account for 53% of the total volume of sales, on average. They are also 30% cheaper, on average, and sell 6 times more units per month (average price in euro 396 (s.e. 234), average sales 146 units (s.e. 331)) relative to models whose rank never exceeds 50 (average price 559 (s.e. 426) and average units 26 (s.e. 66)).

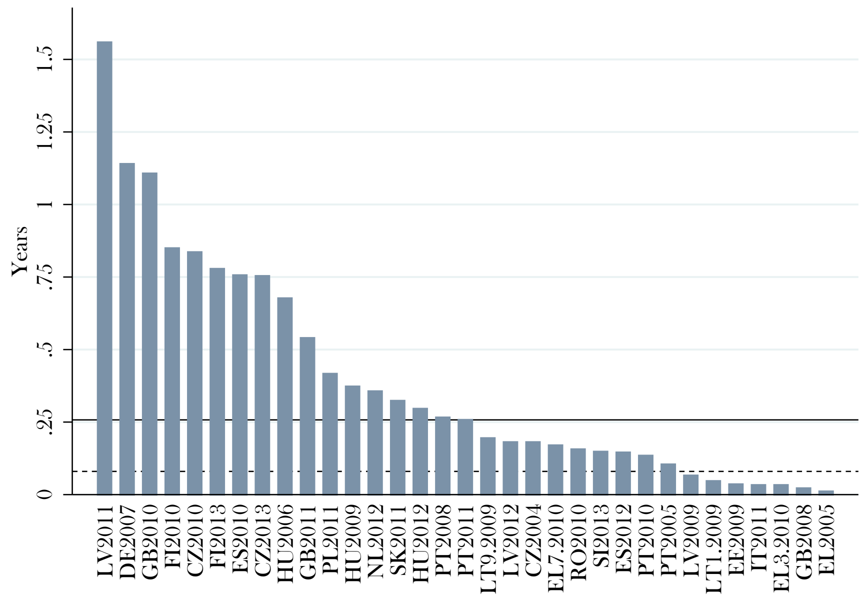
[7] There are non-VAT instruments to stimulate the consumption of energy efficient household goods, summarized in Copenhagen Economics (2008). Some policies are, for example, lump-sum rebates to consumers for the replacement of old household appliances with new ones from a higher energy efficiency class. These programs, however, are unlikely to confound the empirical effects to VAT hikes as they typically focus only on a small subset of models in very narrow time frame.

Table 3: STANDARD VAT RATE CHANGES: 2004-2013

Country	Announcement Date	Implementation Date	Tax Change	Rationale	Classification
Austria	–	–	–	–	–
Belgium	–	–	–	–	–
Czech Republic	26.02.2004	01.05.2004	-0.03	Offsetting,within VAT	Endog.
	03.03.2009	01.01.2010	0.01	GDP-driven, pro-cyclical	Endog.
	02.04.2012	01.01.2013	0.01	Deficit-driven	Exog.
Denmark	–	–	–	–	–
Estonia	18.06.2009	01.07.2009	0.02	Pro-cyclical	Endog.
Finland	26.08.2009	01.07.2010	0.01	GDP-driven, pro-cyclical	Endog.
	24.03.2012	01.01.2013	0.01	Deficit-driven	Exog.
France	–	–	–	–	–
Germany	12.11.2005	01.01.2007	0.03	Debt-driven	Exog.
Greece	29.03.2005	01.04.2005	0.01	Debt-driven	Exog.
	04.03.2010	15.03.2010	0.02	GDP-driven, pro-cyclical	Endog.
	01.05.2010	01.07.2010	0.02	GDP-driven, pro-cyclical	Endog.
Hungary	30.04.2005	01.01.2006	-0.05	GDP-driven, pro-cyclical	Endog.
	16.02.2009	01.07.2009	0.05	GDP-driven, pro-cyclical	Endog.
	16.09.2011	01.01.2012	0.02	Debt-driven	Exog.
Italy	06.09.2011	17.09.2011	0.01	Debt-driven	Exog.
Latvia	09.12.2008	01.01.2009	0.03	GDP-driven, pro-cyclical	Endog.
	12.06.2009	01.01.2011	0.01	Deficit-driven	Exog.
	27.04.2012	01.07.2012	-0.01	Long-run growth	Exog.
Lithuania	16.12.2008	01.01.2009	0.01	GDP-driven, pro-cyclical	Endog.
	23.06.2009	01.09.2009	0.02	GDP-driven, pro-cyclical	Endog.
Netherlands	25.05.2012	01.10.2012	0.02	Debt-driven	Exog.
Poland	03.08.2010	01.01.2011	0.01	Debt-driven	Exog.
Portugal	25.05.2005	01.07.2005	0.02	Debt-driven	Exog.
	26.03.2008	01.07.2008	-0.01	GDP-driven, counter-cyclical	Endog.
	14.05.2010	01.07.2010	0.01	GDP-driven, pro-cyclical	Endog.
	29.09.2010	01.01.2011	0.02	Debt-driven	Exog.
Romania	06.05.2010	01.07.2010	0.05	GDP-driven, pro-cyclical	Endog.
Slovakia	06.09.2010	01.01.2011	0.01	Deficit-driven	Exog.
Slovenia	09.05.2013	01.07.2013	0.02	Long-run growth	Exog.
Spain	29.09.2009	01.07.2010	0.02	GDP-driven, pro-cyclical	Endog.
	11.07.2012	01.09.2012	0.03	GDP-driven, pro-cyclical	Endog.
Sweden	–	–	–	–	–
United Kingdom	24.11.2008	01.12.2008	-0.025	GDP-driven, counter-cyclical	Endog.
	24.11.2008	01.01.2010	0.025	GDP-driven, pro-cyclical	Endog.
	22.06.2010	04.01.2011	0.025	Debt-driven	Exog.

Source: Rates and implementation dates are from Ernst & Young, European Commission, and KPMG. The announcement dates are either specific dates on which the authorities officially announced the future change in the standard VAT rate, or the earliest date a change in VAT was mentioned generally in the media. With the exception of Estonia and Slovenia, the classification and motivation of reforms are taken from Gunter et. al. (2017).

Figure 3: TIME BETWEEN ANNOUNCEMENT AND IMPLEMENTATION



Note: The graph shows the length of the period between announcement and implementation measured in days and scaled by the total number of days in a year, for the 33 VAT reforms summarized in Table 3. The solid horizontal line depicts the median time between announcement and implementation, which is a little over a quarter of a year. All reforms below the dashed line were announced in the same month they were enacted.

The magnitude of the tax rate changes varies from ±1 pp to ±5 pp, and their frequency varies from one to four reforms per country for the time period of interest. Close to 80% of all tax reforms considered in this paper took place between 2008 and 2013, with the majority being tax increases (tax decreases occurred in only 5 instances). Table 3 describes in detail the magnitude of changes in the standard VAT rate, the date of enactment, as well as the date reforms were first announced. For the announcement dates, we rely on official statements by authorities, or if such statements were not found, the first time the specific tax reform was mentioned in the media in general.

All thirty three reforms considered in this paper were pre-announced, with substantial heterogeneity in the time between announcement and implementation, *i.e.* the implementation lag. As shown in Figure 3, the implementation lag varies between three days in the case of the Greek 2005 reform and one and a half years for the 2011 Latvian VAT increase. The median length of the time-interval is a little over a quarter of a year. For seven reforms, announcements occurred in the same month as the implementation. Such short anticipation horizons are typically observed in countries facing economic and fiscal difficulties such as the Baltic states in 2009 or Greece in 2010. Similarly, the temporary VAT cut in the UK in December 2008, intended as a fiscal stimulus to boost sales, became effective one week after its announcement.[8]

The 2008 UK reform fits well within what the so-called narrative approach to analysing fiscal policy would classify as an endogenous tax change. Given its motivation to stimulate consumer spending in the aftermath of the financial crisis, it is a tax reform undertaken "*to offset developments that would cause output growth to differ from normal*" (see Romer and Romer, 2010, p.769). Relying

[8]The 2008 United Kingdom reform is the only VAT change explicitly announced as temporary. Changes in all other countries were announced as permanent in the sense that there was no explicit commitment to a subsequent policy reversal.

on endogenous tax reforms to study how sales and prices of durables react to tax changes might be misleading, since it would be difficult to disentangle the effect of these developments from that of government actions taken in response. A similar issue arises with respect to the above-mentioned pro-cyclical fiscal policy measures observed in the Baltic states and in Greece, enacted as a consequence of the limited access of these governments to international credit markets (Gunter et. al., 2017).

We address the role of policy endogeneity by categorizing the 33 VAT reforms studied in this paper in terms of endogeneity/exogeneity and checking if our results are robust to the exclusion of endogenous reforms. To this end, we rely on Gunter et. al. (2017), who assembled a dataset of 96 tax reforms of baseline consumption taxes worldwide in the period 1970-2014 and classified them based on the narrative approach of Romer and Romer (2010). Table 3 incorporates Gunter et. al. (2017), adds information on two reforms not classified by these authors, and separates reforms into 18 endogenous and 15 exogenous tax changes.

We assume that for all pre-announced reforms, the public is well aware about the forthcoming tax increase/decrease. The following section, which focuses in more detail on Germany and Spain, supports this assumption using data on press coverage of the tax reforms. The section also shows that a consumer response to anticipated tax-rate changes is clearly visible in the raw data.

4 The Cases of Germany and Spain

Germany is one of a handful of countries, which undertook a general VAT increase before 2008. This policy measure is discussed in detail by D'Acunto *et al.* (2016) and Carare and Danninger (2008). Its key motivation was to lower Germany's debt-to-GDP ratio in the long-run. As a reform not tackling current or projected economic conditions, it meets the exogeneity criteria of Romer and Romer (2010).[9] In contrast, the two Spanish VAT increases took place in a more difficult macroeconomic environment and were clearly motivated by fiscal predicaments in the aftermath of the 2008 financial crisis. Gunter et. al. (2017) classify both Spanish reforms as endogenous given their GDP-driven and pro-cyclical nature.

The German reform and the first Spanish reform were announced well in advance – 14 months and 10 months, respectively, whereas the announcement period for the second Spanish VAT increase, which went against the election campaign promises of Prime Minister Rajoy, was only a month and a half. Germany raised the VAT from 16 to 19% on 1.1.2007, with the reform announced in November 2005, whereas Spain first increased VAT on 1.7.2010 (announced in September 2009) by 2pp, from 16 to 18%, and then again from 18 to 21% in September 2012, announced in July the same year. The size of the economies, the variation in announcement periods, and the different prevailing economic circumstances make Germany and Spain interesting cases for more detailed consideration.

Figure 4 graphs the number of articles in the German media discussing the VAT increase, based on four major non-tabloid newspapers in the country. The announcement and implementation dates for the tax reform are marked with reference lines. Two clear spikes in the number of articles are observed at the announcement date, and in the month before the implementation, even though the reform was being discussed continuously throughout 2006. Similarly to Germany, Figure 5 depicts the number of articles discussing the Spanish reforms based on three main newspapers, with the second reform receiving almost double the coverage, given its short announcement and political

[9] Based on Romer and Romer (2010) classification, tax changes serving long run objectives, or those addressing past economic conditions such as tax increases dealing with an inherited budget deficit, are treated as exogenous.

