What Goes Up May Not Come Down: Asymmetric Incidence of Value-Added Taxes.*

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Abstract

This paper shows that prices respond more to increases than to decreases in Value-Added Taxes (VATs). First, using two plausibly exogenous VAT changes, we show that prices respond twice as much to VAT increases than to VAT decreases. Second, we show that this asymmetry results in higher equilibrium profits and markups. Third, we find that firms operating with low profit margins are more likely to respond asymmetrically to VAT changes than firms operating with high profit margins. Fourth, this asymmetry persists several years after the VAT changes take place. Fifth, using all VAT changes in the European Union from 1996 to 2015, we find similar levels of asymmetry.

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1 Introduction

Value-Added Taxes (VATs) affect a large share of the world's economies: all member countries of the Organization for Economic Co-operation and Development (OECD), except for the United States, have adopted some form of VAT. In the European Union (EU), VATs raise 30% of total tax revenue or 12% of GDP, which amounts to the largest source of government revenue. U.S. politicians and think tanks have often mentioned using the VAT as a national sales tax or as a replacement for the corporate tax.[1] For these reasons, understanding the mechanisms underlying the incidence of VATs is both economically and policy-relevant.

In standard tax incidence models, the direction of a tax change is not defined, and supply and demand elasticities are sufficient to determine the proportion of the tax borne by each agent, which does not depend on the direction of the tax change. In this paper, we question the premise that prices respond symmetrically to variation in VATs by empirically showing that there is a consistently higher pass-through to prices for tax increases than for tax decreases.

We perform the analysis at two different levels. First, we focus on two reforms that are plausibly exogenous to the underlying economic conditions. We use a 14 percentage point decrease in the VAT rate applied to Finnish hairdressing services in January 2007 and a subsequent 14 percentage point increase in the same sector in January 2012.[2] We document – using European Commission Council Directives – that the two reforms were part of a VAT experimentation program, and therefore the timing of the reforms and the choice of sector are plausibly exogenous to the underlying economic conditions. Using micro price and corporate tax data, we compare hairdressing services to a control group consisting of beauty salons – which were unaffected by the VAT changes – and find five main results.

[1] During the 2016 US presidential election, two Republican candidates (Senators Ted Cruz and Rand Paul) proposed adopting a VAT. It was also considered by the Obama administration as a possible source of funding for health care costs (Reported in *Washington Post, May 27, 2009*).

[2] Kosonen (2015) analyzes the effect of the January 2007 VAT cut on profits, costs and prices as well as other firm level outcomes. We reproduce some of these results and highlight them in more detail in Section 2.2.

First, we find that prices respond twice as much to the 14 p.p. VAT increase than to the 14 p.p. VAT decrease. Second, we find that this asymmetry persists several years after the VAT cut is repealed, suggesting that equilibrium prices depend on the history of tax changes. Third, we find that the asymmetric pass-through is reflected in both markups and profits: both respond asymmetrically to VAT changes and end up at a higher equilibrium level once the VAT cut is repealed. Firm profits and markups increase following the VAT decrease. However, they decrease by half as much following the VAT increase and remain higher than their pre-reform level relative to the control group. Fourth, we uncover an additional layer of asymmetry: the underlying distribution of price changes following the VAT increase is substantially different from that of the VAT decrease. Following the VAT decrease, 60% of hairdressers keep their prices unchanged, while 40% decrease their prices with no specific target. Following the VAT increase, the distribution is bi-modal, with approximately 50% of hairdressers targeting 100% pass-through, 25% keeping their prices unchanged, and the remaining 25% passing through between 0% and 80% of the VAT increase to prices with no specific pass-through target. Fifth, we find that the asymmetric pass-through can be explained, in part, by firm profit margins. Firms operating with low profit margins are more likely than firms operating with high profit margins to respond asymmetrically to VAT changes.

The second level of analysis broadens the scope of our findings by considering every VAT change that occurred in the Member States of the EU from 1996 to 2015. Using these reforms, we are able to perform several tests of the asymmetry. Because the VAT reforms we consider cover all sectors of the economy, we show that the asymmetry is not specific to small labor-intensive sectors (such as hairdressers) but exist in most other industries regardless of their size. Second, we find asymmetric pass-through both for sector-specific VAT changes and for changes in the main VAT rate, which affects most commodities in the economy, further generalizing our findings.

The Finnish hairdressing reforms were part of a VAT experimentation program and are, therefore, plausibly exogenous to economic conditions. The reforms that we use in the second level of analysis, however, were initiated by Member States. We address the concern that these reforms might be endogenous to economic conditions in several ways. First, we find no significant pre-trends in prices prior to the reforms. Second, we regress the timing of reforms for both VAT increases and decreases on country-specific economic indicators, including GDP and the unemployment rate. We find no correlation between the timing of VAT changes and the economic conditions leading up to the reforms, which mitigates our concern that VAT changes are endogenous to economic conditions. Third, we use matching estimators to match VAT increases and decreases over several key characteristics of the reforms and estimate pass-through on the subset of matched reforms and find similar levels of asymmetric pass-through. This mitigates the concern that VAT increases might be intrinsically different from VAT decreases, which could affect the pass-through of the tax to prices.

Our findings are important for four main reasons. First, although the VAT is one of the taxes that raise the most revenue, there is limited work analyzing it.[3] The policy and research relevance of the VAT is highlighted in the Mirrlees Review (Mirrlees (2010)) which offers key tax reform proposals, with the VAT being prominently featured. The proposals related to the VAT rely on the key assumption that VAT incidence falls fully on consumers, mostly because of lack of empirical evidence, as emphasized in Atkinson (2012). Since the Mirrlees Review has been published, important empirical progress on the incidence of VATs has been made. Gaarder (2018), for example, uses a compelling empirical design to estimate the incidence and distributional effects of a VAT cut on food items in Norway. We add to this important question by contrasting the incidence of VAT increases and decreases. Furthermore, we contribute to our general understanding of the effect of VATs on the economy, along with other papers such as Feldstein & Krugman (1990), Hines & Desai (2005), Naritomi (Forthcoming), Benedek et al. (2015), Benzarti & Carloni (2019), Kosonen (2015), Pomeranz (2015) and Kleven et al. (2016).[4] Second, because the asymmetry is present for a large set of countries and commodities, the results suggest a gap in an essential part

[3]A Proquest search of the expression "Value-Added Tax" returns 17,979 scholarly peer-reviewed articles, while "Income Tax" returns 140,408 such articles.

[4]Notably, Benedek et al. (2015) estimate the pass-through of VATs to prices using the same sources of data as we do. While we focus on providing evidence that prices respond asymmetrically to variation in VAT rates and estimate the magnitude of the asymmetry, Benedek et al. (2015) estimate the pass-through of VATs. There are also some significant differences in the two approaches, as we consider a larger set of commodities, countries and years.

of standard tax incidence analysis and the need to introduce dynamics when assessing the welfare effects of taxation. If responses depend on the direction of tax changes, this should be accounted for when defining tax incidence. For this reason, our empirical findings call for future research to account for dynamics in optimal tax models, in the spirit of Golosov et al. (2011). If asymmetric responses to taxes are prevalent, as documented in our paper, then dynamic models would be key in both assessing the welfare implications of taxation and deriving optimal taxes. Third, our results suggest that reform-based estimates of incidence may be systematically biased if they consider either a tax increase or a tax decrease but not both. Fourth, given that prices adjust upwards but not downwards, using temporary VAT cuts to stimulate demand may have the opposite effect, resulting in a higher equilibrium price once the VAT cut is repealed and benefiting mainly firm owners at the expense of consumers.

This paper also contributes to a growing public finance literature that documents non-standard responses to consumption taxes – such as in Chetty et al. (2009), Marion & Muehlegger (2011), Li et al. (2014), Feldman & Ruffle (2015), Taubinsky & Rees-Jones (2018), Harju et al. (2018) and Kopczuk et al. (2016). More broadly, it is related to a literature in public finance that estimates tax incidence.[5] Our paper is the first to provide systematic evidence on the asymmetric pass-through of taxes and to show that prices consistently respond more to increases than to decreases in tax rates. Our paper is related to Carbonnier (2008), but our findings are different.[6] While we show that prices respond systematically more to VAT increases than to decreases, Carbonnier (2008) finds that prices in some industries respond more to VAT increases, while in others they respond more to VAT decreases.[7] Our paper goes beyond two limitations of

[5]Kotlikoff & Summers (1987) and Fullerton & Metcalf (2002) provide a survey of the tax incidence literature.

[6]The published version is in French: see the working paper version (Carbonnier (2005)) for an English translation.

[7]Politi & Mattos (2011) and Karadi & Reiff (2019) are two other papers that consider asymmetric responses of prices to VAT reforms. They suffer from the same shortcomings as Carbonnier (2008) – namely, they only consider a small set of VAT changes (at most three), they perform their analysis only on one sector (the food sector) and the VAT changes they consider are relatively small (5 percentage points at most). In addition to using an empirical setting that is both more general and more compelling, we document several additional key empirical facts, including the long term persistence of the asymmetry and the asymmetric response of

Carbonnier (2008) which could explain the differences in our findings. First, we consider the entire set of commodities traded in each Member State of the EU, whereas Carbonnier (2008) considers only 11 commodities in France. Second, we examine all VAT changes across all Member States of the EU over a period of 20 years, with substantial variation in the magnitude of the VAT changes, some being as large as 15 percentage points. In contrast, Carbonnier (2008) uses two VAT changes: a two percentage point VAT increase and a one percentage point VAT decrease. Our results also contrast with those of Doyle & Samphantharak (2008), who find *symmetric* responses of prices to a 120-day temporary moratorium on a 5% gasoline tax in 2000. There are two possible explanations for the symmetric response found in Doyle & Samphantharak (2008). First, the moratorium was implemented by the Governor of Indiana during an election year because he was concerned about the effect of soaring gasoline prices on his re-election. For this reason, gasoline retailers were likely to be under both scrutiny and pressure to reduce prices. Second, because the moratorium lasted only 120 days, asymmetric price changes would have been relatively easy to detect and could have resulted in substantial consumer antagonism.

Our findings are also related to a literature in industrial organization that tests for asymmetric pass-through of input costs.[8] There is a fundamental difference between the asymmetry we document and the input cost asymmetry. The empirical evidence on input cost asymmetry shows that prices tend to show a timing asymmetry when responding to cuts in input costs and a convergence to symmetry over time. The asymmetry lasts for one month in Borenstein et al. (1997) and three to five months in Peltzman (2000). Instead, we observe that prices respond immediately to VAT cuts and find no evidence of convergence over time. Further, two main distinctions between changes in costs and changes in consumption taxes make the latter better suited for identification. First, variation in costs can affect different firms differently: for example, an increase in the price of produce is likely to affect fast food restaurants more than it does Michelin star restaurants. Conversely, changes in VATs affect all restaurants similarly, as taxes are a percentage of the final price. Second, variation in VAT rates is

firm level outcomes to the VAT changes.

[8]See Meyer & Cramon-Taubadel (2004) for a survey of this literature.

directly observable. This is important because some of the most convincing explanations of the asymmetric pass-through of input costs – such as Benabou & Gertner (1993) – are based on consumer uncertainty over current and future levels of input costs. This fact has led this literature to focus on goods that have one predominant input that experiences large cost variations. For example, Peltzman (2000) notes that his finding of asymmetric pass-through of input costs relies on a "possibly unrepresentative sample of low-tech, low-value-added items." Peltzman (2000) further notes that this context can lead to spurious asymmetries. Because input costs are not observable, they are measured with error, and if this error is stronger for cost decreases than for increases – possibly because of inflation – that could create spurious asymmetries. Third, changes in VATs do not affect the price of other intermediate inputs, while it is conceivable that changes in the main intermediate input used for identification can affect the price of other intermediate inputs, further weakening identification. These fundamental differences could be some of the reasons that tax incidence analysis in the public finance literature seldom considers the possibility of asymmetric pass-through of taxes, despite the evidence presented in the industrial organization literature.

This paper is organized as follows. Section 2 presents the institutional details and the data we use for the analysis. Section 3 focuses on the Finnish hairdressing services reforms. Section 4 provides evidence of the asymmetry, using all VAT changes that occurred in the European Union from 1996 to 2015. Section 5 discusses possible mechanisms. Section 6 offers policy implications and concludes.

2 Data and Institutional Background

2.1 Value-Added Taxes

VATs apply to the value-added of goods and services sold and is included in consumer prices in the EU. Firms remit the VAT that they collect from consumers to the government and claim credits for the VAT they pay on input costs, which implies that only value-added is taxed. Final consumers, who are the last component of the chain, cannot claim any tax credit and, therefore, pay the tax on the entire value of final goods purchased.

Member countries of the EU generally have several VAT rates in place, including a standard rate that applies to the majority of commodities and a reduced rate for basic necessities such as food, heating and passenger transport, while some commodities are tax-exempt and others zero-rated.[9]

2.2 Finnish Hairdressing Sector VAT Reforms

Institutional background. While the European Commission restricts excessive VAT changes to avoid VAT competition, it allows Member States to experiment with reduced VAT rates for a small sample of labor-intensive services, with the explicit goal of analyzing the incidence of VATs on prices and employment.[10] The European Commission established the full set of services with which countries are allowed to experiment and explicitly listed them in European Commission (1999). While the list includes hairdressing services, it excludes other, very similar services, such as beauty salons. This makes hairdressing services a natural treatment group, and beauty salons a plausible control group. Finland took part in the second wave of the experimentation program, which was set to start in January 2007 (Council Directive 2006/112/EC). It was agreed on in November 2006 that the rate would subsequently revert to its original level. This resulted in a reduction in the VAT rate on hairdressing services from 22% to 8% in January 2007 and a subsequent increase from 9% to 23% in January 2012.[11] Because the timing, magnitude and commodities affected by this reform were set by the European Commission, the reforms are plausibly exogenous to economic conditions.

Hairdressing services are particularly suited to our analysis. First, firm size is relatively small, and there are no large buyers, which mitigates concerns that the asymmetry could be driven by large monopoly or monopsony power. Second, there is nothing particular about the hairdressing sector in Finland that is likely to threaten the external validity of the reforms. For example, there are no specific business or licensing requirements imposed on hairdressers that could create

[9]Producers of zero-rated commodities can claim credits for VATs paid on intermediate inputs, while producers of VAT-exempt commodities cannot.

[10]See European Commission (1999) and European Commission (2006).

[11]The reduced and standard VAT rates were both increased by one percentage point in July 2010.

barriers to entry. Similarly, the sector does not benefit from any particular status relative to other sectors in the Finnish economy.[12]

Importantly, Kosonen (2015) has analyzed the first leg of the reform and we are replicating some of his results in this paper. In particular, Kosonen (2015) has considered the pass-through distribution of the VAT cut (Panel a. of Figure 3) and estimated the effect of the VAT cut on profits (years 2000 to 2009 in Figure 5a). While the paper also documents the effect of the VAT cut on costs, it does not break it down by fixed versus variable costs.[13]

Data. We use price data collected by surveyors from a random sample of the full population of hairdressers before and after each VAT change. Prices for nine types of services were collected: short-hair haircuts, long-hair haircuts, children's haircuts, complicated haircuts, short-hair permanent waves (perms), long-hair permanent waves, short-hair coloring, long-hair coloring and complicated coloring. The prices collected are the "menu" prices rather than transaction prices, but we also have information on whether coupons or discounts are offered in each particular location. The dataset contains 2,822 price observations around the VAT decrease originating from 427 firms and 2,106 price observations around the VAT increase stemming from 347 firms. We also use micro and aggregate price data from Statistics Finland for haircuts, other hairdressing services and beauty salons to analyze the long-term effects of the reforms.

We supplement the price data with corporate tax data covering the entire population of firms in Finland. The data are annual and contain information on every line of profits and losses, thus allowing us to observe turnover, fixed and variable costs separately, as well as the number of employees.[14]

2.3 European VAT Reforms

Institutional background. There are three types of VAT changes in our sample of reforms: (1) standard VAT rate changes that apply to most commodities

[12]See Kosonen (2015) for a detailed description of the hairdressing industry.

[13]Kosonen (2015) also considered the effect of the VAT cut on other variables (turnover and quantity) and other dimensions of heterogeneity (firm size), which we do not consider in our paper.

[14]Appendix Table D.3 shows summary statistics for hairdressers and beauty salons.

in the economy; (2) reduced VAT rate changes that apply to commodities that are generally considered necessities; and (3) sector-specific VAT changes.

Price data. We use price data from Eurostat's *Harmonised Indices of Consumer Prices* (HICP). The dataset contains monthly non-seasonally adjusted information on commodity prices across European countries for the period 1996-2015.[15] The HICP provides monthly price data by Classification of Individual Consumption According to Purpose (COICOP) and is assembled according to a harmonized approach that makes cross-country information comparable.[16] These data represent the single most reliable source of information on prices across EU countries. They do not contain information on the prices of intermediate goods.

Historical VAT rates. Information on VAT rates by commodity and country is provided directly by the European Commission (EC) in its annual report: *VAT Rates Applied in the Member States of the European Community.* The report contains detailed information on the VAT rate applied to each commodity in each European country, as well as the exact date of the VAT reforms. It covers all commodities subject to VATs.

Because the reports only contain information on current EU members we consider 27 European countries: (1) since 1996: Austria, Belgium, Denmark, France, Finland, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom; (2) since 2004: Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia; (3) since 2007: Bulgaria and Romania. We exclude Croatia because it became a member of the EU only in 2013.

We drop Education because, in this sector, for-profit institutions are subject to VATs, whereas not-for-profit institutions are exempt. The majority of institutions are not-for-profit and, therefore, unaffected by the VAT changes, but we cannot differentiate for-profit from not-for-profit institutions in the price dataset. We also drop Clothing and Footwear, as prices exhibit strong seasonality, with most

[15] Eurostat is an organization of the European Commission responsible for collecting and harmonizing data to provide statistical information about Member States of the EU.

[16] Appendix Tables D.4 and D.5 list all the COICOP categories used in our analysis.

sales occurring in January, which is also the month in which most VAT changes occur.

Appendix Figures D.9, D.10, D.11 and D.12 plot the distribution of VAT increases and decreases by commodity, country, economic conditions (unemployment rate and GDP growth), size, time of the VAT changes and pre- and post-reform VAT rates, respectively. Overall, in our sample of VAT changes, 28% are VAT decreases and 83% are economy-wide VAT changes.[17]

3 Finnish Hairdressing Reforms

3.1 Price Response to VAT changes and Long-term Persistence

Figure 1 uses time series from Statistics Finland from January 2005 to November 2015 to show the evolution of hairdressing and beauty salon prices. Prior to the January 2007 reform, the VAT rates for hairdressing services and beauty salons were equal. In January 2007, the VAT was decreased by 14 percentage points for hairdressing services and held fixed for beauty salons. In January 2012, the VAT rate for hairdressing services was increased by 14 percentage points.

Three main empirical patterns emerge from Figure 1. First, beauty salons seem to be a natural control group for hairdressing services: pre-reform, prices follow parallel trends throughout the entire 10-year period. Second, the largest response of hairdressing prices is observed during the first month for both the VAT decrease and increase. Third, after the VAT rate for hairdressing services was returned to the same level as that for beauty salons, hairdressing prices remained higher than beauty salon prices without any signs of convergence. This suggests that the asymmetric response of prices to VAT rates persists over the long run – in this case, for at least 3.5 years. We also estimate the pass-through to prices of the VAT increase and decrease separately for each service offered by hairdressers and controlling for costs and find similar levels of asymmetric pass-through, whereby prices respond approximately twice as much to the VAT

[17] We discuss some of the institutional reasons that explain that there are more VAT increases than decreases in Section 4.3.

increase as to the VAT decrease.[18]

3.2 Pass-Through Distribution

Short-Run Pass-Through Distributions. We use the micro-level price data to plot the short-run distribution of pass-through. We calculate pass-through by taking the log difference of prices one month before and one month after the VAT reform: $\rho_i = \log(p_{after}) - \log(p_{before})$.[19] Figures 3a and 3b plot the distribution of ρ_i for the VAT decrease and increase, respectively, for all nine types of services combined. The pass-through distribution for the VAT increase is bi-modal: 27% of prices do not respond to the VAT increase, while 48% of prices increase by 80% to 120% of the VAT increase. The distribution of pass-through for the VAT decrease is uni-modal: 61% of prices do not change in response to the VAT cut, while the rest decrease but without targeting full pass-through (12% are located within 20% of full pass-through).

The asymmetry in pass-through distributions is not driven by specific services: we systematically observe a bi-modal distribution following the VAT increase and a uni-modal distribution following the VAT decrease for each of the nine services offered by hairdressers.[20] The observed heterogeneity can instead be explained by firm heterogeneity. In Figure 2, we count the number of prices that are changed by any magnitude, divide it by the number of services offered by each firm and then plot the distribution of the resulting ratio. The distributions are bi-modal, which suggests the presence of two types of firms: those that tend to change all prices and those that keep all prices fixed. This finding is consistent with the argument made by Kopczuk & Slemrod (2006) and Slemrod & Gillitzer (2013), who point to the importance of accounting for firm-level heterogeneity when modeling tax behavior. We return to this in subsection 3.5 and show that it is likely to be driven by firms having different profit margins.

[18] The pass-through estimates are reported in Appendix Table D.6.

[19] Appendix Figure D.13 plots a version of Figure 3 that controls for inflation. The distributions are very similar but otherwise shifted to the left.

[20] See Appendix Figures D.14, D.15, D.16 and D.17.

Pass-Through Distribution Dynamics in the Medium Run. To explore the dynamics of the pass-through distributions, we use a different price dataset, collected by Statistics Finland because our dataset does not contain prices for longer horizons. This dataset has three main drawbacks. First, prices are unlikely to be randomly collected.[21] Second, we cannot observe prices immediately after the reform.[22] Third, we do not have access to the VAT increase periods.

Figures 4a, 4b, 4c and 4d plot the distribution of $\rho_i = \log(p_t) - \log(p_0)$, where p_0 is price one month before the VAT change and p_t is price measured $t = \{6, 12, 18, 24\}$ months after the VAT decrease, using the Statistics Finland dataset. These Figures show that most of the price adjustments occur within a six month window, after which the excess mass of inert prices remains constant. The distributions look qualitatively similar to the short-run distributions from Figure 3, with a mass at zero and the remaining price changes being negative with no specific targeting of full pass-through. However, the size of the spike at zero, while constant over time, is different from the one we observe in the short run in Figure 3, using our dataset. This is likely due to the fact that the Statistics Finland dataset does not randomize the collection of prices.

3.3 Asymmetric Response of Profits and Markups

Using the administrative corporate tax data on the full population of hairdressers and beauty salons, we investigate the response of profits and markups to VAT changes. We observe turnover, profits and variable and fixed costs, among other variables. As a proxy for markups, we use turnover minus variable cost divided by variable cost. This proxy is accurate as long as marginal costs are constant, which seems reasonable for hairdressers.

Figure 5a plots the coefficients from a regression of log profits on year dummies from 2000 to 2014 for hairdressers and beauty salons.[23] The graph shows that profits respond asymmetrically to the VAT changes: the VAT decrease results in

[21] Statistics Finland over-samples larger firms and firms with prices that are easy to collect, such as firms with online prices and firms in the Helsinki area.

[22] The price collection is such that not all observations are updated immediately, and it can take up to six months for a given price to be updated.

[23] We exclude firms with less than €10,000 in turnover or €1,000 in profits to exclude small firms that are exempt from remitting VAT.

an increase in profits of 0.2 log points, while the VAT increase leads to a profit decrease of 0.1 log points. Figure 5b shows a similar graph for markups that increase by twice as much following the VAT decrease as they decrease following the VAT increase. We observe no evidence of convergence of profits or markups towards symmetry three years after the VAT reverts to its original level. In contrast to Figures 5c and 5d, we observe no significant changes in variable and fixed costs following the VAT changes, thus suggesting that quantities are not affected by the reform.[24] These observations are consistent with firms using VAT cuts to increase profits, while passing through VAT increases to prices to minimize their impacts on profits.

3.4 Long-term Persistence of the Asymmetry

Figure 1 shows that, once the VAT rate applied to Finnish hairdressers is increased back to its original level, prices remain higher than for the control group 3.5 years later in spite of the VAT rates being equal for both groups. This persistence is also present in profits and markups, as shown in Figures 5a and 5b. In Section 4.4, we provide evidence that asymmetric pass-through is persistent in other markets and countries. This suggests that the market equilibrium depends on the history of tax changes. If markets operate competitively, the rents generated by VAT changes should be reduced to zero. Our data suggest two possible failures of competition that could explain the long-term asymmetry.

The first is that we observe very little entry by new firms. Standard theory predicts that firms would enter the market to capture the windfall generated by the VAT decrease or to charge lower prices following the VAT increase. This increased entry should reduce prices until they reach their competitive levels. We detect no evidence of increased entry (or exit) in the hairdressing sector following the VAT changes.[25] This is especially puzzling because this sector is one in which barriers to entry are relatively low. In Finland, hairdressers face no particular institutional barriers to entry (they are not required to obtain a license or special

[24] We also plot the evolution of investment over time for hairdressers and beauty salons in Appendix Figure D.18 and find no response.

[25] The results are reported in Appendix Figures D.19 and D.20, which plot the number of firms and entry and exit over time, respectively.

training), and startup costs are relatively low.[26]

The second failure of competition is that firms do not appear to react strongly to one another's prices. We calculate the density of hairdressers for each zipcode and generate five quintiles, the first including zipcodes with the lowest density of hairdressers and the fifth the most hairdresser-dense zipcodes. We then test whether markups are more likely to respond differently to changes in VAT rates in denser zipcodes. We find that hairdresser density does not affect the response of markups to the reforms.[27] Overall, both of these explanations suggest that, in contrast to what standard incidence theory usually assumes, these markets do not seem to be operating competitively.

