Sales and Price Effects of Pre-announced Consumption Tax Reforms: Micro-level Evidence from European VAT

Thiess Buettner, FAU and CESifo   Boryana Madzharova, FAU*

July 2, 2019

Abstract

This paper studies the effects of consumption tax reforms on prices and the time path of consumption spending in EU countries utilizing micro-level data on the monthly unit sales and prices of consumer durables. The identification strategy exploits the trading of identical products in multiple countries. The results show that tax-rate changes are fully and quickly shifted into prices and strongly affect the time path of consumption. The empirical findings for consumption spending indicate that tax rate changes exert temporary effects shortly before implementation, which are more than reverted after implementation. Quantitatively, we find that sales increase by about 2.5% in the last month before and drop by almost 5% after implementation if the tax rate increases by one percentage point.

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

JEL Classification: D15; H31; E62; D12; H24

---

*University of Erlangen-Nuremberg, Lange Gasse 20, 90403 Nuremberg, Germany, thiess.buettner@fau.de, boryana.madzharova@fau.de. The project is conducted with data provided by Gesellschaft für Konsumforschung (GfK) Retail and Technology GmbH. We would like to thank Anton Eckl for his insightful comments and help with the data. We are also grateful to David Agrawal, Arkadiusz Bernal, Yussef Benzarti, William Hoyt, Christos Kotsogiannis, Tuomas Kosonen, Christian Merkl and participants at conferences and seminars in Lake Tahoe, NV (IIPF), Mannheim (ZEW), Munich (CESifo), the University of Oslo, the University of Exeter, the University of Zurich, and VŠE Prague for helpful comments and suggestions.

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 incentivize consumers to bring forward or postpone purchases. Since most countries levy broad-based consumption taxes, they could exploit this intertemporal response and raise or discourage consumption through a pre-announced change of the baseline tax rate. Feldstein (2002) 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 counter the decline in the US demand for consumer durables. Correia, Farhi, Nicolini and Teles (2013) use a New Keynesian model to show that engineering over time an increasing path of consumption taxes 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 consumer responsiveness at the intertemporal margin (Attanasio and Weber, 2010), all the more so since consumers may not be fully aware of the consumption tax burden (Chetty, Looney and Kroft, 2009). In addition, conventional assumptions about the pass-through of taxes into prices 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 the effects of pre-announced tax reforms on consumer behavior empirically.

The existing literature offers mixed results. One common finding is high consumer awareness of upcoming changes in the baseline rate of the value-added tax (VAT). Crossley, Low, and Sleeman (2014) analyze the effects of a temporary VAT cut implemented as a fiscal stimulus in the UK in 2008 and find strong positive effects on consumer sentiment. Exploring the effect of a pre-announced VAT 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 VAT 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 sales, results are mixed, however. Crossley, Low, and Sleeman (2014) provide evidence of a positive effect on consumer spending for retail sales in the UK relative to other European countries. They also document that prices started to increase before the temporary tax cut was reversed. Cashin and Unayama (2016), who employ detailed household panel data that allow them to distinguish between goods according to their durability and storability, find only small intertemporal substitution effects for the 1997 tax increase in Japan.

To analyze the effects of pre-announced consumption tax reforms, 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 reforms of the baseline tax rate of the VAT in recent years (DeMooij and Keen, 2013). A key characteristic of the dataset is the availability of information on both prices and units sold, which allows us to study separately the effects of tax reforms on consumer prices and sales for approximately 72,000 different products (models) in the basic specification. We employ a consistent identification strategy for sales and price effects, which exploits the trading of identical products in multiple countries: Counterfactuals for sales and prices of a product in a country experiencing a consumption tax reform are constructed from the contemporaneous sales and prices of exactly the same product in other EU countries.

We generalize the analysis of pre-announced consumption tax rate changes by studying multiple tax reforms, 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 the motivation behind tax reforms. More specifically, we distinguish endogeneous and exogeneous tax reforms following the narrative approach to the analysis of fiscal policy put forward by Romer and Romer (2010).

Our empirical results document that changes in baseline consumption tax rates are fully and quickly passed into consumer prices and strongly affect the time path of consumer spending. Sales of consumer durables are found to differ substantially before and after a tax-rate change. The difference 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 intertemporal shift in total consumer demand. When we incorporate the information on when a policy reform has been announced, our results support full pass-through of consumption tax changes into consumer prices. The pass-through occurs within a short time period of two quarters. When 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 sales effects are similar. Quantitatively, our results show that an exogenous 1 percentage point increase in consumption taxes causes a drop in consumption by almost 5 percent. In addition, purchases of durable goods increase temporarily by about 2.5 percent in the last month before a tax increase.

In exploiting regional information within the European Union, our identification strategy is related to the analysis of local sales taxes in the US by Agarwal, Marwell and McGranahan (2016), who study the consumer response to State 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 levels and find that consumption spending decreases by 2% if the tax rate increases by 1 percentage point. In contrast to state and local sales taxes, the consumption tax effects studied in this paper refer to the baseline tax-rate of a general consumption tax (VAT). As this rate is applied to most consumer goods and not on business purchases,[1] 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.

Given its focus on consumer durables in the context of fiscal stimulus policies, this paper is also closely related to the empirical literature on the effects of temporary vehicle scrappage programs

[1] Ring (1999) shows that about a third of the tax base of the US states' general sales taxes consists of business purchases.

aiming to stimulate consumer spending and promote fuel efficiency. Mian and Sufi (2012) and Green, Melzer, Parker and Rojas (2016) find that the main effect of the US 2009 subsidy was to shift consumer spending within a year. This finding is confirmed by Li, Linn and Spiller (2013). Hoekstra, Puller and West (2017) also find strong short-term effects on car sales, but document that sales perform much worse in the post-program period compared to the counterfactual, pointing to long-term losses in consumer spending, which the authors attribute to fuel efficiency restrictions. While we also find temporary effects on the demand for durables, our results indicate that these effects are even stronger in case of exogenous tax reforms, which do not intend to provide a stimulus.

Our analysis provides new evidence on the pass-through of consumption taxes. While it is frequently assumed that the pass-through is complete and immediate, some recent papers test the validity of this assumption empirically. 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-index data at a two-digit level to study how the 2007 VAT increase in Germany affected consumer prices. Even though their results support full shifting of the tax to the consumer, they find evidence of "inflation smoothing" in the sense that adjustments in prices start before implementation. Using a similar classification, Benedek, deMooij, Keen and Wingender (2015) provide a more comprehensive analysis based on monthly price-index data for European countries. For changes in the standard VAT 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.[2]

Our analysis of price effects differs, since we use primary data that allows us to analyze the pricing of individual products. Further, unlike previous work, which usually does not take reform-announcements into account, we show that information about the timing of the announcement and

[2] Benedek *et al.* (2015) also note that the pass-through of the consumption tax differs between goods taxed at the baseline and at reduced rates. For the latter 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 (see also Benzarti, Carloni, Harju, Kosonen, 2017).

the length of the implementation lag matters and should not be ignored when assessing the effect of pre-announced reforms. Apart from confirming 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 even quicker 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 discussion of the theoretical predictions regarding the effects of a preannounced tax-rate change on the sales of consumer durables. Section 3 describes the dataset, while Section 4 provides graphical 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.

2 Theoretical Predictions for Consumption of Durables

Before we explain in detail, how we measure and identify effects of consumption tax-rate changes empirically, this section gives a brief overview of the theoretical predictions. A theoretical analysis that derives predictions formally is provided in an appendix. The basic life-cycle model with additively separable utility suggests that the level of consumption will differ before and after a pre-announced tax rate change due to intertemporal substitution. This holds in particular, if the tax rate change is fully passed through into consumer prices and if the consumer expects this to happen. If the future tax rate increases, current consumption increases relative to future consumption and so does the value of the optimal stock of durables (Cashin and Unayama, 2016). The opposite holds in case of a tax decrease.

Tax rate changes may additionally exert income effects. A forward-looking consumer would be aware that a future tax increase is equivalent to a decline in the real present value of income. If the policy to change the tax rate is not anticipated, the income effect could reinforce the decline in consumption at the time of implementation. With anticipation, however, the income effect might be present as early as the announcement. When implementation happens later, income effects should not matter, except for myopic behavior or credit constraints.

With regard to consumer durables, however, the consumer response to the implementation of a tax rate change is not only determined by intertemporal substitution. Consumers can also take advantage of the fact, that the value of the stock of durables changes. Facing an increase of the tax rate, for instance, consumers can increase their stock of durables, temporarily, in order to benefit from the appreciation of the stock. If the tax rate is going to decrease, the consumer can reduce the stock of durables in order to limit the decline in the value. To formalize the effect of expected price changes on the time-path of consumption, Ogaki and Reinhard (1998) employ the user cost for the service flow of the durable good. This cost varies inversely with the present value of the price of durables and increases with the rate of depreciation. As we show formally in a theoretical appendix, with full price pass-through, a future tax increase causes the expected future price to rise, and, hence, the user cost displays a temporary decline before implementation and vice versa for a tax decrease.

The extent to which the actual purchases of durables are affected by the temporary change in the user cost depends critically on the intra-temporal elasticity of substitution between durables and nondurables. If this elasticity is large, the consumer would substitute away from nondurables at times when the user cost is low. This would result in a stronger temporary expansion (contraction) of purchases of durable goods before a tax increase (decrease) (see theoretical appendix). Cashin and Unayama (2016) find that the intra-temporal elasticity of substitution is small, however, which suggests that temporary changes in the user cost would have limited effects.

Whereas the temporary effect on the user cost before the tax rate change will be offset after the implementation, the change in the steady state level of the stock of durables before and after a pre-announced tax rate change causes a non-recurring effect on purchases of durables. In the absence of adjustment cost, this long-term effect approximately reveals the intertemporal substitution elasticity (see theoretical appendix). However, it seems unlikely that the consumer can adjust the stock of durables at no cost. Adjustment cost can affect the demand for durable goods in a number of ways. First, if expansion and reduction of the stock of durables are costly, the stock of durables might not reach its new steady-state level immediately after implementation of the tax-rate change. Second, the change in the steady-state level may trigger adjustments of the stock of durables even before implementation. Third, in the presence of adjustment cost, consumers should be less eager to take advantage of the temporary change in the user cost.

The consequences for purchases depend, however, on the nature of the adjustment cost. With convex adjustment cost, frequently used in factor demand models (*e.g.*, Shapiro, 1986, Hamermesh and Pfann, 1996), the temporary and long-term changes in the stock of durables will be distributed over time. In case of a quadratic adjustment cost function, the purchases of durables by the individual household would follow a partial adjustment process, which starts and ends some time before and after the tax-rate change (see theoretical appendix). However, the symmetry of adjustment cost for increases and decreases in the stock of durables seems questionable, as a large decrease may involve selling of the durables in a secondary market, where the price may be depressed due to information asymmetry and "lemons costs" (Bar-Ilan and Blinder, 1992). If adjustment cost is higher for decreases in the stock of durables, depending on whether the tax rate change is positive or negative, adjustments before and after the tax-rate change take more or less time (see theoretical appendix).

If adjustment cost is non-convex, the upcoming tax-rate change will have implications for the timing of purchases. In particular, if the adjustment of the stock of durables is associated with fixed or lumpy transaction cost, the purchase of durables by the individual household would follow an (s,S) policy, where purchases are made rather infrequently (Grossmann and Laroque, 1990, Bar-Ilan and Blinder, 1992). Only if the actual stock of durables deviates sufficiently from its optimal level, a purchase is made. The precise implications for the aggregate demand for durables depend on the cross–sectional distribution of the vintage of the existing stock of durables (Adda and Cooper, 2000). However, the time path of aggregate expenditures need not be much different from a model with convex adjustment cost (Attanasio, 2000).

The above predictions for consumption and for the consumers' purchases of durables rest on the assumption of a full and instantaneous pass-through of tax rate changes into the consumer price. Though this is a standard assumption in models with constant returns to scale and perfect competition (Fullerton and Metcalf, 2002), under conditions of imperfect competition even in the long-run, other degrees of shifting are a possibility (Besley and Rosen, 1999).

Besides the issue of whether the price pass-though is complete, the question arises how fast price adjustment takes place. In the presence of menu cost, the pass-through of cost changes may be delayed (Nakamura and Zerom, 2008). In the context of pre-announced tax rate changes, retailers may also start adjusting prices before implementation. Those pre- and post reform changes in prices could cause earlier consumer responses before implementation and later responses after implementation (see theoretical appendix).

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 product (model) level on unit sales and scanner prices of durable "white goods" for all countries of the European Union, except Bulgaria, Croatia, Cyprus, Ireland, Luxembourg and Malta. The white goods encompass eight major categories: Cookers, refrigerators (coolers), dishwashers, freezers, cooktops (hobs), hoods, tumble driers and washing machines. Each individual product has a unique identification number (id) and a set of physical characteristics. The identifier is the same over time and across countries in case a product is sold in more than one Member State. Table A-1 summarizes the coverage of the data by country and category and Table A-4 provides a detailed description of all available category-specific features. The time period generally extends for 117 months, from January 2004 until September 2013, although data coverage is shorter for some countries.

The units sold of a product in a given country and a specific month is the sum of all sales of this product across all retailers in the country in the respective month. The corresponding price is a monthly unit sales-weighted average of all prices for this product across retailers. Prices are inclusive of consumption taxes and possible discounts received by consumers. Refer to Section A.1.1 in the Appendix for more details on the data generation process.

Annual descriptive statistics disaggregated by product category are presented in Table A-2. For each year, the raw data covers around 110,000 different products with 62 million units sold, and an average annual market size of 26 billion Euro. In terms of quantity and value of sales, refrigerators and washing machines constitute the two biggest categories. While the annual number of products is stable at around 110,000, the composition changes over time, with new products entering the market and older ones exiting. The life cycle, *i.e.* the change in the number of units sold over time for products introduced in a particular year is depicted in Figure 1.[3] Clearly, sales are inversely proportional to a product's age. In the first year, sales of new products account for, on average, 20-25% of the total units sold, peak in the second year, and peter out afterwards. About 80% of new entries drop out of the market in 5 to 6 years. This pattern does not vary much across individual product categories.

Panel A of Table 1 reports descriptive statistics for the basic data per model, country and month. The monthly sales of a product averaged over time, countries and models amount to 50 units and exhibit considerable dispersion ranging from 0 to 25,000 units. The average price in Euro is 527. Detailed analysis of the dataset in terms of missing values, zero values, outliers, and a description of all transformations applied to the data for the purposes of descriptive statistics and the generation of estimation samples are provided in Section A.1.2 in the Appendix.

Two statistics refer to a product's life-cycle: the "product age", reporting the number of months the sales of a product are recorded in any country, and the "market age", which reports the number of months a product is sold in a specific market (country). As the mean of the market age is only three months less than the mean product age, the data points at a rather synchronized market introduction

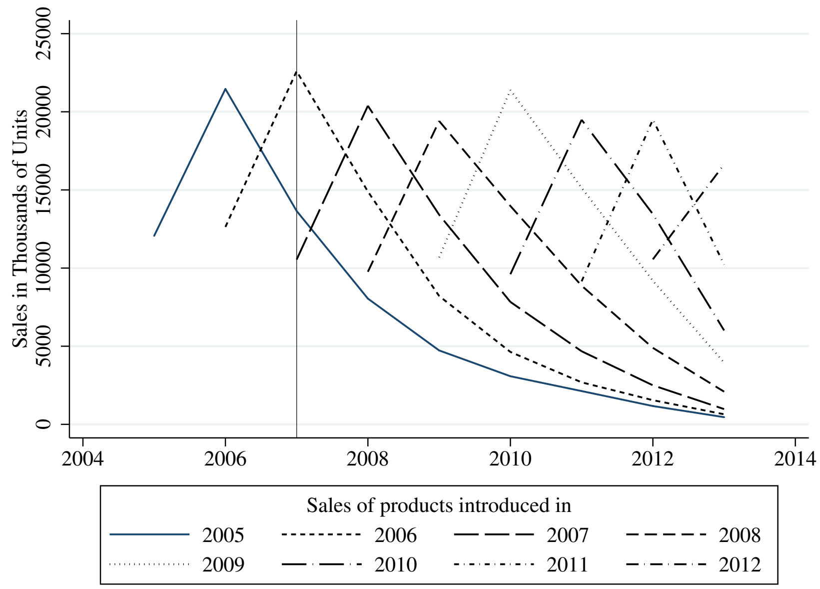
[3]Products' years of introduction are based on the assumption that the first year a product appears in the data (in any country), is the year, in which it was introduced. GfK provided us with a sample plot with exit and entry of fridges based on actual dates of introduction and exit, which was closely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

Table 1: DESCRIPTIVE STATISTICS

	Mean	Std. Dev.	Min	Max	N
	A. Basic dataset				
№ Units sold	50.35	185	0	24,965	12,296,125
Price (Euro)	527	388	0.004	29,826	10,887,367
Product age (months)	30.46	23.22	1	117	20,651,469
Market age (months)	26.87	22.27	1	117	20,651,469
Rank	892	798	1	5,364	20,651,469
	B. Estimation sample (identical products sold in two or more countries)				
№ Units Sold	59.96	181	0*	19,062	4,126,760
$dlog(UNITS)$	-0.016	0.892	-22.3	22.2	4,126,760
Price (Euro)	559	367	0.300	11,392	4,032,501
$dlog(PRICE)$	-0.003	0.092	-0.693	1.10	4,032,501
Market Age (Months)	25.65	17.01	2	117	4,129,009
Rank	450	486	1	5,364	4,129,009
R50	0.180	0.384	0	1	4,129,009
R100	0.307	0.461	0	1	4,129,009
Standard VAT rate	0.205	0.023	0.15	0.27	4,129,009
Unemployment rate	8.54	4.08	3.1	27.8	4,129,009
	C. Estimation sample (products with identical characteristics sold in two or more countries)				
№ Units Sold	67.06	213	0*	24,965	7,784,367
$dlog(UNITS)$	-0.022	0.917	-22.7	22.5	7,784,367
Price (Euro)	539	361	0	23,230	7,496,238
$dlog(PRICE)$	-0.003	0.094	-0.693	1.10	7,596,937
Market age (months)	25.82	18.0	2	117	7,784,367
Rank	553	577	1	5,364	7,784,367
R50	0.159	0.366	0	1	7,784,367
R100	0.274	0.446	0	1	7,784,367
Standard VAT rate	0.201	0.023	0.15	0.27	7,784,367
Unemployment rate	8.78	4.14	3.1	27.8	7,784,367

The table shows summary statistics per model per country per month averaged across time, countries, and models. Data in Panel B is restricted to products sold in at least two countries at the same time. Data in Panel C is restricted to groups of products with an identical set of characteristics traded in at least two countries. Product (market) age captures the number of months a product is sold (in a specific country). A best-selling model in any country, year, and category has a rank 1. $R50/R100 = 1$ if a model reaches a rank ∈[1,50]/[1,100] at least once. The exact value of the entries marked with asterisk is 1.00E^{-08}. For detailed description of the data generation process and all data transformations applied to Panels A, B, and C, refer to Section A.1 in the Appendix.

Figure 1: PRODUCT LIFECYCLE BY YEAR OF INTRODUCTION



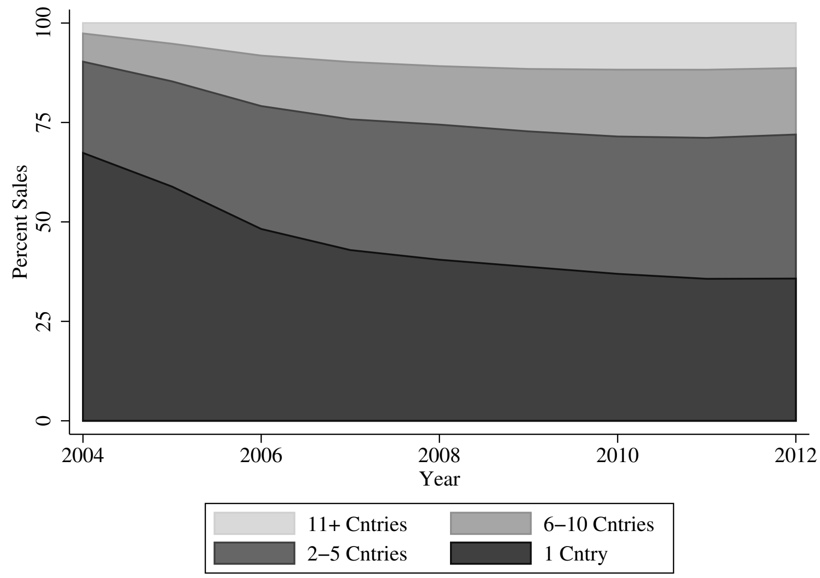
Note: The figure depicts the annual evolution of unit sales by products' year of introduction. The intersection points with a vertical line at a given year denote the number of unit sales within that year based on their years of introduction. For example, in 2007, sales of products introduced in 2005 constituted 21% of total sales, products launched in 2006 – 34%, and new products (launched 2007) –16%. The remaining 29% of sales were of products first appearing in the data in 2004 and not shown in the figure.

of products across countries. 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. Thus, the best selling refrigerator in Germany in a given year has a rank one. $R50$ ($R100$) are binary indicators for top-selling models. They equal unity if a model is part of the top 50(100) best-selling products within its respective category at least once during its life cycle.