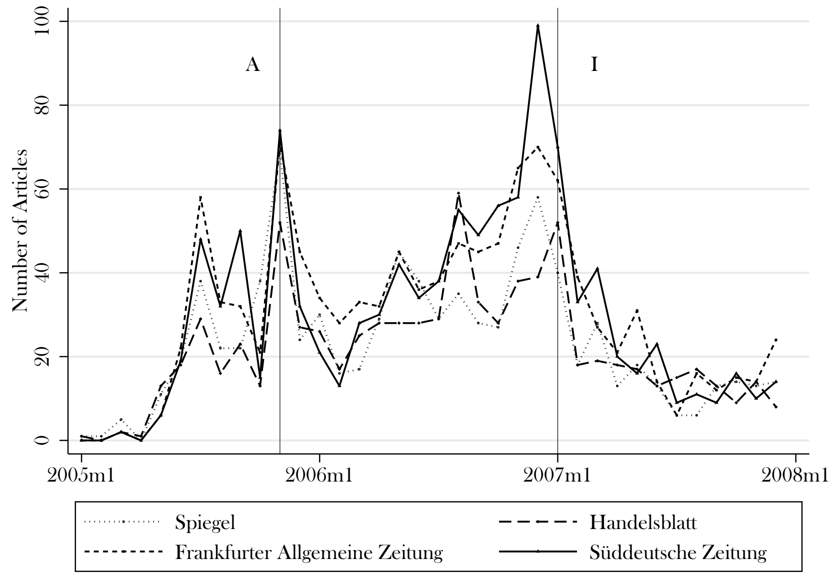
context.

Figures 6 shows annual growth rates of sales and prices in Germany and Spain relative to the same month-of-year. Panel A depicts a strong growth in sales, especially in the last two to three months before the implementation of the 3 percentage point VAT increase in Germany, and a substantial drop afterwards. The period after implementation is characterized by substantially higher prices. This pattern is consistent with the theoretical predictions for sales and with full and instantaneous price pass-through.[10] Carare and Danninger (2008), who study the same tax reform episode in Germany, but focus on all CPI items liable to VAT relative to non-VAT goods, find similar pre-reform jump in sales, but show that price increases were phased in during 2006 and, as a result, changes in core inflation in 2007 were modest.

There is a clear upward trend in German sales starting from 2008. Conversely, the market for white goods in Spain shrank by more than one third from 2007 to 2012 as shown in Panel B. Against this negative trend, the two VAT reforms are associated with temporary pre-reform peaks in sales, without recovery after the first reform. With regard to price effects, a price increase is visible after the first reform, but a year after the reform prices are falling again. The second VAT increase is also not clearly reverting the negative price trend.

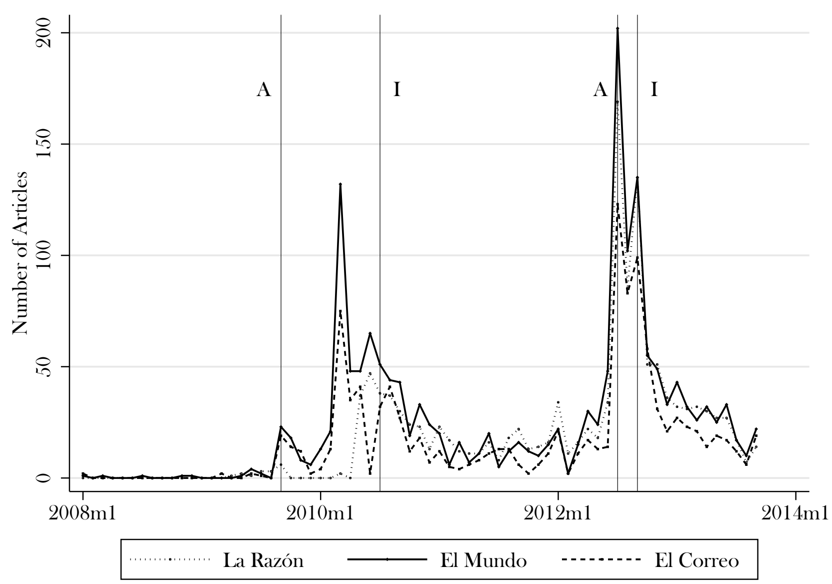
[10] There is a peak in sales also in December 2005, one month after the VAT increase was announced (see also Fig. 6). When we disaggregated the response by categories of models (Figure A-3), we found that three specific categories drive this announcement response: Cooktops, hoods, and cookers, which are usually sold as part of a kitchen unit. Since the data allows us to consider total sales disaggregated by a type of retailer (independent traders, technical superstores and chains, furniture/kitchen specialists, mass merchandisers/DIYs, and from 2006 onwards, internet sales, we were able to determine that the response at the announcement date is entirely driven by sales by Kitchen and Furniture specialising stores. A possible explanation is that those durables may have substantial delivery lags, which would induce consumers to buy early in order to ensure that the lower VAT rate applies to their purchases. The dashed black line in Figure A-2 depicts the same growth rate, but cooktops, hoods and cookers are removed. The announcement response then falls by half. Finally, the figure also shows growth rate of sales in neighbouring Austria, a closely integrated market to the German economy. Austria did not change its standard VAT rate and the sales growth rate does not deviate much around zero.

Figure 4: GERMANY: NEWSPAPER ARTICLES ADDRESSING REFORM, 2005-2007



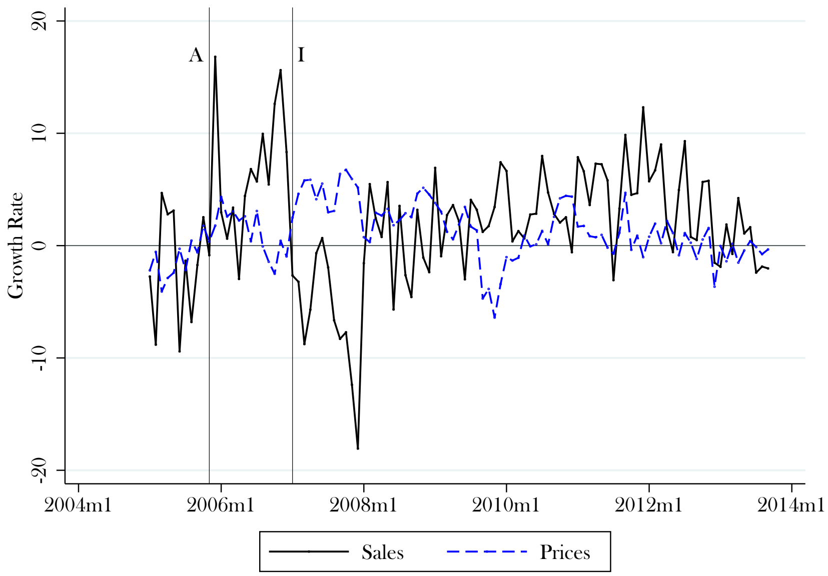
Note: The figure depicts the number of articles in four major German newspapers, which mention "VAT rise" either in the title, or the main text from January 2005 until December 2007. Authors' calculations using the online archives of Der Spiegel, Handelsblatt, Frankfurter Allgemeine Zeitung and Süddeutsche Zeitung. The search keyword is "VAT rise" ("Mehrwertsteuererhöhung"). Germany increased the standard VAT rate from 16 to 19% on 1.1.2007, with the tax increase officially announced in November 2005.

Figure 5: SPAIN: NEWSPAPER ARTICLES ADDRESSING REFORMS, 2008-2013

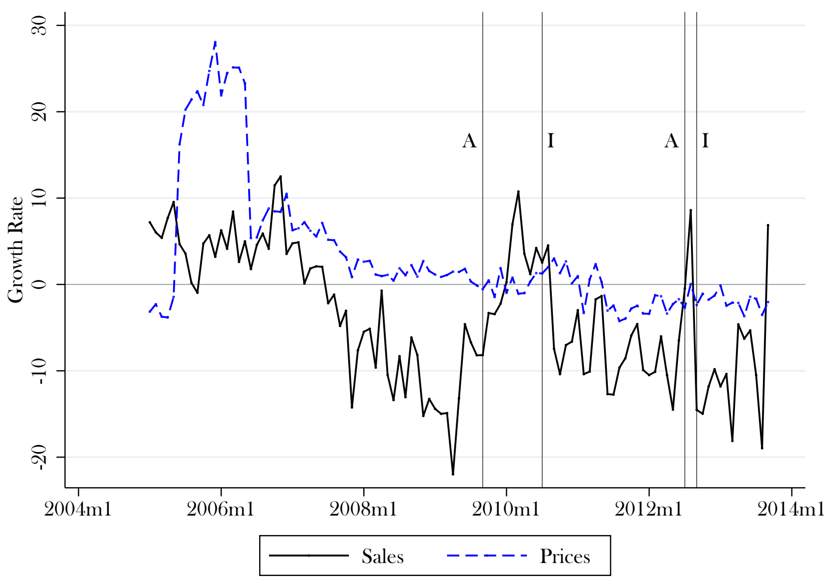


Note: The figure shows the number of articles in three major Spanish newspapers, which mention "VAT rise" either in the title, or the main text from January 2008 until September 2013. Authors' calculations using the online archives of La Razon, El Mundo, El Correo. The search keyword is "VAT rise" ("subida de IVA"). Spain increased the standard VAT rate twice in the depicted period: from 16 to 18% on 1.7.2010, with the tax increase officially announced in September 2009, and from 18 to 21% on 1.9.2012, announced on 11.7.2012.

Figure 6: GROWTH RATE OF SALES AND PRICES
A. Germany



B. Spain



Note: The figure depicts the annual growth rate of sales and prices of white goods (WM, DW, TD, HB, HD, FRZ, RG, CO) in Germany and Spain relative to the same month-of-year, starting from January 2008 and ending in September 2013. Germany increased the standard VAT rate from 16 to 19% on 1.1.2007, with the tax increase officially announced in November 2005. Spain increased the standard VAT rate twice in the depicted period: from 16 to 18% on 1.7.2010, with the tax increase officially announced in September 2009, and from 18 to 21% on 1.9.2012, announced on 11.7.2012.

5 Methodology

A general problem when analyzing broad consumption tax reforms is that changes in standard tax rates apply equally to most goods. This hinders the empirical analysis of tax policy effects, as there is no control group of comparable goods where the tax rate is kept constant. As a consequence, empirical research is often left with the comparison of sales and prices before and after tax-rate changes, which may be affected by many other common shocks. If, however, the sales and prices of a specific good are observed simultaneously in different regions, under certain conditions, the effects of a consumption tax reform in one region can be identified by using as counterfactual outcomes the developments in sales and prices in the other regions in which this good is available. The data for durables described in Section 3 enables us to follow this strategy, since we observe the sales and prices of identical models across EU countries. In addition, the data covers a period characterized by a particularly high frequency of standard VAT rate changes both across and within EU member states.

Under the conventional assumption of full and instantaneous pass-through of the consumption tax into consumer prices, the above theoretical analysis suggests that a tax reform affects the time path of the sales of durables in three periods. In case of a tax increase, for example, first, in the month preceding the tax-rate change consumers take advantage of the temporary decline in the user cost of the stock of durable goods and bring purchases forward. Second, in the month of implementation sales fall due to intertemporal substitution and the reversal of the user cost. Third, in the subsequent month sales recover. Measuring the rate of change in sales with the log difference of units sold, $\Delta \log(UNITS)_{icd}$, of a model i in country c at date d, we formulate the following basic estimation equation:

$$\begin{aligned}\Delta \log(UNITS)_{icd} &= a_1 \mathsf{F}\Delta\tau_{cd} + b\Delta\tau_{cd} + d_1 \mathsf{L}\Delta\tau_{cd} + aX_{icd} \\ &+ \alpha_{id} + \rho_c + \gamma_{cm(d)} + u_{icd}.\end{aligned} \tag{13}$$

Note that the date d varies by month and year such that each date is associated with a specific month $m(d)$ and year $t(d)$. $\Delta\tau_{cd}$ is the current change in the tax rate relative to the previous month, $\mathsf{F}\Delta\tau_{cd}$ is a lead term, capturing the one-period ahead change in the tax rate, and $\mathsf{L}\Delta\tau_{cd}$ is the lagged change in the tax rate. Based on the theoretical discussion in Section 2, we expect that $a_1 > 0$, $b < 0$ and and $d_1 > 0$, where the absolute value of the sum $|a_1 + b + d_1|$ is the intertemporal elasticity of substitution.