3.5 Heterogeneous Firm Response

The main dimension of heterogeneity we uncover is that firms with low profit margins at the time of the VAT change tend to pass through more of the VAT increase than of the decrease, whereas firms with high profit margins are more likely to behave symmetrically. We define profit margins as turnover minus operating costs divided by turnover, and, to mitigate concerns of mean reversion, we calculate a three-year average profit margin prior to the first VAT change (from 2004 to 2006) and break down our sample of hairdressers into five quintile groups from the lowest profit margins to the highest.[28] Figure 6a plots the change in markup (as defined in subsection 3.3), in 2007 and 2012, for each quintile of profit margins and shows that hairdressers in the lowest quintile take advantage of the VAT cut to increase their markups, whereas firms in higher quintiles tend to behave symmetrically. To further mitigate concerns of mean reversion, we carry out two placebo tests: (1) Figure 6b plots the response of the same quintiles

[26] This is consistent with Benzarti et al. (Forthcoming) who find no response of entry or exit of entrepreneurs when the social insurance mandate is relaxed.

[27] The results are reported in Appendix Table D.7. Except for an increase in markups for the most dense zipcode following the VAT decrease – which seems to be due to a decrease in costs – we find no significant effect of density on changes in markups. We perform a similar test using local average markup quintiles instead of density and get similar results, as shown in Appendix Table D.8.

[28] Figures D.21a, D.21b and D.21c perform the same test using a different definition of the quintile margins by using the 2004 to 2006 data for the 2007 reform and the 2009 to 2011 data for the 2012 reform.

in 2006 and 2011 and (2) Figure 6c plots the response of beauty salons in 2007 and 2012. We find that changes in markups are significantly more homogeneous across quintiles in the placebo tests relative to the treatment quintiles.

3.6 What Can We Learn From the Finnish Evidence?

The Finnish VAT experiment has several advantages: (1) the timing and commodities affected by the reforms are not chosen by the Finnish Government but imposed by the European Commission, (2) the VAT increase and decrease are of the same magnitude and are large (14 percentage points) and (3) we have rich firm level and price data that allows us to precisely assess the effects of these changes.

However, this experiment suffers from one main shortcoming: while the VAT increase and decrease affect the same commodities, in the same country and are of the same magnitude, they do not occur at the same time. More importantly, the VAT decrease occurs prior to the Great Recession and the VAT increase after the Great Recession. While we do not detect any sharp changes in prices (Figure 1) or profits (Figure 5a), markups (Figure 5b) and costs (Figures 5c and 5d), in both the treatment and control groups, except at the time of the VAT changes, suggesting that changes in economic conditions do not differentially affect the treatment and control groups, we cannot rule out the fact that the difference in economic conditions in 2007 and 2012 might be affecting pass-through rates in a way that could bias them towards asymmetry.

This is why we turn to using all VAT changes that have occurred in the EU from 1996 to 2015 to address this concern. In addition to providing evidence of asymmetric pass-through in a much larger sample of countries, periods and commodities, we can use this larger sample of reforms to compare similarly sized VAT changes that occur at similar times on similar commodities by implementing a matching approach, which we explain in detail below. If similar VAT increases and decreases still generate asymmetric pass-through, then the concern that the Finnish evidence is an artifact of the VAT changes occurring at different times would be severely mitigated.

4 European VAT Changes

4.1 Graphical Evidence

We use our full sample of VAT changes, as described in Section 2.3, to plot unconditional means of the price index – without controlling for inflation – and the VAT rate in the three months before and after the reform, normalizing the series to 100 in the month before the reform.

Figure 7a plots the unweighted average price of all commodities considered in the full sample for VAT increases and decreases separately and the average VAT changes. It shows that prices increase discontinuously in the month following a VAT increase but do not decrease as much when VATs decrease. The observed asymmetry is not driven by a selected subset of commodities. Instead, when we plot disaggregated versions of Figure 7a by two-digit COICOP groups (in Appendix Figures D.22, D.23 and D.24), we find that all commodities exhibit asymmetric pass-through, with the exception of Communication (COICOP group number 8), for which pass-through of VAT decreases is 318%, and Furnishings, Household Equipment and Routine Household Maintenance (COICOP group number 5), for which pass-through is small for both VAT increases and decreases.[29]

In addition to testing the presence of asymmetric pass-through for sector-specific VAT changes, as with the Finnish hairdressing reforms, the European VAT changes allow us to test whether the asymmetry exists for economy-wide VAT changes. The fact that the asymmetric pass-through of VAT changes holds economy-wide mitigates several concerns, including the fact that the asymmetry is a feature of small labor-intensive sectors (such as hairdressers) or is driven by sector-specific lobbying.

[29]Possibly because of sample size, trends do not appear to be parallel for two COICOP categories: (1) Alcoholic Beverages, Tobacco and Narcotics and (2) Transport. While pass-through is asymmetric in both of these cases, the violation of the parallel assumptions suggest that we should be cautious in interpreting these two figures.

4.2 Empirical Approach

To estimate the pass-through to prices of VAT increases and decreases, we follow the approach of Evans et al. (1999), who estimate the pass-through of cigarette taxes using different tax changes across US states over time. We run the following fixed-effects regression:

$$\begin{aligned}\Delta \log(p_{ict}) &= \beta_0 \Delta \log(1+\tau_{ict}) \\ &\quad + \sum_{k=-10,k\neq 0}^{k=10} \beta_k \Delta \log(1+\tau_{ic(t+k)}) + \Delta\lambda_t + \gamma \Delta X_{ct} + \Delta\epsilon_{ict}, \end{aligned} \quad (1)$$

where i denotes the commodity, c the country and t the month in which the price is observed, λ_t time fixed effects, p_{ict} the price, τ_{ict} the VAT rate and ϵ_{ict} the error term. We control for a given country's nominal interest rate, GDP per capita and unemployment rate with X_{ct}.[30] For each of $x_t = \{\log(p_{ict}), \log(1+\tau_{ict}), \lambda_t, X_{ct}, \epsilon_{ict}\}$, Δx_t is equal to $x_t - x_{t-1}$.

In equation (1), $\beta_0 \in [0,1]$ identifies the pass-through of a VAT change in the month when the change occurs: for example, if $\beta_0 = 0$, then the price does not respond to a VAT change, and if $\beta_0 = 1$, the price responds one-to-one to a VAT change. The second term of the equation estimates any forward- or backward-looking responses of prices to changes in VAT rates; β_{-5}, for example, idenitifies the response of prices at time t to VAT changes that will occur at time $t+5$.

The fixed-effects regression generalizes a difference-in-differences regression with multiple periods, commodities and countries, and its main identification assumption is the same as that for difference-in-differences regressions: absent the tax change, there would have been no change in the prices of the treated relative to the untreated commodities. Figure 7a shows a sharp change in prices at the time of the reform, with no pre-trends and no evidence of anticipatory behavior, which lends support to this identification assumption. Identification relies on within-country-specific commodity variation in VAT rates over time.

The results of the fixed effects regression are reported in Table 1.[31] Columns

[30] We also include a specification without controls (but with time fixed effects) in Appendix Table D.9 and get very similar levels of pass-through

[31] In a recent working paper, Abraham & Sun (2018) compellingly show that event study specifications can be problematic under certain conditions. In our case, this would be a problem

(1) and (2) of Table 1 correspond to VAT increases and decreases, respectively. The first row of each regression (labeled β_0) shows the pass-through of the VAT change to prices one month after the reform. In particular, β_{+i} shows the response of prices to VAT changes i months after the reform, while β_{-i} shows the response of prices i months before the reform. Figures 7b and 7c plot the coefficients from the fixed-effects regression for the VAT increases and decreases, respectively, and show that the pass-through to prices of VAT increases is equal to 34% while that of VAT decreases is equal to 7% one month after the reform, and both are statistically significant. There are no significant price responses in any months within a 10-month window around the VAT increases and decreases. We perform several robustness checks, including running specification (1) separately on reforms that are classified as temporary and permanent, on reforms that are not concurrent with other tax changes, and including country-commodity specific inflation controls and find similar levels of asymmetry.[32]

4.3 Endogeneity Concerns

This section addresses the concern that some of the VAT changes might be endogenous. First, we use economics and institutional knowledge to identify the variables we expect, ex-ante, to be correlated with the timing of VAT changes. Second, we empirically test the correlation between the timing of VAT changes and economic conditions. Third, using different matching algorithms, we estimate the pass-through to prices for VAT increases and decreases of similar size, occurring in similar countries, at similar times and for similar commodities.

Variables that are ex-ante expected to be correlated with VAT changes. Ex-ante, and based on our analysis of the underlying reasons for VAT changes

if there were heterogeneous effects across groups of VAT changes occurring at the same time. Given that our evidence is robust across a wide range of specifications as well as in several subsamples and also when plotting unconditional means in Figure 7a, the concern they raise is unlikely to apply in our setting.

[32]See Appendix Tables D.10 and D.11 for the regression estimates using temporary and permanent reforms, respectively. See Appendix Table D.12 for the regression estimates using only reforms that are not concurrent with other tax changes. And see Appendix Table D.13 for the estimates including country-commodity inflation controls and Appendix Figure D.29 for the equivalent of Figure 7a with inflation controls.

and institutional details laid down below, we can expect VAT changes to occur (1) for political reasons, such as electing more fiscal conservative governments; (2) for institutional reasons, mainly because of the VAT harmonization efforts led by the EU, and (3) for economic reasons, such as using VAT changes to counteract changing economic conditions. We describe each of these below.

First, there are reasons to expect the timing of VAT changes to be correlated with political variables, such as the strength of the governing coalition and changes in the governing party. There is an empirical political economy literature that analyzes the underlying reasons for tax reforms and finds that political reasons are more likely to cause tax reforms than economic conditions. Castanheira et al. (2012), for example, show that political variables (strength of the governing coalition and weakness of the opposition party) are more likely to predict tax reforms than economic conditions (GDP and unemployment). Moreover, Hallerberg & Scartascini (2017) show that electoral considerations are more likely to drive VAT changes than economic considerations. Moreover, Foremny & Riedel (2014) show that changes in local business taxes in Germany are driven by the electoral cycle. In principle, political changes could lead to other changes, which in turn could affect the underlying economic conditions. We perform several tests to ensure that economic conditions are unlikely to explain the asymmetry and discuss them in the third point below.

Second, VAT changes could also be due to institutional reasons. The European Commission adopted legislation in 2006 that significantly restricted the ability of Member States to freely set their VAT rates. Council Directive 2006/112/EC explicitly mandated that Member States should progressively start abiding by the following rules: (1) increase the standard VAT rate above 15% and the reduced VAT rate above 5%; (2) restrict the reduced VAT rate to a pre-specified set of commodities, essentially preventing Member States from artificially reducing VAT rates by reclassifying commodities from the standard to the reduced VAT rate; (3) any reduction of VAT rates below 15% (or reclassification from 15% to 5%) was to be approved by all 28 Member States.[33] Given these restrictions, we can expect the following three patterns, after 2006: (1) fewer VAT decreases,

[33]The third rule is not explicitly laid out in Council Directive 2006/112/EC, but, procedurally, any exemptions to a given Council Directive requires a vote by the 28 Member States.

(2) VAT decreases of smaller magnitude, and (3) more VAT increases aimed at bringing VAT rates above the 5% and 15% minima.

Finally, the timing of VAT changes could be correlated with economic conditions. Except for Council Directive 2006/112/EC, there are no other laws that restrict Member States from using VATs to affect the economy. This could threaten our identification if VAT increases occur at times when economic conditions are particularly different from those of VAT decreases *and* prices respond differently to VAT shocks during those different times. Since this could threaten our identification strategy, we implement the following tests. First, we explicitly test for the correlation of economic conditions with the timing of VAT changes. Second, we implement a matching procedure that identifies similar VAT changes and run specification (1) on the subset of matched VAT changes.

The timing of VAT changes is not correlated with economic conditions. The main threat to identification when using the EU VAT changes is that the underlying economic conditions at the time of VAT increases are significantly different from those during VAT decreases, since economic conditions can also affect prices. While prior empirical research and institutional knowledge suggest that some tax changes are likely to be driven by political and institutional considerations rather than economic ones, we can directly test this using our datasets. To do so, we estimate the correlation of the timing of increases and decreases with measures of economic conditions. To proxy for economic activity, we follow the National Bureau of Economic Research's Business Cycle Dating Committee, which, in the US, is the organization that dates recessions and expansions. The main measures they consider are GDP and employment. The underlying reasoning is that GDP rises during periods of expansions, while unemployment falls, and conversely GDP falls during recessions while unemployment rises. Fuest et al. (2018), for example, estimates the incidence of corporate taxes using changes in corporate tax rates over time, and uses GDP and the unemployment rate to show that corporate tax changes are not driven by economic conditions. We use a similar approach, and test for the correlation of VAT changes with total tax revenue, GDP per capita and the unemployment rate in the 12 months leading to a given VAT reform. We find no significant relationship between VAT reforms and these measures of economic activity. Formally, we run the following regression:

$$Reform_{ict} = \sum_{t=-12}^{t=-1} \alpha_t \log(TR_{ct}) + \sum_{t=-12}^{t=-1} \beta_t \log(GDP_{ct}) + \sum_{t=-12}^{t=-1} \gamma_t \log(UR_{ct}) + \lambda_t + \delta_c + \pi_i + \epsilon_{ict}, \tag{2}$$

where $Reform_{ict}$ is equal to 1 if a VAT change occurs for commodity i in country c in month t and 0 otherwise; TR_{ct} is total tax revenue for country c in month t; GDP_{ct} is the per capita GDP of country c in month t; UR_{ct} is the unemployment rate of country c in month t; λ_t are time (in months) fixed effects; δ_c are country fixed effects; π_i are commodity fixed effects; and ϵ_{ict} is the error term (clustered by month). We run this regression on the full sample, on a subsample excluding VAT decreases and on a subsample excluding VAT increases. The outcome variable for the full sample is equal to one if there is a VAT change and zero otherwise; the outcome variable for the sample excluding VAT decreases is equal to one if there is a VAT increase and zero otherwise; and the outcome variable for the the sample excluding VAT decreases is equal to one if there is a VAT increase and zero otherwise.

Appendix Table D.14 shows that there is no relationship between the timing of VAT changes – whether increases or decreases – with the underlying economic conditions leading up to the reforms or with total tax revenue. Using sector-specific measures of economic conditions instead of GDP, such as turnover by sector, yields similar results, as shown in Appendix Table D.15. This further mitigates our concern that VAT changes are endogenous to economic conditions.

Pass-through is asymmetric for matched VAT increases and decreases. While we show above that some of the underlying reasons for VAT reforms are likely to be political rather than economic and that the timing of VAT changes does not correlate with economic conditions, there still remains the concern that we are never able to observe the effect of VAT increases and decreases at the same time, for the same commodity and in the same country. We address this concern by re-estimating equation (1) on a matched sample, where the matching is done to ensure that observations with VAT increases and decreases are comparable in terms of observable characteristics. This matching approach allows us to compare similarly sized VAT reforms that occur at similar times, for the same commodities with similar pre-reform VAT rates.

Our matching procedure follows Imbens (2015), and in particular the way he implements his approach to the Imbens et al. (2001) lottery data (in Section 6.1). We first estimate the propensity score to predict the probability of having a VAT increase as a function of the following key characteristics: time, measures of economic activity, the magnitude of the VAT change, the pre-reform VAT rate and the type of commodity (two digit COICOP code). Then, we use the estimated propensity scores to trim the sample, as suggested by Crump et al. (2009). Finally, in this trimmed sample, we match the VAT increases and decreases, using the matching estimator outlined in Section 5.4 of Imbens (2015).[34] We provide more details on how the matching procedure is implemented in Appendix Section A, as well as formal tests of pre- and post-matching overlap in observables and further robustness checks.

Overall, our finding of asymmetry is robust to matching, mitigating any remaining concerns over the fact that the asymmetry could be but an artifact of VAT increases and decreases being inherently different. Table 2 shows the pass-through estimates for the matched sample. Using this approach, we estimate a somewhat larger degree of asymmetry than estimated using the full (unmatched) sample of reforms. In Appendix Section A, we also formally test the ability of our matching procedure to increase overlap in covariates. We follow Imbens (2015), who uses normalized differences in order to assess overlap. Our matching procedure substantially improves overlap and reduces all normalized differences. While there is no formal threshold for normalized differences and while our matching procedure does not reduce all normalized differences to zero, they are well in line with the ones estimated by Imbens (2015) using the Imbens et al. (2001) lottery data. Furthermore, the reduction in normalized differences due to the matching procedure tends to exacerbate the degree of asymmetric pass-through, suggesting that the remaining differences in covariates could in fact be biasing estimates against asymmetric pass-through.

[34] We cluster our standard errors as we do in our main specification. Bootstrapping yields similar standard errors, with all VAT increase pass-through estimates significant at least at the 1% level. However, we do not report these because Abadie & Imbens (2008) cautions against using bootstrap with matching estimators.

4.4 Long-term Persistence of the Asymmetry

In subsection 3.4 we showed that the asymmetry in the pass-through of VATs persisted for several years after the Finnish hairdressing reforms were enacted. In this section, we show that this persistence is not a peculiarity of Finnish hairdressers: we observe it in other sectors and countries. To provide additional evidence of this persistence in asymmetry – and because we are considering long-run horizons – we need large VAT changes and sectors in which prices are relatively stable. Absent these conditions, the effect of the VAT changes on prices could be masked by natural variation in prices and inflation. In addition to the experimentation program described above, a few other case studies, that rely on large VAT changes, illustrate the persistence in asymmetric pass-through rates. For example, the European Commission approved an application to reclassify sit-down restaurants from the standard to the reduced VAT rate.[35] Both France and Finland took advantage of this new law. This led to a 14 p.p. VAT cut for French sit-down restaurants and a 9 p.p. cut for Finnish ones. While the VAT rate did not revert to its original level, we exploit smaller increases in the reduced VAT rate: 1.5 and 3 p.p. increases in France and a 1 p.p. increase in Finland. Figures 8a and 8b show that the asymmetric pass-through persisted over several years both in Finland and in France. This evidence is to be interpreted cautiously, in part because the VAT changes are not of the same size and it is conceivable that the asymmetric pass-through is in part due to that.

Next, we consider symmetric VAT changes in Hungary that do not suffer from these issues. The Hungarian reforms also have the advantage of affecting a wide range of commodities beyond restaurants and hairdressers. Hungary cut its standard VAT rate from 25% to 20% in January 2006 and increased it from 20% to 25% in July 2009. These changes were enacted as part of a set of campaign promises preceding the 2006 parliamentary elections. Figure 8c shows the response of commodities that were subject to the standard rate in Hungary compared to a set of control countries.[36] We find that the asymmetry persisted over

[35] Following a campaign promise by then French President Jacques Chirac, France applied for an authorization to reclassify sit-down restaurants from the standard to the reduced VAT rate in 2002. The application was approved for all Member States in January 2009.

[36] We included every commodity subject to the standard VAT rate, with the exception of diesel and gasoline because of strong volatility. Details of the list of commodities and control

several years after the VAT rate was returned to 25%. Because the standard VAT rate applies to a wide range of commodities, this mitigates our concern that the long-term persistence of asymmetry exists only in specific sectors.

5 Mechanisms

In this section, we benchmark our empirical results against standard incidence theory. First, we lay out a framework to assess standard tax incidence models. Second, we benchmark standard incidence theory against the Finnish evidence and the European evidence. Third, we discuss alternative models.

5.1 Standard Incidence Theory

General Framework Assume that the government levies an ad-valorem tax τ, and define the marginal pass-through to prices, i.e. the response of prices to a very small change in τ, by ρ. Further, define the average pass-through of a large change in the ad-valorem tax rate T as:

$$\kappa(T) = \frac{1}{T}\int_0^T \rho(\tau)d\tau. \tag{3}$$

Since the marginal pass-through rate, $\rho(\tau)$, is defined for infinitesimally small tax changes, marginal pass-through rates can never be asymmetric, by definition, as long as ρ is assumed to be continuous. However, larger tax changes could generate some degree of asymmetric pass-through. For this reason, we focus on the average pass-through rate, $\kappa(T)$.

Finnish Evidence In the Finnish experiment, the VAT rate is cut starting from a baseline rate and later is increased by the same magnitude (14 percentage points). Using the notation from above, assume that the VAT rate is reduced by $T \leq t$ from an initial VAT rate of t and then increased back to its original level t. In this case, we are comparing the average pass-through of a VAT cut of size T, $\frac{1}{-T}\int_t^{t-T} \rho(\tau)d\tau$, from a baseline rate of t, to the pass-through of a VAT increase

group countries can be found in Appendix Section C.

of size T, $\frac{1}{T}\int_{t-T}^{t}\rho(\tau)d\tau$, from a baseline VAT rate of $T-t$. By definition, and for any T, t and $\rho(\cdot)$:

$$\frac{1}{-T}\int_{t}^{t-T}\rho(\tau)d\tau=\frac{1}{T}\int_{t-T}^{t}\rho(\tau)d\tau.$$

Therefore, standard incidence theory, with any degree of competition and for any demand and supply functions, cannot rationalize the asymmetry we estimate in the Finnish experiment.

Intuitively, since the VAT rate rate is first cut and then increased to its original level, the pass-through function is integrated over the same interval, and therefore, standard static incidence models predict that the VAT increase and decrease pass-through rates should be identical, no matter what functional forms or market structure models are assumed. Consequently, any standard incidence model predicts that if a tax rate is decreased and then increased back to its original level, the equilibrium price after the tax rate is brought back to its original level should be the same as the equilibrium price before the tax rate is cut. In the Finnish case, the post-increase price is higher than the pre-decrease price, which is inconsistent with standard incidence models.

European Evidence The European VAT changes are of different magnitudes and occur at different baseline VAT rates. Therefore, we cannot compare them, without adjustments, to assess whether standard incidence theory can explain the asymmetry we estimate in the European sample. Instead, we can use our matched sample of reforms in two ways. First, we can perform matching so as to mirror the Finnish evidence and use the same argument that standard incidence theory, with any degree of competition and for any demand and supply functions, cannot generate our empirical findings.[37] Second, we can match VAT increases and decreases on the pre-reform VAT rates (along with other important characteristics) to ensure that the baseline VAT rate is comparable. In this case, we would comparing $\kappa(T)$ to $\kappa(-T)$.

First, we start by matching VAT increases and decreases to create a sample

[37] We are very grateful to anonymous referee 6 for suggesting this empirical test and more generally, for all the helpful and constructive feedback the referee gave us on this section.

of VAT changes that mirrors the Finnish experiment. In the Finnish experiment, as discussed above, we compare the average pass-through rates $\frac{1}{-T}\int_{t}^{t-T}\rho(\tau)d\tau$ and $\frac{1}{T}\int_{t-T}^{t}\rho(\tau)d\tau$. The first expression relates to a decrease of magnitude T starting from a VAT rate of t and the second one to an increase of the same magnitude starting from $t-T$. Similarly, we would compare $\frac{1}{T}\int_{t}^{t+T}\rho(\tau)d\tau$ to $\frac{1}{-T}\int_{t+T}^{t}\rho(\tau)d\tau$ when the tax is first increased by T from a baseline VAT rate of t and then decreased by T from a baseline rate of $t+T$. In the Finnish case, we compare the pass-through of a VAT decrease of magnitude T that occurs at an initial VAT rate of t to the pass-through of a VAT increase of magnitude T that occurs at an initial VAT rate of $t-T$. In the Finnish case, the pre-decrease VAT rate is equal to the post-increase VAT rate. To mirror this experiment in the European sample of reforms, we can match pre-decrease VAT rates to post-increase VAT rates. And vice-versa, for experiments that start with a VAT increase and end with a VAT decrease: we can match pre-increase VAT rates to post-decrease VAT rates. If pass-through is asymmetric when estimated for this matched sample, then we can argue that standard incidence theory, as derived in Section 5.1, is unlikely to explain our finding of asymmetry, for any demand and supply functions and any degree of competition, as we argued for the Finnish case. Appendix Table D.17 shows the pass-through estimates for the sample of reforms matched on time, commodity, economic conditions and when matching the pre-increase VAT rates to the post-decrease VAT rates and the pre-decrease VAT rates to the post-increase VAT rates.[38] We estimate pass-through rates that are similar to our baseline estimates. This test implies that standard incidence theory, with any functional forms and degree of competition, is unlikely to explain our finding of asymmetry.

Second, we can create a sample of reforms that is suited to the comparison of $\kappa(T)$ and $\kappa(-T)$ by matching VAT increases and decreases on the pre-reform VAT rate (as well as other important characteristics). Table 2 shows the result of estimating (1) on this matched sample. We find similar levels of asymmetry as in the sample without matching, suggesting that differences in pre-reform VAT rates are not driving the asymmetry. In Appendix Section D.1 we show, using a Generalized Cournot Model, that standard incidence theory can generate

[38] The corresponding normalized differences are reported in Appendix Table D.22.

$\kappa(T) > \kappa(-T)$ but only with specific functional form assumptions.

Overall, standard incidence theory does not fit well with our finding of asymmetry. First, the Finnish evidence is clearly inconsistent with standard incidence theory. Second, the asymmetry estimated using the European sample of reforms is also inconsistent with such a model given that pass-through is still estimated to be larger for VAT increases relative to decreases when we construct a matched sample that mirrors the Finnish evidence.

5.2 Alternative Explanations

Adjustment cost models can generate some degree of downwards price rigidity. We consider two such models, and show that while they can predict short run asymmetric pass-through, they are less successful at matching the long run dynamics. First, we consider a model similar to Ball & Mankiw (1994), which uses trend inflation along with menu costs to generate downward price rigidity. Intuitively, if inflation and menu costs are high enough, firms might not pass-through costs or tax decreases, but instead keep their nominal prices fixed and wait for inflation to decrease real prices. In Appendix Section D.2.1, we calibrate a simple version of this model and show that, even for large menu costs, we cannot generate the type of medium-run asymmetry we find in the Finnish VAT hairdressing reforms. Intuitively, for long enough horizons, the difference between posted and optimal prices is large enough that firms should always bear the adjustment cost rather than keeping prices fixed.