Panels B and C present descriptive statistics on two restricted samples used in the empirical analysis in Section 6. Panel B removes all products sold in only one country in a given year, and from the remaining products, only those sold contemporaneously in several countries are kept. Compared to Panel A, the restriction leads to the loss of more than half of all observations for units sold and prices, but within a year the products in this sample comprise 51% of all units sold and generate 58% of the value of sales on average (see Table A-2 and Section A.1.2).

The number of products sold in multiple countries increases over time. Figure 2 reports the changing composition of sales disaggregated by number of countries in which products are marketed. While products sold in a single country generated 67% of the total number of units sold in 2004, their share dropped to 35% in 2012, with sales of products sold in two to five countries steadily taking over.

Figure 2: COMPOSITION OF UNIT SALES BY NUMBER OF COUNTRIES IN WHICH PRODUCTS ARE SOLD



Note: The figure depicts the development over time in the share of units sold (percent from total units) of products sold in one country, two to five countries, six to ten countries and in eleven or more countries.

The observation of sales and prices of individual products in multiple countries means that the consumption tax rate varies not only across countries over time, but – for models sold simultaneously in multiple markets – the tax rate also varies within each cell of observations comprising the sales and prices of an individual model in a specific time period. It is this characteristic of the data that we exploit in our main identification strategy as explained in Section 5.

Unlike Panel B, which looks at *identical products* sold in multiple markets, Panel C of Table 1 focuses on groups of products with an *identical set of physical characteristics* sold in multiple markets. Products with missing characteristics are removed (Section A.1.2). This sample re-incorporates models sold in a single country and is used for a robustness check in the subsequent empirical analysis.

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.[4] While from 2004 until 2013 the VAT rates in Austria, Belgium, France, Sweden and Denmark remained unchanged, the other countries in the data altered the standard rate 33 times, which provides time and within country/within product variation.

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 in the time period under investigation. Close to 80% of all tax reforms considered in this paper took place between 2008 and 2013, with the vast majority being tax increases (tax decreases occurred in only 5 instances). Table A-3 in the Appendix describes in detail the magnitude of changes in the standard VAT rate, the date of implementation, 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, on media reports.

Among the thirty three reforms considered in this paper, there is substantial heterogeneity in the time between announcement and implementation, *i.e.* the implementation lag. As shown in Figure A-1 in the Appendix, the implementation lag ranges from one and a half years to three days. The median length of the time-interval is a little over a quarter of a year. In seven cases, announcements occurred less than a month before their 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.[5]

The 2008 UK reform fits well within what the so-called narrative approach to analyzing fiscal

[4]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 products in very narrow time frame.

[5]The 2008 United Kingdom reform is the only explicit temporary tax change. In all other countries, tax changes where enacted as permanent.

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*" (*cf.* Romer and Romer, 2010, p.769). Relying on endogenous tax reforms when studying how sales and prices of durables react to tax changes could be misleading, since it might 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 countries and in Greece, enacted as a consequence of a fiscal crisis and limited access of these governments to international credit markets (Gunter, Riera-Crichton, Végh and Vuletin, 2017).

We address the role of policy endogeneity by categorizing the 33 VAT reforms studied in this paper in terms of endogeneity/exogeneity and check whether our results change when we exclude 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 A-3 adds information on two reforms not classified by Gunter *et al.* (2017), and separates all reforms into 18 endogenous and 15 exogenous tax changes.

4 The Cases of Germany and Spain

The above analysis assumes that consumers are well aware of a forthcoming tax increase/decrease. This section focuses in more detail on Germany and Spain to check this assumption using data on the press coverage of tax reforms. It also explores whether sales and price effects of tax-rate changes are visible in the raw data.

The German VAT increase of 3pp. in 2007 is discussed in detail by D'Acunto *et al.* (2016) and Carare and Danninger (2008). As a reform not tackling current or projected economic conditions, it meets the exogeneity criteria of Romer and Romer (2010).[6] In contrast, the VAT increases in Spain

[6]Based on Romer and Romer's (2010) classification, tax changes serving long-run objectives, or those addressing

in 2010 (by 2pp.) and 2012 (by 3pp.) took place in a more difficult macroeconomic environment and were clearly motivated by fiscal predicaments in the aftermath of the 2008 financial crisis. Consequently, 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 implementation lag for the second Spanish VAT increase was only a month and a half.

Figure A-2 in the Appendix 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, one at the announcement date and one in the month before the implementation, even though the reform was being discussed continuously throughout 2006. Similarly to Germany, Figure A-3 depicts the number of articles discussing the Spanish reforms based on three main newspapers, with the second reform receiving almost double the coverage, which is not surprising given its short announcement and political context.

Figure A-4 in the Appendix shows annual growth rates of sales and prices in Germany and Spain relative to the same month of the previous year. Panel A depicts a strong growth in sales, especially in the last two to three months before the implementation of the 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.[7] Carare and Danninger (2008), who study the same tax reform

past economic conditions such as tax increases dealing with an inherited budget deficit, are treated as exogenous.

[7]The growth rate of unit sales jumps also in December 2005, one month after the VAT increase was announced (see also Fig. A-4). When we disaggregated the response by categories of products (see Fig. A-5 in the Appendix), 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 of 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-6 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

episode in Germany, but focus on all CPI items liable to VAT relative to non-VAT goods, report a similar pre-reform jump in sales, but find that price increases were phased in during 2006.

As shown in Panel B of Figure A-4, the market for white goods in Spain shrank considerably from 2007 to 2012. Against this negative trend, the two VAT reforms are associated with temporary pre-reform peaks in sales. In contrast to the German case, at least after the first reform, sales seem not to recover. 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.

5 Methodology

Changes of the standard tax rate of general consumption taxes and VAT apply equally to most goods. Hence, there is no readily available control group of comparable goods, whose 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 other 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 products within the EU common market. In addition, the data covers a period characterized by a relatively 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 discussion suggests that a pre-announced change of the tax rate affects the time path of the sales of durables in three periods. In case of a tax

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.

increase, for example, the first period affected is the time preceding the tax-rate change, since consumers take advantage of the temporary decline in the user cost of the stock of durable goods and bring purchases forward. Second, at the time of implementation, sales fall due to intertemporal substitution and the reversal of the user cost. Third, in the subsequent time period, sales recover offsetting the temporary decline. Measuring the rate of change in sales with the log difference of units sold, $\Delta \log(UNITS)_{icd}$, of a product i in country c at date d, we formulate the following estimation equation:

$$\begin{aligned} \Delta \log(UNITS)_{icd} &= \sum_{j=1}^{p} a_j \mathsf{L}^{-j} \Delta\tau_{cd} + b\Delta\tau_{cd} + \sum_{j=1}^{q} d_j \mathsf{L}^{j} \Delta\tau_{cd} + aX_{icd} \\ &+ \alpha_{id} + \rho_c + \gamma_{cm(d)} + u_{icd}. \end{aligned} \tag{5.1}$$

Note that the date d varies by month and year such that each observation 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, $\mathsf{L}^{-j}\Delta\tau_{cd}$ is a lead term, capturing the j-month-ahead change in the tax rate, and $\mathsf{L}^{j}\Delta\tau_{cd}$ is the change in the tax rate lagged by j-months, where p and q indicate the number of leads and lags of the tax-rate change. If adjustment cost is unimportant and price-pass through is quick, the time intervals before and after the tax-rate change will be short and $p, q = 1$. In this case, $a_1 > 0$, $b < 0$ and $d_1 > 0$. However, if adjustment cost is large or if the price-pass through takes more time, setting $p, q = 1$ would exclude systematic effects on pre-reform outcomes, and hence, could result in a bias (see Malani and Reif, 2015). Hence, the empirical analysis allows $p, q > 1$, and tests for tax effects using wider pre- and post-reform windows.

α_{id} denotes a product-date-specific fixed effect that absorbs any product specific movements in sales. Incorporating a product fixed effect is essential since each product has specific features that distinguish it from other products in the market. But, given technological progress and product innovation, the (relative) quality of a product and, hence, its attractiveness to consumers vary over time. This is reflected in the striking product-cycle patterns displayed in Figure 1. Inclusion of product-date fixed effects α_{id} ensures that identification only comes from differences in the growth rate of sales of the same product across countries.[8]

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 each product-date cell. In case of a consumption tax reform in country c, the sales of product i at date d are compared to the sales in all other countries in which product i is available. Consequently, we restrict the sample to products sold in at least two countries at the same time. Note that the product-date-specific fixed effects also capture differences in the size of individual cells driven by the varying number of countries, in which products are traded.

Since the variation in tax policy takes place at country level over time, standard errors produced by a fixed-effects panel regression at product level may suffer from random-group bias (Bertrand, Duflo, and Mullainathan). Therefore, we provide standard error estimates adjusted for clustering at country level among each product category.

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, the sales of a product would have followed the same time trend as the sales of this product in the no-reform countries $r \neq c$. As different trends might be associated with the business cycle, X_{icd} includes the monthly unemployment rate in country c as an explanatory variable. In order to deal with differences in seasonality of sales across countries, we include a country-specific fixed effect for each month $\gamma_{cm(d)}$ together with a 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 product has been sold in a specific country: The market age, $M.age$, varies by country within a product-date cell, if this product does not enter all markets at the same time. For the purpose of capturing non-linear product cycle effects, $M.age$ is also entered squared.

Since the data provides separate information on prices, we explore whether and to what extent the data supports complete and immediate pass-through of taxes into prices. To this end, we follow the

[8] In an analysis of subsidy effects on car sales at product level, Li, Linn and Spiller (2013) follow a similar approach and employ product-year-specific fixed effects.

same estimation strategy and use differences in outcomes within a product-date cell 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

$$\begin{aligned} \Delta \log(PRICE)_{icd} &= \sum_{j=1}^{P} A_j \mathsf{L}^{-j} \Delta\tau_{cd} + B\Delta\tau_{cd} + \sum_{j=1}^{Q} D_j \mathsf{L}^{j} \Delta\tau_{cd} + \alpha X_{icd} \\ &+ \alpha_{id} + \rho_c + \gamma_{cm(d)} + \nu_{icd}. \end{aligned} \quad (5.2)$$

$\Delta \log(PRICE)_{icd}$ denotes the difference in the log consumer price of product i in country c in month d relative to the previous month. As before, α_{id}, ρ_c, and $\gamma_{cm(d)}$ denote product-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. (5.2) 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 can be interpreted as a pass-through elasticity (Benedek *et al.* (2015)). 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 pass-through is included as a special case, which requires that $B = 1$ and $A_j = D_j = 0$.

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.[9] 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 A-3 and replace j-period ahead lead terms, $\mathsf{L}^{-j}\Delta\tau_{cd}$, with their expected values $\mathsf{E}_{d-j}\left[\mathsf{L}^{-j}\Delta\tau_{cd}\right]$ taking account of the precise point

[9] 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 centered around the month of implementation.

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 $\mathsf{E}_{d-j}\left[\mathsf{L}^{-j}\Delta\tau_{cd}\right] = 0,\ \forall j > n$, whereas $\mathsf{E}_{d-j}\left[\mathsf{L}^{-j}\Delta\tau_{cd}\right] = \mathsf{L}^{-j}\Delta\tau_{cd},\ \forall j \leq n$. While this ensures that the specification fully reflects publicly available information about upcoming reforms, higher-order lead terms mix pre-reform responses with announcement effects. In addition, the 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. A-1. As a consequence, estimates of the pre-reform response are likely biased due to composition effects. Table A-5 lists the number of reforms and countries identifying the coefficients for leads of order $j \in [1, 14]$. Clearly, the number of reforms captured by a lead term is declining for higher order 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 A-1 shows that the median implementation lag is about a quarter. Therefore, we focus on leads in the interval $j \in [1, 3]$. 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 A-1). In these cases, one can neither separate the effects of government policy from those of the economic shocks that may have triggered the government intervention in the first place, nor distinguish the income effect associated with the announcement of tax-policy changes from the effects on the consumption path. For this reason, we also provide results of specifications excluding these reforms. In the empirical section below, we generally consider the same pre-reform window range for unit sales as for prices.

Given the size of the EU common market, tax rate changes in a single EU country can be affected to exert no important effects on the total market. However, if a product is sold just in say two markets, and one market is hit by a consumption-tax-induced demand shock, the country without a tax rate change might not serve as a valid control group. The reason is that, a strong demand shock in one country may change prices and hence exert effects also in the other country. An alternative reason for cross-country effects of tax reforms is cross-border shopping.

Generally, the existence of those cross-country effects of tax rate changes 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 of sales effects would vary in specifications using products sold in an increasing number of countries.[10]

Restricting the sample to products sold in two or more countries for the purposes of identification can lead to estimates that are specific to this group, if products sold in a single country differ systematically from those sold in multiple countries. The latter might be of higher quality and more expensive, compared to single-country products, which are probably domestically produced or specifically designed for a market. The incentives to buy before and after consumption tax reforms could, therefore, vary between these two types of products.

As a robustness check, we employ an alternative approach to identifying the tax effects in equations (5.1) and (5.2), which enables us to re-incorporate single-country products into the estimation sample by using larger cells comprising not just identical products, but a group of products with the same characteristics. A drawback of this procedure is that, due to the limited number of available characteristics (Table A-4), there will be heterogeneity left in the individual group-date cells. If the basic parameters shaping the optimal time path of demand for single and multi-country products are the same, the estimates resulting from this approach should be similar to those obtained from specifications that focus on cells composed only of identical products.

6 Results

6.1 Basic Results

Results from a basic specification of tax effects on sales of durables following eq. (5.1) are presented in Table 2. The estimation sample includes data for 22 EU countries.[11] We explore the

[10] As the same identification approach is used for prices, spillover effects could also bias the coefficient estimates of eq. (5.2). Consequently, similar robustness tests are applied to the estimates of price effects.

[11] 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,

effects of 33 consumption tax reforms that altered the baseline consumption tax rate. As summarized in Table 1, the sample employs data for approximately 72,000 unique products sold in at least two countries, resulting in about 1,330,000 product-date pairs, and over 4 million product-country-date observations.

The estimation results presented in Table 2 have with pre- and post implementation periods restricted to one month each. The first column of reports estimates from a specification using only product-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 due to differences in the timing of holidays, for instance. In this specification, the contemporaneous tax effect is larger and the lagged response smaller. Column (3) additionally controls for the market age, $M.age$, as well as $M.age^2$. The estimates indicate that sales growth declines with the number of months a product is sold in a country.[12] 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 error for all tax terms.

The point estimates in column (3) indicate that a tax increase by 1 percentage point causes sales to rise by 2.4% in the last month with a low tax rate. Once the higher tax rate is implemented, sales drop by about 4.4% 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 consumer prices However, the coefficient of the lagged change in the tax rate is at odds with the theoretical predictions, since it indicates that sales do not recover in the month after the tax change. Instead, with a tax-rate increase of 1 percentage point, sales decline further by 1.7%. With this caveat in mind, note that the sum of the coefficients for lead, lagged, and contemporaneous tax change effects is about 3.7 in the basic specifications, indicating that spending drops by 3.7% in the long-run.

2010, respectively.

[12]To avoid reporting very small coefficients $M.age$ and $M.age^2$ are scaled by $1/100$ and $1/100^2$ in the estimations.

Table 2: BASIC ESTIMATES OF SALES EFFECTS

	(1)	(2)	(3)	(4)
$\mathsf{F}\Delta\tau_d$	2.615	2.444	2.426	2.421
	(0.366)	(0.314)	(0.315)	(0.340)
$\Delta\tau_d$	-3.817	-4.338	-4.350	-4.412
	(0.648)	(0.415)	(0.415)	(0.436)
$\mathsf{L}\Delta\tau_d$	-2.146	-1.700	-1.717	-1.754
	(0.433)	(0.289)	(0.291)	(0.313)
$Unempl$	0.001	0.001	0.001	-0.001
	(0.000)	(0.000)	(0.000)	(0.002)
$M.age$			-0.485	-0.532
			(0.038)	(0.038)
$M.age2$			0.420	0.468
			(0.040)	(0.041)
$Constant$	-0.023	-0.024	0.058	0.085
	(0.002)	(0.002)	(0.006)	(0.015)
Cumulative Effects				
Total $(a_1 + b + d_1)$	-3.349	-3.594	-3.640	-3.744
	(0.544)	(0.453)	(0.454)	(0.571)
Month-country effects	No	Yes	Yes	Yes
Year-country effects	No	No	No	Yes
N	4,126,760	4,126,760	4,126,760	4,126,760
Product-date effects	1,331,154	1,331,154	1,331,154	1,331,154
Products	72,056	72,056	72,056	72,056

Notes: Regressions in columns (1)-(4) are based on data for 22 EU countries. 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 monthly change in the standard VAT rate is denoted by $\Delta\tau_d$. The lead term, $\mathsf{F}\Delta\tau_d$, captures all reforms in the month before their implementation. The lag term, $\mathsf{L}\Delta\tau_d$, refers to the month after implementation. $Unempl$ is the monthly unemployment rate. $M.age$ is the number of months a product appears in the data in a specific country, scaled by $1/100$. All specifications include a full set of product-date specific (id) and country-specific fixed effects. Standard errors in parentheses are robust in all specifications and clustered by product category-country.

6.2 Price Effects

The basic estimates of sales effects presented above rest 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 possibly more accurate empirical representation of the price response, this subsection studies the dynamics of price adjustment to VAT rate changes.

Table 3 reports results of a regression of the monthly (log) change in consumer prices on tax-rate changes following eq. (5.2) 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 2. Column (1) reports a contemporaneous price increase of 0.22% if the tax rate increases by 1 percentage point, 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 some time 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 at usual levels of significance. Widening the window to three months before and after implementation 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 but do not account for the different implementation lags of reforms. As discussed above, in several cases, this means that the estimation uses information on tax policy that, in fact, was not available to consumers. To remedy this, 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 before and after implementation (column (4)), the estimated

Table 3: PRICE EFFECTS

Reforms	All			All		$n \geq 1$		n>3
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\mathsf{F}^3\Delta\tau_d$			0.154					
			(0.033)					
$\mathsf{F}^2\Delta\tau_d$			-0.104					
			(0.064)					
$\mathsf{F}\Delta\tau_d$		0.116	0.116					
		(0.031)	(0.031)					
$\mathsf{E}\left[\mathsf{F}^3\Delta\tau_d\right]$					0.220		0.250	0.229
					(0.037)		(0.037)	(0.043)
$\mathsf{E}\left[\mathsf{F}^2\Delta\tau_d\right]$					0.045		0.034	0.116
					(0.027)		(0.028)	(0.033)
$\mathsf{E}\left[\mathsf{F}\Delta\tau_d\right]$				0.126	0.126	0.141	0.142	0.158
				(0.031)	(0.032)	(0.032)	(0.032)	(0.035)
$\Delta\tau_d$	0.219	0.219	0.217	0.219	0.218	0.164	0.163	0.100
	(0.047)	(0.047)	(0.046)	(0.047)	(0.047)	(0.038)	(0.037)	(0.043)
$\mathsf{L}\Delta\tau_d$		0.388	0.387	0.389	0.389	0.432	0.431	0.507
		(0.037)	(0.037)	(0.037)	(0.037)	(0.034)	(0.034)	(0.035)
$\mathsf{L}^2\Delta\tau_d$			-0.126		-0.128		-0.125	-0.250
			(0.046)		(0.045)		(0.051)	(0.043)
$\mathsf{L}^3\Delta\tau_d$			0.086		0.086		0.104	0.160
			(0.031)		(0.031)		(0.032)	(0.041)
Cumulative Effects								
Total	0.219	0.723	0.730	0.734	0.956	0.737	0.999	1.021
	(0.047)	(0.050)	(0.069)	(0.050)	(0.070)	(0.047)	(0.070)	(.086)
Pre-reform		0.116	0.166	0.126	0.391	0.141	0.426	0.504
		(0.031)	(0.087)	(0.031)	(0.055)	(0.032)	0.056)	(0.061)
Post-reform		0.608	0.564	0.608	0.565	0.596	0.573	0.517
		(0.043)	(0.062)	(0.043)	(0.062)	(0.038)	0.052)	(0.056)
Pass-through F(1)		30.00	15.34	28.46	0.39	30.82	0.00	0.06
N	4,032,508	4,032,508	4,032,508	4,032,508	4,032,508	3,916,700	3,916,700	3,747,035
Product-date effects	1,302,880	1,302,880	1,302,880	1,302,880	1,302,880	1,275,887	1,275,887	1,227,989
Products	71,223	71,223	71,223	71,223	71,223	70,663	70,663	71,167

Notes: Regressions are based on data for 22 EU countries. The dependent variable is the change in the logarithm of the actual consumer price $\Delta \log(PRICE)$. The data is restricted to goods sold contemporaneously in at least 2 countries. Estimates in columns (6) and (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. The monthly change in the standard VAT rate is denoted by $\Delta\tau_d$. Note that $\mathsf{E}\left[\mathsf{F}^j\Delta\tau_d\right] = \mathsf{F}^n\Delta\tau_d$ for all reforms that were announced $n > j$ periods ahead, and $\mathsf{E}\left[\mathsf{F}^j\Delta\tau_d\right] = 0$ for reforms announced $n \leq j$. All specifications include a full set of product-date, country, and country-month fixed effects. The monthly unemployment rate, $Unempl$, and the number of months a product appears in the data in a specific country, $M.age$, as well as $M.age^2$ are controlled for but not reported. Standard errors in parentheses are robust in all specifications and clustered by product category-country.

magnitude of the total pass-through, 73%, is not statistically different from the case with no announcements (column (2)). However, the ex-ante price adjustment rises to 39% once a longer window is employed, with all leading terms in specification (5) exhibiting larger and consistently positive coefficients in contrast to specification (3). As the post-reform pass-through implied by specification (5) is 57%, the cumulative price effect is not significantly different from unity at usual levels of significance (F-statistic of 0.55). This suggests that full price pass-through occurs within a seven-month period – three months before and three months after the tax-rate change. The substantially higher estimate of the pre-reform pass-through in column (5) in comparison to (3) clearly highlights the importance of the announcement information: Despite a sufficiently long window, the specification in (3) would point to an incomplete pass-through of taxes.

