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# 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 the 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 a standard incidence model, the direction of a tax change does not matter for incidence, as supply and demand elasticities are sufficient to determine the proportion of the tax borne by each agent. 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 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. 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.

First, we find that prices respond twice as much to the 14 p.p. VAT increase

[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.

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 the population 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 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 the main economic indicators at the country level, including GDP and 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 presumably could affect pass-through.

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] This paper contributes to our understanding of its effect on the economy, along with other papers such as Feldstein & Krugman (1990), Hines & Desai (2005), Naritomi (2018), Benedek et al. (2015), Benzarti & Carloni (Forthcoming), 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 of standard tax incidence analysis and the need to introduce dynamics when assessing the welfare effects of taxation. Incidence theory treats changes in tax rates symmetrically, and, as a consequence, incidence formulas are derived using increases and decreases in tax rates interchangeably. 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

[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.

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 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

[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) is another paper that considers asymmetric responses of prices to VAT reforms. It suffers from the same shortcomings as Carbonnier (2008) – namely, small sample size and small tax changes.

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: prices tend to show a timing asymmetry when responding to cuts in input costs and typically converge 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 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 also 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

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

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 reforms 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 final value of 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,

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

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 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]

[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.

[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.

**Datasets.** 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 for the decrease reform originating from 427 firms and 2,106 price observations for the increase reform 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 affect most commodities in the economy; (2) reduced VAT rate changes that affect commodities that are 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

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

[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.

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

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

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

# 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, the price levels are similar and 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 responses of prices to VAT rates persist over the long run – in this case, for at least 3.5 years. We also estimate the VAT increase and decrease pass-through 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 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 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 $\rho_i$

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

[19] Appendix Figure D.12 plots a version of Figure 3 that controls for inflation. The distributions are very similar but otherwise shifted to the left.

for the VAT decrease and increase, respectively, for all nine types of services combined. The pass-through distribution for VAT increases 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 insist on 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.

**Pass-Through 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

[20] See Appendix Figures D.13, D.14, D.15 and D.16.

[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.

$t = \{6, 12, 18, 24\}$ 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 few prices are changed as the excess mass of inert prices remains constant thereafter. 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. In addition, using the subset of firms for which prices were collected, we compare changes in the markup proxy with changes in prices and find that they are reasonably correlated.[23]

Figure 5a plots the coefficients from a regression of log profits on year dummies from 2000 to 2014 for hairdressers and beauty salons.[24] The graph shows that profits respond asymmetrically to the VAT changes: the VAT decrease results in 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

[23] See Appendix Figure D.17.

[24] 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.

affected by the reform.[25] 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.[26] This is especially puzzling because this sector is one in which barriers to entry are relatively low in the Finnish economy. In Finland, hairdressers face no particular institutional barriers to entry (they are not required to obtain a license or special training), and startup costs are relatively low.

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

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

[26] 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.

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 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.[29]

[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.

[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.

[29] Further, and using our original price data linked to the corporate tax data, we correlate an indicator variable equal to 1 if a firm does not pass-through the VAT cut with the log of profit margins and find a negative correlation with a coefficient of -0.0589 (0.0265). This suggests that firms with low profit margins are more likely to not pass-through the VAT cut and is consistent with Figures 6a and D.17.

# 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 three-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.[30]

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.

[30]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:

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

where $i$ denotes the commodity, $c$ the country and $t$ the month in which the price is observed, $\lambda_t$ time fixed effects, $p_{ict}$ the price, $\tau_{ict}$ the tax rate and $\epsilon_{ict}$ the error term. We control for a given country's nominal interest rate, GDP per capita and unemployment rate with $X_{ct}$. For each of $x_t = \{\log(p_{ict}), \log(1+\tau_{ict}), \lambda_t, X_{ct}, \epsilon_{ict}\}$, $\Delta x_t$ 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; $\beta_{-5}$, for example, estimates 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. The identification is obtained from within-country-specific commodity variation in VAT rates over time.

The results of the fixed effects regression are reported in Table 1. Columns (1) and (2) of Table 1 correspond to VAT increases and decreases, respectively. The first row of each regression (labeled $\beta_0$) corresponds to the pass-through of the VAT change to prices one month after the reform; it takes values between

0 and 1 and is equal to 0 for 0% pass-through and 1 for 100% pass-through. $\beta_{+i}$ corresponds to the response of prices to VAT changes $i$ months after the reform, while $\beta_{-i}$ corresponds to 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 of our main specification, including running specification (1) separately on reforms that are classified as temporary and permanent and also including country-commodity specific inflation controls and find similar levels of asymmetry.[31]

## 4.3 Endogeneity Concerns

This section addresses the concern that some of the VAT changes are likely to 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 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 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 corre-

[31] See Appendix Tables D.8 and D.9 for the regression estimates using temporary and permanent reforms, respectively. And see Appendix Table D.10 for the estimates including country-commodity inflation controls.

lated 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.

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.[32] Given these restrictions, we can expect the following three patterns, after 2006: (1) fewer VAT decreases, (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

[32]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.

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, is a paper that 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 GDP per capita and the unemployment rate in the 12 months leading to a given VAT reform and find no significant relationship between VAT reforms and these measures of economic activity. Formally, we run the following regression:

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

where $Reform_{ict}$ is equal to 1 if a VAT change occurs for commodity $i$ in country $c$ in month $t$ and 0 otherwise; $GDP_{ct}$ is the per capita GDP of country $c$ in month

$t$; $UR_{ct}$ is the unemployment rate of country $c$ in month $t$; $\lambda_t$ are time (in months) fixed effects; $\gamma_c$ are country fixed effects; $\pi_i$ are commodity fixed effects; and $\epsilon_{ict}$ is the error term (clustered by month). We run this regression on the full sample, on a subsample excluding VAT decreases and another 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.11 shows that there is no relationship between the timing of VAT changes – whether increases or decreases – and the underlying economic conditions leading up to the reforms. Using sector-specific measures of economic conditions instead of GDP, such as turnover by sector, yields similar results, as shown in Appendix Table D.12. 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 matching VAT increases to VAT decreases over several key characteristics in order to ensure that these characteristics are not driving the asymmetry. This matching approach allows us to compare similarly sized VAT reforms that occur in similar countries, for the same commodities and at times of similar economic conditions.

Our matching procedure follows three steps. First, we employ two different strategies to match VAT increases and decreases: (1) we compare similarly sized VAT changes that occur in the same *countries* for the same commodities at times of similar economic conditions, and (2) we compare similarly sized VAT changes that occur in the same *month and year* for the same commodities across countries. Therefore, in the first case, the matching focuses on within-country variation in

VAT changes, and the second approach uses across-country variation in reforms within time. We also include other key matching characteristics: the commodity considered, the size of the VAT change, measures of economic conditions (GDP growth, GDP per capita, unemployment rate and interest rate) and a dummy for whether the reform happened before or after the Great Recession. Second, we estimate propensity scores for all VAT increases and VAT decreases based on the key characteristics we consider and exclude VAT reforms that are not good matches, i.e. those with propensity scores that lie outside of the common support of the two distributions and those that are not matched by our matching algorithms. Third, we run our main specifications, using equation (1), on the subsample of reforms that are matched and are part of the common support to estimate the VAT pass-through in each case. When implementing this matching procedure, we need to make one additional important choice: the matching algorithm we implement. In a survey of the matching literature, Caliendo & Kopeinig (2008) suggest using a nearest neighbor matching algorithm, as they find it to be the simplest and most commonly used algorithm. For this reason, our baseline matching estimation uses a nearest neighbor matching algorithm, although we also use other common algorithms: radius matching, kernel matching, local linear regression matching and coarsened exact matching.

Depending on the specification and algorithm used, the proportion of reforms that are not found to be good matches and are dropped ranges from 28% to 51% of our sample. Columns (1) and (2) in Table 2 report the results of running specification (1) on the country matched subsample. Similarly, columns (3) and (4) in Table 2 report the results of running specification (1) on the time matched subsample. Both of these specifications, and all subsequent matching specifications we consider, report very similar levels of asymmetric pass-through to our main fixed effects specification with no matching. This mitigates our concern that the asymmetry is driven by inherently different characteristics of VAT increases versus decreases.

We also plot, in Appendix Figures D.9, D.10 and D.11 the distribution of all VAT increases and decreases by country, commodity, time (year and month), size of the VAT change, GDP growth rate and unemployment rate. These Figures provide a non-parametric way of assessing how much overlap there is along these

six dimensions. While the distributions of VAT increases and decreases are not identical, there are substantial areas of common support.

Finally, we implement several additional matching specifications by considering alternative sets of key matching characteristics. Appendix Section A provides an exhaustive list of the 20 different specifications we consider and the results they yield. Overall, all of these specifications generate very similar levels of asymmetric pass-through.

## 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; otherwise, the VAT changes would be masked by natural variation in prices and inflation. VAT reductions that would bring the rate below 15% are restricted by the European Commission to avoid VAT competition. In addition to the experimentation program described above, the European Commission approved an application to reclassify sit-down restaurants from the standard to the reduced VAT rate.[33] 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

[33]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.

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.[34] We find that the asymmetry persisted over 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 several explanations against the three empirical patterns we observe in our data: (1) *short-run asymmetry:* prices respond asymmetrically to VAT changes and the response is immediate (Figures 1 and 7a); (2) *long-run asymmetry:* prices do not converge to symmetry in the medium run (Figures 1, 8a, 8b and 8c); (3) *heterogeneous response:* firms respond heterogeneously to VAT changes (Figures 2 and 3) and this heterogeneity appears to be driven by differences in profit margins (Figure 6a).

## 5.1 Standard Imperfect and Perfect Competition Models

We assume a Generalized Cournot Model, which is attractive because it covers most standard symmetric imperfect competition models, as shown in Weyl & Fabinger (2013), as well as perfect competition and tacit collusion.[35]

We use the framework from Hamilton (1999), and assume that there are $n$ symmetric firms that produce a homogeneous good. Firm $i$ produces $y$ units of the good and the aggregate industry output is given by $Y = ny$. $P(Y)$ is the industry's inverse demand function and its derivative is negative and defined throughout its support. The profit function of firm $i$ is given by $\Pi = P(Y)y - c(y)$,

[34] 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 group countries can be found in Appendix Section C.

[35] All formal derivations and calibrations are detailed in Appendix Section D.1.

where $c(\cdot)$ is firm $i$'s cost function. We assume that marginal cost is constant.[36]

We denote by $\delta = \frac{dY}{dy}$ 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 $\delta = 0$ corresponding to perfect competition and $\delta = n$ to tacit collusion.

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

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

Since the marginal pass-through rate, $\rho(t)$, is defined for infinitesimally small tax changes, marginal pass-through rates can never be asymmetric, by definition. However, because elasticities are different along convex demand functions, larger tax changes could generate some degree of asymmetric pass-through. For this reason, we focus on the average pass-through rate, $\kappa(T)$. Intuitively, for average pass-through rates to be as asymmetric as we estimate in Sections 3 and 4, we need very different elasticities above and below a given tax rate. We show that this is unlikely to hold for most demand functions.

Formally, note that the average pass-through rates are asymmetric if $\kappa(T) > \kappa(-T)$. We show that this condition can only be satisfied with non-standard demand functions both in the cases of perfect and imperfect competition.

**Imperfect Competition.** As shown in Appendix Section D.1.2 and in Hamilton (1999), the marginal pass-through to prices under imperfect competition is given by:

[36] We make this simplifying assumption for two reasons: (1) it simplifies the derivations and makes the condition for asymmetric pass-through more transparent, (2) it allows us to focus on asymmetric pass-through generated by demand functions which are more commonly studied in the literature than supply functions. However, we address non-constant marginal cost functions in the perfect competition case, where this assumption does not add significant complexity to the derivations.

$$\rho(t) = \frac{n}{n + \delta(1-\epsilon)}, \tag{4}$$

where $\epsilon = -\frac{P_{YY}Y}{P_Y}$ is a measure of the convexity of demand and is a function of $t$.

In Appendix Section D.1.2, we show that the condition that the average pass-through is asymmetric, i.e., $\kappa(T) > \kappa(-T)$, rules out most commonly used demand functions including exponential and constant elasticity demand functions, irrespective of what degree of competition, $\delta$, we assume. More generally, this condition rules out the most common class of demand functions, which is the one for which consumer valuations are drawn from Generalized Pareto Distributions (GPD), as shown in Ausubel et al. (2014). Therefore, this implies that either (1) standard imperfect competition models cannot rationalize our asymmetric pass-through results, or (2) most standard demand functions used in economics are an inaccurate description of consumer behavior.[37]

**Perfect Competition.** In the case of perfect competition, the standard formula for marginal pass-through is:

$$\rho = \frac{S'(\cdot)}{S'(\cdot) - D'(\cdot)}, \tag{5}$$

where $S(\cdot)$ and $D(\cdot)$ are the supply and demand functions, respectively.[38] Similarly to the imperfect competition case above, the condition for average pass-through to be asymmetric is $\kappa(T) > \kappa(-T)$.

While this condition rules out common demand functions in the case of imperfect competition, it is not as strong in the case of perfect competition. To assess the degree of asymmetric pass-through this generates in the perfect competition case, we consider commonly used demand and supply functions and calibrate $\kappa(T) - \kappa(-T)$, in Appendix Section D.1.4. We find that demand elasticities in

[37] In Appendix Section D.1.2, we further consider the condition under which functions for which consumer valuations are *not* drawn from GPD can predict asymmetry. We show that this condition is relatively stringent as it imposes a strict relationship between the relative magnitudes of the first, second and third derivatives of the demand function.

[38] We re-derive this equation in Appendix Section D.1.

excess of 100 are needed to generate the asymmetric pass-through rates we observe using the European VAT changes. Large VAT changes, such as the Finnish hairdressing sector 14 percentage point changes, require smaller elasticities to generate asymmetric pass-through, but still much larger than commonly estimated. Our calibration shows that we need demand elasticities in excess of 15 to generate the degree of asymmetry we estimate in the Finnish hairdressing case. This is inconsistent with (1) commonly estimated demand elasticities, such as in DellaVigna & Gentzkow (2017) where their demand elasticities fall between two and three and (2) the fact that previous research has estimated an elasticity of 0.2 in the case of Finnish hairdressing services, as shown in Kosonen (2015). We also show, in Appendix Section D.1.4, that commonly used supply functions predict very small levels of asymmetric pass-through.

## 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 it always justifies bearing 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, sug-

gesting 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 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

[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.

pass-through of VATs of equal or larger welfare implications, which are left for future research to assess and investigate.

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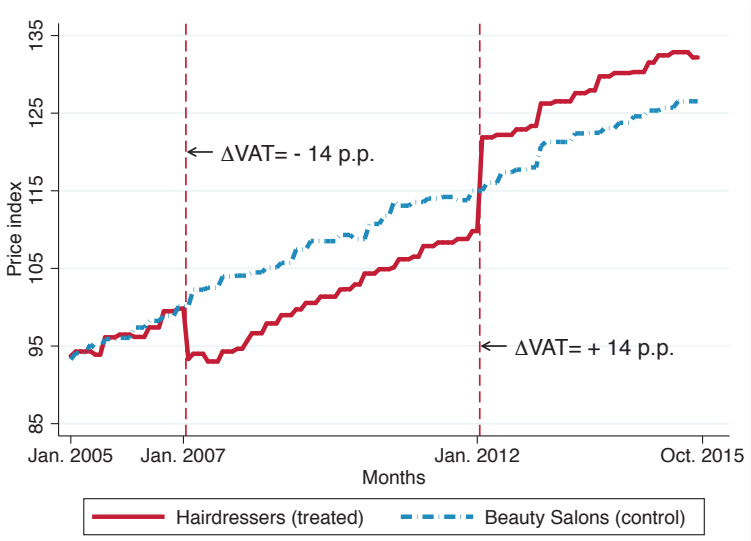
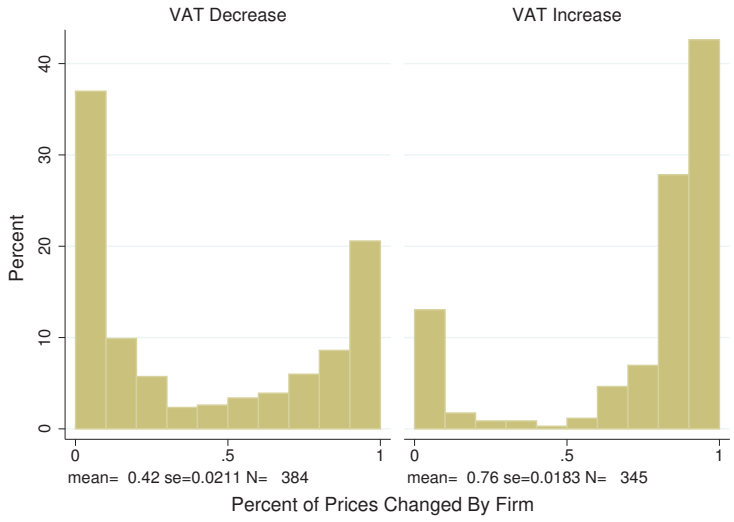
Figure 1: Finnish Hairdressing Sector VAT Reforms




*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.

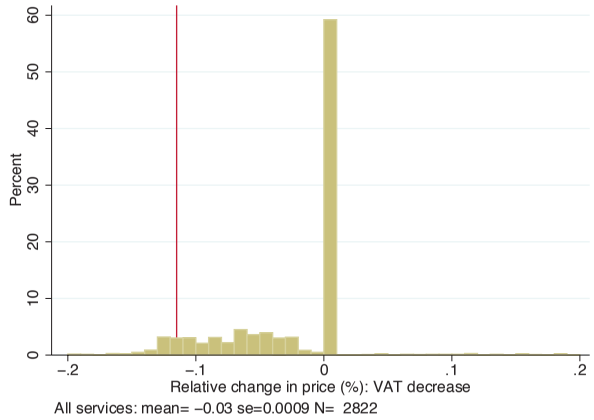
Figure 2: Proportion of Prices Changed by Hairdresser



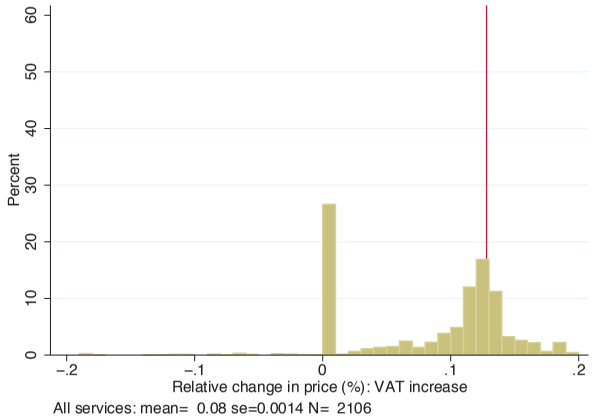

*Notes:* This figure plots the distribution of the within-hairdresser ratio of services for which prices were changed over total services offered following the VAT cut and hike.

Figure 3: Distributional Asymmetry

(a) VAT Decrease Pass-Through



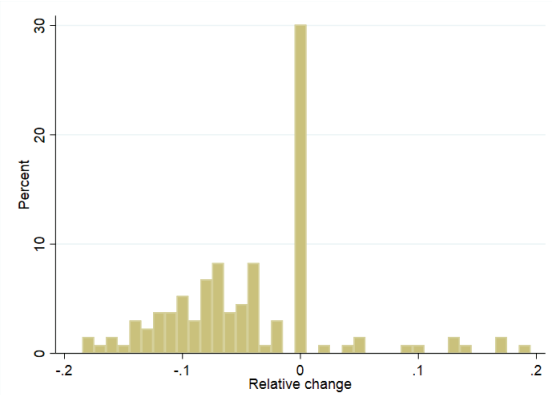

(b) VAT Increase Pass-Through



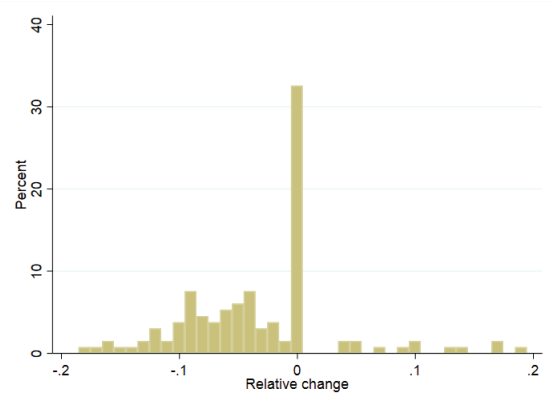

*Notes:* These figures compare the observed pass-through distributions for the VAT decrease (Figure 3a) to those of the VAT increase (Figure 3b) for Finnish hairdressing services. The red vertical line represents 100% pass-through.