Second, we consider binding capacity constraints as a possible explanation. We show, in Appendix Section D.2.2, that while capacity constraints can generate downwards price rigidity, they also predict incremental and lagged price decreases following the VAT cut, as the capacity constraints are being relaxed. This is inconsistent with the fact that we observe parallel trends in prices post-VAT cut for our treatment and control groups in the Finnish hairdressing experiments, suggesting no lagged responses to the VAT cut. Second, binding capacity constraints are inconsistent with the persistence of the asymmetry we observe in Figures 1, 8c, 8a and 8b. Finally, explaining the European evidence with binding capacity constraints seems implausible as it would imply that most of the economy is operating at full capacity.

Given that our empirical evidence seems to fit poorly with standard economic theory, non-standard models could be potential explanations. For example, while untestable in our setting, models where customers and/or firms deviate from rationality could generate asymmetric pass-through. In a recent paper, Eyster et al. (2017), using evidence from Kahneman et al. (1986a), show that fairness and pricing norms can explain some of our evidence.[39] It is also conceivable for firms to have biased beliefs over the future path of VAT changes, mistakenly predicting, for example, mean reversion in VAT rates, which would justify not adjusting prices downward.[40] Coibion et al. (2018) shows, for example, that firm managers hold biased beliefs over key economic parameters.

6 Conclusion

In this paper, we show that prices respond asymmetrically to VAT changes. First, prices respond more to VAT increases than to VAT decreases. Second, this asymmetric response of prices results in an asymmetric pass-through of VAT changes to profits and markups. Third, the asymmetry persists over the long run. Fourth, several empirical features of this asymmetry are inconsistent with standard tax incidence models.

While the asymmetric pass-through of VATs appears to be of policy relevance, precisely assessing the welfare implications of our result requires further theoretical work. Introducing dynamics in optimal taxation models, in the spirit of Golosov et al. (2011), appears to be crucial in light of our findings. In particular, such models are necessary to draw the precise welfare implications of our results. Furthermore, there could be additional dimensions of heterogeneous pass-through of VATs of equal or larger welfare implications, which are left for future research to assess and investigate.

[39]See Appendix D.3 for a more detailed discussion of Eyster et al. (2017) and Kahneman et al. (1986a).

[40]We find no evidence of mean reversion in VAT rates in our data, but because VAT changes are a relatively rare event, it is possible that firms may have biased expectations.

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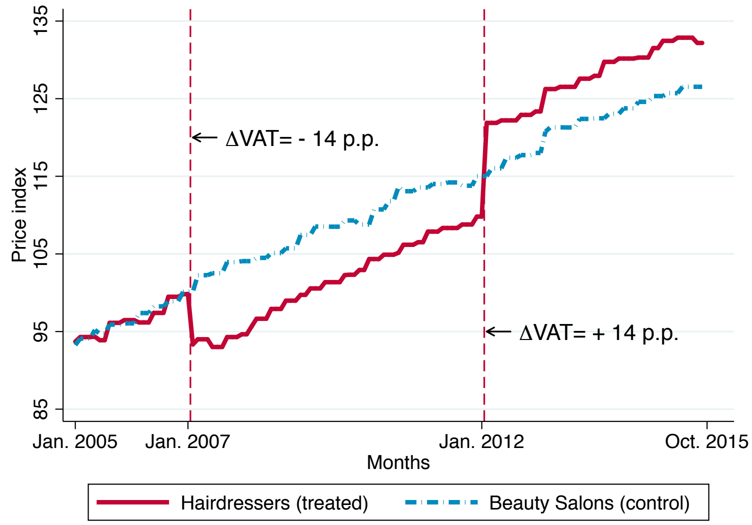
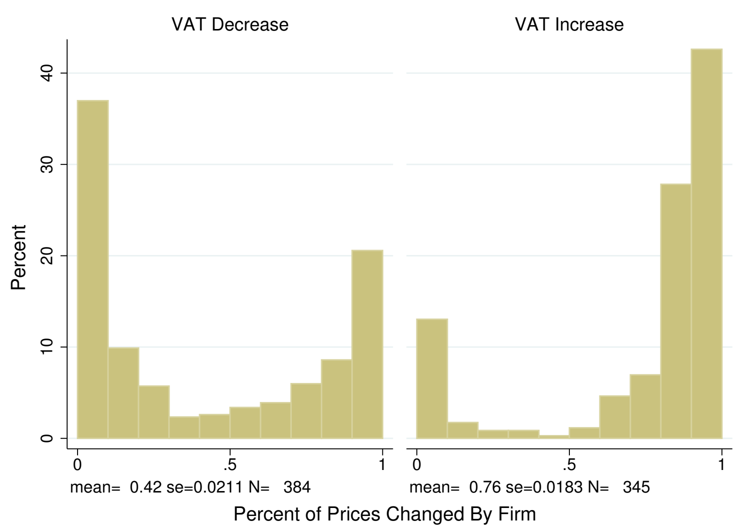
Figure 1: Finnish Hairdressing Sector VAT Reforms



Notes: This figure shows the price of hairdressing services and beauty salons before and after the 14 percentage point hairdressing services VAT cut in January 2007 and the 14 percentage point VAT hairdressing services hike in January 2012.

Figure 2: Proportion of Prices Changed by Hairdresser

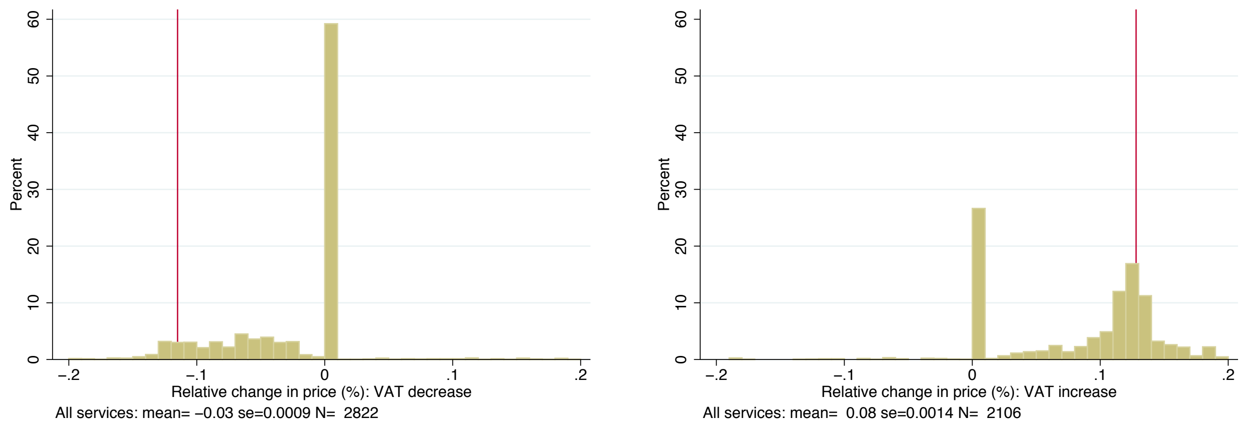


Notes: This figure plots the distribution of the within-hairdresser ratio of services for which prices were changed over total services offered following the VAT cut and hike.

Figure 3: Distributional Asymmetry

(a) VAT Decrease Pass-Through

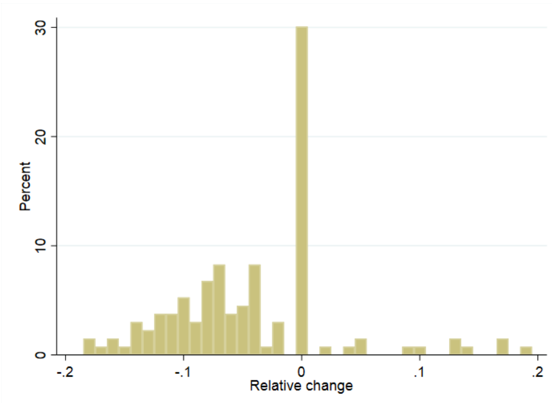
(b) VAT Increase Pass-Through



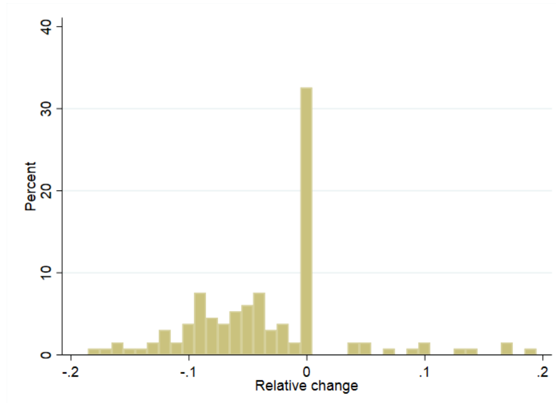
Notes: These figures compare the observed pass-through distributions for the VAT decrease (Figure 3a) to those of the VAT increase (Figure 3b) for Finnish hairdressing services. The red vertical line represents 100% pass-through.

Figure 4: Long Term Pass-Through of VAT Decrease

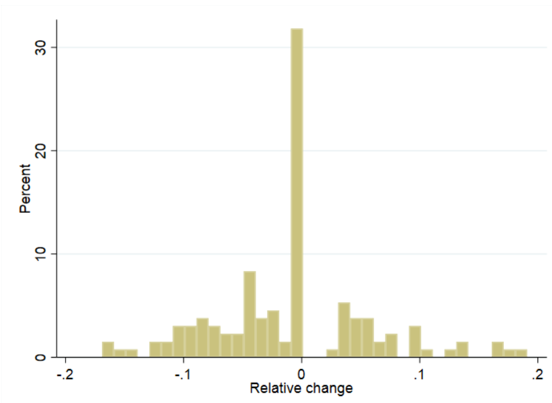
(a) VAT Decrease Pass-Through After 6 Months



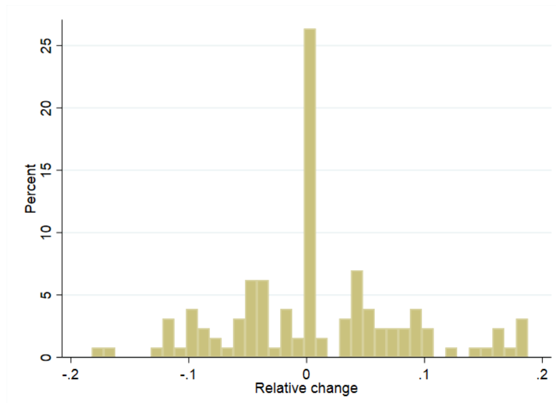
(b) VAT Decrease Pass-Through After 12 Months



(c) VAT Decrease Pass-Through After 18 Months



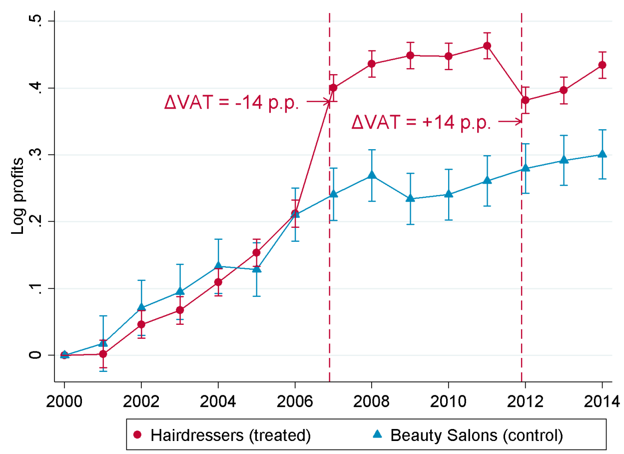
(d) VAT Decrease Pass-Through After 24 Months



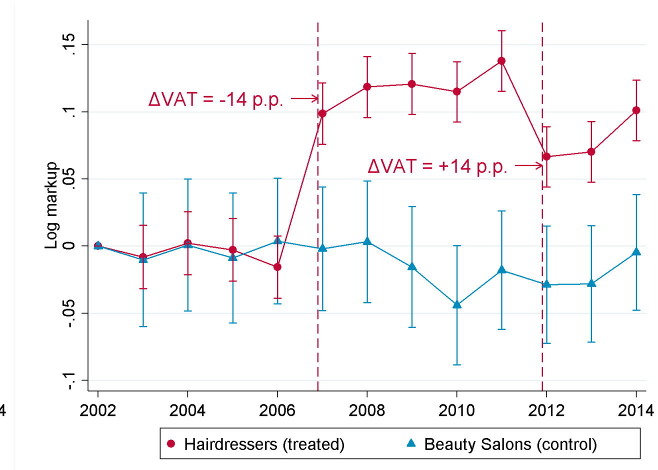
Notes: These figures show the distribution of VAT decrease pass-through over four different horizons: 6, 12, 18 and 24 months. Pass-through is calculated as $\log(p_t) - log(p_0)$, where p_0 is the price one month before the reform and p_t is the price $t = 6, 12, 18, 24$ months after the reform.

Figure 5: Profits, Markups, Variable and Fixed Costs

(a) Profits

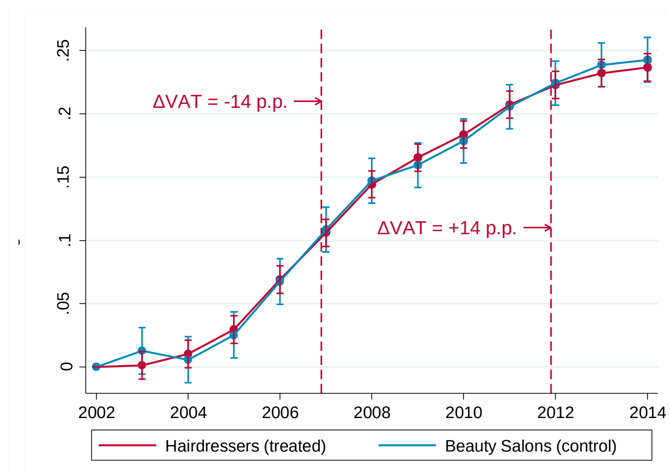


(b) Markups



(c) Variable Costs

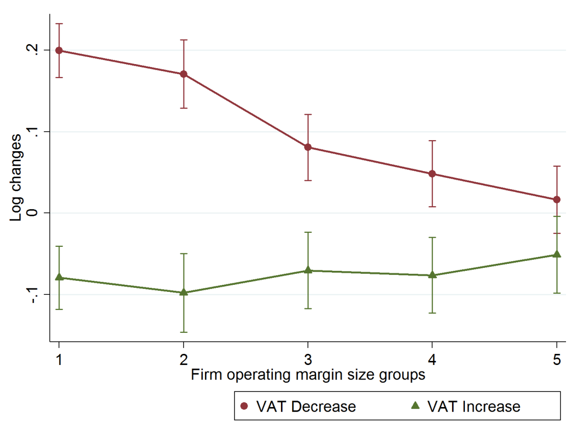
(d) Fixed Costs



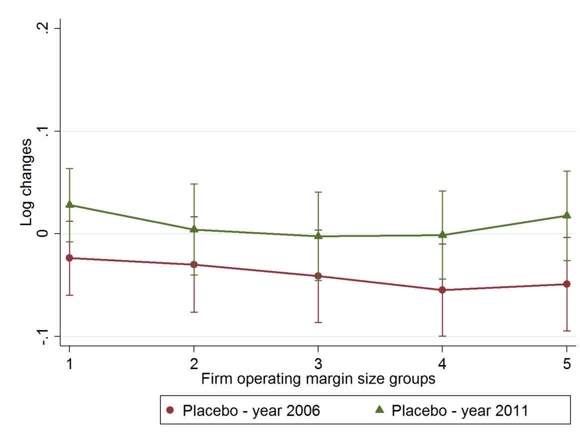
Notes: Figures 5a, 5b, 5c and 5d plot the coefficients from a regression of log profits, log markups, log variable costs and log fixed costs respectively, on year dummies for Finnish hairdressers and beauty salons.

Figure 6: Changes in Markups by Quintile of Profit Margins for Finnish VAT Reforms

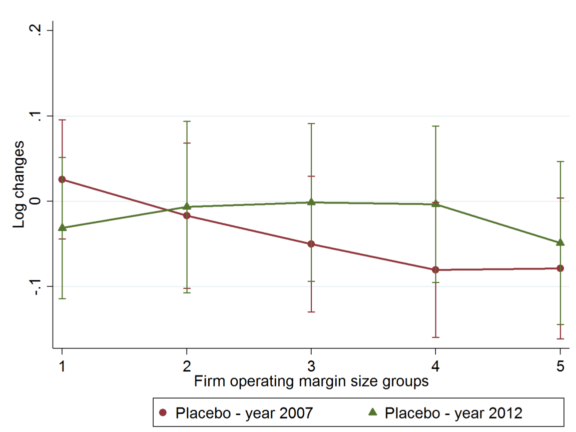
(a) Hairdressers in 2007 and 2012 (Reforms)



(b) Placebo: Hairdressers in 2006 and 2011



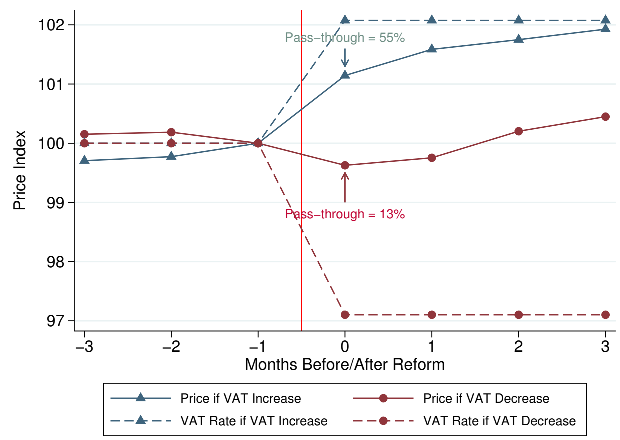
(c) Control: Finnish Beauty Salons in 2007 and 2012



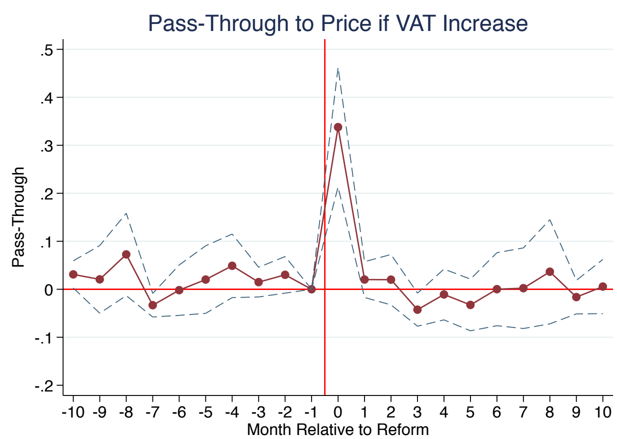
Notes: To generate these graphs, we break down the sample of firms into 5 quintiles with respect to profit margins (turnover minus deductible costs divided by turnover) using data from 2004 to 2006, with 1 being firms with the smallest profit margins. For each quintile, we plot changes in their markup following changes in VAT. Figure 6a considers the 14 p.p. VAT increase and decrease for Finnish hairdressers. Figure 6b considers the Finnish hairdressers in 2006 and 2011. Figure 6c considers Finnish beauty salons (which we use a control group for hairdressers) in 2007 and 2012.

Figure 7: Asymmetric Response of Prices to VAT Changes

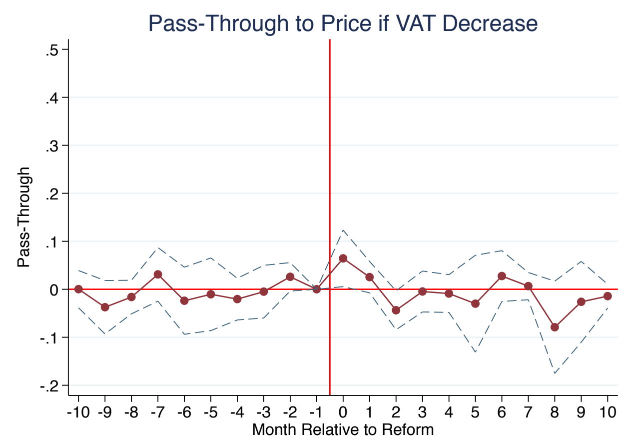
(a) Unconditional Means



(b) Fixed Effects Regression: Increase



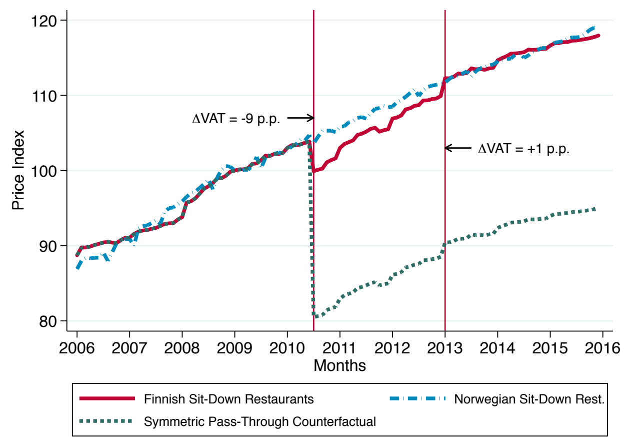
(c) Fixed Effects Regression: Decrease



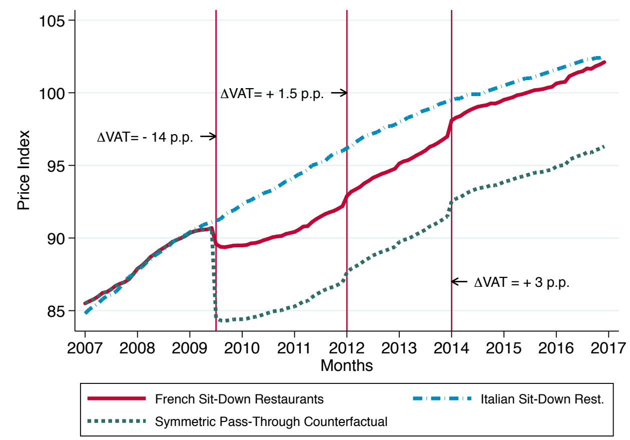
Notes: Figure 7a plots the response of the unconditional means of prices to VAT increases and decreases. Figure 7b and 7c plot the coefficients from the fixed effects regression (1) for VAT increases (7b) and VAT decreases (7c) on the full sample of reforms and includes ten-month leads and lags.

Figure 8: Long-term Persistence of the Asymmetry

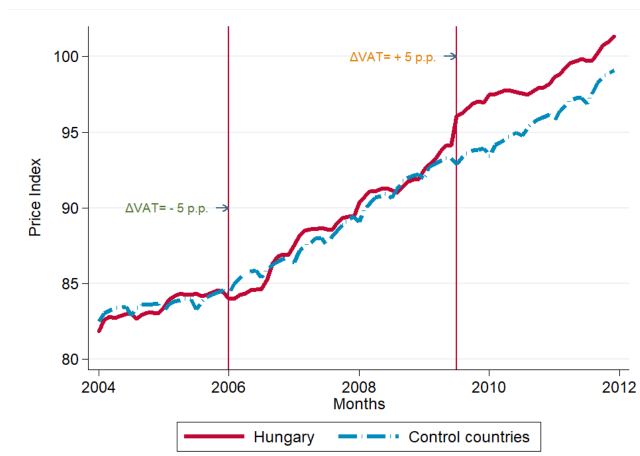
(a) Finnish Restaurants



(b) French Restaurants



(c) Hungary's Standard VAT Rate Changes



Notes: Figure 8a plots the response of Finnish sit-down restaurants to a 9 p.p. VAT decrease and a 1 p.p. VAT increase compared to a control group of Norwegian sit-down restaurants. Figure 8b plots the response of French sit-down restaurants to a 14 p.p. VAT decrease and 1.5 p.p. and 3 p.p. VAT increases relative to a control group of Italian restaurants. We also include a counterfactual that uses the VAT increase pass-through for VAT decreases. Figure 8c plots the response of all commodities subject to the standard VAT rate in Hungary (excluding diesel and gasoline) to a 5 p.p. VAT decrease and a 5 p.p. VAT increase relative to a control group consisting of neighboring countries.

Table 1: Pass-Through Estimates Using Fixed Effects Regression (Full Sample)

	Δ log Price	
	Increase	Decrease
β_0	0.34	0.064
	(0.063)	(0.030)
β_{+1}	0.020	0.025
	(0.019)	(0.017)
β_{-2}	0.030	0.026
	(0.019)	(0.015)
β_{+2}	0.020	-0.044
	(0.027)	(0.021)
β_{-3}	0.015	-0.005
	(0.016)	(0.028)
β_{+3}	-0.043	-0.004
	(0.017)	(0.022)
β_{-4}	0.049	-0.020
	(0.034)	(0.022)
β_{+4}	-0.011	-0.008
	(0.027)	(0.020)
Time FE	Yes	Yes
R^2	0.014	0.014
Observations	386557	342792

Notes: The coefficients reported in this table show the pass-through of VAT increases and decreases to prices, estimated using specification (1) on the full sample of reforms. The first column shows the estimates for VAT increases and the second those for VAT decreases. Standard errors are clustered by month and are in parentheses. β_0 measures the pass-through of the VAT change at the time of the reform, and β_i measures price changes i months away from the reform.

