The Role of Market Structure and Timing in Determining VAT Pass-Through

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Abstract

We examine the role of market characteristics and timing in explaining observed heterogeneity in VAT pass-through. We first extend existing theory to characterize the roles of imperfect competition and product differentiation, then investigate these relationships empirically using a panel of 14 Eurozone countries between 1999 and 2013. We find important roles for product market regulation and product quality, and little impact of advance announcement of reforms. Our findings have important implications for policy-makers considering VAT rate adjustments, by illuminating which of the consumers or the producers would experience the brunt of a reform across different settings.

Keywords: VAT; Price effect; Pass through; Competition; Product Differentiation

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1 Introduction

Value added taxes raise about a fifth of total tax revenues both worldwide and among the members of the OECD (OECD 2018). Given the relative ease of modifying the rates, they are frequently at the center of policy debates during economic crises – whether for fiscal stimulus (as in the 2009 VAT reform in China) or for domestic revenue mobilization (as in Europe in the 2010s). How the impact of a VAT change will be divided between firms and consumers is critical for policymakers aiming to target their support or to minimize the tax burden for one group relative to the other. Who bears the consequences of a VAT reform is governed by the key parameter of 'pass-through' – the elasticity of consumer prices with respect to the VAT rate (Weyl & Fabinger (2013)).

There is a vast literature estimating the impact of VAT changes on prices. Yet, estimates of VAT pass-through to consumer prices can vary greatly across studies.[1] This paper builds on the recent empirical methodology of Benedek, De Mooij, Keen & Wingender (2020, hereafter BDKW) to explain how differences in VAT pass-through can be related to differences in market characteristics. Specifically, we examine the role of market competition, product differentiation and timing in explaining heterogenous VAT pass-through. We find that VAT pass-through is greater for products requiring inputs produced more competitively and for products with greater scope for vertical differentiation, namely quality. We do not find any significant difference in pass-through for reforms announced more in advance.

We start by extending existing theory to identify how supply and demand features can influence the degree of VAT pass-through under different market structures. We develop four simple partial equilibrium models. We first consider equally productive firms competing on price under monopolistic competition. Building on Dierickx et al. (1988), the next two consider VAT changes in a market with heterogeneous firms where the downstream and upstream sectors in turn produce under Cournot competition. In the three cases, we find that the effect of competition intensity on pass-through depends on whether producers have increasing or decreasing marginal costs. In the intuitive case of increasing marginal costs, pass-through increases with competition because greater competition prevents producers from realizing and passing on savings from scaling down in response to a tax hike.

[1] From, for instance, full pass-through (100%) of a cut in the Norwegian VAT on food (Gaarder 2018) to 9.7% for a cut in the French VAT on sit-down restaurants (Benzarti & Carloni 2017).

The fourth model generalizes the 'quality ladder' model in Khandelwal (2010) to allow for substitution or complementarity effects between consumer valuation of affordability and quality. We find that variation in pass-through depends on price-quality complementarity. For products with longer 'quality ladders', where differences in quality are starkest, we show that pass-through is larger when there is a high enough degree of price-quality complementarity. In this case, consumers faced with higher prices from higher taxes ask for objects of greater quality, resulting in even higher prices. With less complementarity, consumers prefer lower quality and a lower price increase.

We then investigate empirically the relationships between market characteristics and pass-through using a panel of 14 Eurozone countries between 1999 and 2013. We follow closely the methodology developed in BDKW to systematically quantify the effects of VAT reforms in Europe over time, at the product and country levels. We enrich their specification by interacting VAT reforms with measures of competition and scope for quality. We also examine the role of different varieties of VAT reform (e.g. reforms announced well in advance vs. surprise reforms, or tax hikes vs. tax cuts) in explaining some of the pass-through heterogeneity.

Firstly, we find that changes in regulation in supplier markets play a substantial role, with a one standard deviation rise in the competition-friendliness of regulation (roughly equal to the difference between Austria and relatively uncompetitive Italy in 2013) increasing pass-through by up to 55%. We benchmark this effect against other supply-side characteristics, and find that it is more significant and more important. These results are also significant in a historical context. Liberalizing reforms over the last thirty years have substantially increased the competition-friendliness of regulation in European product markets, so our findings imply that VAT cuts today will be passed on to consumers substantially more than in the past.

Secondly, we investigate the role of product differentiability, and find that the greater the scope for quality differentiation the larger is pass-through. Our empirical results are consistent with our theoretical framework and suggest the existence of complementarity between preferences for quality and price.

Many recent VAT policy changes have been announced significantly before they come into effect.[2] This constitutes a form of 'fiscal forward guidance' (see e.g. Fujiwara & Waki 2019), which could have real effects (Leeper et al. 2013, Mertens & Ravn 2010, 2011, 2012). Even

[2]For instance, the German standard rate VAT cut announced on June 4 took effect on July 1.

outside times of crisis, fiscal policy uncertainty is large, so it is important to understand the effects of advance communication by policymakers.[3] We therefore match data on VAT changes to the Tax Policy Reform Database (Amaglobeli et al. 2018) to create the first cross-sector database of VAT reforms including announcement dates, and use it to provide the first systematic assessment of announcement effects across many product categories.[4] We find little overall support for 'anticipation' or 'total effect' hypotheses.

Together our results imply that market structure should be an important consideration when reforming VAT. For a government seeking to mobilize revenue through raising VAT (e.g. Saudi Arabia in May 2020), a greater share of the burden of higher taxes will fall on consumers relative to firms for products with higher upstream competition or for products characterized by a wider quality range. For a government using a VAT cut to stimulate consumption (e.g. Germany in June 2020), or to support firm profits, the effects are opposite. Firms will retain more of the VAT cut in higher markups, and consumers will experience smaller price reductions, the less competitive the upstream sector or the narrower the range of product quality.

The rest of this paper proceeds as follows. The next section provides a review of the literature. Section 3 outlines the theoretical motivation, then Section 4 describes the data and outlines the empirical strategy. Section 5 presents the results, and Section 6 addresses their robustness. Section 7 concludes. The Appendix surveys related literature, provides detailed theoretical derivations, and presents additional results and robustness checks.

2 Literature review

A substantial literature exists estimating the effects of specific tax changes. Carbonnier (2007) considers the impact of decreasing VAT on cars and housing repairs in France; Benzarti & Carloni (2017) consider a VAT cut for French restaurants, Mariscal & Werner (2018) consider the impact of differences in VAT for Mexican border cities, and Gaarder (2018) considers a cut in the VAT on food in Norway. A few studies consider effects across multiple countries:

[3] E.g. Baker et al. (2016) note that "fiscal matters, especially tax policy, stand out... as the largest source of policy uncertainty, especially in recent years."

[4] Buettner & Madzharova (2017) also construct a dataset of VAT reforms with announcement dates, but only include specific durable 'white goods' (cookers, dishwashers etc.).

while Benzarti et al. (2017) focus on changes in the VAT on hairdressing in Finland, they also consider all VAT changes across EU member states, and Andrade et al. (2015) consider the impact on French export prices of VAT changes in several destination markets. This paper builds primarily on the work of Benedek et al. (2015), who constructed the core dataset of European VAT rates used in this paper. Like BDKW, in estimating VAT pass-through across a broad range of countries and consumption categories we aim to provide more general results than can be reached in studies of a small number of countries, sectors or reforms. We also use the same identification strategy and a product-country panel which, by comparing products across countries and countries across products, provides better controls than product-specific studies or economy-wide cross-country studies.

To measure the impact of upstream regulation on a sector, we use the *Regimpact* indicator developed by the OECD (Conway & Nicoletti 2006, Égert & Wanner 2016, Koske et al. 2015). This has been widely used to study the impacts of regulation on productivity (Amable et al. 2007, Arnold et al. 2008, Bourlès et al. 2013, Cette et al. 2013, 2014, Copenhagen Economics 2013, European Commission 2007, Havik et al. 2008, International Monetary Fund 2015, Yahmed & Dougherty 2012), and to a lesser extent to study the impacts on competitiveness (Braila et al. 2010) and firms' input sourcing decisions (Di Ubaldo & Siedschlag 2018). These studies generally find a positive effect of deregulation on productivity, competitiveness, and the propensity of firms to purchase inputs rather than source them intra-firm through FDI. To the best of our knowledge the *Regimpact* indicator has not previously been used to investigate VAT pass-through.

Other studies of upstream service sector reform have found substantial downstream effects on firms. Arnold et al. (2016) construct a measure of services liberalization in India, and find a strong positive effect on the productivity of manufacturing firms intensive in the liberalizing services. Bertrand et al. (2007) find similar effects on French manufacturing firms of banking deregulation in the 1980s. Our finding that features of the upstream market have substantial downstream effects also parallels an established result from the trade literature that input tariffs can have major effects in output markets (e.g. Amiti & Konings 2007, De Loecker et al. 2016, Goldberg et al. 2010, Topalova & Khandelwal 2010).

To measure the degree of quality differentiation, we use the 'quality ladder' measure derived in Khandelwal (2010). While this method requires assumptions on the structure on demand, it has the advantage of producing estimates of the quality range for a broad class of consumption categories. In contrast, papers using directly observed quality measures tend to be confined to a limited range of products (e.g. rugs, wine or coffee respectively in Atkin et al. 2017, Chen & Juvenal 2016, Macchiavello & Miquel-Florensa 2017), so cannot be used to study VAT reforms which affect a wide range of products simultaneously.

Several previous studies consider the impact of anticipated fiscal shocks on aggregate economic variables, both in theory and empirically (Bi et al. 2013, Fujiwara & Waki 2019, Mertens & Ravn 2012, 2011, Ramey 2011). To the best of our knowledge this is the first study to consider product-level announcement effects across many different VAT reforms. In using the Tax Policy Reform Database (Amaglobeli et al. 2018) to identify announcement effects of VAT reforms on consumer prices, our paper also parallels the work of Pallan (2019), who considers the impact on stock prices.

3 Theoretical Motivation

We examine the role of market structure and consumer preferences in determining pass-through by considering four specific cases, building on earlier work by Dierickx et al. (1988) and Delipalla & Keen (1992). Consider a good i, with consumer price p_i and producer price $\widetilde{p}_i$ subject to ad valorem tax-exclusive rates τ_i, meaning that $p_i = \widetilde{p}_i(1+\tau_i)$. As is standard, we define the degree of pass-through to the consumer as the proportionate response of the consumer price to an increase in the tax factor:

$$\gamma^i = \frac{\partial \ln p_i}{\partial \ln (1+\tau_i)} \tag{1}$$

We investigate the factors determining γ^i in the following settings. All proofs are in the Theory section in Appendix.

3.1 Imperfect competition in a downstream sector

We consider a single-good market in which there are N producers. We infer the role of greater competition by studying the impact of having more producers. Every firm indexed by n

produces a quantity q_n under the cost function

$$C_n(q_n) = a + c_n q_n + \frac{b}{2} q_n^2 \qquad \text{with } a > 0;\ c_n > 0; \tag{2}$$

where $b < 0$ corresponds to decreasing marginal costs and $b > 0$ corresponds to increasing marginal costs. We examine two different market structures in turn.

First, we consider the case of monopolistic competition where each firm produces a different variety of the good and competes on price. To keep the problem tractable, we assume in this case that all firms are equally productive ($c_n = c$ for all n). Preferences over the different varieties follow the standard Dixit-Stigliz form and we assume that aggregate demand $Q = \left(\int_1^N q_n^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}$ is isoelastic, implying that $q_n = \left(\frac{p_n}{P}\right)^{-\sigma} \frac{A}{P}$, with $A > 0$, the elasticity of substitution across varieties $\sigma > 1$ and P the price index which takes the form $P = \left(\int_1^N p_n^{1-\sigma}\right)^{\frac{1}{1-\sigma}}$.[5] Thus, each firm chooses its price $\widetilde{p}_n$ to maximize profits $\pi_n = \widetilde{p}_n q_n - C(q_n)$ subject to the demand for their variety. Because all firms are identical, the prices they choose are identical and we can drop the subscript n for prices. We also show in the appendix that tax pass-through is the same whether it is computed at the individual or aggregate price level.

Second, we consider a more general case with heterogeneous firms that have different production costs. In this case, there is no differentiation and firms are competing in quantities at a common price $\widetilde{p}$ under Cournot competition as described in Dierickx et al. (1988). Total demand $Q = \sum_n q_n$ is assumed to be isoelastic and such that $p(Q) = A'Q^{-\beta}$, with parameters $A' > 0$ and $\beta > 0$ and such that the demand function is steep enough ($\frac{\partial \widetilde{p}}{\partial q} - b < 0$) and concave enough ($\frac{\partial p}{\partial q} + \frac{\partial^2 p}{\partial q^2} q_n < 0$).[6][7] Each firm n chooses its output q_n independently to maximize profits $\widetilde{p}_n(q_n) q_n - C_n(q_n)$.

[5] As we show in the appendix, this demand function stems from a simple utility maximization problem.

[6] Dierickx et al. (1988) shows that these conditions ensure the existence, stability and uniqueness of the Cournot-Nash equilibrium.

[7] See footnote 5.

Proposition 1 *In the Monopolistic competition and Cournot competition cases, pass-through respectively takes the form*

$$\gamma^{Monopolistic} = 1 - \frac{bA}{(1+\tau)N\widetilde{p}\left(2\frac{\sigma-1}{\sigma}\widetilde{p} - c\right)}\,; \qquad and \tag{3}$$

$$\gamma^{Cournot} = \left[1 + \frac{bA'^{\frac{1}{\beta}}}{(1+\tau)^{\frac{1}{\beta}}(N-\beta)\beta\widetilde{p}^{\frac{\beta+1}{\beta}}}\right]^{-1}. \tag{4}$$

In both cases, pass-through increases with the number of firms N only when $b > 0$, when marginal costs are increasing. Otherwise, pass-through decreases with N if $b < 0$ and is independent of N if costs are linear $b = 0$.

Proxying 'competitiveness' by the number of firms in the market, we thus show that the impact of competition on pass-through depends on the cost functions. For any cost function, lower demand resulting from higher taxes induces producer to scale back production. With increasing marginal costs, a reduction in scale implies some savings on production costs which, in turn, allows for lower producer prices.[8] Greater competition dampens producer costs adjustment. With few large firms with stretched production capacities and increasing marginal costs, a reduction in scale yields large savings. With many smaller firms competing, savings from scaling down are smaller and producers are less able to lower their prices in compensation for higher VAT. Therefore, greater competition with increasing marginal costs implies a greater pass-through.

Conversely, in the case of decreasing marginal costs, the reduction in demand induced by a higher VAT rate has a different effect on producers. Faced with higher marginal costs, producers choose to sell at higher producer prices and pass-through is greater than one ($\gamma > 1$ when $b < 0$). Once again, greater competition dampens producer price adjustments. Thus, greater competition with decreasing marginal costs implies a lower pass-through.

We investigate in the empirical section whether the impact of competition on pass-through is consistent with increasing or decreasing marginal costs.

[8]This can be seen because $\gamma < 1$ when $b > 0$ (see the Theory section in appendix for details).

3.2 Imperfect competition in the upstream sector

We now examine the case of two sectors, with perfect competition in the downstream sector selling the final good and with Cournot competition in the upstream sector. Demand for the final good is characterized by $p_F(Q_F) = A'Q_F^{-\beta}$ and is the same as in the previous case with Cournot competition. Assuming perfect competition in the downstream sector allows us to consider a representative final good producer which maximizes profits $\widetilde{p}_F Q_F - p_I Q_I$ by choosing a quantity Q_F to produce given the input cost function $Q_I = d(1-\rho)Q_F^{\frac{1}{1-\rho}}$ with $0 < \rho < 1$ and $d > 0$. Final good producers take the producer price $\widetilde{p}_F = \frac{p_F}{1+\tau}$ as given.

Solving the final good producer maximization problem to get input demand, we show in the appendix that the demand function is isoelastic and a function of the final good price: $p_I = \widetilde{p}_F d^{\rho-1}(1-\rho)^{\rho} Q_I^{-\rho}$. We impose the same concavity conditions on this function as in the previous case under Cournot competition to ensure the existence and uniqueness of an equilibrium solution.

For the sake of clarity, we assume that inputs Q_I produced in the upstream sector are only consumed by final good producers and that inputs are not taxed (producer and consumer prices are then the same, meaning that $\widetilde{p}_I = p_I$). Each input producer n chooses quantity $q_{I,n}$ independently to maximize profits $\widetilde{p}_I(Q_I)q_{I,n} - C_n(q_{I,n})$ subject to the isoelastic input demand function. As before, upstream firms internalize their impact on total production $Q_I = \sum_n q_{I,n}$ and the cost function follows equation (2). Consequently, operations in the upstream sector are very similar to those described in the single sector case under Cournot competition presented in the previous section.

Proposition 2 *In the 2-sector case with Cournot competition in the upstream sector and perfect competition in the final good sector, pass-through in the final good sector takes the form*

$$\gamma^F = \left[1 + \frac{\rho}{\beta(1-\rho)} + \frac{bd^2(1+\tau)^{-\frac{1+\rho}{\beta(1-\rho)}} A'^{\frac{1+\rho}{\beta(1-\rho)}}}{\beta(N-\rho)\widetilde{p}_F^{\,1+\frac{1+\rho}{\beta(1-\rho)}}} \right]^{-1} \tag{5}$$

Furthermore, the pass-through increases with the number of firms N only when $b > 0$, when marginal costs are increasing. Otherwise, pass-through decreases with N if $b < 0$ and is independent of N if costs are linear $b = 0$.

We obtain the same result as in the previous section. An increase in VAT lowers demand for the final good, and now also reduces demand for upstream inputs. In the case of increasing marginal costs ($b > 0$), a reduction in scale for input producers means lower cost, which are then passed through to input prices. Cheaper input costs allow for lower producer prices in the downstream sector. As in the previous case, greater competition dampens the variation in producer costs in response to VAT rate changes. With more firms competing, production capacities are not overly stretched, implying smaller savings from scaling down, and a lower reduction in producer prices. The results are the same as in the single sector case: pass-through increases (decreases) with competition when marginal costs are increasing (decreasing). We investigate in the empirical section whether the impact of competition in upstream sectors on pass-through is consistent with increasing or decreasing marginal costs.

3.3 Differences in scope for quality in the final good

We now examine a sector in which consumers make 'discrete choices', meaning that they choose at most one of the competing products. There are many varieties indexed by n that differ along a horizontal and a vertical dimension as in Khandelwal (2010).

Horizontal differentiation is assumed to randomly appeal more to some consumers than others and to be costless, implying that all varieties are consumed in equilibrium.[9] Following standard practice in the discrete choice literature, horizontal characteristics denoted ξ_{nk} are assumed to be distributed i.i.d. type-I extreme value with mean zero.