Figure 4: Long Term Pass-Through of VAT Decrease

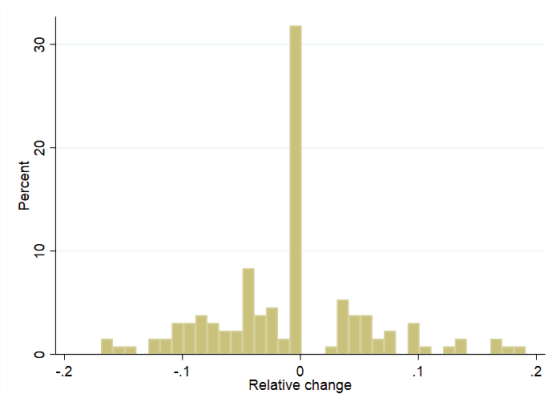
(a) VAT Decrease Pass-Through After 6 Months



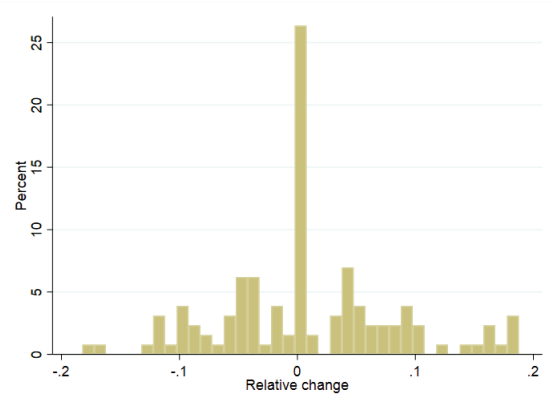

(b) VAT Decrease Pass-Through After 12 Months




(c) VAT Decrease Pass-Through After 18 Months

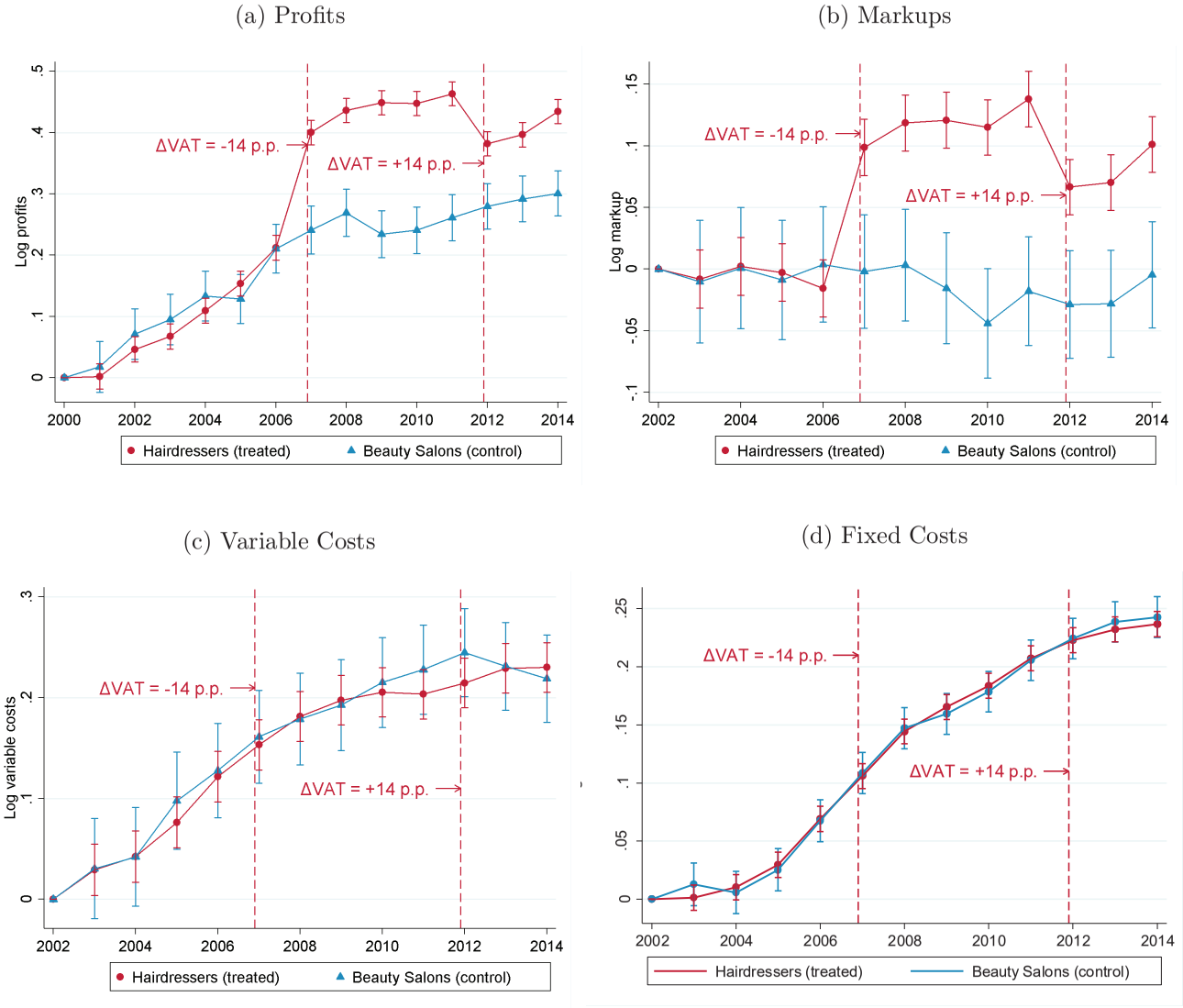



(d) VAT Decrease Pass-Through After 24 Months




*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.

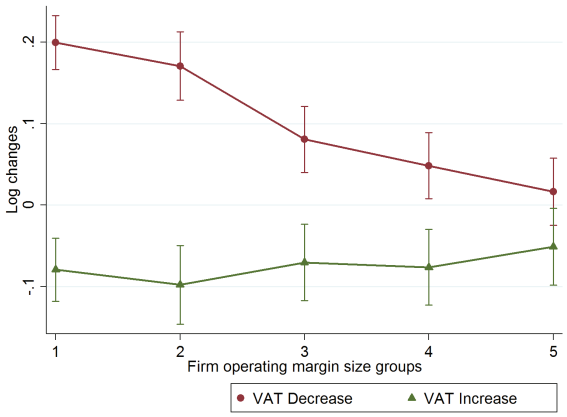
Figure 5: Profits, Markups, Variable and Fixed Costs



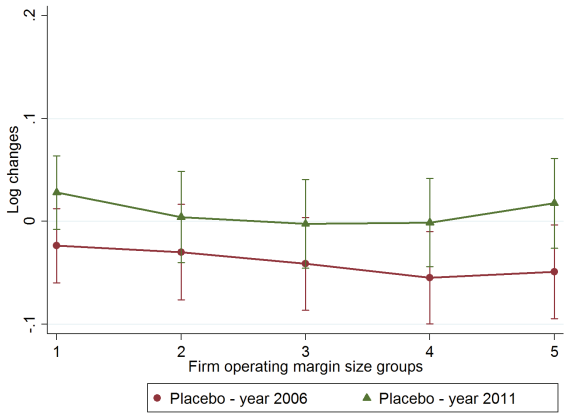

*Notes:* Figures 5a, 5b, 5c and 5d plot the coefficients from a regression of log profits, log markups, log variable costs and log fixed costs respectively, on year dummies for Finnish hairdressers and beauty salons.

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

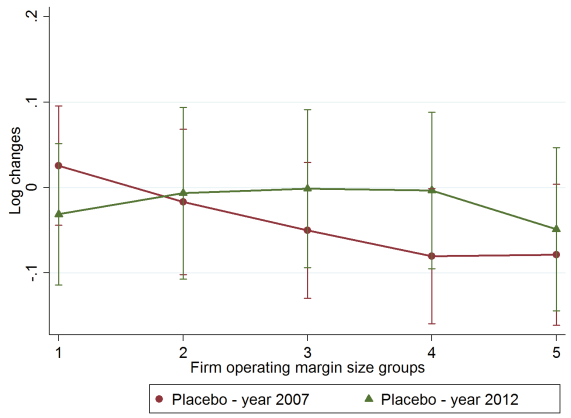
(a) Hairdressers in 2007 and 2012 (Reforms)




(b) Placebo: Hairdressers in 2006 and 2011



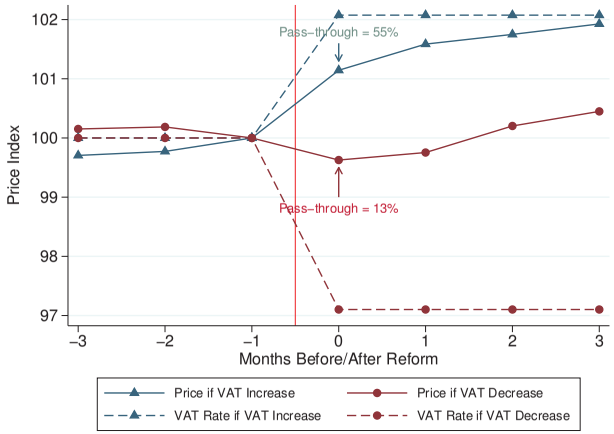

(c) Control: Finnish Beauty Salons in 2007 and 2012



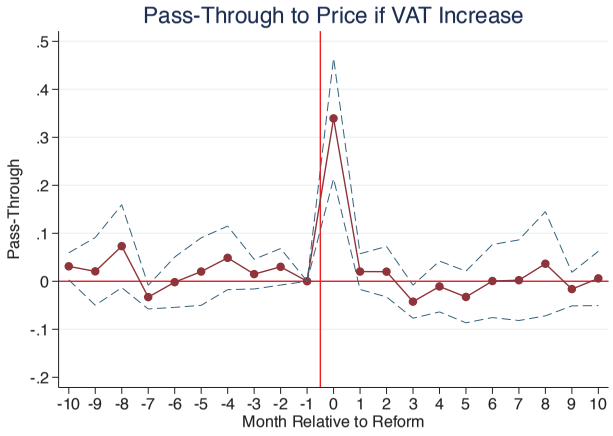

*Notes:* To generate these graphs, we break down the sample of firms into 5 quintiles with respect to profit margins (turnover minus deductible costs divided by turnover) using data from 2004 to 2006, with 1 being firms with the smallest profit margins. For each quintile, we plot changes in their markup 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

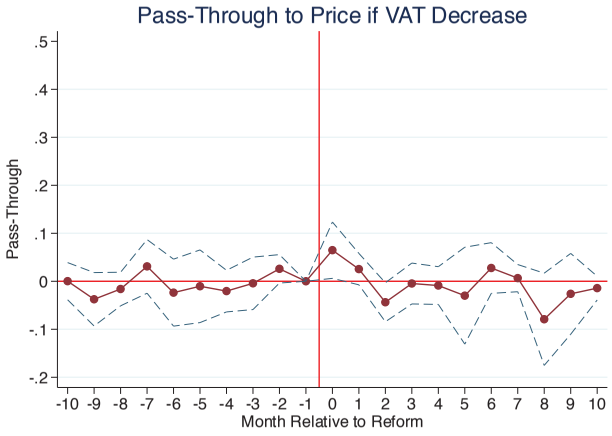
(a) Unconditional Means




(b) Fixed Effects Regression: Increase



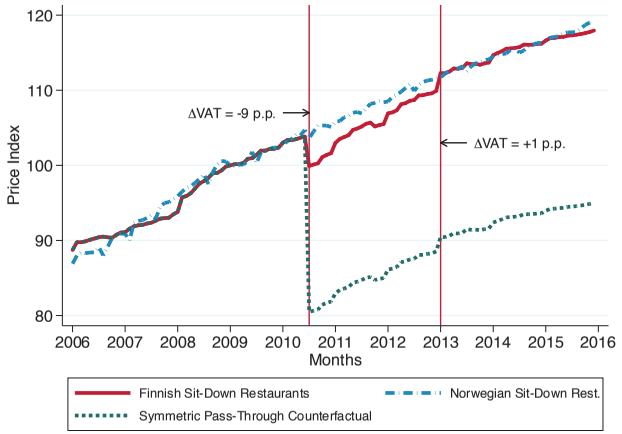

(c) Fixed Effects Regression: Decrease



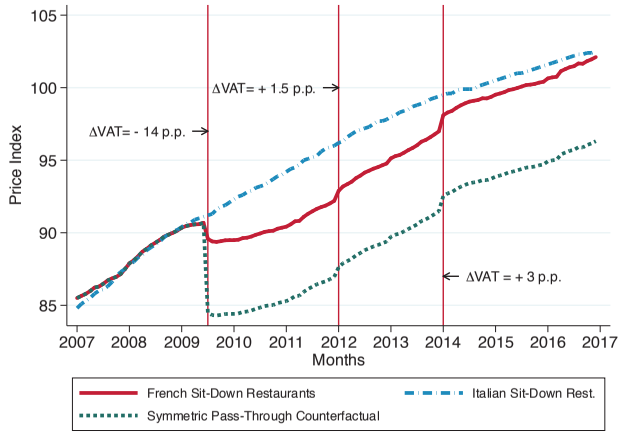

*Notes:* Figure 7a plots the response of the unconditional means of prices to VAT increases and decreases. Figure 7b and 7c plot the coefficients from the fixed effects regression (1) for VAT increases (7b) and VAT decreases (7c) on the full sample of reforms and includes ten-month leads and lags.

Figure 8: Long-term Persistence

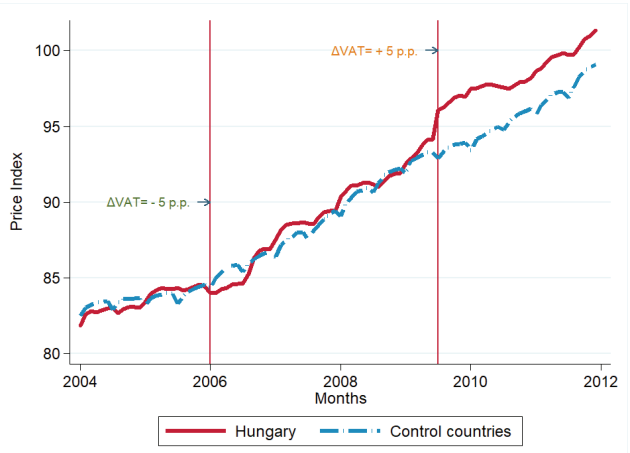
(a) Finnish Restaurants




(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)

| | $\Delta$ log Price | |
|---|---|---|
| | Increase | Decrease |
| $\beta_0$ | 0.34 | 0.065 |
| | (0.064) | (0.030) |
| $\beta_{+1}$ | 0.020 | 0.025 |
| | (0.019) | (0.017) |
| $\beta_{-2}$ | 0.030 | 0.026 |
| | (0.019) | (0.015) |
| $\beta_{+2}$ | 0.020 | -0.044 |
| | (0.027) | (0.021) |
| $\beta_{-3}$ | 0.015 | -0.0043 |
| | (0.016) | (0.028) |
| $\beta_{+3}$ | -0.043 | -0.0046 |
| | (0.018) | (0.022) |
| $\beta_{-4}$ | 0.049 | -0.020 |
| | (0.034) | (0.022) |
| $\beta_{+4}$ | -0.011 | -0.0089 |
| | (0.027) | (0.020) |
| Time FE | Yes | Yes |
| $R^2$ | 0.014 | 0.014 |
| Observations | 385,547 | 341,782 |

*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. 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. $\beta_0$ measures the pass-through of the VAT change at the time of the reform, and $\beta_i$ measures price changes $i$ months away from the reform.

Table 2: Pass-Through Estimates: Matched Sample

| | Country Specification $\Delta$ log Price | | Timing Specification $\Delta$ log Price | |
|---|---|---|---|---|
| | Increase | Decrease | Increase | Decrease |
| $\beta_0$ | 0.32 | -0.013 | 0.33 | 0.019 |
| | (0.073) | (0.025) | (0.066) | (0.038) |
| $\beta_{+1}$ | 0.020 | 0.025 | 0.020 | 0.025 |
| | (0.019) | (0.017) | (0.019) | (0.017) |
| $\beta_{-2}$ | 0.031 | 0.026 | 0.030 | 0.026 |
| | (0.019) | (0.015) | (0.019) | (0.015) |
| $\beta_{+2}$ | 0.020 | -0.044 | 0.020 | -0.044 |
| | (0.027) | (0.021) | (0.027) | (0.021) |
| $\beta_{-3}$ | 0.015 | -0.0050 | 0.015 | -0.0050 |
| | (0.016) | (0.028) | (0.016) | (0.028) |
| $\beta_{+3}$ | -0.042 | -0.0047 | -0.042 | -0.0046 |
| | (0.018) | (0.022) | (0.018) | (0.022) |
| $\beta_{-4}$ | 0.050 | -0.020 | 0.049 | -0.020 |
| | (0.034) | (0.022) | (0.034) | (0.022) |
| $\beta_{+4}$ | -0.0098 | -0.0089 | -0.0096 | -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 | 385,538 | 342,500 | 386,076 | 342,482 |

*Notes:* The coefficients reported in this table indicate the pass-through of VAT increases and decreases to prices estimated using specification (1) on matched reforms, using nearest neighbor matching. The country specification (first and second columns) matches on country, commodity, an indicator variable for being post-Great Recession, size of VAT change and GDP growth. The timing specification (third and fourth columns) matches on month and year, commodity, size of VAT change and GDP growth. The first and third columns 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. $\beta_0$ measures the pass-through of the VAT change at the time of the reform and $\beta_i$ measures price changes $i$ months away from the reform. Overall, 49% of the VAT changes in the country specification and 29% of the VAT changes in the time specification are dropped by the matching algorithm.

# 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.

**Nearest Neighbor Matching** We use a Nearest Neighbor Matching approach in Section 4.3, because it appears to be the most straightforward and used matching algorithm, as argued in the following two surveys of the matching literature: Caliendo & Kopeinig (2008) and Heinrich et al. (2010). The nearest neighbor matching algorithm proceeds in the following way: assume a set $I$ of VAT increases and a set $D$ of VAT decreases. Our goal is to match VAT increases to decreases on key characteristics (size of VAT change, economic conditions, country and commodity). Assume we are trying to match reform $i \in I$ to a given reform in $D$. Nearest neighbor matching proceeds in two steps. First, propensity scores for all reforms in $I$ and $D$ are estimated based on the key characteristics we are matching on. Second, for each $i \in I$, the algorithm will find the nearest reform in $D$, which is defined as the one that minimizes the distance in propensity scores. We implement this algorithm with replacement, which is the common way of doing it in the literature, in part because it does not suffer from issues raised by the order in which the reforms are matched (see Heinrich et al. (2010) and Caliendo & Kopeinig (2008)). The matching algorithm then provides us with a subset of matched reforms in $I$ and $D$. We then use this subset to estimate equation (1).