Table 2: Pass-Through Estimates: Matched Sample

	With Trimming		Without Trimming	
	Δ log Price		Δ log Price	
	Increase	Decrease	Increase	Decrease
β_0	0.35	0.067	0.30	0.048
	(0.069)	(0.079)	(0.060)	(0.063)
β_{+1}	0.021	0.025	0.020	0.025
	(0.019)	(0.017)	(0.019)	(0.017)
β_{-2}	0.031	0.026	0.030	0.026
	(0.019)	(0.015)	(0.019)	(0.015)
β_{+2}	0.021	-0.044	0.020	-0.044
	(0.027)	(0.021)	(0.027)	(0.021)
β_{-3}	0.016	-0.005	0.015	-0.005
	(0.016)	(0.028)	(0.016)	(0.028)
β_{+3}	-0.042	-0.004	-0.042	-0.004
	(0.018)	(0.022)	(0.018)	(0.022)
β_{-4}	0.051	-0.020	0.049	-0.020
	(0.034)	(0.022)	(0.034)	(0.022)
β_{+4}	-0.009	-0.008	-0.009	-0.0089
	(0.027)	(0.020)	(0.027)	(0.020)
Time FE	Yes	Yes	Yes	Yes
R^2	0.013	0.014	0.014	0.014
Observations	384,412	342,442	386,051	342,458

Notes: This table reports the pass-through estimates of VAT increases and decreases to prices estimated using specification (1) on matched reforms. The first two columns implement the matching estimator on a trimmed sample using the approach outlined in Imbens (2015). The third and fourth columns report the estimates for the matched sample without trimming. VAT increases and decreases are matched on time, type of commodity (COICOP digit 2), size of VAT change, pre-reform VAT rate and GDP growth. The first and third column show the estimates for VAT increases and the second and fourth that for VAT decreases. Standard errors are clustered by month and are in parentheses. β_0 measures the pass-through of the VAT change at the time of the reform and β_i measures price changes i months away from the reform.

APPENDIX FOR ONLINE PUBLICATION

A Matching VAT Increases and Decreases

In this section, we first provide details of the matching approach we use in Section 4.3 and then discuss and provide the results of several alternative matching algorithms and specifications.

Matching estimator. Our matching approach follows Imbens (2015). We follow the application of his approach to the Imbens et al. (2001) lottery data, outlined in Section 6.1 of Imbens (2015).[41] The matching procedure outlined in Imbens (2015) follows three steps. First, he estimates propensity scores in the original sample using a logistic regression. Second, he trims the original sample by dropping extreme observations, using the threshold derived in Crump et al. (2009) (referred to as CHIM), by removing any observations with extreme propensity scores. Third, he implements a matching algorithm – which is described in detail in section 5.4 of Imbens (2015) – on the resulting sample. We implement these three steps on our sample of VAT increases and decreases and then re-estimate specification (1) on the resulting subsample of VAT reforms.

Note that we report the resulting estimates for both the trimmed and matched sample (which corresponds to the Imbens (2015) approach) as well as the matched sample without trimming (which skips the second step in Imbens (2015)). We do this because the trimmed specification has an even more stringent definition of poor matches compared to the matched only specification. Indeed, it drops observations with extreme propensity scores that would otherwise be kept in the matched only specification. Assessing the difference in estimates between the no-matching specification (Table 1), the matched only specification (Table 2 col. 3 and 4) and the matched and trimmed specification (Table 2 col. 1 and 2) should give us a sense of how likely the estimated asymmetry is due to VAT increases and decreases being different. If pass-through estimates for VAT increases and decreases become closer as the sample of VAT increases and decreases is made

[41] We rely on the first example, because it is the closest to our setting as the second and third examples rely on experimental data.

more comparable by matching and trimming, one should be seriously concerned as to whether the estimated asymmetry is mechanically driven by the VAT changes being inherently different. If instead, the estimated asymmetry remains constant, or is even exacerbated by the matching and trimming, concerns that differences in the samples of VAT increases and decreases are driving the asymmetry would be seriously mitigated.

Table 2 reports the results of this matching estimator. Overall, our finding of asymmetry is robust both in the matched sample (columns 3 and 4) as well as in the matched and trimmed sample (columns 1 and 2). The more stringent specification, which is the trimmed and matched sample, produces somewhat larger asymmetric pass-through estimates than the matched only sample or the full sample, making a strong case against the concern that the differences between the VAT increase and decrease samples are driving the asymmetry. Nevertheless, we conduct several robustness checks and a further adjustment suggested by Imbens (2015) below.

Assessing the performance of the matching estimator Imbens (2015) suggests using normalized differences rather than using t-statistics or visually comparing distributions, in order to assess overlap between the matched samples. Following the notation of Imbens (2015), the formula for normalized differences is given by:

$$\Delta_{X,k} = \frac{\overline{X_{inc,k}} - \overline{X_{dec,k}}}{\sqrt{(S^2_{X,inc,k} + S^2_{X,dec,k})/2}}, \tag{4}$$

where $\overline{X_{dec,k}} = \frac{1}{N_{dec}} \sum\limits_{i \in D} X_{i,k}$, and $\overline{X_{inc,k}} = \frac{1}{N_{inc}} \sum\limits_{i \in I} X_{i,k}$ and

$S^2_{X,dec,k} = \frac{1}{N_{dec}-1} \sum\limits_{i \in D} (X_{i,k} - \overline{X_{dec,k}})^2$ and $S^2_{X,inc,k} = \frac{1}{N_{inc}-1} \sum\limits_{i \in I} (X_{i,k} - \overline{X_{inc,k}})^2$
where i is a given VAT change, $X_{i,k}$ is an element of the covariate vector X_i, N_{inc} is the number of VAT increases, N_{dec} the number of VAT decreases, I is the set of VAT increases and D is the set of VAT decreases.

Imbens (2015) argues that normalized differences are better suited than t-statistics for assessing overlap between two samples because t-statistics can be large when the sample size is large, rejecting that two sample means are equal even when they are not substantively different. As written in Imbens (2015), "The normalized differences provide a scale and sample size free way of assessing overlap."

Larger normalized differences indicate larger average differences in covariates in the two groups that are being compared. Importantly, there is no specific "threshold" above which normalized differences are considered to be too large. Instead, we benchmark our normalized differences against those estimated by Imbens (2015) for the lottery data. In addition to assessing the level of normalized differences, another useful test is to compare the pre- and post-trimming normalized differences. A well performing matching should reduce any large normalized differences.

Appendix Table D.21 reports the normalized differences for the main covariates we consider in our main specification: time, magnitude of VAT change, economic conditions, pre-reform VAT rate and commodity type. Note that rather than reporting normalized differences for the 235 different months, and since the main concern with timing is that reforms might happen in times of different economic conditions, we report instead normalized differences for a variable that is equal to 1 if the month is a month during which the economy is in a recession and 0 otherwise.

Two important points are worth emphasizing: (1) the normalized differences in the trimmed sample are small and, relatedly, (2) trimming substantially reduces any large normalized differences estimated in the original sample. On point (1): while there is no specific threshold for normalized differences, Imbens (2015) mentions 0.3, in absolute value, for example as a possible benchmark in Section 6.1.1. The normalized differences we estimate in the trimmed sample are all smaller than 0.3. Moreover, the normalized differences we estimate are smaller than the ones Imbens (2015) estimates using the lottery data. For example, two covariates in Imbens (2015) have normalized differences in excess of 0.3 in his trimmed sample (0.51 and -0.47), while the largest normalized difference in our trimmed sample is 0.21, in absolute value. On point (2), the variables that have large normalized differences in the full sample of VAT reforms are substantially affected by trimming: the normalized differences for economic conditions are reduced from 0.43 to -0.21, for pre-reform VAT rate from -1.06 to 0.00, for size of VAT change from -0.32 to -0.02 and for recession months from 0.56 to 0.08. The remaining normalized differences for commodity types are small even before trimming.

Overall, trimming performs well, making the sample of VAT increases and decreases plausibly comparable. In spite of this substantial reduction in differences between the sample of VAT increases and decreases, we still estimate that pass-through is larger for VAT increases relative to VAT decreases, mitigating concerns that the asymmetry is an artifact of VAT increases and decreases being inherently different.

Further Robustness We implement two sets of further robustness checks and one regression correction that should account for any remaining imbalance and assess the plausibility of unconfoundedness.

First, we ensure that our results are robust to the variables we match on. Imbens (2015) automatizes the choice of matching variables by using an algorithm as well as lasso. We do not follow this approach for two reasons: (1) matching on the variables we choose performs very well at reducing normalized differences and (2) the variables we choose are driven by specific concerns and we believe these concerns provide a better justification than using automatic algorithms; Heckman et al. (1997), for example, insists on using economic theory to choose what variables need to be included when implementing a matching estimator. In our case, the goal of implementing a matching estimator is to mitigate the concern that we are never able to observe similarly sized VAT increases and decreases for the same commodity at times of similar economic conditions. Nevertheless, we ensure that our results are not sensitive to variable choices and implement several additional specifications. We match on unemployment rate, in addition to annual growth in Appendix Table D.19. In addition, we match pre-VAT increase rates to post-VAT decrease rates and post-VAT increase rates to pre-VAT decrease rates instead of pre-VAT reform rates in Table D.17. Finally, we exclude all matching variables and match only pre-VAT increase rates to post-VAT decrease rates and post-VAT increase rates to pre-VAT decrease rates in Appendix Table

D.18. While the estimated pass-through rates vary slightly, we systematically estimate similar levels of asymmetric pass-through, mitigating concerns that our main matching specification is not robust.

Second, Imbens (2015) insists (in Section 5.2) on testing whether the results are sensitive to estimating the propensity score using probit instead of logit. In Appendix Table D.16, we re-estimate our main matching specification using probit and find similar levels of asymmetric pass-through.

Third, Imbens (2015) points out that "[...] unless a particular estimator is robust to modest changes in the implementation, any results should be viewed with suspicion." Therefore, in addition to the estimator used by Imbens (2015) in the lottery data, we implement three more matching algorithms. Appendix Table D.20 shows the pass-through estimated using these alternative algorithms. We find very similar levels of asymmetric pass-through.

Fourth, Imbens (2015) proposes a way of assessing whether unconfoundedness is plausible, which is to estimate the same baseline specification on the trimmed sample but instead of using the actual outcome, using a lagged outcome. The test passes if the estimated coefficient is small and not statistically significant. We implement this test and estimate a coefficient on our lagged outcome of 0.003 (0.014) for VAT increases and 0.036 (0.026) for VAT decreases. Given the small magnitude of the estimates and the fact that none are statistically significant, unconfoundedness seems plausible.

Fifth, Imbens (2015) proposes a method to correct for any differences in the two samples that remain after the samples are trimmed. The approach is explained in detail in Section 5.4 of Imbens (2015). Appendix Table D.23 shows the result of implementing this correction to our estimate. The magnitude of the asymmetry is very similar to our main matching specification, which is not surprising, given that the normalized differences we estimate in the trimmed sample are small.

B Narrative Approach

We use a narrative approach in the spirit of Romer & Romer (2010) to describe the underling reasons for VAT changes. We flag any reforms that were enacted as part of stimulus packages or austerity measures. We gathered this information from official documents from the EU Member States we are considering. We describe this documentation here and can make it available upon request: we used legislative documents, central bank annual reports and, when documentation was not readily available, we reached out directly to Finance Ministries.

First, we used legislative documents. These documents often give an official reason for why governments implement VAT changes, and often also detail other changes occurring in the same year. These documents are often easily available online and date back to the early 1990s. Some examples include the following: for Finland www.finlex.fi/en/, for France www2.assemblee-nationale.fr/documents-parlementaires, and for the UK www.legislation.gov.uk.

Second, we complemented and corroborated the legislative documents with a second source of information emanating from Member States' central banks. Central banks describe the economic situation in detail, and discuss measures of fiscal policy and how they relate to potential monetary policies undertaken. For our purposes this was useful for being able to categorize reforms into those that were part of larger economic reform packages, or part of a response to an economic downturn. For example, the documentation for Germany is from annual reports of the Bundesbank, available online at https://www.bundesbank.de/Navigation/EN/Home/home_node.html, and for Portugal from the online documentation of Banco de Portugal available in English at https://www.bportugal.pt/en.

C Hungarian Reforms: List of Commodities and Control Group Countries

Commodities: The commodities included in Figure 8c are all commodities subject to the standard rate except for diesel and gasoline. The full list is: Actual rentals for housing, Audio-visual, photographic and information processing equipment, Books, Carpets and other floor coverings, Catering services, Clothing, Clothing materials, Electrical appliances for personal care; other appliances, articles and products, Electricity, Furniture and furnishings, carpets and other floor coverings, Glassware, tableware and household utensils, Hairdressing salons and personal grooming establishments, Household textiles, Information processing equipment, Jewelry, clocks and watches, Maintenance and repair of personal transport equipment, Maintenance and repair of the dwelling, Major durables for indoor and outdoor recreation including musical instruments, Materials for the maintenance and repair of the home, Personal effects n.e.c., Pharmaceutical products, Photographic and cinematographic equipment and optical instruments, Purchase of vehicles, Refuse collection, Repair of furniture, furnishings and floor coverings, Restaurants and hotels, Restaurants, cafs and the like, Services for the maintenance and repair of the home, Sewerage collection, Tools and equipment for the home and garden, Water supply.

Control Group Countries: The control group countries are an unweighted average of Austria, Belgium, Bulgaria, Estonia, Germany, Italy, Luxembourg, Norway and Romania.

D Appendix to Section 5 (Mechanisms)

D.1 Standard Perfect and Imperfect Competition Models

In this section, we derive the conditions under which standard perfect and imperfect competition models can generate asymmetric pass-through. We use the framework of Hamilton (1999).

D.1.1 General Framework

We assume that there are n firms that produce a homogeneous good. Firm i produces y_i units of the good and the aggregate industry output is given by $Y = \sum_{i=1}^{n} y_i$. $P(Y)$ is the industry's inverse demand function, its derivative is negative and defined throughout its support. The profit of firm i is given by

$$\Pi_i = P(Y)y_i - c_i(y_i)$$

We denote by $\delta = \frac{dY}{dy_i}$ the response of aggregate output to changes in the output of firm i. This key parameter is a sufficient statistic for the degree of competition in the market. The degree of competition is negatively correlated with $\delta \in (0, n]$, with $\delta = n$ corresponding to tacit collusion and $\delta = 1$ to Cournot-Nash. Following Hamilton (1999), we assume that δ is constant.

The first and second order conditions, as derived in Hamilton (1999), are given by:

$$\Pi_y = P + y\delta P_y - c_y = 0 \tag{5}$$

$$\Pi_{yy} = 2\delta P_y + y\delta^2 P_{yy} - c_{yy} < 0 \tag{6}$$

D.1.2 Generalized Cournot Model

The Generalized Cournot Model corresponds to the case where $\delta \in (0, n]$. To estimate the pass-through of taxes to prices, we introduce an ad-valorem tax τ. The first order condition, as derived in Hamilton (1999), is given by:

$$P = c_i'(y_i)(1 + \tau) - P_Y \delta y_i. \tag{7}$$

Assuming that marginal cost is constant and summing up condition (7) over all firms i, we get:

$$P = \frac{C(1 + \tau)}{n} - \frac{P_Y \delta Y}{n}, \tag{8}$$

where $C = \sum_i c_i'(y_i)$ and $Y = \sum_i y_i$.

Denote by $\rho(\tau) = \frac{d \log(P)}{d \log(1+\tau)} = \frac{dP}{d(1+\tau)} \frac{1+\tau}{P}$. We differentiate (8) with respect to $1 + \tau$ and get the following condition:

$$\rho(\tau) = \frac{C}{n}\frac{1+\tau}{P} - \frac{\delta}{n}\left(P_{YY}\frac{dY}{dP}\frac{dP}{d(1+\tau)}Y + P_Y\frac{dY}{dP}\frac{dP}{d(1+\tau)}\right)\frac{1+\tau}{P},$$

which can be re-written as:

$$\rho(\tau) = \frac{C}{n}\frac{1+\tau}{P} + \frac{\delta}{n}\epsilon\rho(\tau) - \frac{\delta}{n}\rho(\tau)$$

where $\epsilon = -\frac{P_{YY}Y}{P_Y}$, is a measure of the curvature of the inverse demand function and is a function of τ. This equation simplifies to:

$$\rho(\tau) = \frac{C(1+\tau)}{P(n+\delta(1-\epsilon))}. \tag{9}$$

Notice, from (8), that $C(1+\tau) = nP + P_Y \delta Y$ and replace it in (9) to get:

$$\rho(\tau) = \frac{nP + P_Y \delta Y}{P(n+\delta(1-\epsilon))}. \tag{10}$$

Denote by $\epsilon^D = -\frac{dY}{dP}\frac{P}{Y} = -\frac{1}{P_Y}\frac{P}{Y}$. Therefore, (10) can be written as:

$$\rho(\tau) = \frac{n - \frac{\delta}{\epsilon^D}}{n+\delta(1-\epsilon)}. \tag{11}$$

Note that both ϵ and ϵ_D can, in principle, depend on τ, depending on what demand function we assume. Intuitively, $\rho(\tau)$ is a measure of the marginal pass-through of a small change in taxes. Marginal and average pass-through rates can be very close if the tax change is small, but are not necessarily equal for large tax changes. We denote by $\kappa(T) = \frac{1}{T}\int_0^T \rho(\tau)d\tau$ the average pass-through of a large change T in the ad-valorem tax rate.

It is worth emphasizing that, as long as the inverse demand function is twice differentiable, marginal pass-through rates are always *symmetric* for increases and decreases in tax rates, which implies that average pass-through rates, for sufficiently small tax changes, are always symmetric. For sufficiently large tax changes, there are two possible thought experiments. The first one considers a tax decrease (increase) of magnitude T, starting from a baseline rate t and followed by a tax increase (decrease) of the same magnitude. As argued in Section 5.1, asymmetric pass-through is inconsistent with standard incidence in such cases. The second thought experiment considers tax changes of similar magnitude but of different direction, starting from the same baseline rate. Formally, pass-through is asymmetric in this case if $\kappa(T) > \kappa(-T)$, i.e.,

$$\int_0^T [\rho(\tau) - \rho(-\tau)]\, d\tau > 0 \tag{12}$$

While this condition has no closed-form solution, we can rule out some standard demand functions, such as constant elasticity demand functions, which are the most commonly used demand functions, according to Fabinger & Weyl (2018).

Importantly, these demand functions can be ruled out for any degree of competition and any magnitude of demand (or supply) elasticity in the Generalized Cournot Model. The argument for why constant elasticity demand functions cannot generate any asymmetry in this case, relies on the fact that $\frac{d\rho}{d\tau} = 0$, since both $\frac{d\epsilon}{\tau} = 0$ and $\frac{d\epsilon^D}{d\tau} = 0$, which necessarily implies symmetric pass-through, since $\kappa(T) = \kappa(-T)$. Note that we cannot rule out linear or exponential demand functions without relying on calibrations.

In general, whether pass-through can be larger for VAT increases relative to decreases depends on the sign of $\frac{d\rho}{d\tau}$. If $\frac{d\rho}{d\tau} < 0$, then pass-through is larger for decreases relative to increases, which is inconsistent with our evidence. If instead, $\frac{d\rho}{d\tau} = 0$, then pass-through is symmetric. And if ρ is non-monotonic with respect to τ, i.e., $\frac{d\rho}{d\tau}$ changes sign, then pass-through can be either larger or smaller for increases relative to decreases, depending on the range over which ρ is evaluated, but is not systematically larger for increases relative to decreases, as we show. Therefore, a necessary condition for pass-through to be larger for increases relative to decreases is that $\frac{d\rho}{d\tau} > 0$, i.e.,

$$\frac{d\rho}{d\tau} = \frac{\frac{\delta}{(\epsilon^D)^2}\frac{d\epsilon^D}{d\tau}(n + \delta(1-\epsilon)) + \delta\frac{d\epsilon}{d\tau}(n - \frac{\delta}{\epsilon^D})}{(n + \delta(1-\epsilon))^2} > 0 \tag{13}$$

which imposes parametric restrictions over the relative magnitudes of the first, second and third derivatives of the demand function, as well as on how competitive the market is, as measured by δ. And while functional forms that would satisfy this condition would yield larger pass-through for VAT increases relative to decreases, i.e., $\kappa(T) > \kappa(-T)$ further parametric restrictions are needed in order to generate asymmetric pass-through of the magnitude we estimate, i.e., $\kappa(T) > \mu\kappa(-T)$, where μ varies between 2 and 5 depending on the estimates.

D.1.3 Perfect Competition

Marginal pass-through under perfect competition can be derived from the equilibrium condition $D(P) = S(\frac{P}{1+\tau})$, where S is the supply function, D the demand function, P the consumer price and the producer price is given by $Q = \frac{P}{1+\tau}$. Differentiating this condition with respect to $1 + \tau$ yields:

$$\rho(\tau) = \frac{S'}{S' - (1+\tau)D'},$$

where $\rho(\tau) = \frac{d\log(P)}{d(1+\tau)}$.

Denote by $\epsilon^S = \frac{dS}{dQ}\frac{Q}{S} = S'\frac{P}{(1+\tau)S}$ the supply elasticity and $\epsilon^D = -\frac{dD}{dP}\frac{P}{D} = -D'\frac{P}{D}$ the demand elasticity. Since $D = S$ in equilibrium, we can re-write $\rho(\tau)$ as:

$$\rho(\tau) = \frac{\epsilon^S}{\epsilon^S + \epsilon^D}. \tag{14}$$

Similarly to the imperfect competition case, for pass-through to be asymmetric, we need $\frac{d\rho}{d\tau} > 0$, i.e.,

$$\frac{\frac{d\epsilon^S}{d\tau}\epsilon^D - \frac{d\epsilon^D}{d\tau}\epsilon^S}{(\epsilon^S + \epsilon^D)^2} > 0. \tag{15}$$

Similarly to the imperfect competition case, underlying this condition are parametric restrictions on the first and second derivatives of the demand and supply functions and even if these restrictions are met, stricter parametric restrictions are needed in order to generate asymmetric pass-through rates of the magnitude we estimate.

D.2 Adjustment Cost Models

D.2.1 Menu Cost Models

Simple adjustment cost models can predict some short-run asymmetry. We sketch one such model in this section and show that it quantitatively matches the short-run evidence but does not predict any *long-run* asymmetry.[42] These models require either large menu costs or very high inflation rates to match our findings in the short run and do not predict any long-run asymmetry.

[42]These models are, in spirit, similar to Ball & Mankiw (1994) who use trend inflation and menu costs to generate downward price rigidity. It is also related, in spirit, to Karadi & Reiff (2019) who use a menu cost model, similar to Ball & Mankiw (1994), to generate downwards price rigidity and estimate it using three VAT changes and price data from the processed food sector in Hungary in 2004 and 2006 (all three VAT changes, which affected the reduced and standard VAT rates, are included in our sample of European VAT changes).

The model we consider relies on the following assumption: firms face a positive cost C from increasing prices but no cost from decreasing them.[43] As a consequence, firms fail to adjust prices upwards when faced with a cost shock smaller than C.

We denote by p^{i*} the target price of a given firm i and by p^i its posted price. In every period, firms face a shock θ_t to their optimal price. At any given time t, firm i's price dynamics are determined by the following equations:

$$p_t^i = \begin{cases} p_{t-1}^i + \Theta_{t-1}^i + \theta_t & \text{if } \Theta_{t-1}^i + \theta_t \leq 0, \\ p_{t-1}^i & \text{if } 0 \leq \Theta_{t-1}^i + \theta_t < C^i, \\ p_{t-1}^i + \Theta_{t-1}^i + \theta_t & \text{if } C^i \leq \Theta_t^i + \theta_t, \end{cases} \tag{16}$$

where $\Theta_{t-1}^i = p_{t-1}^{i*} - p_{t-1}^i$ is the stock of shocks θ that were not passed through to price in previous periods, and C^i is the cost of adjusting prices upwards for firm i. The firm passes through $\Theta_{t-1}^i + \theta_t$ if this quantity is negative because it bears no cost from adjusting prices downwards. If this quantity is positive but smaller than its adjustment cost C^i, it keeps prices fixed. It does so until this quantity becomes greater than C^i, at which point the difference between the posted and optimal price is too large, and it becomes optimal to pass through $\Theta_{t-1}^i + \theta_t$.

Assume that firm i enters period t with $\Theta_t^i > 0$ and that the VAT rate increases by τ. Denote by ρ the incidence of the tax had there been no adjustment cost C and as determined by the supply (ϵ_S) and demand elasticities (ϵ_D): $\rho = \frac{\epsilon_S}{\epsilon_S - \epsilon_D}$. The firm will pass through $\Theta_t^i + \rho\tau$ when it is greater than C^i. If, instead, the VAT decreases by τ, the firm will pass through $\Theta_t^i - \rho\tau$ if it is lower than zero. As a consequence, the pass-through of VAT increases and decreases is asymmetric by Θ_t^i.

To simulate the price dynamics, we use equation (16) and assume that each firm has an adjustment cost C^i, which is a random variable drawn from a given distribution F. In every period t, firms are hit by a shock θ_t, which is also a random variable drawn from a distribution G. Figure D.28 shows the results of our simulation. Figure D.28a shows simulated price time series for a treatment group that experiences a 14 p.p. VAT cut followed by a 14 p.p. VAT increase five

[43] The results carry through if we instead assume that the cost of increasing prices is greater than that of decreasing them.

years later and compares it to a control group that does not experience any VAT changes. We choose these values so as to match the Finnish hairdressing VAT reforms. The simulations show that the pass-through is asymmetric, but prices *converge to symmetry* over time. The simulated distributions of pass-through following the VAT increase and decrease are simply given by $p_t - p_{t-1}$, where t is the time of the reforms. These distributions are plotted in Figures D.28b and D.28c and roughly match the patterns observed in Figures 3a and 3b.

D.2.2 Capacity Constraints.

In this section, we consider whether binding capacity constraints can generate the price response patterns we observe. We benchmark this explanation against the price dynamics we observe in the Finnish hairdressing case in Figure 1. Capacity constraints can lead to price rigidity: if firms cannot cater to additional demand, they may be less likely to change prices. However, we show below that this explanation does not match the dynamics we observe in the Finnish case. Specifically, assume firms experience a capacity constraint K above which they cannot supply additional quantities. This implies a kinked supply function such that $\epsilon_S \geq 0$ below K and $\epsilon_S = 0$ above K.

Case 1: Suppose that capacity constraints are binding prior to the 2007 VAT cut. Firms are therefore operating on the portion of the supply function where $\epsilon_S = 0$. As the VAT is cut, firms will still be operating on this same portion of the supply function and therefore we should not expect a response of prices to the VAT cut. This is illustrated in Appendix Figure D.25. This finding is inconsistent with the fact that we observe that prices respond to the VAT cut.