By contrast, vertical differentiation, i.e. 'quality', is costly to produce but is regarded by all consumers as superior: holding prices fixed, all consumers would prefer higher quality objects. Each consumer k knows her valuation of horizontal (ξ_{nk}) and vertical (λ_n) characteristics of every variety and chooses the variety n that gives her the highest indirect utility.

$$V_{nk} = \delta_n + \xi_{nk}, \qquad \text{with } \delta_n \equiv \left(\theta\lambda_n^{\psi} - p_n^{\psi}\right)^{1/\psi} \qquad \text{and } \psi < 1 \tag{6}$$

where δ_n represents the mean consumer valuation of variety n. δ_n increases with quality

[9] Costless horizontal differentiation means that varieties differ on some characteristics, like color, that appeal more to some consumers than others while having no impact on production costs and no relation to prices.

and decreases with price.[10] The parameter ψ controls the degree of substitution between price and quality, with higher ψ indicating the two characteristics are more easily substituted – i.e. consumers are happy to sacrifice quality for a lower price – while a lower, possibly negative, ψ indicates greater complementarity. In other words and as we show in the appendix, the marginal willingness to pay for quality increases with the quality-price ratio when ψ is positive while it decreases with the quality-price ratio when ψ is negative. Greater values of the parameter θ indicate a longer 'quality ladder', as defined in Khandelwal (2010), and imply that firms have incentives to produce higher quality.

Each firm n produces a variety subject to a marginal cost function that is increasing with quality, $w + \frac{\lambda_n}{Z}$. Under the distributional assumption, the market share of variety n is given by the familiar logit formula $m_n = \frac{e^{\delta_n}}{\sum_m e^{\delta_m}}$. We assume that the market is characterized by monopolistic competition with a sufficiently large number of firms so that no one firm can influence the market equilibrium prices and qualities. A firm n maximizes profits by choosing the price and quality.

$$\max_{\widetilde{p}_n, \lambda_n} \left[\widetilde{p}_n - w - \frac{\lambda_n}{Z} \right] \frac{e^{\delta_n}}{\sum_m e^{\delta_m}} \tag{7}$$

Proposition 3 *In the case of discrete choices with monopolistic competition, pass-through takes the form*

$$\gamma = 1 + \frac{-\psi/(1-\psi)}{\theta^{\frac{1}{\psi-1}} \left(\frac{Z}{1+\tau}\right)^{\frac{\psi}{\psi-1}} - 1} - \frac{1}{1 - \theta^{\frac{1}{1-\psi}} \left(\frac{Z}{1+\tau}\right)^{\frac{\psi}{1-\psi}} + w(1+\tau)\left(1 - \theta^{\frac{1}{1-\psi}} \left(\frac{Z}{1+\tau}\right)^{\frac{\psi}{1-\psi}}\right)^{\frac{1}{\psi}}} \tag{8}$$

Furthermore, the pass-through decreases with the length of the quality ladder θ when $0 < \psi < 1$, in the substitution case when the marginal willingness to pay for quality increases with the quality-price ratio. Conversely, pass-through increases with θ when ψ is negative enough, for example when $\psi < -\frac{1}{w(1+\tau)}$

Thus, the effect of quality on VAT pass-through depends on ψ, the degree of substitution-complementarity between consumer valuations of price and quality. In the substitution case when $\psi > 0$ (as in Khandelwal (2010)), for a given increase in consumer price resulting from a tax hike, consumers prefer a mitigation in the price increase at the expense of lower

[10] Equation (6) is a generalization of the specification in Khandelwal (2010) which would be obtained when $\psi \to 1$.

quality. Producers respond accordingly and pass-through is lower. The opposite is true in the complementarity case when $\psi < 0$ is negative enough: consumers prefer to tolerate a larger price increase and to be compensated with relatively higher quality. Those effects are magnified by the scope for quality, or 'quality ladder', θ. Therefore, pass-through decreases with the quality ladder in the substitution case, while the opposite is true in the complementarity case. We investigate in the empirical section whether the effect of the scope for quality on pass-through is consistent with price-quality complementarity or substitution.

3.4 Early Announcement

Early announcement can, in theory, generate anticipation and smoothing effects, i.e. an early and/or prolonged increase in pass-through. On the supply side, the presence of menu costs or Calvo pricing (Calvo 1983) encourages firms to smooth the price response to an announced VAT change to save on adjustment costs. As discussed in Buettner & Madzharova (2017), for durables there is an extra effect through the demand channel: consumers aware of a future tax fall will defer consumption, reducing demand before the reform and hence lowering prices. Conversely, for an anticipated tax hike, consumers raise pre-reform demand, thereby contributing to higher prices before the rate increase – as observed before the German VAT increase in January 2007 (Danninger et al. 2008). Lastly, in a situation of information overload and rational inattention (Sims 2003), early announcement may increase the salience of a particular reform to consumers and firms, increasing total pass-through. We investigate these 'anticipation' and 'total effects' in the empirical section.

4 Data and Empirical Specification

We use data on monthly VAT rates across European countries and consumption categories constructed by BDKW from the European Commission publication *VAT Rates Applied in the Member States of the European Union* and from additional publications by the International Bureau for Fiscal Documentation. The distribution and characteristics of VAT reforms across countries are summarized in Tables B.1 and B.2 in the Appendix. All the countries studied are in the Eurozone, reducing distortions due to differing exchange rates or monetary policies.[11]

[11] For instance, the influence of common monetary policy changes on pass-through will be removed by time fixed effects in the regressions.

Data on monthly prices are from Eurostat's Harmonized Index of Consumer Prices, categorized according to the 'Classification of Individual Consumption According to Purpose' (COICOP). We follow BDKW in limiting our sample to those categories for which prices are sufficiently market-driven – excluding, for example, rental accommodation, electricity and healthcare.

We measure the competition-friendliness of regulation in upstream non-manufacturing industries using the *Regimpact* indicator from the Organization for Economic Co-operation and Development (Conway & Nicoletti 2006, Égert & Wanner 2016, Koske et al. 2015). This uses country-specific input-output weights w_{jk} to combine survey-based measures of anti-competitive regulation in several upstream non-manufacturing industries ($REGNMI_{jt}$), producing a measure of the degree of regulation affecting final output sectors:[12][13]

$$Regimpact_{ikt} = \sum_{j=1}^{J} REGNMI_{jt} \cdot w_{jk} \tag{9}$$

where k denotes the output sectors of interest and j denotes upstream non-manufacturing sectors. The distribution in product market regulation across consumption categories is shown in Figure B.1 in the Appendix. The trends in regulation are shown in Figure B.3 in the Appendix; in general regulation became much more pro-competitive over the period.

We construct two measures of market competitiveness in the downstream sectors affected by the VAT change, using trade data from UN Comtrade.[14] Firstly, we use the sum of imports and exports over total consumption as a measure of openness to trade:

$$Openness_{ikt} = \frac{Imports_{ikt} + Exports_{ikt}}{Consumption_{ikt}} \tag{10}$$

[12] We use the 'wide' version of the *Regimpact* indicator, which contains the broadest range of upstream non-manufacturing industries. The precise industries that it covers, and the categories upon which they are scored to generate the aggregate REGNMI indicator, are shown in Figure B.4 in the Appendix. We use the version with country-specific weights to account for differences in input-output patterns across countries.

[13] The lower the score, the more competition-friendly the regulatory environment. For instance, one question on 'entry regulation' for the electricity industry sub-indicator is: "What is the minimum consumption threshold that consumers must exceed in order to be able to choose their electricity supplier?" (Conway and Nicoletti, 2006). The lack of any threshold scores zero, a threshold less than 250 gigawatts scores one, 250-500 gigawatts scores two, etc.

[14] We use the BACI refinement of the Comtrade database, compiled by CEPII, which cleans and harmonizes the data through a series of procedures described in Gaulier & Zignago (2010).

where consumption data are drawn from Eurostat at the 3-digit sector level (rather than the 4-digit level for which VAT rates are available). Secondly, we construct a Herfindahl-Hirschman Index based on import origins to proxy for market concentration:

$$ImportConcentration_{ikt} = \sum_{c=1}^{N} s_{ickt}^2 \tag{11}$$

where:

$$s_{ickt} = \frac{M_{ickt}}{\sum_{c=1}^{N} M_{ickt}} = \frac{\text{Imports into } i \text{ from } c}{\text{Total imports into } i} \tag{12}$$

Both of these are imperfect measures of competitiveness, but serve in the absence of relevant firm-level data. Assuming that firms are evenly distributed across producing countries, a high degree of concentration observed among import origins is a necessary consequence of high market concentration among firms, though not sufficient to guarantee it.[15]

We use the scope for product differentiability derived in Khandelwal (2010). The scope for quality, or 'quality ladder', is backed out from price and quantity data. High market share conditional on price suggests that a product is high quality and long quality ladders correspond to products with a large dispersion in estimated quality. Khandelwal constructs his product-level measure using trade data on goods, which means 'quality ladder' estimates are only available for the subset of good industries and do not vary across countries.[16] This prevents us from using the full price and VAT dataset, and some controls, with this measure – so we also perform several robustness checks to verify that our results are not driven by the restrictions related to these data limitations. The distribution of quality scope across consumption categories is shown in Figure B.2 in the Appendix.

We standardize all four measures (*Regimpact*, trade openness, import concentration and quality ladder length) so that their impacts are comparable. The four measures are only weakly correlated, as shown in Table B.3 in the Appendix. We also match VAT reforms in the BDKW

[15] For instance, a market dominated by a single foreign firm producing in one country would have $ImportConcentration_{ikt} = 1$, yet having $ImportConcentration_{ikt} = 1$ is also compatible with there being substantial competition in the supply of the good – if all those firms competing are located in the same country.

[16] Given the lack of quantity data over our whole period, we use only cross-sectional product-wise variation in quality.

data to the IMF's new Tax Policy Reform Database (Amaglobeli et al. 2018), which contains announcement dates. Summary statistics for those VAT changes that we can match to announcement dates are shown in Appendix Table B.5. Lastly, we use consumption data from Eurostat to weight observations by their consumption share, and total value added from EU KLEMS in a robustness check. Overall, we use an unbalanced panel of approximately 110k observations spanning January 1998 to December 2013. The variables are summarized in Table B.4 in the Appendix.

We build on the specification in BDKW and estimate pass-through from VAT changes to price rates by regressing country-product prices on taxes:

$$\Delta \ln(p_{ikt}) = \beta_0 + \sum_{j=-6}^{6} \beta_{1j} \cdot \Delta \ln(1 + \tau_{ikt+j}) \tag{13}$$

$$+ \sum_{j=-6}^{6} \boldsymbol{\beta}_{2j} \cdot \Delta \ln(1 + \tau_{ikt+j}) \cdot \mathbf{X}_{ikt} \tag{14}$$

$$+ \boldsymbol{\beta}_3 \cdot \mathbf{X}_{ikt} + \varphi_{it} + \varphi_{kt} + \varphi_{ik} + \epsilon_{ikt} \tag{15}$$

where p_{ikt} denotes the price of product k in country i in month t and τ_{ikt+j} represents the VAT rate in country i for product k in month t. The coefficients of interest β_{1j} capture the average pass-through across products at different horizons j, while $\boldsymbol{\beta}_{2j}$ measures deviations from the mean pass-through across several covariates. Specifically, the sequences of β_{1j} and $\boldsymbol{\beta}_{2j}$ capture the magnitude of pass-through adjustments at different times around the reform dates, i.e. at a number of months j before and after the reform date.[17] The coefficients γ_{it}, ϕ_{kt} and φ_{ik} are country-time, product-time, and country-product fixed effects, and ϵ_{ikt} is the error term.[18] $\mathbf{X}_{ikt}$ denotes country-product-time covariates of interest, specifically product market regulation, quality range, openness to trade, and import concentration. In our main specification we de-seasonalize and de-trend all price indices, weight observations by their consumption share, and cluster standard errors at the country-product level to account for possible autocorrelation in the error term.

[17] In this paper we focus on the medium-run, i.e. a 12-month window centered on the date of the reform, as we do not find significant effects outside this window.

[18] We also report results using separate country, product and time fixed effects, and no fixed effects, as in BDKW. Our preferred specification includes all three interaction fixed effects, as shown, since this accounts for all industry trends and country-specific macroeconomic conditions.

To investigate the effects of early announcement, we run a similar specification with the change in VAT also interacted with a dummy for whether the announcement-to-implementation lag for a particular reform is above or below the median. In this case the interaction of the dummy with the sum of pre-reform coefficients $\sum_{j=1}^{6} \boldsymbol{\beta}_{2j}$ tests for an anticipation effect, and the interaction of the dummy with the cumulation of all the $\boldsymbol{\beta}_{2j}$ terms across the whole window $j \in \{-6, ..., 6\}$ tests for a total effect.

5 Results

This section presents our three main results – on product market regulation, quality scope and early announcement. The subsequent section outlines various robustness checks, while the Appendix includes additional results, for example on the heterogeneity of announcement effects.

5.1 Product market regulation

Table 1 shows results from the main specification in the full dataset; column (1) shows results with no fixed effects, column (2) shows results with individual fixed effects, and column (3) uses interaction fixed effects. The first four estimates correspond to β_1 in the main estimating equation above – they estimate the relationship between changes in the VAT rate and changes in prices, i.e. baseline pass-through. 'Pre-Reform' refers to the total effect across the six months preceding the VAT change, and 'Post-Reform' refers to that across the six months afterwards; 'Contemporaneous' refers to effects in the month of the reform, and 'Total' is the sum of effects over the whole window. The remaining estimates correspond to different elements of $\boldsymbol{\beta}_2$, and in turn reflect the impact of variation in the elements of $\boldsymbol{X}_{ikt}$ – specifically, $Openness_{ikt}$, $ImportConcentration_{ikt}$ and $Regimpact_{ikt}$ – on pass-through.[19]

Average baseline pass-through of a VAT rise to prices is 31% in column (3).[20] As in BDKW's

[19]Pre-Reform, Contemporaneous, Post-Reform and Total effects are estimated for each of Openness, Concentration and *Regimpact*. Across the first three the lowest p-value for either Openness or Concentration is 0.236, for the Post-Reform effects of Openness in model (1), so these rows are omitted from the results tables for brevity. Indeed, under the tighter fixed effects of model (3) the strongest effect corresponds to Pre-Reform Concentration, with a p-value of 0.336 – i.e. only extremely weak evidence of any effect.

[20]This is close to BDKW's main estimate of 25%; it differs slightly because (i) we use only the subset

estimates, this effect is almost entirely driven by the contemporaneous pass-through effect – i.e. by the impact on prices in the month that the reform is introduced. A one standard deviation fall in *Regimpact* (i.e. a one standard deviation rise in the competition-friendliness of upstream regulation, equivalent to the gap between Italy and relatively competitive Austria in 2013) raises pass-through by a further 18 percentage points, a 56 percent increase in pass-through.

These effects are more significant and more important than the other supply-side competition measures of openness to trade and import concentration. To the extent that openness and concentration proxy for the competitiveness of the downstream sector, this suggests that the theoretical mechanism outlined in section 3.2 is stronger than that in section 3.1. As discussed further in the Appendix, this result aligns with findings elsewhere that upstream reforms affecting inputs can have substantial downstream effects (e.g. Amiti & Konings 2007, Arnold et al. 2016, Bertrand et al. 2007). A full analysis of the conditions under which such upstream effects can amplify further downstream, rather than decay into insignificance, is beyond the scope of this paper (for details, see e.g. Acemoglu et al. 2012).

Figure 1 plots the cumulated values of the estimated coefficients β_{1r} for the 12 months surrounding a VAT change for the specification with the most complete set of fixed effects. The dashed line shows pass-through over time for a consumption category with exactly average levels of upstream product market regulation, openness to trade, and market concentration. There is little pass-through prior to the change, then most of the total effect comes within the first month of the reform. The black line illustrates the marginal impact of upstream regulation on these dynamics: it plots the marginal impact on pass-through of having upstream regulation that is one standard deviation more competition-friendly than the average. Again, most of the marginal impact occurs in the month of the VAT reform, with some additional impact in the six months after the reform. This is consistent with the purchaser-supplier relationships described in section II adjusting to the change reasonably quickly. The extent to which forewarning of the reform speeds up such processes is examined in section 5.3 below.

Reforms over the last thirty years have substantially increased the competition-friendliness of regulation in European product markets (Égert & Wanner 2016). The overall median

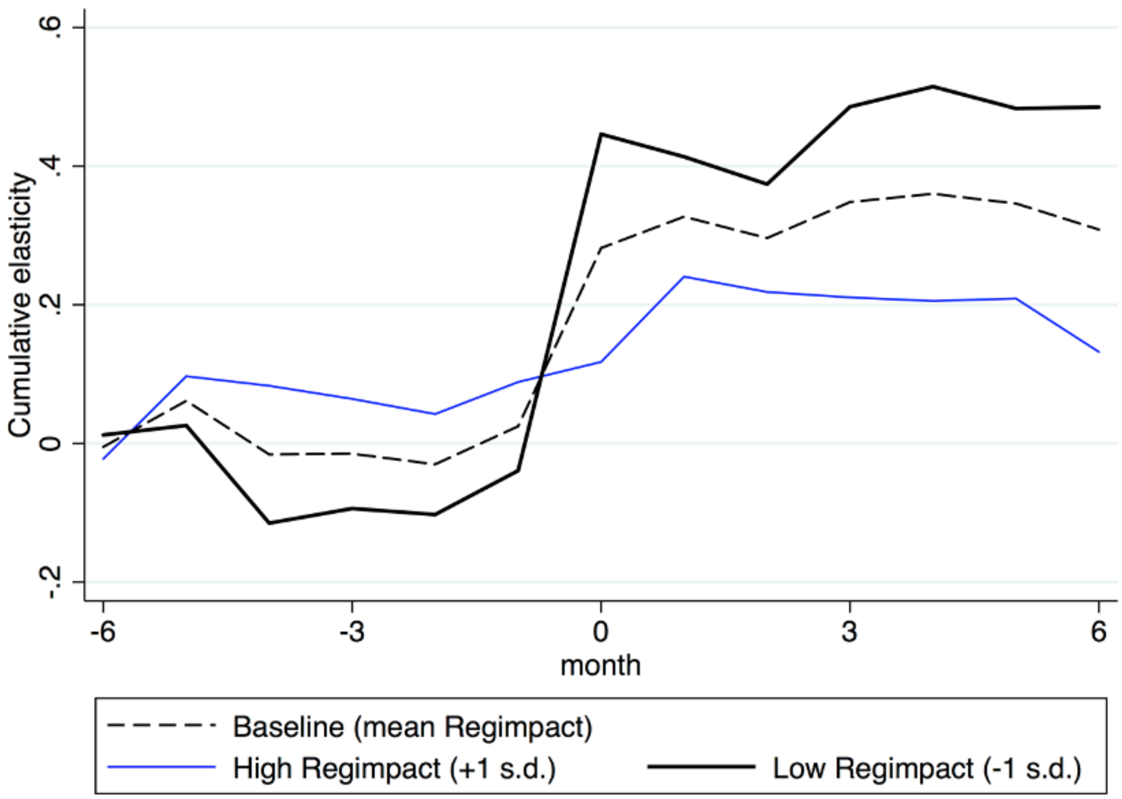
of their observations for which measures of regulation, openness and concentration are available, and (ii) they sum over a 24-month window around the reform.