**Key Matching Characteristics:** Matching algorithms can be sensitive to the choice of matching variables, as shown, for example, by Heckman et al. (1997). Caliendo & Kopeinig (2008), in a review of the matching literature, recommend 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, in the same country and at the same time. This a possible concern, mainly because economic conditions could be different at different times, which could in turn affect the degree of pass-through differentially. This suggests two possible sets of key matching characteristics: (1) match on country, commodity, size of change and economic conditions (2) match on time, commodity, size of change and economic conditions. There is no ambiguity over how to define country, commodity and size of change as these are directly observable in the data. We use GDP per capita as a proxy for economic conditions, but also consider GDP growth, the unemployment rate and the interest rate. While we run a specification that includes all of these economic variables, Bryson et al. (2002) warn against over-parametrization and, therefore, we only include GDP per capita in the main specification in Section 4.3. Overall, we run the nearest neighbor matching estimator, described above, using the following five specifications: (1) we match on country, commodity, size of reform, a dummy for being post-Great Recession and GDP per capita, (2) we match on country, commodity, size of reform, a dummy for being post-Great Recession and unemployment rate, (3) we match on country, commodity, size of reform, a dummy for being post-Great Recession and interest rate, (4) We match on country, commodity, size of reform, a dummy for being post-Great Recession GDP per capita, GDP growth, unemployment rate and interest rate (5) we use logit (instead of probit) to match on country, commodity, size of reform, a dummy for being post-Great Recession and GDP per capita. The results of these specifications are reported in Tables D.13, D.14, D.15, D.16 and D.17. All of these specifications generate very similar levels of asymmetric pass-through to our main fixed effects specification without matching, with a pass-through rate for VAT increases higher than 30% and a pass-through rate for VAT decreases lower than 5%.

**Alternative Matching Algorithms:** In addition to the nearest neighbor matching algorithm we implement above, we also use four alternative matching algorithms: coarsened exact matching, kernel matching, radius matching and local linear regression matching. Caliendo & Kopeinig (2008) and Heinrich et al. (2010) provide details on how each algorithm operates. We use these additional match-

ing algorithms because, in spite of nearest neighbor matching being the most common and simple algorithm, there does not seem to be a clear consensus on what algorithm is best as each has its own advantages in terms of bias reduction versus efficiency. Caliendo & Kopeinig (2008), for example, give the following advice regarding choice of matching algorithms: "Pragmatically, it seems sensible to try a number of approaches. Should they give similar results, the choice may be unimportant. Should results differ, further investigation may be needed in order to reveal more about the source of the disparity."

The results of the coarsened exact matching, kernel matching, radius matching and local linear regression matching are reported in Tables D.18, D.19, D.20 and D.21. All of these specifications yield very similar levels of asymmetric pass-through to our main fixed effects specification with no matching with a VAT increase pass-through rate higher than 30% and a VAT decrease pass-through rate lower than 7%

# 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 test the extent to which standard perfect and imperfect competition models can generate asymmetric pass-through. We use the framework of Hamilton (1999). For imperfect competition to predict some degree of asymmetry, one has to use demand functions that fall outside of the most commonly used class of demand functions in economics. Even then, strong assumptions regarding the first, second and third derivatives are needed in order to generate any degree of asymmetry. In the case of perfect competition, demand elasticities in excess of 100 are needed to rationalize our findings. Therefore, unless true demand elasticities are much larger than previously thought and the functional forms that are widely used are unrealistic, we cannot rationalize our finding of asymmetric pass-through with standard perfect or imperfect competition models.

### 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 restrict attention to symmetric equilibria, which implies that $\forall i$, $c_i(.) = c(.)$, $y_i = y$ and $Y = ny$. Therefore, $\forall i$, $\Pi_i = \Pi = P(Y)y - c(y)$.

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 $\delta = 0$ corresponding to perfect competition and $\delta = n$ to tacit collusion. Below, we allow $\delta$ to vary, in order to assess how the degree of competition affects the extent of asymmetry.

The first and second order conditions are given by:

$$\Pi_y = P + y\delta P_y - c_y = 0 \tag{6}$$

$$\Pi_{yy} = 2\delta P_y + y\delta^2 P_{yy} - c_{yy} < 0 \tag{7}$$

### D.1.2 Generalized Cournot Model

The Generalized Cournot Model corresponds to the case where $\delta \in (1, n)$.[41] For simplicity, we assume that marginal cost is constant and equal to $c > 0$.[42] To estimate the pass-through of taxes to prices, we introduce an ad-valorem tax $t$. The first order condition (6) becomes:

$$\Pi_y = P + y\delta P_y - c - t = 0 \tag{8}$$

Summing up condition (8) over all firms, we get:

$$nP + Y\delta P_Y - nc - nt = 0 \tag{9}$$

Denote by $\rho(t) = \frac{dP}{dt}$ the response of price to changes in the tax rate and notice that $\rho(t) = P_Y \frac{dY}{dt}$. We differentiate (9) with respect to the $t$ and get the following condition:

$$\rho(t) = \frac{n}{n + \delta(1 - \epsilon)} \tag{10}$$

where $\epsilon = -\frac{P_{YY}Y}{P_Y}$, is a measure of the curvature of the inverse demand function and is a function of $t$. $\rho_t$ is a measure of the marginal pass-through of a

[41] Weyl & Fabinger (2013) show that Generalized Cournot models cover most standard symmetric imperfect competition cases. In principle one can analyze more complex imperfect competition models where firms respond to each others' behavior in a heterogeneous manner. However, in the commodity tax literature, these more complex models are seldom used.

[42] Below, we show that asymmetric pass-through can be driven by the convexity of the market demand function. When marginal cost is not constant, similar arguments can be used to generate asymmetric pass-through.

small change in taxes. We assume that the demand function is weakly convex, i.e. $\epsilon \geq 0$, which is a standard assumption.[43]

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 $\kappa(T) = \frac{1}{T}\int_0^T \rho(t)dt$ 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 $\frac{d\rho_t}{dt}$ 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. Non-linearity in the demand/supply function can only generate asymmetric pass-through for sufficiently large tax changes. For a large enough $T$, pass-through is larger for increases than decreases if $\kappa(T) > \kappa(-T)$, i.e.,

$$\int_0^T [\rho(t) - \rho(-t)]\, dt > 0 \tag{11}$$

There are two possible cases under which this condition can be satisfied:

1. $\rho$ is non-monotonic but takes sufficiently large values for $t > 0$, such that inequality (11) is satisfied. If $\rho$ is non-monotonic, then equation (10) implies that $\epsilon$ would be non-monotonic as well. This requires a demand function with the property that its degree of convexity does not vary monotonically and yet it would be convex throughout.

2. $\rho$ is monotonic, in which case, for inequality (11) to be satisfied, $\frac{d\rho}{dt}$ needs to be positive. From equation (10), it follows that a necessary and sufficient condition for $\frac{d\rho}{dt} > 0$ is that $\frac{d\epsilon}{dt} > 0$.

Condition (1) rules out most demand functions in economics, as it is usual to use functions with non-monotonic convexity. Condition (2) rules out most commonly used demand functions including linear demand functions, but also exponential and constant elasticity demand functions which, according to Fabinger & Weyl (2018), is the most commonly used demand function. Condition (2) in

[43] Convexity is usually assumed because concavity leads, for example, to quantities demanded being capped even if prices tend to zero.

fact rules out an entire class of demand function, which are all demand functions where consumer valuations are drawn from Generalized Pareto Distributions, as shown in Ausubel et al. (2014). These are the most commonly used demand functions. For this reason, our results imply that, conditional on this standard imperfect competition model being accurate, this entire class of demand functions is inconsistent with our finding.

Even demand functions where consumer valuations are *not* drawn from Generalized Pareto Distributions do not necessarily generate larger pass-through for increases versus decreases. For this to happen, we need $\frac{d\epsilon}{dt} > 0$, i.e.:

$$\frac{d\epsilon}{dt} = \frac{dY}{dt}\frac{-P_{YYY}YP_Y - P_{YY}P_Y + P_{YY}^2 Y}{P_Y^2} > 0 \tag{12}$$

From this expression follows that the sign of $\frac{d\epsilon}{dt}$ depends on the sign of $-P_{YYY}YP_Y - P_{YY}P_Y + P_{YY}^2 Y$. This expression can either be positive or negative: its sign depends on the relative magnitudes of the first, second and third derivative of the demand function, as well as the magnitude of Y. Notice also that the degree of competition, $\delta$, while it affects pass-through, it does not affect the degree of asymmetry.

Overall, our finding of asymmetric pass-through rules out any demand function where consumer valuations are drawn from Generalized Pareto Distributions, which are the most commonly used demand functions in economics, and for the remaining ones imposes a condition that depends on a relationship between first, second and third derivatives of the demand function.

### D.1.3 Perfect Competition

Marginal pass-through under perfect competition is equal to $\rho = \frac{S'(\cdot)}{S'(\cdot)-D'(\cdot)}$ where $S$ and $D$ are supply and demand functions, respectively. Similarly to the imperfect competition case above, for pass-through to be asymmetric, the following quantity needs to be positive: $\int_0^T [\rho(t) - \rho(-t)]\, dt > 0$, which can also occur in one of two cases: (1) $\rho$ is non-monotonic, (2) $\rho$ is monotonic and $\frac{\partial \rho}{\partial t} > 0$. Similarly to the imperfect competition case, we focus on case (2), i.e., the monotonic $\rho$ case. Pass-through is asymmetric if $\int_0^T [\rho(t) - \rho(-t)]\, dt > 0$. Given that $\rho$ is

monotonic, a necessary condition is that $\frac{d\rho}{dt} > 0$.

$$\frac{d\rho}{dt} = \frac{S''(1-\rho)D' + D''\rho S'}{(S'-D')^2}. \tag{13}$$

We know that $S' \geq 0$, $D' \leq 0$. Also, $0 \leq \rho \leq 1$ which can be derived from $\rho = \frac{S'(\cdot)}{S'(\cdot)-D'(\cdot)}$. This implies that the sign of $\frac{d\rho}{dt}$ depends on sign of $S''$, which corresponds to the third derivative of the cost function, and of $D''$. We consider each possible combination of signs to determine the cases under which asymmetry can be generated.

- Cases that generate unambiguously positive asymmetric pass-through, i.e., cases where the increase pass-through is larger than the decrease pass-through:

  1. $S'' \leq 0$ and $D'' \geq 0$ implies that $S''(1-\rho)D' \geq 0$ and $D''\rho S' \geq 0$. Therefore, $\frac{d\rho}{dt} \geq 0$.

  We calibrate this case below to assess how much asymmetry it generates.

- Ambiguous cases where asymmetric pass-through can only be generated with functional forms that rely on specific relationship between the first and second derivative of the demand and supply functions:

  1. $S'' < 0$ and $D'' < 0$ implies that $S''(1-\rho)D' \geq 0$ and $D''\rho S' \leq 0$. Therefore, the sign of $\frac{d\rho}{dt}$ depends on the relative magnitudes of the first and second derivatives of $S$ and $D$.
  2. $S'' > 0$ and $D'' > 0$ implies that $S''(1-\rho)D' \leq 0$ and $D''\rho S' \geq 0$. Therefore, the sign of $\frac{d\rho}{dt}$ depends on the relative magnitudes of the first and second derivatives of $S$ and $D$.

- Cases that generate unambiguously *negative* asymmetric pass-through, i.e. cases where the decrease pass-through is larger than the increase pass-through, which are inconsistent with our empirical evidence of *positive* asymmetric pass-through:

1. $S'' \geq 0$ and $D'' \leq 0$ implies that $S''(1-\rho)D' \leq 0$ and $D''\rho S' \leq 0$. Therefore, $\frac{d\rho}{dt} \leq 0$.

### D.1.4 Calibration

In this section, we calibrate the cases that unambiguously generate asymmetric pass-through in the case of perfect competition.[44] We do not consider the ambiguous cases for the following two reasons: (1) some ambiguous cases require concave demand functions, which are not usually used in economics; (2) the unambiguous cases are more likely to yield larger magnitudes of asymmetry and therefore constitute the best possible candidates for falsification tests.

**Convex Demand and Linear Supply.** This corresponds to the first case above, i.e. $D'' > 0$ and $S'' = 0$. To calibrate this, we assume a constant elasticity demand function, which corresponds to the following inverse demand function: $P(Y) = aY^{-b}$.[45] This functional form has the advantage of being commonly used (see, for example, Fabinger & Weyl (2018)), is tractable and is convex throughout its support. We discipline our calibration by choosing parameters $a$ and $b$ to match the pass-through estimate for the VAT increase. Since there are two parameters and only one identifying equation, we consider different combinations of $a$ and $b$. We assume constant marginal cost, since $S'' = 0$. We estimate the marginal cost $c$, using the cost data from Finnish hairdressers. With a CES market demand function, marginal pass-through is equal to:

$$\rho(t) = \frac{c}{c + \frac{1}{b}\left(\frac{p+t}{a}\right)^{-\frac{1+b}{b}}}$$

and therefore, the following quantity determines the magnitude and sign of the asymmetry:

$$\int_0^T \rho(t)dt + \int_{-T}^0 \rho(t)dt = \int_0^T \left[\rho(t) + \rho(-t)\right] dt$$

[44] We do not calibrate the imperfect competition case because it excludes the class of demand functions for which consumer valuations are drawn from Generalized Pareto Distributions, which are the most commonly used demand functions.

[45] The market demand function is equal to $D(p) = \left(\frac{p}{a}\right)^{-\frac{1}{b}}$.

which, when assuming a constant elasticity demand function, is equal to:

$$\Gamma(a,b,c,p,T) = \int_0^T \left[ \frac{c}{c + \frac{1}{b}\left(\frac{p+t}{a}\right)^{-\frac{1+b}{b}}} + \frac{c}{c + \frac{1}{b}\left(\frac{p-t}{a}\right)^{-\frac{1+b}{b}}} \right] dt$$

To estimate $\Gamma$, we proceed in the following way. First, we set $p = 100$ and choose $c$ so as to match the estimated markup in the case of the Finnish hairdressers. Second, we vary the demand elasticity, which is equal to $\frac{1}{b}$, and choose the corresponding $a$ to match our empirical estimate of VAT increase pass-through. We use these parameters to calculate $\Gamma$. We implement this approach separately to match (1) the Finnish hairdressing experiment estimates, i.e. with $T = 14$ and a pass-through rate of VAT increases of 80% (2) the pass-through estimates from the European evidence, i.e. $T = 3\%$ and a pass-through of VAT increases of 55%.

Table D.22 shows the results of this calibration for common levels of demand elasticities. The VAT increase pass-through is constant since we use it to estimate $a$ for given values of $b$. The VAT decrease pass-through is allowed to vary: because of the convexity of the market demand function, it is always smaller than the VAT increase pass-through, consistent with the derivations above. The curvature of the demand function predicts very little asymmetry in the case of the European evidence because the VAT changes are relatively small. For the Finnish evidence, because the VAT rate changes by 14 percentage points, the asymmetry generated by the curvature of the demand function is more substantial, although still far from our empirical estimates. As the elasticity grows, the generated asymmetry increases, and naturally, for very large values of this elasticity (in excess of 15), we can generate similar levels of asymmetry as the ones we estimate. While, price elasticities higher than 15 are in principle possible, they seem unlikely. DellaVigna & Gentzkow (2017), for example, estimate elasticities that range between 2 and 3. In our case, Kosonen (2015) estimates a demand elasticity of 0.2 for Finnish hairdressers.

Overall, this suggests that the curvature of the demand function in the case of perfect competition can only work for elasticities that are orders of magnitude higher than commonly estimated ones.

**Linear Demand and Concave Supply Functions.** This corresponds to the second case above, i.e. $D'' = 0$ and $S'' < 0$. Because of perfect competition, the supply function is equal to marginal cost, which corresponds to the first derivative of the cost function. Therefore, for the supply function to be concave, the third derivative of the cost function needs to be negative. This rules out any supply function derived using Cobb-Douglas production functions and more generally any Constant Elasticity of Substitution (CES) production functions. We prove these statements below:

1. Cobb-Douglas Production Functions:

   Assume a Cobb-Douglas production function with parameters $\alpha > 0$ and $\beta > 0$, the corresponding cost function is given by $C(w_1, w_2, q) = q^{\frac{1}{\alpha+\beta}}\theta\Phi(w_1, w_2)$, where $w_1$ and $w_2$ are the cost of labor and capital, $\theta = \left(\frac{\alpha}{\beta}\right)^{\frac{\beta}{\alpha+\beta}} + \left(\frac{\alpha}{\beta}\right)^{\frac{-\alpha}{\alpha+\beta}}$, which is positive, and $\Phi(w_1, w_2) = w_1^{\frac{\alpha}{\alpha+\beta}} w_2^{\frac{\beta}{\alpha+\beta}}$ which is also positive.

   The supply function is equal to the first derivative of the cost function, $p = \frac{1}{\alpha+\beta}Q^{\frac{1}{\alpha+\beta}-1}\theta\Phi(w_1, w_2)$ and is only defined as long as the second derivative of the cost function is positive, i.e. as long as $\alpha + \beta < 1$. This corresponds to a market supply function equal to $S(p) = N\left(\frac{(\alpha+\beta)p}{\theta\Phi(w_1,w_2)}\right)^{\frac{\alpha+\beta}{1-(\alpha+\beta)}}$, where $N$ is the number of firms and firms are assumed to be symmetric. To get asymmetric pass-through, in this case, we need $D''(\cdot) = 0$ and $S''(.) < 0$. The first derivative of the market supply function is given by $S'(p) = N\frac{(\alpha+\beta)^2}{(1-(\alpha+\beta))\theta\Phi(w_1,w_2)}\left(\frac{(\alpha+\beta)p}{\theta\Phi(w_1,w_2)}\right)^{\frac{\alpha+\beta}{1-(\alpha+\beta)}-1}$. We calibrate this case using the following parameters:

   - We set $w_1 = w_2 = 1$. This virtually makes no difference in the degree of asymmetry (or pass-through) generated.
   - We set $N = 100$ to simulate perfect competition. Higher values of $N$ generate pass-through levels that are closer to 1 for both increases and decreases but do not affect the degree of asymmetry.
   - We set $\alpha = \beta$ and vary $\alpha + \beta$ for values ranging from 0.1 to 0.9.
   - We set the change in tax rate to 14% to match the Finnish case and to 3% to match the European case.

Table D.23 summarizes our findings. Values of $\alpha+\beta < 0.5$ yield larger pass-through rates for VAT decreases relative to VAT increases, albeit with a very small difference. This case is therefore inconsistent with our empirical evidence. Values of $\alpha+\beta \geq 0.5$ yield larger pass-through for VAT increases than decreases. However, the differences in pass-through are negligible.

2. CES Production Functions:

   Assume a CES production function $F(K,L) = (\alpha_1 L^\rho + \alpha_2 K^\rho)^{1/\rho}$, where $\alpha_1 > 0$, $\alpha_2 > 0$ and $\rho < 1$ are parameters. It can be shown that the corresponding cost function is equal to

$$C(q) = q \left[ \frac{w \left(\frac{w}{\alpha_1}\right)^{\frac{1}{\rho-1}} + r \left(\frac{r}{\alpha_2}\right)^{\frac{1}{\rho-1}}}{\left(\alpha_1 \left(\frac{w}{\alpha_1}\right)^{\frac{\rho}{\rho-1}} + \alpha_2 \left(\frac{r}{\alpha_2}\right)^{\frac{\rho}{\rho-1}}\right)^{\frac{1}{\rho}}} \right] \tag{14}$$

   where $w$ is the the price of labor and $r$ the price of capital. From equation 14 follows that marginal cost is constant, and therefore, $S''(p) = 0$. This implies that asymmetric pass-through cannot be generated using CES production functions.

## 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.[46] 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.

The model we consider relies on the following assumption: firms face a positive cost $C$ from increasing prices but no cost from decreasing them.[47] As a

[46] These models are, in spirit, similar to Ball & Mankiw (1994) who use trend inflation and menu costs to generate downward price rigidity. Karadi & Reiff (2016) use a similar model to Ball & Mankiw (1994) and estimate it using two VAT changes in Hungary.