Case 2: Assume instead, as in Appendix Figure D.26, that capacity constraints are close to binding prior to the 2007 VAT cut, but not binding. In this case, we should observe that prices respond to the VAT cut, as firms are operating on the portion of the supply function where $\epsilon_S > 0$. However, the VAT cut will bring the equilibrium to the portion of the supply function where $\epsilon_S = 0$, i.e., as the VAT is cut, capacity constraints become binding. Next there are two possibilities: capacity constraints can either (1) remain fixed over time, or (2) get relaxed as firms increase their investments or number of employees. If capacity constraints remain fixed over time, then as the VAT rate increases in 2012, firms will still be operating on the portion of the supply function where $\epsilon_S = 0$. In this case, there should be no lagged response of prices to the VAT cut and prices should revert back to their original level after the VAT increase in 2012. In this case, we should observe a *symmetric* response of prices to the VAT changes. This is inconsistent with the fact that we find that prices respond more to the VAT increase.

Case 3: Assume instead, as in Appendix Figure D.27, that capacity constraints are relaxed over time. In this case, prices should incrementally decrease following the VAT cut: we should observe a lagged response of prices to the 2007 VAT cut. This is inconsistent with our evidence as we observe that treatment and control prices follow parallel trends in Figure 1 with no evidence of lagged responses. Finally, if capacity constraints are relaxed over time, we should observe that prices return to their pre-VAT cut equilibrium once the VAT rate is raised back to its original level. Instead, we observe that post-2012, prices are higher than their pre-2007 equilibrium levels.

Overall, binding capacity constraints are unlikely to explain the price dynamics we observe in the Finnish hairdressing VAT experiments. Further, for this explanation to rationalize the European evidence, we would need to assume that most industries across Europe are operating close to capacity. This seems unlikely as emphasized, for example, by Tirole (1988): "Except in special cases, a firm usually has some leeway to increase its production beyond its efficient level."

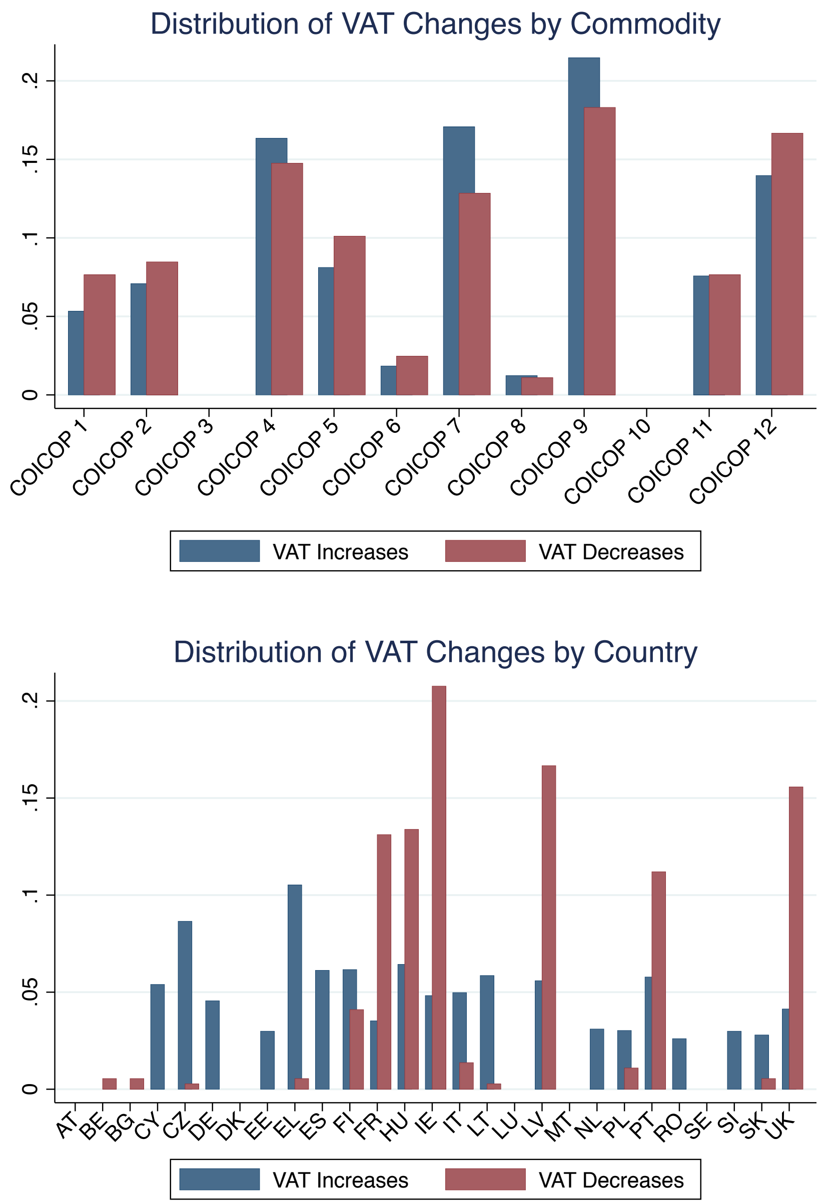
D.3 Fairness and Consumer Loyalty

Kahneman et al. (1986a) shows that customers will accept price increases when costs increase but not when demand increases. Conversely, consumers do not feel antagonistic when firms fail to adjust prices downwards when costs decrease. Based on this evidence, Kahneman et al. (1986b) conclude that "there is a notable asymmetry between the rules of fairness that apply when circumstances increase or decrease the profits of a firm. The rules of fairness evidently permit firms to pass on the entire amount of a cost increase, but [...] firms are allowed to retain most of the benefits of a cost reduction."

Okun (1981) reports some evidence that firms might respond to fairness considerations when setting prices because of the risk of losing some of their loyal customers which threatens future profits.

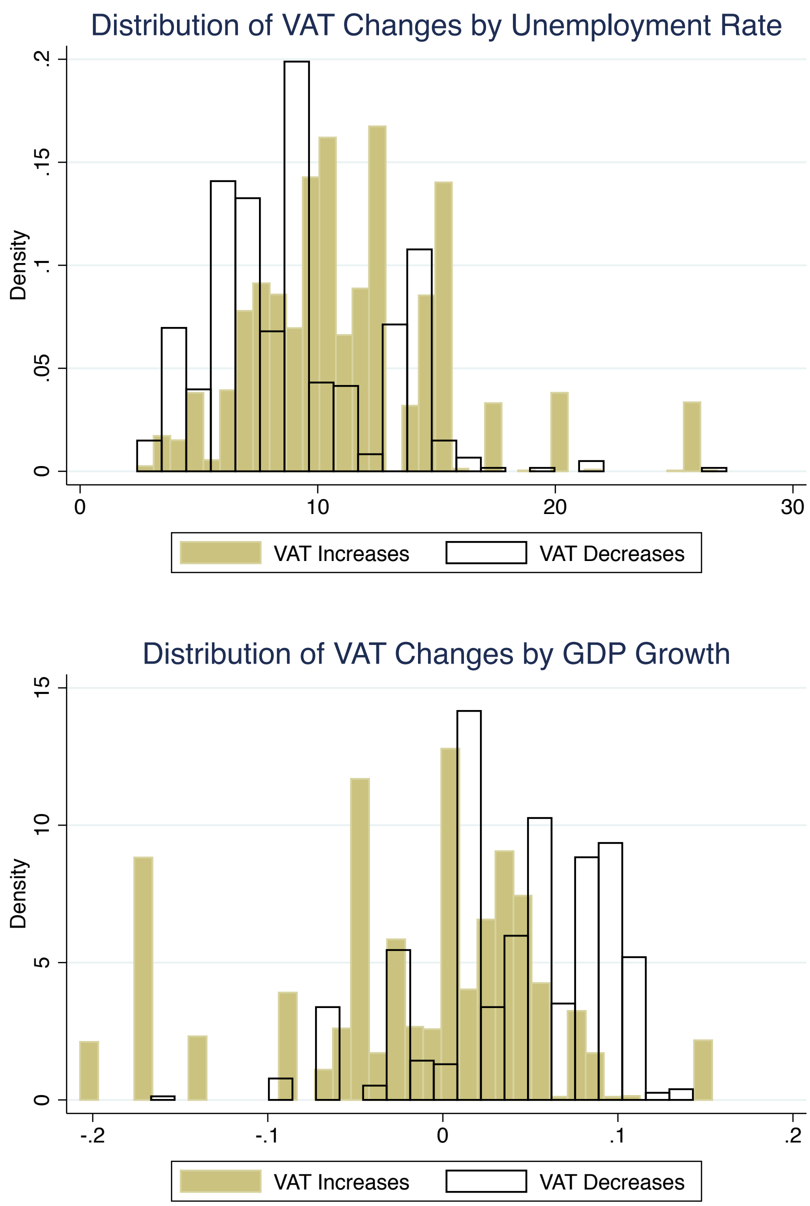
Eyster et al. (2017), in an effort to rationalize our finding, show that introducing the insights from Kahneman et al. (1986a) in a simple monopolistic pricing model yields asymmetric pass-through of taxes. Eyster et al. (2017) make two main assumptions. First, customers care about markups: high markups are perceived to be unfair and reduce the utility derived from consuming the good. Second, customers misinfer markups from prices: they underappreciate the extent to which higher prices reflect higher markups. Firms can educate customers if it is to their advantage – i.e. when markups are perceived to be high when in reality they are low. Eyster et al. (2017) show that when costs (or taxes) increase it is more profitable for firms to reveal markups rather than conceal them because perceived markups are likely to increase relative to true markups. When taxes decrease, the opposite holds true: perceived markups are likely to be lower than true markups and firms have no incentive to educate consumers. Eyster et al. (2017) show that this asymmetric behavior leads to asymmetric pass-through of taxes. Further, their model is consistent with Figure 6a, which shows that firms with low markups are more likely to pass through tax increases than firms with high markups, while pass-through in the case of tax decreases is homogeneous across firms.

Figure D.9: Summary Statistics: Country and Commodity



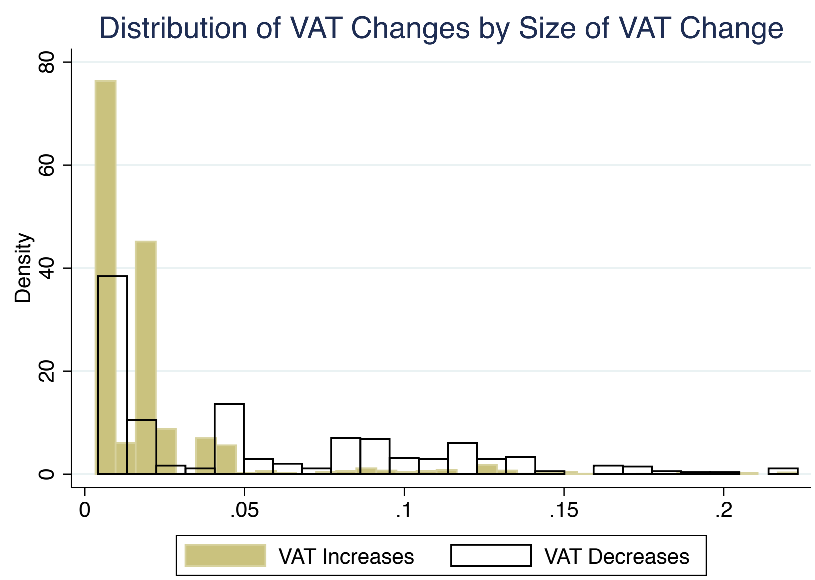
Notes: The first panel shows the distribution of all VAT increases and decreases by two-digit COICOP category. The second panel shows the distribution of all VAT increases and decreases by country. The description of the 2-digit COICOP categories is provided in Appendix Tables D.4 and D.5.

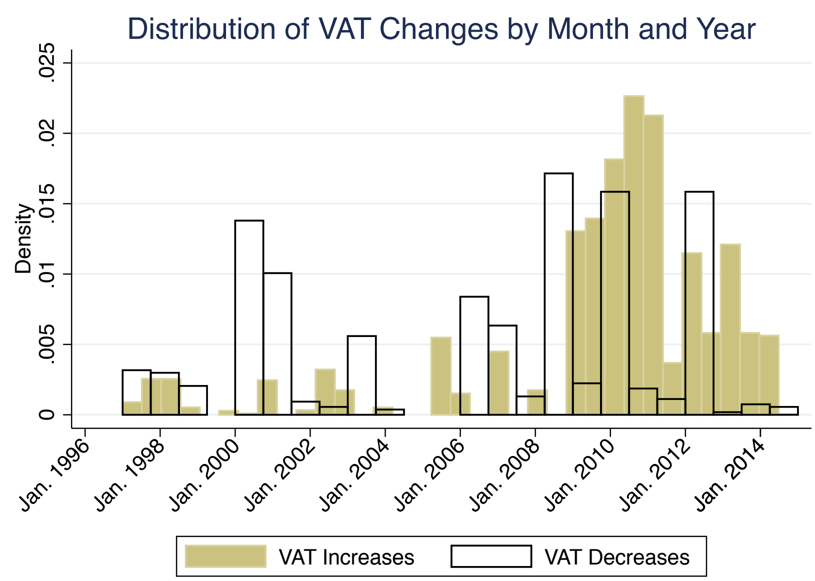
Figure D.10: Summary Statistics: Economic Conditions



Notes: The first panel shows the distribution of all VAT increases and decreases by unemployment rate. The second panel shows the distribution of all VAT increases and decreases by GDP growth rates.

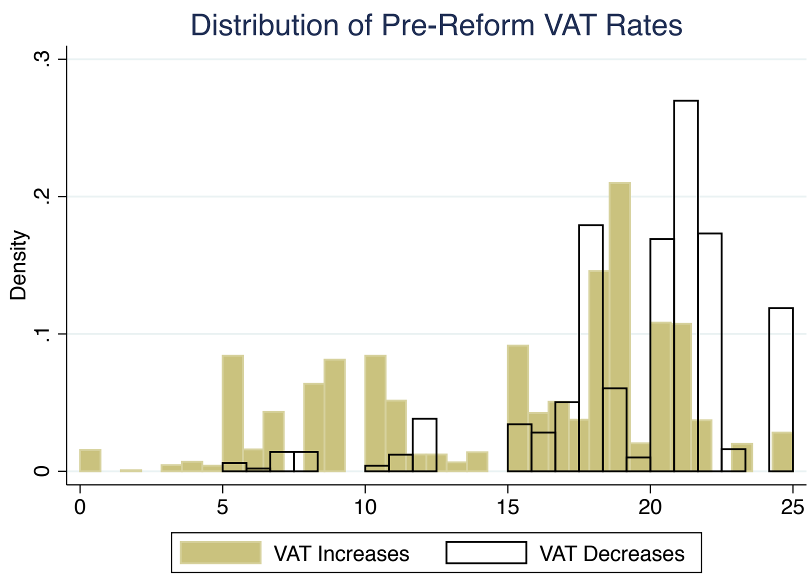
Figure D.11: Summary Statistics: Size and Timing

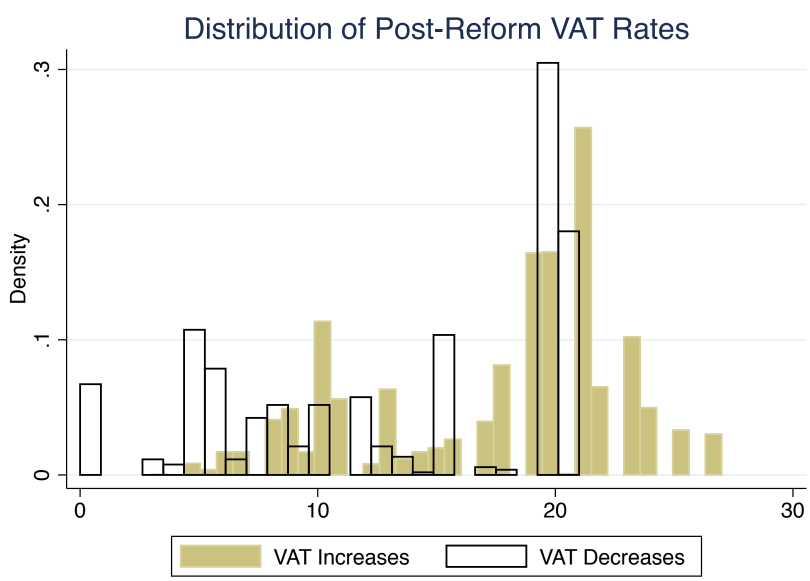




Notes: The first panel shows the distribution of all VAT increases and decreases by the size of the VAT change in absolute value. The second panel shows the distribution of all VAT increases and decreases by month and year.

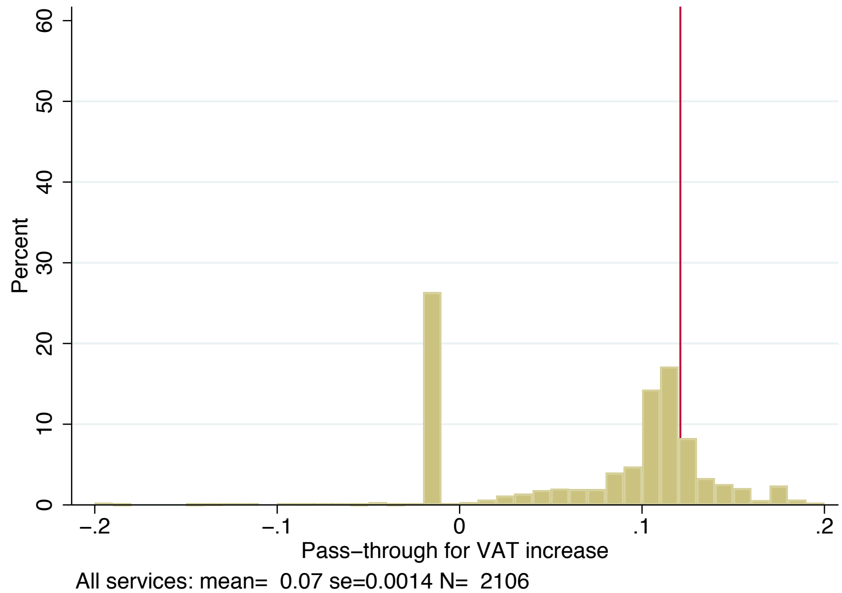
Figure D.12: Distribution of Pre- and Post-Reform VAT Rates

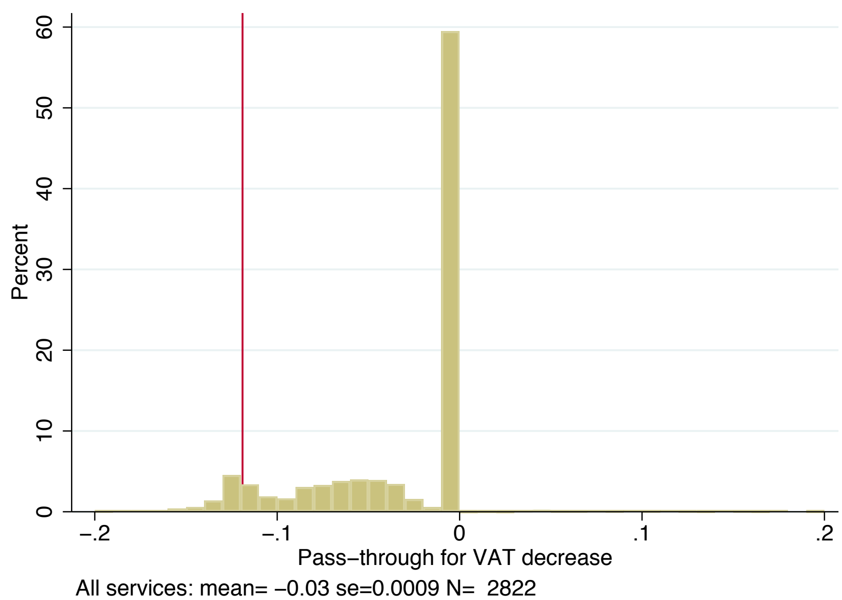




Notes: The first panel shows the distribution of VAT increases and decreases by pre-reform VAT rates. The second panel shows the distribution of VAT increases and decreases by post-reform VAT rates.

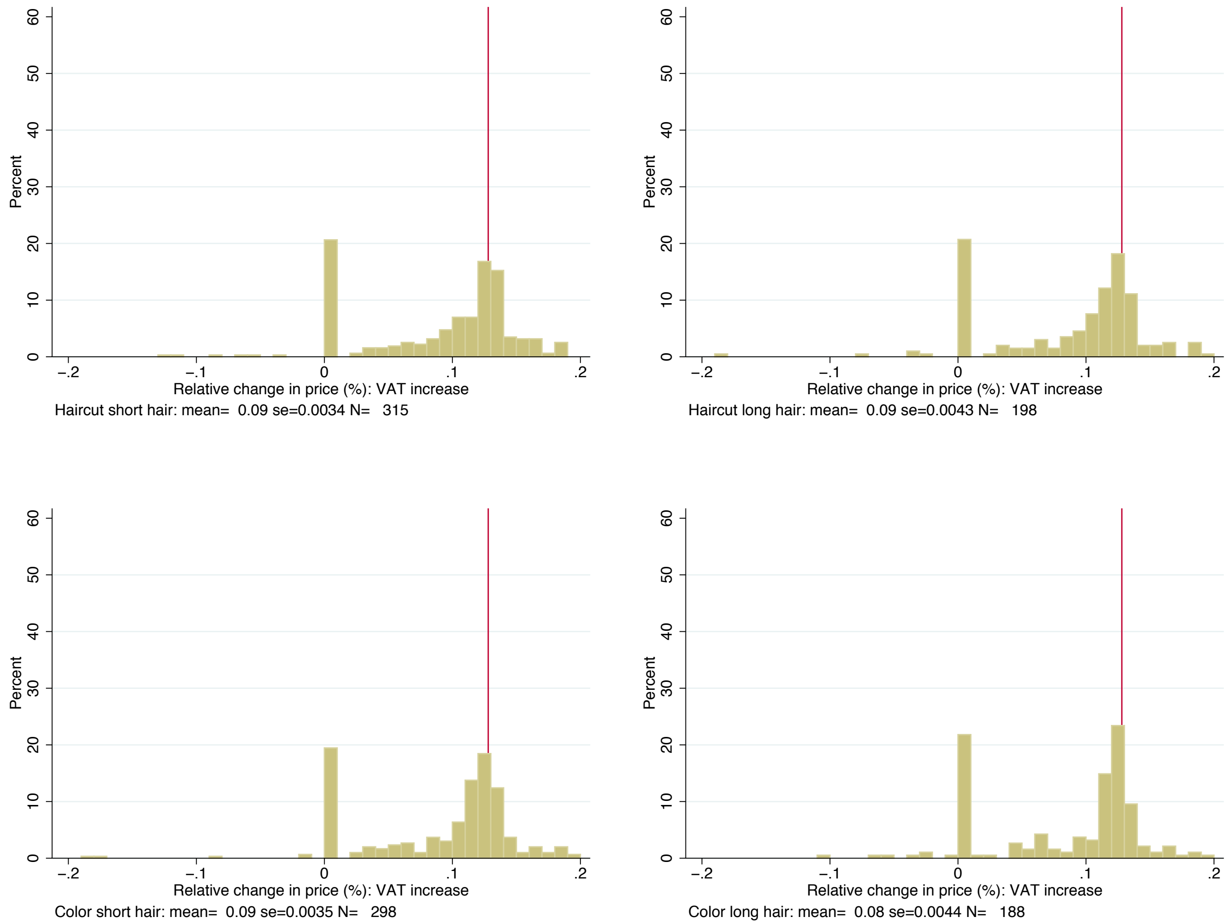
Figure D.13: Finnish Hairdressing VAT Reforms Pass-Through Distributions With Controls For Inflation





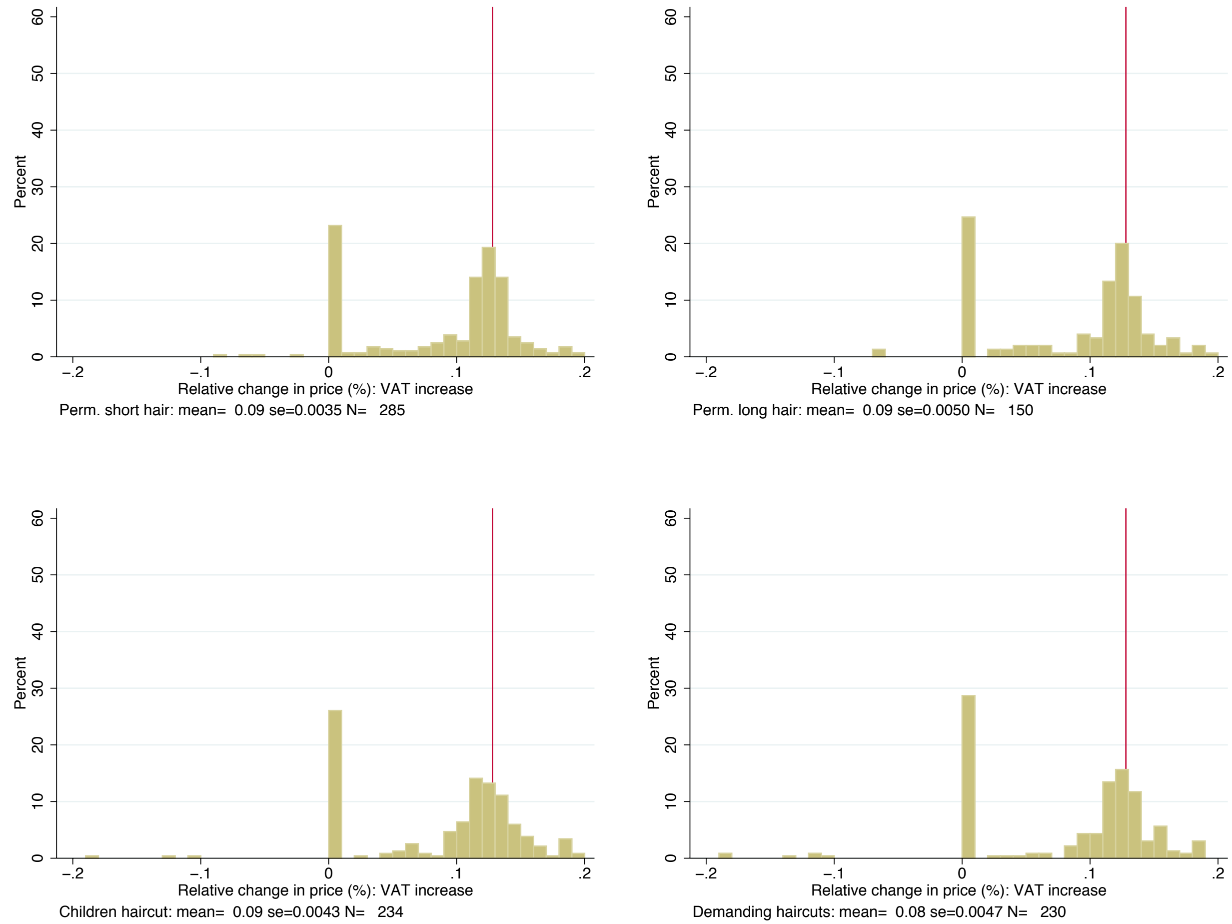
Notes: These Figures plot the pass-through distribution of the Finnish hairdressing sector VAT increase and decrease experiments (as in Figure 3), while controlling for inflation.