Table 1: Estimates of pass-through heterogeneity

		Dependent variable: change in log prices		
		No FEs	Individual FEs	Interaction FEs
Baseline β_1:	Pre-Reform	0.193	0.181*	0.0247
	– i.e. $\sum_{j=1}^{6} \beta_{1j}$	(0.152)	(0.056)	(0.640)
	Contemporaneous	0.331***	0.325***	0.257***
	– i.e. β_{10}	(0.000)	(0.000)	(0.001)
	Post-Reform	0.156	0.114	0.0267
	– i.e. $\sum_{j=-6}^{-1} \beta_{1j}$	(0.142)	(0.226)	(0.712)
	Total	0.681***	0.620***	0.309***
	– i.e. $\sum_{j=-6}^{6} \beta_{1j}$	(0.000)	(0.000)	(0.001)
Openness:	Total	0.638	0.522	0.00263
		(0.172)	(0.377)	(0.995)
Concentration:	Total	-0.0209	-0.00425	-0.0351
		(0.896)	(0.977)	(0.754)
Regimpact:	Pre-Reform	-0.0553	-0.0188	0.0639
		(0.430)	(0.724)	(0.289)
	Contemporaneous	-0.157***	-0.180***	-0.228***
		(0.005)	(0.001)	(0.002)
	Post-Reform	-0.0172	-0.00685	-0.0123
		(0.798)	(0.897)	(0.783)
	Total	-0.229**	-0.206**	-0.177*
		(0.041)	(0.038)	(0.052)
FEs		None	i,k,t	it,kt,ik
Clustering		None	ik	ik
N		100,983	100,983	100,983

Notes: p-values in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Estimates are the sum of the price elasticity coefficients with respect to tax changes over each period. Prices are de-trended and de-seasonalized, and observations are weighted by their share of national consumption. *Regimpact*, openness and market concentration are standardized so the coefficients can be interpreted as the impact on pass-through of a one-standard-deviation rise in the regressor. Pre-Reform, Contemporaneous and Post-Reform effects are also estimated for Openness and Concentration, but are not significant so omitted for conciseness.

FIGURE 1: Cumulative effect of upstream regulation on pass-through



Notes: This graph shows cumulative baseline pass-through and the impact upon this of upstream regulation. The black (blue) lines show cumulative pass-through in a country-product pair with regulation that is exactly one standard deviation more (less) competition-friendly.

value of the *Regimpact* measure since 1999 is shown in Figure 2, while the trends in each country and consumption category are shown in Figure B.3 in the Appendix. A back-of-the-envelope calculation takes the observed changes in the *Regimpact* index for each country-product category over the observed period and multiplies them by the coefficient on the VAT-PMR interaction term in Table 1. The smoothed distribution of these estimated changes in VAT pass-though is shown in Figure 3. Because regulations were loosened almost everywhere, our results imply that VAT pass-through increased practically everywhere for all products. The median estimated impact of the large increase in the competition-friendliness of regulation since 1999 is an increase in pass-through of approximately 21 percentage points, while the vast majority of the distribution has an increase in pass-through of more than 10 percentage points. This is a direct extrapolation of our results without proper identification, but this illustrates that changes in upstream regulation are likely to have substantially affected the consequences of most VAT reforms in recent history.

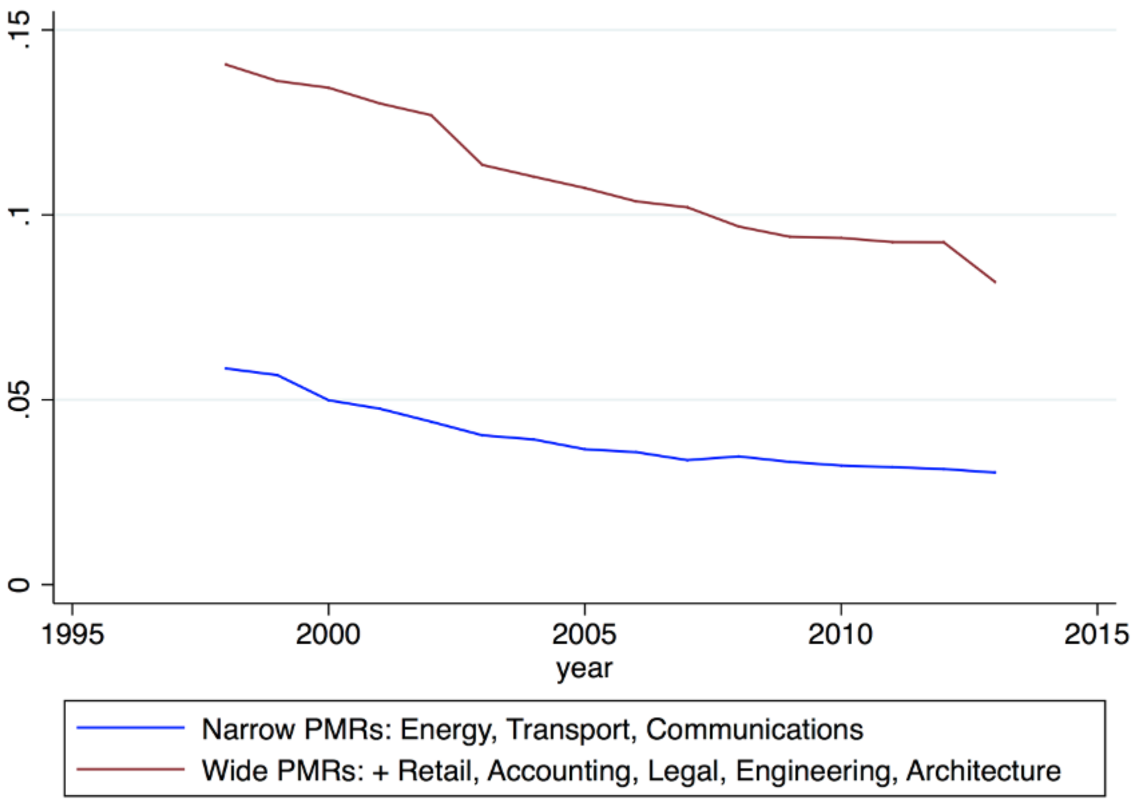
5.2 Scope for quality

Table 2 repeats the analysis for those products for which measures of the scope for quality are available.[21] Since the 'quality ladder' data only vary across products, not across countries, we cannot include product-time fixed effects as these would remove all variation. We therefore include only country-product, country-time, product and time fixed effects in the 'Interaction FEs' quality specification. This slight loosening has little impact on the *Regimpact* results, which remain consistent across columns, suggesting that the 'lighter' specification still provides informative estimates for the effect of quality range.

The results in Table 2 show that a one standard deviation increase in the length of the 'quality ladder' of a product can raise pass-through by more than 40 percentage points. This fits the theory in section 3 in the case that demand for quality is relatively more important to consumers when prices are higher – i.e. in the 'complementarity' case. In this scenario, firms opt to pass on more of a VAT rise rather than reduce quality to dampen the impact on prices; the greater the scope for quality differentiation, the stronger this effect, so the higher is pass-through.

[21] All variables are re-standardized for the regressions on this smaller quality-inclusive sample, so that each estimated coefficient retains the interpretation as 'the impact on pass-through of a one-standard deviation rise in the variable'.

Figure 2: Median index of regulation over time



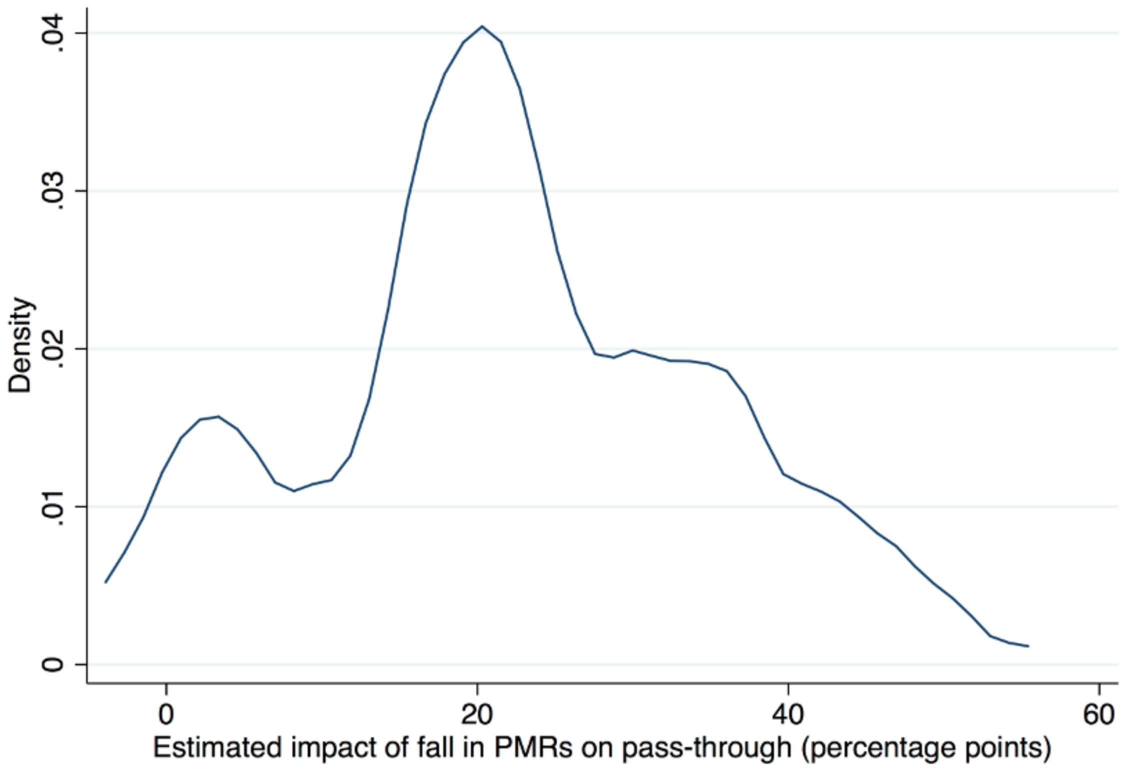
Notes: This graph shows the trends over time in the median value, across all countries and products, of the 'wide' and 'narrow' *Regimpact* indices of product market regulation. A lower value of the index reflects a more competition-friendly regulatory stance in upstream non-manufacturing industries.

Considering Table 1 and Table 2 together, the regulation and quality effects have comparable magnitudes, while the regulation effect is somewhat more robust across different specifications. Figure B.5 in the Appendix below shows the dynamics of the quality scope effect. While there is again a significant effect in the month of the reform, the effect also continues to grow over the six months following the reform.

5.3 Early announcement

To investigate the role of early announcement empirically, we consider the dynamics of those cases where we can match a VAT change to an announcement date in the TPRD. We create

Figure 3: Distribution of estimated impact of regulation on pass-through



Notes: This graph shows the smoothed distribution across country-product categories of the estimated increase in pass-through resulting from changes in regulation between 1999 and 2013. It applies the main estimate from Table 1 to the observed change in the *Regimpact* indicator across the period observed, using only those country-product categories with observations spanning at least ten years.

Table 2: Estimates of pass-through heterogeneity, including quality range

		Dependent variable: change in log prices		
		No FEs	Individual FEs	Interaction FEs
Baseline β_1:	Pre-Reform	0.191	0.226**	0.116
		(0.565)	(0.045)	(0.429)
	Contemporaneous	0.234	0.201**	0.0169
		(0.192)	(0.019)	(0.891)
	Post-Reform	-0.0381	-0.000174	-0.067
		(0.889)	(0.999)	(0.468)
	Total	0.387	0.427***	0.066
		(0.384)	(0.009)	(0.764)
Openness:	Total	-0.573	-0.409	-0.551
		(0.572)	(0.485)	(0.433)
Concentration:	Total	-0.152	-0.202	-0.153
		(0.692)	(0.220)	(0.398)
Regimpact:	Pre-Reform	-0.0558	-0.0466	0.122
		(0.676)	(0.559)	(0.450)
	Contemporaneous	-0.212***	-0.278***	-0.444***
		(0.003)	(0.000)	(0.003)
	Post-Reform	-0.0853	-0.0897**	-0.0945*
		(0.461)	(0.016)	(0.075)
	Total	-0.353*	-0.414***	-0.416**
		(0.067)	(0.002)	(0.029)
Quality range:	Pre-Reform	-0.0838	-0.0996	-0.0368
		(0.829)	(0.384)	(0.754)
	Contemporaneous	0.213	0.228**	0.256***
		(0.326)	(0.041)	(0.009)
	Post-Reform	0.268	0.256**	0.268***
		(0.401)	(0.033)	(0.003)
	Total	0.397	0.385**	0.487**
		(0.440)	(0.025)	(0.010)
FEs		None	i,k,t	it,k,t,ik
Clustering		None	ik	ik
N		49,598	49,598	49,598

Notes: p-values in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Estimates are the sum of the price elasticity coefficients with respect to tax changes over each period. Prices are de-trended and de-seasonalized, and observations are weighted by their share of national consumption.

a dummy *AnnouncedEarly* that equals one if the lag between announcement and implementation is greater than the median implementation lag of 32 days. Interacting this with the pass-through term in the baseline dynamic regression finds that there is no significant anticipation effect in the six months before the reform, as shown in Table 3, though there may be some small cumulative effect over the whole one year window. The full dynamics are illustrated in Figure 4.

To check whether this null result is driven by the above/below median specification, in Table B.7 in the Appendix we also present results using a continuous implementation lag variable. We find that an additional month of implementation lag is weakly associated with up to 6% additional total pass-through, but there is again no significant anticipation effect. Anticipation effects through the demand channel may be particularly strong for durables, as noted in section 3.4, since they offer greater opportunity to expedite or defer consumption in response to future price changes. We therefore also split the results between durables and non-durables, shown in Table B.8 in the Appendix, and again find no evidence for anticipation effects.[22] Lastly, a positive result may be obscured by variation in market competitiveness, which we know plays a role as discussed above. Therefore in Table B.9 in the Appendix we also include regulation, quality, openness and concentration in the specification, but again find no evidence for announcement effects.

Overall, while there is some weak evidence that reforms announced earlier tend to have slightly larger pass-through, there is no strong support for either the 'anticipation' or 'total effect' hypotheses.[23] We consider this null result a useful and constructive contribution to the literature. To the best of our knowledge this is the first study to systematically match broad country-product VAT reform data to announcement dates – and thus we are able to examine a potential 'missing variable' in important works such as BDKW and Benzarti et al. (2017). Our null result thus reinforces the findings of these papers, by suggesting that, in aggregate, announcement effects are unlikely to be playing a substantial confounding role.

[22]This contrasts, for instance, with the work of Buettner & Madzharova (2017), who find a large anticipatory demand effect for eight categories of 'white goods' (e.g. dishwashers, refrigerators). Our results likely differ due to the broader range of goods in our dataset – we include other durables such as carpets, furniture, IT equipment, jewellery etc.

[23]There is, however, substantial heterogeneity across reforms, as discussed in Appendix B.2.

Table 3: Impact of early announcement on pass-through

		Dependent variable: change in log prices		
		No FEs	Individual FEs	Interaction FEs
Baseline:	Pre-Reform	0.163*	0.171*	0.0571
		(0.0885)	(0.0818)	(0.466)
	Contemporaneous	0.244**	0.214*	0.0848
		(0.017)	(0.0541)	(0.527)
	Post-Reform	0.0532	0.0632	-0.0377
		(0.546)	(0.388)	(0.443)
	Total	0.460***	0.448**	0.104
		(0.005)	(0.0272)	(0.375)
Announced Early:	Pre-Reform	-0.0633	-0.051	-0.00404
		(0.853)	(0.748)	(0.979)
	Contemporaneous	0.0609	0.0794	0.133
		(0.737)	(0.573)	(0.408)
	Post-Reform	0.247	0.12	0.208
		(0.326)	(0.593)	(0.161)
	Total	0.244	0.149	0.337*
		(0.589)	(0.663)	(0.0646)
# of VAT changes:		564	564	564
FEs		None	i,k,t	it,kt,ik
Clustering		None	ik	ik
N		100,983	100,983	100,983

Notes: p-values in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Estimates are the sum of the price elasticity coefficients with respect to tax changes over each period. Prices are de-trended and de-seasonalized, and observations are weighted by their share of national consumption.

6 Robustness Checks

To reduce the influence of regulatory outliers, Table B.10 in the Appendix replaces *Regimpact* with *RegimpactHML*, which takes value 1 if the observation is in the top quartile of the *Regimpact* distribution, value -1 if in the bottom quartile, and zero otherwise. Results remain similar, with a strong negative relationship between *RegimpactHML* and pass-through.

Secondly, we check whether pass-through heterogeneity depends on the direction of the VAT change, following recent work on asymmetric pass-through (e.g. Benzarti et al. 2017, Carbonnier 2007, Politi & Mattos 2011). Pass-through heterogeneity for increases and decreases are estimated by $\boldsymbol{\beta}_{2j}^{(inc)}$ and $\boldsymbol{\beta}_{2j}^{(dec)}$ in:

$$\begin{aligned}\Delta \ln(p_{ikt}) = \beta_0 &+ \sum_{d\in\{inc,dec\}} \sum_{j=-6}^{6} \beta_{1j}^{(d)} \cdot \Delta \ln(1+\tau_{ikt+j}^{(d)}) \\ &+ \sum_{d\in\{inc,dec\}} \sum_{j=-6}^{6} \boldsymbol{\beta}_{2j}^{(d)} \cdot \Delta \ln(1+\tau_{ikt+j}^{(d)}) \cdot \mathbf{X}_{ikt} \\ &+ \boldsymbol{\beta}_3 \cdot \mathbf{X}_{ikt} + \varphi_{it} + \varphi_{kt} + \varphi_{ik} + \epsilon_{ikt} \end{aligned} \tag{16}$$

Results comparing pass-through across products impacted differently by regulation are shown in Table B.11 in the Appendix. The previous literature has found evidence for greater price rigidity with respect to decreases than increases; however, like BDKW, we find little evidence of this in our data – the final column of Table B.11 show few significant differences between the coefficients on increases and decreases. As discussed in BDKW, the mostly insignificant differences are likely due to substantial heterogeneity across product categories in our dataset, without direct association with the reform type (a VAT hike or cut).