[47] The results carry through if we instead assume that the cost of increasing prices is greater

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 $\theta_t$ to their optimal price. At any given time $t$, firm $i$'s price dynamics are determined by the following equations:

$$p_t^i = \begin{cases} p_{t-1}^i + \Theta_{t-1}^i + \theta_t & \text{if } \Theta_{t-1}^i + \theta_t \leq 0, \\ p_{t-1}^i & \text{if } 0 \leq \Theta_{t-1}^i + \theta_t < C^i, \\ p_{t-1}^i + \Theta_{t-1}^i + \theta_t & \text{if } C^i \leq \Theta_t^i + \theta_t, \end{cases} \tag{15}$$

where $\Theta_{t-1}^i = p_{t-1}^{i*} - p_{t-1}^i$ is the stock of shocks $\theta$ 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 $\tau$. Denote by $\rho$ the incidence of the tax had there been no adjustment cost $C$ and as determined by the supply ($\epsilon_S$) and demand elasticities ($\epsilon_D$): $\rho = \frac{\epsilon_S}{\epsilon_S - \epsilon_D}$. The firm will pass through $\Theta_t^i + \rho\tau$ when it is greater than $C^i$. If, instead, the VAT decreases by $\tau$, 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 $\Theta_t^i$.

To simulate the price dynamics, we use equation (15) 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 $\theta_t$, which is also a random variable drawn from a distribution $G$. Figure D.28 shows the results of our simulation. Figure D.30a 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 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

than that of decreasing them.

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.30b and D.30d 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.

To corroborate these findings, we surveyed 187 restaurant customers in France. The customers were approached by our surveyor when exiting a mid-range sit-down restaurant in Paris. They were asked to rank the following situations as (1) very fair, (2) fair, (3) neutral, (4) unfair and (5) very unfair. We report the average ranking and the standard deviations:

1. A restaurant increases prices after a VAT increase. Average: 1.3; standard deviation: 0.65.

2. A restaurant does not increase prices after a VAT increase. Average: 2.5; standard deviation: 1.36.

3. A restaurant decreases prices after a VAT decrease. Average: 2.7; standard deviation: 1.36.

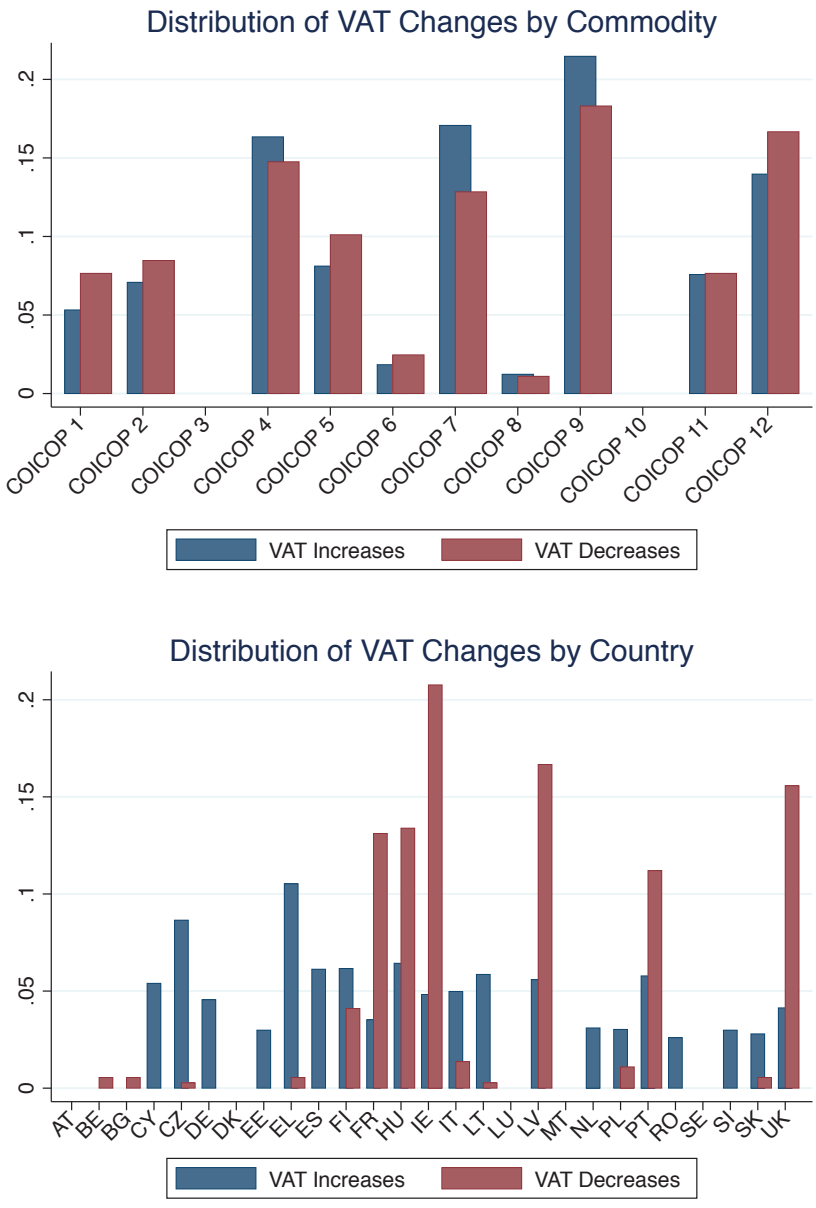
4. A restaurant does not decrease prices after a VAT decrease. Average: 3.1; standard deviation: 1.15.

5. Assume taxes and costs do not change. A restaurant increases prices to increase profits. Average: 4.2; standard deviation: 1.27.

6. Assume taxes and costs do not change. A restaurant decreases prices to increase profits. Average: 1.8; standard deviation: 0.99.

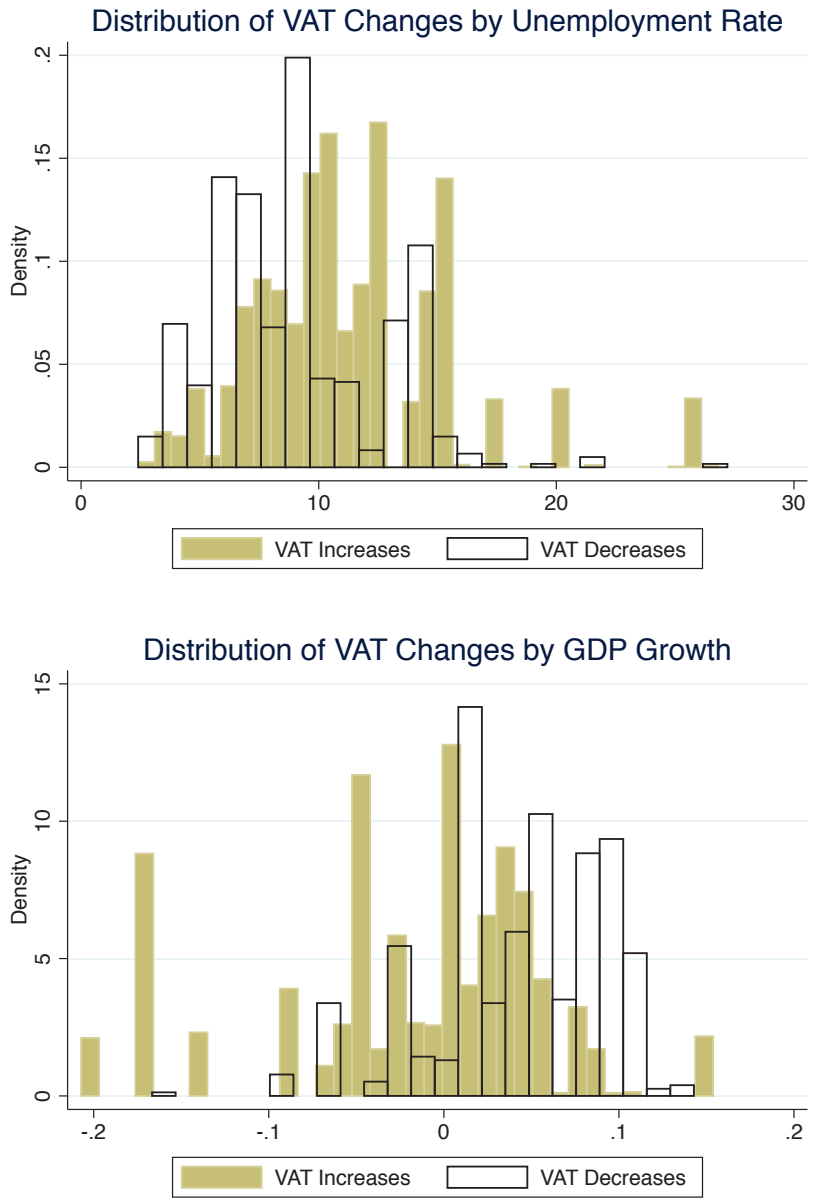
These results suggest that increasing prices to compensate for an increase in the VAT rate is perceived to be very fair, while keeping prices fixed following a VAT decrease is perceived to be neutral. This suggests that passing through VATs asymmetrically is not perceived to break any pricing norms. However, increasing prices to increase profits is heavily frowned upon as it is perceived to be the least fair scenario. If managers are taking fairness into account when setting prices, as suggested by Blinder et al. (1998) they could use these pricing norms to increase their markups without antagonizing their customer base.

Figure D.9: Summary Statistics: Country and Commodity



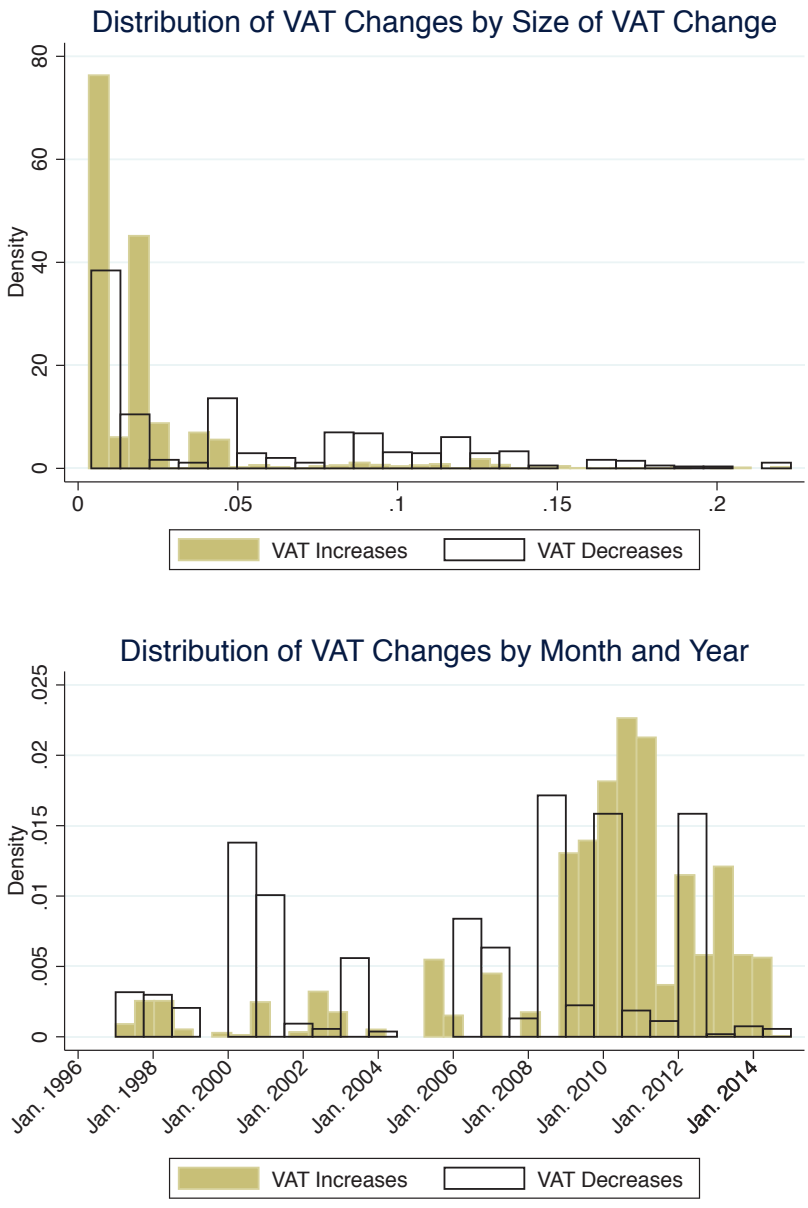

*Notes:* The first panel shows the distribution of all VAT increases and decreases by two-digit COICOP category. The second panel shows the distribution of all VAT increases and decreases by country. The description of the 2-digit COICOP categories is provided in Appendix Tables D.4 and D.5.

Figure D.10: Summary Statistics: Economic Conditions



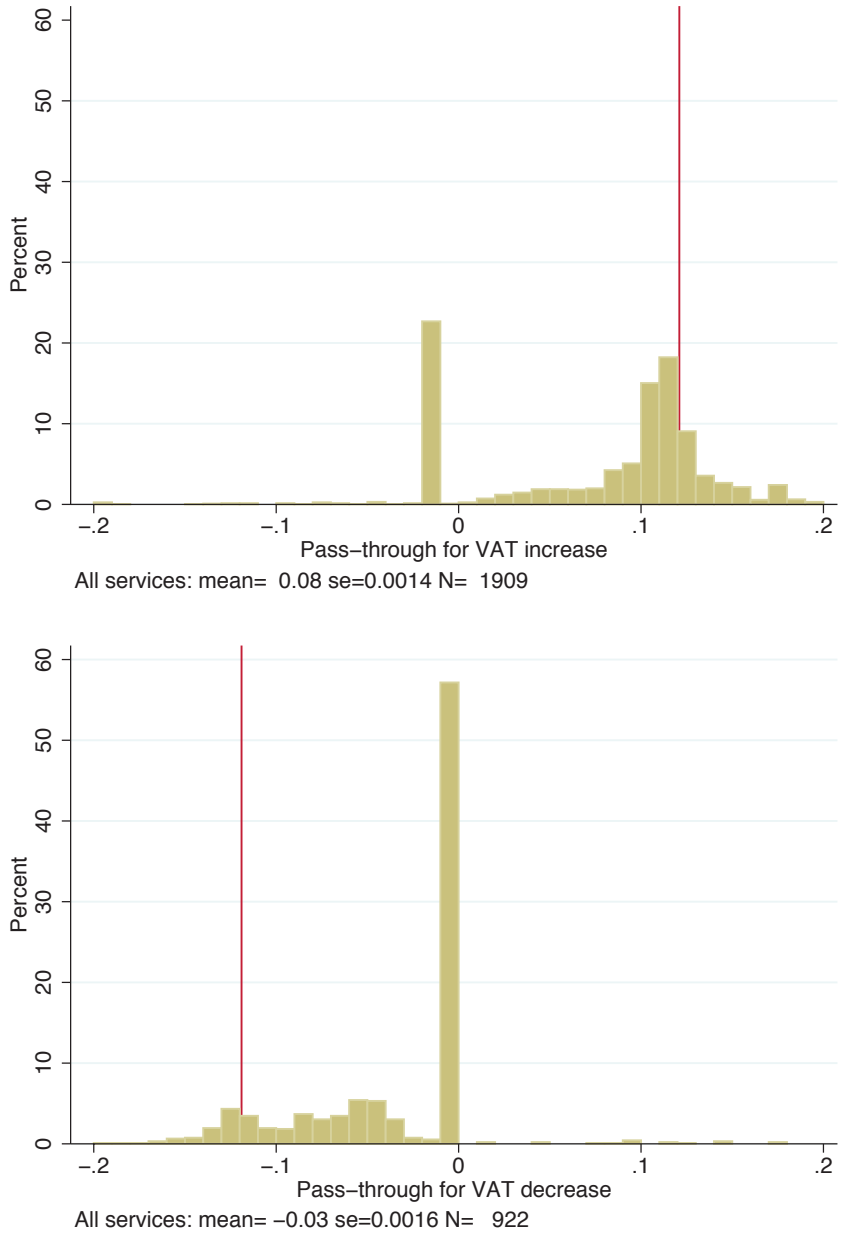

*Notes:* The first panel shows the distribution of all VAT increases and decreases by unemployment rate. The second panel shows the distribution of all VAT increases and decreases by GDP growth rates.

Figure D.11: Summary Statistics: Size and Timing



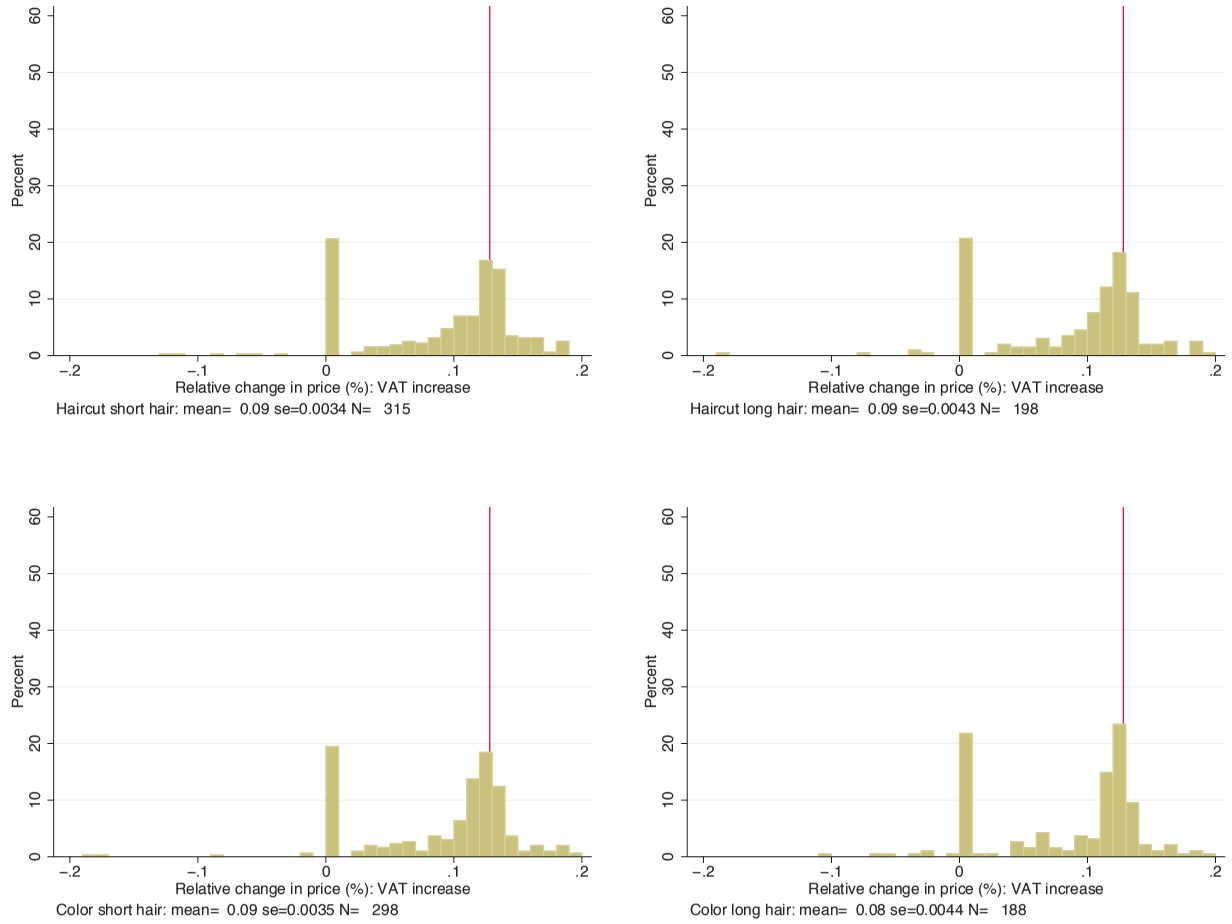

*Notes:* The first panel shows the distribution of all VAT increases and decreases by the size of the VAT change in absolute value. The second panel shows the distribution of all VAT increases and decreases by month and year.