Columns (6) and (7) exclude observations associated with reforms pre-announced by less than a month, since the pre-reform adjustment may capture the effect of the announcement itself, as well as the effect of the economic circumstances that have motivated the government to act quickly.[13] The pre-reform pass-through effects are found to be qualitatively and quantitatively similar to those reported in columns (4) and (5). The estimates in column (7) indicate that a tax rate increase by 1 percentage point causes consumer prices to rise by 0.43% before the reform and by 0.57% after the reform, one third of which is a contemporaneous effect. Again, the cumulative price effect in this specification is equal to unity, which is consistent with full price pass-through.

A closer inspection of column (7) of Table 3 reveals that price pass-through starts a quarter prior to a tax-rate change and is already completed by the second month after implementation. Figure 3 provides a graphical representation of this development by plotting the cumulative coefficients of a regression including four leads and lags of the tax rate change. All in all, it takes five months for the tax-rate change to be fully reflected in consumer prices.

Even though the results presented in columns (6) and (7) focus on tax-rate changes that were announced before implementation, it seems possible that they capture income effects to some extent.

[13]Observations are excluded six months before and six months after implementation for products in the relevant countries and years, without removing the product from the data in non-reform years, or its sales in other countries. See Section A.1.2 for description of the exact procedure.

As a robustness check, we restrict attention to those tax-rate changes, where the time-interval between announcement and implementation is longer. Following the classification of Mertens and Ravn (2012), a tax shock may be regarded as anticipated only if the time-interval exceeds 90 days. Column (8) provides results obtained by focusing on the corresponding tax-rate changes. The results are found to be similar indicating full price pass-trough with half of the price adjustment taking place after the implementation. This suggests that income effects are not important for the empirical adjustment path of prices.

The pass-through estimates are also robust to a more demanding identification strategy achieved through sample reduction. Excluding reforms announced less than a month before their entry into force and using expected values of tax-rate changes as in columns (6) to (7) of Table 3, Table A-6 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 product-date cell. The null hypothesis of full pass-through cannot be rejected at usual levels of significance, even when the sample is down to 6,690 products traded in at least eight countries.

6.3 Generalized 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 tax reforms. This implies that the pre-reform response 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 4 applies a specification with additional leads and lags of the tax rate change. All specifications include a full set of product-date, country and country-month fixed effects and the same controls as in column (3) of Table 2. 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 three months before a tax-rate change. With regard to lagged terms, demand continues to decline in the second month after the tax rate change, and only the third month shows a recovery. The specifications in columns (3) and (4) employ the expected rather than the actual tax-rate change to capture pre-reform effects. The coefficients for the pre- and post-reform effects are similar to those in columns (1) and (2). Columns (5)-(6) report estimates obtained after excluding observations before and after reforms for which the time-interval between announcement and implementation is less than a month. Column (7) focuses on reforms for which this interval exceeds three month.

Across specifications with the same order of leads and lags the results show minor differences indicating that the parsimonious specification for sales is not much affected by implementation lags. Only the exclusion of reforms implemented on short notice in columns (5) and (6) point to somewhat stronger effects in the month of implementation. The estimation results presented in column (7) are based on the sub-set of tax-rate changes announced more than three months before implementation. Compared with column (6), the results are qualitatively similar: the total cumulative effect is about the same and also the relative magnitudes of pre- and post implementation effects are similar. To check further 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. Also, adding higher order lags of the tax-rate change did not yield significantly different results. Visually, the estimated coefficients from a regression adding fourth order lead and lag are displayed in Panel B of Figure 3.

The identification of tax effects in our analysis relies on differences in the consumption tax treatment of a product across countries. As noted in Section 5, this strategy might be invalidated by cross-country effects of tax-rate changes. To check for the presence of such effects, Table A-7 in the Appendix 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 product-date cells. The estimates are similar to the benchmark results presented in column (6) of Table 4.

Table A-8 in the Appendix performs another robustness check on whether the estimates using

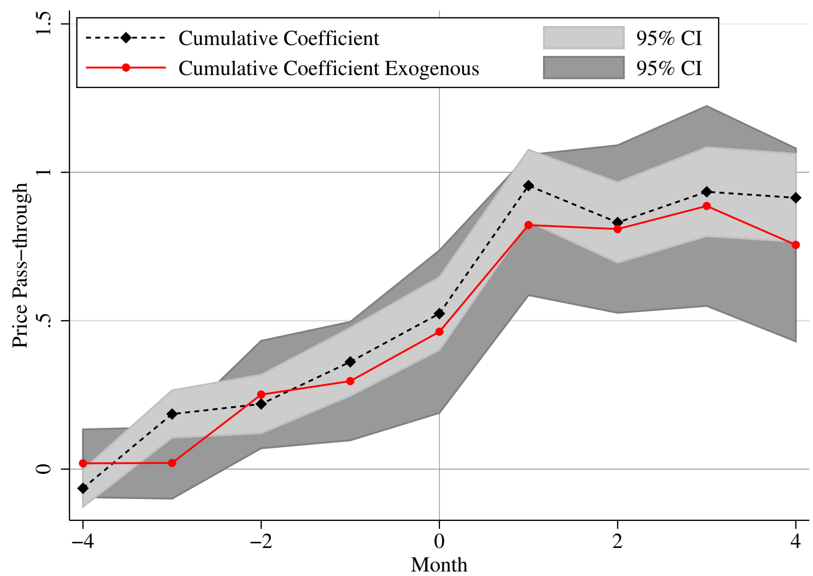
Table 4: GENERALIZED ESTIMATES OF SALES EFFECTS

Reforms	All		All		n ≥ 1		n>3
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\mathsf{F}^3\Delta\tau_d$		-0.850					
		(0.296)					
$\mathsf{F}^2\Delta\tau_d$		-0.218					
		(0.306)					
$\mathsf{F}\Delta\tau_d$	2.426	2.397					
	(0.315)	(0.313)					
$\mathsf{E}\left[\mathsf{F}^3\Delta\tau_d\right]$				-0.833		-0.937	-1.345
				(0.362)		(0.371)	(0.365)
$\mathsf{E}\left[\mathsf{F}^2\Delta\tau_d\right]$				-0.331		-0.416	-0.030
				(0.316)		(0.320)	(0.428)
$\mathsf{E}\left[\mathsf{F}\Delta\tau_d\right]$			2.349	2.320	2.464	2.455	2.241
			(0.324)	(0.324)	(0.327)	(0.326)	(0.383)
$\Delta\tau_d$	-4.350	-4.357	-4.351	-4.358	-4.797	-4.806	-4.387
	(0.415)	(0.414)	(0.415)	(0.414)	(0.440)	(0.439)	(0.477)
$\mathsf{L}\Delta\tau_d$	-1.717	-1.689	-1.716	-1.702	-1.432	-1.417	-1.891
	(0.291)	(0.290)	(0.291)	(0.292)	(0.305)	(0.304)	(0.325)
$\mathsf{L}^2\Delta\tau_d$		-0.456		-0.453		-0.452	0.186
		(0.289)		(0.289)		(0.309)	(0.361)
$\mathsf{L}^3\Delta\tau_d$		1.197		1.198		1.193	0.702
		(0.306)		(0.306)		(0.290)	(0.302)
	Cumulative Effects						
Total	-3.640	-3.976	-3.717	-4.159	-3.765	-4.379	-4.525
	(0.454)	(0.553)	(0.453)	(0.592)	(0.506)	(0.612)	(0.724)
Pre-reform	2.426	1.329	2.349	1.156	2.464	1.102	0.865
	(0.315)	(0.454)	(0.324)	(0.512)	(0.327)	(0.504)	(0.558)
Post-reform	-6.066	-5.304	-6.067	-5.315	-6.229	-5.481	-5.390
	(0.417)	(0.531)	(0.417)	(0.530)	(0.450)	(0.582)	(0.660)
N	4,126,760	4,126,760	4,126,760	4,126,760	4,006,044	4,006,044	3,834,262
Product-date effects	1,331,154	1,331,154	1,331,154	1,331,154	1,302,736	1,302,736	1,254,537
Products	72,056	72,056	72,056	72,056	71,492	71,492	72,003

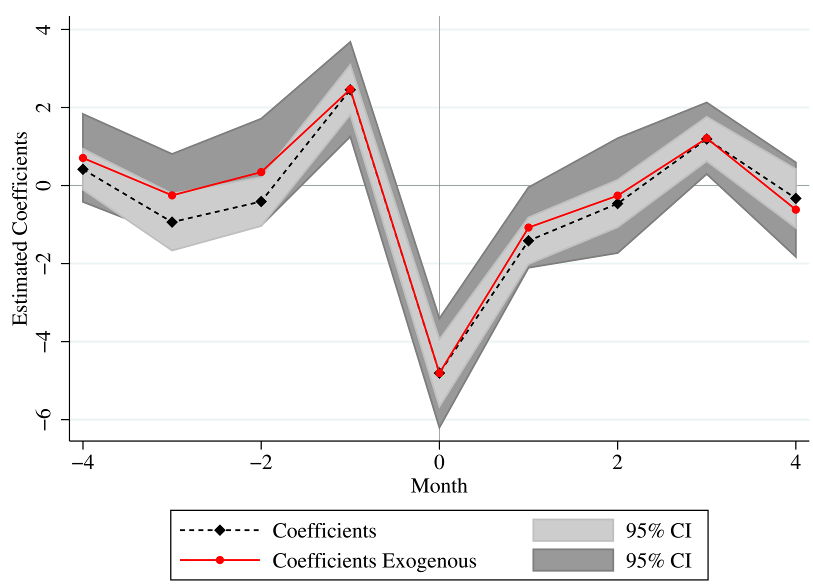
Notes: Regressions are based on data for 22 EU countries. The dependent variable is the change in the logarithm of sales, $\Delta\log(UNITS)$. The data is, restricted to goods sold contemporaneously in at least 2 countries. Estimates in columns (5) and (6) are based on a reduced sample, in which observations in countries with reforms announced less than a month before implementation, are removed around the respective reform date. The monthly change in the standard VAT rate is denoted by $\Delta\tau_d$. Note that $\mathsf{E}\left[\mathsf{F}^j\Delta\tau_d\right] = \mathsf{F}^n\Delta\tau_d$ for all reforms that were announced $n > j$ periods ahead, and $\mathsf{E}\left[\mathsf{F}^j\Delta\tau_d\right] = 0$ for reforms announced $n \leq j$. All specifications include a full set of product-date, country, and country-month-specific fixed effects. The monthly unemployment rate, $Unempl$, and the number of months a products appears in the data in a specific country, $M.age$, as well as $M.age^2$ are controlled for but not reported. Standard errors in parentheses are robust in all specifications and clustered by product category-country.

Figure 3: DYNAMICS OF SALES AND PRICES

A. Cumulative Price Pass-through



B. Tax Effects on Change of Sales



Note: Panel A depicts the cumulative sum of the estimated coefficients in a price regression extending the specification in Column (7) of Table 3 by including a fourth lead and lag of the percentage change of the VAT rate. Panel B depicts the estimated coefficients from a corresponding extension of the regression for changes of sales in Column (6) of Table 4 (both not reported). The month of the reform is denoted by zero. In both panels the shaded area captures the 95% confidence interval based on the robust estimate of the covariance matrix.

products traded in at least two countries can be extrapolated to the full sample. It employs an alternative estimation approach, which, as explained in Section 5, groups observations not based on the product identifier, but based on product characteristics. Hence, single-country products are included in the estimation sample as they are grouped together with other products having an identical set of characteristics.[14] Despite heterogeneity within group-date cells as indicated by larger standard errors, the estimates in Table A-8 remain very close to those reported in Table 4.

The above theoretical discussion indicated that pre-reform price effects may arise depending on the price adjustment. If price adjustment is costly, and, therefore, infrequent, firms may start altering prices immediately after announcement. 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 might expect that best-selling products exhibit different price pass-through and sales patterns around a tax-rate change compared to products that sell fewer units. In order to test this expectation, as explained in Section 3, we create binary indicators for market power using the within-year, within-category, and within-country ranking of products on the basis of their volume of sales. The dummy variables $R50$($R100$) equal one for all products that reach ranks between one and fifty (one and hundred) in at least one year throughout their life-cycle.[15]

Table A-9 in the Appendix reports results of specifications extending equations (5.1) and (5.2) by adding the $R50$ or $R100$ dummies and their interactions with all leads, lags as well as the contemporaneous tax variable. Once announcement information is taken into account, the results point to small differences between best-selling and other products. While no significant effects are detected for the sales response, the pre-reform price pass-through of top-selling products is found to be larger. This effect, however, is small relative to the standard error. The absence of market power effects is also confirmed by the analysis of best selling brands, which produdes qualitatively

[14] This procedure results in 686 unique characteristic sets (*e.g.*, 5 kg, 1200 spin speed front-loading washing machines *etc.*) and approximately 50,000 characteristic-set-date fixed effects.

[15] Together, the top 50 products in each of the eight categories of white goods in each country account for 53% of the total number of units sold, on average. On average, they are 30% cheaper and sell 6 times more units per month (average price in euro 402 (s.e. 233), average sales of 157 units (s.e. 356)) relative to products whose rank never exceeds 50 (average price 561 (s.e. 424) and average sales of 27 (s.e. 73).

similar effects (see Section 6.5, below).

6.4 Exogenous Reforms

Table 5 reports results only for tax reforms classified as exogenous (see Table A-3). All observations for the sales and prices of products 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. Given a median implementation lag of three months, this ensures that the immediate, and any pre- and post-reform effects are removed from the estimation sample.[16]

The first three columns of Table 5 show results for prices, which are qualitatively similar to the results presented in Section 6.2. The point estimates are also plotted in Figure 3. When the timing of announcements is taken into account, full price pass-through cannot be rejected at usual levels of significance, and about a third of the price change takes place before a reform's 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 columns (2) and (3) in contrast to the considerably different results with and without announcements documented in Table 3.

Since our data refers to scanner prices they include sales. Hence, the observed price pass-through may be affected by the frequency of sales. If sales are less frequent in recessions, the observed price might increase before endogenous tax rate changes. But the recent literature indicates that the frequency of sales does not decline in downturns (Coibion *et al.*, 2015, and Anderson *et al.*, 2017). However, following Coibion *et al.* (2015) the average price paid is also affected by the effort of consumers to search for a lower price. If consumers are putting less effort into this search before and more effort after implementation of a tax increase, the price adjustment would show the observed pattern.

[16] For example, a product sold in Spain in July 2010 when a tax increase was implemented will have missing values for its Spanish sales and prices from January to December 2010.

Table 5: EXOGENOUS TAX REFORMS

Dependent variable	$\Delta\log(PRICE)$			$\Delta\log(UNITS)$		
Reforms	All		n ≥ 1	All		n ≥ 1
	(1)	(2)	(3)	(4)	(5)	(6)
$\mathsf{F}^3\Delta\tau_d$	-0.011			-0.207		
	(0.051)			(0.518)		
$\mathsf{F}^2\Delta\tau_d$	0.234			0.786		
	(0.061)			(0.668)		
$\mathsf{F}\Delta\tau_d$	0.014			2.480		
	(0.043)			(0.606)		
$\mathsf{E}\left[\mathsf{F}^3\Delta\tau_d\right]$		0.002	0.001		-0.235	-0.252
		(0.051)	(0.052)		(0.536)	(0.541)
$\mathsf{E}\left[\mathsf{F}^2\Delta\tau_d\right]$		0.230	0.230		0.364	0.343
		(0.063)	(0.063)		(0.698)	(0.698)
$\mathsf{E}\left[\mathsf{F}\Delta\tau_d\right]$		0.041	0.045		2.485	2.469
		(0.043)	(0.044)		(0.621)	(0.618)
$\Delta\tau_d$	0.170	0.170	0.166	-4.563	-4.563	-4.806
	(0.083)	(0.083)	(0.085)	(0.710)	(0.710)	(0.713)
$\mathsf{L}\Delta\tau_d$	0.362	0.362	0.359	-1.491	-1.488	-1.079
	(0.066)	(0.066)	(0.068)	(0.541)	(0.541)	(0.525)
$\mathsf{L}^2\Delta\tau_d$	-0.017	-0.017	-0.013	-0.153	-0.149	-0.256
	(0.057)	(0.057)	(0.059)	(0.717)	(0.717)	(0.749)
$\mathsf{L}^3\Delta\tau_d$	0.073	0.073	0.078	1.222	1.222	1.211
	(0.056)	(0.056)	(0.059)	(0.485)	(0.485)	(0.467)
	Cumulative Effects					
Total	0.824	0.861	0.867	-1.927	-2.364	-2.369
	(0.153)	(0.156)	(0.162)	(0.945)	(0.934)	(0.957)
Pre-reform	0.237	0.273	0.277	3.059	2.613	2.560
	(0.092)	(0.094)	(0.094)	(0.759)	(0.772)	(0.783)
Post-reform	0.587	0.588	0.590	-4.986	-4.977	-4.929
	(0.109)	(0.110)	(0.115)	(0.753)	(0.753)	(0.776)
Pass-through F(1)	1.32	0.80	0.68			
N	3,633,795	3,633,795	3,589,523	3,724,133	3,724,133	3,676,201
Product-date effects	1,200,757	1,200,757	1,189,120	1,228,615	1,228,615	1,215,792
Products	69,614	69,614	69,277	70,455	70,455	70,118

Notes: Regression results 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 A-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. The monthly change in the standard VAT rate is denoted by $\Delta\tau_d$. Note that $\mathsf{E}\left[\mathsf{F}^j\Delta\tau_d\right] = \mathsf{F}^n\Delta\tau_d$ for all reforms that were announced $n > j$ periods ahead, and $\mathsf{E}\left[\mathsf{F}^j\Delta\tau_d\right] = 0$ for reforms announced $n \leq j$. All specifications include a full set of product-date, country and country-month specific fixed effects. The monthly unemployment rate, $Unempl$, and the number of months a product appears in the data in a specific country, $M.age$, as well as $M.age^2$ are controlled for but not reported. Standard errors in parentheses are robust in all specifications and clustered by product category-country.

Columns (4) to (6) report the corresponding sales effects. Similar to prices, we find that the sales responses take place in a narrower time interval. Pre-reform effects are concentrated in the last-period before the reform and, cumulatively, are much larger than in the equivalent specifications in Table 4. Conversely, the cumulative post-reform effect is found to be slightly smaller. The recovery in sales is of similar magnitude and shows up three months after the reform, as above. Taken together, the cumulative results for exogenous reforms point to a stronger temporary shift in consumer demand before implementation. The point estimates from our preferred specification (6) suggest that a tax reform, which exogenously raises the tax rate by 1 percentage point triggers a temporary growth of sales by about 2.5 percent in the month preceding the reform. After implementation, sales drop by about 5 percent.