Figure D.14: Pass-Through Distribution By Service: VAT Increase



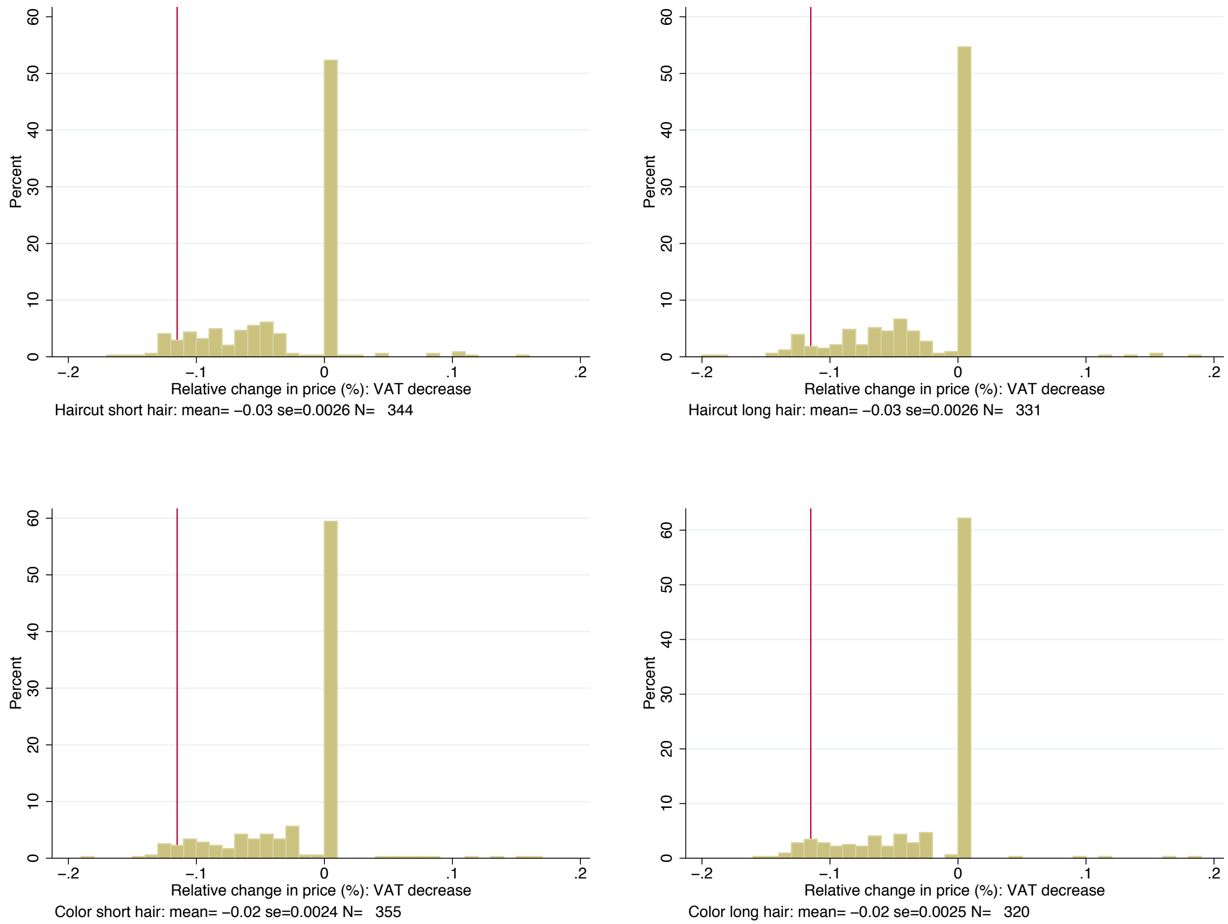
Notes: These figures are a disaggregated version of Figure 3. Each figure plots the distribution of pass-through following a VAT increase for each service offered by hairdressers.

Figure D.15: Pass-Through Distribution By Service: VAT Increase



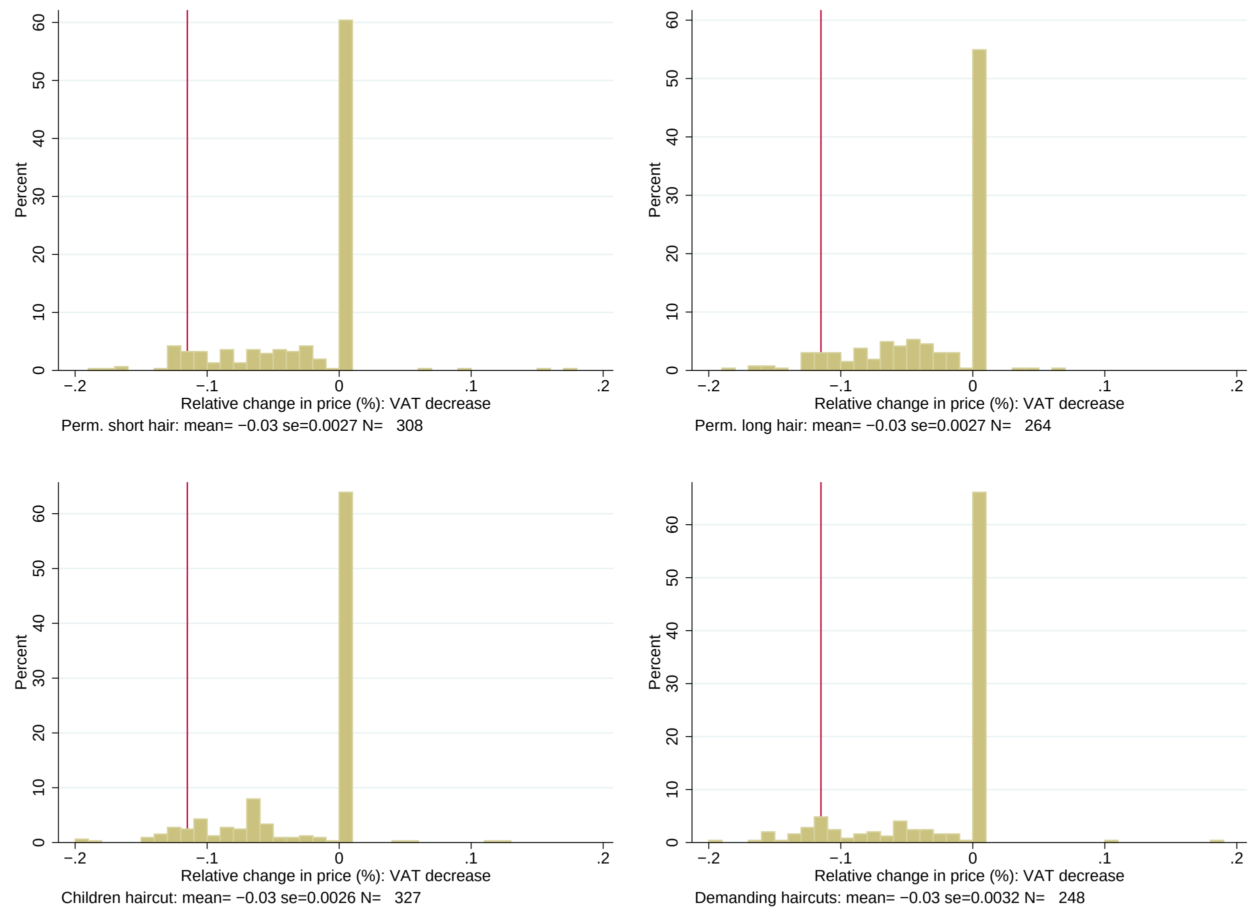
Notes: These figures are a disaggregated version of Figure 3. Each figure plots the distribution of pass-through following a VAT increase for each service offered by hairdressers.

Figure D.16: Pass-Through Distribution By Service: VAT Decrease



Notes: These figures are a disaggregated version of Figure 3. Each figure plots the distribution of pass-through following a VAT decrease for each service offered by hairdressers.

Figure D.17: Pass-Through Distribution By Service: VAT Decrease

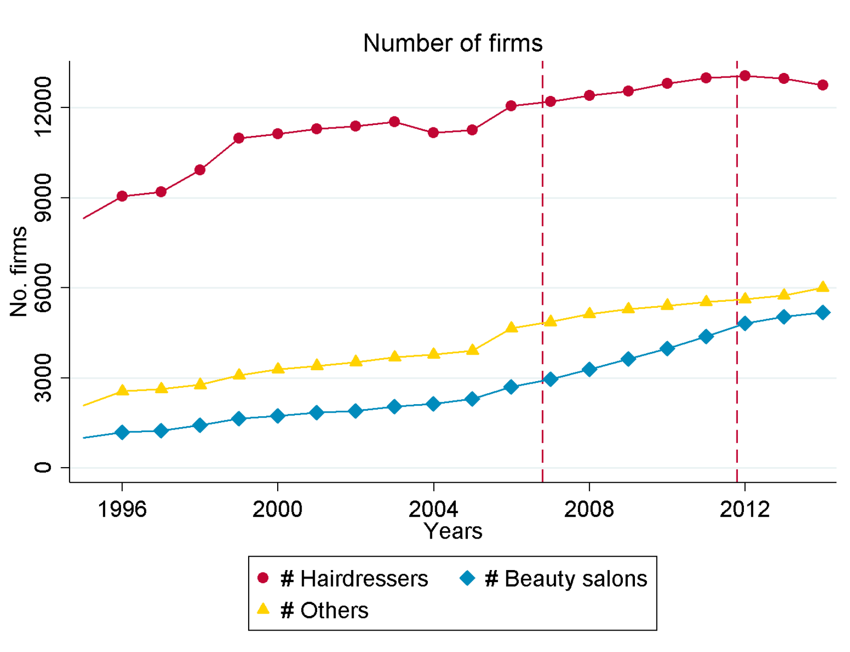


Notes: These Figures are a disaggregated version of Figure 3. Each Figure plots the distribution of pass-through following a VAT decrease for each service offered by hairdressers.

Figure D.18: Finnish Hairdressing Reforms: Investments

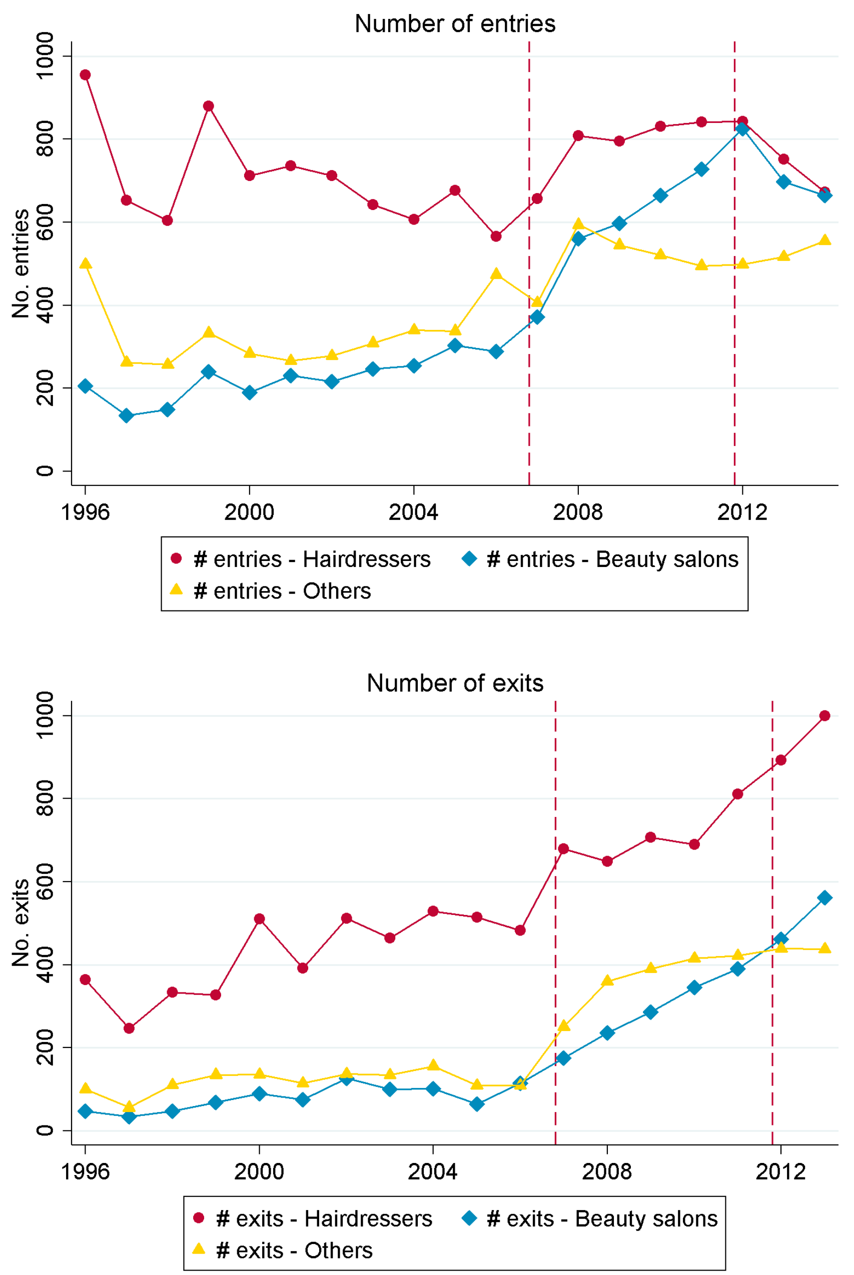
Notes: This Figure plots the response of investments to the Finnish VAT hairdressing reforms.

Figure D.19: Number of Firms in Finnish Hairdressing Sector



Notes: This figure uses the administrative dataset containing information on the full population of Finnish hairdressers, beauty salons, massage parlors and physical therapists to plot the number of firms in each sector over time. Others include massage parlors and physical therapy industries in Finland.

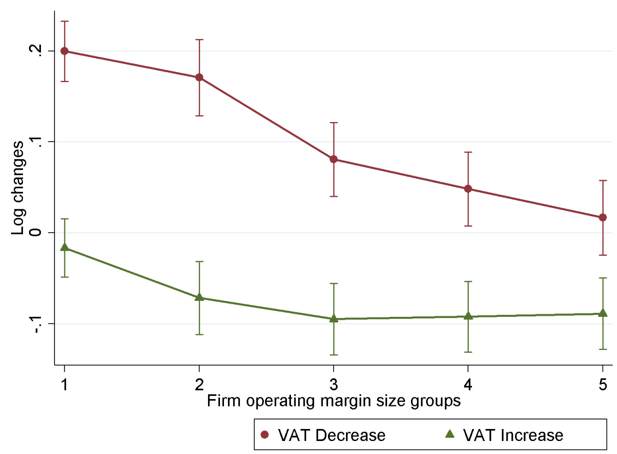
Figure D.20: Entry and Exit in Finnish Hairdressing Sector



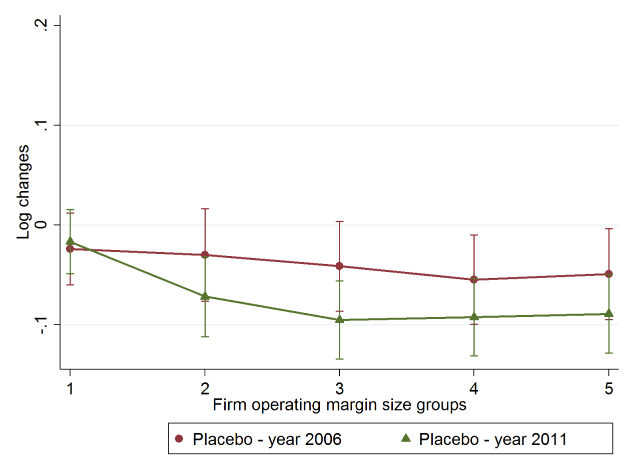
Notes: These figures use the administrative dataset containing information on the full population of Finnish hairdressers, beauty salons, massage parlors and physical therapists to plot the number of firms entering and exiting each sector over time. Others include entry and exit in the massage parlor and physical therapy industries in Finland.

Figure D.21: Changes in Markups by Quintile of Operating Margins for Finnish VAT Reforms

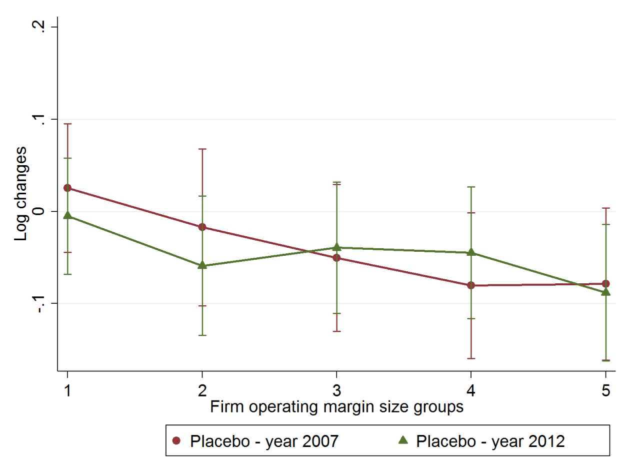
(a) Hairdressers in 2007 and 2012 (Reforms)



(b) Placebo 1: Hairdressers in 2006 and 2011

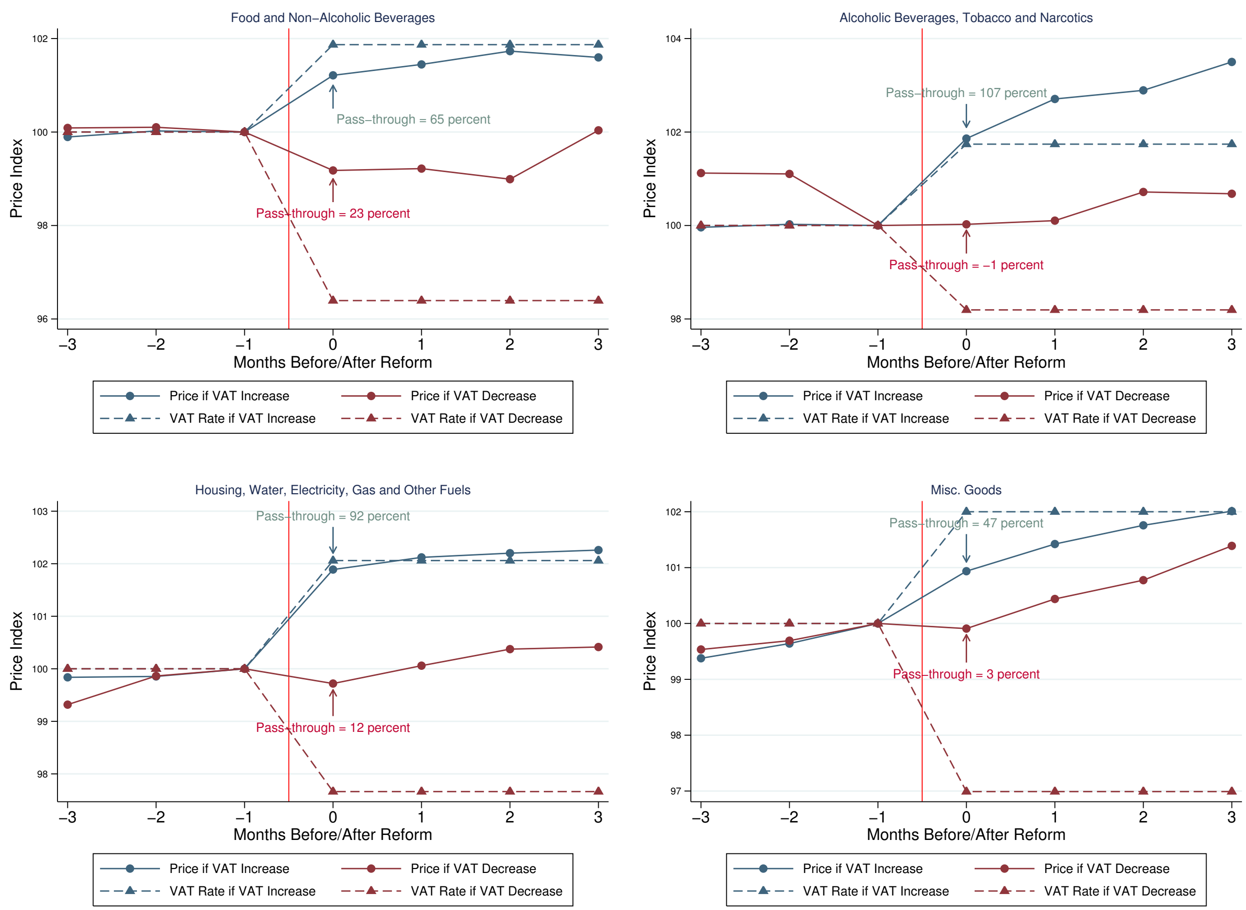


(c) Placebo 2: Finnish Beauty Salons in 2007 and 2012



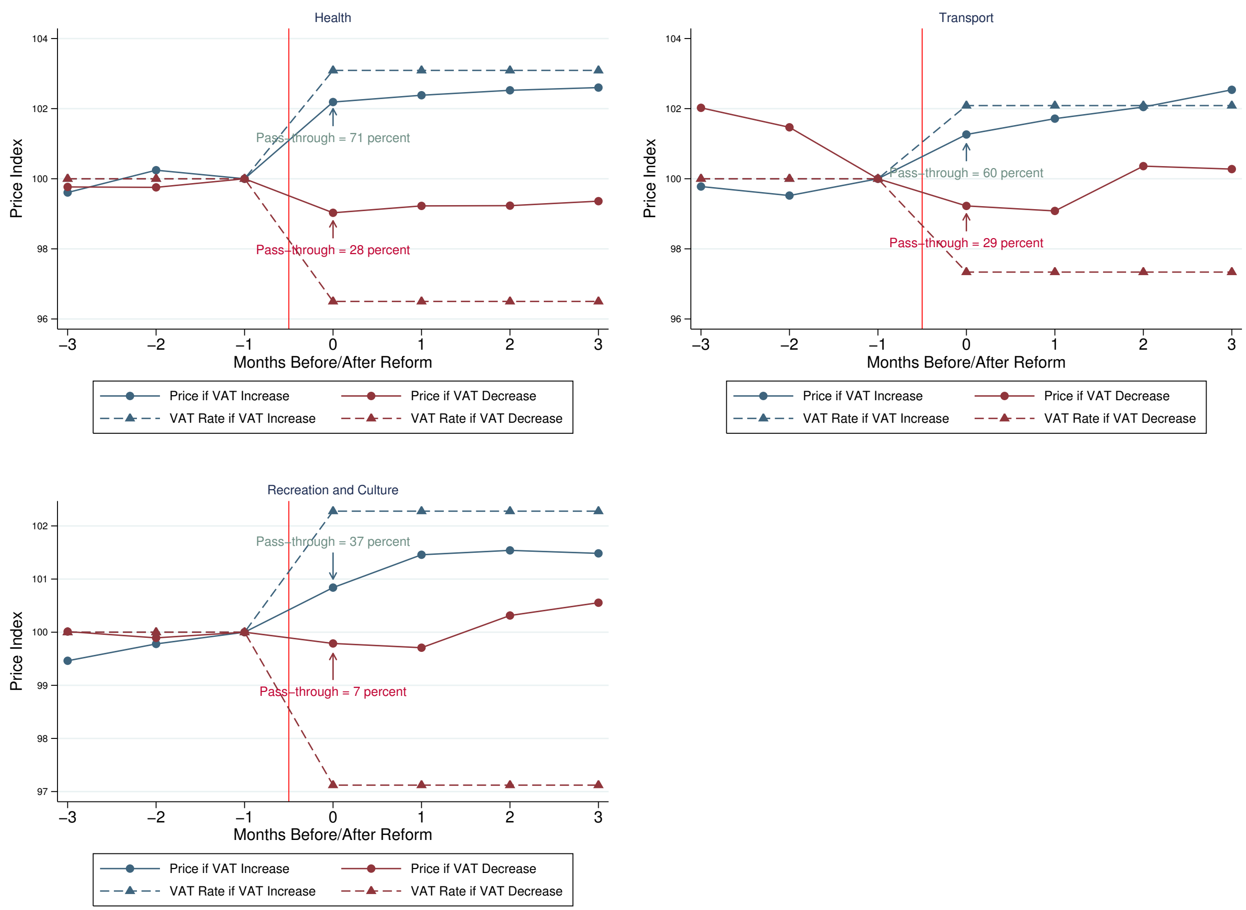
Notes: To generate these graphs, we break down the sample of firms into 5 quintiles with respect to operating margins (turnover minus deductible costs divided by turnover) using data from 2004 to 2006 for 2007 and 2009 to 2011 for 2012 , with 1 being firms with the smallest operating margins. For each quintile, we plot changes in their markup following changes in VAT. Figure D.21a considers the 14 p.p. VAT increase and decrease for Finnish hairdressers. Figure D.21b considers the Finnish hairdressers in 2006 and 2011. Figure D.21c considers Finnish beauty salons (which we use a control group for hairdressers) in 2007 and 2012.