Figure D.12: Finnish Hairdressing VAT Reforms Pass-Through Distributions With Controls For Inflation



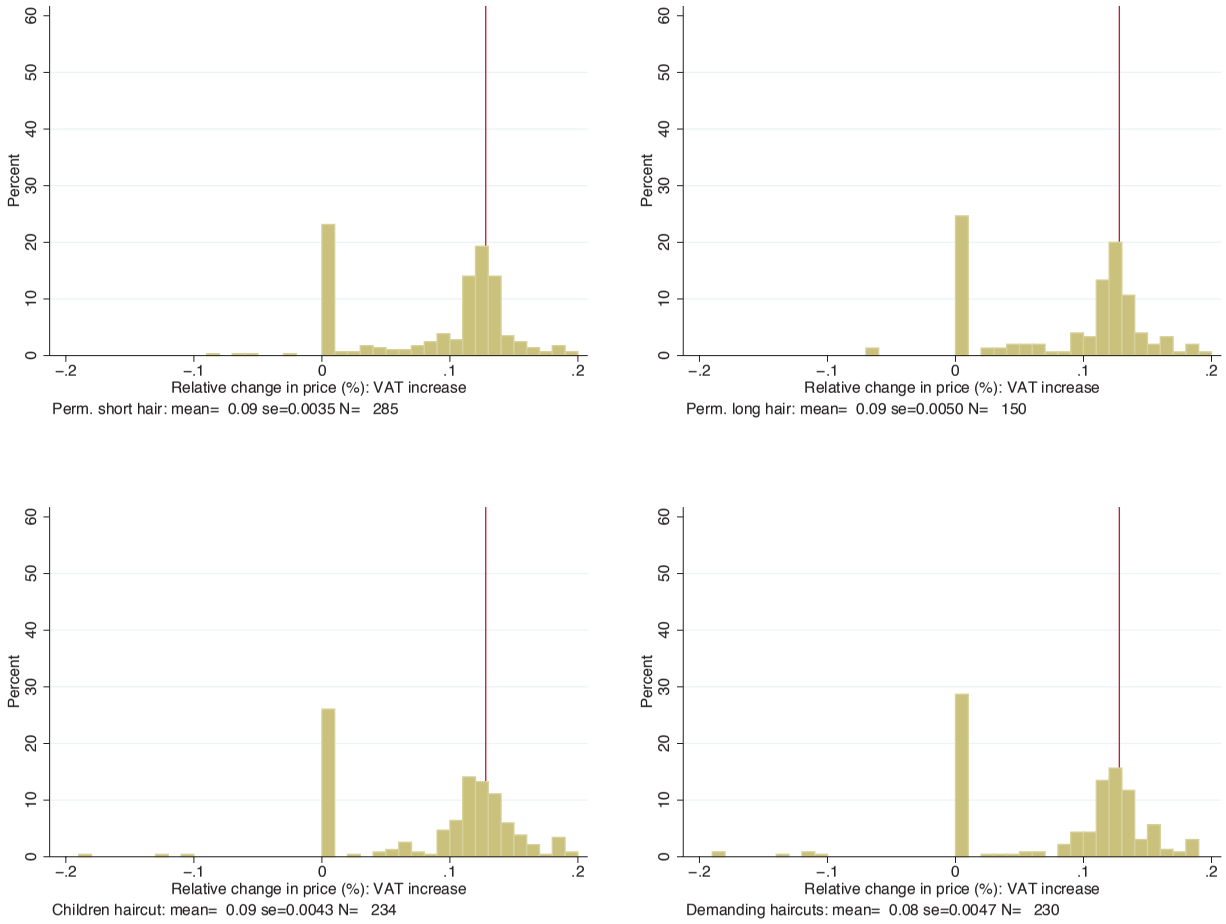

*Notes:* These Figures plot the pass-through distribution of the Finnish hairdressing sector VAT increase and decrease experiments (as in Figure 3), while controlling for inflation.

Figure D.13: Pass-Through Distribution By Service: VAT Increase



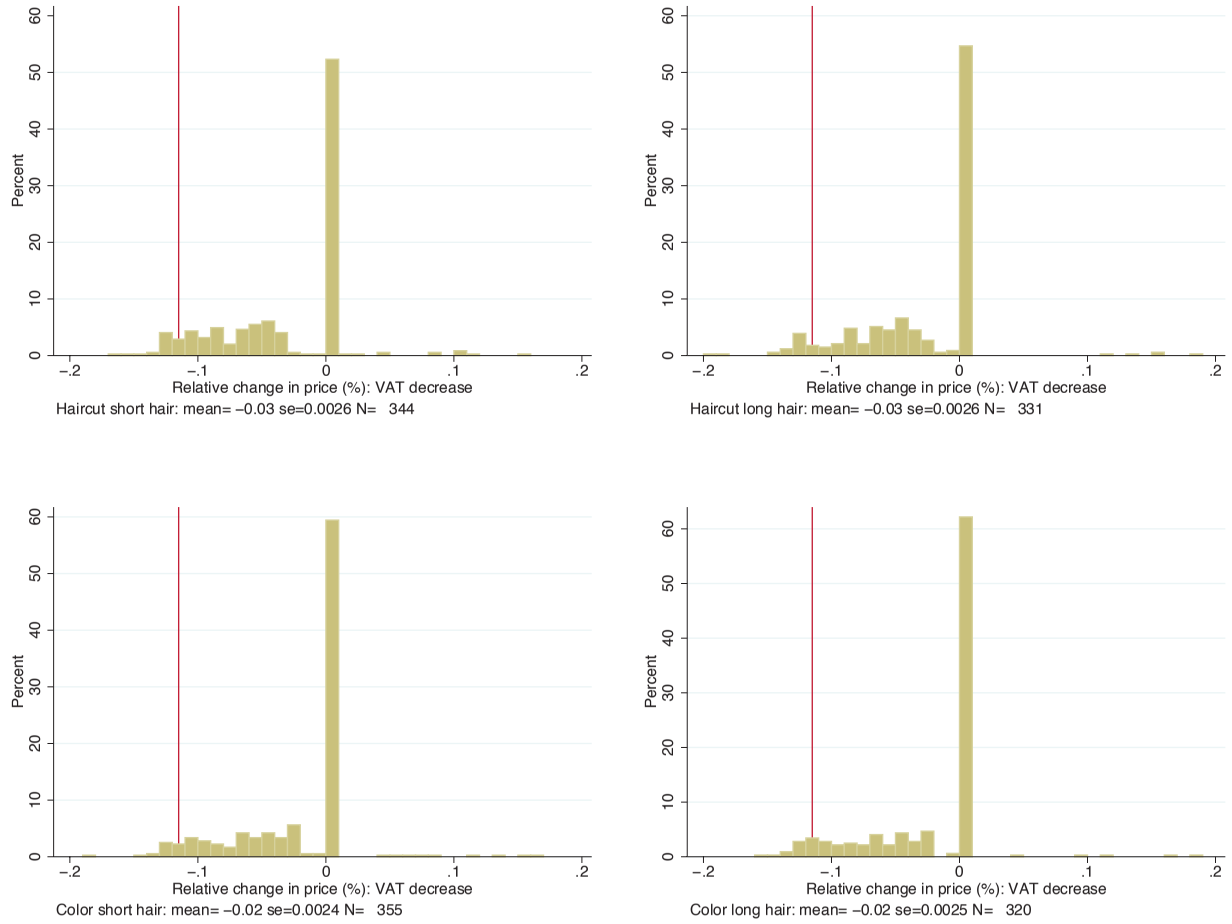

*Notes:* These figures are a disaggregated version of Figure 3. Each figure plots the distribution of pass-through following a VAT increase for each service offered by hairdressers.

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



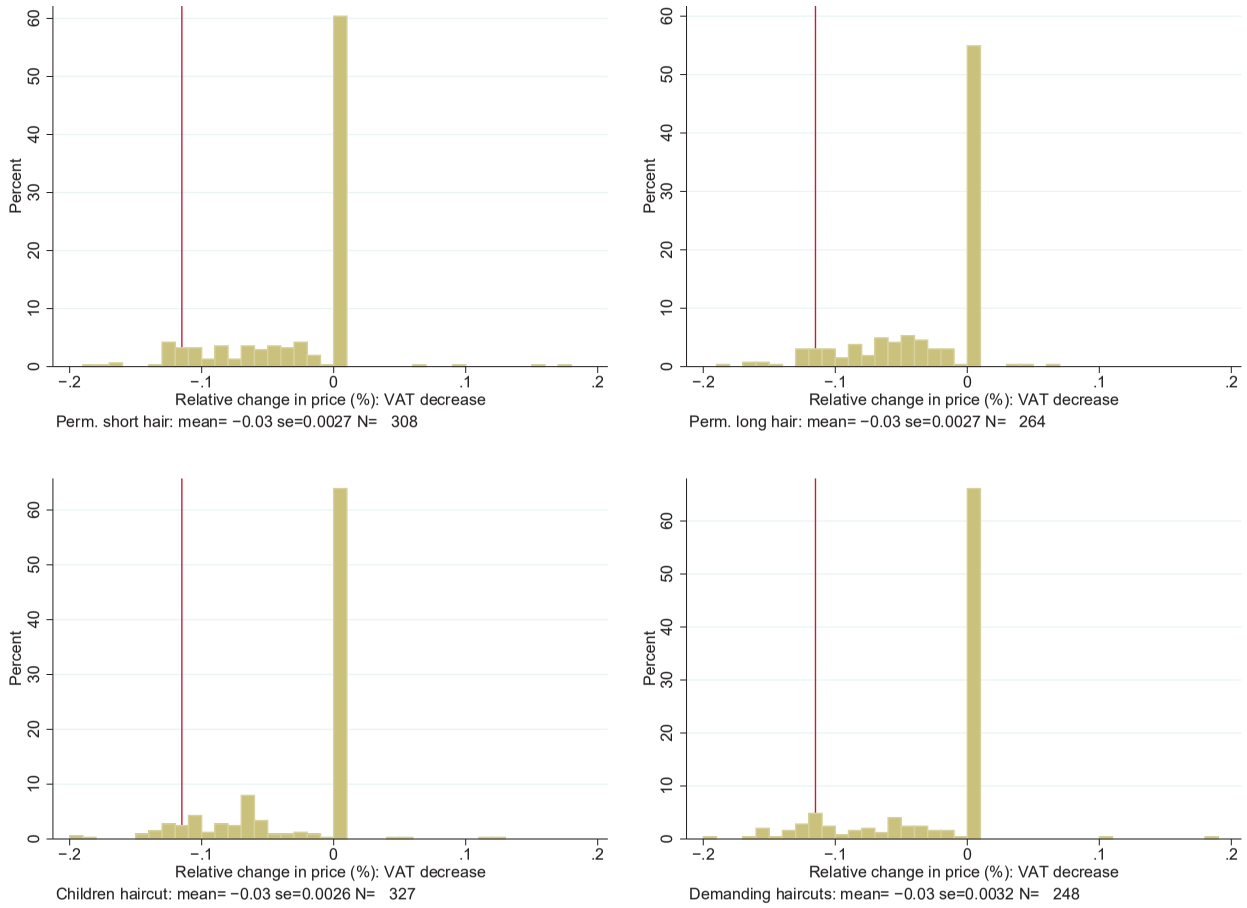

*Notes:* These figures are a disaggregated version of Figure 3. Each figure plots the distribution of pass-through following a VAT increase for each service offered by hairdressers.

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



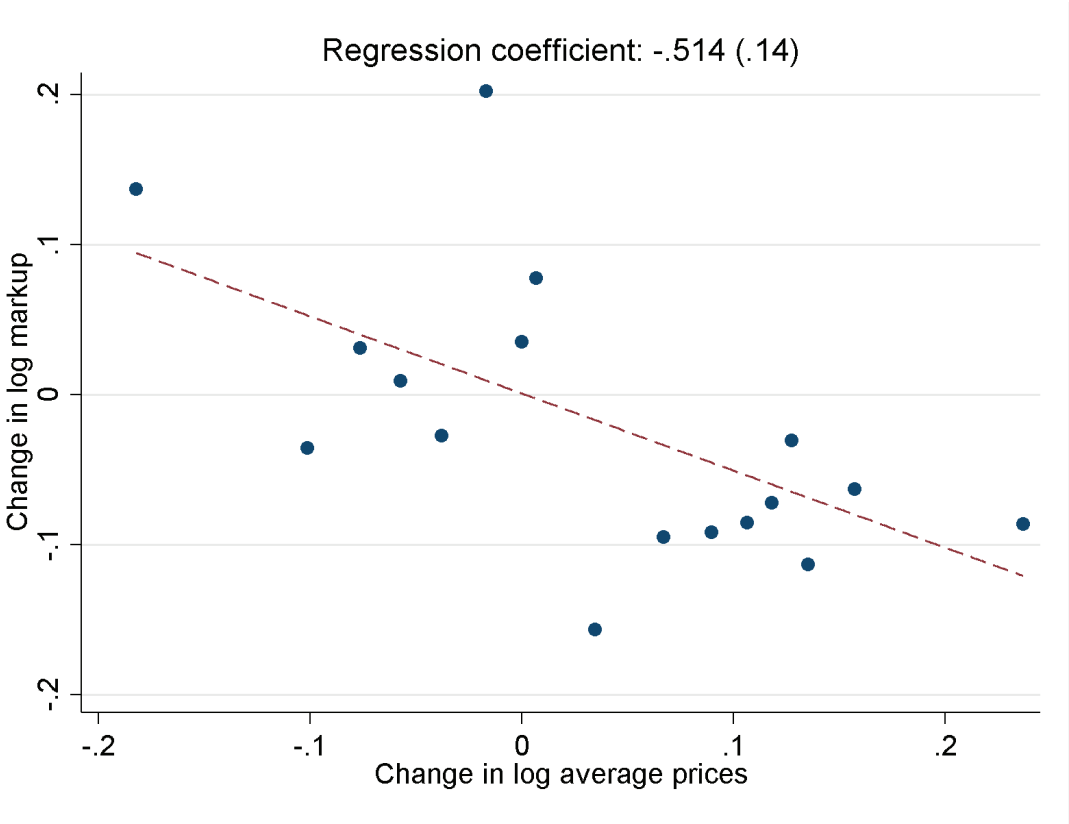

*Notes:* These figures are a disaggregated version of Figure 3. Each figure plots the distribution of pass-through following a VAT decrease for each service offered by hairdressers.

Figure D.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: Markup Changes and Price Changes

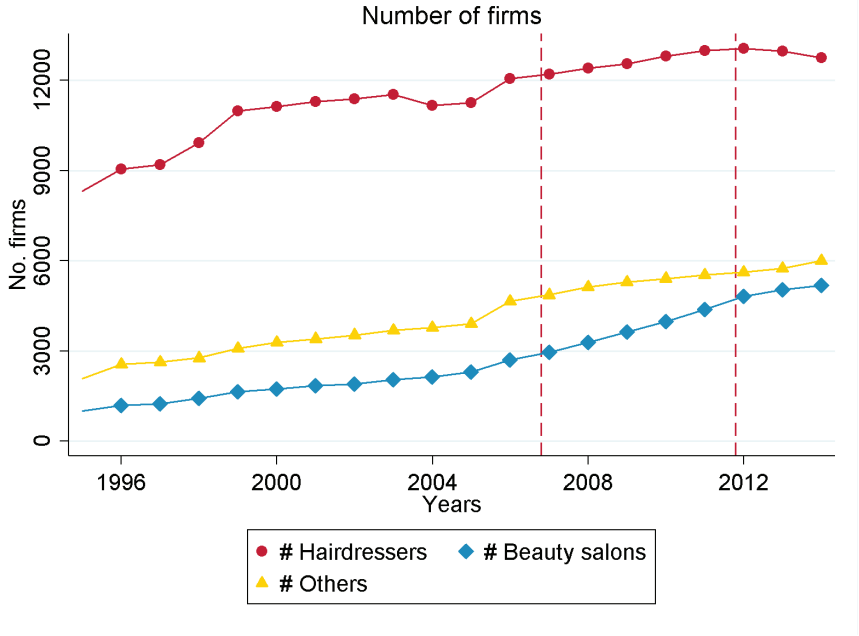



*Notes:* This figure presents a bin-scatter plot of changes in log markup versus changes in log average price using the linked price corporate tax data for Finnish hairdressers.

Figure D.18: Finnish Hairdressing Reforms: Investments

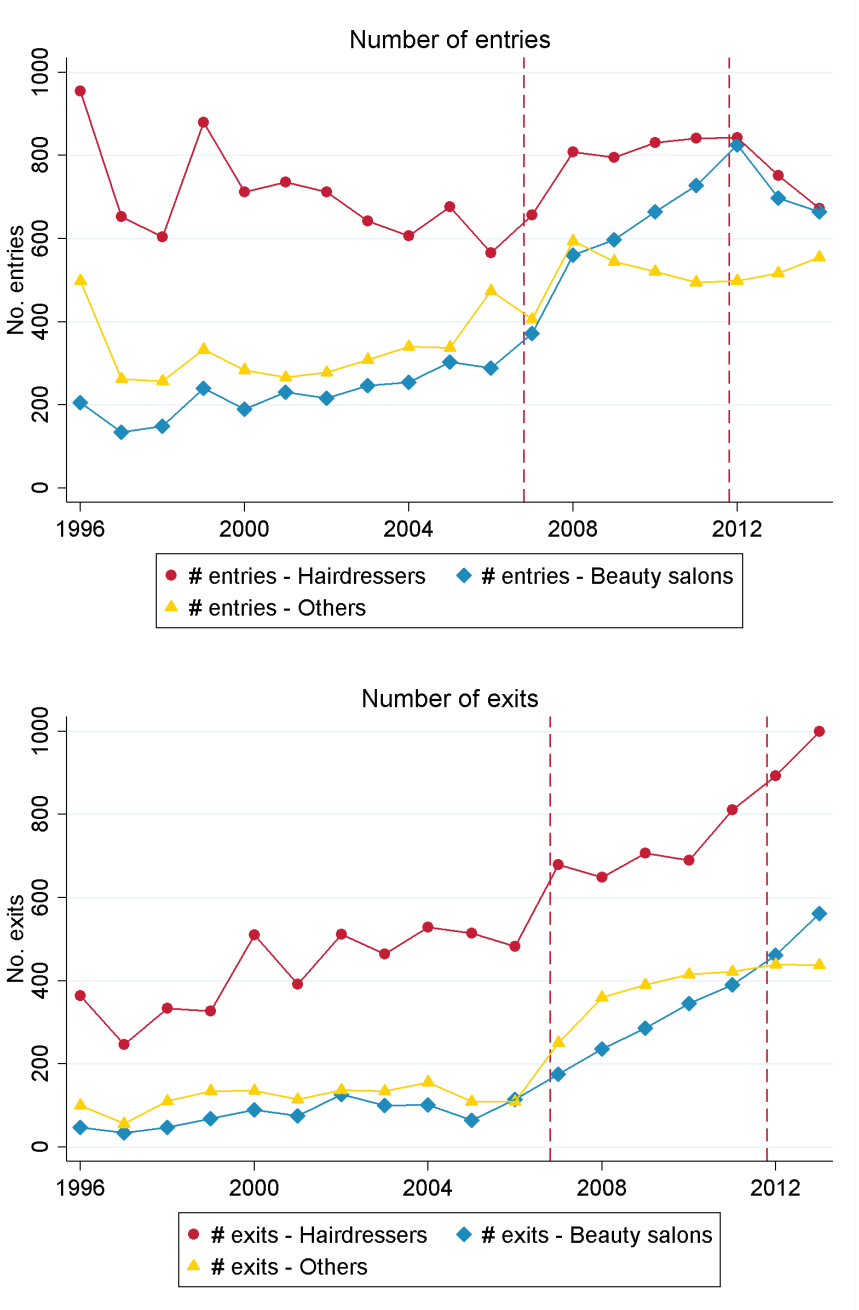

*Notes:* This Figure plots the response of investments to the Finnish VAT hairdressing reforms.

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.