α_{id} denotes a model-date specific fixed effect which absorbs any model specific movements in sales. Incorporating this fixed effect is important since each model has a set of features that distinguish it from other competing products in the market. Given technological progress and product innovation, the (relative) quality of a model and, hence, its attractiveness to consumers vary over time. This is reflected in the striking product-cycle patterns displayed in Figure 2.

Inclusion of α_{id} further ensures that identification only comes from differences in the growth rate of sales of a model between countries. Identification of the tax effect on sales thus relies on changes in the consumption tax treatment that affect only a sub-group of the observations within a model-date cell. In case of a consumption tax reform in country c, the sales of model i at date d are compared to the sales in all other countries in which model i is available. Consequently, we restrict the sample to models sold in at least two countries at the same time (see Table 2).[11] Note that the model-date

[11] An alternative, but less precise identification strategy is to keep quality constant not by looking at the same

specific fixed effects also capture differences in the size of the individual cells.

A key assumption for causal interpretation is the *Common-Trend Assumption*, which, in the current setting, requires that, conditional on all controls, had there been no reform in country $c = r$, the sales of a model would have followed the same time trend as the sales of this model in the no-reform countries $c \neq r$. As different trends might be associated with the business cycle, X_{icd} includes the monthly unemployment rate as an explanatory variable. In order to deal with differences in the seasonality of sales across countries, we include a country-specific fixed effect for each month $\gamma_{cm(d)}$ together with a full set of country specific fixed effects ρ_c. Differences in trends might also reflect heterogeneity in market entry. Therefore, we employ an indicator for the time period a model has been sold in a specific market. The market age, $m.age$, varies by country within a single model, if this model does not enter all markets at the same time. For the purpose of capturing non-linear model cycle effects, $m.age$ is also entered squared.

As shown by the theoretical analysis, if producer prices vary with demand for durables, the anticipation of a tax reform could trigger changes in consumer prices and sales in months before $t - 1$. In this case, equation (13) would fail to measure the full pre-reform effect of anticipated tax-rate changes. Failing to account for the resulting systematic effects on pre-reform outcomes could result in a substantial bias (see Malani and Reif, 2015). Similarly, in the presence of producer price effects,

model across countries, but by grouping models together based on their characteristics. Apart from quantities and prices, the data additionally provides a list of main characteristics for each model. For washing machines, for example, this includes a model's type (front-, top-loading, washer-dryer), spin speed and capacity in kg. Grouping all models based on an identical set of characteristics, while not ideal, given that many important characteristics are absent, has the advantage of re-incorporating single-country models into the estimation. The new fixed effect is thus a set of characteristics group-date dummy. There are several reasons for wanting to include single-country models into the estimation, the most important one being that they are the cheapest. An investigation of the data showed that a model's price is increasing in the number of countries, in which it is traded. Therefore, it is possible that the empirical results below would underestimate the response to tax changes, if the sample is predominantly composed of imported higher-end goods. However, with regard to the sales response, this alternative estimation strategy yields almost identical results. In some cases, however, the price pass-through is less than one. Results are available upon request.

the adjustment of sales after a reform might take longer than one month, which could also bias results. For instance, the post-reform recovery of sales may be underestimated.

Since the data provides separate information on prices and quantities, we explore whether and to what extent the data supports complete and immediate pass-through into prices. To this end, we follow the same estimation strategy and use differences in outcomes within a model-date group to identify tax effects. In order to test for pre-reform pass-through of tax changes into consumer prices and for lagged consumer price adjustments, we consider a specification with higher order leads and lags of the tax-rate change

$$\begin{aligned} \Delta \log(PRICE)_{icd} &= \sum_{j=1}^{P} A_j \mathsf{F}^j \Delta\tau_{cd} + B\Delta\tau_{cd} + \sum_{j=1}^{Q} D_j \mathsf{L}^j \Delta\tau_{cd} + \alpha X_{icd} \\ &+ \alpha_{id} + \rho_c + \gamma_{cm(d)} + v_{icd}. \end{aligned} \tag{14}$$

$\Delta \log(PRICE)_{icd}$ denotes the difference in the log consumer price of model i in country c in month d relative to the previous month. As before, α_{id} , ρ_c, and $\gamma_{cm(d)}$ denote model-date, country, and country-month specific fixed effects. P determines the order of lead terms and Q the order of lagged terms of $\Delta\tau_{cd}$. Estimation of eq. (14) enables us to test whether there is full pass-through of consumption taxes into consumer prices and how fast the pass-trough takes place. The sum $\sum_{j=1}^{P} A_j + B + \sum_{j=1}^{Q} D_j$ gives the long-term effect of the change in the VAT rate on prices, which, as pointed out by Benedek et. al. (2015), can be interpreted as a pass-through elasticity. In the current framework, an elasticity of unity would indicate complete pass-through. Under-shifting (over-shifting) occurs when the elasticity is smaller (greater) than one. Instantaneous and complete pass-through is included as a special case, which requires that $P, Q = 0$, and $B = 1$. The presence and magnitude of any pre-reform or post-reform pass-through can be assessed using the statistical significance and the quantitative estimates of the slope parameters of the lead and lag terms.

The optimal width of a window around a reform, or, equivalently, the values of P and Q, could be selected via statistical testing that checks whether a gradual extension of the specification with wider windows of tax effects provides a better fit.[12] With the introduction of higher-order leads, however, this procedure would employ information about an upcoming tax reform, regardless of whether it has already been announced or not.

To provide empirical estimates that take account of the information set of agents, at least in a stylized way, we utilize the announcement dates reported in Table 3 and replace j-period ahead lead terms, $\mathsf{F}^j\Delta\tau_{cd}$, with their expected values $\mathsf{E}_{d-j}\left[\mathsf{F}^j\Delta\tau_{cd}\right]$ taking account of the precise point in time when information about an upcoming VAT change becomes available in a given country. In particular, if a reform is announced n months in advance, we set $\mathsf{E}_{d-j}\left[\mathsf{F}^j\Delta\tau_{cd}\right] = 0,\ \forall j > n$, whereas $\mathsf{E}_{d-j}\left[\mathsf{F}^j\Delta\tau_{cd}\right] = \mathsf{F}^j\Delta\tau_{cd},\ \forall j \leq n$. While this ensures that the specification fully reflects publicly available information about future reforms, empirical estimation of higher-order-lead terms rests on a declining number of identifying reforms (and countries) due to the varying length of the implementation lags as shown in Fig. 3. As a consequence, estimates of the pre-reform response are likely biased due to composition effects. Table A-2 lists the different number of reforms and countries identifying the coefficients of up to 14 leads. Clearly, even a pre-reform window as short as three months involves a changing set of reforms across the three leads. In order to mitigate possible biases from composition effects, the empirical analysis employs a parsimonious specification with a limited number of lead terms. Figure 3 shows that 55% of all reforms were announced at least a

[12] An alternative statistical procedure starts out with a long window and tests whether the window size can be reduced. This is, for example, the strategy employed by Benedek et. al. (2015) who consider a two-year time span cantered around the month of implementation.

quarter of a year before their entry into force. Therefore, we restrict P to three months, or less.

Seven out of the 33 VAT reforms analyzed in this paper were announced less than a month before the tax rate change became effective (Figure 3). In these cases, one can neither distinguish the announcement effects from the intertemporal consumer response, nor clearly separate the effects of government policy from those of the economic shocks that may have triggered the government intervention in the first place. For this reason, we also provide results of specifications excluding these reforms.[13]

In light of the theoretical analysis, if price pass-through is not instantaneous, we need to extend the basic specification for sales in (13) with further leads and lags of the tax rate change. A generalized reduced-form specification that takes account of the consumer response to producer-price effects is

$$\begin{aligned} \Delta \log(UNITS)_{icd} \quad &= \quad \sum_{j=1}^{p} a_j \mathsf{F}^j \Delta\tau_{cd} + b\Delta\tau_{cd} + \sum_{j=1}^{q} d_j \mathsf{L}^j \Delta\tau_{cd} + aX_{icd} \\ &+ \quad \alpha_{id} + \rho_c + \gamma_{cm(d)} + u_{icd}, \end{aligned} \tag{15}$$

where p and q indicate the number of leads and lags of the tax rate change. The basic specification above is a special case with $p, q = 1$. With $p, q > 1$, the impact of a tax reform would be captured by wider pre- and post-reform windows. In the empirical section below, we generally consider the same pre-reform window range for sales as for prices, since, similarly to the price equation, the choice of specification for sales needs to balance between testing for early pre-reform adjustments and biases due to composition effects.

Producer price effects may not only alter the time path of sales: If a single producer serves just two

[13] Note that these specifications exclude observations one and two quarters before and after shortly announced reforms.

markets, and one market is hit by a consumption-tax-induced demand shock, the country without a tax reform might not serve as a valid control group. The reason is that, given a strong demand shock, the effect on the producer price may trigger opposing demand effects in the other country. More specifically, in the month before the reform, the producer price might increase and hence contribute to a decline in demand in the other country. Similarly, if demand drops in the first period after a consumption tax increase, the producer price might fall and lead to an increase in demand in the no-reform country. These cross-country effects would cause an upward bias in the empirical estimates.

The existence of such cross-market effects would violate what is referred to as the *Stable Unit Treatment Value Assumption* in the econometric literature (*e.g.*, Lechner, 2011). To see whether this is a relevant concern, we test sales and price regressions in subsamples with products sold in more than 2, 3, 4 *etc.* markets. In the presence of cross-country effects, the empirical estimates should get smaller in specifications using products sold in a large number of countries.

6 Results

6.1 Basic Results

Results from the basic specification of tax effects on sales of durables following eq. (13) are presented in Table 4. The estimation sample includes data on 22 EU countries.[14] We explore the effects of 33 consumption tax reforms that altered the baseline consumption tax rate. As summarized in Table 2 the sample employs data for approximately 34,500 unique models sold in at least two countries,

[14]To avoid structural breaks stemming from the transition of Slovenia, Slovakia, and Estonia from national currencies to Euro, data for these countries is restricted to after Jan. 1st, 2007, after Jan. 1st, 2009, and before Dec. 31st, 2010, respectively.

resulting in about 900,000 model-date pairs, and close to 3 million model-date-country observations.

The first column of Table 4 reports estimates from a specification using only model-date and country-specific fixed effects. The second column adds a full set of country-month dummies, which account for country-specific seasonality in sales such as variability in the timing of discount offers, (school) holidays and others. Column (3) additionally controls for the market age, $m.age$, as well as $m.age^2$. These explanatory variables exert significant non-linear effects, with stronger growth in the first months after a model's introduction and slower growth as models get older. As a robustness check, column (4) additionally contains country-specific year effects, which might be important in the presence of annual budgeting of households, or due to annual economic shocks from fiscal policy. Compared to the results in column (3), augmenting the specification with country-year dummies yields similar results – the differences in the estimated slope parameters for the tax effects are below the standard errors in all cases.