Figure D.22: Asymmetric Response of Prices to VAT Changes by 2-Digit COICOP Code in the Full Sample



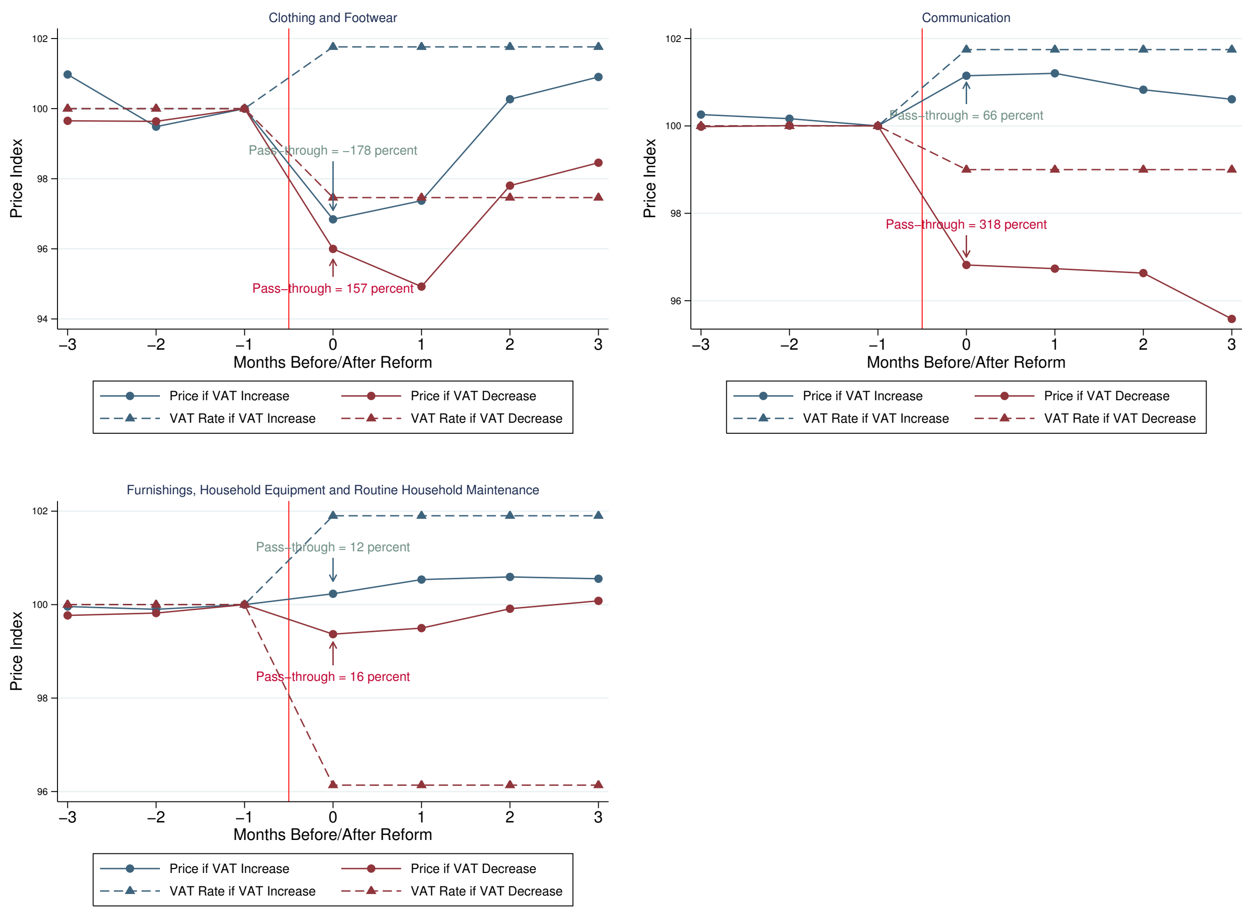
Notes: Each of these graphs is a disaggregated version of Figure 7a: they plot the response of prices to variation in the VAT rate by groups of commodities.

Figure D.23: Asymmetric Response of Prices to VAT Changes by 2-Digit COICOP Code in the Full Sample



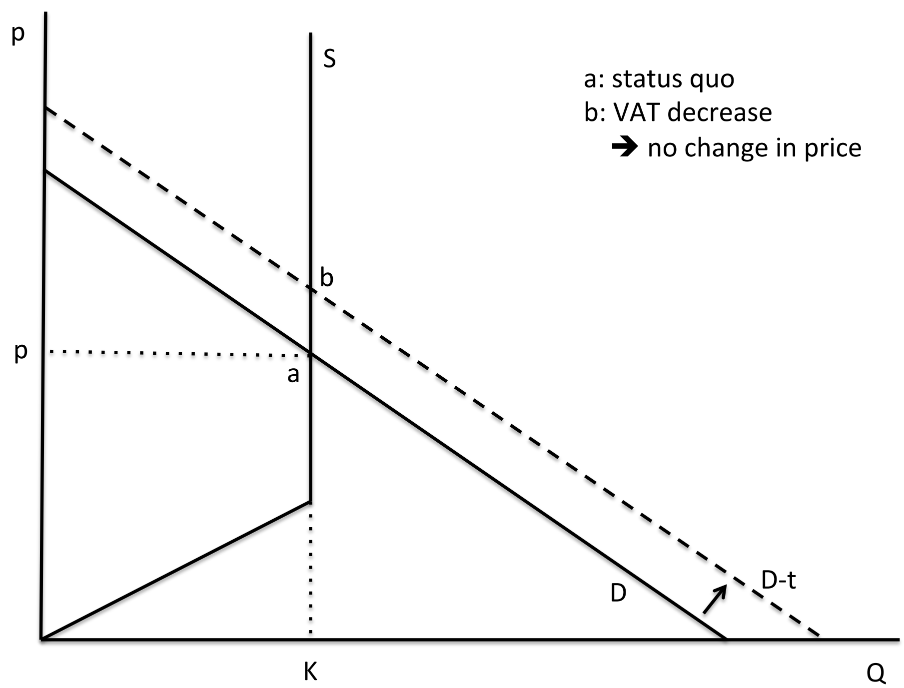
Notes: Each of these graphs is a disaggregated version of Figure 7a: they plot the response of prices to variation in the VAT by groups of commodities.

Figure D.24: Commodities With No Asymmetry



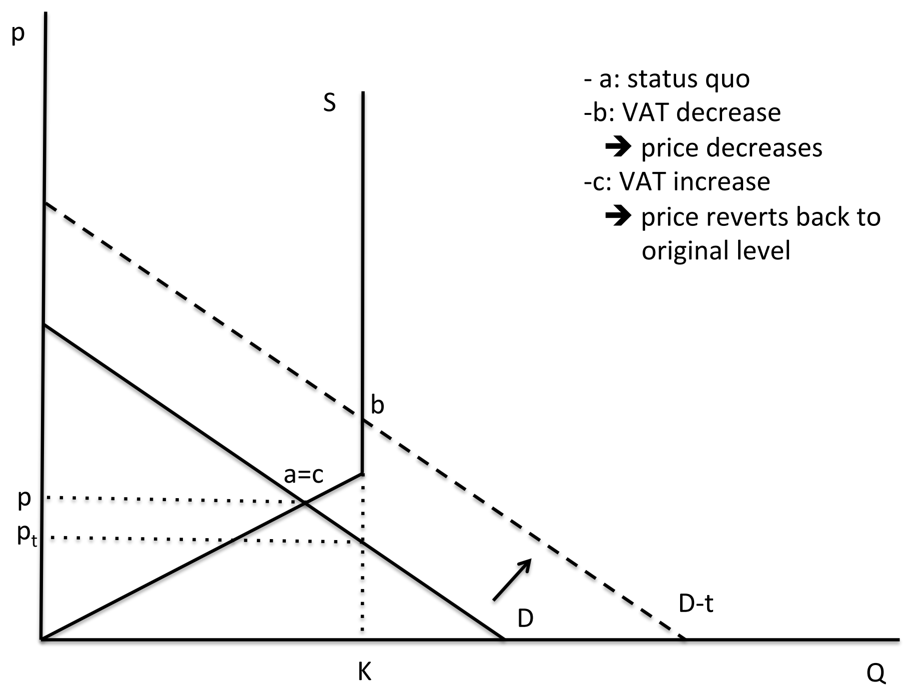
Notes: Each of these graphs is a disaggregated version of Figure 7a: they plot the response of prices to variation in the VAT by groups of commodities. This panel shows the commodities for which there is no asymmetry. Clothing and Footwear shows a price decrease for both VAT increases and decreases consistent with sales occurring at the same time as VAT reforms (mostly in January), it is excluded from our main specification. Communication and Furnishings, Household equipment etc. are included in our main specification.

Figure D.25: Capacity Constraints (case 1)



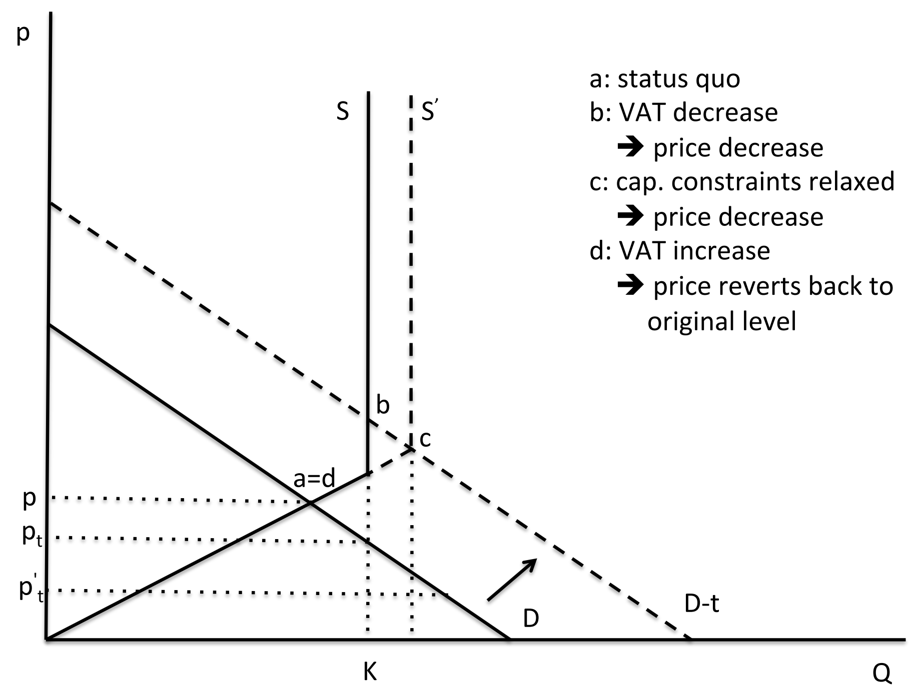
Notes: In this figure, we assume that capacity constraints are binding prior to the VAT cut (a). As the VAT rate is cut, prices inclusive of VAT do not change (b), since firms are operating on the portion of the supply function where $\epsilon_S = 0$.

Figure D.26: Capacity Constraints (case 2)



Notes: In this figure, we assume that firms are operating just below capacity constraints (a), prior to the VAT cut. As the VAT rate is decreased, firms decrease prices (b). If capacity constraints are not relaxed, then prices respond symmetrically to the VAT increase as they did to the VAT decrease (c).

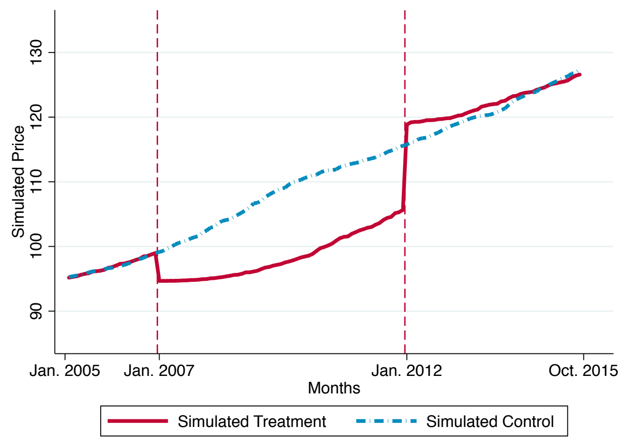
Figure D.27: Capacity Constraints (case 3)



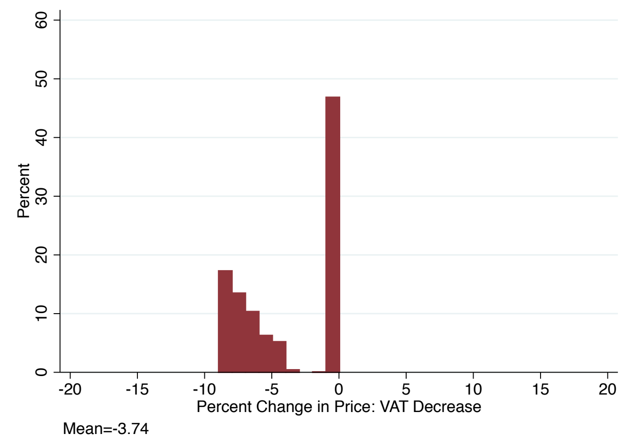
Notes: In this figure, we assume that firms are operating just below capacity constraints (a), prior to the VAT cut. As the VAT rate is decreased, firms decrease prices (b). Capacity constraints are then gradually relaxed, leading to incremental price decreases (c). When the VAT rate is increased, prices revert back to their original levels (d).

Figure D.28: Adjustment Cost Model Simulations

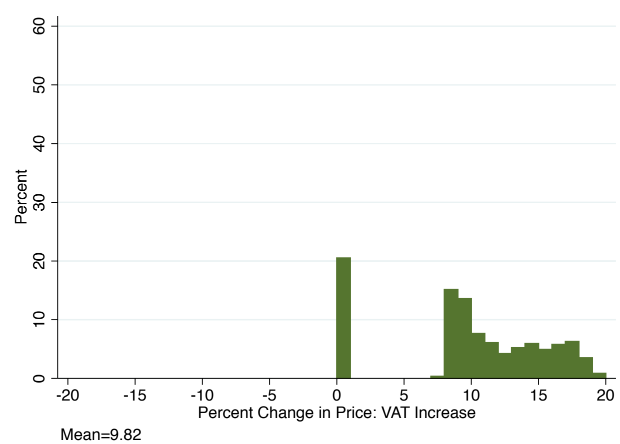
(a) Time Series Simulation



(b) VAT Decrease Distribution Simulation

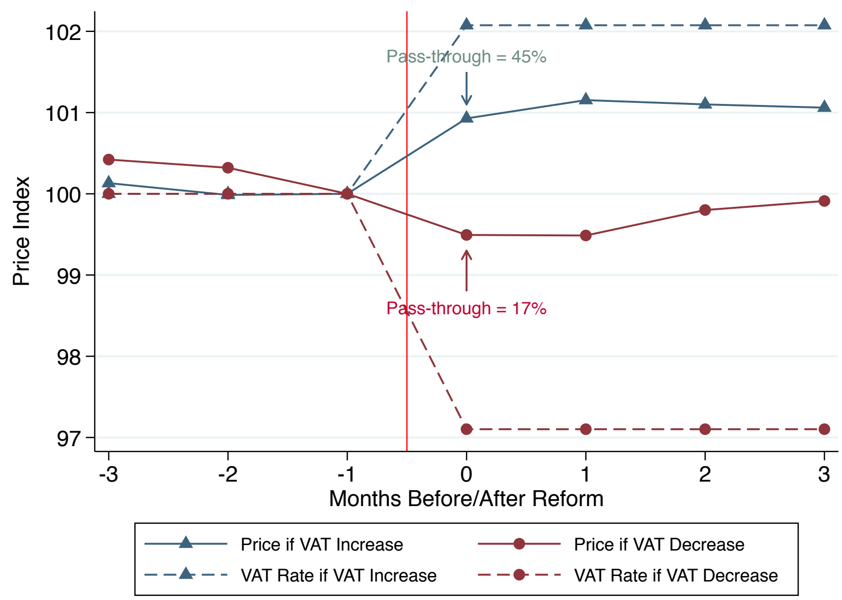


(c) VAT Increase Distribution Simulation



Notes: Figures D.28a, D.28b and D.28c plot results of the simulation of the model from section D.2.1 respectively for the time series and pass-through distributions for VAT decreases and increases.

Figure D.29: Asymmetric Response of Prices to VAT Changes (Real Prices)



Notes: This figure plots the response of prices to VAT increases and decreases, while controlling for inflation. The underlying dataset consists of three-month window price and VAT time series around each VAT reform from 1996 to 2015. We average out and normalize each series to 100 one month before the reform.

Table D.3: Summary Statistics For Finnish Hairdressers and Beauty Salons

	Hairdressers				Beauty Salons			
	Mean	Median	S.D.	N.	Mean	Median	S.D.	N.
Turnover	40190	25924	231039	157082	35643	18504	143747	45368
Profits	13787	11330	15193	155837	9610	5048	19365	44332
Costs	26699	13285	213093	162634	26865	11415	126093	47347
Total Assets	12841	2834	79027	112682	13065	2115	84635	36984
Nb. Employees	0.40	0	4.22	162634	0.37	0	3.53	47347
Cost of Employees	1129	0	20138	145729	766	0	10709	43649
Sole Proprietors	0.91	1	0.29	162634	0.89	1	0.31	47347
Partnerships	0.05	0	0.21	162634	0.03	0	0.18	47347
Corporations	0.05	0	0.21	162634	0.07	0	0.26	47347
Nb. of firms in 2006	12,301				3,073			

Notes: This table reports annual summary statistics on the full population of Finnish hairdressers and beauty salons using corporate tax data.

Table D.4: COICOP Codes

COICOP Codes	Description
01	**Food and Non-Alcoholic Beverages**
01.1	Food
01.2	Non-Alcoholic Beverages
02	**Alcoholic Beverages, Tobacco and Narcotics**
02.1	Alcoholic Beverages
02.2	Tobacco
02.3	Narcotics
03	**Clothing and Footwear**
03.1	Clothing
03.2	Footwear
04	**Housing, Water, Electricity, Gas and Other Fuels**
04.1	Actual Rentals For Housing
04.2	Imputed Rentals For Housing
04.3	Maintenance and Repair of the Dwelling
04.4	Water Supply and Misc Services Relating to the Dwelling
04.5	Electricity, Gas and Other Fuels
05	**Furnishings, Household Equipment and Routine Household Maintenance**
05.1	Furniture and Furnishings, Carpets and Other Floor Coverings
05.2	Household Textiles
05.3	Household Appliances
05.4	Glassware, Tableware and Household Utensils
05.5	Tools and Equipment for House and Garden
05.6	Goods and Services for Routine Household Maintenance
06	**Health**
06.1	Medical Products, Appliances and Equipment
06.2	Outpatient Services
06.3	Hospital Services
07	**Transport**
07.1	Purchase of Vehicles
07.2	Operation of Personal Transport Equipment
07.3	Transport Services

Notes: This table reports the COICOP codes used by Eurostat to describe price categories.

Table D.5: COICOP Codes (continued)

COICOP Code	Description
08	**Communication**
08.1	Postal Services
08.2	Telephone and Telefax Equipment
08.3	Telephone and Telefax Services
09	**Recreation and Culture**
09.1	Audio-Visual, Photographic and Information Processing Equipment
09.2	Other Major Durables For Recreation and Culture
09.3	Other Recreational Items and Equipment, Gardens and Pets
09.4	Recreational and Cultural Services
09.5	Newspapers, Books and Stationery
09.6	Package Holidays
10	**Education**
10.1	Pre-Primary and Primary Education
10.2	Secondary Education
10.3	Post-Secondary Non-Tertiary Education
10.4	Tertiary Education
10.5	Education Not Definable By Level
11	**Restaurants and Hotels**
11.1	Catering Services
11.2	Accommodation Services
12	**Misc. Goods and Services**
12.1	Personal Care
12.2	Prostitution
12.3	Personal Effects
12.4	Social Protection
12.5	Insurance
12.6	Financial Services
12.7	Other Services

Notes: This table reports the COICOP codes used by Eurostat to describe price categories.

Table D.6: Finnish VAT Pass-Through with Cost Controls by Hairdressing Service

	VAT Increase Pass-Through	VAT Decrease Pass-Through
Men's haircut	0.751	0.354
	(0.0512)	(0.0926)
Observations	266	268
Women's haircut	0.723	0.235
	(0.0546)	(0.0337)
Observations	163	299
Coloring	0.844	0.248
	(0.0498)	(0.0344)
Observations	260	287
Coloring - demanding	0.723	0.166
	(0.0416)	(0.200)
Observations	159	283
Perm	0.768	0.377
	(0.0365)	(0.119)
Observations	234	113
Perm - demanding	0.742	0.420
	(0.0495)	(0.0744)
Observations	120	285
Kid's haircut	0.927	0.363
	(0.0747)	(0.0452)
Observations	212	280
Special haircut	0.684	0.280
	(0.0638)	(0.109)
Observations	202	237

Notes: This table shows VAT increase (column (1)) and decrease (column (2)) pass-through estimates for every hairdressing service we observe with controls for variable costs. Pass-through is estimated by regressing differences in log prices over time normalized by the size of the VAT change on an indicator variable equal to 1 for post-reform and zero otherwise as well as control variables for variable costs. Standard errors are clustered at the firm level and are reported in parenthesis.

Table D.7: Heterogeneity by Zipcode Density

	Markup (decrease)	Markup (increase)	Log variable costs (decrease)	Log variable costs (increase)	Log turnover (decrease)	Log turnover (increase)
2nd most dense*reform	0.002	-0.004	0.006	-0.002	0.019	-0.01
	(0.021)	(0.02)	(0.022)	(0.019)	(0.014)	(0.013)
3rd most dense*reform	0.019	0.014	-0.0188	-0.022	0.003	-0.016
	(0.018)	(0.021)	(0.019)	(0.018)	(0.012)	(0.013)
4th most dense*reform	-0.01	0.003	0.02	-0.021	0.020	-0.023
	(0.021)	(0.02)	(0.021)	(0.02)	(0.012)	(0.013)
5th most dense*reform	0.041	-0.001	-0.050	-0.005	-0.013	-0.009
	(0.019)	(0.019)	(0.018)	(0.015)	(0.012)	(0.013)
2nd most dense	-0.001	0.001	0.024	0.03	0.018	0.037
	(0.026)	(0.026)	(0.03)	(0.028)	(0.019)	(0.018)
3rd most dense	-0.014	0.005	0.069	0.05	0.061	0.064
	(0.028)	(0.033)	(0.029)	(0.031)	(0.018)	(0.019)
4th most dense	-0.023	-0.033	0.122	0.141	0.117	0.136
	(0.025)	(0.03)	(0.026)	(0.027)	(0.021)	(0.02)
5th most dense	-0.021	0.02	0.198	0.148	0.205	0.193
	(0.03)	(0.03)	(0.056)	(0.053)	(0.045)	(0.044)
VAT Increase		-0.052		0.057		0.030
		(0.015)		(0.014)		(0.01)
VAT Decrease	0.113		0.136		0.202	
	(0.014)		(0.014)		(0.009)	
Constant	0.947	1.060	8.833	8.969	10.18	10.38
	(0.018)	(0.018)	(0.022)	(0.02)	(0.018)	(0.015)
Observations	91,544	79,003	92,347	79,195	91,789	79,195
R-squared	0.006	0.001	0.009	0.004	0.036	0.011

Notes: This table shows the changes in the level of markups, variable costs and turnover by quintiles of zipcode density; 2nd most dense, 3rd most dense, etc. are dummies for hairdressers being located in a zipcode that belongs to the 2nd most dense quintile, 3rd most dense quintile, etc. of zipcodes. The variable 2nd most dense*reform is the interaction of the quintile density dummy with a dummy for reform year. VAT increase and VAT decrease are dummies for the years when the VAT increase and decrease occur. We use 10 years of data when we study the VAT decrease (2002-2011), 5 years before and after the reform, and 8 years of data when we examine the VAT increase (2007-2014), 4 years before and after the reforms. Standard errors are clustered by municipalities and are in parentheses. The dummy for the least dense zipcodes and the interaction of this dummy with a dummy for the reform year are both omitted.