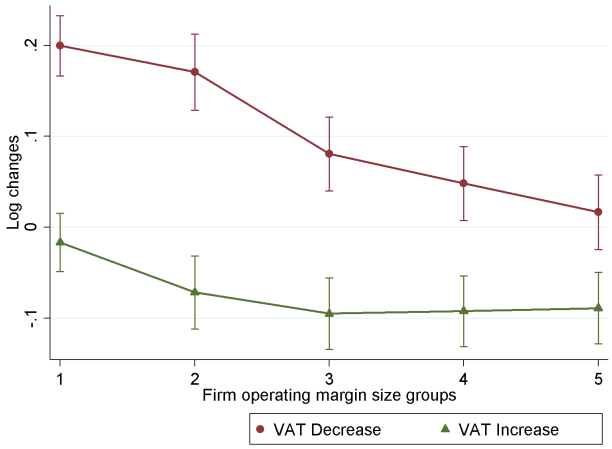
Figure D.20: Entry and Exit in Finnish Hairdressing Sector



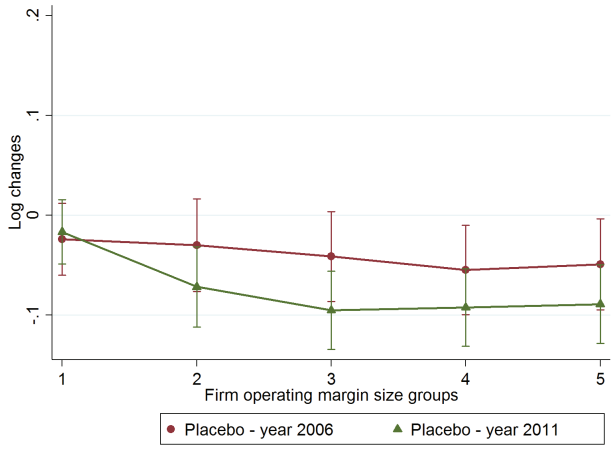

*Notes:* These figures use the administrative dataset containing information on the full population of Finnish hairdressers, beauty salons, massage parlors and physical therapists to plot the number of firms entering and exiting each sector over time. Others include entry and exit in the massage parlor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

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

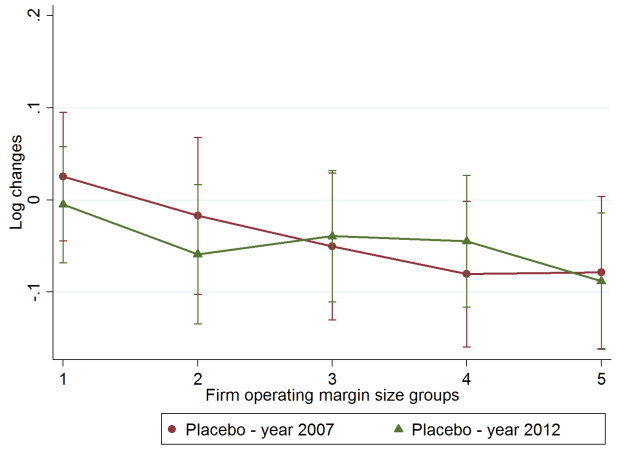
(a) Hairdressers in 2007 and 2012 (Reforms)




(b) Placebo 1: Hairdressers in 2006 and 2011

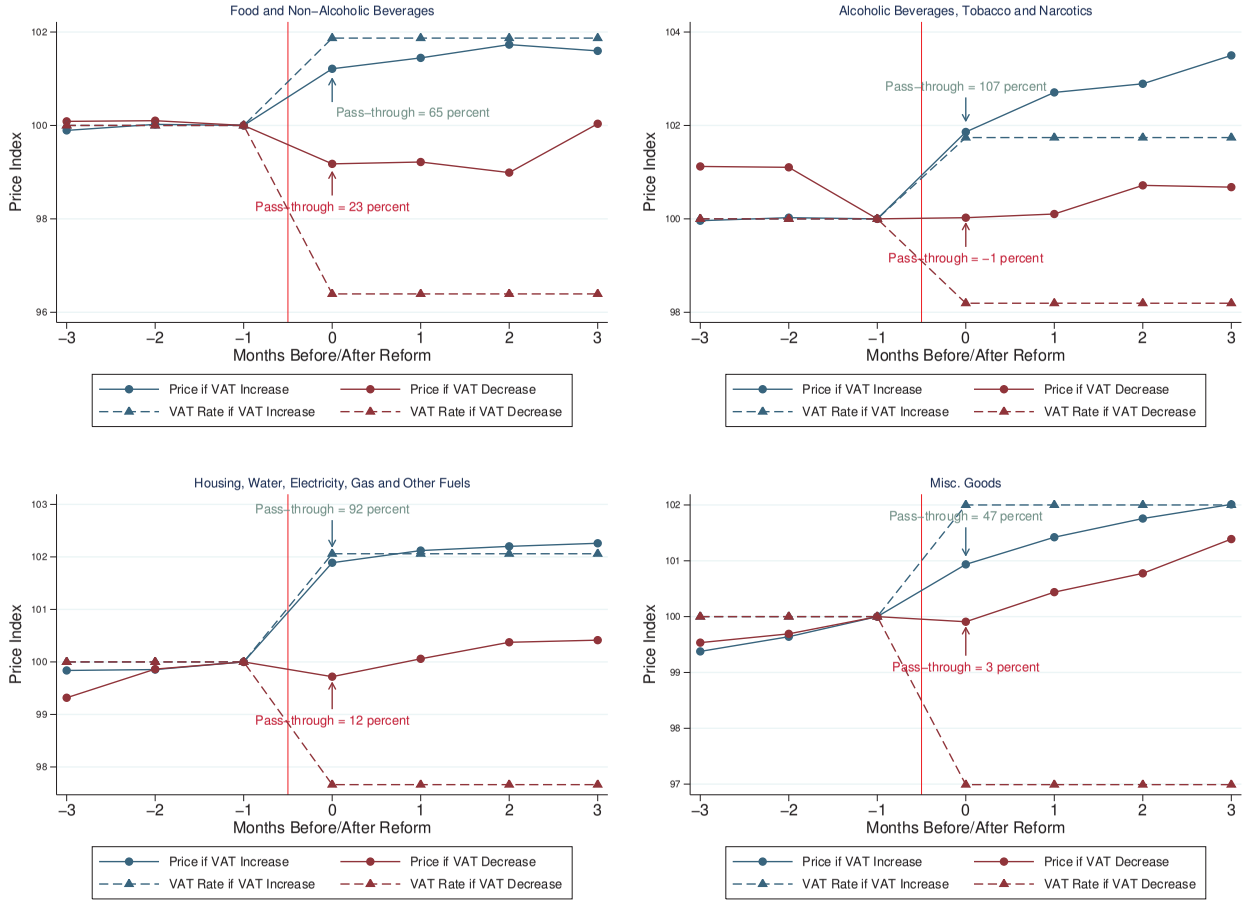



(c) Placebo 2: Finnish Beauty Salons in 2007 and 2012



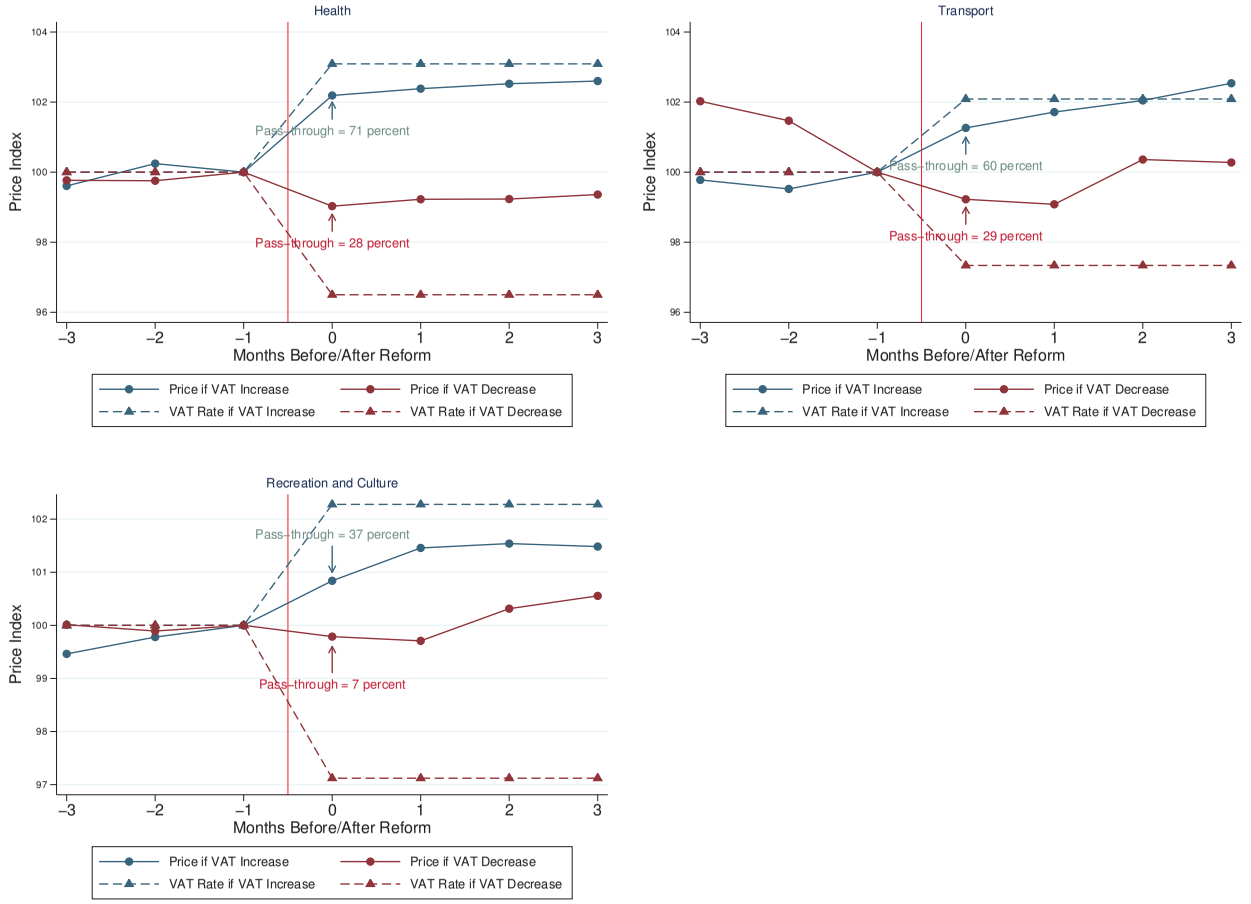

*Notes:* To generate these graphs, we break down the sample of firms into 5 quintiles with respect to operating margins (turnover minus deductible costs divided by turnover) using data from 2004 to 2006 for 2007 and 2009 to 2011 for 2012 , with 1 being firms with the smallest operating margins. For each 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



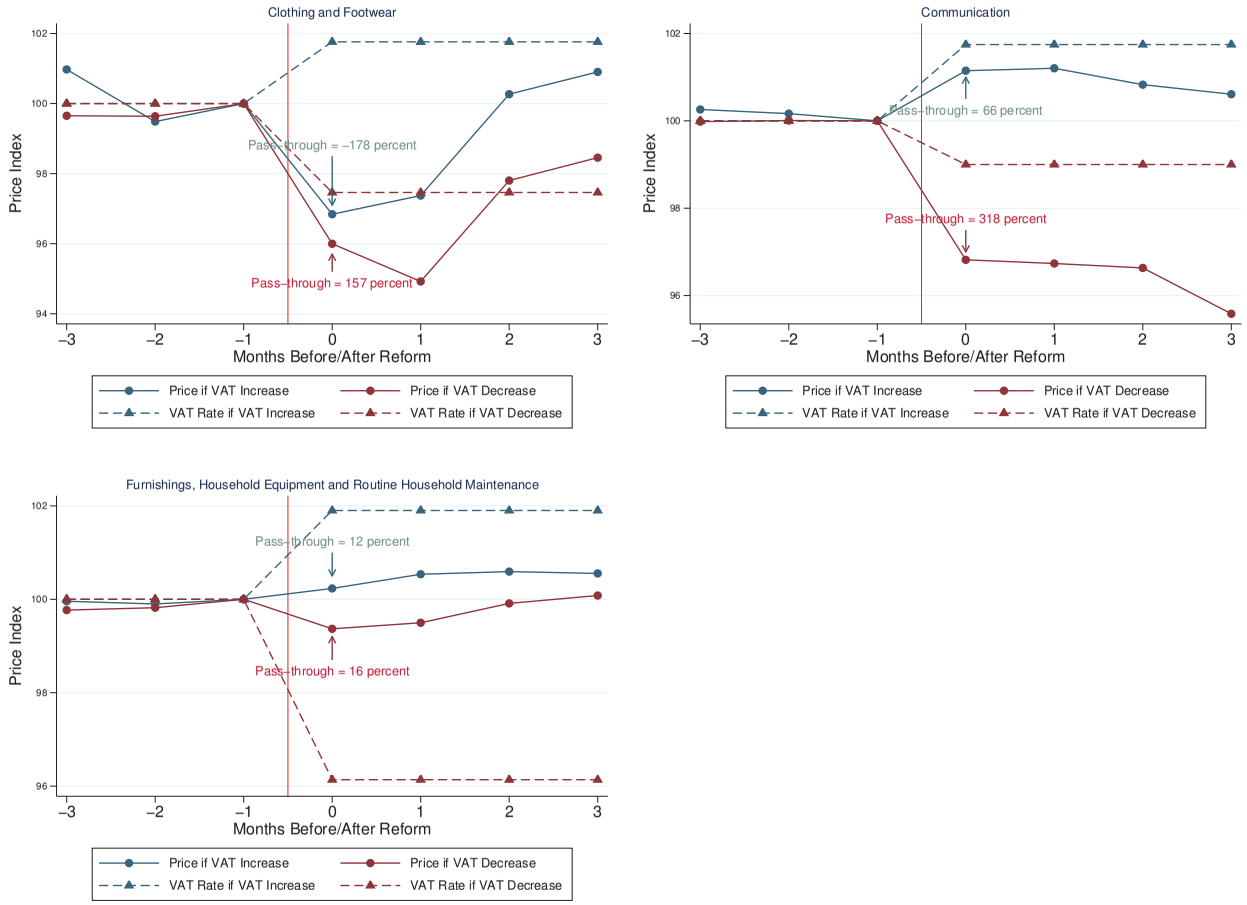

*Notes:* Each of these graphs is a disaggregated version of Figure 7a: they plot the response of prices to variation in the VAT rate by groups of commodities.

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



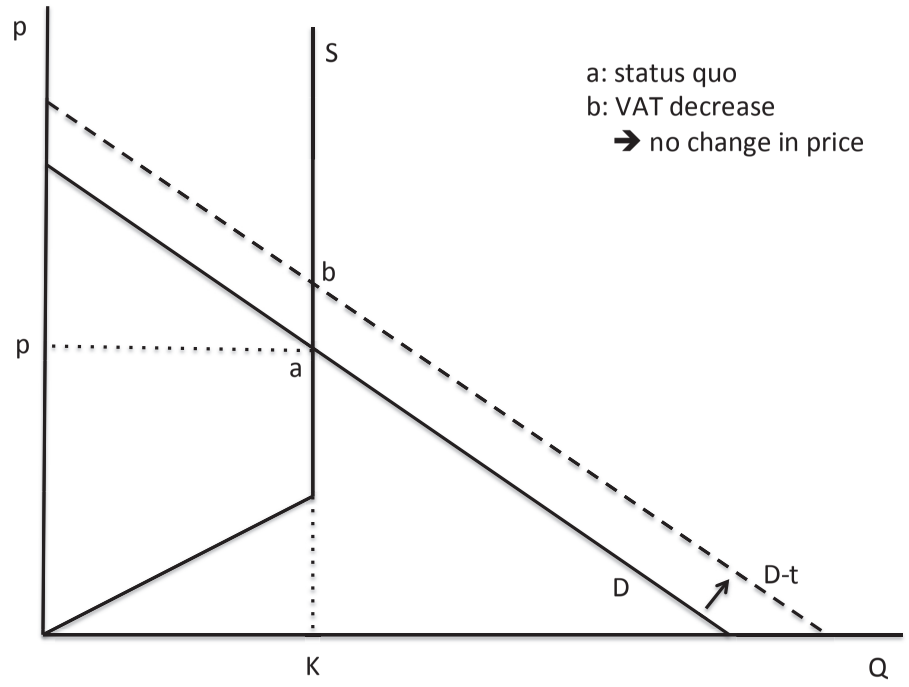

*Notes:* Each of these graphs is a disaggregated version of Figure 7a: they plot the response of prices to variation in the VAT by groups of commodities.

Figure D.24: Commodities With No Asymmetry



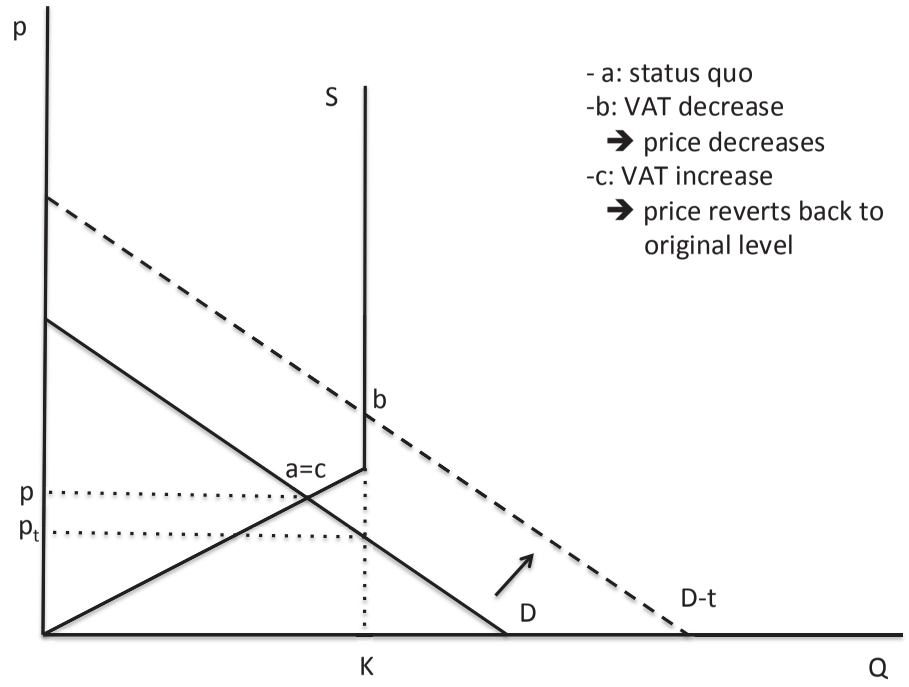

*Notes:* Each of these graphs is a disaggregated version of Figure 7a: they plot the response of prices to variation in the VAT by groups of commodities. This panel shows the commodities for which there is no asymmetry. Clothing and Footwear shows a price decrease for both VAT increases and decreases 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)



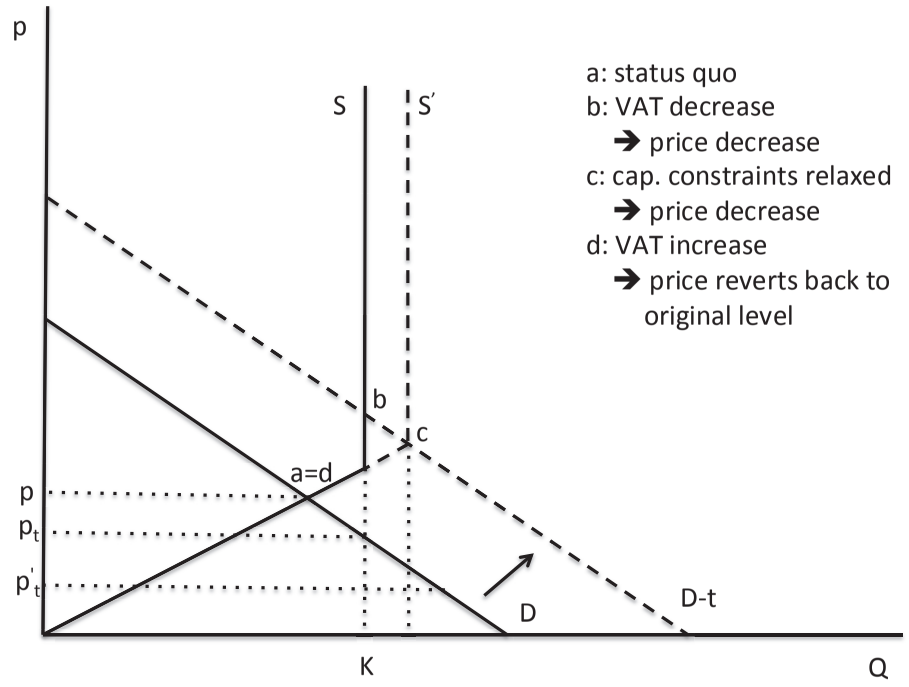

*Notes:* In this figure, we assume that capacity constraints are binding prior to the VAT cut (a). As the VAT rate is cut, prices inclusive of VAT do not change (b), since firms are operating on the portion of the supply function where $\epsilon_S = 0$.