The point estimates in column (3) indicate that a tax increase by one percentage point causes sales to rise by 2.8% in the last month with a low tax rate. Once the higher tax rate is implemented, sales drop by about 4.6% relative to the month before the reform. These effects are consistent with the theoretical predictions derived under the assumption of full and instantaneous pass-through of taxes into constant producer prices. However, the coefficient of the lagged change in the tax rate is at odds with the theoretical prediction, since it indicates that sales do not recover after the first month. Instead, with a tax-rate increase by 1 percentage point, sales decline further by 2.2% in the month after the tax change. With this caveat in mind, note that the sum of the coefficients for lead, lagged, and contemporaneous tax change effects is close to 4 in the basic specifications. This points to a rather large elasticity of intertemporal substitution in comparison to the existing

Table 4: BASIC ESTIMATES

	(1)	(2)	(3)	(4)
$\mathsf{F}^1\Delta\tau_d$	3.357***	2.811***	2.803***	2.744***
	(0.202)	(0.214)	(0.214)	(0.226)
$\Delta\tau_d$	-4.485***	-4.582***	-4.586***	-4.667***
	(0.214)	(0.221)	(0.221)	(0.232)
$\mathsf{L}^1\Delta\tau_d$	-2.370***	-2.157***	-2.165***	-2.229***
	(0.211)	(0.223)	(0.223)	(0.235)
unempl	0.001***	0.001***	0.001***	-0.000
	(0.000)	(0.000)	(0.000)	(0.001)
mage			-0.480***	-0.527***
			(0.019)	(0.020)
$mage^2$			0.405***	0.453***
			(0.022)	(0.023)
Cons.	-0.032***	-0.257***	-0.175***	-0.140***
	(0.005)	(0.014)	(0.014)	(0.027)
Cumulative Effect				
Total $(a_1 + b + d_1)$	-3.498***	-3.928***	-3.949***	-4.151***
	(0.367)	(0.382)	(0.382)	(0.430)
Month-Country Effects	No	Yes	Yes	Yes
Year-Country Effects	No	No	No	Yes
N	3,045,284	3,045,284	3,045,284	3,045,284
Model-date groups	902,017	902,017	902,017	902,017
Models	34,505	34,505	34,505	34,505

Notes: Regressions in columns (1)-(4) are based on data for 22 EU countries and 33 VAT reforms. Data for Slovenia and Slovakia is restricted to after Jan. 1st, 2007, and Jan. 1st, 2009, respectively. Data for Estonia is considered up to Dec. 31st, 2010. The data is restricted to goods sold contemporaneously in at least 2 countries. The dependent variable is the change in the logarithm of sales $\Delta \log(UNITS)$. The lead term, $\mathsf{F}^1\Delta\tau_d$, captures all reforms in the month before their implementation. All specifications include a full set of model-date (*id*) specific and country fixed effects. All categories of white goods, namely WM, TD, DW, HB, HD, CO, FRZ, RG, are covered. The monthly change in the standard VAT rate is denoted as $\Delta\tau_d$. *unempl* is the monthly unemployment rate. *m.age* is the number of months a model appears in the data in a specific country. Standard errors are robust in all specifications and clustered by model-date cells. Standard errors in parentheses.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

estimates in the literature (see Cashin and Unayama, 2016.)

6.2 Price Effects

The basic estimation for sales presented above rests on the conventional assumption of full and instantaneous pass-through of taxes in consumer prices. To test this assumption and to come up with a more accurate empirical representation of the price response, this subsection studies the dynamics of price adjustment to VAT rate changes.

Table 5 reports results of a regression of the monthly (log) change in consumer prices on tax-rate changes following eq. (14) with varying lengths of the pre- and post-reform windows. All specifications include an identical set of fixed effects and control variables as in column (3) of Table 4. Column (1) reports a contemporaneous tax effect of a 0.25% rise in prices per 1 percentage point tax increase, clearly rejecting the null hypothesis of full and instantaneous pass-through.

Column (2) includes the tax-rate changes in the preceding as well as in the following month, with both coefficients being significantly positive. The magnitude and statistical significance of the leading and lagged terms indicate that the pass-through for major domestic appliances starts before a reform becomes effective and continues for sometime after implementation. The cumulative effect, as reported in the lower portion of the table, suggests that within these three months, about three quarters of the tax-rate change is shifted onto the consumer. According to the corresponding F-statistic, full pass-through can still be rejected. Widening the window to three months yields an almost identical estimate of the total pass-through, although the specification clearly points to a price response as early as a quarter of a year before the policy adoption.

The specifications in columns (2) and (3) employ forward terms of tax-rate changes ignoring dif-

Table 5: PRICE EFFECTS

Reforms	All			All		n $\geq$ 1		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\mathsf{F}^3\Delta\tau_d$			0.128***					
			(0.023)					
$\mathsf{F}^2\Delta\tau_d$			-0.121***					
			(0.023)					
$\mathsf{F}\Delta\tau_d$		0.099***	0.099***					
		(0.022)	(0.022)					
$\mathsf{E}\left[\mathsf{F}^4\Delta\tau_d\right]$								-0.043
								(0.029)
$\mathsf{E}\left[\mathsf{F}^3\Delta\tau_d\right]$					0.207***		0.210***	0.210***
					(0.028)		(0.028)	(0.028)
$\mathsf{E}\left[\mathsf{F}^2\Delta\tau_d\right]$					0.056**		0.050**	0.050**
					(0.024)		(0.024)	(0.024)
$\mathsf{E}\left[\mathsf{F}\Delta\tau_d\right]$				0.119***	0.119***	0.131***	0.130***	0.130***
				(0.022)	(0.022)	(0.023)	(0.023)	(0.023)
$\Delta\tau_d$	0.247***	0.247***	0.245***	0.247***	0.246***	0.197***	0.196***	0.197***
	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)	(0.024)	(0.024)	(0.024)
$\mathsf{L}^1\Delta\tau_d$		0.368***	0.366***	0.368***	0.369***	0.396***	0.397***	0.397***
		(0.023)	(0.023)	(0.023)	(0.023)	(0.024)	(0.024)	(0.024)
$\mathsf{L}^2\Delta\tau_d$			-0.063***		-0.067***		-0.052**	-0.052**
			(0.023)		(0.023)		(0.023)	(0.023)
$\mathsf{L}^3\Delta\tau_d$			0.058**		0.060**		0.067***	0.067***
			(0.024)		(0.024)		(0.025)	(0.025)
$\mathsf{L}^4\Delta\tau_d$								-0.024
								(0.024)
				Cumulative effects:				
Total		0.714***	0.712***	0.734***	0.990***	0.724***	0.999***	0.931***
		(0.040)	(0.061)	(0.040)	(0.063)	(0.041)	(0.064)	(0.074)
Pre-reform		0.099***	0.106***	0.119***	0.382***	0.131***	0.390***	0.347***
		(0.022)	(0.039)	(0.022)	(0.043)	(0.023)	(0.043)	(0.052)
Post-reform	0.247***	0.615***	0.606	0.615***	0.608***	0.594***	0.609***	0.584***
	(0.023)	(0.033)	(0.047)	(0.033)	(0.047)	(0.033)	(0.033)	(0.053)
Pass-through F(1)		51.3***	22.1***	43.6***	0.031	44.7***	0.00	0.356
$F\left(A_4=0, D_4=0\right)$								1.59
N	2,978,933	2,978,933	2,978,933	2,978,933	2,978,933	2,882,385	2,882,385	2,882,385
Model-date groups	885,039	885,039	885,039	885,039	885,039	863251	863,251	863,251
Models	34,283	34,283	34,283	34,283	34,283	33,892	33,892	33,892

Notes: Regressions are based on data for 22 EU countries and up to 33 VAT reforms. The dependent variable is the change in the logarithm of the actual consumer price $\Delta\log(PRICE)$. Data for Slovenia and Slovakia is restricted to after Jan. 1st, 2007, and Jan. 1st, 2009, respectively. Data for Estonia is considered up to Dec. 31st, 2010. The data is restricted to goods sold contemporaneously in at least 2 countries. Estimates in columns (6) to (8) are based on a reduced sample, in which observations in countries with reforms announced less than a month before implementation, are removed around the respective reform date. Note that $\mathsf{E}_{d-j}\left[\mathsf{F}^j\Delta\tau_d\right] = \mathsf{F}^n\Delta\tau_d$ for all reforms that were announced $n > j$ periods ahead, and $\mathsf{E}_{d-j}\left[\mathsf{F}^j\Delta\tau_d\right] = 0$ for reforms announced $n \leq j$. All specifications include a full set of model-date, country, and country-month fixed effects. All categories of white goods, namely WM, TD, DW, HB, HD, CO, FRZ, RG, are covered. The monthly change in the standard VAT rate is denoted as $\Delta\tau_d$. The monthly unemployment rate, *unempl*, and the number of months a model appears in the data in a specific country, *m.age*, as well as $m.age^2$ are controlled for not reported. Standard errors are robust in all specifications and clustered by model-date cells. Standard errors in parentheses.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

ferences across reforms stemming from the timing between announcement and implementation. As discussed above, in some cases, this means that the estimation uses information on tax policy that, in fact, was not available to consumers and producers. The specifications in columns (4) and (5) employ expected values of upcoming tax-rate changes. These variables take account of the actual information set by restricting leading terms to zero in the months when an upcoming tax reform has not yet been announced. For the short window of one month around implementation, the estimated magnitude of the total pass-through, 73%, is not statistically different from the case with no announcements. However, the ex-ante price adjustment rises to 38% once a longer window is employed, with all leading terms now exhibiting larger and consistently positive coefficients as compared to specification (3). As the post-reform pass-through implied by this specification is still about 60%, the cumulative price effect is not significantly different from unity with an F-statistic of 0.031. The substantially higher pre-reform pass-through estimate in column (5) relative to column (3) clearly highlights the importance of the announcement information: Despite a sufficiently long window, the specification in (3) would point to a much lower pre-reform response of prices.

Columns (6) to (8) drop observations associated with reforms pre-announced by less than a month, since the pre-reform adjustment may capture not only the effect of the announcement itself, but also the economic circumstances that could have motivated the government to act quickly.[15] The pre-reform pass-through effects are found to be qualitatively and quantitatively similar to those reported in columns (3) and (4). The estimates in column (7) indicate that a tax rate increase by one percentage point causes consumer prices to rise by 0.39% before the reform and by 0.60% after the reform, one third of which is a contemporaneous effect. Again, the cumulative price effect

[15] Observations are dropped six months before and six months after implementation for models in the relevant countries and years, without removing the model from the data in non-reform years, or its sales in other countries.

in this specification is not significantly different from unity, which is consistent with full but not instantaneous price pass-through.