Table B.12 in the Appendix repeats this exercise for those observations with quality data. In this case, greater pass-through for products with a longer 'quality ladder' as estimated in section 5.2 appears to be essentially driven by reforms with VAT increases. According to our theoretical framework, the result would suggest that producers respond to a VAT hike by increasing quality, while they choose to leave quality unchanged in the case of VAT cuts.

Thirdly, we use a similar method to investigate whether pass-through varies with the business cycle. We use recession indicators from the OECD (Federal Reserve Bank of St. Louis 2020, OECD 2020), constructed by using statistical methods to identify turning points in the time series of industrial output and GDP. We run:

$$\Delta \ln(p_{ikt}) = \beta_0 + \sum_{d\in\{exp,rec\}} \sum_{j=-6}^{6} \beta_{1j}^{(d)} \cdot \Delta \ln(1+\tau_{ikt+j}^{(d)}) \tag{17}$$

$$+ \sum_{d\in\{exp,rec\}} \sum_{j=-6}^{6} \boldsymbol{\beta}_{2j}^{(d)} \cdot \Delta \ln(1+\tau_{ikt+j}^{(d)}) \cdot \mathbf{X}_{ikt} \tag{18}$$

$$+ \boldsymbol{\beta}_3 \cdot \mathbf{X}_{ikt} + \varphi_{it} + \varphi_{kt} + \varphi_{ik} + \epsilon_{ikt} \tag{19}$$

where $\beta_{1j}^{(rec)}$ and $\beta_{1j}^{(exp)}$ reflect baseline pass-through in recessionary and expansionary periods respectively, and $\boldsymbol{\beta}_{2j}^{(rec)}$ and $\boldsymbol{\beta}_{2j}^{(exp)}$ reflect heterogeneity likewise. The results are shown in Table B.13 in the Appendix. We find some evidence that pass-through effects are stronger in expansions, possibly because prices are more flexible when inflation is higher, but ultimately cannot reject equality of pass-through coefficients across expansionary/contractionary periods.

Lastly, in additional specifications (available on request) we allow for differential effects of regulation and quality across types of VAT change – specifically standard rate changes, reduced rate changes and reclassifications, as discussed in detail in BDKW. However, with current data we cannot make clear inferences about the triple interaction between reform, regulation/quality and reform-type, as our results may simply be driven by the composition of reforms in our dataset. For instance, the vast majority of reforms in our data our standard rate changes, affecting relative standard errors in estimates across the varieties. The average sizes of the reforms also vary substantially across type, as shown in Table B.5, which could affect the estimated coefficients if the relationship between reform size and pass-through is non-linear. We therefore focus on the pooled effects, but also note that Figure 2 of BDKW shows similar effects across reform types – particularly once the reform is introduced, i.e. in the period for which we find regulation and quality to be important.

7 Conclusion

This paper investigates the role of market structure and timing in pass-through heterogeneity. We extend existing theory by modelling four different settings in which market competitiveness can influence pass-through. We test these relationships empirically using a consumption panel across 14 Eurozone countries, and find that upstream product market regulation and quality have a substantial impact – both in absolute terms and relative to other market characteristics. Our results indicate that pass-through to consumer prices is greater the more competitive the upstream sector or the wider the quality range of the taxed product.

Extending such analysis beyond pricing behaviour – e.g. to direct observation of firm markups and marginal costs – is likely to be a fruitful area for future research. We model imperfect competition in upstream and downstream sectors independently and in a partial equilibrium framework, so future work could also extend the theory to a GE setting – allowing for broader linkages between sectors.

The substantial loosening in regulations to encourage greater competition in upstream sectors at the beginning of the century suggests that there has been a substantial decrease in pass-through in recent history. We also provide the first systematic evidence on 'fiscal forward guidance' with respect to VAT reforms, finding that early announcement is unlikely to have large anticipation or total effects.

Together our results are relevant for governments considering VAT reforms with the view of stimulating demand, supporting supply or protecting either side of the market. Because pass-through affects whether supply or demand is more affected by a VAT reform (Weyl & Fabinger 2013), policy-makers should factor in market characteristics. A greater or smaller VAT rate change may be needed to achieve a certain price variation objective depending on market characteristics. In the cases where pass-through is such that producer or consumer prices are unresponsive to VAT change, policymakers willing to achieve some targeted support could look for more cost-effective instruments than VAT changes.

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A Theoretical Appendix

We examine the four separate case studies presented in the main text one at a time. For every case, we find it is convenient to use an expression of the degree of pass-through based on producer prices that can be derived from the definition (1)

$$\begin{aligned}\gamma - 1 &= \frac{\partial \ln p}{\partial \ln \widetilde{p}}.\frac{\partial \ln \widetilde{p}}{\partial \widetilde{p}}.\frac{\partial \widetilde{p}}{\partial \tau}.\frac{\partial \tau}{\partial \ln (1+\tau)} - 1 \\ \gamma - 1 &= \frac{\partial \ln \widetilde{p}}{\partial \tau}.\frac{(1+\tau)}{\widetilde{p}} \qquad (20)\end{aligned}$$

A.1 Monopolistic Competition in the Downstream Sector

We focus on a good with horizontal differentiation where each of the N firm in this market sells a quantity q_n of its own variety at a price p_n. Preferences over the different varieties follow the standard Dixit-Stigliz form and we assume that aggregate demand $Q = \left(\int_1^N q_n^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}$ with $\sigma > 1$ is associated with price index P which takes the form $P = \left(\int_1^N p_n^{1-\sigma}\right)^{\frac{1}{1-\sigma}}$. We assume that there are other goods that we represent with an outside good Q_o and its price P_o. A representative consumer chooses consumption q_n and Q_o to buy to maximize a CES utility function

$$U = \left(aQ^{1-\beta} + (1-a)Q_o^{1-\beta}\right)^{\frac{\nu}{1-\beta}} \qquad (21)$$

with parameters $1 > a > 0$, $\nu > 0$, $1 > \beta > 0$ and under the budget constraint $\int_1^N p_n q_n + P_o Q_o = I$ where I is aggregate income.

The first order conditions (FOC) of the consumer problem are:

$$\begin{aligned}\nu U^{\frac{\nu/(1-\beta)-1}{\nu/(1-\beta)}} aQ^{\frac{(1-\beta)\sigma/(\sigma-1)-1}{(1-\beta)\sigma/(\sigma-1)}} q_n^{\frac{\sigma-1}{\sigma}-1} &= \eta p_n \qquad (22) \\ \nu(1-a)Q_o^{-\beta} U^{\frac{\nu/(1-\beta)-1}{\nu/(1-\beta)}} &= \eta P_o \qquad (23)\end{aligned}$$

Where η is the Lagrange multiplier associated to the budget constraint. By using the FOC (22) for any two goods n and m to eliminate η, we obtain that $q_m = q_n \left(\frac{p_m}{p_n}\right)^{-\sigma}$. After multiplying both sides by p_m, summing up over m and using the budget constraint, we obtain

$I - P_o Q_o = q_n p_n^{\sigma} P^{1-\sigma}$. We obtain the demand curve introduced in the main text after reordering the different terms and introducing the parameter $A = I - P_o Q_o$

$$q_n = \left(\frac{p_n}{P}\right)^{-\sigma} \frac{A}{P} \tag{24}$$

In what follows, our partial equilibrium approach assumes that variations in the tax rate applied to the varieties q_n affect neither aggregate income nor the amount spend on the outside good. Hence, A is assumed to be exogenous.

On the supply side, we assume that firms compete in price under monopolistic competition. Every firm has the same cost function given by equation (2) in the main text $C_n(q_n) = a + c_n q_n + \frac{b}{2} q_n^2$ with $a > 0$, $c_n = c > 0$ for all n, and where $b < 0$ corresponds to decreasing marginal costs and $b > 0$ corresponds to increasing marginal costs. In this case, we assume that

Each firm chooses its price $\widetilde{p}_n$ to maximize profits $\pi_n = \widetilde{p}_n q_n - C(q_n)$. The first order condition of the maximization problem is $q_n + (\widetilde{p}_n - c - bq_n)\frac{\partial q_n}{\partial \widetilde{p}_n} = 0$ and the second order equation is $\frac{\partial q_n}{\partial \widetilde{p}_n} + (1 - b\frac{\partial q_n}{\partial \widetilde{p}_n})\frac{\partial q_n}{\partial \widetilde{p}_n} + (\widetilde{p}_n - c - bq_n)\frac{\partial^2 q_n}{\partial \widetilde{p}_n^2} < 0$. The derivatives of q_n are obtained using the demand function (24).[24] We get $\frac{\partial q_n}{\partial \widetilde{p}_n} = -\sigma \frac{q_n}{p_n}(1+\tau)$ and $\frac{\partial^2 q_n}{\partial \widetilde{p}_n^2} = \sigma(\sigma+1)(1+\tau)^2 \frac{q_n}{p_n^2}$.

Because all firms are equally productive, all firm prices and quantities are identical and, from now on, we can drop the subscript n for conciseness. This also implies that $Q = qN^{\frac{\sigma}{\sigma-1}}$, $P = pN^{\frac{1}{1-\sigma}}$. The latter entails that $\gamma = \frac{\partial \ln P}{\partial \ln(1+\tau)} = \frac{\partial \ln p}{\partial \ln(1+\tau)}$. We also obtain that demand for a single variety is given by $q = \frac{A}{\widetilde{p}(1+\tau)N}$.

We can then express the system of the first and second order conditions as:

$$\frac{\sigma-1}{\sigma}\widetilde{p}^2 - c\widetilde{p} - \frac{bA}{(1+\tau)N} = 0 \tag{25}$$

$$c - \frac{\sigma-1}{\sigma}\frac{\sigma+1}{\sigma}\widetilde{p}^2 < 0 \tag{26}$$

[24]Note that monopolistic firms ignore the impact of their pricing decisions on the aggregate price index P.

This system of equations admits a unique positive solution $\widetilde{p} = \frac{c+\sqrt{c^2+\frac{4bA(\sigma-1)}{(1+\tau)N\sigma}}}{2\frac{\sigma-1}{\sigma}}$. This implies

$$2\frac{\sigma-1}{\sigma}\widetilde{p} - c > 0 \tag{27}$$

We take the derivative of equation (25) with respect to N and obtain

$$2\frac{\sigma-1}{\sigma}\frac{\partial\widetilde{p}}{\partial N}\widetilde{p} - c\frac{\partial\widetilde{p}}{\partial N} - \frac{bA}{(1+\tau)N^2} = 0$$

After some manipulations, we can solve for $\frac{\partial\widetilde{p}}{\partial N}$:

$$\frac{\partial\widetilde{p}}{\partial N} = -\frac{bA}{(1+\tau)N^2\left(2\frac{\sigma-1}{\sigma}\widetilde{p} - c\right)} \tag{28}$$

As a result, we found that prices are decreasing with the number of firms N if and only if $b > 0$.

To obtain an expression for the degree of pass-through, we start with equation (25), take the derivative with respect to τ and multiply by $\frac{1+\tau}{\widetilde{p}}$. In what follows, we make use of equation (20) to introduce $(\gamma - 1)$. We get

$$\begin{aligned}
0 &= 2\left(\frac{\partial\widetilde{p}}{\partial\tau}\frac{1+\tau}{\widetilde{p}}\right)\frac{\sigma-1}{\sigma}\widetilde{p} - c\left(\frac{\partial\widetilde{p}}{\partial\tau}\frac{1+\tau}{\widetilde{p}}\right) + \frac{bA}{(1+\tau)^2N}\left(\frac{1+\tau}{\widetilde{p}}\right) \\
0 &= 2\frac{\sigma-1}{\sigma}(\gamma-1)\widetilde{p} - c(\gamma-1) + \frac{bA}{(1+\tau)N\widetilde{p}}
\end{aligned}$$

After some more algebra where we make use of equation (25) to substitute for $\widetilde{p}^2$, we get equation (3) as reported in **proposition 1**:

$$\begin{aligned}
\gamma &= 1 - \frac{bA}{(1+\tau)N\widetilde{p}\left(2\frac{\sigma-1}{\sigma}\widetilde{p} - c\right)} = 1 - \frac{bA}{(1+\tau)N\left(2c\widetilde{p} + \frac{2bA}{(1+\tau)N} - c\widetilde{p}\right)} \\
\gamma &= 1 - \frac{1}{\frac{(1+\tau)c}{bA}N\widetilde{p} + 2} \qquad (3)
\end{aligned}$$

We take the derivative of the above equation (3) with respect to N and use equation (28) to obtain:

$$
\begin{aligned}
\frac{\partial\gamma}{\partial N} &= \frac{\frac{(1+\tau)c}{bA}\widetilde{p}+\frac{(1+\tau)c}{bA}N\frac{\partial\widetilde{p}}{\partial N}}{\left(\frac{(1+\tau)c}{bA}N\widetilde{p}+2\right)^2} = \frac{\frac{(1+\tau)c}{bA}\widetilde{p}-\frac{c}{N\left(2\frac{\sigma-1}{\sigma}\widetilde{p}-c\right)}}{\left(\frac{(1+\tau)c}{bA}N\widetilde{p}+2\right)^2} \\
&= c.\frac{(1+\tau)\widetilde{p}N\left(2\frac{\sigma-1}{\sigma}\widetilde{p}-c\right)-bA}{bAN\left(2\frac{\sigma-1}{\sigma}\widetilde{p}-c\right)\left(\frac{(1+\tau)c}{bA}N\widetilde{p}+2\right)^2} \\
&= c(1+\tau)N.\frac{2\frac{\sigma-1}{\sigma}\widetilde{p}^2-c\widetilde{p}-\frac{bA}{(1+\tau)N}}{bAN\left(2\frac{\sigma-1}{\sigma}\widetilde{p}-c\right)\left(\frac{(1+\tau)c}{bA}N\widetilde{p}+2\right)^2} \\
&= \frac{(1+\tau)c\frac{\sigma-1}{\sigma}\widetilde{p}^2}{bA\left(2\frac{\sigma-1}{\sigma}\widetilde{p}-c\right)\left(\frac{(1+\tau)c}{bA}N\widetilde{p}+2\right)^2} \qquad (29)
\end{aligned}
$$

Using inequality (27), we find that the terms in brackets in the denominator are positive as well as all the terms in the numerator. Hence, we find that the degree of pass-through increases if and only if $b > 0$, that is when firm production is characterized by decreasing returns to scale. This proves that pass-through variations with N under monopolistic competition are as described in **proposition 1**.

A.2 Cournot competition in the downstream sector

We now assume that the first good Q is homogeneous but produced by heterogeneous firms that differ in productivity and who compete in quantities under Cournot competition. Total demand is the sum of every firm's production, $Q = \sum_{n=1}^{N} q_n$. Aggregate consumer preferences are characterized by the same utility function (21) as before.

The first order condition of the consumer problem with respect to the first good yields $\nu a Q^{-\beta} U^{\frac{\nu/(1-\beta)-1}{\nu/(1-\beta)}} = \eta p$. We combine it with the other FOC (23) to eliminate η and get the aggregate demand curve introduced in the main text

$$p(Q) = A' Q^{-\beta} \qquad (30)$$

where $A' = P_o Q_o^{\beta} \frac{a}{(1-a)}$. As in the previous case, we adopt a partial equilibrium approach and we here assume that variations in the tax rate applied to the first good Q affect neither the price nor the quantity of the outside good. Hence, A' is assumed to be exogenous. As described in Dierickx et al. (1988), we also assume that the demand function is steep enough ($\frac{\partial \widetilde{p}}{\partial Q} - b < 0$) and concave enough ($\frac{\partial p}{\partial Q} + \frac{\partial^2 p}{\partial Q^2} q_n < 0$ for all q_n) because these conditions ensure the existence, stability and uniqueness of the Cournot-Nash equilibrium. In the present setting, these conditions become

$$-\beta \frac{\widetilde{p}}{Q} - b < 0 \tag{31}$$

$$-\beta \frac{p}{Q} + \beta(\beta+1) \frac{p}{Q^2} q_n < 0 \tag{32}$$

After summing up the second inequality for all n, we get that it implies $(\beta + 1) < N$.

Each firm n facing the cost function (2) chooses its output q_n independently to maximize profits $\widetilde{p}(q_n)q_n - C_n(q_n)$ and, while doing so, firms internalize their impact on total output. In equilibrium, the first order condition of the profit maximization problem is

$$\widetilde{p}(q_n) + \frac{\partial \widetilde{p}}{\partial q_n} q_n - c_n - b q_n = 0 \text{ for all } n \tag{33}$$

Summing (33) across firms and then using the demand function (30) rewritten as $Q = \left(\frac{A'}{\widetilde{p}(1+\tau)}\right)^{1/\beta}$ and the associated derivative $\frac{\partial \widetilde{p}}{\partial q_n} = -\beta \frac{\widetilde{p}}{Q}$, yields

$$N\widetilde{p} - \beta\widetilde{p} - N\bar{c} - b\left(\frac{A'}{\widetilde{p}(1+\tau)}\right)^{1/\beta} = 0 \tag{34}$$

where $\bar{c} = \sum_n c_n/N$. Note that we assumed that the mean of the cost distribution is fixed and independent from N. Together with inequality (31), this implies that $\widetilde{p} - \bar{c} > 0$.

We can examine how producer prices vary with competition by differentiating equation (34) with respect to N:

$$\begin{aligned} 0 &= \widetilde{p} + (N-\beta)\frac{\partial \widetilde{p}}{\partial N} - \bar{c} + \frac{1}{\beta}\frac{\partial \widetilde{p}}{\partial N}\frac{b}{\widetilde{p}}\left(\frac{A'}{\widetilde{p}(1+\tau)}\right)^{1/\beta} \\ \frac{\partial \widetilde{p}}{\partial N} &= \frac{\bar{c} - \widetilde{p}}{(N-\beta) + \frac{b}{\beta\widetilde{p}}\left(\frac{A'}{\widetilde{p}(1+\tau)}\right)^{1/\beta}} = -\frac{\widetilde{p}(\widetilde{p} - \bar{c})}{N\bar{c} + \frac{\beta+1}{\beta} b \left(\frac{A'}{\widetilde{p}(1+\tau)}\right)^{1/\beta}} \end{aligned} \tag{35}$$

We can find out the sign of the above derivative by examining the denominator:

$$\beta\widetilde{p}(N-\beta)+b\left(\frac{A'}{\widetilde{p}(1+\tau)}\right)^{1/\beta}=[\beta\widetilde{p}(N-1-\beta)]+[\beta\widetilde{p}+bQ]>0$$

which is positive because both terms in square brackets turns out to be positive after comparing them to conditions (31) and (32) respectively. The numerator is negative as noted in the previous paragraph. Therefore, prices decline with the number of competing firms.