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).

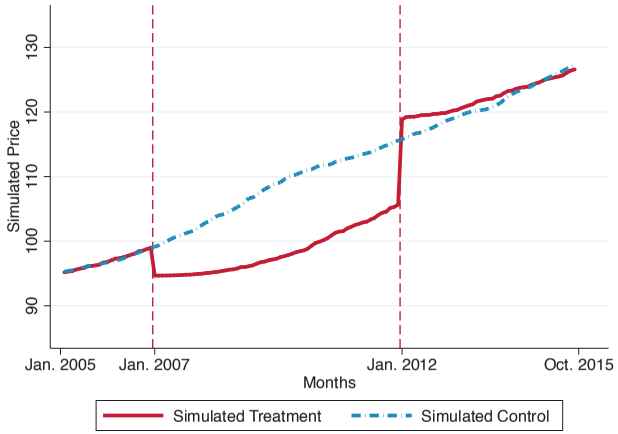
Figure D.27: Capacity Constraints (case 3)



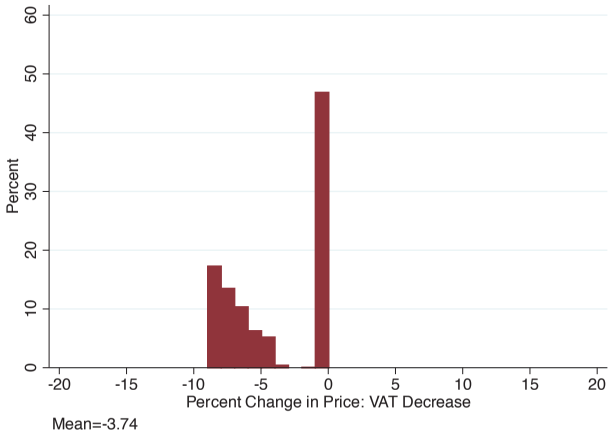

*Notes:* In this figure, we assume that firms are operating just below capacity constraints (a), prior to the VAT cut. As the VAT rate is decreased, firms decrease prices (b). Capacity constraints are then gradually relaxed, leading to incremental price decreases (c). When the VAT rate is increased,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

Figure D.28: Adjustment Cost Model Simulations

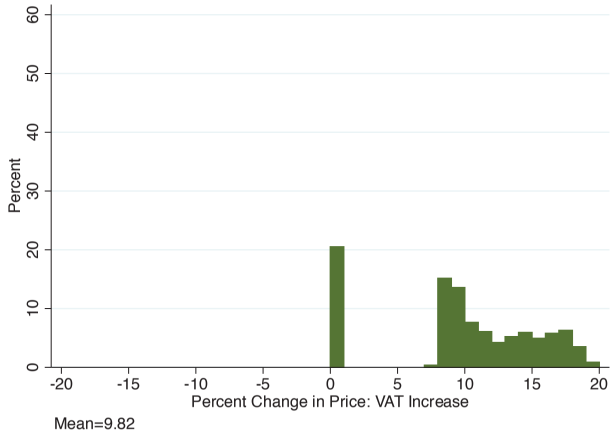
(a) Time Series Simulation




(b) VAT Decrease Distribution Simulation

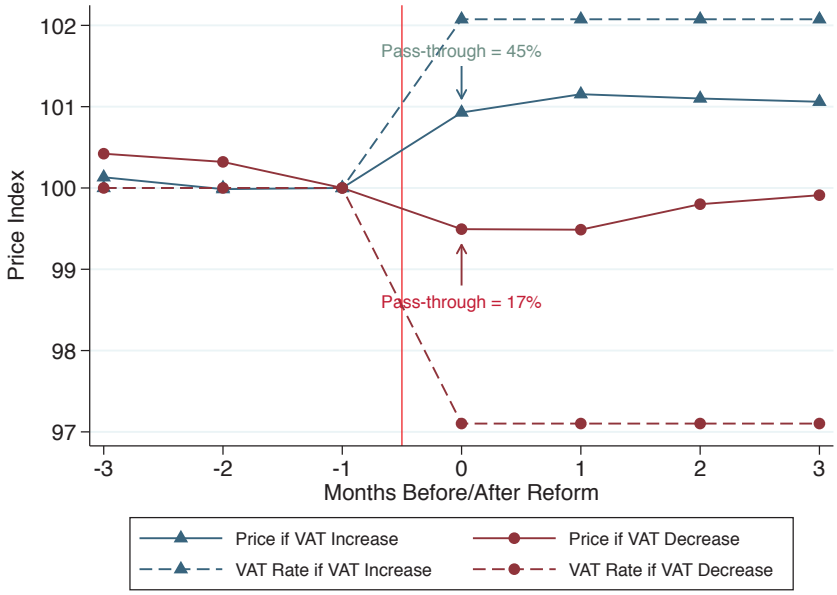



(c) VAT Increase Distribution Simulation




*Notes:* Figures D.30a, D.30b and D.30d 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.

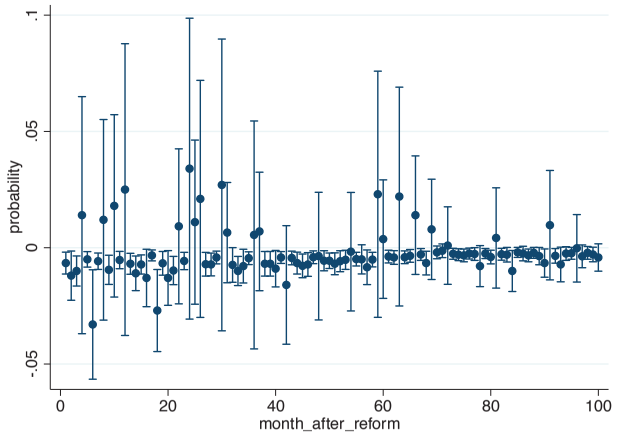
Figure D.29: Asymmetric Response of Prices to VAT Changes (Real Prices)



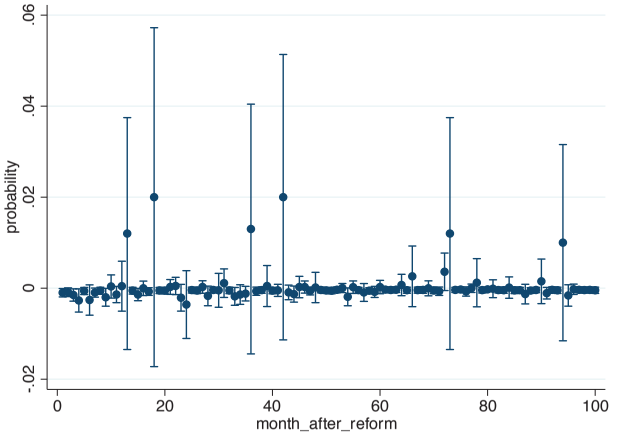

*Notes:* This figure plots the response of prices to VAT increases and decreases, while controlling for inflation. The underlying dataset consists of three-month window price and VAT time series around each VAT reform from 1996 to 2015. We average out and normalize each series to 100 one month before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

Figure D.30: Path of VAT Changes After VAT Change

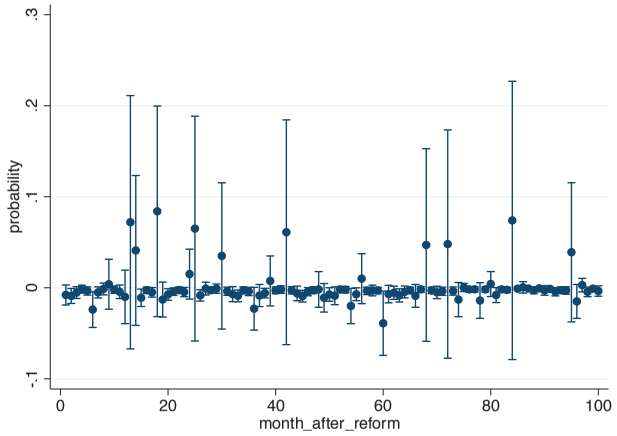
(a) Probability of VAT Increase After a VAT Increase



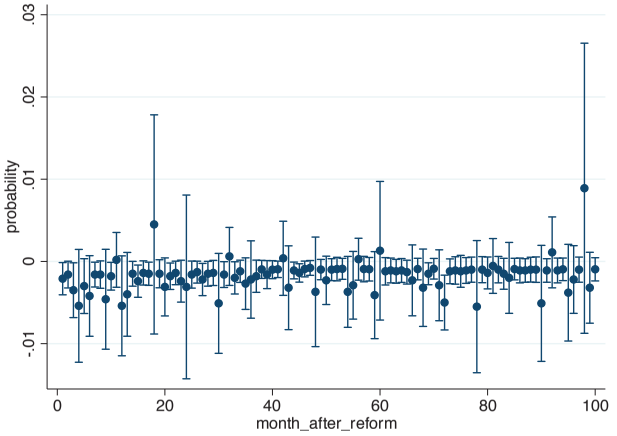

(b) Probability of VAT Increase After a VAT Decrease




(c) Probability of VAT Decrease After a VAT Increase




(d) Probability of VAT Decrease After a VAT Decrease




*Notes:* These Figures plot the probability that a VAT change occurs 1 to 100 months after a given VAT change. Panel a. plots the probability of a VAT increase after a VAT increase, panel b. the probability of a VAT increase after a VAT decrease, panel c. the probability of a VAT decrease after a VAT increase and panel d. the probability of a VAT decrease after a VAT decrease.

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: Pass-Through Estimates For Temporary VAT Changes

| | $\Delta$ log Price | |
|---|---|---|
| | Increase | Decrease |
| $\beta_0$ | 0.34 | 0.079 |
| | (0.084) | (0.043) |
| $\beta_{+1}$ | 0.032 | 0.038 |
| | (0.023) | (0.025) |
| $\beta_{-2}$ | 0.036 | 0.024 |
| | (0.022) | (0.016) |
| $\beta_{+2}$ | -0.010 | -0.038 |
| | (0.024) | (0.028) |
| $\beta_{-3}$ | 0.0049 | 0.00058 |
| | (0.018) | (0.036) |
| $\beta_{+3}$ | -0.051 | -0.020 |
| | (0.022) | (0.027) |
| $\beta_{-4}$ | 0.042 | -0.0070 |
| | (0.039) | (0.024) |
| $\beta_{+4}$ | -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. $\beta_0$ measures the pass-through of the VAT change at the time of the reform, and $\beta_i$ measures price changes $i$ months away from the reform.

Table D.9: Pass-Through Estimates For Permanent VAT Changes

| | $\Delta$ log Price | |
|---|---|---|
| | Increase | Decrease |
| $\beta_0$ | 0.26 | 0.028 |
| | (0.073) | (0.023) |
| $\beta_{+1}$ | -0.023 | 0.012 |
| | (0.014) | (0.019) |
| $\beta_{-2}$ | 0.019 | 0.010 |
| | (0.022) | (0.013) |
| $\beta_{+2}$ | 0.045 | -0.031 |
| | (0.023) | (0.022) |
| $\beta_{-3}$ | 0.013 | -0.0011 |
| | (0.015) | (0.026) |
| $\beta_{+3}$ | -0.0090 | 0.0030 |
| | (0.019) | (0.019) |
| $\beta_{-4}$ | 0.037 | -0.024 |
| | (0.034) | (0.023) |
| $\beta_{+4}$ | -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. $\beta_0$ measures the pass-through of the VAT change at the time of the reform, and $\beta_i$ measures price changes $i$ months away from the reform.

Table D.10: Pass-Through Estimates Using Fixed Effects Regression (Inflation Controls)

| | $\Delta$ log Price | |
|---|---|---|
| | Increase | Decrease |
| $\beta_0$ | 0.33 | 0.066 |
| | (0.060) | (0.031) |
| $\beta_{+1}$ | 0.013 | 0.027 |
| | (0.018) | (0.018) |
| $\beta_{-2}$ | 0.023 | 0.029 |
| | (0.017) | (0.015) |
| $\beta_{+2}$ | 0.013 | -0.042 |
| | (0.029) | (0.020) |
| $\beta_{-3}$ | 0.0078 | -0.0017 |
| | (0.016) | (0.030) |
| $\beta_{+3}$ | -0.050 | -0.0027 |
| | (0.021) | (0.022) |
| $\beta_{-4}$ | 0.042 | -0.017 |
| | (0.032) | (0.021) |
| $\beta_{+4}$ | -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. $\beta_0$ measures the pass-through of the VAT change at the time of the reform, and $\beta_i$ measures price changes $i$ months away from the reform.

Table D.11: Correlation of VAT Changes with GDP and Unemployment Rate

| | VAT Change | VAT Increase | VAT Decrease |
|---|---|---|---|
| $\beta_{-1}$ | -0.0012 | -0.0011 | -0.000100 |
| | (0.0011) | (0.0010) | (0.00034) |
| $\beta_{-2}$ | -0.000057 | -0.00024 | 0.00018 |
| | (0.0012) | (0.00097) | (0.00056) |
| $\beta_{-3}$ | -0.0017 | -0.0013 | -0.00044 |
| | (0.0012) | (0.0011) | (0.00027) |
| $\beta_{-4}$ | -0.0015 | -0.0012 | -0.00027 |
| | (0.0017) | (0.0017) | (0.00030) |
| $\beta_{-5}$ | -0.0014 | -0.0010 | -0.00036 |
| | (0.0011) | (0.0010) | (0.00035) |
| $\gamma_{-1}$ | 0.00097 | 0.0016 | -0.00063 |
| | (0.0044) | (0.0037) | (0.0016) |
| $\gamma_{-2}$ | -0.0054 | -0.0036 | -0.0018 |
| | (0.0048) | (0.0040) | (0.0026) |
| $\gamma_{-3}$ | 0.0019 | 0.00091 | 0.00094 |
| | (0.0042) | (0.0040) | (0.00098) |
| $\gamma_{-4}$ | -0.0014 | -0.0020 | 0.00059 |
| | (0.0075) | (0.0074) | (0.0012) |
| $\gamma_{-5}$ | 0.0025 | 0.0018 | 0.00072 |
| | (0.0041) | (0.0037) | (0.0012) |
| $R^2$ | 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. 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 GDP and unemployment rate in the twelve months leading up to the reform.

Table D.12: Correlation of VAT Changes with Industry Turnover and Unemployment Rate

| | VAT Change | VAT Increase | VAT Decrease |
|---|---|---|---|
| $\beta_{-1}$ | -0.0016 | -0.0010 | -0.00059 |
| | (0.0012) | (0.00093) | (0.00057) |
| $\beta_{-2}$ | 0.0012 | 0.00069 | 0.00053 |
| | (0.0014) | (0.0011) | (0.00052) |
| $\beta_{-3}$ | -0.0015 | -0.0010 | -0.00051 |
| | (0.0011) | (0.0010) | (0.00028) |
| $\beta_{-4}$ | -0.0019 | -0.0017 | -0.00018 |
| | (0.0014) | (0.0014) | (0.00014) |
| $\beta_{-5}$ | -0.00075 | -0.00040 | -0.00035 |
| | (0.00088) | (0.00082) | (0.00030) |
| $\gamma_{-1}$ | -0.00076 | -0.00081 | 0.000052 |
| | (0.0016) | (0.0015) | (0.00051) |
| $\gamma_{-2}$ | -0.0078 | -0.0058 | -0.0020 |
| | (0.0037) | (0.0030) | (0.0015) |
| $\gamma_{-3}$ | -0.0020 | -0.0022 | 0.00018 |
| | (0.0018) | (0.0018) | (0.00028) |
| $\gamma_{-4}$ | -0.0037 | -0.0036 | -0.00011 |
| | (0.0032) | (0.0032) | (0.00027) |
| $\gamma_{-5}$ | -0.0015 | -0.0015 | -0.000029 |
| | (0.0015) | (0.0014) | (0.00039) |
| $R^2$ | 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, with industry turnover instead of GDP as one of the main regressor (the remaining variables are the same). 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 industry turnover and unemployment rate in the twelve months leading up to the reform.

Table D.13: Pass-Through Estimates: Matched Sample (GDP Per Capita)

| | Country Specification $\Delta$ log Price | | Timing Specification $\Delta$ log Price | |
|---|---|---|---|---|
| | Increase | Decrease | Increase | Decrease |
| $\beta_0$ | 0.32 | 0.0021 | 0.33 | 0.025 |
| | (0.075) | (0.037) | (0.067) | (0.044) |
| $\beta_{+1}$ | 0.020 | 0.025 | 0.020 | 0.025 |
| | (0.019) | (0.017) | (0.019) | (0.017) |
| $\beta_{-2}$ | 0.031 | 0.026 | 0.030 | 0.026 |
| | (0.019) | (0.015) | (0.019) | (0.015) |
| $\beta_{+2}$ | 0.020 | -0.044 | 0.020 | -0.044 |
| | (0.027) | (0.021) | (0.027) | (0.021) |
| $\beta_{-3}$ | 0.015 | -0.0050 | 0.015 | -0.0050 |
| | (0.016) | (0.028) | (0.016) | (0.028) |
| $\beta_{+3}$ | -0.042 | -0.0046 | -0.042 | -0.0046 |
| | (0.018) | (0.022) | (0.018) | (0.022) |
| $\beta_{-4}$ | 0.050 | -0.020 | 0.049 | -0.020 |
| | (0.034) | (0.022) | (0.034) | (0.022) |
| $\beta_{+4}$ | -0.010 | -0.0089 | -0.0096 | -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 | 385892 | 342502 | 386096 | 342502 |

*Notes:* The coefficients reported in this table indicate the pass-through of VAT increases and decreases to prices estimated using specification (1) on matched reforms, using nearest neighbor matching. The country specification (first and second columns) matches on country, commodity, an indicator variable for being post-Great Recession, size of VAT change and GDP per capita. The timing specification (third and fourth columns) matches on month and year, commodity, size of VAT change and GDP per capita. The first and third columns 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. $\beta_0$ measures the pass-through of the VAT change at the time of the reform and $\beta_i$ measures price changes $i$ months away from the reform. Overall, 38% of the VAT changes in the country specification and 28% of the VAT changes in the time specification are dropped by the matching algorithm.