6.5 Differences by Brand and Product Category

The above theoretical discussion has noted that the predicted response of purchases of durables depends on the adjustment cost. In the context of household appliances, this cost might be high, in particular, due to the price differential between new products and the secondary market. Since the price decline between first sale and resale will tend to be steeper for unreliable brands (Hendel, I., Lizzeri, 1999), we should expect the temporary effects of a tax-rate change to differ among brands. To test for this, we have split the sample into three subgroups of products based on the brand. Classification into high, medium and low level is based on the average price for the models sold by brand. Qualitatively, the estimation results are similar across the three groups of observations (see Table A-10 in the Appendix). Quantitatively, the results support much stronger short term effects for high-level brands. Panel A of Figure 4 reports the point estimates of the effect on sales. It shows much stronger pre-reform increases and post-reform decreases for products of top brands. The quantitative difference is considerable with an expansion of sales of high-level brands by 3.0% in the last month before a 1 percentage point tax increase for high-level brands compared to 2.4% for medium and 1.0% for low level brands. Also the decline in sales after the implementation is predicted to be much stronger for high-level brands than for other brands. The smallest effect is reported for low-level brands. Note that the price effects do not show major differences and no monotonous relationship with the brand level (see Table A-11 in the Appendix).

Besides adjustment cost, the strength of the effects of tax rate changes also depends on the intra-temporal elasticity of substitution. Household appliances with a higher (lower) elasticity of substitution are expected to show a stronger (weaker) expansion before a tax rate increase. This suggests that the effects differ between product categories. To test for those differences, we conducted a separate analysis for various product categories. Again, the same qualitative pattern is found for all (groups of) product categories (see Table A-12 in the Appendix), but some quantitative differences are found. Panel B of Figure 4 reports the point estimates of the effect on sales. Accordingly, strongest effects are found for tumbledryers and dishwashers, whereas washing machines display weakest effects. It is tempting to relate those differences to the fact that the share of households owning washing machines is particular high, whereas the share of households owning tumbledryers and dishwashers is much lower.[17]

7 Summary and Conclusions

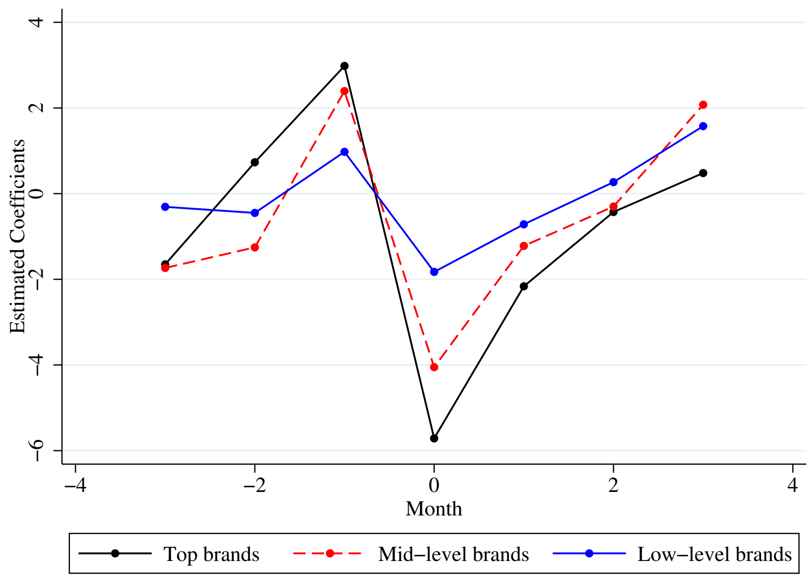
Economic theory suggests that an upcoming tax-rate change would induce consumers to bring forward or postpone spending. In addition, the demand for consumer durables is expected to display a further temporary shock immediately before implementation. The empirical analysis provided in this paper supports these predictions and shows that the changes of baseline consumption tax rates in the EU countries in recent years have indeed affected the time path of consumer spending.

We utilize a unique micro data set on consumer durables that allows us to observe monthly unit-sales of individual products and their prices in 22 European countries over the last decade. We implement a reduced-form specification for sales that tests theoretical predictions of a standard model of consumer choice under different assumptions about the price pass-through of taxes. To

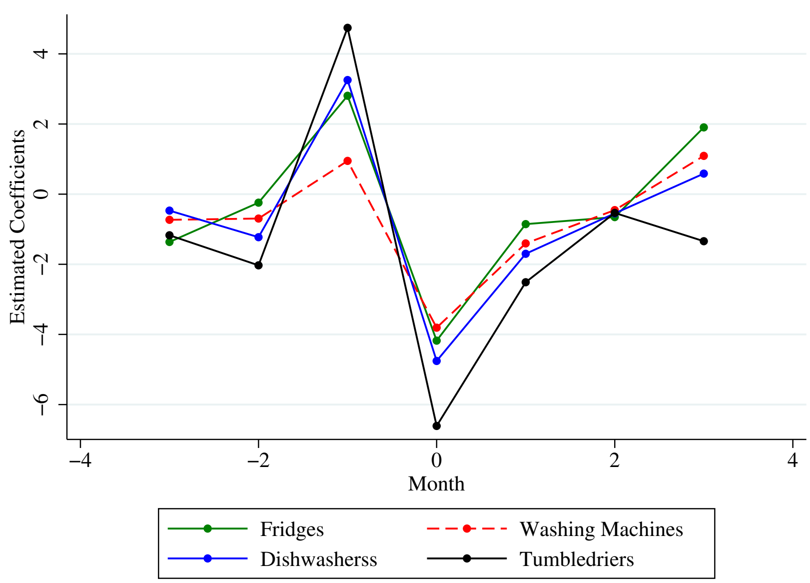
[17]For instances, the German household survey (EVS) reports ownership rates for tumbledreyers of 46.5%, for dishwashers with 68.7% and for washing mashines with 94.4% in 2013.

Figure 4: DYNAMICS OF SALES: BRANDS AND PRODUCT TYPES

A. Tax Effects on Change of Sales by Brands



B. Tax Effects on Change of Sales by Product Category



Note: Panel A depicts the estimated coefficients from a extension of the regression for sales in Column (6) of Table 4 (both not reported). The month of the reform is denoted by zero. In both panels the shaded area captures the 95% confidence interval based on the robust estimate of the covariance matrix.

identify tax effects, we explore how prices and sales of identical products differ in countries with tax rate changes compared to countries in which tax rates remain constant.

Though the price data clearly supports the full pass-through of consumption taxes into prices, 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 and is completed in the first quarter after implementation. Given the finding of full price pass-through, it is difficult to explain pre-reform price adjustments with imperfect competition. Robustness checks also did not detect major differences between the groups of top-sellers or top-brands and other products. Hence, pre-reform price effects are more likely a consequence of staggered price adjustment. Since the price data includes sales and rebates, we cannot preclude that the observed pre-reform price adjustment simply reflects a decline in the frequency of sales before implementation. However, recent literature argues that varying frequency of sales is not an important source of observed price trends.

The empirical findings point to a significant intertemporal effect and confirm an additional temporary effect of tax changes on the sales of durable goods shortly before the tax-rate changes. Our analysis also shows that consumer responses differ 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 exert stronger pre-reform effects on consumer spending than endogenous reforms, which are related to current GDP shocks. This seems to contradict findings of more pronounced effects of fiscal policy in a recessionary economic environment (*e.g.*, Auerbach and Gorodnichenko, 2012). However, empirical effects of VAT reforms that take place in response to GDP shocks may be confounded by the concurrent economic developments. Based on exogenous tax rate changes, the point estimates suggest that a one percentage point increase in consumption tax rates causes a drop in sales by about 5 percent and a temporary pre-reform increase of sales of durables by about 2.5 percent. Although this indicates a relatively strong intertemporal substitution effect of about 2.5 percent, the observed pattern shows a slow recovery of sales after implementation, which points at substantial, asymmetric adjustment cost. It is likely, therefore, that our analysis based on monthly data overstates the long-term effect.

The empirical findings of this paper support the potential of using pre-announced tax increases as an instrument of fiscal policy. The evidence from numerous VAT rate changes in Europe in recent years indicates that higher consumption taxes in the future induce a temporary increase in the demand for durable goods. In terms of the implied annual changes in spending, the estimated temporary effect is small, however. The sharp and longer drop in sales after a tax increase is implemented, indicates stronger long-term effects on consumer spending. It also points to the risks of possible adverse effects on future consumer spending, leading us to conclude that a fiscal policy using consumption taxes to stimulate consumption spending should be based on a careful intertemporal policy design.

References

Adda, J., Cooper, R., 2000. Balladurette and Juppette: A discrete analysis of scrapping subsidies. *Journal of Political Economy* 108(4), 778-806.

Agarwal, S., Marwell, N., McGranahan, L., 2016. Consumption Responses to Temporary Tax Incentives: Evidence from State Sales Tax Holidays. *American Economic Journal: Economic Policy*, forthcoming.

Agrawal, D., 2015. The Tax Gradient: Spatial Aspects of Fiscal Competition. *American Economic Journal: Economic Policy* 7(2), 1-29.

Anderson, E., Malin, B. A., Nakamura, E., Simester, D., Steinsson, J., 2017. Informational rigidities and the stickiness of temporary sales. *Journal of Monetary Economics* 90, 64-83.

Attanasio, O. P., 2000. Consumer durables and inertial behaviour: Estimation and aggregation of (s, s) rules for automobile purchases. *Review of Economic Studies* 67(4), 667-696.

Attanasio, O. Weber, G., 2010. Consumption and saving: models of intertemporal allocation and their implications for public policy. *Journal of Economic literature* 48(3), 693-751.

Auerbach, A. J., Gorodnichenko, Y., 2012. Measuring the output responses to fiscal policy. *American Economic Journal: Economic Policy* 4(2), 1-27.

Baker, S. R., Kueng, L., 2017. Shopping for Lower Sales Tax Rates. *Unpublished manuscript*.

Bar-Ilan, A., and Blinder, A. S., 1992. Consumer durables: Evidence on the optimality of usually doing nothing. Journal of Money, credit and Banking, 24(2), 258-272.

Benedek, M. D., De Mooij, R. A., Keen, M., Wingender, M. P. , 2015. Estimating VAT Pass Through. *IMF Working Paper* 15-214.

Benzarti, Y., Carloni, D., Harju, J., Kosonen, T., 2017. What Goes Up May Not Come Down: Asymmetric Incidence of Value-Added Taxes. *NBER Working Paper* No. 23849.

Bertrand, M., Duflo, E., Mullainathan, S., 2004. How much should we trust differences-in-differences estimates? *Quarterly Journal of Economics* 119(1), 249-275.

Besley, T. J., and Rosen, H. S., 1999. Sales Taxes and Prices: An Empirical Analysis. *National Tax Journal*, 52(2), 157-178.

Carare, A., Danninger, S., 2008. Inflation Smoothing and the Modest Effect of VAT in Germany. *IMF Working Paper* 08-175.

Carbonnier, C., 2007. Who pays sales taxes? Evidence from French VAT reforms, 1987-1999. *Journal of Public Economics* 91(5), 1219-1229.

Cashin, D., Unayama, T., 2016. Measuring intertemporal substitution in consumption: evidence from a VAT increase in Japan. *Review of Economics and Statistics* 98(2), 285-297.

Cashin, D., 2017. The Household Expenditure Response to a Consumption Tax Rate Increase. *Finance and Economics Discussion Series, Board of Governors of the Federal Reserve System (U.S.)* 2017-035, Washington D.C.

Chetty, R., Looney, A., Kroft, K., 2009. Salience and taxation: Theory and evidence. *American Economic Review* 99(4), 1145-1177.

Copenhagen Economics (2008), *Reduced VAT for Environmentally-friendly Products*, Final Report, Copenhagen.

Coibion, O., Gorodnichenko, Y., Hong, G. H., 2015. The cyclicality of sales, regular and effective prices: Business cycle and policy implications. *American Economic Review*, 105(3), 993-1029.

Copeland, A., Kahn, J., 2013. The production impact of "Cash-for-Clunkers": Implications for stabilization policy. *Economic Inquiry* 51(1), 288-303.

Correia, I., Farhi, E., Nicolini, J.P., Teles, P., 2013. Unconventional fiscal policy at the zero bound. *American Economic Review* 103(4), 1172-1211.

Crossley, T. F., Low, H., Sleeman, C., 2014. Using a temporary indirect tax cut as a fiscal stimulus: Evidence from the UK. *IFS Working Paper* No. W14/16.

D'Acunto, F., Hoang, D. Weber. M., 2016. The effect of unconventional fiscal policy on consumption expenditure. *NBER Working Paper* No. 22563.

De Mooij, R., Keen M., 2013. Fiscal devaluation and fiscal consolidation: The VAT in troubled times. In: Alesina, A., Giavazzi, F. (Eds.), *Fiscal Policy after the Financial Crisis*, Chicago University Press, Chicago and London, 443-485.

Feldstein, M., 2002. Commentary: Is there a role for discretionary fiscal policy? In: Federal Reserve Bank of Kansas City (ed.), *Rethinking Stabilization Policy*, 151-162.

Fischer, C., 2012. Price convergence in the EMU? Evidence from micro data. *European Economic Review* 56(4), 757-776.

Fullerton, D., Metcalf, G. E., 2002. Tax incidence. *Handbook of Public Economics* 4, 1787-1872.

Green, D., Melzer, B. T., Parker, J. A., Rojas, A., 2016. Accelerator or Brake? Cash for Clunkers, Household Liquidity, and Aggregate Demand. *NBER Working Paper* No. 22878.

Grossman, S., Laroque, G., 1990. Asset Pricing and Optimal Portfolio Choice in the Presence of Illiquid Durable Consumption Goods. *Econometrica*, 58(1), 25-51.

Gunter, S., Riera-Crichton, D., Végh, C.A., Vuletin, G., 2017. Non-linear distortion-based effects of tax changes on output: A worldwide narrative approach. *Inter-American Development Bank Discussion Paper*, No. 540.

Hall, R. E., 2011. The long slump. *American Economic Review* 101(2), 431-469.

Hamermesh, D. S., Pfann, G. A., 1996. Adjustment costs in factor demand. Journal of Economic Literature, 34(3), 1264-1292.

Hendel, I., Lizzeri, A., 1999. Adverse selection in durable goods markets. *American Economic Review*, 89(5), 1097-1115.

Hoekstra, M., Puller, S. L., West, J., 2017. Cash for Corollas: When Stimulus Reduces Spending. *American Economic Journal: Applied Economics* 9(3), 1-35.

Lechner, M., 2011. The estimation of causal effects by difference-in-difference methods. *Foundations and Trends(R) in Econometrics* 4 (3), 165–224.

Li, S., Linn, J., Spiller, E., 2013. Evaluating "Cash-for-Clunkers": Program effects on auto sales and the environment. *Journal of Environmental Economics and Management* 65(2), 175-193.

Kosonen, T. 2015. More and cheaper haircuts after VAT cut? On the efficiency and incidence of service sector consumption taxes. *Journal of Public Economics* 131, 87-100.

Malani, A., Reif, J. 2015. Interpreting pre-trends as anticipation: Impact on estimated treatment effects from tort reform. *Journal of Public Economics* 124, 1-17.

Mertens, K., Ravn, M. O., 2012. Empirical evidence on the aggregate effects of anticipated and unanticipated US tax policy shocks. *American Economic Journal: Economic Policy* 4(2), 145-181.

Mian, A., Sufi, A., 2012. The effects of fiscal stimulus: Evidence from the 2009 cash for clunkers program. *Quarterly Journal of Economics* 127(3), 1107-1142.

Nakamura, E., and Zerom, D. 2010. Accounting for incomplete pass-through. *Review of Economic Studies* 77(3), 1192-1230.

Ogaki, M., Reinhart, C. M., 1998. Measuring intertemporal substitution: the role of durable goods. *Journal of Political Economy* 106(5), 1078-1098.

Poterba, J. M., 1996. Retail price reactions to changes in state and local sales taxes. *National Tax Journal* 49(2), 165-176.

Ring Jr., R. J., 1999. Consumers' share and producers' share of the general sales tax. *National Tax Journal* 52(1), 79-90.

Romer, C. D., Romer, D.H. 2010. The macroeconomic effects of tax changes: Estimates based on a new measure of fiscal shocks. *American Economic Review* 100(3), 763-801.

Shapiro, M.D., 1986. The Dynamic Demand for Capital and Labor. *Quarterly Journal of Economics* 101(3), 513–542.

Appendix
Sales and Price Effects of Pre-announced Consumption Tax Reforms: Micro-level Evidence from European VAT

July 2, 2019

Thiess Buettner, FAU and CESifo, Boryana Madzharova, FAU

Contents

A.1 Data Analysis

A.1.1 Data Production

Gesellschaft für Konsumforschung (GfK) Retail and Technology GmbH generates 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 the universe of retailers. This is achieved through census data and special questionnaires to dealers/retailers. Once the universe is 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 product. GfK collects price and quantity data retailer by retailer. Incoming data from different sources referring to the same product is translated into one single definite GfK product code. Once checked, the basic data is extrapolated for each distribution channel. GfK's data collection, sampling and extrapolation methodology are described in detail in Fischer (2012), who uses similar data for washing machines from 1995-2005, at a four-monthly or bi-monthly frequency, to study price convergence in the countries of the European Monetary Union (EMU).

A.1.2 Data Transformation

Transformations applied to all estimation samples:

The complete untransformed data contains a total of 20,666,643 observations, some of which are removed. In particular, observations without an identifier (id) are dropped (10,242 obs.), observations for products for which all units/price variables are missing across all years, and observations within a product for which all units and prices in a given year are reported as zero (4,932 obs). A small number of units sold (13,512 obs.) and prices (1,336 obs.) have negative values, which are replaced with missing observations. The negative values likely arise due to returned items. Out of 20,666,643 observations for units sold, 8,341,832 are missing values, and 1,370,799 are zeros. For prices, 8,901,213 data points are missing and 861,537 are zeros. Usually zero/missing units sold are coupled with a zero/missing price.

Monthly percentage changes in prices calculated within product-country groups are restricted to no more than 200% increases and no less that 50% decreases by replacing prices with missing observations when the percentage change exceeds the specified range. This affects 272,175 observations (decreases), of which the vast majority, 255,084, are due to a percentage change exactly equal to -100%, which occurs when a positive price is followed by a price of zero. 17,091 changes are due to prices falling by more than 50% from one month to the next, while 3,808 prices are replaced with missing values because the increase is larger than 200%. This restriction applies to all descriptive statistics presented in Panels B and C of Table 1. All results are robust to an alternative transformation, which drops zero prices without imposing any other restriction on the percentage change. In this case, the mean of $\Delta\log(PRICE)$ is -0.005 (0.142) with a min. -11.15 and a max of 33.57. Further, results remain robust if zero prices are left in the data as they are. Both sets of results are available upon request.

Due to membership into the EMU, in all estimation samples, data for Slovakia is dropped before January 1st, 2009 (175,848 obs), for Slovenia – before January 1st, 2007 (65,520 obs.), and for Estonia all observations after December 2010 are excluded (94,641 obs.). Panel A of Table 1 reports descriptive statistics based on all available data for Slovenia, Slovakia, and Estonia.

For the purpose of providing descriptive statistics, prices in Table 1 are shown in Euro, calculated using monthly exchange rates sourced by Eurostat, but all log-changes used in the estimation and summarized in Table 1 are based on prices in national currencies.

Outliers in $\Delta\log(UNITS)$ are present as clearly shown by the min-max range of this variable in Panels B and C in Table 1. Such outliers arise as a result of two characteristics of the data. First, 543,832 units sold lie in an interval (0,1), with some values as small as 0.0000001, which typically occurs in the last year a model is in the panel. The log-transformation of such small values results in substantial log-changes in units. Our results are robust to the replacement of all such values with zero (results available upon request). In this case, the mean of $\Delta \log(UNITS)$ becomes -0.016 (0.878) with a minimum of -7.87 and a maximum of 8.89. The maximum value of 8.89 is for a product entering the German market with units sold of 1 in its first month and 7,276 in the second month. The minimum value is generated by a product that exits the market with sales of 1 unit in its last month, but 2,626 units in the preceding month. Apart from the (0,1) values, therefore, outliers in $\Delta \log(UNITS)$ arise naturally from the fluctuations in sales at the beginning and the end of products' life-cycles.

Transformations applied to estimation sample of Panel B of Table 1

In this estimation sample the data is restricted to models traded in at least two countries at the same time. This results in the loss of 9,644,145 observations. Refer to Table A-2 for some summary statistics of the full and the reduced sample. The restriction removes two thirds of all models in the data, but the remaining 29,683 products on average account for 53% of all units sold and generate 58% of the sales value within a year. Panel B of Table 1 provides summary statistics only for the observations that are actually used in the estimations in Tables 2 and 3. The remaining variables in Panel B are summarized based on the union of sales and price estimation samples.

Transformations applied to estimation sample of Panel C of Table 1

The estimates in Table A-8 are based on the estimation sample described in Panel C of Table 1. This is the sample that incorporates models traded in only one country in the estimation by collecting, within a product category, all models with an identical set of characteristics into one group (Table A-4). For example, all built-in, 2-door, freezer-top refrigerators with a no-frost system belong into one group. A number of models have a single or multiple unknown/non-available characteristics, which necessitated dropping these models from the data. In total, 39,481 models (2,207,532 obs.) were removed. 92% of the lost observations stem from two product categories

– hoods and cooktops, which have numerous models with missing information on the shape of chimney and heating type characteristics (see Table A-4). We further had to ensure that models in the resulting products groups-date cells are traded in at least two countries, which resulted in the loss of 26,217 additional observations. Panel C of Table 1 provides summary statistics only for the observations that are actually used in the estimation in Table A-8.