The pass-through is obtained once again using equation (20). We differentiate equation (34) with respect to τ and multiply it by $\frac{1+\tau}{\widetilde{p}}$ to introduce $(\gamma-1)$. We recover one of the central results in Dierickx et al. (1988) and equation (4) in **proposition 1**:

$$\begin{aligned}
0 &= (N-\beta)(\gamma-1)+\frac{b}{\beta}A'^{1/\beta}\left(\widetilde{p}^{-\frac{1}{\beta}-1}(1+\tau)^{-\frac{1}{\beta}}(\gamma-1)+\widetilde{p}^{\frac{1}{\beta}-1}(1+\tau)^{-\frac{1}{\beta}}\right) \\
\gamma &= \left[1+\frac{bA'^{\frac{1}{\beta}}}{(1+\tau)^{\frac{1}{\beta}}(N-\beta)\beta\widetilde{p}^{\frac{\beta+1}{\beta}}}\right]^{-1}=\frac{1}{1+\frac{b(1+\tau)^{-\frac{1}{\beta}}A'^{\frac{1}{\beta}}}{(N-\beta)\beta\widetilde{p}^{\frac{\beta+1}{\beta}}}} \qquad (4)
\end{aligned}$$

We examine how pass-through vary with competition by deriving the variations of γ

with respect to the number of firms.

$$\begin{aligned}
\frac{\partial \gamma}{\partial N} &= \frac{\left[\widetilde{p}+\frac{\beta+1}{\beta}\frac{\partial \widetilde{p}}{\partial N}(N-\beta)\right]\frac{b}{\beta}(1+\tau)^{-\frac{1}{\beta}}A'^{\frac{1}{\beta}}(N-\beta)^{-2}\widetilde{p}^{-\frac{2\beta+1}{\beta}}}{\left[1+\frac{b(1+\tau)^{-\frac{1}{\beta}}A'^{\frac{1}{\beta}}}{(N-\beta)\beta p^{\frac{\beta+1}{\beta}}}\right]^2} \\
&= \left[1-\frac{(N-\beta)}{N}\frac{(\beta+1)\widetilde{p}+\frac{\beta+1}{\beta}b\left(\frac{A'}{\widetilde{p}(1+\tau)}\right)^{1/\beta}}{N\bar{c}+\frac{\beta+1}{\beta}b\left(\frac{A'}{\widetilde{p}(1+\tau)}\right)^{1/\beta}}\right]*\frac{\frac{b}{\beta}(1+\tau)^{-\frac{1}{\beta}}A'^{\frac{1}{\beta}}(N-\beta)^{-2}\widetilde{p}^{-\frac{\beta+1}{\beta}}}{\left[1+\frac{b(1+\tau)^{-\frac{1}{\beta}}A'^{\frac{1}{\beta}}}{(N-\beta)\beta p^{\frac{\beta+1}{\beta}}}\right]^2} \\
&= \left[\frac{N^2\bar{c}-(N-\beta)(\beta+1)\widetilde{p}+(\beta+1)b\left(\frac{A'}{\widetilde{p}(1+\tau)}\right)^{1/\beta}}{N^2\bar{c}+N\frac{\beta+1}{\beta}b\left(\frac{A'}{\widetilde{p}(1+\tau)}\right)^{1/\beta}}\right]*\frac{\frac{b}{\beta}(1+\tau)^{-\frac{1}{\beta}}A'^{\frac{1}{\beta}}(N-\beta)^{-2}\widetilde{p}^{-\frac{\beta+1}{\beta}}}{\left[1+\frac{b(1+\tau)^{-\frac{1}{\beta}}A'^{\frac{1}{\beta}}}{(N-\beta)\beta p^{\frac{\beta+1}{\beta}}}\right]^2} \\
&= \left[\frac{(N-\beta-1)\bar{c}}{N\bar{c}+\frac{\beta+1}{\beta}b\left(\frac{A'}{\widetilde{p}(1+\tau)}\right)^{1/\beta}}\right]*\frac{\frac{b}{\beta}(1+\tau)^{-\frac{1}{\beta}}A'^{\frac{1}{\beta}}(N-\beta)^{-2}\widetilde{p}^{-\frac{\beta+1}{\beta}}}{\left[1+\frac{b(1+\tau)^{-\frac{1}{\beta}}A'^{\frac{1}{\beta}}}{(N-\beta)\beta p^{\frac{\beta+1}{\beta}}}\right]^2} \qquad (36)
\end{aligned}$$

By comparing the first term in squared bracket with equation (35), we deduct that the term is positive. Therefore the derivative $\partial\gamma/\partial N$ has the sign of b and this proves that pass-through variations with N under Cournot competition with heterogeneous firms are as described in **proposition 1**.

A.3 Cournot competition in the upstream sector

We examine the case of two sectors, with perfect competition in the downstream sector and Cournot competition in the upstream sector. For clarity purpose, we assume that inputs q_I produced in the upstream sector are only consumed by producers of the final good and that inputs q_I are not taxed. The representative consumer as the same aggregate utility function (21) as in the previous section. This implies that aggregate demand for the final good Q_F is given by $Q_F = \left(\frac{p_F}{A'}\right)^{-\frac{1}{\beta}}$ as in equation (30).

Taking prices as given because of perfect competition, the representative producer of the final good maximizes profits $\widetilde{p}_F Q_F - p_I Q_I$ by choosing the quantity Q_F to produce given the cost function $Q_I = d(1-\rho)Q_F^{\frac{1}{1-\rho}}$ with $0 < \rho < 1$ and $d > 0$. The first order condition of the profit maximization problem yields the input demand function:

$$p_I = \frac{\widetilde{p}_F}{d} Q_F^{\frac{-\rho}{1-\rho}} \tag{37}$$
$$p_I = \widetilde{p}_F d^{\rho-1}(1-\rho)^{\rho} Q_I^{-\rho} \tag{38}$$

Similarly to the previous section, the existence and uniqueness of a solution in the upstream sector requires the following two constraints on input demand:

$$\frac{\partial p_I}{\partial Q_I} - b < 0$$
$$\frac{\partial p_I}{\partial Q_I} + \frac{\partial^2 p_I}{\partial Q_I^2} q_{I,n} < 0$$

which imply

$$-\frac{\rho}{d}\left(\frac{1+\tau}{A'}\right)^{\frac{\rho}{\beta(1-\rho)}} \widetilde{p}_F^{\,1+\frac{\rho}{\beta(1-\rho)}} - bd(1-\rho)\left(\frac{A'}{\widetilde{p}_F(1+\tau)}\right)^{\frac{1}{\beta(1-\rho)}} < 0 \tag{39}$$
$$-N + (\rho+1) < 0 \tag{40}$$

In the upstream sector, each firm n chooses output independently to maximize profits $\widetilde{p}_I(Q_I)q_{I,n} - C_n(q_{I,n})$ subject to (38) as upstream firms internalize their impact on total production $Q_I = \sum_n q_{I,n}$. In equilibrium, the first order conditions of the profit maximization problem for all upstream firms is such that

$$\widetilde{p}_I(Q_I) + \frac{\partial \widetilde{p}_I}{\partial q_{I,n}} q_{I,n} - c_n - b q_{I,n} = 0 \tag{41}$$

Summing (41) across firms, noting that $\widetilde{p}_I = p_I$, and using the demand function (38) yield

$$(N-\rho)p_I - N\bar{c} - b(1-\rho)d^{(\rho-1)/\rho}\left(\frac{\widetilde{p}_F}{p_I}\right)^{1/\rho} = 0 \tag{42}$$

where $\bar{c} = \sum_n c_n/N$. We can use the demand equation (37) and the above supply equation (42) to solve for the input price and obtain the final good supply function:

$$\begin{aligned} 0 &= (N-\rho)\frac{\widetilde{p}_F}{d}Q_F^{\frac{-\rho}{1-\rho}} - N\bar{c} - b(1-\rho)d^{(\rho-1)/\rho}\left(dQ_F^{\frac{\rho}{1-\rho}}\right)^{1/\rho} \\ \widetilde{p}_F &= \frac{N\bar{c}dQ_F^{\frac{\rho}{1-\rho}} + b(1-\rho)d^2Q_F^{\frac{1+\rho}{1-\rho}}}{(N-\rho)} \end{aligned} \tag{43}$$

We combine the above supply side equation (43) with the final good demand equation (30) to obtain the equation that pins down the final good price:

$$\begin{aligned} \widetilde{p}_F &= \frac{N\bar{c}A'^{\frac{\rho}{\beta(1-\rho)}}\left((1+\tau)\widetilde{p}_F\right)^{-\frac{\rho}{\beta(1-\rho)}} + b(1-\rho)dA'^{\frac{1+\rho}{\beta(1-\rho)}}\left((1+\tau)\widetilde{p}_F\right)^{-\frac{1+\rho}{\beta(1-\rho)}}}{(N-\rho)/d} \\ 0 &= \frac{N-\rho}{d}\left(\frac{1+\tau}{A'}\right)^{\frac{\rho}{\beta(1-\rho)}}\widetilde{p}_F^{\,1+\frac{\rho}{\beta(1-\rho)}} - N\bar{c} - b(1-\rho)d\left(\frac{A'}{(1+\tau)\widetilde{p}_F}\right)^{\frac{1}{\beta(1-\rho)}} \end{aligned} \tag{44}$$

We can examine how producer prices vary with competition by differentiating equation (44) with respect to N:

$$0 = \left(\frac{1+\tau}{A'}\right)^{\frac{\rho}{\beta(1-\rho)}}\frac{\widetilde{p}_F^{\,1+\frac{\rho}{\beta(1-\rho)}}}{d}\left(1+(N-\rho)\frac{\rho+\beta(1-\rho)}{\beta(1-\rho)\widetilde{p}_F}\frac{\partial\widetilde{p}_F}{\partial N}\right) - \bar{c} + \frac{bd}{\beta\widetilde{p}_F}\left(\frac{A'}{(1+\tau)\widetilde{p}_F}\right)^{\frac{1}{\beta(1-\rho)}}\frac{\partial\widetilde{p}_F}{\partial N}$$

$$\frac{\partial\widetilde{p}_F}{\partial N} = \frac{\bar{c} - \left(\frac{1+\tau}{A'}\right)^{\frac{\rho}{\beta(1-\rho)}}\frac{\widetilde{p}_F^{\,1+\frac{\rho}{\beta(1-\rho)}}}{d}}{(N-\rho)\frac{\rho+\beta(1-\rho)}{\beta(1-\rho)d}\left(\frac{1+\tau}{A'}\right)^{\frac{\rho}{\beta(1-\rho)}}\widetilde{p}_F^{\frac{\rho}{\beta(1-\rho)}} + \frac{bd}{\beta\widetilde{p}_F}\left(\frac{A'}{(1+\tau)\widetilde{p}_F}\right)^{\frac{1}{\beta(1-\rho)}}} \tag{45}$$

The same logic as in the previous section applies and condition (39) together with equation (44) implies that the numerator is negative. The denominator can be expressed as

$$\frac{\left[(N-\rho)\frac{\rho+\beta(1-\rho)}{d} - \frac{\rho}{d}\right]\left(\frac{1+\tau}{A'}\right)^{\frac{\rho}{\beta(1-\rho)}}\widetilde{p}_F^{\,1+\frac{\rho}{\beta(1-\rho)}} + \left[\frac{\rho}{d}\left(\frac{1+\tau}{A'}\right)^{\frac{\rho}{\beta(1-\rho)}}\widetilde{p}_F^{\,1+\frac{\rho}{\beta(1-\rho)}} + bd(1-\rho)\left(\frac{A'}{(1+\tau)\widetilde{p}_F}\right)^{\frac{1}{\beta(1-\rho)}}\right]}{\beta\widetilde{p}_F(1-\rho)}$$

where we can see that the two terms in square brackets are positive because of conditions (39) and (40). Hence, the price of inputs decreases with N.

The pass-through is again obtained using equation (20). We differentiate equation (34) with respect to τ and multiply it by $\frac{1+\tau}{\widetilde{p}_F}$ to introduce $(\gamma^F - 1)$. We obtain the expression for the pass-trough reported in **proposition 2**.

$$\begin{aligned}
0 &= \frac{N-\rho}{d}\left(\frac{1+\tau}{A'}\right)^{\frac{\rho}{\beta(1-\rho)}}\widetilde{p}_F^{\frac{\rho}{\beta(1-\rho)}}\left(\frac{\rho}{\beta(1-\rho)}+\left(1+\frac{\rho}{\beta(1-\rho)}\right)(\gamma^F-1)\right)...\\
&\qquad + \frac{b(1-\rho)d}{\beta(1-\rho)}\left(\frac{A'}{1+\tau}\right)^{\frac{1}{\beta(1-\rho)}}\widetilde{p}_F^{-\frac{1}{\beta(1-\rho)}-1}\left(1+(\gamma^F-1)\right)\\
\gamma^F &= \frac{1}{1+\frac{\rho}{\beta(1-\rho)}+\frac{bd^2(1+\tau)^{-\frac{1+\rho}{\beta(1-\rho)}}A'^{\frac{1+\rho}{\beta(1-\rho)}}}{\beta(N-\rho)\widetilde{p}_F^{1+\frac{1+\rho}{\beta(1-\rho)}}}} \qquad (5)
\end{aligned}$$

The sign of $\frac{\partial\gamma^F}{\partial N}$ is the same as the sign of $\partial\left[\frac{\beta(N-\rho)}{b}\widetilde{p}_F^{1+\frac{1+\rho}{\beta(1-\rho)}}\right]/\partial N$.

$$\begin{aligned}
\frac{\partial\left[\frac{\beta(N-\rho)}{b}\widetilde{p}_F^{1+\frac{1+\rho}{\beta(1-\rho)}}\right]}{\partial N} &= \frac{\beta}{b}\widetilde{p}_F^{1+\frac{1+\rho}{\beta(1-\rho)}}+\frac{1+\rho+\beta(1-\rho)}{b(1-\rho)}(N-\rho)\widetilde{p}_F^{\frac{1+\rho}{\beta(1-\rho)}}\frac{\partial\widetilde{p}_F}{\partial N}\\
&= \frac{\beta}{b}\widetilde{p}_F^{\frac{1+\rho}{\beta(1-\rho)}}\left(\frac{[denominator]\widetilde{p}_F+\frac{1+\rho+\beta(1-\rho)}{\beta(1-\rho)}(N-\rho)\left(\bar{c}-\left(\frac{1+\tau}{A'}\right)^{\frac{\rho}{\beta(1-\rho)}}\frac{\widetilde{p}_F^{1+\frac{\rho}{\beta(1-\rho)}}}{d}\right)}{(N-\rho)\frac{\rho+\beta(1-\rho)}{\beta(1-\rho)d}\left(\frac{1+\tau}{A'}\right)^{\frac{\rho}{\beta(1-\rho)}}\widetilde{p}_F^{\frac{\rho}{\beta(1-\rho)}}+\frac{bd}{\beta\widetilde{p}_F}\left(\frac{A'}{(1+\tau)\widetilde{p}_F}\right)^{\frac{1}{\beta(1-\rho)}}}\right)\\
&= \frac{\beta}{b}\widetilde{p}_F^{\frac{1+\rho}{\beta(1-\rho)}}\left(\frac{\frac{bd}{\beta}\left(\frac{A'}{(1+\tau)\widetilde{p}_F}\right)^{\frac{1}{\beta(1-\rho)}}+\frac{1+\rho+\beta(1-\rho)}{\beta(1-\rho)}(N-\rho)\bar{c}-\frac{(N-\rho)}{\beta(1-\rho)d}\left(\frac{1+\tau}{A'}\right)^{\frac{\rho}{\beta(1-\rho)}}\widetilde{p}_F^{1+\frac{\rho}{\beta(1-\rho)}}}{(N-\rho)\frac{\rho+\beta(1-\rho)}{\beta(1-\rho)d}\left(\frac{1+\tau}{A'}\right)^{\frac{\rho}{\beta(1-\rho)}}\widetilde{p}_F^{\frac{\rho}{\beta(1-\rho)}}+\frac{bd}{\beta\widetilde{p}_F}\left(\frac{A'}{(1+\tau)\widetilde{p}_F}\right)^{\frac{1}{\beta(1-\rho)}}}\right)\\
&= \frac{[(\rho+\beta(1-\rho))N-(1+\rho+\beta(1-\rho))\rho)]\frac{\bar{c}}{b(1-\rho)}\widetilde{p}_F^{\frac{1+\rho}{\beta(1-\rho)}}}{(N-\rho)\frac{\rho+\beta(1-\rho)}{\beta(1-\rho)d}\left(\frac{1+\tau}{A'}\right)^{\frac{\rho}{\beta(1-\rho)}}\widetilde{p}_F^{\frac{\rho}{\beta(1-\rho)}}+\frac{bd}{\beta\widetilde{p}_F}\left(\frac{A'}{(1+\tau)\widetilde{p}_F}\right)^{\frac{1}{\beta(1-\rho)}}} \qquad (46)
\end{aligned}$$

The denominator is positive as was shown for equation (45). Using inequality (40), we find that

$$(\rho+\beta(1-\rho))N-(1+\rho+\beta(1-\rho))\rho) > (\rho+\beta(1-\rho))(\rho+1)-(1+\rho+\beta(1-\rho))\rho) \geq 0$$

In equation (46), this implies that the term in square brackets is positive and therefore that $\frac{\partial \gamma^F}{\partial N}$ has the sign of b as stated in **proposition 2**.

A.4 Differences in scope for quality in the final good

We examine a sector characterized by 'discrete choices', meaning that consumers can decide to purchase at most one variety of the product. For any consumer, not buying any variety and spending all her income on an outside good is always an option. We consider a partial equilibrium in which income and the outside good are unaffected by changes in the tax rate in the sector that we examine. N homogeneous firms compete by manufacturing horizontally and vertically distinct varieties as in Khandelwal (2010). Horizontal differentiation is assumed to be costless, implying that in equilibrium, all firms produce horizontally distinct varieties.

Consumer k observes all varieties and chooses the variety n with price p_n and quality λ_n that provides her with the highest indirect utility

$$V_{nk} = \delta_n + \xi_{nk}, \qquad \text{with } \delta_n \equiv \left(\theta \lambda_n^{\psi} - p_n^{\psi}\right)^{1/\psi} \qquad \text{and } \psi < 1 \tag{6}$$

Quality is defined as an attribute whose valuation is agreed upon by all consumers: holding prices fixed, all consumers would prefer higher quality objects. The "quality ladder" parameter θ reflects the consumers' valuation for quality.