Table D.14: Pass-Through Estimates: Matched Sample (Unemployment Rate)

| | Country Specification $\Delta$ log Price | | Timing Specification $\Delta$ log Price | |
|---|---|---|---|---|
| | Increase | Decrease | Increase | Decrease |
| $\beta_0$ | 0.30 | 0.021 | 0.33 | 0.032 |
| | (0.075) | (0.038) | (0.066) | (0.050) |
| $\beta_{+1}$ | 0.020 | 0.025 | 0.020 | 0.025 |
| | (0.019) | (0.017) | (0.019) | (0.017) |
| $\beta_{-2}$ | 0.031 | 0.026 | 0.031 | 0.026 |
| | (0.019) | (0.015) | (0.019) | (0.015) |
| $\beta_{+2}$ | 0.020 | -0.044 | 0.020 | -0.044 |
| | (0.027) | (0.021) | (0.027) | (0.021) |
| $\beta_{-3}$ | 0.015 | -0.0050 | 0.015 | -0.0050 |
| | (0.016) | (0.028) | (0.016) | (0.028) |
| $\beta_{+3}$ | -0.042 | -0.0046 | -0.042 | -0.0046 |
| | (0.018) | (0.022) | (0.018) | (0.022) |
| $\beta_{-4}$ | 0.050 | -0.020 | 0.050 | -0.020 |
| | (0.034) | (0.022) | (0.034) | (0.022) |
| $\beta_{+4}$ | -0.0098 | -0.0089 | -0.0095 | -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 | 385477 | 342501 | 385675 | 342503 |

*Notes:* The coefficients reported in this table indicate the pass-through of VAT increases and decreases to prices estimated using specification (1) on matched reforms, using nearest neighbor matching. The country specification (first and second columns) matches on country, commodity, an indicator variable for being post-Great Recession, size of VAT change and the unemployment rate. The timing specification (third and fourth columns) matches on month and year, commodity, size of VAT change and the unemployment rate. The first and third columns 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. $\beta_0$ measures the pass-through of the VAT change at the time of the reform and $\beta_i$ measures price changes $i$ months away from the reform. Overall, 51% of the VAT changes in the country specification and 40% of the VAT changes in the time specification are dropped by the matching algorithm.

Table D.15: Pass-Through Estimates: Matched Sample (Interest Rate)

| | Country Specification $\Delta$ log Price | | Timing Specification $\Delta$ log Price | |
|---|---|---|---|---|
| | Increase | Decrease | Increase | Decrease |
| $\beta_0$ | 0.35 | 0.018 | 0.33 | 0.020 |
| | (0.074) | (0.031) | (0.062) | (0.042) |
| $\beta_{+1}$ | 0.020 | 0.025 | 0.020 | 0.025 |
| | (0.019) | (0.017) | (0.019) | (0.017) |
| $\beta_{-2}$ | 0.030 | 0.026 | 0.031 | 0.026 |
| | (0.019) | (0.015) | (0.019) | (0.015) |
| $\beta_{+2}$ | 0.020 | -0.044 | 0.020 | -0.044 |
| | (0.027) | (0.021) | (0.027) | (0.021) |
| $\beta_{-3}$ | 0.015 | -0.0049 | 0.015 | -0.0050 |
| | (0.016) | (0.028) | (0.016) | (0.028) |
| $\beta_{+3}$ | -0.042 | -0.0046 | -0.042 | -0.0046 |
| | (0.018) | (0.022) | (0.018) | (0.022) |
| $\beta_{-4}$ | 0.049 | -0.020 | 0.049 | -0.020 |
| | (0.034) | (0.022) | (0.034) | (0.022) |
| $\beta_{+4}$ | -0.011 | -0.0089 | -0.0096 | -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 | 385879 | 342502 | 385951 | 342502 |

*Notes:* The coefficients reported in this table indicate the pass-through of VAT increases and decreases to prices estimated using specification (1) on matched reforms, using nearest neighbor matching. The country specification (first and second columns) matches on country, commodity, an indicator variable for being post-Great Recession, size of VAT change and the interest rate. The timing specification (third and fourth columns) matches on month and year, commodity, size of VAT change and the interest rate. The first and third columns 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. $\beta_0$ measures the pass-through of the VAT change at the time of the reform and $\beta_i$ measures price changes $i$ months away from the reform. Overall, 38% of the VAT changes in the country specification and 33% of the VAT changes in the time specification are dropped by the matching algorithm.

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

| | Country Specification | | Timing Specification | |
|---|---|---|---|---|
| | $\Delta$ log Price | | $\Delta$ log Price | |
| | Increase | Decrease | Increase | Decrease |
| $\beta_0$ | 0.32 | 0.0082 | 0.33 | 0.017 |
| | (0.076) | (0.031) | (0.066) | (0.037) |
| $\beta_{+1}$ | 0.020 | 0.025 | 0.020 | 0.025 |
| | (0.019) | (0.017) | (0.019) | (0.017) |
| $\beta_{-2}$ | 0.031 | 0.026 | 0.030 | 0.026 |
| | (0.019) | (0.015) | (0.019) | (0.015) |
| $\beta_{+2}$ | 0.020 | -0.044 | 0.020 | -0.044 |
| | (0.027) | (0.021) | (0.027) | (0.021) |
| $\beta_{-3}$ | 0.015 | -0.0050 | 0.015 | -0.0050 |
| | (0.016) | (0.028) | (0.016) | (0.028) |
| $\beta_{+3}$ | -0.042 | -0.0046 | -0.042 | -0.0046 |
| | (0.018) | (0.022) | (0.018) | (0.022) |
| $\beta_{-4}$ | 0.050 | -0.020 | 0.049 | -0.020 |
| | (0.034) | (0.022) | (0.034) | (0.022) |
| $\beta_{+4}$ | -0.0099 | -0.0089 | -0.0096 | -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 | 385586 | 342500 | 386076 | 342478 |

*Notes:* The coefficients reported in this table indicate the pass-through of VAT increases and decreases to prices estimated using specification (1) on matched reforms, using nearest neighbor matching. The country specification (first and second columns) matches on country, commodity, an indicator variable for being post-Great Recession, GDP per capita, GDP growth, unemployment rate, interest rate and size of change. The timing specification (third and fourth columns) matches on month and year, commodity, GDP per capita, GDP growth, unemployment rate, interest rate and size of change. The first and third columns 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. $\beta_0$ measures the pass-through of the VAT change at the time of the reform and $\beta_i$ measures price changes $i$ months away from the reform. Overall, 48% of the VAT changes for the country specification and 32% for the time specification are dropped by the matching algorithm.

Table D.17: Pass-Through Estimates: Matched Sample (Logit)

| | Country Specification | | Timing Specification | |
|---|---|---|---|---|
| | $\Delta$ log Price | | $\Delta$ log Price | |
| | Increase | Decrease | Increase | Decrease |
| $\beta_0$ | 0.32 | 0.000022 | 0.33 | 0.033 |
| | (0.074) | (0.029) | (0.066) | (0.041) |
| $\beta_{+1}$ | 0.020 | 0.025 | 0.020 | 0.025 |
| | (0.019) | (0.017) | (0.019) | (0.017) |
| $\beta_{-2}$ | 0.031 | 0.026 | 0.030 | 0.026 |
| | (0.019) | (0.015) | (0.019) | (0.015) |
| $\beta_{+2}$ | 0.020 | -0.044 | 0.020 | -0.044 |
| | (0.027) | (0.021) | (0.027) | (0.021) |
| $\beta_{-3}$ | 0.015 | -0.0049 | 0.015 | -0.0050 |
| | (0.016) | (0.028) | (0.016) | (0.028) |
| $\beta_{+3}$ | -0.042 | -0.0046 | -0.042 | -0.0046 |
| | (0.018) | (0.022) | (0.018) | (0.022) |
| $\beta_{-4}$ | 0.050 | -0.020 | 0.049 | -0.020 |
| | (0.034) | (0.022) | (0.034) | (0.022) |
| $\beta_{+4}$ | -0.0098 | -0.0089 | -0.0096 | -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 | 385617 | 342499 | 386080 | 342482 |

*Notes:* The coefficients reported in this table indicate the pass-through of VAT increases and decreases to prices estimated using specification (1) on matched reforms, using nearest neighbor matching and logit instead of probit to estimate the propensity scores. The country specification (first and second columns) matches on country, commodity, an indicator variable for being post-Great Recession, GDP growth and size of change. The timing specification (third and fourth columns) matches on month and year, commodity, GDP growth and size of change. This specification uses logit instead of probit (which is used in all other specifications) to estimate the propensity scores. The first and third columns 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. $\beta_0$ measures the pass-through of the VAT change at the time of the reform and $\beta_i$ measures price changes $i$ months away from the reform. Overall, 47% of the VAT changes for the country specification and 29% for the time specification are dropped by the matching algorithm.

Table D.18: Pass-Through Estimates: Matched Sample (Coarsened Exact Matching)

| | Country Specification $\Delta$ log Price | | Timing Specification $\Delta$ log Price | |
|---|---|---|---|---|
| | Increase | Decrease | Increase | Decrease |
| $\beta_0$ | 0.34 | 0.064 | 0.38 | 0.061 |
| | (0.063) | (0.030) | (0.060) | (0.031) |
| $\beta_{+1}$ | 0.020 | 0.025 | 0.020 | 0.025 |
| | (0.019) | (0.017) | (0.019) | (0.017) |
| $\beta_{-2}$ | 0.030 | 0.026 | 0.031 | 0.026 |
| | (0.019) | (0.015) | (0.019) | (0.015) |
| $\beta_{+2}$ | 0.020 | -0.044 | 0.021 | -0.044 |
| | (0.027) | (0.021) | (0.027) | (0.021) |
| $\beta_{-3}$ | 0.015 | -0.0050 | 0.015 | -0.0050 |
| | (0.016) | (0.028) | (0.016) | (0.028) |
| $\beta_{+3}$ | -0.043 | -0.0046 | -0.042 | -0.0045 |
| | (0.017) | (0.022) | (0.018) | (0.022) |
| $\beta_{-4}$ | 0.049 | -0.020 | 0.050 | -0.020 |
| | (0.034) | (0.022) | (0.034) | (0.022) |
| $\beta_{+4}$ | -0.011 | -0.0089 | -0.0094 | -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 | 386557 | 342792 | 385515 | 342730 |

*Notes:* The coefficients reported in this table indicate the pass-through of VAT increases and decreases to prices estimated using specification (1) on matched reforms, using coarsened exact matching. The country specification (first and second columns) matches on country, commodity, an indicator variable for being post-Great Recession, size of VAT change and GDP growth. The timing specification (third and fourth columns) matches on month and year, commodity, size of VAT change and GDP growth. The first and third columns 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. $\beta_0$ measures the pass-through of the VAT change at the time of the reform and $\beta_i$ measures price changes $i$ months away from the reform. Overall, 2.1% of the VAT changes for the country specification and 40.4% for the time specification are dropped by the matching algorithm.

Table D.19: Pass-Through Estimates: Matched Sample (Kernel Matching)

| | Country Specification $\Delta$ log Price | | Timing Specification $\Delta$ log Price | |
|---|---|---|---|---|
| | Increase | Decrease | Increase | Decrease |
| $\beta_0$ | 0.32 | 0.053 | 0.33 | 0.071 |
| | (0.073) | (0.025) | (0.066) | (0.034) |
| $\beta_{+1}$ | 0.020 | 0.025 | 0.020 | 0.025 |
| | (0.019) | (0.017) | (0.019) | (0.017) |
| $\beta_{-2}$ | 0.031 | 0.026 | 0.030 | 0.026 |
| | (0.019) | (0.015) | (0.019) | (0.015) |
| $\beta_{+2}$ | 0.020 | -0.044 | 0.020 | -0.044 |
| | (0.027) | (0.021) | (0.027) | (0.021) |
| $\beta_{-3}$ | 0.015 | -0.0050 | 0.015 | -0.0050 |
| | (0.016) | (0.028) | (0.016) | (0.028) |
| $\beta_{+3}$ | -0.042 | -0.0046 | -0.042 | -0.0046 |
| | (0.018) | (0.022) | (0.018) | (0.022) |
| $\beta_{-4}$ | 0.050 | -0.020 | 0.049 | -0.020 |
| | (0.034) | (0.022) | (0.034) | (0.022) |
| $\beta_{+4}$ | -0.0098 | -0.0089 | -0.0096 | -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 | 385538 | 342787 | 386076 | 342769 |

*Notes:* The coefficients reported in this table indicate the pass-through of VAT increases and decreases to prices estimated using specification (1) on matched reforms, using kernel matching. The country specification (first and second columns) matches on country, commodity, an indicator variable for being post-Great Recession, size of VAT change and GDP growth. The timing specification (third and fourth columns) matches on month and year, commodity, size of VAT change and GDP growth. The first and third columns 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. $\beta_0$ measures the pass-through of the VAT change at the time of the reform and $\beta_i$ measures price changes $i$ months away from the reform. Overall, 40% of the VAT changes for the country specification and 20% for the time specification are dropped by the matching algorithm.

Table D.20: Pass-Through Estimates: Matched Sample (Radius Matching)

| | Country Specification $\Delta$ log Price | | Timing Specification $\Delta$ log Price | |
|---|---|---|---|---|
| | Increase | Decrease | Increase | Decrease |
| $\beta_0$ | 0.32 | 0.053 | 0.33 | 0.064 |
| | (0.073) | (0.025) | (0.066) | (0.030) |
| $\beta_{+1}$ | 0.020 | 0.025 | 0.020 | 0.025 |
| | (0.019) | (0.017) | (0.019) | (0.017) |
| $\beta_{-2}$ | 0.031 | 0.026 | 0.030 | 0.026 |
| | (0.019) | (0.015) | (0.019) | (0.015) |
| $\beta_{+2}$ | 0.020 | -0.044 | 0.020 | -0.044 |
| | (0.027) | (0.021) | (0.027) | (0.021) |
| $\beta_{-3}$ | 0.015 | -0.0050 | 0.015 | -0.0050 |
| | (0.016) | (0.028) | (0.016) | (0.028) |
| $\beta_{+3}$ | -0.042 | -0.0046 | -0.042 | -0.0046 |
| | (0.018) | (0.022) | (0.018) | (0.022) |
| $\beta_{-4}$ | 0.050 | -0.020 | 0.049 | -0.020 |
| | (0.034) | (0.022) | (0.034) | (0.022) |
| $\beta_{+4}$ | -0.0098 | -0.0089 | -0.0096 | -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 | 385538 | 342787 | 386076 | 342790 |

*Notes:* The coefficients reported in this table indicate the pass-through of VAT increases and decreases to prices estimated using specification (1) on matched reforms, using radius matching. The country specification (first and second columns) matches on country, commodity, an indicator variable for being post-Great Recession, size of VAT change and GDP growth. The timing specification (third and fourth columns) matches on month and year, commodity, size of VAT change and GDP growth. The first and third columns 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. $\beta_0$ measures the pass-through of the VAT change at the time of the reform and $\beta_i$ measures price changes $i$ months away from the reform. Overall, 40% of the VAT changes for the country specification and 19% for the time specification are dropped by the matching algorithm.

Table D.21: Pass-Through Estimates: Matched Sample (Local Linear Regression Matching)

| | Country Specification $\Delta$ log Price | | Timing Specification $\Delta$ log Price | |
|---|---|---|---|---|
| | Increase | Decrease | Increase | Decrease |
| $\beta_0$ | 0.32 | -0.013 | 0.33 | 0.019 |
| | (0.073) | (0.025) | (0.066) | (0.038) |
| $\beta_{+1}$ | 0.020 | 0.025 | 0.020 | 0.025 |
| | (0.019) | (0.017) | (0.019) | (0.017) |
| $\beta_{-2}$ | 0.031 | 0.026 | 0.030 | 0.026 |
| | (0.019) | (0.015) | (0.019) | (0.015) |
| $\beta_{+2}$ | 0.020 | -0.044 | 0.020 | -0.044 |
| | (0.027) | (0.021) | (0.027) | (0.021) |
| $\beta_{-3}$ | 0.015 | -0.0050 | 0.015 | -0.0050 |
| | (0.016) | (0.028) | (0.016) | (0.028) |
| $\beta_{+3}$ | -0.042 | -0.0047 | -0.042 | -0.0046 |
| | (0.018) | (0.022) | (0.018) | (0.022) |
| $\beta_{-4}$ | 0.050 | -0.020 | 0.049 | -0.020 |
| | (0.034) | (0.022) | (0.034) | (0.022) |
| $\beta_{+4}$ | -0.0098 | -0.0089 | -0.0096 | -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 | 385538 | 342500 | 386076 | 342482 |

*Notes:* The coefficients reported in this table indicate the pass-through of VAT increases and decreases to prices estimated using specification (1) on matched reforms, using local linear regression matching. The country specification (first and second columns) matches on country, commodity, an indicator variable for being post-Great Recession, size of VAT change and GDP growth. The timing specification (third and fourth columns) matches on month and year, commodity, size of VAT change and GDP growth. The first and third columns 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. $\beta_0$ measures the pass-through of the VAT change at the time of the reform and $\beta_i$ measures price changes $i$ months away from the reform. Overall, 50% of the VAT changes for the country specification and 29% for the time specification are dropped by the matching algorithm.

Table D.22: Pass-Through Calibration With Convex Demand Function and Perfect Competition

| | Finnish Estimates | | | European Estimates | | |
|---|---|---|---|---|---|---|
| Price Elasticity of Demand | Increase Pass-Through | Decrease Pass-Through | Difference | Increase Pass-Through | Decrease Pass-Through | Difference |
| 0.10 | 0.80 | 0.77 | 0.03 | 0.33 | 0.32 | 0.01 |
| 0.50 | 0.80 | 0.76 | 0.04 | 0.33 | 0.32 | 0.01 |
| 1.00 | 0.80 | 0.75 | 0.05 | 0.33 | 0.32 | 0.01 |
| 1.50 | 0.80 | 0.74 | 0.06 | 0.33 | 0.31 | 0.02 |
| 2.00 | 0.80 | 0.72 | 0.08 | 0.33 | 0.31 | 0.02 |
| 2.50 | 0.80 | 0.71 | 0.09 | 0.33 | 0.31 | 0.02 |
| 3.00 | 0.80 | 0.70 | 0.10 | 0.33 | 0.30 | 0.03 |
| 3.50 | 0.80 | 0.68 | 0.12 | 0.33 | 0.30 | 0.03 |
| 4.00 | 0.80 | 0.67 | 0.13 | 0.33 | 0.30 | 0.03 |

*Notes:* This Table shows the result of a calibration of the pass-through of VAT increases and decreases implied by a perfect competition model with a market demand function equal to $D(p) = \left(\frac{p}{a}\right)^{-\frac{1}{b}}$, where $-\frac{1}{b}$ is equal to the price elasticity of demand. Column (1) shows the different elasticity parameters we consider, columns (2) to (4) show the results of the calibration using the Finnish estimates, while columns (5) to (7) show the results of the calibration using the European estimates.

Table D.23: Pass-Through Calibration With Concave Supply Function and Perfect Competition

| | Finnish Estimates | | | European Estimates | | |
|---|---|---|---|---|---|---|
| $\alpha + \beta$ | Increase Pass-Through | Decrease Pass-Through | Difference | Increase Pass-Through | Decrease Pass-Through | Difference |
| 0.1 | 0.06 | 0.07 | -0.01 | 0.06 | 0.06 | 0.00 |
| 0.2 | 0.17 | 0.19 | -0.02 | 0.18 | 0.18 | 0.00 |
| 0.3 | 0.40 | 0.42 | -0.02 | 0.40 | 0.41 | 0.00 |
| 0.4 | 0.71 | 0.72 | -0.01 | 0.71 | 0.71 | 0.00 |
| 0.5 | 0.93 | 0.93 | 0.00 | 0.93 | 0.93 | 0.00 |
| 0.6 | 0.99 | 0.99 | 0.00 | 0.99 | 0.99 | 0.00 |
| 0.7 | 1.00 | 1.00 | 0.00 | 1.00 | 1.00 | 0.00 |
| 0.8 | 1.00 | 1.00 | 0.00 | 1.00 | 1.00 | 0.00 |
| 0.9 | 1.00 | 1.00 | 0.00 | 1.00 | 1.00 | 0.00 |

*Notes:* This Table shows the result of a calibration of the pass-through of VAT increases and decreases implied by a perfect competition model with a Cobb-Douglas production function with parameters $\alpha$ and $\beta$. Column (1) shows the different $\alpha + \beta$ parameters we consider, columns (2) to (4) show the results of the calibration using the Finnish estimates, while columns (5) to (7) show the results of the calibration using the European estimates.