Endogenous reforms and reforms announced less than a month before implementation

Seven reforms were announced less than one month before their implementation (see Table A-3 and Figure A-1). To identify observations affected by these reforms, we generated a variable $early$, which has a value of unity for all observations in countries undergoing such reforms six months before and six months after the respective implementation dates. All specifications excluding relevant models' observations around the seven reforms are estimated on the condition that $early = 0$. Endogenous reforms are identified in a similar fashion. We generated a variable $endog$, which is set to unity six months before and six months after the implementation dates of all endogenous reforms listed in Table A-3. Specifications using exogenous reforms are run subject to $endog = 0$.

Table A-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 (5.52); BE=Belgium (5.40); CZ=the Czech Republic (4.56); DE=Germany (10.01); DK=Denmark (2.88); EE=Estonia (1.27); ES=Spain (7.62); FI=Finland (2.67); FR=France (9.47); GR=Greece (2.99); HU=Hungary (3.24); IT=Italy (8.25); LV=Latvia (0.96); LT=Lithuania (1.73); NL=the Netherlands (5.48); PL=Poland (4.87); PT=Portugal (5.02); RO=Romania (1.10); SE=Sweden (3.84); SI=Slovenia (1.90); SK=Slovakia (2.80); UK=United Kingdom (8.43). Numbers in parentheses after the country labels are the number of observations associated with the respective country as a percent from total observations in the dataset.

Table A-2: FULL SAMPLE: DESCRIPTIVE STATISTICS BY PRODUCT CATEGORY

	Mean	Std. Dev.	Min	Max
	Average № Products per Year			
Total, of which:	109,848	3,890	102,879	117,844
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
Sold in at least 2 countries	29,683	6,466	10,095	36,540
	Average № of Units Sold per Year (Thousands)			
Total, of which:	62,408	5,079	47,083	65,712
Cookers	8,623	729	6,252	9,207
Fridges	14,069	1,101	10,708	15,020
Dishwashers	6,784	686	5,401	7,432
Freezers	3,836	381	2,631	4,113
Cooktops	5,920	464	4,691	6,342
Hoods	4,949	433	3,714	5,371
Tumble dryers	3,523	415	2,268	3,942
Washing machines	14,729	1,205	11,416	15,655
Sold in at least 2 countries	33,159	5,906	13,829	38,692
	Average Value of Sales per Year (Millions Euro)			
Total, of which:	25,987	2,193	19,447	27,883
Cookers	3,908	386	2,740	4,334
Fridges	6,313	538	4,765	6,859
Dishwashers	3,413	302	2,604	3,638
Freezers	1,349	118	976	1,440
Cooktops	2,178	189	1,720	2,337
Hoods	1,245	108	974	1,337
Tumble dryers	1,427	151	1,032	1,598
Washing machines	6,171	498	4,635	6,565
Sold in at least 2 countries	15,187	2,558	6,743	17,389
	Product Age			
Full sample:	30.5	23.2	1	117
Cookers	30.8	23.4	1	117
Fridges	28.9	21.8	1	117
Dishwashers	27.7	20.7	1	117
Freezers	28.6	22.0	1	117
Cooktops	34.5	25.5	1	117
Hoods	36.9	27.6	1	117
Tumble dryers	29.5	22.0	1	117
Washing machines	27.1	20.3	1	117
Sold in at least 2 countries	31.2	21.8	1	117

Note: The product age shows the average number of months from the earliest date a product enters the market in any country and the latest date it exits the market in any country in the data.

Table A-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).

Table A-4: PRODUCT CHARACTERISTICS

Product Category	Characteristics
Cookers	Construction (built-in, under-, freestanding); type (cooker, oven); fuel (electric, gas, mixed).
Coolers/Refrigerators	No-frost system (yes/no); construction (built-in, under-, freestanding); type (1 door (dr) 81-90 cm, 1 dr.>90 cm, 1 dr. up to 80 cm, 2 drs. freezer bottom, 2 drs. freezer top, 3+ drs., side-by-side).
Dishwashers	Construction (built-in, under, freestanding); size (compact, full size, slimline, table top); integration (fully, partly, no).
Freezers	Construction (built-in, under, freestanding); type (upright, chest, box); height in cm (42-213 cm).
Hobs/Cooktops	Fuel (electric, gas, mixed); surface (ceramic/glass, sealed, gas on glass, mixed sealed+ceramic); heating type (halogen, induction, radiant).
Hoods	Hood type (canopy/cartridge, ceiling, chimney, integrated, standard, table/hob extra, telescopic); chimney (corner, island, wall, no chimney/deco); shape chimney (box, decorative, head-free, pyramid/trapeze, not applicable).
Tumble Driers	Type (condensor, ventilation); control type (electronic, timer); loading capacity in kg (1-10 kg).
Washing Machines	Type (front- or top-loading, wash-dry, other); spin speed (400-3100); loading capacity in kg (1-17 kg).
Brands	For each model, the dataset provides the name of brand. Classification into high, medium, and low quality brands is based on the average prices by brand.

Notes: The characteristic sets used in the group-date fixed effects in Table A-8 are all possible combinations of the characteristics above per product category. In total, in the estimation sample of Panel C of Table 1, there are 686 groups of products with an identical set of characteristics. Refer to Section A.1 in the Appendix for details on how the groups were constructed.

Table A-5: NUMBER OF IDENTIFYING REFORMS BY ORDER OF LEADS

Lead	№ Identifying countries	№ Identifying reforms
$\Delta\tau_d$	17	33
$\mathsf{E}\left[\mathsf{F}^1\Delta\tau_d\right]$	16	29
$\mathsf{E}\left[\mathsf{F}^2\Delta\tau_d\right]$	15	26
$\mathsf{E}\left[\mathsf{F}^3\Delta\tau_d\right]$	12	20
$\mathsf{E}\left[\mathsf{F}^4\Delta\tau_d\right]$	11	17
$\mathsf{E}\left[\mathsf{F}^5\Delta\tau_d\right]$	9	12
$\mathsf{E}\left[\mathsf{F}^6\Delta\tau_d\right]$	7	10
$\mathsf{E}\left[\mathsf{F}^7\Delta\tau_d\right]$	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 varying number of VAT reforms and countries captured by higher-order leads of the change in the tax rate, $\Delta\tau_d$. 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-6: PRICE EFFECTS: INCREASING NUMBER OF CONTROL COUNTRIES IN PRODUCT-DATE CELLS

	(1) $c \geq 3$	(2) $c \geq 4$	(3) $c \geq 5$	(4) $c \geq 6$	(5) $c \geq 7$	(6) $c \geq 8$
$\mathsf{E}\left[\mathsf{F}^3\Delta\tau_d\right]$	0.241	0.234	0.240	0.234	0.237	0.250
	(0.039)	(0.044)	(0.048)	(0.050)	(0.060)	(0.067)
$\mathsf{E}\left[\mathsf{F}^2\Delta\tau_d\right]$	0.046	0.045	0.046	0.059	0.069	0.080
	(0.029)	(0.031)	(0.033)	(0.036)	(0.041)	(0.047)
$\mathsf{E}\left[\mathsf{F}^1\Delta\tau_d\right]$	0.130	0.113	0.111	0.085	0.082	0.089
	(0.034)	(0.036)	(0.040)	(0.043)	(0.047)	(0.053)
$\Delta\tau_d$	0.165	0.184	0.197	0.222	0.263	0.260
	(0.038)	(0.039)	(0.041)	(0.041)	(0.042)	(0.047)
$\mathsf{L}^1\Delta\tau_d$	0.438	0.443	0.445	0.421	0.412	0.390
	(0.034)	(0.034)	(0.037)	(0.039)	(0.043)	(0.043)
$\mathsf{L}^2\Delta\tau_d$	-0.120	-0.111	-0.088	-0.079	-0.050	-0.039
	(0.054)	(0.057)	(0.060)	(0.058)	(0.062)	(0.065)
$\mathsf{L}^3\Delta\tau_d$	0.100	0.115	0.106	0.104	0.083	0.089
	(0.033)	(0.034)	(0.037)	(0.039)	(0.045)	(0.043)
	Cumulative Effects					
Total pass-through	1.000	1.022	1.057	1.045	1.096	1.119
	(0.072)	(0.073)	(0.080)	(0.076)	(0.086)	(0.100)
Pre-reform	0.416	0.392	0.398	0.378	0.387	0.420
	(0.058)	(0.059)	(0.065)	(0.066)	(0.071)	(0.079)
Post-reform	0.584	0.631	0.660	0.667	0.708	0.700
	(0.054)	(0.057)	(0.061)	(0.059)	(0.068)	(0.077)
N	3,190,634	2,562,872	2,077,872	1,671,169	1,337,784	1,057,569
Product-date effects	912,854	648,451	470,798	341,567	248,367	179,899
Products	42,066	26,809	18,366	12,943	9,274	6,690

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. The monthly change in the standard VAT rate is denoted by $\Delta\tau_d$. Note that $\mathsf{E}\left[\mathsf{F}^j\Delta\tau_d\right] = \mathsf{F}^n\Delta\tau_d$ for all reforms that were announced $n > j$ periods ahead, and $\mathsf{E}\left[\mathsf{F}^j\Delta\tau_d\right] = 0$ for reforms announced $n \leq j$. All specifications include a full set of product-date (id), country and country-month specific fixed effects. The monthly unemployment rate, $Unempl$, and the number of months a product appears in the data in a specific country, $M.age$, as well as $M.age^2$ are controlled for but not reported. Standard errors in parentheses are robust in all specifications and clustered by product category-country

Table A-7: SALES EFFECTS: INCREASING NUMBER OF CONTROL COUNTRIES IN PRODUCT-DATE CELLS

	(1) $c \geq 3$	(2) $c \geq 4$	(3) $c \geq 5$	(4) $c \geq 6$	(5) $c \geq 7$	(6) $c \geq 8$
$\mathsf{E}\left[\mathsf{F}^3\Delta\tau_d\right]$	-0.922	-1.112	-1.145	-1.106	-1.233	-0.957
	(0.279)	(0.303)	(0.331)	(0.364)	(0.406)	(0.456)
$\mathsf{E}\left[\mathsf{F}^2\Delta\tau_d\right]$	-0.689	-0.644	-0.768	-0.775	-1.008	-1.034
	(0.244)	(0.263)	(0.286)	(0.313)	(0.347)	(0.388)
$\mathsf{E}\left[\mathsf{F}^1\Delta\tau_d\right]$	2.794	2.924	2.967	3.081	3.382	3.508
	(0.240)	(0.259)	(0.281)	(0.308)	(0.341)	(0.381)
$\Delta\tau_d$	-4.635	-4.799	-4.789	-4.723	-4.674	-4.394
	(0.238)	(0.255)	(0.275)	(0.299)	(0.330)	(0.367)
$\mathsf{L}^1\Delta\tau_d$	-1.655	-1.924	-2.143	-2.306	-2.287	-2.216
	(0.239)	(0.257)	(0.278)	(0.303)	(0.335)	(0.372)
$\mathsf{L}^2\Delta\tau_d$	-0.419	-0.365	-0.284	-0.169	-0.383	-0.193
	(0.240)	(0.258)	(0.278)	(0.303)	(0.334)	(0.371)
$\mathsf{L}^3\Delta\tau_d$	1.172	0.989	0.850	0.917	0.842	0.712
	(0.241)	(0.259)	(0.280)	(0.306)	(0.338)	(0.376)
	Cumulative Effects					
Total	-4.353	-4.931	-5.311	-5.080	-5.362	-4.573
	(0.659)	(0.709)	(0.769)	(0.842)	(0.933)	(1.041)
Pre-reform	1.183	1.168	1.054	1.200	1.141	1.518
	(0.445)	(0.480)	(0.522)	(0.573)	(0.637)	(0.713)
Post-reform	-5.536	-6.095	-6.366	-6.281	-6.503	-6.091
	(0.484)	(0.520)	(0.561)	(0.612)	(0.676)	(0.751)
N	3,255,452	2,611,985	2,115,467	1,700,080	1,359,930	1,074,686
Product-date effects	927,440	656,984	475,835	344,538	250,059	180,918
Products	42,298	26,897	18,400	12,963	9,281	6,693

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, $\Delta\log(UNITS)$. 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. The monthly change in the standard VAT rate is denoted by $\Delta\tau_d$. Note that $\mathsf{E}\left[\mathsf{F}^j\Delta\tau_d\right] = \mathsf{F}^n\Delta\tau_d$ for all reforms that were announced $n > j$ periods ahead, and $\mathsf{E}\left[\mathsf{F}^j\Delta\tau_d\right] = 0$ for reforms announced $n \leq j$. All specifications include a full set of product-date, country and country-month specific fixed effects. The monthly unemployment rate, $Unempl$, and the number of months a products appears in the data in a specific country, $M.age$, as well as $M.age^2$ are controlled for but not reported. Standard errors in parentheses are robust in all specifications and clustered by product category-country

Table A-8: SALES EFFECTS: INCLUDING SINGLE COUNTRY PRODUCTS

Reforms	All		All		n≥ 1	
	(1)	(2)	(3)	(4)	(5)	(6)
$F^3 \Delta\tau_d$		-0.357				
		(0.286)				
$F^2 \Delta\tau_d$		-0.346				
		(0.271)				
$F^1 \Delta\tau_d$	1.897	1.874				
	(0.267)	(0.267)				
$E\left[F^3 \Delta\tau_d\right]$				-0.311		-0.402
				(0.309)		(0.315)
$E\left[F^2 \Delta\tau_d\right]$				-0.536		-0.641
				(0.278)		(0.274)
$E\left[F^1 \Delta\tau_d\right]$			2.014	1.987	2.050	2.043
			(0.291)	(0.290)	(0.300)	(0.299)
$\Delta\tau_d$	-3.426	-3.433	-3.428	-3.436	-3.941	-3.957
	(0.529)	(0.530)	(0.529)	(0.530)	(0.538)	(0.539)
$L^1 \Delta\tau_d$	-1.775	-1.759	-1.773	-1.764	-1.379	-1.372
	(0.295)	(0.293)	(0.295)	(0.295)	(0.298)	(0.298)
$L^2 \Delta\tau_d$		-0.774		-0.770		-0.995
		(0.249)		(0.249)		(0.258)
$L^3 \Delta\tau_d$		1.116		1.115		1.324
		(0.232)		(0.231)		(0.225)
	Cumulative Effects					
Total	-3.304	-3.678	-3.187	-3.715	-3.270	-3.999
	(0.316)	(0.455)	(0.300)	(0.478)	(0.319)	(0.409)
Pre-reform	1.897	1.172	2.014	1.140	2.050	1.000
	(0.267)	(0.433)	(0.291)	(0.455)	(0.300)	(0.440)
Post-reform	-5.201	-4.849	-5.201	-4.855	-5.320	-5.000
	(0.429)	(0.450)	(0.428)	(0.450)	(0.449)	(0.456)
N	7,784,370	7,784,370	7,784,370	7,784,370	7,579,291	7,579,291
Group-date effects	44,457	44,457	44,457	44,457	44,062	44,062
Products	236,743	236,743	236,743	236,743	234,265	234,265

Notes: Regressions are based on data for 22 EU countries. The dependent variable is the change in the logarithm of sales, $\Delta\log(UNITS)$. Estimates in columns (5) to (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. The monthly change in the standard VAT rate is denoted by $\Delta\tau_d$. Note that $E\left[F^j \Delta\tau_d\right] = F^n \Delta\tau_d$ for all reforms that were announced $n > j$ periods ahead, and $E\left[F^j \Delta\tau_d\right] = 0$ for reforms announced $n \leq j$.All specifications include a full set of country-, country-month specific and group-date-specific fixed effects, where the groups are based on all possible combinations of the characteristics per product category as shown in Table A-4. Group-date cells, which contain a single country, are dropped from the estimation. The monthly unemployment rate, $Unempl$, and the number of months a product appears in the data in a specific country, $M.age$, as well as $M.age^2$ are controlled for but not reported. Standard errors in parentheses are robust in all specifications and clustered by group-date cells.

Table A-9: DIFFERENTIAL SALES AND PRICE EFFECTS FOR TOP-SELLING PRODUCTS

Forward terms	$\mathsf{F}^i \Delta\tau_d$	$\mathsf{E}\left[\mathsf{F}^i \Delta\tau_d\right]$	
Reforms	All	All	$n \geq 1$
	(1)	(2)	(3)
		Price effects $R50$	
Total	0.592	0.349	0.217
	(0.120)	(0.121)	(0.125)
Pre-reform	0.375	0.132	0.130
	(0.077)	(0.078)	(0.080)
Post-reform	0.217	0.217	0.086
	(0.093)	(0.093)	(0.095)
		Price effects $R100$	
Total	0.611	0.342	0.215
	(0.102)	(0.110)	(0.114)
Pre-reform	0.412	0.143	0.123
	(0.059)	(0.072)	(0.074)
Post-reform	0.199	0.199	0.092
	(0.083)	(0.083)	(0.086)
N	4,033,450	4,033,450	3,917,656
Product-date effects	1,303,336	1,303,336	1,276,343
Products	71,237	71,237	70,677
		Sales effects $R50$	
Total	-1.06	-0.835	-0.083
	(1.17)	(1.18)	(1.23)
Pre-reform	-0.306	-0.081	-0.012
	(0.780)	(0.798)	(0.821)
Post-reform	-0.753	-0.754	-0.070
	(0.870)	(0.870)	(0.908)
		Sales effects $R100$	
Total	-0.679	-0.559	-0.558
	(0.977)	(1.07)	(1.11)
Pre-reform	-0.461	-0.337	-0.521
	(0.576)	(0.717)	(0.739)
Post-reform	-0.218	-0.222	-0.037
	(0.788)	(0.788)	(0.823)
N	4,127,049	4,127,049	4,006,331
Product-date effects	1,331,295	1,331,295	1,302,878
Products	72,057	72,057	71,493

Notes: The table shows regressions for sales and prices following eq. (5.1) and (5.2), with a full set of interaction terms for $\Delta\tau_d$ with indicators $R50$ ($R100$). The latter denote dummy variables equal to one if a product reaches a top 50 (top 100) rank within its respective category at some point in its life-cycle. 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, it focuses solely on the differential effect for top-sellers and other goods. The monthly change in the standard VAT rate is denoted by $\Delta\tau_d$. Note that $\mathsf{E}\left[\mathsf{F}^i \Delta\tau_d\right] = \mathsf{F}^n \Delta\tau_d$ for all reforms that were announced $n > j$ periods ahead, and $\mathsf{E}\left[\mathsf{F}^j \Delta\tau_d\right] = 0$ for reforms announced $n \leq j$. All specifications include a full set of product-date, country and country-month specific fixed effects. The monthly unemployment rate, $Unempl$, and the number of months a products appears in the data in a specific country, $M.age$, as well as $M.age^2$ are controlled for but not reported. Standard errors in parentheses are robust in all specifications and clustered by product-date cells.