The price-quality indifference curves are given by $p_n = \left(\theta \lambda_n^{\psi} - \delta_n^{\psi}\right)^{1/\psi}$. The marginal willingness to pay $\frac{\partial \ln p_n}{\partial \ln \lambda_n} = \theta \left(\frac{p_n}{\lambda}\right)^{\psi}$ is increasing in the quality-price ratio if $\psi > 0$ and decreasing with the the quality-price ratio if $\psi < 0$. In other words in the case when $\psi < 0$, consumers demand cheaper quality when quality increases.

Horizontal product differentiation is introduced in (6) through the consumer-variety-specific term, ξ_{nk}. Following standard practice in the discrete choice literature, ξ_{nk} is assumed to be distributed i.i.d. type-I extreme value. Unlike the vertical attribute, the horizontal attribute has the property that some people prefer it while others do not, and on average, it provides zero utility. Therefore, the mean valuation for variety n is δ_n. Under the distributional assumption, the market share of variety n is given by the familiar logit formula $m_n = \frac{e^{\delta_n}}{\sum_m e^{\delta_m}}$.

Each firm n produces a variety subject to a marginal cost function that is increasing with quality, $w + \frac{\lambda_n}{Z}$. We assume that the market is characterized by monopolistic competition with a sufficiently large number of firms so that no one firm can influence the market equilibrium prices and qualities. A firm n maximizes profits by choosing the price and quality.

$$\max_{\widetilde{p}_n, \lambda_n} \left[\widetilde{p}_n - w - \frac{\lambda_n}{Z} \right] \frac{e^{\delta_n}}{\sum_m e^{\delta_m}} \tag{47}$$

The two first order conditions are

$$0 = e^{\delta_n} - \left(\widetilde{p}_n - w - \frac{\lambda_n}{Z} \right) (1+\tau)^{\psi} \widetilde{p}_n^{\psi-1} \left(\theta \lambda_n^{\psi} - (\widetilde{p}_n(1+\tau))^{\psi} \right)^{\frac{1-\psi}{\psi}} e^{\delta_n} \tag{48}$$

$$0 = -\frac{1}{Z} e^{\delta_n} + \left(\widetilde{p}_n - w - \frac{\lambda_n}{Z} \right) \theta \lambda_n^{\psi-1} \left(\theta \lambda_n^{\psi} - (\widetilde{p}_n(1+\tau))^{\psi} \right)^{\frac{1-\psi}{\psi}} e^{\delta_n} \tag{49}$$

We obtain quality and mean valuation as functions of price by combining the first order conditions.

$$\lambda_n^{1-\psi} = \frac{\theta Z}{(1+\tau)^{\psi}} \widetilde{p}_n^{1-\psi} \tag{50}$$

$$\begin{aligned} \delta_n &= \left(\theta \left(\frac{\theta Z}{(1+\tau)^{\psi}} \right)^{\frac{\psi}{1-\psi}} \widetilde{p}_n^{\psi} - (\widetilde{p}_n(1+\tau))^{\psi} \right)^{\frac{1}{\psi}} \\ &= \left(\theta^{\frac{1}{1-\psi}} Z^{\frac{\psi}{1-\psi}} (1+\tau)^{\frac{\psi}{\psi-1}} - 1 \right)^{\frac{1}{\psi}} (1+\tau) \widetilde{p}_n \end{aligned} \tag{51}$$

We solve for prices by substituting quality and mean valuation using equations (50) and (51) in the first order condition (48).

$$
\begin{aligned}
0 &= 1-\left(\widetilde{p}_n - w - \frac{\lambda_n}{Z}\right)(1+\tau)^{\psi}\widetilde{p}_n^{\psi-1}\left(\theta^{\frac{1}{1-\psi}}\left(\frac{Z}{1+\tau}\right)^{\frac{\psi}{1-\psi}}-1\right)^{\frac{1-\psi}{\psi}}\quad((1+\tau)\widetilde{p}_n)^{1-\psi}\\
0 &= 1-\left(\widetilde{p}_n - w - \frac{\widetilde{p}_n}{Z}\left(\frac{\theta Z}{(1+\tau)^{\psi}}\right)^{\frac{1}{1-\psi}}\right)\left(\theta^{\frac{1}{1-\psi}}\left(\frac{Z}{1+\tau}\right)^{\frac{\psi}{1-\psi}}-1\right)^{\frac{1-\psi}{\psi}}\quad(1+\tau)\\
\widetilde{p}_n &= w\left(1-\theta^{\frac{1}{1-\psi}}Z^{\frac{\psi}{1-\psi}}(1+\tau)^{\frac{\psi}{\psi-1}}\right)^{-1}+\frac{1}{(1+\tau)}\left(1-\theta^{\frac{1}{1-\psi}}Z^{\frac{\psi}{1-\psi}}(1+\tau)^{\frac{\psi}{\psi-1}}\right)^{-\frac{1}{\psi}} \qquad (52)
\end{aligned}
$$

The existence of a positive price solution therefore requires that $\theta < \left(\frac{1+\tau}{Z}\right)^{\psi}$.

We obtain pass-through as stated in **proposition 3** by taking the derivative of the equation (52) and multiplying by $\frac{(1+\tau)}{\widetilde{p}_n}$.

$$
\begin{aligned}
(\gamma-1) = &-w\theta^{\frac{1}{1-\psi}}Z^{\frac{\psi}{1-\psi}}\frac{\psi}{1-\psi}\frac{(1+\tau)^{\frac{\psi}{\psi-1}}}{\widetilde{p}_n}\left(1-\theta^{\frac{1}{1-\psi}}Z^{\frac{\psi}{1-\psi}}(1+\tau)^{\frac{\psi}{\psi-1}}\right)^{-2}\\
&-\theta^{\frac{1}{1-\psi}}Z^{\frac{\psi}{1-\psi}}\frac{1}{1-\psi}\frac{(1+\tau)^{\frac{\psi}{\psi-1}}}{\widetilde{p}_n}\frac{1}{(1+\tau)}\left(1-Z^{\frac{\psi}{1-\psi}}\theta^{\frac{1}{1-\psi}}(1+\tau)^{\frac{\psi}{\psi-1}}\right)^{-\frac{1}{\psi}-1}\\
&-\frac{1}{\widetilde{p}_n}\frac{1}{(1+\tau)}\left(1-Z^{\frac{\psi}{1-\psi}}\theta^{\frac{1}{1-\psi}}(1+\tau)^{\frac{\psi}{\psi-1}}\right)^{-\frac{1}{\psi}}\\
(\gamma-1) = &-w\theta^{\frac{1}{1-\psi}}Z^{\frac{\psi}{1-\psi}}\frac{\psi}{1-\psi}\frac{(1+\tau)^{\frac{\psi}{\psi-1}}}{\widetilde{p}_n}\left(1-\theta^{\frac{1}{1-\psi}}Z^{\frac{\psi}{1-\psi}}(1+\tau)^{\frac{\psi}{\psi-1}}\right)^{-2}\\
&-\frac{1}{\widetilde{p}_n}\frac{1}{(1+\tau)}\left(1-Z^{\frac{\psi}{1-\psi}}\theta^{\frac{1}{1-\psi}}(1+\tau)^{\frac{\psi}{\psi-1}}\right)^{-\frac{1}{\psi}-1}\left(1+\frac{\psi}{1-\psi}Z^{\frac{\psi}{1-\psi}}\theta^{\frac{1}{1-\psi}}(1+\tau)^{\frac{\psi}{\psi-1}}\right)\\
= &-\frac{\psi}{1-\psi}\frac{Z^{\frac{\psi}{1-\psi}}\theta^{\frac{1}{1-\psi}}(1+\tau)^{\frac{\psi}{\psi-1}}}{\left(1-\theta^{\frac{1}{1-\psi}}Z^{\frac{\psi}{1-\psi}}(1+\tau)^{\frac{\psi}{\psi-1}}\right)}-\frac{1}{\widetilde{p}_n}\frac{1}{(1+\tau)}\left(1-Z^{\frac{\psi}{1-\psi}}\theta^{\frac{1}{1-\psi}}(1+\tau)^{\frac{\psi}{\psi-1}}\right)^{-\frac{1}{\psi}-1}\\
= &-\frac{\psi}{1-\psi}\frac{Z^{\frac{\psi}{1-\psi}}\theta^{\frac{1}{1-\psi}}(1+\tau)^{\frac{\psi}{\psi-1}}}{\left(1-\theta^{\frac{1}{1-\psi}}Z^{\frac{\psi}{1-\psi}}(1+\tau)^{\frac{\psi}{\psi-1}}\right)}-\frac{\frac{1}{(1+\tau)}\left(1-Z^{\frac{\psi}{1-\psi}}\theta^{\frac{1}{1-\psi}}(1+\tau)^{\frac{\psi}{\psi-1}}\right)^{-\frac{1}{\psi}}}{w+\frac{1}{(1+\tau)}\left(1-Z^{\frac{\psi}{1-\psi}}\theta^{\frac{1}{1-\psi}}(1+\tau)^{\frac{\psi}{\psi-1}}\right)^{-\frac{1}{\psi}+1}}\\
= &\frac{-\psi/(1-\psi)}{\theta^{\frac{1}{\psi-1}}\left(\frac{Z}{1+\tau}\right)^{\frac{\psi}{\psi-1}}-1}-\frac{1}{1-\theta^{\frac{1}{1-\psi}}\left(\frac{Z}{1+\tau}\right)^{\frac{\psi}{1-\psi}}+w(1+\tau)\left(1-\theta^{\frac{1}{1-\psi}}\left(\frac{Z}{1+\tau}\right)^{\frac{\psi}{1-\psi}}\right)^{\frac{1}{\psi}}} \qquad (8)
\end{aligned}
$$

We take the derivative of the above with respect to θ to examine the variations of pass-through with respect to the scope for quality.

$$\frac{\partial\gamma}{\partial\theta} = -\frac{\psi}{(1-\psi)^2} Z^{\frac{\psi}{\psi-1}} \theta^{\frac{\psi}{1-\psi}} (1+\tau)^{\frac{\psi}{1-\psi}} \left(\theta^{\frac{1}{\psi-1}} Z^{\frac{\psi}{\psi-1}} (1+\tau)^{\frac{\psi}{1-\psi}} - 1\right)^{-2}$$
$$- \frac{\frac{\theta^{\frac{\psi}{1-\psi}}}{1-\psi} \left(\frac{Z}{1+\tau}\right)^{\frac{\psi}{1-\psi}} \left[1 + \frac{w(1+\tau)}{\psi} \left(1 - \theta^{\frac{1}{1-\psi}} \left(\frac{Z}{1+\tau}\right)^{\frac{\psi}{1-\psi}}\right)^{\frac{1}{\psi}-1}\right]}{\left[1 - \theta^{\frac{1}{1-\psi}} \left(\frac{Z}{1+\tau}\right)^{\frac{\psi}{1-\psi}} + w(1+\tau) \left(1 - \theta^{\frac{1}{1-\psi}} \left(\frac{Z}{1+\tau}\right)^{\frac{\psi}{1-\psi}}\right)^{\frac{1}{\psi}}\right]^2} \tag{53}$$

When $0 < \psi < 1$, the above is negative. When $\psi < 0$, the above is positive when ψ is negative enough and for example when $\psi < -\frac{1}{w(1+\tau)} < -\frac{1}{w(1+\tau)} \left(1 - \theta^{\frac{1}{1-\psi}} \left(\frac{Z}{1+\tau}\right)^{\frac{\psi}{1-\psi}}\right)^{\frac{1-\psi}{-\psi}}$.

The above proves the remaining results in **proposition 3**. A tax hike implies higher consumer prices. Note that the marginal cost of increasing quality does not depend on price. Quality adjustments by producers crucially depends on changes in consumers' valuation for quality which are characterized by the degree of substitution/complementarity. If substitution dominates (as in Khandelwal (2010)) consumers faced with a higher price prefer a reduction in quality as it allows producers to reduce prices. If complementarity dominates, consumers would rather get higher quality when they pay more, and producers will increase prices at the expense of a lower reduction in producer prices (possibly an increase in producer prices). Those effects are magnified by the scope for quality. Therefore, pass-through decreases with the quality ladder in the substitution case, while the opposite is true in the complementarity case.

B Empirical Appendix

B.1 Descriptive Statistics

Table B.1: Summary of VAT Reforms by Country

	First year in data	Number of reforms	Products affected	Product-Months affected
Austria	1998	1	1	1
Finland	1998	2	48	59
France	1998	3	35	36
Germany	1998	2	36	72
Greece	2000	3	48	144
Ireland	1998	7	34	153
Italy	1998	2	36	36
Luxembourg	2003	1	1	1
Netherlands	1998	1	29	29
Portugal	1998	7	49	193
Slovakia	2008	1	45	45
Slovenia	2006	1	1	1
Spain	1998	2	38	76
Total		33	401	846

Table B.2: Summary of Observed VAT Rates and Prices

		Obs	Mean	S.D.	Min	Max
VAT levels	Reduced rate	31,147	0.075	0.033	0.021	0.17
	Standard rate	74,010	0.194	0.02	0.15	0.23
	Zero rate	2,393	0	0	0	0
VAT changes	All	846	0.01	0.02	-0.15	0.17
	Standard	722	0.01	0.01	-0.01	0.03
	Reduced	116	0.01	0.02	-0.05	0.07
	Reclassification	8	-0.03	0.12	-0.15	0.17
	VAT decrease	143	-0.02	0.03	-0.15	-0.01
	VAT increase	703	0.02	0.01	0.01	0.17
Price levels		108,000	102.5	19.9	18.8	527.6

Table B.3: Pairwise correlation between competitiveness variables

	(1)	(2)	(3)	(4)
(1) Openness	1.000			
(2) *Regimpact*	-0.122*	1.000		
(3) Concentration	0.022*	-0.045*	1.000	
(4) Quality range	0.050*	0.029*	-0.054*	1.000

* shows significance at the 5% level

Table B.4: Summary statistics for main variables

Variable	Obs	Mean	S.D.	Min	Max
Δ ln(Price)	107,550	.001	.024	-.414	.415
Δ ln(1 + VAT)	107,550	0	.002	-.134	.149
Regimpact	107,550	.112	1.005	-2.098	3.774
Quality range	52,970	.052	.996	-1.933	1.785
Openness	107,550	.026	1.149	-.224	92.187
Concentration	107,550	-.024	.987	-1.263	5.997
TAX_package	107,550	.005	.069	0	1
Consumption	107,550	1.19e+08	3.35e+08	1456.954	1.67e+09
ValueAdded	106,542	18207.45	45043.92	.4	559000

Table B.5: VAT changes for which announcement dates are observed

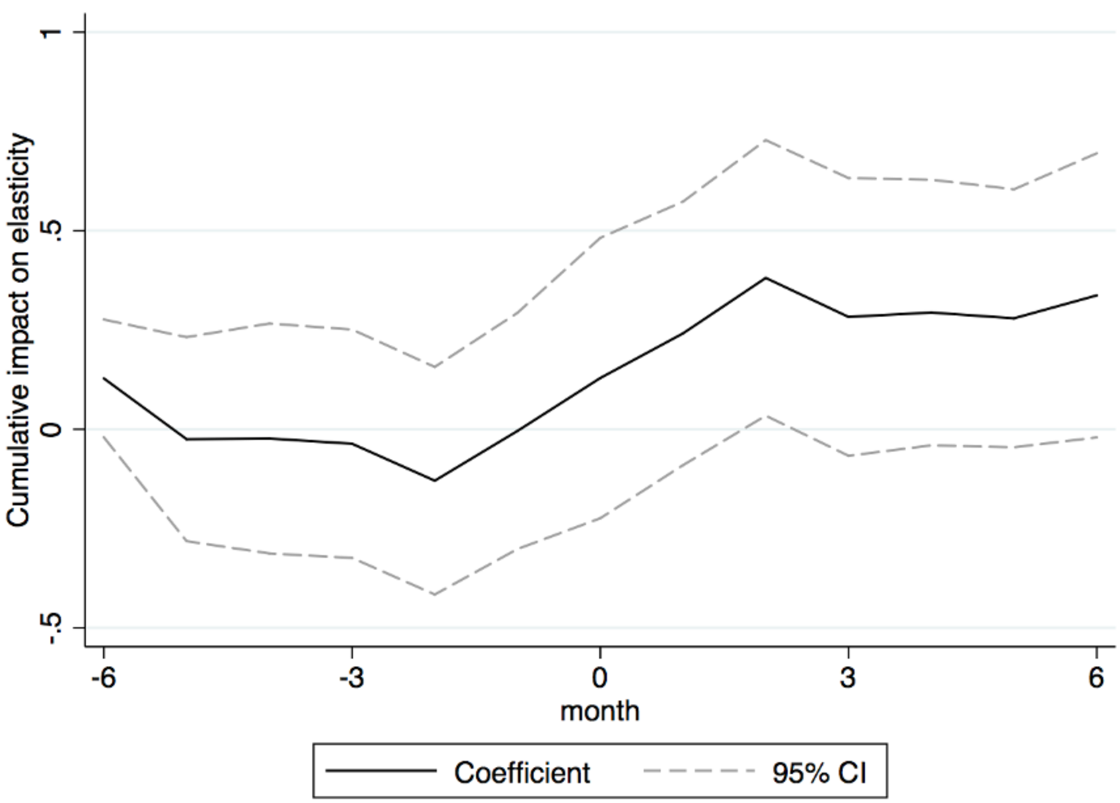
		Obs	Mean	S.D.	Min	Max
VAT changes	All	565	0.01	0.02	-0.15	0.17
	Standard	489	0.01	0.01	-0.01	0.03
	Reduced	71	0.01	0.01	-0.05	0.02
	Reclassification	5	-0.01	0.14	-0.15	0.17
	VAT decrease	101	-0.01	0.02	-0.15	-0.01
	VAT increase	464	0.02	0.01	0.01	0.17

Table B.6: Correlation among other market structure variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) Openness	1.000						
(2) Concentration	0.013*	1.000					
(3) *Regimpact*	-0.104*	-0.038*	1.000				
(4) Quality ladder	0.055*	-0.072*	0.031*	1.000			
(5) Dependence on external finance	0.022*	-0.042*	0.072*	0.147*	1.000		
(6) Export elasticity	0.044*	0.013*	0.022*	-0.216*	0.132*	1.000	
(7) Import elasticity	-0.029*	-0.013*	0.076*	0.133*	0.016*	0.020*	1.000