Table D.8: Heterogeneity by Local Markup

	Markup (decrease)	Markup (increase)	Log variable costs (decrease)	Log variable costs (increase)	Log turnover (decrease)	Log turnover (increase)
2nd highest local markup*reform	-0.0231	-0.015	0.0112	0.00862	-0.00178	0.000689
	(0.0169)	(0.0163)	(0.0169)	(0.0193)	(0.0126)	(0.0124)
3rd highest local markup*reform	-0.00669	0.00889	-0.00177	-0.00478	-0.00905	0.00196
	(0.0184)	(0.0222)	(0.0181)	(0.0212)	(0.0121)	(0.0158)
4th highest local markup*reform	0.00719	-0.0505	-0.0263	0.0297	-0.0280	-0.00169
	(0.0187)	(0.018)	(0.0191)	(0.0184)	(0.0131)	(0.0121)
5th highest local markup*reform	0.00296	0.000987	-0.00551	-0.0225	-0.0105	-0.0184
	(0.0198)	(0.0211)	(0.0213)	(0.021)	(0.013)	(0.0126)
2nd highest local markup	0.0357	0.0126	0.00253	0.0137	0.0298	0.0281
	(0.0221)	(0.0228)	(0.0328)	(0.0325)	(0.0263)	(0.0234)
3rd highest local markup	0.0461	0.0394	0.0136	0.0118	0.0587	0.0496
	(0.0272)	(0.0252)	(0.0374)	(0.0365)	(0.0313)	(0.0284)
4th highest local markup	0.0500	0.0572	0.00837	-0.0179	0.0552	0.0271
	(0.0281)	(0.025)	(0.0492)	(0.0449)	(0.0405)	(0.0372)
5th highest local markup	0.0576	0.0605	-0.0278	-0.0333	0.0173	0.00683
	(0.0199)	(0.0242)	(0.0272)	(0.0278)	(0.0232)	(0.0207)
VAT Increase		-0.0374		0.0423		0.0199
		(0.0142)		(0.0151)		(0.00926)
VAT Decrease	0.130		0.131		0.219	
	(0.0142)		(0.0139)		(0.00969)	
Constant	0.897	1.027	8.916	9.047	10.22	10.44
	(0.0165)	(0.0184)	(0.0262)	(0.0264)	(0.0245)	(0.0226)
Observations	91,827	79,339	92,632	79,531	92,073	79,531
R-squared	0.006	0.002	0.004	0.001	0.026	0.001

Notes: This table shows the changes in the level of markups, variable costs and turnover by quintiles of local average markup; 2nd highest local markup, 3rd highest local markup, etc. are dummies for hairdressers being located in a zipcode with the 2nd highest local markup quintile, 3rd highest local markup quintile, etc. of zipcodes. The variable 2nd highest local markup*reform is the interaction of the local average markup quintile with a dummy for reform year. VAT increase and VAT decrease are dummies for the years when the VAT increase and decrease occur. We use 10 years of data when we study the VAT decrease (2002-2011), 5 years before and after the reform, and 8 years of data when we examine the VAT increase (2007-2014), 4 years before and after the reforms. Standard errors are clustered by municipalities and are in parentheses. The dummy for the lowest local markup zipcodes and the interaction of this dummy with a dummy for the reform year are both omitted.

Table D.9: Pass-Through Estimates Without Controls

	Δ log Price	
	Increase	Decrease
β_0	0.33	0.071
	(0.061)	(0.028)
β_{+1}	0.011	0.028
	(0.016)	(0.017)
β_{-2}	0.017	0.039
	(0.019)	(0.015)
β_{+2}	0.027	-0.038
	(0.031)	(0.020)
β_{-3}	-0.0067	0.0044
	(0.015)	(0.025)
β_{+3}	-0.038	-0.0061
	(0.019)	(0.023)
β_{-4}	0.034	-0.027
	(0.031)	(0.037)
β_{+4}	-0.016	-0.0047
	(0.026)	(0.020)
Time FE	Yes	Yes
R^2	0.017	0.018
Observations	434070	387175

Notes: The coefficients reported in this table indicate the pass-through of VAT increases and decreases to prices, estimated using specification (1) without controls (but including time fixed effects). The first column shows the estimates for VAT increases and the second those for VAT decreases. Standard errors are clustered by month and are in parentheses. β_0 measures the pass-through of the VAT change at the time of the reform, and β_i measures price changes i months away from the reform.

Table D.10: Pass-Through Estimates For Temporary VAT Changes

	Δ log Price	
	Increase	Decrease
β_0	0.34	0.079
	(0.084)	(0.043)
β_{+1}	0.032	0.038
	(0.023)	(0.025)
β_{-2}	0.036	0.024
	(0.022)	(0.016)
β_{+2}	-0.010	-0.038
	(0.024)	(0.028)
β_{-3}	0.0049	0.00058
	(0.018)	(0.036)
β_{+3}	-0.051	-0.020
	(0.022)	(0.027)
β_{-4}	0.042	-0.0070
	(0.039)	(0.024)
β_{+4}	-0.033	-0.0063
	(0.027)	(0.028)
Time FE	Yes	Yes
R^2	0.014	0.014
Observations	367631	331157

Notes: The coefficients reported in this table indicate the pass-through of VAT increases and decreases to prices, estimated using specification (1) on temporary VAT changes. The first column shows the estimates for VAT increases and the second those for VAT decreases. Standard errors are clustered by month and are in parentheses. β_0 measures the pass-through of the VAT change at the time of the reform, and β_i measures price changes i months away from the reform.

Table D.11: Pass-Through Estimates For Permanent VAT Changes

	Δ log Price	
	Increase	Decrease
β_0	0.26	0.028
	(0.073)	(0.023)
β_{+1}	-0.023	0.012
	(0.014)	(0.019)
β_{-2}	0.019	0.010
	(0.022)	(0.013)
β_{+2}	0.045	-0.031
	(0.023)	(0.022)
β_{-3}	0.013	-0.0011
	(0.015)	(0.026)
β_{+3}	-0.0090	0.0030
	(0.019)	(0.019)
β_{-4}	0.037	-0.024
	(0.034)	(0.023)
β_{+4}	-0.0063	0.011
	(0.031)	(0.020)
Time FE	Yes	Yes
R^2	0.014	0.014
Observations	364272	332067

Notes: The coefficients reported in this table indicate the pass-through of VAT increases and decreases to prices, estimated using specification (1) on permanent VAT changes. The first column shows the estimates for VAT increases and the second those for VAT decreases. Standard errors are clustered by month and are in parentheses. β_0 measures the pass-through of the VAT change at the time of the reform, and β_i measures price changes i months away from the reform.

Table D.12: Pass-Through Estimates Excluding VAT Changes Concurrent With Other Tax Changes

	Δ log Price	
	Increase	Decrease
β_0	0.34	0.046
	(0.070)	(0.026)
β_{+1}	0.026	0.020
	(0.019)	(0.019)
β_{-2}	0.035	0.019
	(0.020)	(0.013)
β_{+2}	0.017	-0.032
	(0.029)	(0.022)
β_{-3}	0.0088	-0.0060
	(0.017)	(0.028)
β_{+3}	-0.044	0.0080
	(0.019)	(0.019)
β_{-4}	0.057	-0.024
	(0.035)	(0.022)
β_{+4}	-0.0050	-0.012
	(0.029)	(0.023)
Time FE	Yes	Yes
R^2	0.014	0.014
Observations	378251	336872

Notes: The coefficients reported in this table indicate the pass-through of VAT increases and decreases to prices, estimated using specification (1) on a subsample of reforms that excludes VAT changes that occur at the same time as other tax changes. The first column shows the estimates for VAT increases and the second those for VAT decreases. Standard errors are clustered by month and are in parentheses. β_0 measures the pass-through of the VAT change at the time of the reform, and β_i measures price changes i months away from the reform.

Table D.13: Pass-Through Estimates Using Fixed Effects Regression (Inflation Controls)

	Δ log Price	
	Increase	Decrease
β_0	0.33	0.066
	(0.060)	(0.031)
β_{+1}	0.013	0.027
	(0.018)	(0.018)
β_{-2}	0.023	0.029
	(0.017)	(0.015)
β_{+2}	0.013	-0.042
	(0.029)	(0.020)
β_{-3}	0.0078	-0.0017
	(0.016)	(0.030)
β_{+3}	-0.050	-0.0027
	(0.021)	(0.022)
β_{-4}	0.042	-0.017
	(0.032)	(0.021)
β_{+4}	-0.018	-0.0069
	(0.029)	(0.021)
Time FE	Yes	Yes
R^2	0.018	0.018
Observations	386557	342792

Notes: The coefficients reported in this table indicate the pass-through of VAT increases and decreases to prices, estimated using specification (1) on the full sample of reforms, while also controlling for linear trends in country*commodity specific inflation rates. The first column shows the estimates for VAT increases and the second those for VAT decreases. Standard errors are clustered by month and are in parentheses. β_0 measures the pass-through of the VAT change at the time of the reform, and β_i measures price changes i months away from the reform.

Table D.14: Correlation of VAT Changes with Total Tax Revenue, Unemployment Rate and GDP Per Capita

	VAT Change	VAT Increase	VAT Decrease
α_{-1}	-0.00014	0.00034	-0.00048
	(0.0015)	(0.0013)	(0.00043)
α_{-2}	0.0041	0.0035	0.00056
	(0.0036)	(0.0031)	(0.00061)
α_{-3}	-0.00055	-0.00012	-0.00043
	(0.0014)	(0.0013)	(0.00035)
α_{-4}	-0.00069	-0.00049	-0.00021
	(0.0017)	(0.0016)	(0.00023)
α_{-5}	0.00058	0.00090	-0.00031
	(0.0014)	(0.0012)	(0.00047)
β_{-1}	-0.0012	-0.0012	0.0000028
	(0.0011)	(0.00099)	(0.00040)
β_{-2}	-0.00091	-0.00097	0.000063
	(0.0013)	(0.0012)	(0.00055)
β_{-3}	-0.0016	-0.0013	-0.00036
	(0.0011)	(0.0010)	(0.00030)
β_{-4}	-0.0014	-0.0011	-0.00023
	(0.0016)	(0.0015)	(0.00032)
β_{-5}	-0.0015	-0.0012	-0.00030
	(0.0011)	(0.00099)	(0.00033)
γ_{-1}	0.0010	0.0014	-0.00040
	(0.0044)	(0.0039)	(0.0015)
γ_{-2}	-0.0074	-0.0053	-0.0020
	(0.0053)	(0.0044)	(0.0026)
γ_{-3}	0.0021	0.00098	0.0012
	(0.0044)	(0.0042)	(0.00093)
γ_{-4}	-0.0011	-0.0018	0.00069
	(0.0078)	(0.0077)	(0.0011)
γ_{-5}	0.0022	0.0013	0.00088
	(0.0043)	(0.0039)	(0.0013)
R^2	0.070	0.072	0.022
Observations	462,706	462,706	462,706

Notes: This Table shows the results of estimating specification (2), which correlates the timing of VAT changes with the underlying economic conditions leading up to the VAT change which include tax revenue (α), GDP per capita (β) and the unemployment rate (γ). The first column uses as an outcome variable an indicator variable for VAT changes, the second one uses an indicator variable for VAT increases and the third one an indicator variable for VAT decreases. We regress these outcome variables on the log of tax revenue, GDP per capita and unemployment rate in the twelve months leading up to the reform.

Table D.15: Correlation of VAT Changes with Total Tax Revenue, Industry Turnover and Unemployment Rate

	VAT Change	VAT Increase	VAT Decrease
α_{-1}	-0.00037	-0.00013	-0.00024
	(0.0014)	(0.0014)	(0.00031)
α_{-2}	0.0034	0.0030	0.00046
	(0.0031)	(0.0027)	(0.00063)
α_{-3}	-0.0014	-0.00082	-0.00056
	(0.0015)	(0.0015)	(0.00029)
α_{-4}	-0.0011	-0.00072	-0.00035
	(0.0024)	(0.0023)	(0.00027)
α_{-5}	-0.00028	0.00017	-0.00046
	(0.0015)	(0.0013)	(0.00051)
β_{-1}	-0.0015	-0.00098	-0.00051
	(0.0010)	(0.00062)	(0.00060)
β_{-2}	-0.00016	-0.00049	0.00033
	(0.00076)	(0.00066)	(0.00036)
β_{-3}	-0.00095	-0.00065	-0.00030
	(0.00071)	(0.00068)	(0.00025)
β_{-4}	-0.0015	-0.0014	-0.000052
	(0.00082)	(0.00082)	(0.00015)
β_{-5}	-0.00063	-0.00045	-0.00018
	(0.00054)	(0.00052)	(0.00018)
γ_{-1}	-0.00056	-0.00077	0.00021
	(0.0023)	(0.0023)	(0.00053)
γ_{-2}	-0.0097	-0.0074	-0.0023
	(0.0051)	(0.0043)	(0.0017)
γ_{-3}	-0.0013	-0.0018	0.00052
	(0.0025)	(0.0025)	(0.00036)
γ_{-4}	-0.0031	-0.0032	0.00011
	(0.0044)	(0.0045)	(0.00037)
γ_{-5}	-0.0013	-0.0016	0.00026
	(0.0023)	(0.0022)	(0.00066)
R^2	0.070	0.072	0.022
Observations	462,706	462,706	462,706

Notes: This Table shows the results of estimating specification (2), which correlates the timing of VAT changes with the underlying economic conditions leading up to the VAT change which include tax revenue (α), industry GDP (β) and the unemployment rate (γ). The first column uses as an outcome variable an indicator variable for VAT changes, the second one uses an indicator variable for VAT increases and the third one an indicator variable for VAT decreases. We regress these outcome variables on the log of tax revenue, industry turnover and unemployment rate in the twelve months leading up to the reform.

Table D.16: Pass-Through Estimates: Matched Sample (Probit)

	With Trimming		Without Trimming	
	$\Delta \log$ Price		$\Delta \log$ Price	
	Increase	Decrease	Increase	Decrease
β_0	0.37	-0.046	0.30	-0.039
	(0.071)	(0.043)	(0.060)	(0.042)
β_{+1}	0.021	0.025	0.020	0.025
	(0.019)	(0.017)	(0.019)	(0.017)
β_{-2}	0.031	0.026	0.030	0.026
	(0.019)	(0.015)	(0.019)	(0.015)
β_{+2}	0.021	-0.044	0.020	-0.044
	(0.027)	(0.021)	(0.027)	(0.021)
β_{-3}	0.016	-0.0050	0.015	-0.0050
	(0.016)	(0.028)	(0.016)	(0.028)
β_{+3}	-0.042	-0.0046	-0.042	-0.0046
	(0.018)	(0.022)	(0.018)	(0.022)
β_{-4}	0.051	-0.020	0.049	-0.020
	(0.034)	(0.022)	(0.034)	(0.022)
β_{+4}	-0.0092	-0.0089	-0.0097	-0.0089
	(0.027)	(0.020)	(0.027)	(0.020)
Time FE	Yes	Yes	Yes	Yes
R^2	0.013	0.014	0.014	0.014
Observations	384,521	342,448	386,050	342,460

Notes: This table reports the pass-through estimates of VAT increases and decreases to prices estimated using specification (1) on matched reforms. This specification uses logit to estimate the propensity score. The first two columns implement the matching estimator on a trimmed sample using the approach outlined in Imbens (2015). The third and fourth columns report the estimates for the matched sample without trimming. VAT increases and decreases are matched on time, type of commodity (COICOP digit 2), size of VAT change, pre-reform VAT rate and GDP growth. The first and third column show the estimates for VAT increases and the second and fourth that for VAT decreases. Standard errors are clustered by month and are in parentheses. β_0 measures the pass-through of the VAT change at the time of the reform and β_i measures price changes i months away from the reform.

Table D.17: Pass-Through Estimates: Matched Sample With Convexity/Concavity Test

	With Trimming		Without Trimming	
	Δ log Price		Δ log Price	
	Increase	Decrease	Increase	Decrease
β_0	0.29	0.042	0.33	0.056
	(0.10)	(0.047)	(0.066)	(0.037)
β_{+1}	0.021	0.025	0.020	0.025
	(0.019)	(0.017)	(0.019)	(0.017)
β_{-2}	0.031	0.026	0.030	0.026
	(0.019)	(0.015)	(0.019)	(0.015)
β_{+2}	0.021	-0.044	0.020	-0.044
	(0.027)	(0.021)	(0.027)	(0.021)
β_{-3}	0.016	-0.0050	0.015	-0.0050
	(0.016)	(0.028)	(0.016)	(0.028)
β_{+3}	-0.042	-0.0047	-0.042	-0.0046
	(0.018)	(0.022)	(0.018)	(0.022)
β_{-4}	0.051	-0.020	0.049	-0.020
	(0.034)	(0.022)	(0.034)	(0.022)
β_{+4}	-0.0092	-0.0089	-0.0096	-0.0089
	(0.027)	(0.020)	(0.027)	(0.020)
Time FE	Yes	Yes	Yes	Yes
R^2	0.013	0.014	0.014	0.014
Observations	384,559	342,453	386,080	342,477

Notes: This table reports the pass-through estimates of VAT increases and decreases to prices estimated using specification (1) on matched reforms. The first two columns implement the matching estimator on a trimmed sample using the approach outlined in Imbens (2015). The third and fourth columns report the estimates for the matched sample without trimming. VAT increases and decreases are matched on time, type of commodity (COICOP digit 2), size of VAT change and GDP growth. In addition, we match the pre-increase VAT rate to the post-decrease VAT rate and the post-increase VAT rate to the pre-decrease VAT rate. The first and third column show the estimates for VAT increases and the second and fourth that for VAT decreases. Standard errors are clustered by month and are in parentheses. β_0 measures the pass-through of the VAT change at the time of the reform and β_i measures price changes i months away from the reform.

Table D.18: Pass-Through Estimates: Matched Sample With Convexity/Concavity Test Variables Only

	With Trimming		Without Trimming	
	Δ log Price		Δ log Price	
	Increase	Decrease	Increase	Decrease
β_0	0.36	0.093	0.39	0.11
	(0.046)	(0.071)	(0.048)	(0.072)
β_{+1}	0.020	0.025	0.020	0.025
	(0.019)	(0.017)	(0.019)	(0.017)
β_{-2}	0.030	0.026	0.030	0.026
	(0.019)	(0.015)	(0.019)	(0.015)
β_{+2}	0.020	-0.044	0.020	-0.044
	(0.027)	(0.021)	(0.027)	(0.021)
β_{-3}	0.015	-0.0050	0.015	-0.0050
	(0.016)	(0.028)	(0.016)	(0.028)
β_{+3}	-0.042	-0.0047	-0.042	-0.0047
	(0.018)	(0.022)	(0.018)	(0.022)
β_{-4}	0.049	-0.020	0.049	-0.020
	(0.034)	(0.022)	(0.034)	(0.022)
β_{+4}	-0.010	-0.0089	-0.010	-0.0089
	(0.027)	(0.020)	(0.027)	(0.020)
Time FE	Yes	Yes	Yes	Yes
R^2	0.014	0.014	0.014	0.014
Observations	385,727	342,444	386,503	342,449

Notes: This table reports the pass-through estimates of VAT increases and decreases to prices estimated using specification (1) on matched reforms. The first two columns implement the matching estimator on a trimmed sample using the approach outlined in Imbens (2015). The third and fourth columns report the estimates for the matched sample without trimming. We match the pre-increase VAT rate to the post-decrease VAT rate and the post-increase VAT rate to the pre-decrease VAT rate (we do not use any other matching variables). The first and third column show the estimates for VAT increases and the second and fourth that for VAT decreases. Standard errors are clustered by month and are in parentheses. β_0 measures the pass-through of the VAT change at the time of the reform and β_i measures price changes i months away from the reform.

Table D.19: Pass-Through Estimates: Matched Sample With Additional Economic Variables

	With Trimming		Without Trimming	
	Δ log Price		Δ log Price	
	Increase	Decrease	Increase	Decrease
β_0	0.30	0.091	0.30	0.11
	(0.093)	(0.12)	(0.060)	(0.079)
β_{+1}	0.021	0.025	0.020	0.025
	(0.019)	(0.017)	(0.019)	(0.017)
β_{-2}	0.031	0.026	0.030	0.026
	(0.019)	(0.015)	(0.019)	(0.015)
β_{+2}	0.021	-0.044	0.020	-0.044
	(0.027)	(0.021)	(0.027)	(0.021)
β_{-3}	0.016	-0.0050	0.015	-0.0050
	(0.016)	(0.028)	(0.016)	(0.028)
β_{+3}	-0.042	-0.0046	-0.042	-0.0046
	(0.018)	(0.022)	(0.018)	(0.022)
β_{-4}	0.051	-0.020	0.049	-0.020
	(0.034)	(0.022)	(0.034)	(0.022)
β_{+4}	-0.0093	-0.0089	-0.0097	-0.0089
	(0.027)	(0.020)	(0.027)	(0.020)
Time FE	Yes	Yes	Yes	Yes
R^2	0.013	0.014	0.014	0.014
Observations	384,367	342,440	386,050	342,454

Notes: This table reports the pass-through estimates of VAT increases and decreases to prices estimated using specification (1) on matched reforms. The first two columns implement the matching estimator on a trimmed sample using the approach outlined in Imbens (2015). The third and fourth columns report the estimates for the matched sample without trimming. VAT increases and decreases are matched on time, type of commodity (COICOP digit 2), size of VAT change, pre-reform VAT rate, unemployment rate and GDP growth. The first and third column show the estimates for VAT increases and the second and fourth that for VAT decreases. Standard errors are clustered by month and are in parentheses. β_0 measures the pass-through of the VAT change at the time of the reform and β_i measures price changes i months away from the reform.

Table D.20: Pass-Through Estimates: Matched Sample With Alternative Matching Algorithms

	Kernel		Radius		Local Linear Reg.	
	Δ log Price		Δ log Price		Δ log Price	
	Increase	Decrease	Increase	Decrease	Increase	Decrease
β_0	0.30	0.064	0.30	0.059	0.30	0.048
	(0.060)	(0.030)	(0.060)	(0.033)	(0.060)	(0.063)
β_{+1}	0.020	0.025	0.020	0.025	0.020	0.025
	(0.019)	(0.017)	(0.019)	(0.017)	(0.019)	(0.017)
β_{-2}	0.030	0.026	0.030	0.026	0.030	0.026
	(0.019)	(0.015)	(0.019)	(0.015)	(0.019)	(0.015)
β_{+2}	0.020	-0.044	0.020	-0.044	0.020	-0.044
	(0.027)	(0.021)	(0.027)	(0.021)	(0.027)	(0.021)
β_{-3}	0.015	-0.0050	0.015	-0.0050	0.015	-0.0050
	(0.016)	(0.028)	(0.016)	(0.028)	(0.016)	(0.028)
β_{+3}	-0.042	-0.0046	-0.042	-0.0046	-0.042	-0.0047
	(0.018)	(0.022)	(0.018)	(0.022)	(0.018)	(0.022)
β_{-4}	0.049	-0.020	0.049	-0.020	0.049	-0.020
	(0.034)	(0.022)	(0.034)	(0.022)	(0.034)	(0.022)
β_{+4}	-0.0097	-0.0089	-0.0097	-0.0089	-0.0097	-0.0089
	(0.027)	(0.020)	(0.027)	(0.020)	(0.027)	(0.020)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.014	0.014	0.014	0.014	0.014	0.014
Observations	386,051	342,790	386,051	342,716	386,051	342,458

Notes: This table reports the pass-through estimates of VAT increases and decreases to prices estimated using specification (1) on matched reforms, using kernel matching (col. 1 and 2), radius matching (col. 3 and 4) and local linear regression matching (col. 5 and 6). VAT increases and decreases are matched on time, type of commodity (COICOP digit 2), size of VAT change, pre-reform VAT rate and GDP growth. The first, third and fifth columns show the estimates for VAT increases and the second, fourth and sixth that for VAT decreases. Standard errors are clustered by month and are in parentheses. β_0 measures the pass-through of the VAT change at the time of the reform and β_i measures price changes i months away from the reform.

Table D.21: Normalized Differences Before and After Matching (Trimmed Sample)

	Normalized Differences	
	Full Sample	Trimmed Sample
Economic Conditions	0.43	-0.21
Pre-Reform VAT Rate	-1.06	0.00
Size of VAT Change	-0.32	-0.02
Recession Months	0.56	0.08
COICOP 1	-0.09	0.20
COICOP 2	-0.05	-0.03
COICOP 3	0.04	0.09
COICOP 4	-0.07	-0.04
COICOP 5	-0.04	0.12
COICOP 6	0.12	-0.12
COICOP 7	0.01	-0.11
COICOP 8	0.08	-0.11
COICOP 9	0.00	0.06
COICOP 10	-0.07	-0.04

Notes: This table reports the normalized differences for the variables we use to match VAT increases to VAT decreases using our main matching specification. The first column reports the normalized differences for the full sample of reforms and the second column for the trimmed sample of reforms.

Table D.22: Normalized Differences Before and After Matching (Convexity/Concavity Test)

	Normalized Differences	
	Full Sample	Trimmed Sample
Pre-increase post-decrease	-0.33	0.09
Pre-decrease post-increase	-0.60	0.03
Economic Conditions	0.43	0.10
Size of VAT Change	-0.32	-0.03
Recession Months	0.56	0.32
COICOP 1	-0.09	-0.08
COICOP 2	-0.05	0.00
COICOP 3	0.04	0.05
COICOP 4	-0.07	-0.02
COICOP 5	-0.04	0.00
COICOP 6	0.12	-0.05
COICOP 7	0.01	-0.03
COICOP 8	0.08	0.02
COICOP 9	0.00	0.07
COICOP 10	-0.07	0.01

Notes: This table reports the normalized differences for the variables we use to match VAT increases to VAT decreases using our main matching specification. The first column reports the normalized differences for the full sample of reforms and the second column for the trimmed sample of reforms. The pre-increase post-decrease and pre-decrease post-increase variables are variables added to address the concavity/convexity concern. Pre-increase post-decrease matches pre-increase VAT rates to post-decrease VAT rates and pre-decrease post-increase matches pre-decrease VAT rates to post-increase VAT rates.

Table D.23: Regression Adjustment of Matched Sample

	Δ log Price	
	Increase	Decrease
β_0	0.35	0.054
	(0.077)	(0.018)
β_{+1}	0.021	0.025
	(0.019)	(0.017)
β_{-2}	0.031	0.026
	(0.019)	(0.015)
β_{+2}	0.021	-0.044
	(0.027)	(0.021)
β_{-3}	0.016	-0.0051
	(0.016)	(0.028)
β_{+3}	-0.042	-0.0038
	(0.018)	(0.021)
β_{-4}	0.051	-0.020
	(0.034)	(0.022)
β_{+4}	-0.0096	-0.0090
	(0.027)	(0.020)
Time FE	Yes	Yes
R^2	0.013	0.014
Observations	384,412	342,770

Notes: The coefficients reported in this table indicate the pass-through of VAT increases and decreases to prices, estimated using the matched sample that results from the main matching specification and the regression adjustment outlined in Imbens (2015) which accounts for the remaining differences between the matched VAT increases and decreases that are not accounted for using matching and trimming. The first column shows the estimates for VAT increases and the second those for VAT decreases. Standard errors are clustered by month and are in parentheses. β_0 measures the pass-through of the VAT change at the time of the reform, and β_i measures price changes i months away from the reform.