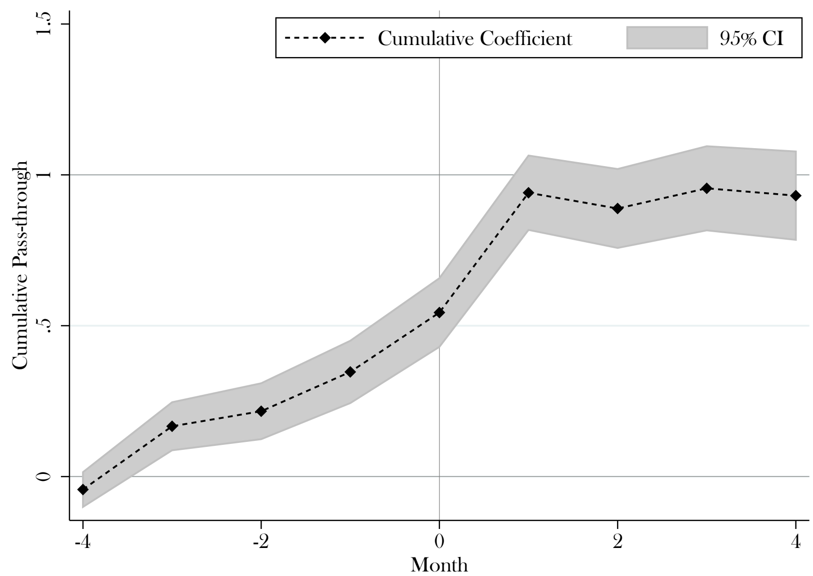
Column (8) includes a fourth lead and lag. Both prove insignificant, and the joint test, reported at the bottom of the table, does not allow us to reject the absence of tax effects at the edges of the pre- and post-reform windows. This suggests that full price pass-through occurs within a seven-month period – three months before and three months after the tax-rate change. A closer inspection of the coefficients in column (8) of Table 5 as well as of their cumulative graphical representation in Figure 7, reveals that price pass-through starts a quarter prior to a reform and is already completed by the second month after implementation. All in all, it takes five months for the tax-rate change to be fully reflected in consumer prices.

The pass-through estimates are robust to a more demanding identification strategy achieved through sample reduction. Excluding reforms announced in the same month of their entry into force as in columns (6) to (8) of Table 5, Table A-3 in the Appendix gradually restricts the sample to products traded in more and more countries simultaneously. This ensures that there are multiple observations from countries without a reform within each model-date cell. The null hypothesis of full cumulative pass-through in the long-run cannot be rejected, even when the sample is down to 5,000 products traded in at least eight countries.

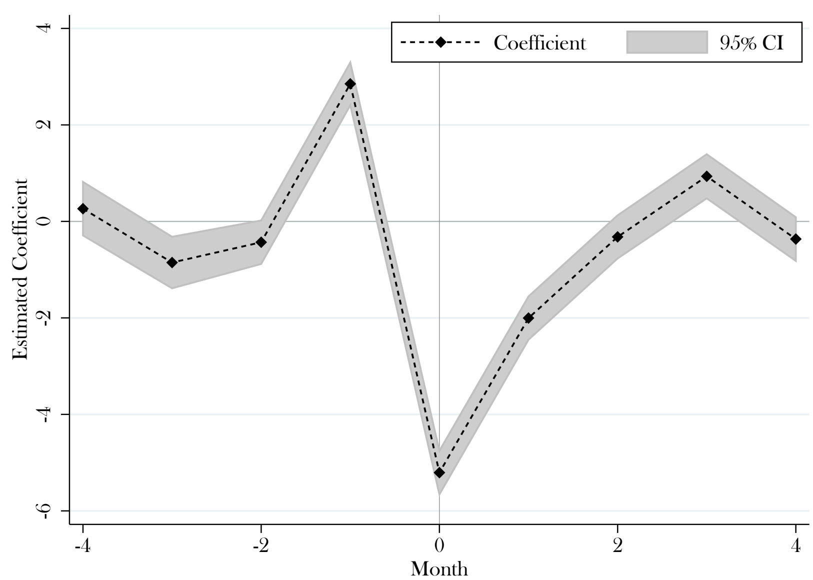
6.3 Sales Effects

Given the findings in the previous section, the data supports full price pass-through in accordance with the conventional view in the literature. However, the price pass-through is not instantaneous, and, in particular, prices start to rise before a tax reform. This implies that the pre-reform response

Figure 7: DYNAMICS OF SALES AND PRICES AROUND VAT REFORMS
A. Cumulative Pass-through



B. Estimated Leading and Lagged Coefficients for Sales



Note: Panel A depicts the cumulative sum of the estimated coefficients in a price regression including four leads and lags of the percentage change of the VAT rate. The month of the reform is denoted by zero. The full set of coefficients, on which this plot is based, is reported in Table 5, specification (8). Panel B plots the estimated coefficients from the sales regression of specification (7) in Table 6.

of sales might not be confined to the last period before the reform. In addition, the recovery of demand might not take place immediately after implementation. To test for implications of non-instantaneous pass-through, Table 6 extends the basic reduced-form specification in (13) with additional leads and lags of the tax rate change.

All specifications include a full set of model-date, country- and country-month fixed effects and the same controls as in Column (3) of Table 4. For convenience, Column (1) repeats the results of this specification. Column (2) uses a wider window of three months before and after the tax rate change, with the results pointing at a drop in purchases a quarter prior to a reform, which conforms with a pre-reform pass-through of taxes. With regard to lagged terms, demand continues to decline in the second month after the tax rate change, but the third month shows weak recovery.

The specifications in Columns (3) and (4) employ the expected rather than the actual tax-rate change to capture any pre-reform effects. While the post-reform response is quite similar, the coefficients for the pre-reform effects are slightly smaller. As noted above, however, the observations encompass reforms for which the time between announcement and implementation is less than a month. In these cases, the expected tax-rate change also captures an announcement effect and estimates may also be confounded by specific economic events that caused quick government action. For this reason, Columns (5)-(6) report estimates obtained after dropping observations before and after these reforms. The results point to a stronger loss in sales in the first month after implementation. Moreover, in the month before the tax-rate change, we find a slightly stronger positive effect. To check for announcement effects, we added a variable using an indicator of the tax-rate change at the time of the announcement, but did not detect any significant response. Column (7) includes a fourth lead and lag. Both prove insignificant, suggesting the absence of further tax

Table 6: SALES EFFECTS

Reforms	All		All		n $\geq$ 1		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\mathsf{F}^3\Delta\tau_d$		-0.901***					
		(0.223)					
$\mathsf{F}^2\Delta\tau_d$		-0.249					
		(0.218)					
$\mathsf{F}\Delta\tau_d$	2.803***	2.778***					
	(0.214)	(0.214)					
$\mathsf{E}\left[\mathsf{F}^4\Delta\tau_d\right]$							0.263
							(0.283)
$\mathsf{E}\left[\mathsf{F}^3\Delta\tau_d\right]$				-0.822***		-0.852***	-0.852***
				(0.270)		(0.272)	(0.272)
$\mathsf{E}\left[\mathsf{F}^2\Delta\tau_d\right]$				-0.288		-0.433*	-0.431*
				(0.227)		(0.230)	(0.230)
$\mathsf{E}\left[\mathsf{F}\Delta\tau_d\right]$			2.630***	2.611***	2.876***	2.853***	2.851***
			(0.217)	(0.217)	(0.226)	(0.226)	(0.226)
$\Delta\tau_d$	-4.586***	-4.591***	-4.596***	-4.599***	-5.207***	-5.215***	-5.207***
	(0.221)	(0.221)	(0.221)	(0.221)	(0.230)	(0.230)	(0.230)
$\mathsf{L}^1\Delta\tau_d$	-2.165***	-2.139***	-2.165***	-2.155***	-2.014***	-2.004***	-2.003***
	(0.223)	(0.223)	(0.223)	(0.223)	(0.229)	(0.229)	(0.229)
$\mathsf{L}^2\Delta\tau_d$		-0.167		-0.166		-0.317	-0.321
		(0.221)		(0.221)		(0.228)	(0.228)
$\mathsf{L}^3\Delta\tau_d$		0.844***		0.841***		0.937***	0.935***
		(0.227)		(0.227)		(0.233)	(0.233)
$\mathsf{L}^4\Delta\tau_d$							-0.365
							(0.231)
	Cumulative Effects						
Total	-3.949***	-4.426***	-4.141***	-4.579***	-4.345***	-5.032***	-5.130***
	(0.382)	(0.587)	(0.384)	(0.612)	(0.399)	(0.629)	(0.725)
Pre-reform	2.803***	1.628***	2.630***	1.501***	2.876***	1.567***	1.831***
	(0.214)	(0.380)	(0.217)	(0.416)	(0.266)	(0.424)	(0.510)
Post-reform	-6.752***	-6.054***	-6.760***	-6.079***	-7.221***	-6.599***	-6.961***
	(0.314)	(0.449)	(0.314)	(0.449)	(0.326)	(0.464)	(0.518)
N	3,045,284	3,045,284	3,045,284	3,045,284	2,944,436	2,944,436	2,944,436
Model-date groups	902,017	902,017	902,017	902,017	879,015	879,015	879,015
Models	34,505	34,505	34,505	34,505	34,112	34,112	34,112

Notes: Regressions are based on data for 22 EU countries and up to 33 VAT reforms. The dependent variable is the change in the logarithm of sales, $\Delta\log(UNITS)$. Data for Slovenia and Slovakia is restricted to after Jan. 1st, 2007, and Jan. 1st, 2009, respectively. Data for Estonia is considered up to Dec. 31st, 2010. The data is restricted to goods sold contemporaneously in at least 2 countries. Estimates in columns (5) to (7) are based on a reduced sample, in which observations in countries with reforms announced less than a month before implementation, are removed around the respective reform date. Note that $\mathsf{E}_{d-j}\left[\mathsf{F}^j\Delta\tau_d\right] = \mathsf{F}^n\Delta\tau_d$ for all reforms that were announced $n > j$ periods ahead, and $\mathsf{E}_{d-j}\left[\mathsf{F}^j\Delta\tau_d\right] = 0$ for reforms announced $n \leq j$. All specifications include a full set of model-date, country-, and country-month fixed effects. All categories of white goods, namely WM, TD, DW, HB, HD, CO, FRZ, RG, are covered. The monthly change in the standard VAT rate is denoted as $\Delta\tau_d$. The monthly unemployment rate, *unempl*, and the number of months a model appears in the data in a specific country, $m.age$, as well as $m.age^2$ are controlled for but not reported. Standard errors are robust in all specifications and clustered by model-date cells. Standard errors in parentheses.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

effects at the edges of the pre- and post-reform windows. Visually, the estimated coefficients from Column (7) are displayed together with the cumulative price pass-through in Panels A and B of Figure 7.

The identification of tax effects in our analysis relies on differences in the consumption tax treatment of a model across countries. As noted in Section 5, this strategy might be invalidated by cross-country effects on producer prices. To check for the presence of such effects, we test our specifications in subsamples of products sold in more than just two markets. Table 7 shows estimation results obtained by gradually restricting the sample to products sold in an increasing number of countries, which ensures that identification of the effect of tax-rate changes on sales comes from a larger number of control countries within model-date cells. Column (1) removes products traded in only two countries, Column (3) further drops products sold in 3 countries, and so on until Column (6), which looks at products sold in 8 or more countries at the same time. The estimates of the anticipatory response as well as the total effect are very robust and comparable to the benchmark results presented in Column (6) of Table 6, which leads us to conclude that it is unlikely that cross-country effects are driving the results.