* shows significance at the 0.05 level

Figure 4: Marginal effect on pass-through of early announcement

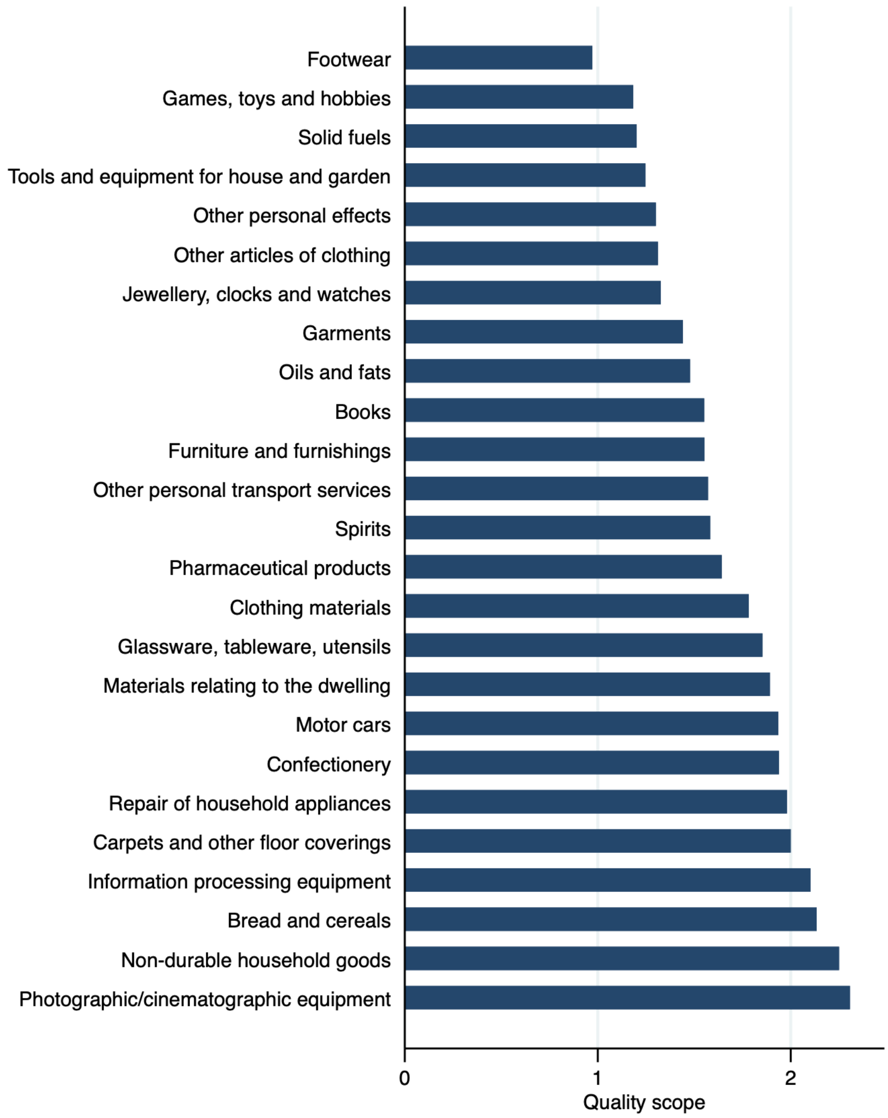


Notes: This graph shows the cumulative marginal impact on baseline pass-through of having an implementation lag (announcement date minus implementation date) above the median.

Figure B.1: Distribution of regulation across consumption categories

Notes: These plots summarize the distribution of the *Regimpact* measure across consumption categories. A lower value of the indicator reflects a more competition-friendly regulatory stance among input industries. Each box depicts the 25th, 50th and 75th percentiles, with extending lines to the minimum and maximum values, excluding outliers (defined as 1.5IQR below/above the lower/upper quartile).

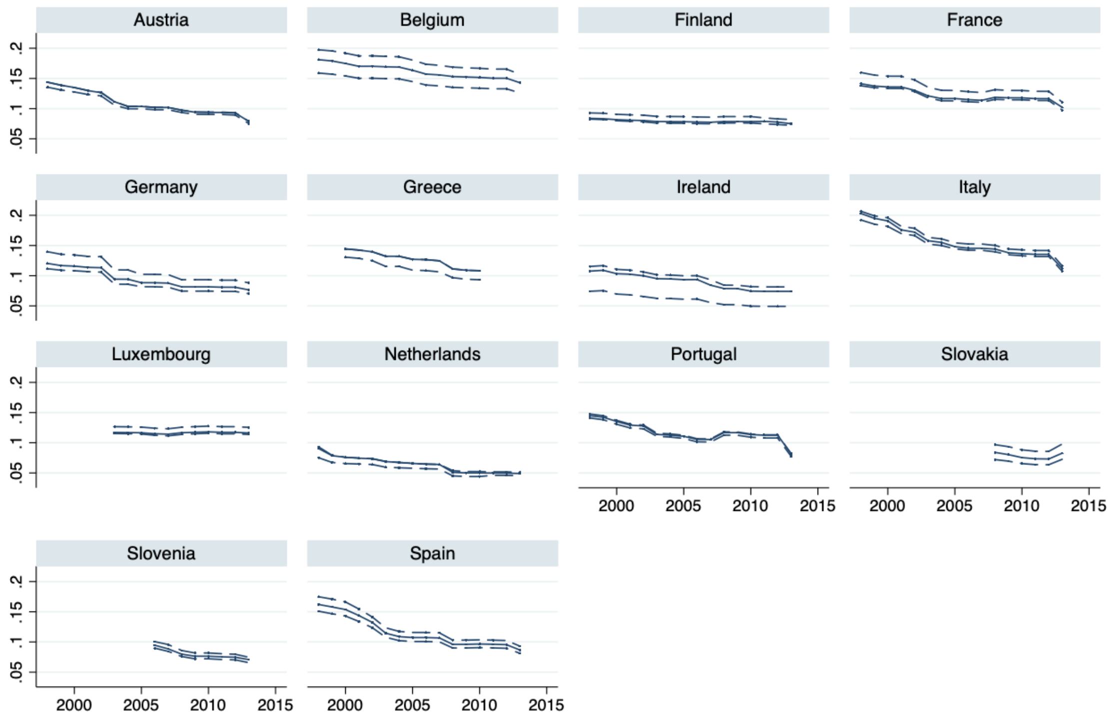
FIGURE B.2: Distribution of quality scope across consumption categories



Notes: This graph depicts the estimated quality range across different consumption categories. A higher value of the indicator reflects a longer average 'quality ladder' (Khandelwal 2010).

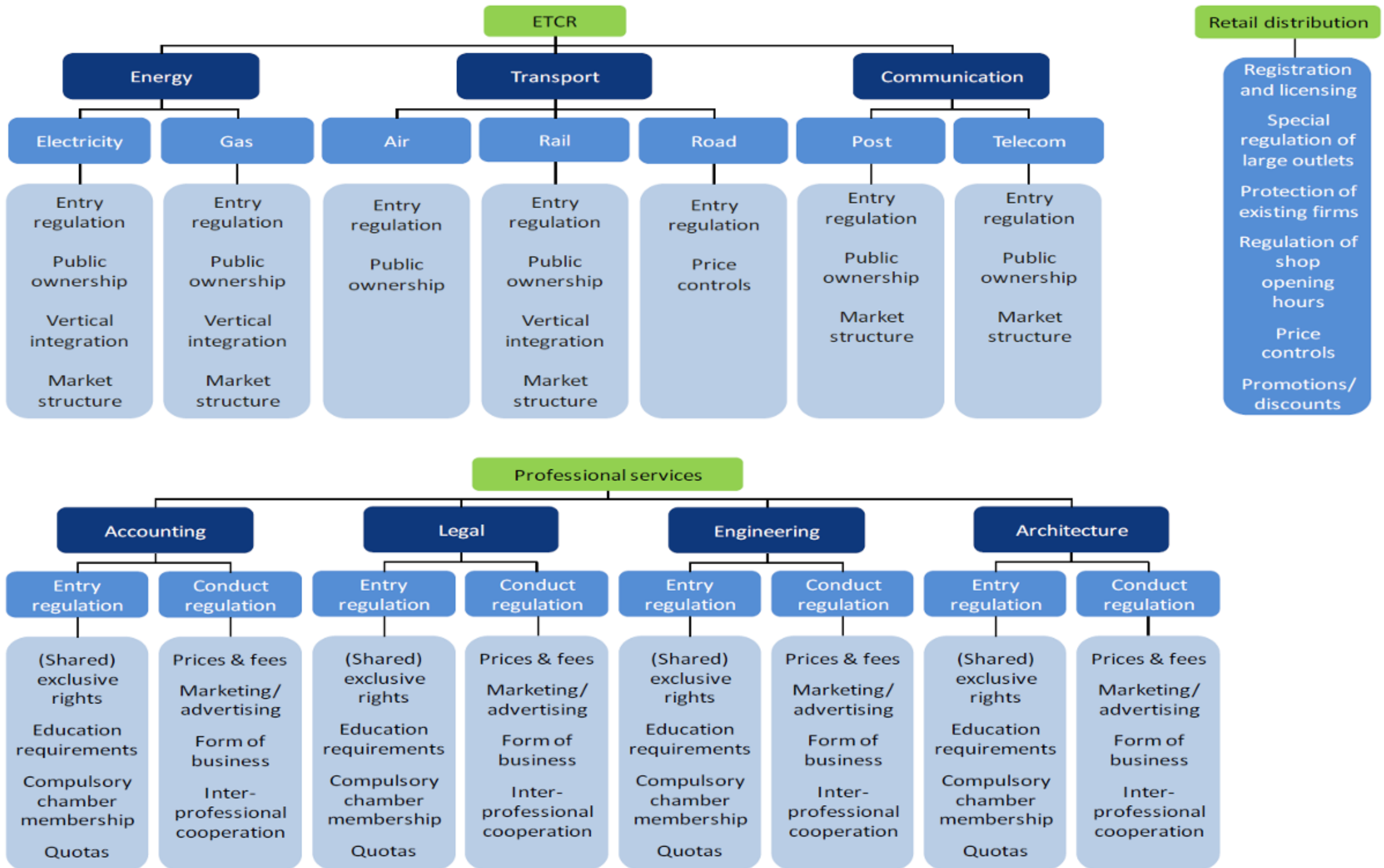
Figure B.3: Changes in upstream regulation by country and consumption category

(a) Median *Regimpact* by country over time – 25th, 50th and 75th percentiles



(b) Median *Regimpact* by consumption category over time – 25th, 50th and 75th percentiles

FIGURE B.4: Upstream industries included in *Regimpact* indicator, and the categories upon which they are scored



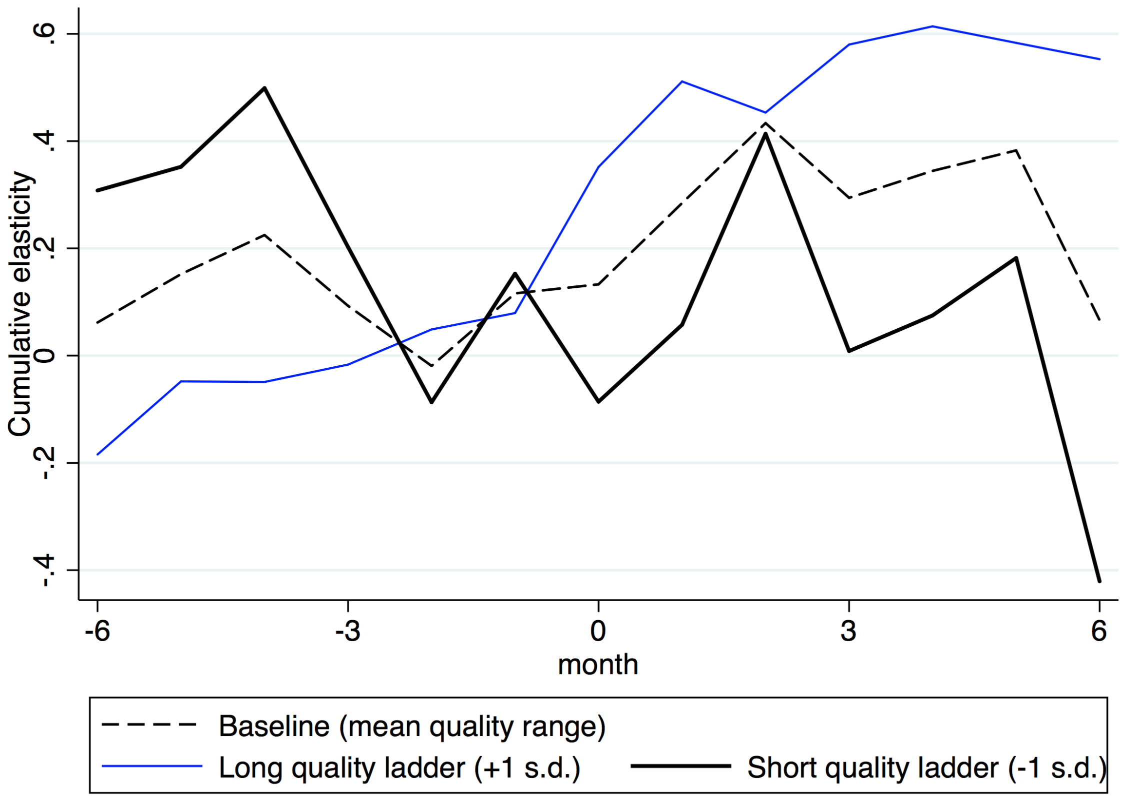
Source: Égert & Wanner (2016)

B.2 Additional Figures and Results

Heterogeneity in the Effects of Early Announcement:

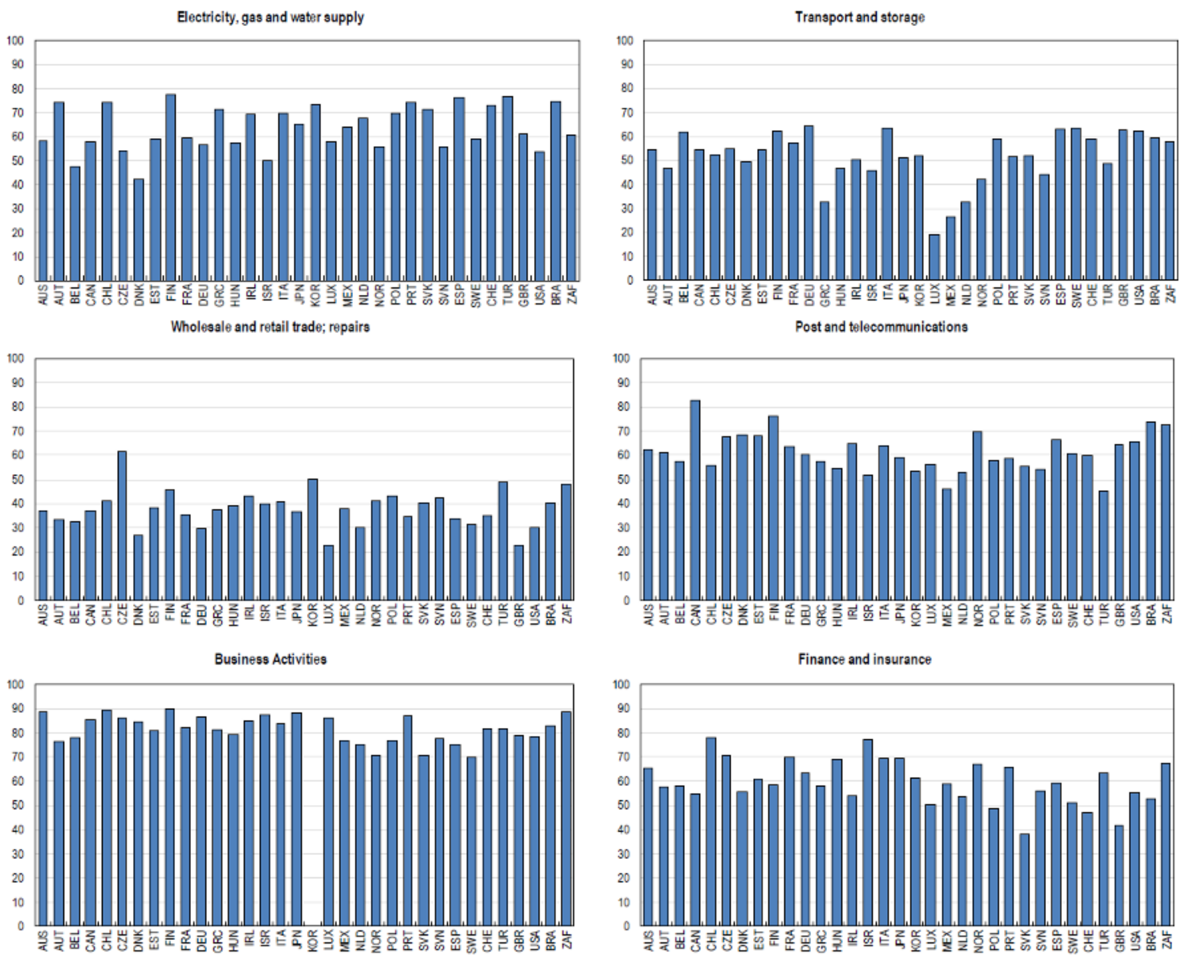
The top-left panel of Figure B.7 below shows contemporaneous pass-through by implementation lag for all country-product pairs for which we have data on announcement dates. The specific cases highlighted illustrate the heterogeneity: the bottom-left panel shows a relatively large possible announcement effect for a rise in VAT on package holidays in Luxembourg, while the bottom-right panel shows no announcement effect for a rise in VAT on restaurants and cafés in Portugal. Future research to gather more complete data on announcement dates will allow systematic evaluation of the factors determining whether advance announcement impacts pass-through.

FIGURE B.5: Cumulative effect of quality scope on pass-through



Notes: This graph shows cumulative baseline pass-through and the impact upon this of quality scope. The blue (black) lines show cumulative pass-through in a country-product pair with a quality ladder that is exactly one standard deviation longer (shorter) than the mean.