Table A-10: SALES EFFECTS: BRAND DIFFERENTIATION

	(1)	(2) Subsample	(3) Top	(4) Mid	(5) Low
$\mathsf{E}\left[\mathsf{F}^3\Delta\tau_d\right]$	-1.183	-1.327	-1.651	-1.735	-0.308
	(0.552)	(0.517)	(0.493)	(0.810)	(0.673)
$\mathsf{E}\left[\mathsf{F}^2\Delta\tau_d\right]$	-0.227	-0.318	0.732	-1.255	-0.450
	(0.474)	(0.508)	(0.673)	(0.627)	(0.632)
$\mathsf{E}\left[\mathsf{F}^1\Delta\tau_d\right]$	2.182	2.249	2.981	2.395	0.976
	(0.504)	(0.515)	(0.670)	(0.612)	(0.942)
$\Delta\tau_d$	-4.110	-4.140	-5.713	-4.051	-1.827
	(0.582)	(0.529)	(0.728)	(0.361)	(0.856)
$\mathsf{L}^1\Delta\tau_d$	-1.199	-1.441	-2.164	-1.220	-0.716
	(0.377)	(0.359)	(0.539)	(0.404)	(0.740)
$\mathsf{L}^2\Delta\tau_d$	-0.471	-0.206	-0.428	-0.301	0.269
	(0.402)	(0.388)	(0.754)	(0.531)	(0.550)
$\mathsf{L}^3\Delta\tau_d$	1.477	1.319	0.481	2.075	1.576
	(0.446)	(0.448)	(0.600)	(0.649)	(0.756)
			Cumulative Effects		
Total	-3.532	-3.862	-5.762	-4.093	-0.479
	(0.770)	(0.729)	(1.489)	(1.030)	(1.228)
Pre-reform	0.771	0.605	2.061	-0.595	0.218
	(0.747)	(0.709)	(0.841)	(1.102)	(1.195)
Post-reform	-4.304	-4.467	-7.824	-3.498	-0.698
	(0.620)	(0.636)	(1.100)	(0.774)	(1.171)
N	2,090,542	1,481,867	685,218	475,306	321,343
Product-date effects	644,210	390,977	176,295	134,972	79,710
Products	34,216	16,668	7,106	6,145	3,417

Notes: Regression results in columns (1) to (5) are based on data for 22 EU countries and three type of products: refrigerators, washing machines, and freezers. The list of top brands includes 32 brands, with Liebherr, Bosch, Siemens, AEG. Miele, Samsung, LG and Neff covering 92% of top-brands' observations. 24 brands are classified as medium-level, of which Whirlpool, Electrolux, Gorenje, Hotpoint-Ariston, Bauknecht, Tradebrand, and Fagor cover 91% of all observations. The list of lower-level brands is composed of 76 brands, with 92% of all observations accounted for by Candy, Indesit, Zanussi, Beko, Exquisit, Ardo, and Severin. The dependent variable is the change in the logarithm of sales, $\Delta \log(UNITS)$. Reforms' announcement information is fully incorporated. The monthly change in the standard VAT rate is denoted by $\Delta\tau_d$. Note that $\mathsf{E}\left[\mathsf{F}^j\Delta\tau_d\right] = \mathsf{F}^n\Delta\tau_d$ for all reforms that were announced $n > j$ periods ahead, and $\mathsf{E}\left[\mathsf{F}^j\Delta\tau_d\right] = 0$ for reforms announced $n \leq j$. All specifications include a set of product-date (id), country and country-month specific fixed effects. The monthly unemployment rate, $Unempl$, and the number of months a product appears in the data in a specific country, $M.age$, as well as $M.age^2$ are controlled for but not reported. Standard errors in parentheses are robust in all specifications and clustered by product category-country

Table A-11: PRICE EFFECTS: BRAND DIFFERENTIATION

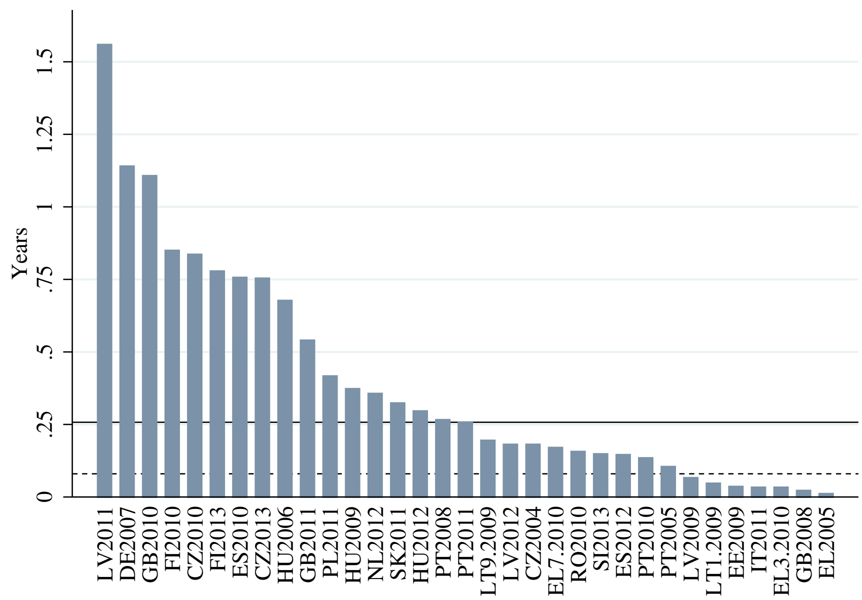
	(1)	(2) Subsample	(3) Top	(4) Mid	(5) Low
$\mathsf{E}\left[\mathsf{F}^3\Delta\tau_d\right]$	0.150	0.146	0.066	0.260	0.087
	(0.047)	(0.047)	(0.081)	(0.044)	(0.085)
$\mathsf{E}\left[\mathsf{F}^2\Delta\tau_d\right]$	0.041	0.026	-0.034	0.048	0.082
	(0.038)	(0.034)	(0.038)	(0.045)	(0.066)
$\mathsf{E}\left[\mathsf{F}^1\Delta\tau_d\right]$	0.123	0.139	0.168	0.115	0.134
	(0.051)	(0.052)	(0.084)	(0.065)	(0.059)
$\Delta\tau_d$	0.241	0.223	0.174	0.232	0.285
	(0.073)	(0.072)	(0.067)	(0.103)	(0.087)
$\mathsf{L}^1\Delta\tau_d$	0.404	0.430	0.464	0.413	0.398
	(0.051)	(0.049)	(0.077)	(0.061)	(0.080)
$\mathsf{L}^2\Delta\tau_d$	-0.110	-0.121	-0.073	-0.146	-0.155
	(0.069)	(0.071)	(0.075)	(0.103)	(0.072)
$\mathsf{L}^3\Delta\tau_d$	-0.000	0.018	0.095	0.042	-0.123
	(0.047)	(0.048)	(0.069)	(0.059)	(0.094)
			Cumulative Effects		
Total pass-through	0.849	0.862	0.861	0.964	0.710
	(0.101)	(0.096)	(0.132)	(0.119)	(0.150)
Pre-reform	0.314	0.312	0.201	0.422	0.304
	(0.079)	(0.082)	(0.115)	(0.100)	(0.103)
Post-reform	0.535	0.550	0.660	0.541	0.406
	(0.090)	(0.092)	(0.114)	(0.115)	(0.155)
Pass-through $\mathsf{F}(1)$	2.20	2.07	1.11	0.09	3.72
N	2,045,318	1,450,514	667,930	466,099	316,485
Product-date effects	631,443	383,624	172,368	132,561	78,695
Products	33,877	16,575	7,054	6,118	3,403

Notes: Regression results in columns (1) to (6) are based on data for 22 EU countries. The list of top brands includes 32 brands, with Liebherr, Bosch, Siemens, AEG. Miele, Samsung, LG and Neff covering 92% of top-brands' observations. 24 brands are classified as medium-level, of which Whirlpool, Electrolux, Gorenje, Hotpoint-Ariston, Bauknecht, Tradebrand, and Fagor cover 91% of all observations. The list of lower-level brands is composed of 76 brands, with 92% of all observations accounted for by Candy, Indesit, Zanussi, Beko, Exquisit, Ardo, and Severin. 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. The monthly change in the standard VAT rate is denoted by $\Delta\tau_d$. Note that $\mathsf{E}\left[\mathsf{F}^j\Delta\tau_d\right] = \mathsf{F}^n\Delta\tau_d$ for all reforms that were announced $n > j$ periods ahead, and $\mathsf{E}\left[\mathsf{F}^j\Delta\tau_d\right] = 0$ for reforms announced $n \leq j$. All specifications include a full set of product-date (id), country and country-month specific fixed effects. The monthly unemployment rate, $Unempl$, and the number of months a product appears in the data in a specific country, $M.age$, as well as $M.age^2$ are controlled for but not reported. Standard errors in parentheses are robust in all specifications and clustered by product category-country

Table A-12: SALES RESPONSES: PRODUCT CATEGORIES

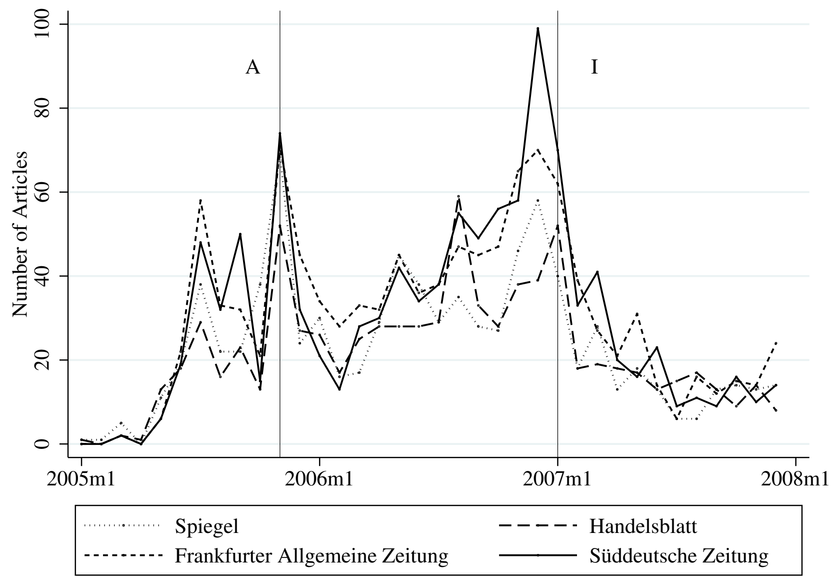
	(1) Fridges	(2) Washing M.	(3) Dishwasher	(4) Tumbledr.	(5) Freezer	(6) Hob, Hoods Cookers
$\mathsf{E}\left[\mathsf{F}^3\Delta\tau_d\right]$	-1.363	-0.731	-0.469	-1.172	-1.466	-0.343
	(0.856)	(0.468)	(0.705)	(2.194)	(1.360)	(0.629)
$\mathsf{E}\left[\mathsf{F}^2\Delta\tau_d\right]$	-0.242	-0.695	-1.227	-2.029	0.785	0.147
	(0.751)	(0.406)	(0.702)	(1.462)	(1.460)	(0.521)
$\mathsf{E}\left[\mathsf{F}\Delta\tau_d\right]$	2.806	0.949	3.254	4.743	2.651	1.881
	(0.715)	(0.405)	(0.672)	(1.375)	(1.091)	(0.699)
$\Delta\tau_d$	-4.177	-3.807	-4.756	-6.609	-4.580	-4.415
	(0.895)	(0.749)	(0.833)	(1.255)	(1.756)	(1.007)
$\mathsf{L}\Delta\tau_d$	-0.854	-1.404	-1.700	-2.511	-2.168	-2.613
	(0.623)	(0.453)	(0.708)	(1.677)	(0.860)	(0.820)
$\mathsf{L}^2\Delta\tau_d$	-0.654	-0.454	-0.548	-0.535	0.012	-0.252
	(0.631)	(0.602)	(1.074)	(1.517)	(1.031)	(0.475)
$\mathsf{L}^3\Delta\tau_d$	1.904	1.092	0.586	-1.341	0.686	1.208
	(0.713)	(0.618)	(0.751)	(1.295)	(1.003)	(0.515)
			Cumulative Effects			
Total	-2.580	-5.051	-4.861	-9.453	-4.080	-4.387
	(1.220)	(0.793)	(1.217)	(2.751)	(2.590)	(1.296)
Pre-reform	1.202	-0.478	1.557	1.542	1.970	1.685
	(1.228)	(0.701)	(1.261)	(3.645)	(2.354)	(0.747)
Post-reform	-3.782	-4.573	-6.419	-10.995	-6.050	-6.071
	(0.888)	(0.834)	(0.926)	(1.913)	(1.723)	(1.193)
N	1,176,352	601,355	612,129	156,767	312,835	1,267,322
Product-date effects	353,643	198,594	199,056	48,344	91,973	439,544
Products	72,056	72,056	72,056	72,056	71,492	71,492

Figure A-1: TIME BETWEEN ANNOUNCEMENT AND IMPLEMENTATION



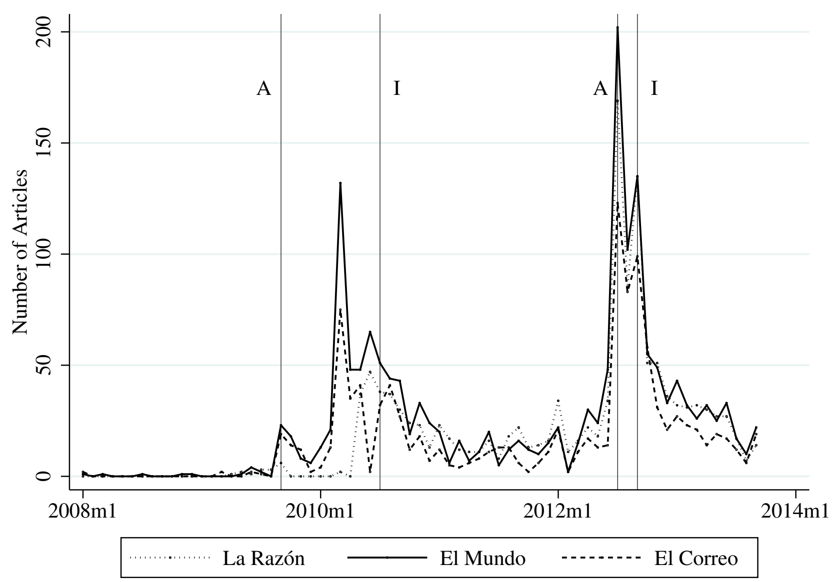
Note: The graph shows the length of the period between announcement and implementation measured in days and scaled by the total number of days in a year for the 33 VAT reforms summarized in Table A-3. The solid horizontal line depicts the median time between announcement and implementation, which is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

Figure A-2: 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.

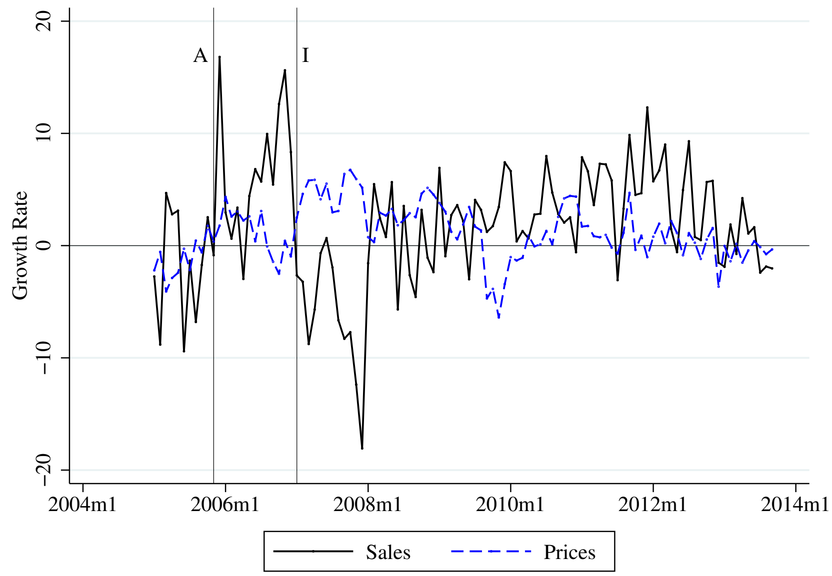
Figure A-3: SPAIN: NEWSPAPER ARTICLES ADDRESSING REFORMS, 2008-2013



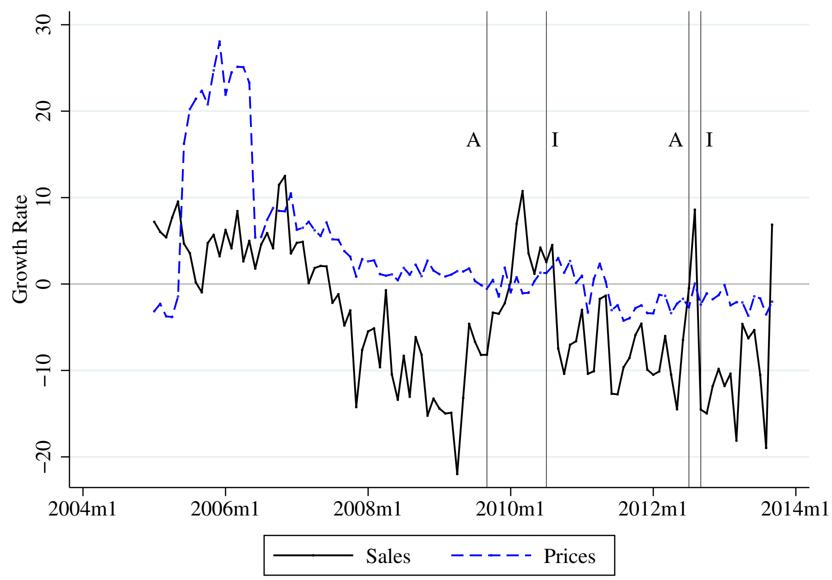
Note: The figure shows the number of articles in three major Spanish newspapers, which mention "VAT rise" either in the title, or the main text from January 2008 until September 2013. Authors' calculations using the online archives of La Razon, El Mundo, and El Correo. The search keyword is "VAT rise" ("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 A-4: GROWTH RATE OF SALES AND PRICES

A. Germany

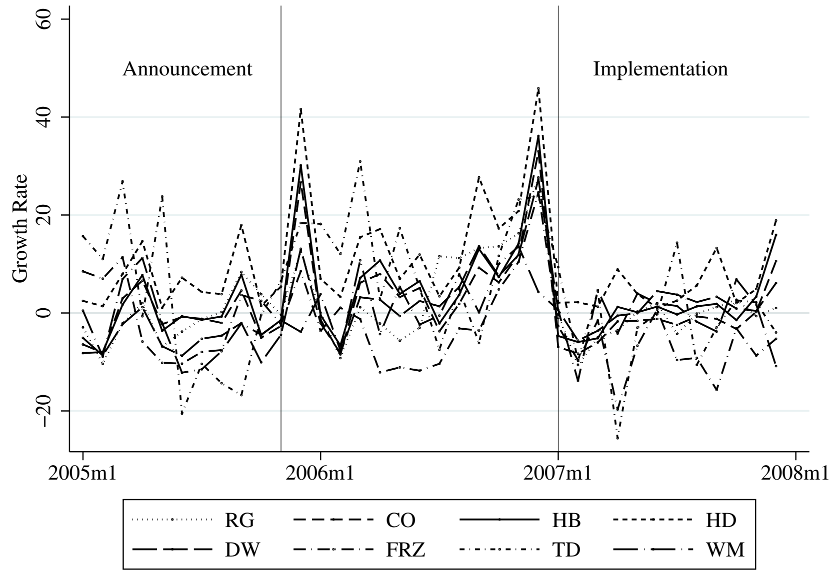


B. Spain



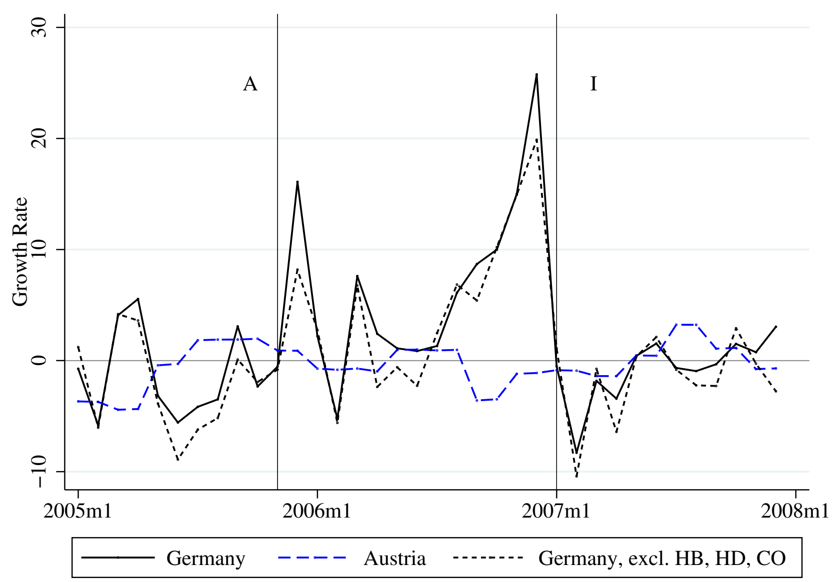
Note: The figure depicts the annual growth rate of sales and prices in Germany and Spain relative to the same month of the previous year, starting from January 2004 and ending in September 2013. Germany increased the standard VAT rate from 16 to 19% on 1.1.2007, with the tax increase officially announced 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.

Figure A-5: GERMANY: GROWTH RATE OF WHITE GOODS' SALES BY PRODUCT CATEGORY, 2005-2007



Note: The figure depicts the growth rate of the number of units sold 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 two different ways in Figures A-4 and A-6. Germany increased the standard VAT rate from 16 to 19% on 1.1.2007, with the tax increase officially announced in November 2005.

Figure A-6: GERMANY: GROWTH RATE OF SALES



Note: The figure depicts the growth rate of the total number of units sold in Germany. 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 in 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 black dashed line depicts the same growth rate excluding HB, HD, and CO. The dashed line is the growth rate of units sold in Austria, where no VAT rate change occurred.