Across all specifications, the estimates point to pre-reform effects not only in sales, but also in prices. The pre-reform producer price effects might be explained by various kinds of adjustment costs. If price adjustment is costly, and therefore, infrequent, firms may start altering prices as early as the VAT change announcement (Carare and Danninger, 2008). Adjustment cost may also occur with changes in production capacity. Producers facing such costs would not fully adjust production capacity in response to temporary demand changes around a tax-reform. As a consequence, even if the pre-reform change in demand is expected, producer prices might vary with the short-term

Table 7: SALES EFFECTS: INCREASING NUMBER OF CONTROL COUNTRIES IN THE MODEL-DATE CELLS

	(1) $c \geq 3$	(2) $c \geq 4$	(3) $c \geq 5$	(4) $c \geq 6$	(5) $c \geq 7$	(6) $c \geq 8$
$\mathsf{E}\left[\mathsf{F}^3\Delta\tau_d\right]$	-0.931***	-1.068***	-1.111***	-1.009***	-1.081***	-0.645
	(0.291)	(0.309)	(0.338)	(0.369)	(0.400)	(0.447)
$\mathsf{E}\left[\mathsf{F}^2\Delta\tau_d\right]$	-0.682***	-0.587**	-0.613**	-0.693**	-1.000***	-1.055***
	(0.241)	(0.256)	(0.274)	(0.296)	(0.327)	(0.363)
$\mathsf{E}\left[\mathsf{F}\Delta\tau_d\right]$	3.093***	3.134***	3.035***	3.115***	3.533***	3.616***
	(0.241)	(0.258)	(0.279)	(0.303)	(0.328)	(0.365)
$\Delta\tau_d$	-5.037***	-5.201***	-5.095***	-5.145***	-4.947***	-4.854***
	(0.242)	(0.256)	(0.272)	(0.293)	(0.319)	(0.355)
$\mathsf{L}\Delta\tau_d$	-2.077***	-2.259***	-2.396***	-2.524***	-2.585***	-2.560***
	(0.243)	(0.259)	(0.280)	(0.304)	(0.333)	(0.368)
$\mathsf{L}^2\Delta\tau_d$	-0.253	-0.291	-0.228	-0.214	-0.425	-0.203
	(0.238)	(0.252)	(0.268)	(0.290)	(0.318)	(0.352)
$\mathsf{L}^3\Delta\tau_d$	1.010***	0.860***	0.852***	0.864***	0.887**	0.717*
	(0.248)	(0.266)	(0.288)	(0.314)	(0.344)	(0.382)
	(0.015)	(0.016)	(0.017)	(0.018)	(0.020)	(0.022)
				Cumulative Effects		
Total	-4.844***	-5.412***	-5.557***	-5.606***	-5.617***	-4.983***
	(0.666)	(0.708)	(0.763)	(0.828)	(0.904)	(1.01)
Pre-reform	1.480***	1.479***	1.311**	1.412**	1.453**	1.917***
	(0.450)	(0.479)	(0.519)	(0.564)	(0.614)	(0.685)
Post-reform	-6.357***	-6.892***	-6.867***	-7.019***	-7.069***	-6.899***
	(0.490)	(0.521)	(0.559)	(0.606)	(0.662)	(0.734)
N	2,532,188	2,108,796	1,750,962	1,435,722	1,160,986	923,894
Model-date groups	672,891	499,403	374,012	278,404	205,290	150,309
Models	23,346	16,352	12,094	9,015	6,704	4,987

Notes: Regression results in columns (1) to (6) are based on data for 22 EU countries. The dependent variable is the change in the logarithm of sales, $\Delta \log(UNITS)$. Observations in countries with reforms announced less than a month before implementation are removed around the respective reform date. The sample is gradually restricted to products sold contemporaneously in at least 3 up to at least 8 countries. All specifications include a full set of model-date, country- and country-month fixed effects. All categories of white goods, namely WM, TD, DW, HB, HD, CO, FRZ, RG, are covered. The monthly change in the standard VAT rate is denoted as $\Delta\tau_d$. The monthly unemployment rate, *unempl*, and the number of months a model appears in the data in a specific country, $m.age$, as well as $m.age^2$ are controlled for but not reported. Standard errors are robust in all specifications and clustered by model-date cells. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

fluctuation in demand.

An alternative explanation rests on imperfect competition. Producers that have some market-power, may adjust their prices to take advantage of expected shifts in consumer demand (Carare and Danninger, 2008). If imperfect competition explains pre-reform price pass-through, we should expect that its extent varies depending on models' market power. Market leaders may exhibit divergent pass-through and sales patterns around a consumption tax reform as compared to goods that sell fewer units. As discussed in Section 3, we create binary indicators for market power using the within year, within category, and within country ranking of models on the basis of their volume of sales. In particular, the dummy variables $R5$($R10$) equal one for all models that reach ranks between one and fifty (one and hundred) in at least one year throughout their life-cycle.

Based on the separation of products, Table A-4 in the Appendix reports results of specifications extending equations (13) and (14) by adding the $R5$ or $R10$ dummies and their interactions with all leads, lags as well as the contemporaneous term.[16] Once announcement information is taken into account, the results point to little difference between best selling and other models. While no significant effects are detected for the sales response, the post-reform price pass-through of top 50 models is found to be larger. But this effect is only weakly significant and is sensitive to whether the analysis focuses on exogenous reforms or not.

[16]The table reports the cumulative sum of pre-reform and post-reform coefficients as well as the total effect only for the interaction terms. In other words, Table A-4 focuses solely on the differential effect for top-sellers and other goods.

6.4 Exogenous Reforms

Table 8 reports results only for tax reforms classified as exogenous (see Table 3). Given a median implementation lag of three months, all observations for the sales and prices of models in countries with endogenous tax reforms are removed from the estimation six months before and six months after implementation, as well as in the month of the reform. This ensures that the immediate effects of these reforms as well as any pre- and post-reform effects are removed from the estimation sample. For example, a model sold in several countries including Spain in 2009 will have missing values for its Spanish sales and prices from January to December 2009. In such a manner, we minimize the loss of model-date pairs from the estimation sample.

The first three columns of Table 8 show results for prices, which are qualitatively similar to the results presented in section 6.2. At least when the timing of announcements is taken into account, full price pass-through cannot be rejected and about third of the price change takes place before the implementation. However, price adjustment occurs within a shorter time period: The price change starts two instead of three months before the reform, and is completed in the month after implementation. Across specifications, we find that announcement dates and implementation lags matter less: The total pass-through estimated in Column (1) is only slightly below that in Column (2) as opposed to the vastly different results with and without announcements in Table 5.

Columns (4) to (6) report the corresponding sales effects. Similarly to prices, we find that the sales response takes place in a narrower time interval. Pre-reform effects are concentrated in the last-period before the reform and, cumulatively, are larger than in Table 6. Conversely, the cumulative post-reform effect is found to be slightly smaller. Taken together, the results for exogenous reforms point to a stronger temporary shift in consumer demand and a smaller long-term effect. The point

Table 8: EXOGENOUS TAX REFORMS

Dependent variable	$\Delta\log(PRICE)$			$\Delta\log(UNITS)$		
Reforms		All	$n \geq 1$		All	$n \geq 1$
No		Yes				
	(1)	(2)	(3)	(4)	(5)	(6)
$\mathsf{F}^3\Delta\tau_d$	-0.030			-0.198		
	(0.040)			(0.402)		
$\mathsf{F}^2\Delta\tau_d$	0.207***			0.520		
	(0.047)			(0.448)		
$\mathsf{F}\Delta\tau_d$	0.012			2.480***		
	(0.039)			(0.373)		
$\mathsf{E}\left[\mathsf{F}^3\Delta\tau_d\right]$		-0.028	-0.028		0.126	0.112
		(0.042)	(0.042)		(0.399)	(0.398)
$\mathsf{E}\left[\mathsf{F}^2\Delta\tau_d\right]$		0.246***	0.245***		0.352	0.346
		(0.048)	(0.048)		(0.447)	(0.448)
$\mathsf{E}\left[\mathsf{F}\Delta\tau_d\right]$		0.075*	0.079**		2.129***	2.116***
		(0.040)	(0.040)		(0.370)	(0.370)
$\Delta\tau_d$	0.174***	0.175***	0.173***	-4.346***	-4.347***	-4.609***
	(0.045)	(0.045)	(0.046)	(0.427)	(0.427)	(0.437)
$\mathsf{L}^1\Delta\tau_d$	0.396***	0.395***	0.392***	-2.409***	-2.407***	-1.987***
	(0.038)	(0.038)	(0.039)	(0.374)	(0.374)	(0.376)
$\mathsf{L}^2\Delta\tau_d$	-0.002	-0.003	0.003	0.043	0.046	- 0.065
	(0.043)	(0.043)	(0.044)	(0.423)	(0.423)	(0.434)
$\mathsf{L}^3\Delta\tau_d$	0.052	0.052	0.056	0.824**	0.823**	0.836**
	(0.040)	(0.040)	(0.041)	(0.389)	(0.389)	(0.390)
Cumulative Effects						
Total	0.809***	0.912***	0.919***	-3.086***	-3.278***	-3.251***
	(0.111)	(0.112)	(0.114)	(1.071)	(1.068)	(1.079)
Pre-reform	0.189***	0.292***	0.296***	2.802***	2.607***	2.575***
	(0.073)	(0.075)	(0.076)	(0.709)	(0.705)	(0.705)
Post-reform	0.620***	0.620***	0.623***	-5.888***	-5.885***	-5.825***
	(0.084)	(0.084)	(0.086)	(0.807)	(0.807)	(0.819)
Pass-through F(1)	2.97*	0.62	0.50			
N	2,623,501	2,623,501	2,581,065	2,686,457	2,686,457	2,640,473
Model-date groups	797,159	797,159	786,148	813,936	813,936	801,779
Models	33,232	33,232	32,895	33,469	33,469	33,129

Notes: Regression results in columns (1) to (6) are based on data for 22 EU countries. The dependent variable in columns (1) to (3) is the change in the logarithm of price, $\Delta\log(PRICE)$, and in columns (4) to (6) it is the change in the logarithm of sales, $\Delta\log(UNITS)$. Observations up to two quarters before and after reforms classified as endogenous(see Table 3) are removed from the estimation. Estimates in columns (3) and (6) are based on a reduced sample, in which observations in countries with reforms announced less than a month before implementation, are removed around the respective reform date. All specifications include a full set of model-date, country- and country-month fixed effects. All categories of white goods, namely WM, TD, DW, HB, HD, CO, FRZ, RG, are covered. The monthly change in the standard VAT rate is denoted as $\Delta\tau_d$. The monthly unemployment rate, *unempl*, and the number of months a model appears in the data in a specific country, *m.age*, as well as $m.age^2$ are controlled for but not reported. Standard errors are robust in all specifications and clustered by model-date cells. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

estimates suggest that a tax reform, which exogenously raises the tax rate by one percentage point triggers a temporary growth of sales by two and a half percent in the month preceding the reform. The long-term effect on sales is a drop by about three percent.

7 Conclusions

Interest in a fiscal policy using consumption taxes to stimulate consumer demand has recently increased. Theory suggests that an upcoming tax-rate change would provide an incentive to consumers to bring forward or post-pone spending. In addition, the demand for consumer durables is expected to display a further temporary shock immediately before implementation. The empirical analysis provided in this paper supports this view and shows that the changes of baseline consumption tax rates in the EU countries in recent years have in fact exerted very strong effects on the time path of consumer spending.

We utilize a unique micro data set for consumer durables which allows us to distinguish between the monthly purchases of individual products and their consumer prices in 22 European countries over the last decade, which has seen numerous changes in consumer tax rates. We implement a reduced-form specification for sales that tests theoretical predictions by a standard inter-temporal model of consumer choice under different assumptions about the consumer price effects of taxes. To identify tax effects empirically, we explore how prices and sales of individual products differ in countries where the baseline consumption tax-rate is changed relative to countries where taxes remain unchanged. Separate analysis of the number of sales of individual products and their prices allows us to provide evidence on tax effects that are not confounded by shifts between products of different quality.