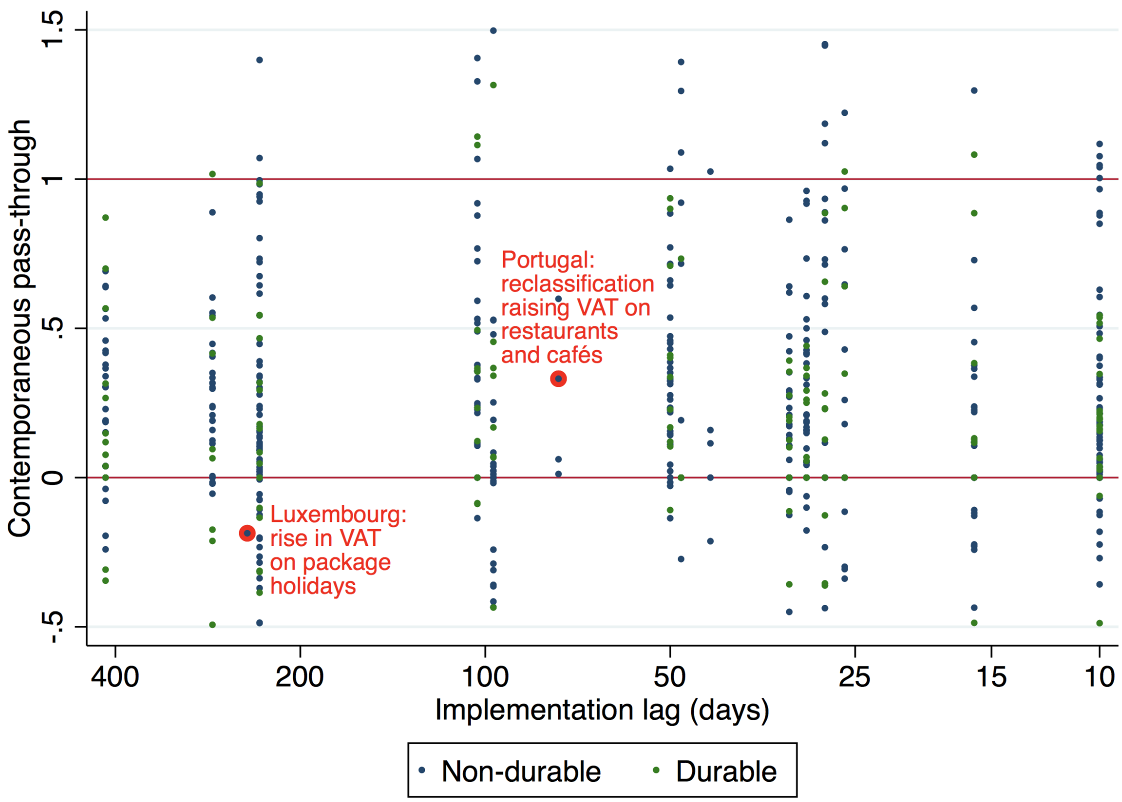
FIGURE B.6: Share of intermediate demand in gross output of non-manufacturing sectors



Notes: These graphs show the share of intermediate demand in gross output of non-manufacturing sectors across countries in the mid-2000s. The 'wide' *Regimpact* measure includes the first five sectors, while the 'narrow' measure includes only 'Electricity, gas and water supply', 'Transport and storage', and 'Post and telecommunications'. *Source:* Égert & Wanner (2016).

Figure B.7: Heterogeneity in announcement effects

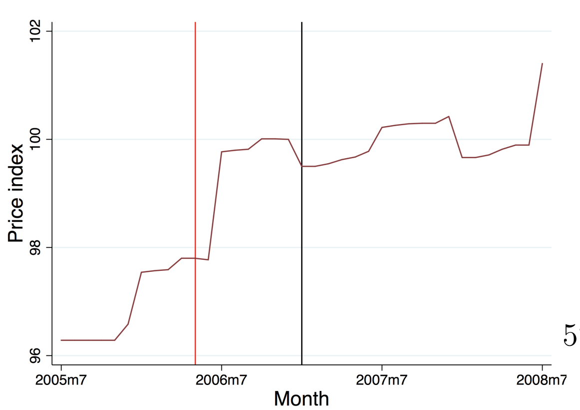
(a) Heterogeneity of pass-through by implementation lag



Notes: This graph shows the distribution of contemporaneous pass-through by implementation lag, across reforms for which announcement date data is available. The vertical spread illustrates the substantial heterogeneity in pass-through, even after controlling for implementation lags. The two reform episodes circled in red are shown in detail below.

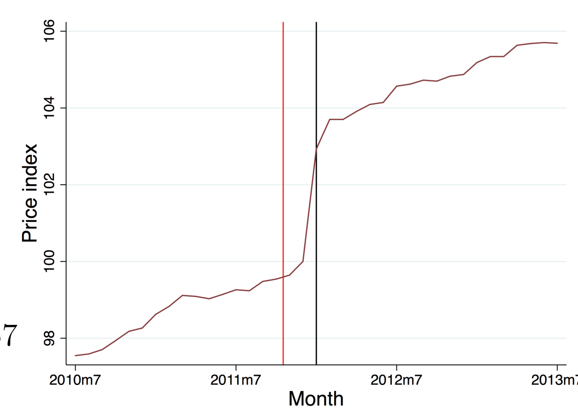
(b) Possible announcement effect:

Package holidays in Luxembourg



(c) No announcement effect:

Restaurants and cafés in Portugal



Notes: These two graphs show prices for two example goods over their respective reform episodes. In each case the first vertical line is the date the reform was announced, and the second is the date it was implemented. The lefthand graph shows a potential anticipation effect, unlike that on the right.

Table B.7: Impact of early announcement on pass-through, for continuous implementation lag

		Dependent variable: change in log prices				
		(1)	(2)	(3)	(4)	(5)
		No FEs	Individual FEs	Interaction FEs	Individual FEs + Controls	Interaction FEs + Controls
Baseline:	Pre-Reform	0.164	0.162*	0.0451	0.161*	0.0476
		(0.189)	(0.0711)	(0.556)	(0.0660)	(0.529)
	Contemporaneous	0.305***	0.257**	0.115	0.263**	0.115
		(0.003)	(0.0131)	(0.336)	(0.0170)	(0.337)
	Post-Reform	0.0838	0.0884	0.007	0.0827	0.00899
		(0.345)	(0.270)	(0.909)	(0.302)	(0.885)
	Total	0.554***	0.507***	0.167	0.507***	0.171
		(0.002)	(0.004)	(0.126)	(0.00442)	(0.122)
Implementation Lag:	Pre-Reform	-0.00248	0.00613	0.0323	0.00838	0.0316
		(0.951)	(0.806)	(0.157)	(0.738)	(0.166)
	Contemporaneous	-0.0263	-0.0114	0.00271	-0.00899	0.0195
		(0.187)	(0.541)	(0.907)	(0.650)	(0.403)
	Post-Reform	0.0304	0.00589	0.00603	0.0107	0.00596
		(0.333)	(0.802)	(0.761)	(0.651)	(0.766)
	Total	0.00165	0.000637	0.0410	0.0101	0.0571*
		(0.976)	(0.987)	(0.155)	(0.801)	(0.053)
	Controls	No	No	No	Yes	Yes
	X_ikt	No	No	No	Yes	Yes
	FEs	None	i,k,t	it,kt,ik	i,k,t	it,kt,ik
	Clustering	None	ik	ik	ik	ik
	N	100,983	100,983	100,983	100,023	100,023

Notes: p-values in parentheses. * p <0.10, ** p <0.05, *** p <0.01. 'X_ikt' refers to the inclusion of *Regimpact*, openness to trade and import concentration in the regression. Specifications (4) and (5) also controls for value added, consumption and whether the reform was part of a package. 'Implementation Lag' is measured in months, so a coefficient of 0.01, for example, implies that announcing a VAT reform one additional month in advance is associated with a 1% increase in pass-through.

Table B.9 considers the interaction between early announcement and openness, concentration, regulation and quality. Once again there is no evidence of an anticipation or total effect. The impact of regulation is driven by reforms which were announced fewer than 32 days in advance, but this is likely driven by the composition of that group – it contains a substantially higher share of changes to the reduced rate, which have the strongest effects as discussed above. The quality range effect is similar across implementation lag groups.

Additional tables (available on request) repeat the main specifications using country-level clustering and product-level clustering in turn. Results are similar with product-level clustering, while with country-level clustering the contemporaneous effect of *Regimpact* remains significant while the total effect is marginally insignificant.

Table B.8: Impact of early announcement on pass-through, for continuous implementation lag, by durability

		Dependent variable: change in log prices			
		Individual FEs		Interaction FEs	
		Non-Durables	Durables	Non-Durables	Durables
Baseline:	Pre-Reform	0.126	0.156*	-0.0479	0.131
		(0.254)	(0.0705)	(0.392)	(0.346)
	Contemporaneous	0.410***	-0.00241	0.299***	-0.156
		(0.00)	(0.962)	(0.00)	(0.240)
	Post-Reform	0.119	0.0334	0.0473	-0.0509
		(0.314)	(0.446)	(0.586)	(0.238)
	Total	0.655***	0.187	0.298**	-0.0753
		(0.003)	(0.201)	(0.0134)	(0.584)
Imp. Lag:	Pre-Reform	0.00617	0.0183	0.0439*	0.0224
		(0.847)	(0.238)	(0.0505)	(0.408)
	Contemporaneous	-0.0403*	0.0590***	-0.0272	0.0561**
		(0.0748)	(0.001)	(0.213)	(0.0190)
	Post-Reform	0.0126	-0.0209**	0.00150	0.0122
		(0.678)	(0.0241)	(0.947)	(0.493)
	Total	-0.0215	0.0564**	0.0182	0.0906***
		(0.656)	(0.0253)	(0.560)	(0.003)
# of VAT changes:		444	120	444	120
X_ikt		No		No	
FEs		i,k,t		it,kt,ik	
Clustering		ik		ik	
N		100,983		100,983	

Notes: p-values in parentheses. * p <0.10, ** p <0.05, *** p <0.01. The 'Individual FEs' and 'Interaction FEs' specifications correspond to models (2) and (3) in Table B.7, but with coefficients estimated independently for Non-Durables and Durables. 'Implementation Lag' is measured in months, so a coefficient of 0.01, for example, implies that announcing a VAT reform one additional month in advance is associated with a 1% increase in pass-through.

Table B.9: Regulation, quality and announcement effects

		Dependent variable: change in log prices			
		Full sample, no quality		Sample incl. quality	
Implementation lag (days):		>32=Early	<32	>32=Early	<32
Baseline β_1:	Pre-Reform	0.054	0.0165	0.766	0.059
		(0.708)	(0.765)	(0.147)	(0.647)
	Contemporaneous	0.26***	0.282***	-0.0356	0.0591
		(0.008)	(0.008)	(0.928)	(0.642)
	Post-Reform	0.101	-0.0349	-0.517	0.147**
		(0.440)	(0.663)	(0.245)	(0.021)
	Total	0.415***	0.263**	0.214	0.265
		(0.009)	(0.032)	(0.781)	(0.212)
Openness:	Total	-0.0145	-0.0123	4.195***	-1.474**
		(0.982)	(0.978)	(0.005)	(0.043)
Concentration:	Total	-0.0197	-0.0198	-0.286	-0.233
		(0.898)	(0.889)	(0.174)	(0.283)
Regimpact:	Pre-Reform	0.364	0.0531	1.387***	0.0397
		(0.118)	(0.382)	(0.000)	(0.749)
	Contemporaneous	0.0801	-0.254***	0.309	-0.523***
		(0.541)	(0.003)	(0.359)	(0.000)
	Post-Reform	-0.0033	0.0176	0.321	-0.136***
		(0.990)	(0.701)	(0.585)	(0.006)
	Total	0.441	-0.183*	2.017***	-0.62***
		(0.274)	(0.068)	(0.010)	(0.000)
Quality range:	Pre-Reform			-0.186	-0.0587
				(0.168)	(0.705)
	Contemporaneous			0.0127	0.418***
				(0.906)	(0.000)
	Post-Reform			0.398**	0.0616
				(0.012)	(0.527)
	Total			0.224*	0.421*
				(0.089)	(0.086)
# of VAT changes:		344	502	185	264
# of which:	Standard	308	414	178	234
	Reduced	33	83	7	29
	Reclassification	3	5	0	1
Average size of VAT change (pp):		1.6	0.6	1.6	0.7
FEs		it,kt,ik		it,k,t,ik	
Clustering		ik		ik	
N		100,983		49,598	

Notes: p-values in parentheses. * p <0.10, ** p <0.05, *** p <0.01.

B.3 Additional Tables for Robustness Checks

Table B.10: Estimates using discrete PMR variable

		Dependent variable: change in log prices		
		No FEs	Individual FEs	Interaction FEs
Baseline:	Pre-Reform	0.210	0.190*	0.0341
		(0.135)	(0.059)	(0.555)
	Contemporaneous	0.323***	0.317***	0.243***
		(0.000)	(0.000)	(0.001)
	Post-Reform	0.159	0.112	0.0373
		(0.139)	(0.248)	(0.609)
	Total	0.692***	0.619***	0.314***
		(0.000)	(0.001)	(0.002)
Openness:	Total	0.691	0.589	-0.0212
		(0.134)	(0.306)	(0.954)
Concentration:	Total	-0.0406	-0.0246	-0.0378
		(0.807)	(0.874)	(0.747)
$RegimpactHML$:	Pre-Reform	-0.137	-0.0596	0.0631
		(0.333)	(0.550)	(0.533)
	Contemporaneous	-0.199*	-0.252**	-0.351**
		(0.058)	(0.011)	(0.011)
	Post-Reform	-0.0664	-0.0177	-0.0606
		(0.666)	(0.865)	(0.490)
	Total	-0.402*	-0.330*	-0.348**
		(0.083)	(0.091)	(0.043)
FEs		None	i,k,t	it,kt,ik
Clustering		None	ik	ik
N		100,983	100,983	100,983

Notes: p-values in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Estimates are the sum of the price elasticity coefficients with respect to tax changes over each period. Prices are de-trended and de-seasonalized, and observations are weighted by their share of national consumption. $RegimpactHML$ is a discrete variable taking value 1 if the observation is in the top quartile of the *Regimpact* distribution, value -1 if in the bottom quartile, and zero otherwise. Openness and market concentration are standardized so the coefficients can be interpreted as the impact on pass-through of a one-standard-deviation rise in the regressor. Pre-Reform, Contemporaneous and Post-Reform effects are also estimated for Openness and Concentration, but are not significant so omitted for conciseness.

Table B.11: Estimates by direction of VAT change

		Dependent variable: change in log prices		
		Increases	Decreases	Coeff.s Equal
Baseline:	Pre-Reform	0.0435	-0.0511	0.26
		(0.734)	(0.293)	
	Contemporaneous	0.0000215	0.296***	0.00
		(0.459)	(0.001)	
	Post-Reform	0.00122	0.0483	0.71
		(0.990)	(0.543)	
	Total	0.0447	0.293**	0.25
		(0.784)	(0.027)	
Openness:	Total	0.370	-1.123*	0.07
		(0.481)	(0.0826)	
Concentration:	Total	0.126	0.00695	0.58
		(0.470)	(0.957)	
Regimpact:	Pre-Reform	0.0112	-0.0385	0.54
		(0.879)	(0.324)	
	Contemporaneous	-0.172**	-0.126	0.75
		(0.0294)	(0.242)	
	Post-Reform	-0.00767	0.0439	0.62
		(0.894)	(0.612)	
	Total	-0.169	-0.121	0.83
		(0.200)	(0.498)	
# of VAT changes:		707	151	
FEs		it,kt,ik		
Clustering		ik		
N		105,616		

Notes: p-values in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Estimates are the sum of the price elasticity coefficients with respect to tax changes over each period. Prices are de-trended and de-seasonalized, and observations are weighted by their share of national consumption. *Regimpact*, openness and market concentration are standardized so the coefficients can be interpreted as the impact on pass-through of a one-standard-deviation rise in the regressor. The final column presents p-values from a Wald test of equality between the Increase and Decrease coefficients.

Table B.12: Estimates by direction of VAT change, including quality range

		Dependent variable: change in log prices		
		Increases	Decreases	Coeff.s Equal
Baseline:	Pre-Reform	0.12	0.162	0.90
		(0.697)	(0.256)	
	Contemporaneous	0.00	0.539***	0.00
		(0.553)	(0.003)	
	Post-Reform	-0.282	0.0747	0.11
		(0.116)	(0.552)	
	Total	-0.163	0.775***	0.02
		(0.609)	(0.000)	
Openness:	Total	-0.322	0.0651	0.78
		(0.729)	(0.942)	
Concentration:	Total	0.0342	-1.16***	0.00
		(0.872)	(0.001)	
Regimpact:	Pre-Reform	0.0928	0.264	0.55
		(0.641)	(0.234)	
	Contemporaneous	-0.421**	-0.0214	0.26
		(0.017)	(0.945)	
	Post-Reform	-0.00824	-0.357	0.15
		(0.927)	(0.113)	
	Total	-0.336	-0.114	0.63
		(0.171)	(0.758)	
Quality range:	Pre-Reform	-0.0621	0.0701	0.50
		(0.635)	(0.694)	
	Contemporaneous	0.187*	0.17	0.95
		(0.083)	(0.443)	
	Post-Reform	0.345***	-0.352*	0.01
		(0.002)	(0.072)	
	Total	0.471**	-0.111	0.16
		(0.030)	(0.691)	
# of VAT changes:		373	80	
FEs		it,k,t,ik		
Clustering		ik		
N		49,598		

Notes: p-values in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Estimates are the sum of the price elasticity coefficients with respect to tax changes over each period. Prices are de-trended and de-seasonalized, and observations are weighted by their share of national consumption. *Regimpact*, openness, market concentration and quality range are standardized so the coefficients can be interpreted as the impact on pass-through of a one-standard-deviation rise in the regressor. The final column presents p-values from a Wald test of equality between the Increase and Decrease coefficients.

Table B.13: Estimates across the business cycle

		Dependent variable: change in log prices		
		Expansions	Contractions	Coeff.s Equal FEs
Baseline β_1:	Pre-Reform	-0.0227	0.0602	0.53
		(0.757)	(0.589)	
	Contemporaneous	0.286***	0.13	0.38
		(0.000)	(0.413)	
	Post-Reform	0.142	-0.035	0.20
		(0.181)	(0.689)	
	Total	0.405***	0.155	0.31
		(0.001)	(0.455)	
Openness:	Total	-0.107	0.0354	0.86
		(0.826)	(0.950)	
Concentration:	Total	-0.255	0.118	0.13
		(0.198)	(0.394)	
Regimpact:	Pre-Reform	0.0707	0.0957	0.82
		(0.318)	(0.268)	
	Contemporaneous	-0.219***	-0.187	0.86
		(0.000)	(0.266)	
	Post-Reform	-0.0804	0.114	0.05
		(0.175)	(0.145)	
	Total	-0.228***	0.0226	0.35
		(0.000)	(0.932)	
# of VAT changes:		300	558	
Average size of VAT change (pp):		0.54	1.2	
FEs		it,kt,ik		
Clustering		ik		
N		100,983		

Notes: p-values in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Estimates are the sum of the price elasticity coefficients with respect to tax changes over each period. Prices are de-trended and de-seasonalized, and observations are weighted by their share of national consumption. Openness and market concentration are standardized so the coefficients can be interpreted as the impact on pass-through of a one-standard-deviation rise in the regressor. Pre-Reform, Contemporaneous and Post-Reform effects are also estimated for Openness and Concentration, but are not significant so omitted for conciseness.