Theoretical Appendix

Sales and Price Effects of Pre-announced Consumption Tax Reforms: Micro-level Evidence from European VAT

July 2, 2019

Thiess Buettner, FAU and CESifo, Boryana Madzharova, FAU

Contents

B.1 Demand for Consumer Durables with Preannounced Tax Rate Change

This appendix provides a theoretical analysis of the demand for a consumer durable good by a household facing a pre-announced change in a general consumption tax. The following section characterizes the houshold's optimization problem. Subsequently, section B.3 derives Euler equations, *i.e.* the optimal time path of consumption of durable and non-durable goods. Section B.4 derives empirical predictions. This discussion explores in particular the role of the household's adjustment cost and of staggered price adjustment.

B.2 Household Objective and Budget Constraint

The household derives utility from the consumption of durable and non-durable goods. The intra-period utility function is

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

where x_s is current consumption of non-durable goods and k_s indicates the consumption of services from the stock of consumer durables in the same period, ϵ denotes the elasticity of substitution.

Since the analysis deals with pre-announced changes in the tax rate, the consumer's choice is analyzed in a setting of 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 in the specific case, where $\sigma = \epsilon$, the utility function becomes additively separable in durable and non-durable goods consumption.

The stock of consumer durables evolves according to

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

where δ is the rate of depreciation. Writing $d = 1 - \delta$, we can solve for gross investment

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

Following standard practice we assume convex adjustment cost, formally

$$\frac{c}{2}\left(k_s - k_{s-1}\right)^2 .$$

Note that, for simplicity, we assume that adjustment cost only arises with net-investment and not with replacement investment.[18] Normalizing the pre-tax price of non-durables to unity and setting the pre-tax price of the durable good to q_s, consumer prices for durable and non-durable goods are

$$p_s = (1 + \tau_s)\, q_s \text{ and } (1 + \tau_s)\,,$$

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 durable goods

$$a_{s+1} - a_s = w_s + r a_s - (1 + \tau_s)\, x_s - (1 + \tau_s)\, q_s \left(k_s - k_{s-1} d\right) - \frac{c}{2}\left(k_s - k_{s-1}\right)^2 , \tag{B.2}$$

where a_s is the stock of wealth at the beginning of period s, and r is the interest rate.

B.3 Demand for Consumer-Durables

In each period s, the household chooses consumption of non-durables x_s and of durables k_s to maximize expected discounted utility subject to constraint (B.2). Eliminating i_s by plugging (B.1)

[18] Similar results would be obtained if adjustment cost is associated with gross investment $(k_s - d k_{s-1})$ as in Shapiro (1986).

into (B.2), the consumer chooses x_s and k_s.[19] The first order conditions for consumption of non-durables and durables are

$$u_s^{-\frac{1}{\sigma}} \frac{\partial u_s}{\partial x_s} - \lambda_{s+1} (1 + \tau_s) \stackrel{!}{=} 0 \quad (B.1)$$

$$u_s^{-\frac{1}{\sigma}} \frac{\partial u_s}{\partial k_s} - \lambda_{s+1} (1 + \tau_s) q_s + \lambda_{s+2} d\beta (1 + \tau_{s+1}) q_{s+1} - \lambda_{s+1} c (k_s - k_{s-1}) + \lambda_{s+2} \beta c (k_{s+1} - k_s) \stackrel{!}{=} 0 \quad (B.2)$$

where λ_{s+1} represents the marginal utility of income. With the simplifying assumption that $\beta (1 + r) = 1$, the Euler equation for the wealth simplifies to $\frac{\lambda_{t+2}}{\lambda_{s+1}} = 1$.

The optimal consumption structure obeys

$$\frac{k_s}{x_s} = \frac{b}{1 - b} (Q_s + C_s)^{-\epsilon} . \quad (B.3)$$

Q_s denotes the user cost of the service flow of the durable good (Ogaki and Reinhard, 1998). C_s denotes the marginal adjustment cost. Basically, if $\epsilon > 0$, equation (B.3) states that a reduction in the user cost and a decline in the adjustment cost is associated with a substitution of non-durable with durable-goods. The user cost is defined as

$$Q_s = \left[1 - \rho d \left(\frac{p_{s+1}}{p_s}\right)\right] q_s,$$

where $\rho = \frac{1}{1+r}$ and $d = 1 - \delta$. Note that the user cost depends on the change in the consumer price in the next period ($\frac{p_{s+1}}{p_s} = \frac{1+\tau_{s+1}}{1+\tau_s} \frac{q_{s+1}}{q_s}$). The user cost of consumer durables declines in period s if the consumer price increases in $s + 1$. There are two components of this change. One component is the change in the pre-tax price. The second component is the change in the tax rate. C_s denotes

[19] The Lagrangian for the intertemporal optimization problem is

$$\mathcal{L} = \sum_{s=t}^{\infty} \left\{ \beta^{s-t} \frac{\sigma}{\sigma - 1} u_s^{1-\frac{1}{\sigma}} + \lambda_{s+1} \beta^{s-t} \left[(1 + r) a_s + w_s - (1 + \tau_s) x_s - (1 + \tau_s) q_s (k_s - k_{s-1} d) - \frac{c}{2} (k_s - k_{s-1})^2 - a_{s+1} \right] \right\},$$

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

the marginal adjustment cost

$$C_s \quad = \quad \frac{c}{1+\tau_s}\left[(k_s - k_{s-1}) - \beta\,(k_{s+1} - k_s)\right].$$

In order to derive implications for the demand for durable goods, we first consider the time path of consumption of non-durables. From the first-order condition (B.1) and noting that $\lambda_{s+2} = \lambda_{s+1}$, the optimal time-path of consumption of non-durables obeys

$$u_{s+1}^{\frac{1}{\epsilon}-\frac{1}{\sigma}} x_{s+1}^{-\frac{1}{\epsilon}} = \left(\frac{1+\tau_{s+1}}{1+\tau_s}\right) u_s^{\frac{1}{\epsilon}-\frac{1}{\sigma}} x_s^{-\frac{1}{\epsilon}}. \tag{B.4}$$

To simplify this expression, we decompose utility

$$u_s = x_s F_s, \text{ where } \quad F_s = \left[(1-b)^{\frac{1}{\epsilon}} + b^{\frac{1}{\epsilon}}\left(\frac{k_s}{x_s}\right)^{\frac{\epsilon-1}{\epsilon}}\right]^{\frac{\epsilon}{\epsilon-1}}.$$

F_s is the utility per unit of non-durable goods. If we insert the optimum relationship (B.3), we can express the latter by $F_s = (1-b)^{\frac{1}{\epsilon-1}}\left[1 + \frac{b}{1-b}\,(Q_s + C_s)^{1-\epsilon}\right]^{\frac{\epsilon}{\epsilon-1}}$. If replace u_s and u_{s+1} in equation (B.4) we obtain the Euler-equation for consumption of non-durables

$$x_{s+1} \quad = \quad x_s\left(\frac{1+\tau_{s+1}}{1+\tau_s}\right)^{-\sigma}\left(\frac{1+\frac{b}{1-b}\,(Q_{s+1}+C_{s+1})^{1-\epsilon}}{1+\frac{b}{1-b}\,(Q_s+C_s)^{1-\epsilon}}\right)^{\frac{\sigma-\epsilon}{\epsilon-1}}.$$

If we log-linearize this equation around the initial steady state, the change in the deviation of consumption from the steady state is

$$\frac{x_{s+1}-x_0}{x_0} - \frac{x_s - x_0}{x_0} \quad = \quad -\sigma\left(\frac{\tau_{s+1}-\tau_s}{1+\tau_0}\right) - (\sigma-\epsilon)\,\varphi\left(\frac{Q_{s+1}+C_{s+1}-Q_s-C_s}{Q_0+C_0}\right), \tag{B.5}$$

with

$$\varphi = \frac{\frac{b}{1-b}\,(Q_0+C_0)^{1-\epsilon}}{1+\frac{b}{1-b}\,(Q_0+C_0)^{1-\epsilon}}.$$

Q_0 denotes the user cost in the steady state, which is determined by the interest and depreciation rates $Q_0 = (1 - \rho d)\, q$. C_0 denotes the marginal adjustment cost in the steady state, which is zero if adjustment cost is a function of net-investment. [20]

B.4 Effects of a Tax Rate Change

Abstracting from adjustment cost, equation (B.5) suggests that there are two effects of taxes on the optimal consumption path. First, there is an effect associated with intertemporal substitution. If the tax rate is changed, say it is increased at a specific date, consumption is changed increased before and future consumption after the tax increase is reduced. The strength of this effect increases with the elasticity of intertemporal substitution. Second, there is an effect associated with the user cost of durables. If the tax rate increases in period $t + 1$ relative to period t, the user cost of durables declines temporarily $Q_{t+1} - Q_t < 0$. If the two types of consumption goods are substitutes, $\epsilon > 0$, this provides an incentive to substitute the consumption of non-durable goods with durable goods. How this affects the time path of consumption of non-durables depends on the elasticity of intratemporal substitution. If it is small, $\sigma > \epsilon$, this effect will further contribute to an increase of consumer spending. If the elasticity of intratemporal substitution is large, $\sigma < \epsilon$, the intratemporal substitution of non-durable with durable goods is so strong that it works against an increase in spending on non-durables. In the case of separable utility $\sigma = \epsilon$, the time path would only be affected by intertemporal substitution effects (Cashin and Unayama, 2016).

Inserting from equation (B.3), we can use (B.5) to derive the Euler equation for the capital stock

$$k_{s+1} = k_s \left(\frac{Q_{s+1} + C_{s+1}}{Q_s + C_s} \right)^{-\epsilon} \left(\frac{1 + \tau_{s+1}}{1 + \tau_s} \right)^{-\sigma} \left(\frac{1 + \frac{b}{1-b} \left(Q_{s+1} + C_{s+1} \right)^{1-\epsilon}}{1 + \frac{b}{1-b} \left(Q_s + C_s \right)^{1-\epsilon}} \right)^{\frac{\sigma - \epsilon}{\epsilon - 1}} . \tag{B.1}$$

[20] If the cost function is related to gross investment, the steady state adjustment cost is just reflecting the replacement investment $C_0 = \frac{\delta k_0}{1+\tau_0} \frac{Q_0}{q}$.

Taking logs and using a first-order Taylor approximation, we can approximate equation (B.1) by

$$\frac{k_{s+1}-k_0}{k_0}-\frac{k_s-k_0}{k_0} = -\sigma\left(\frac{\tau_{s+1}-\tau_s}{1+\tau_0}\right)-\left(\underbrace{\epsilon+(\sigma-\epsilon)\,\varphi}_{\gamma}\right)\left(\frac{Q_{s+1}+C_{s+1}-Q_s-C_s}{Q_0+C_0}\right) \tag{B.2}$$

Equation (B.2) shows that, as in the case of non-durables, two effects determine the influence of taxes on the time-path of the stock of durables. First, there is intertemporal substitution. Suppose the tax rate increases, all consumption including consumption of durables is increased today and future consumption is reduced. Second, there is an effect associated with the user cost of durables. In contrast to the time path of non-durables, the effect of the user cost on the time path of durables is unambiguous. If the tax rate increases in period $t+1$, the user cost of durables declines temporarily $Q_t - Q_{t-1} < 0$, and, *ceteris paribus*, consumption of durable goods in period t is expanded. This holds regardless of how large the elasticity of intratemporal substitution is. Even if the utility function is separable in consumption of durable and non-durable goods $\sigma = \epsilon$, the decline in the user cost contributes to a pre-reform expansion of the stock of durables. In the period $t+1$, the user cost of durables reverts to the initial level and $Q_{t+1} - Q_t > 0$. This contributes to a decline in the stock of capital.

The marginal cost of adjustment on the right-hand side of equation (B.2) is a function of the changes in the capital stock. It can be approximated by

$$C_{s+1} = \frac{ck_0}{1+\tau_0}\left[\frac{k_{s+1}-k_0}{k_0}-\frac{k_s-k_0}{k_0}\right]-\beta\frac{ck_0}{1+\tau_0}\left[\frac{k_{s+2}-k_0}{k_0}-\frac{k_{s+1}-k_0}{k_0}\right]. \tag{B.3}$$

Since C_{s+1} is affected by the change in the capital stock in the subsequent period $s+2$ and since C_s is affected by the change in the capital stock in period s, the system (B.2) and (B.3) defines a higher order difference equation in the capital stock.

B.4.1 Tax Effects in Absence of Adjustment Cost

To discuss the model predictions, consider a log-linear approximation of the user cost

$$\frac{Q_s - Q_0}{Q_0} = \frac{q_s - q_0}{q_0} - \alpha \left[\frac{p_{s+1} - p_0}{p_0} - \frac{p_s - p_0}{p_0} \right],$$

where $\alpha = \frac{\beta d}{1-\beta d}$, If pre-tax prices are constant

$$\frac{Q_s - Q_0}{Q_0} = -\alpha \frac{\tau_{s+1} - \tau_s}{1 + \tau_0}.$$

If the initial tax rate is zero

$$\frac{Q_s - Q_0}{Q_0} = -\alpha \Delta \tau_{s+1}.$$

Since the user cost is a function of the tax rate change we can characterize the investment response as a closed form solution of tax rate changes. From equation (B.2)

$$\begin{aligned} \Delta \log i_{s+1} &= \frac{1}{\delta} \left[-\sigma \Delta \tau_{s+1} - \gamma \frac{Q_{s+1} - Q_0}{Q_0} + \gamma \frac{Q_s - Q_0}{Q_0} \right] \\ &\quad - \frac{d}{\delta} \left[-\sigma \Delta \tau_s - \gamma \frac{Q_s - Q_0}{Q_0} + \gamma \frac{Q_{s-1} - Q_0}{Q_0} \right]. \end{aligned}$$

Inserting for $\frac{Q_s - Q_0}{Q_0}$ gives

$$\begin{aligned} \Delta \log i_{s+1} &= -\frac{\sigma}{\delta} \Delta \tau_{s+1} + \frac{\alpha\gamma}{\delta} \Delta \tau_{s+2} - \frac{\alpha\gamma}{\delta} \Delta \tau_{s+1} \\ &\quad \frac{d\sigma}{\delta} \Delta \tau_s - \frac{d\alpha\gamma}{\delta} \Delta \tau_{s+1} + \frac{d\alpha\gamma}{\delta} \Delta \tau_s \end{aligned}$$

This implies that the log change in investment is determined by tax rates changes including lagged and forward terms

$$\Delta \log i_{s+1} = \left[\frac{\alpha\gamma}{\delta} \right] \Delta \tau_{s+2} - \left[\frac{\sigma}{\delta} + \frac{\alpha\gamma}{\delta} + \frac{d\alpha\gamma}{\delta} \right] \Delta \tau_{s+1} + \left[\frac{d\sigma}{\delta} + \frac{d\alpha\gamma}{\delta} \right] \Delta \tau_s. \tag{B.4}$$

This indicates that without adjustment cost and price effects, the change in investment is a function of current, future and lagged tax rate changes. Note that the sum of bracketed terms is

$$-\sigma = \left[\frac{\alpha\gamma}{\delta}\right] - \left[\frac{\sigma}{\delta} + \frac{\alpha\gamma}{\delta} + \frac{d\alpha\gamma}{\delta}\right] + \left[\frac{d\sigma}{\delta} + \frac{d\alpha\gamma}{\delta}\right].$$

Hence, the absolute value of the sum of the tax effects is approximately equal to the intertemporal substitution elasticity.

The time path is depicted in Figure B-1. It shows results from a numerical solution of the adjustment path.[21] The intertemporal elasticity of substitution is set to $\sigma = 0.21$ following Cashin and Unayama (2016). The elasticity of intratemporal subsitution $\epsilon = 0.18$ is taken from Pakos (2011). The monthly rate of interest r is set to 0.0025 equivalent to an annual rate of 3%, the monthly depreciation is set to 0.022 corresponding to an annual depreciation rate of 0.23 (see Cashin, 2017). b is set to 0.25 to match the actual spending share for consumer durables in the European Union in 2016.[22]

Without adjustment cost, investment increases in the month before the tax-rate increase by 1 percentage point. Note that the response is quite strong, given that the tax rate is supposed to increase by only 1 percentage point. However, owing to the small elasticity of intertemporal substitution, the sum of all changes in the houshehold's purchases of durables is only about -0.21%.

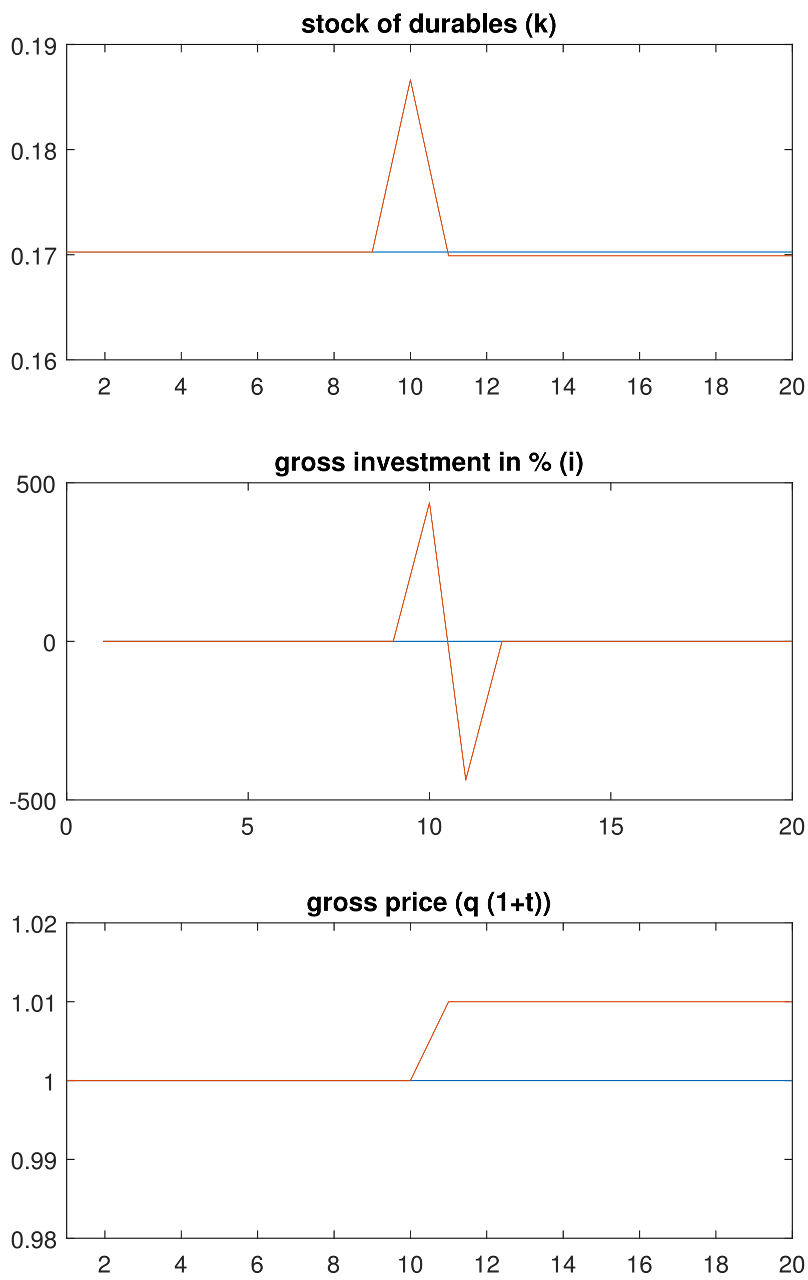
B.4.2 Tax Effects with Symmetric Adjustment Cost

In the presence of symmetric adjustment cost, if the capital stock is constant in all periods except immediately before and after a tax rate increase, the marginal adjustment cost C_s will deviate from

[21] We use Dynare 4.5.7. in Matlab R2018b.

[22] Final consumption expenditure of households by consumption purpose (COICOP 3 digit), Source: Eurostat.