While the price data clearly supports the full pass-through of consumption taxes as typically assumed in the theoretical literature, the results indicate that about a third of the pass-through takes place pre-reform, more specifically in the last quarter before implementation. Price pass-through is completed in the first quarter after implementation. Given the finding of full price pass-through, it is difficult to explain the pre-reform adjustment in prices with imperfect competition. Robustness checks also did not detect major differences between the group of top-sellers and other models. Hence, the pre-reform price effects are most likely a consequence of adjustment costs faced by producers. The empirical results for sales confirm the theoretical predictions under full price pass-through. Purchases differ substantially before and after the tax-rate change and this difference is not just offsetting the short-run demand effect for durables on the verge of the tax reform but points to a strong inter-temporal shift in total consumer demand. The basic results suggest that an increase of an ad-valorem consumption tax rate by one percentage point causes an inter-temporal shift of consumption by up to 5 percent. In addition, purchases in durable goods are found to increase temporarily by about 2 percent in the last month before the tax increase.

In the standard models of consumer choice with forward-looking consumers who have full access to the capital market, these results imply a sizeable inter-temporal elasticity of consumption. Yet our analysis also shows that the consumer response differs between reforms even if differences in the implementation lag after announcement are taken into account. More specifically, following the narrative approach to the analysis of fiscal policy and distinguishing reforms by their motivation, we find that exogenous consumption tax reforms which are unrelated to GDP shocks exert smaller effects on consumer spending than results from specifications including all reforms. Reforms implemented by countries facing limited access to capital markets or being forced to reduce cyclical deficits in order to meet the EU's fiscal policy requirements, elicit stronger consumptions responses.

This seems to be in line with evidence of stronger effects of fiscal policy in a recessionary economic environment (*e.g.*, Auerbach and Gorodnichenko, 2012). However, in the presence of GDP shocks, reform effects may be confounded by economic developments. Focusing on exogenous reforms, we find that the price-pass through is quicker, the temporary shift in the demand for durables is more pronounced, and the long-term inter-temporal shift in consumption is smaller. Based on these results, a one percentage point increase in consumption taxes causes an inter-temporal shift of consumption by about 3 percent. Still, this is a large effect that points to the potential of using consumer taxes as an instrument of fiscal policy.

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A.1 Household Optimization

The Lagrangian for the intertemporal optimization problem is

$$\mathcal{L} = \sum_{s=t}^{\infty} \Big\{ \beta^{s-t} \frac{\sigma}{\sigma-1} u_s^{1-\frac{1}{\sigma}} + \lambda_{s+1} \beta^{s-t} \left[(1+r) a_s + w_s - (1+\tau_s) x_s - p_s (k_s - (1-\delta) k_{s-1}) - a_{s+1} \right] \Big\},$$

where λ_{s+1} is the Lagrange multiplier in current value terms.

The first order condition for the consumption of non-durables is

$$u_s^{-\frac{1}{\sigma}} \frac{\partial u_s}{\partial x_s} - \lambda_{s+1} (1+\tau_s) \stackrel{!}{=} 0, \tag{A.16}$$

where λ_{s+1} represents the marginal utility of income in period s. The condition for the optimal stock of consumer durables is

$$u_s^{-\frac{1}{\sigma}} \frac{\partial u_s}{\partial k_s} - \lambda_{s+1} p_s + (1-\delta) \beta p_{s+1} \lambda_{s+2} \stackrel{!}{=} 0. \tag{A.17}$$

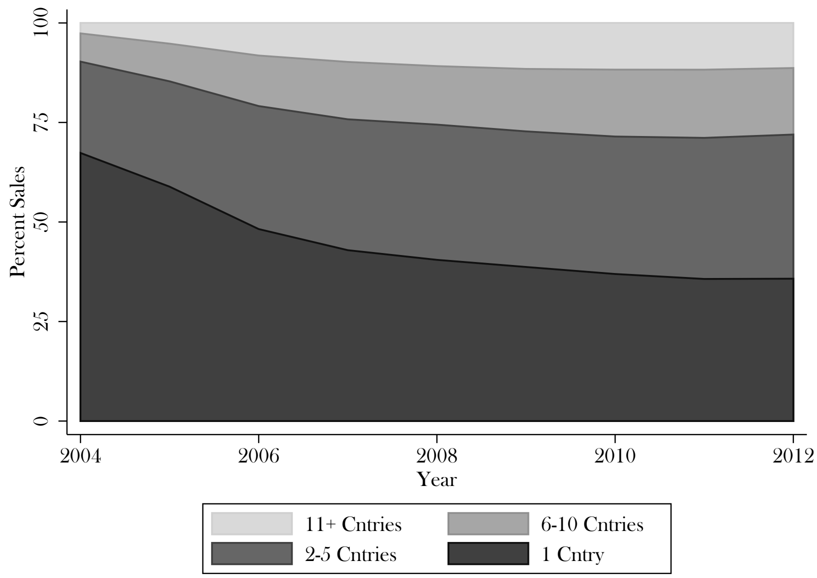
Assuming that $\beta(1+r) = 1$, the Euler equation for wealth simplifies to $\frac{\lambda_{s+2}}{\lambda_{s+1}} = 1$. Given a CES intra-temporal utility function, $\frac{\partial u_s}{\partial k_s} = b u_s^{\frac{1}{\epsilon}} k_s^{\frac{-1}{\epsilon}}$ and $\frac{\partial u_s}{\partial x_s} = u_s^{\frac{1}{\epsilon}} x_s^{\frac{-1}{\epsilon}}$. Replacing λ_{s+1} (and λ_{s+2}) in (A.17) by using eq. (A.16), and rearranging terms yields eq. (3) with user cost as defined in eq. (4).

Eq. (6) is obtained by replacing λ_{s+2} and λ_{s+1} in the Euler equation $\frac{\lambda_{s+2}}{\lambda_{s+1}} = 1$ using eq. (A.16), which yields

$$\frac{u_{s+1}^{\sigma-\epsilon} x_{s+1}^{-\sigma}}{u_{s+1}^{\sigma-\epsilon} x_s^{-\sigma}} = \left(\frac{1+\tau_{s+1}}{1+\tau_s} \right)^{\sigma\epsilon}$$

Noting that $u_s = x_s \left[1 + b \left(\frac{k_s}{x_s} \right)^{\frac{\epsilon-1}{\epsilon}} \right]^{\frac{\epsilon}{\epsilon-1}}$, using eq. (3) and rearranging terms, yields eq. (6).

Figure A-1: COMPOSITION OF THE VOLUME OF SALES BY NUMBER OF COUNTRIES IN WHICH MODELS ARE SOLD



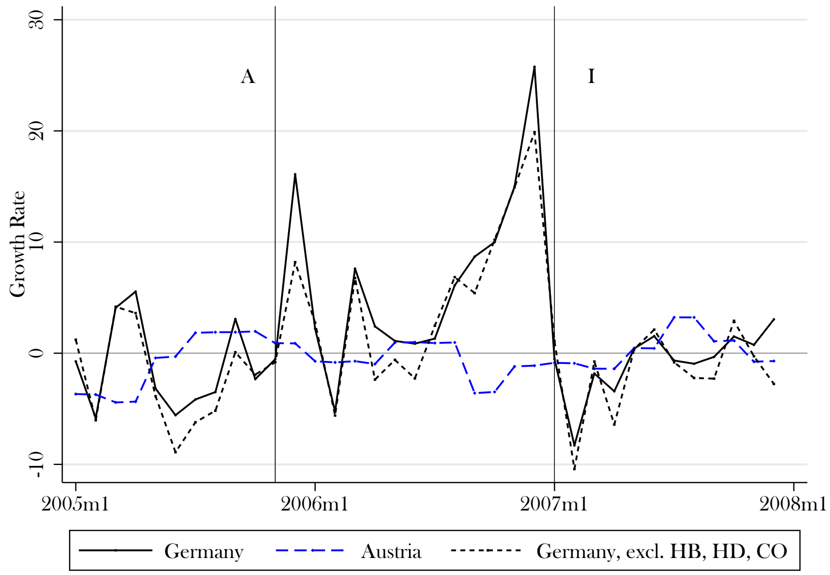
Note: The figure depicts the development over time in the share of units sold (percent from total units) of models marketed in one country, two to five countries, six to ten countries and in eleven or more countries. Refer to Figure 1 in the main text for more information on the cross-country marketing of models.

Table A-1: FULL SAMPLE: DESCRIPTIVE STATISTICS BY MODEL CATEGORY

	Mean	Std. Dev.	Min	Max
	Average № Models per Year			
Cookers	21,582	503	20,477	22,134
Fridges	24,102	1,359	22,402	26,712
Dishwashers	11,185	1,318	8,745	13,305
Freezers	6,265	416	5,722	7,117
Cooktops	14,006	783	12,572	14,875
Hoods	14,918	1,733	10,810	17,148
Tumble dryers	3,195	196	2,966	3,531
Washing machines	14,877	708	13,855	16,019
	Average № of Units Sold per Year (Thousands)			
Cookers	8,623	729	6,252	9,206
Fridges	14,067	1,100	10,707	15,018
Dishwashers	6,783	686	5,401	7,431
Freezers	3,836	380	2,631	4,112
Cooktops	5,919	463	4,691	6,342
Hoods	4,948	433	3,714	5,370
Tumble dryers	3,522	414	2,268	3,942
Washing machines	14,728	1,205	11,415	15,654
	Average Value of Sales per Year (Millions Euro)			
Cookers	3,935	389	2,756	4,356
Fridges	6,350	542	4,786	6,887
Dishwashers	3,431	303	2,618	3,659
Freezers	1,354	118	980	1,445
Cooktops	2,192	191	1,729	2,352
Hoods	1,260	110	986	1,356
Tumble dryers	1,430	151	1,035	1,601
Washing machines	6,184	500	4,643	6,577
	Average Market Age [Average Months Model Sold]			
Cookers	27.6 [30.8]	22.6 [23.4]	1	117
Fridges	25.3 [28.9]	20.8 [21.8]	1	117
Dishwashers	24.3 [27.7]	19.9 [20.7]	1	117
Freezers	25.7 [28.6]	21.1 [22.0]	1	117
Cooktops	29.8 [34.5]	24.5 [25.5]	1	117
Hoods	32.5 [36.9]	26.7 [27.6]	1	117
Tumble dryers	26.7 [29.5]	21.4 [22.0]	1	117
Washing machines	24.1 [27.1]	19.5 [20.3]	1	117

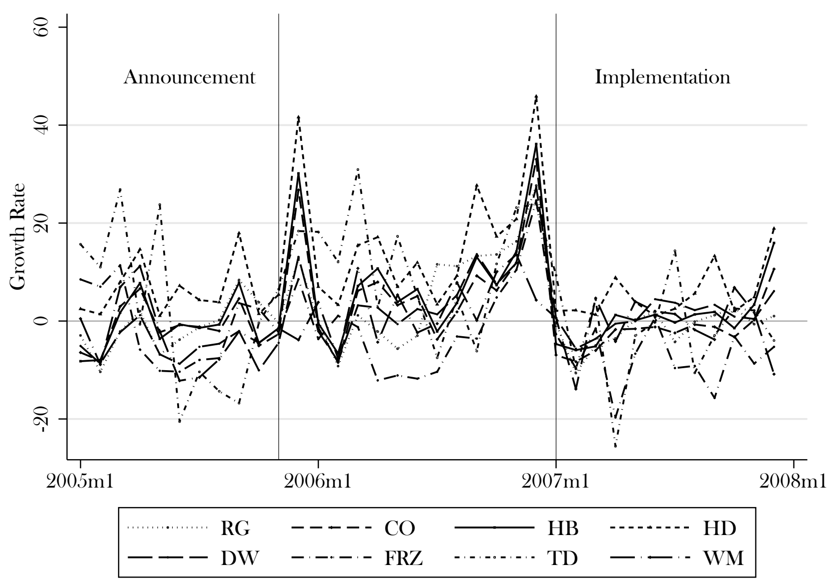
Note: The market age is the number of months a model is sold in a specific country as opposed to the total number of months a model appears in the data irrespective of the location of sales (Average Months Model Sold). Descriptive statistics for the full sample as well as for the reduced sample of models traded in at least two countries, are presented in Table 2.