Figure B-1: Investment around Tax Increase: No Adjustment Cost



Note: The figure depicts a numerical solution of the adjustment given a tax increase by 1 percentage point in period 10. Preference parameters are $\sigma = 0.21$ and $\epsilon = 0.18$. Adjustment cost is zero. The monthly rate of interest r is set to 0.0025 equivalent to an annual rate of 3%, the monthly depreciation is set to 0.022 corresponding to an annual depreciation rate of 0.23, b is set to 0.25.

zero in periods $t-1$, t and $t+1$. More specifically, from equation (B.5)

$$\begin{aligned} C_{t-1} &= -\frac{ck_0}{1+\tau_0}\beta\frac{k_t-k_{t-1}}{k_0} \\ C_t &= \frac{ck_0}{1+\tau_0}\left[\frac{k_t-k_{t-1}}{k_0}+\beta\frac{k_t-k_{t+1}}{k_0}\right] \\ C_{t+1} &= -\frac{ck_0}{1+\tau_0}\frac{k_t-k_{t+1}}{k_0}. \end{aligned}$$

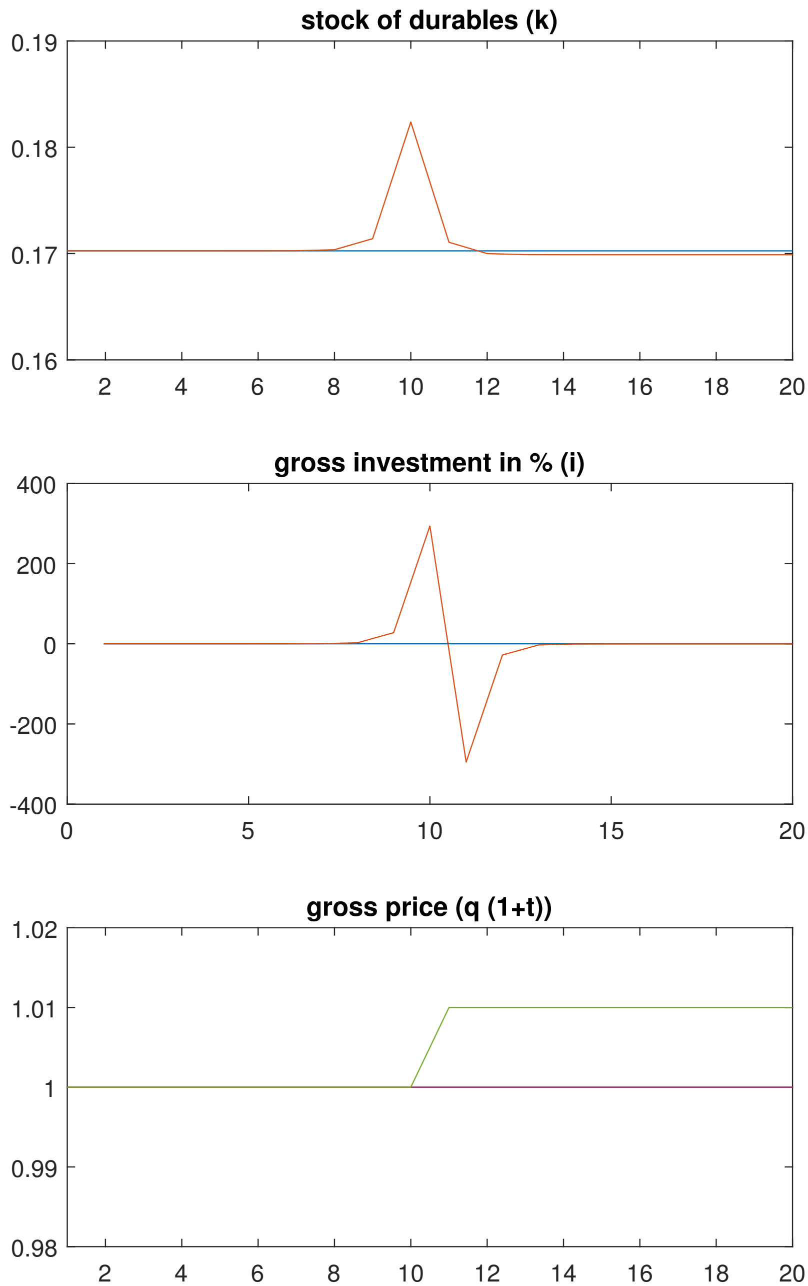
This implies that

$$\begin{aligned} C_{t-1}-C_{t-2} &< 0 \\ C_t-C_{t-1} &> 0 \\ C_{t+1}-C_t &< 0 \\ C_{t+2}-C_{t+1} &> 0. \end{aligned}$$

According to equation (B.2), $C_t - C_{t-1} > 0$ works against the decline in the user cost and thus mitigates the increase in the capital stock in period t. $C_{t-1} - C_{t-2} < 0$, however, implies that the capital stock starts to increase already in $t-1$. Thus adjustment cost provide the consumer with an incentive not to wait for the last month t with low taxes and start with higher purchases already in $t-1$. $C_{t+1} - C_t < 0$ mitigates the drop in the capital stock which results from $Q_{t+1} - Q_t < 0$. However, $C_{t+2} - C_{t+1} > 0$ implies that the capital stock still declines in period $t+2$. Thus, the adjustment cost provides an incentive to postpone the recovery in the capital stock for a later period.

This intuition is confirmed by a numerical solution of the adjustment path (see Figure B-2). The adjustment cost parameter c is set to 0.09 (Cashin, 2017). With adjustment cost, the increase in investment is much weaker than above. The time path also shows that investment starts to increase before the last month at low tax rates. However, the total effect on sales remains small, pointing to a long term decline of spending for durable of about -0.24%.

Figure B-2: Investment around Tax Increase: Symmetric Adjustment Cost



Note: Note: The figure depicts a numerical solution of the adjustment given a tax increase by 1 percentage point in period 10. Adjustment cost is symmetric with parameter $c = 0.09$. All other parameters the same as those used for Figure B-1, *i.e.* $\sigma = 0.21$, $\epsilon = 0.18$, $r = 0.0025$, monthly depreciation of to 0.022, $b = 0.25$.

B.4.3 Tax Effects with Asymmetric Adjustment Cost

The literature has discussed various alternative specifications for the adjustment cost including asymmetry adjustment cost, that differs depending on whether capital grows or declines (... reference needed ...). Formally,

$$\begin{array}{lll} (k_s - k_{s-1})^2 \frac{c^+}{2}, & \text{if } k_s > k_{s-1}, & c^+ > 0 \\ (k_s - k_{s-1})^2 \frac{c^-}{2}, & \text{if } k_s < k_{s-1}, & c^- > 0 \\ 0 & \text{if } k_s = k_{s-1}. & \end{array}$$

In this case, the marginal adjustment cost term C_s is

$$\begin{aligned} C_s \;=\; & \frac{c^+}{1+\tau_s} I\left[k_s - k_{s-1}\right](k_s - k_{s-1}) + \frac{c^-}{1+\tau_s} I\left[k_{s-1} - k_s\right](k_s - k_{s-1}) \\ & - \frac{\beta c^+}{1+\tau_s} I\left[k_{s+1} - k_s\right](k_{s+1} - k_s) - \frac{\beta c^-}{1+\tau_s} I\left[k_s - k_{s+1}\right](k_{s+1} - k_s), \end{aligned} \tag{B.5}$$

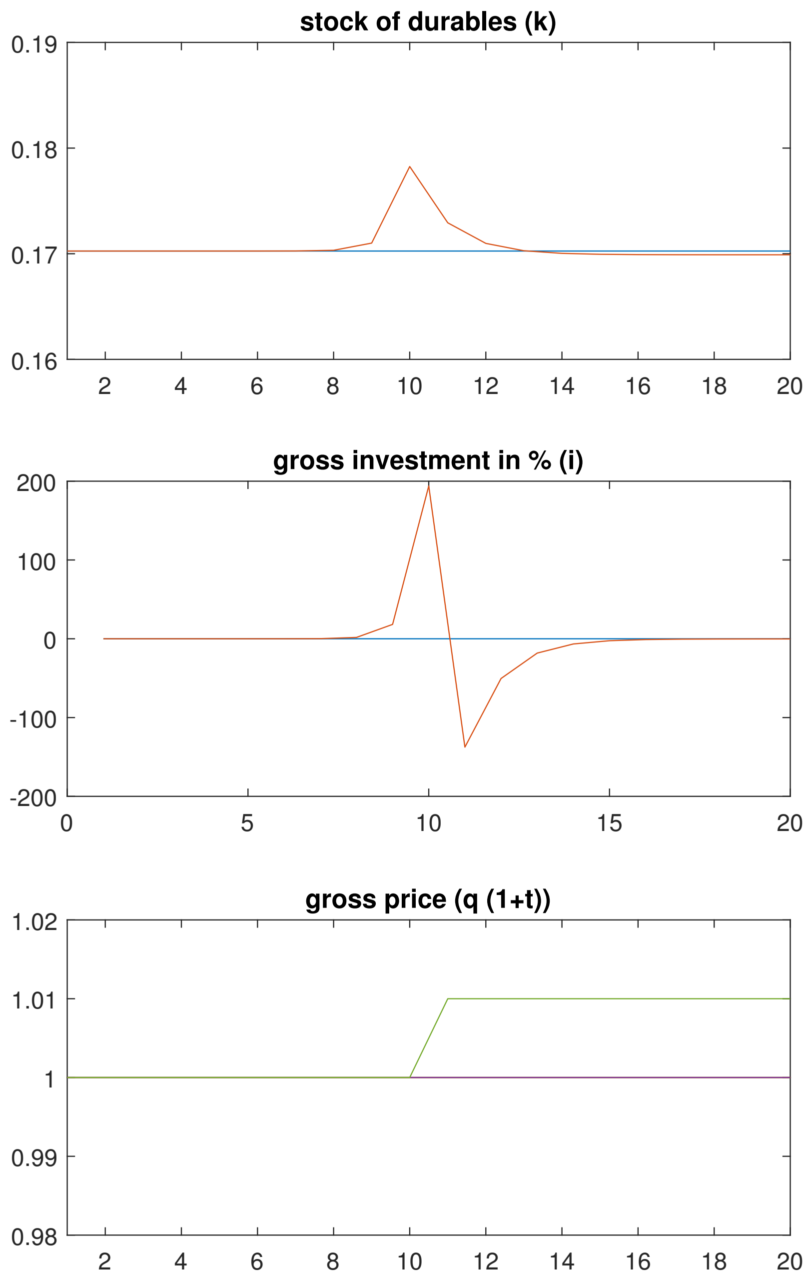
where $I[x]$ has unit value if $x > 0$ and is zero, otherwise. In the steady state, marginal adjustment cost is zero, as above.

The implication is shown by another numerical solution of the adjustment path (see Figure B-3). While the adjustment cost parameter for an increase in the stock of capital is unchanged, the downward adjustment is assumed to be associated with larger adjustment cost ($c^+ < c^-$). As the figure shows, the increase in investment is smaller than with symmetric adjustment cost and the recovery of investment takes more time and a longer time period is required to estimate the long-term effect on the purchases of durables.

B.4.4 Tax Effects with Staggered Price Adjustment

Depending on how the pre-tax price changes over the course of a tax increase, however, the user cost is not only affected by tax rate change and adjustment cost. To explore the implications, we

Figure B-3: Investment around Tax Increase: Asymmetric Adjustment Cost



Note: Note: The figure depicts a numerical solution of the adjustment given a tax increase by 1 percentage point in period 10. Adjustment cost is asymmetric with $c^{+} = 0.09$ and $c^{-} = 0.59$. All other parameters the same as those used for Figure B-1, *i.e.* $\sigma = 0.21$, $\epsilon = 0.18$, $r = 0.0025$, monthly depreciation of to 0.022, $b = 0.25$.

consider a scenario, where the retailer displays staggered price adjustment. More specifically, we assume that the retailer facing a tax increase by 1 percentag point, raises the price in three steps rather than in one. The retail price increases already in the last month before the tax rate change, and full price pass through is reached one month after the tax rate change.

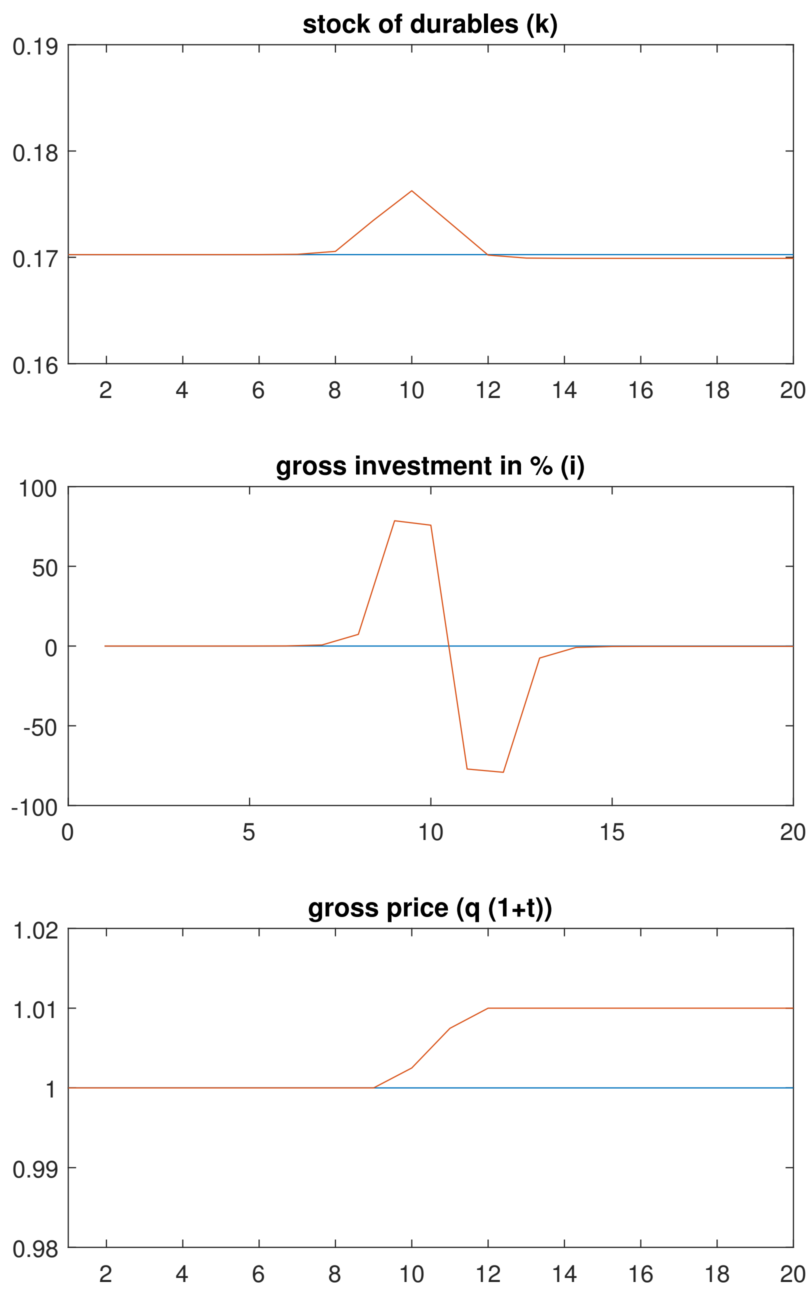
What is the intuition for the effect on the investment path? The retailer's price increase mitigates the decline in the user cost before the tax rate increases. At the same time, it implies that the user cost declines already in period t-1. Thus, the pre-retail price effects provide the consumer with an incentive not to wait for the last month to start with higher purchases. Moreover, as the tax increase is not fully shifted to the consumer in period $t + 1$, the user cost will not fully recover in period $t + 1$. This mitigates the drop in demand in period $t + 1$.

This intuition is confirmed by the numerical solution of the adjustment path (see Figure B-4). The figure depicts the adjustment path obtained with symmetric adjustment cost under the assumption that the retailer increases the price by 0.25% in the last month before the tax rate increases by 1% point. In the first month with the higher tax rate, the retailer is assumed to give a pre-tax discount by 0.25%. As depicted in the lower panel, the consumer price is 0.25% higher than the initial price in the period before the tax increase. It is about 0.75% higher in the first month with the higher tax rate. In the second month after the reform, the price is 1% higher than the initial price, such that there full pass-through.

Interestingly, the small price increase is quite effective in curtailing the strong investment demand in period t. Actually, in period $t - 1$ the investment increase is even higher. After the tax increase, investment drops less. While investment spending continues to be below the steady state level, recovery of investment spending is reached in period $t + 3$.

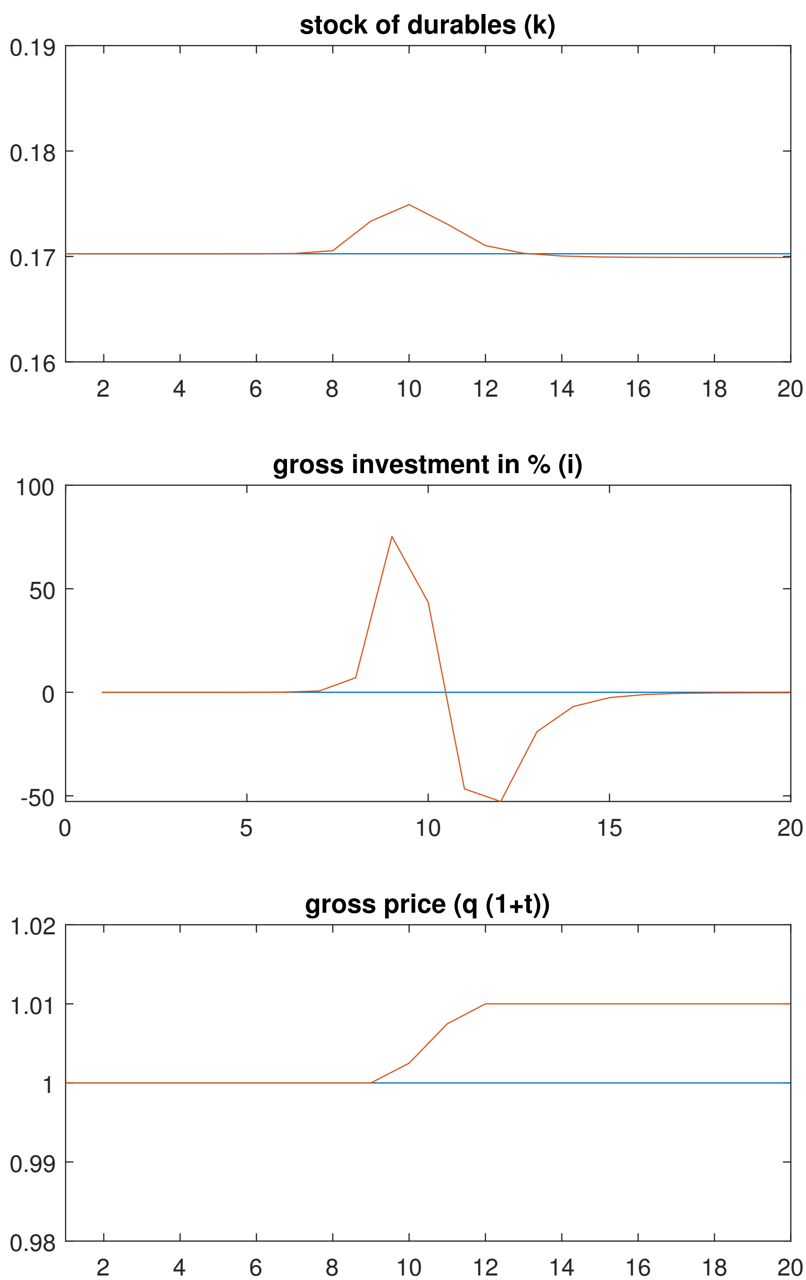
If the staggered price adjustment is combined with asymmetric adjustment cost, recovery of investment is further retarded (see Figure B-5).

Figure B-4: Investment around Tax Increase: Pre-Tax Price Effects



Note: The figure depicts a numerical solution of the adjustment path to a tax increase by 1 percentage point in period 10. The retail price is assumed to increase by 0.25 percentage points in period 9, 0.5 percentage points in period 10, and 0.25 percentage points in period 11. Adjustment cost is symmetric adjustment with common parameter $c = 0.09$. All other parameters the same as those used for Figure B-1, *i.e.* $\sigma = 0.21$, $\epsilon = 0.18$, $r = 0.0025$, monthly depreciation of to 0.022, $b = 0.25$.

Figure B-5: Investment around Tax Increase: Pre-Tax Price Effects and Asymmetric Adj.Cost



Note: The figure depicts a numerical solution of the adjustment path to a tax increase by 1 percentage point in period 10. The retail price is assumed to increase by 0.25 percentage points in period 9, 0.5 percentage points in period 10, and 0.25 percentage points in period 11. Adjustment cost is asymmetric with $c^{+} = 0.09$ and $c^{-} = 0.59$, as in Figure B-3. All other parameters the same as those used for Figure B-1, *i.e.* $\sigma = 0.21$, $\epsilon = 0.18$, $r = 0.0025$, monthly depreciation of to 0.022, $b = 0.25$.

References

Cashin, D., Unayama, T., 2016. Measuring intertemporal substitution in consumption: evidence from a VAT increase in Japan. *Review of Economics and Statistics* 98(2), 285-297.

Cashin, D., 2017. The Household Expenditure Response to a Consumption Tax Rate Increase. *Finance and Economics Discussion Series, Board of Governors of the Federal Reserve System (U.S.)* 2017-035, Washington D.C.

Ogaki, M., Reinhart, C. M., 1998. Measuring intertemporal substitution: the role of durable goods. *Journal of Political Economy* 106(5), 1078-1098.

Pakos, M. (2011). Estimating intertemporal and intratemporal substitutions when both income and substitution effects are present: the role of durable goods. *Journal of Business and Economic Statistics* 29(3), 439–454.

Shapiro, M.D., 1986. The Dynamic Demand for Capital and Labor. *Quarterly Journal of Economics* 101(3), 513–542.