Figure A-2: GERMANY: GROWTH RATE OF SALES



Note: The figure depicts the growth rate of the volume of sales of white goods (WM, DW, TD, HB, HD, FRZ, RG, CO). The upper panel shows the growth rate in month m in years 2005, 2006, and 2007 relative to the average sales in 2004 and 2008 for the same month m. For example, sales in Dec. 2005 were 16% higher relative to the average sales in Dec. 2004 and Dec. 2008. The blue dashed line is the same growth rate in Austria. Germany increased the standard VAT rate from 16 to 19% on 1.1.2007, with the tax increase officially announced in November 2005. No VAT rate change occurred in Austria. The black dashed line depicts the growth rate excluding HB, HD, and CO.

Figure A-3: GERMANY: GROWTH RATE OF WHITE GOODS' SALES PER PRODUCT GROUP, 2005-2007



Note: The figure depicts the growth rate of the volume of sales of white goods in month m in years 2005, 2006, and 2007 relative to the average sales in 2004 and 2008 for the same month m for eight categories of durable goods: refrigerators (RG), cookers (CO), hobs/cooktops (HB), hoods (HD), dishwashers (DW), freezers (FRZ), tumble driers (TD) and washing machines (WM). The aggregate growth rate is depicted in Figure 4 in the main text. Germany increased the standard VAT rate from 16 to 19% on 1.1.2007, with the tax increase officially announced in November 2005.

Table A-2: COMPOSITION OF IDENTIFYING REFORMS (COUNTRIES) PER LEAD

Lead	№ Identifying countries	№ Identifying reforms
$\Delta\tau_d$	18	33
$\mathsf{E}\left[\mathsf{F}\Delta\tau_d\right]$	12	25
$\mathsf{E}\left[\mathsf{F}^2\Delta\tau_d\right]$	12	23
$\mathsf{E}\left[\mathsf{F}^3\Delta\tau_d\right]$	10	17
$\mathsf{E}\left[\mathsf{F}^4\Delta\tau_d\right]$	9	14
$\mathsf{E}\left[\mathsf{F}^5\Delta\tau_d\right]$	8	10
$\mathsf{E}\left[\mathsf{F}^6\Delta\tau_d\right]$	6	8
$\mathsf{E}\left[\mathsf{F}^7\Delta\tau_d\right]$	6	8
$\mathsf{E}\left[\mathsf{F}^8\Delta\tau_d\right]$	6	8
$\mathsf{E}\left[\mathsf{F}^9\Delta\tau_d\right]$	6	8
$\mathsf{E}\left[\mathsf{F}^{10}\Delta\tau_d\right]$	5	6
$\mathsf{E}\left[\mathsf{F}^{11}\Delta\tau_d\right]$	3	3
$\mathsf{E}\left[\mathsf{F}^{12}\Delta\tau_d\right]$	2	2
$\mathsf{E}\left[\mathsf{F}^{13}\Delta\tau_d\right]$	2	2
$\mathsf{E}\left[\mathsf{F}^{14}\Delta\tau_d\right]$	2	2

The table shows the various composition of VAT reforms and countries involved in the estimation of each lead. Due to data limitations for Latvia such as market size and narrower time and category coverage, we take the earliest announcement in the data to be that of the German VAT increase in 2007, which was announced 14 months prior to implementation. For this reason, no more than 14 leads are considered.

Table A-3: ROBUSTNESS PRICES: INCREASING NUMBER OF CONTROL COUNTRIES IN MODEL-DATE CELLS

	(1) $c \geq 3$	(2) $c \geq 4$	(3) $c \geq 5$	(4) $c \geq 6$	(5) $c \geq 7$	(6) $c \geq 8$
$\mathsf{E}\left[\mathsf{F}^3\Delta\tau_d\right]$	0.205^{***}	0.208^{***}	0.219^{***}	0.216^{***}	0.223^{***}	0.235^{***}
	(0.030)	(0.032)	(0.035)	(0.038)	(0.042)	(0.048)
$\mathsf{E}\left[\mathsf{F}^2\Delta\tau_d\right]$	0.056^{**}	0.058^{**}	0.052^{*}	0.050	0.054	0.066^{*}
	(0.025)	(0.027)	(0.029)	(0.031)	(0.035)	(0.039)
$\mathsf{E}\left[\mathsf{F}\Delta\tau_d\right]$	0.121^{***}	0.107^{***}	0.109^{***}	0.087^{***}	0.087^{**}	0.110^{***}
	(0.025)	(0.027)	(0.029)	(0.032)	(0.035)	(0.039)
$\Delta\tau_d$	0.203^{***}	0.217^{***}	0.234^{***}	0.254^{***}	0.285^{***}	0.284^{***}
	(0.025)	(0.027)	(0.029)	(0.031)	(0.034)	(0.038)
$\mathsf{L}\Delta\tau_d$	0.403^{***}	0.404^{***}	0.405^{***}	0.386^{***}	0.385^{***}	0.357^{***}
	(0.025)	(0.027)	(0.029)	(0.031)	(0.034)	(0.038)
$\mathsf{L}^2\Delta\tau_d$	-0.045^{*}	-0.043	-0.020	-0.014	0.010	0.012
	(0.025)	(0.026)	(0.028)	(0.030)	(0.034)	(0.037)
$\mathsf{L}^3\Delta\tau_d$	0.062^{**}	0.071^{**}	0.071^{**}	0.068^{**}	0.046	0.049
	(0.026)	(0.028)	(0.031)	(0.034)	(0.037)	(0.041)
Total pass-through ($\sum A_j + B + \sum D_j$)	1.01^{***}	1.02^{***}	1.07^{***}	1.05^{***}	1.09^{***}	1.11^{***}
	(0.069)	(0.073)	(0.079)	(0.086)	(0.095)	(0.106)
Pre-reform ($\sum A_j$)	0.383^{***}	0.372^{***}	0.380^{***}	0.353^{***}	0.364^{***}	0.409^{***}
	(0.047)	(0.049)	(0.054)	(0.059)	(0.065)	(0.073)
Post-reform ($B + \sum D_j$)	0.623^{***}	0.650^{***}	0.689	0.694^{***}	0.726^{***}	0.701^{***}
	(0.051)	(0.054)	(0.058)	(0.064)	(0.069)	(0.078)
N	2,482,603	2,069,168	1,719,084	1,410,431	1,141,101	908,292
Model-date groups	663,360	493,540	370,322	276,152	203,942	149,460
Models	23,274	16,320	12,075	9,008	6,699	4,984

Notes: Regression results in columns (1) to (6) are based on data for 22 EU countries. The dependent variable is the change in the logarithm of price, $\Delta\log(PRICE)$. Reforms' announcement information is fully incorporated. Observations in countries with reforms announced less than a month before implementation are removed around the respective reform date. The sample is gradually restricted to products sold contemporaneously in at least 3 up to at least 8 countries. All specifications include a full set of model-date (id) specific fixed effects, country- and country-month fixed effects. All categories of white goods, namely WM, TD, DW, HB, HD, CO, FRZ, RG, are covered. The monthly change in the standard VAT rate is denoted as $\Delta\tau_d$. The monthly unemployment rate, *unempl*, and the number of months a model appears in the data in a specific country, $m.age$, as well as $m.age^2$ are controlled for but not reported. Standard errors are robust in all specifications and clustered by model-date cells. Standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A-4: ROBUSTNESS CHECK: DIFFERENTIAL EFFECTS FOR TOP-SELLING MODELS

Forward terms	$\mathsf{F}^i \Delta\tau_d$		$\mathsf{E}\left[\mathsf{F}^i \Delta\tau_d\right]$	
Reforms	All	All	$n \geq 1$	$n \geq 1$ & exog
	(1)	(2)	(3)	(4)
	Cumulative price effects			
$R5$				
Cumulative	0.662***	0.367***	0.247*	0.455*
	(0.127)	(0.129)	(0.133)	(0.250)
Pre-reform	0.441***	0.147*	0.132	0.136
	(0.082)	(0.085)	(0.086)	(0.164)
Post-reform	0.221**	0.220**	0.115	0.319*
	(0.096)	(0.096)	(0.099)	(0.186)
$R10$				
Cumulative	0.666***	0.342***	0.236*	0.183
	(0.108)	(0.118)	(0.122)	(0.218)
Pre-reform	0.456***	0.134*	0.115	-0.043
	(0.063)	(0.079)	(0.081)	(0.144)
Post-reform	0.210**	0.208**	0.121	0.226
	(0.088)	(0.088)	(0.091)	(0.163)
N	2,978,933	2,978,933	2,874,333	2,586,289
Model-date groups	885,039	885,039	861,547	787,455
Models	34,283	34,283	33,852	32,922
	Cumulative sales effects			
$R5$				
Cumulative	-0.795	-0.602	-0.006	-3.61
	(1.23)	(1.25)	(1.30)	(2.31)
Pre-reform	-0.159	0.030	-0.042	-1.84
	(0.825)	(0.850)	(0.872)	(1.52)
Post-reform	-0.635	-0.632	0.036	-1.76
	(0.911)	(0.911)	(0.954)	(1.72)
$R10$				
Cumulative	-0.060	-0.339	-0.408	-2.94
	(1.04)	(1.14)	(1.18)	(2.04)
Pre-reform	-0.131	-0.407	-0.636	-1.71
	(0.612)	(0.769)	(0.789)	(1.32)
Post-reform	0.071	0.068	0.228	-1.24
	(0.831)	(0.832)	(0.870)	(1.53)
N	3,045,284	3,045,284	2,936,035	2,645,734
Model-date groups	902,017	902,017	877,225	803,089
Models	34,505	34,505	34,071	33,153

Notes: The table shows regressions for sales, $\Delta \log(UNITS)_{icd} = \sum_{j=1}^{3} a_j \mathsf{F}^j \log \Delta\tau_{cd} + b \log \Delta\tau_{cd} + \sum_{j=1}^{3} d_j \mathsf{L}^j \Delta\tau_{cd} + R5 * (\sum_{j=1}^{3} a_j \mathsf{F}^j \log \Delta\tau_{cd} + b \log \Delta\tau_{cd} + \sum_{j=1}^{3} d_j \mathsf{L}^j \Delta\tau_{cd}) + cR5 + aX_{icd} + \alpha_{id} + \rho_c + \gamma_{cm(d)} + u_{icd}$, and an identical regression for prices, where $R5$ ($R10$) are dummy variables equal to one if a model reaches a top 50 (top 100) rank within its respective category at some point in its life-cycle.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.