How much changes in VAT affect consumer prices? Estimation of VAT pass-through in the EU Passenger Transport Sector

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Abstract

In the passenger transport sector in the European Union, there currently exists a byzantine system of VAT taxation, with little uniformity across modes or countries, and calls for increased harmonization have often been heard, on account of "leveling the playing field" for different operators across the EU. This paper looks at the critical element of any tax intervention, that is the extent to which changes in VAT rates are actually shifted on final prices. Using regression techniques we estimate the magnitudes of pass-through in four modes of passenger transport: airline, road, railways and waterways, and assess the impact of market competition on the transmission of tax liabilities to prices. The results indicate that railways and airline exhibit nearly full shifting, while the other two modes show under shifting of VAT tax changes. We confirm theoretical insights that on more competitive markets the pass-through of VAT on customers is ceteris paribus larger.

Highlights

- Theoretical determinants of tax pass-through are discussed
- Econometric model of pass-through is developed
- Magnitudes of vat pass-through in four passenger modes are obtained
- Competition effect is determined

Keywords

Pass-through, VAT, tax incidence, imperfect competition, passenger transport

JEL Classification

H22; L91; R48

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1. INTRODUCTION

The extent of pass-through to final prices of changes in VAT rates is of great importance for policy purposes. Reductions or holidays in VAT rates in selected popular expenditure items have been used in the past in an attempt to stimulate final demand during difficult economic times. Whether the changes in VAT rates actually lead to reduced prices is of great importance for the effectiveness of such policy attempts. Similarly, when considering VAT regime changes aiming at harmonizing the treatment of certain market participants, the extent of the pass-through will determine how much of the (costs or benefits) of harmonization will fall onto consumers or providers. In the passenger transport sector in the European Union, for instance, there currently exists a rather byzantine system of VAT taxation, with little uniformity across modes or countries, and calls for increased harmonization have often been heard, on account of "leveling the playing field" for different operators across the EU.

Standard economic theory of supply and demand argues that changes in market prices resulting from changes in tax rates, including VAT, will typically be split in different proportions between suppliers and consumers. According to textbook economics, this tax incidence is determined by the ratio of supply and demand elasticities (Varian 1992). Only in special cases, when either supply or demand is completely inelastic, the price change is absorbed, respectively, by suppliers and consumers. We refer to those two extreme cases as zero or full pass-through.

The above textbook insight is useful as a starting point in the study of the economics of tax incidence in passenger transport, but it misses important subtleties which are present in state-of-art research on the subject. The main reason why the determination of pass-through on transport markets is a complex issue is their imperfectly competitive nature. Many theoretical and empirical contributions related to imperfectly competitive markets point to the fact that the impact of tax on consumer price, including also, the possibility of tax over shifting, depends on numerous factors other than just demand and supply elasticities: such as market structure and type of competition, number of firms, cost and demand structures, and the time horizon in which the tax shifting is analyzed (Fullerton and Metcalf 2002). Hence, if a market of interest has an oligopolistic structure, as is the case of passenger transport, then analyzing taxation impact on customer and producer prices by extrapolating results from either perfect competition or monopoly might be misleading (Katz and Rosen 1985).

This paper describes an econometric model to assess the extent of VAT pass-through in the passenger transport sector in the European Union and discusses its results. We briefly review the theoretical literature and discuss how increased competition, measured by a number of firms or concentration index, may lead to a higher pass-through on customers. This counter-intuitive result implies that on imperfectly competitive markets, profit-maximizing transport carriers strategically absorb a greater part of the tax to reduce output distortion induced by demand response. The second, more intuitive result is that tax pass-through decreases with growing demand elasticity. Thus, for example the stronger inter-mode substitutability possibilities for passengers, the more tax will be absorbed by transport carriers.

While theoretical literature provides quite detailed and complex picture of factors influencing tax pass-through, empirical evidence is quite limited to selected markets such as tobacco or automotive industry. Applied studies for close to perfectly competitive markets reasonably assume full shifting. However, situation is much more complicated in the case of oligopolistic market structures where both under shifting and over shifting is possible depending on the relative curvature of industry demand and firms cost functions, see for example Delipalla and O'Donnell (1998) or Fullerton and Metcalf (2002) Fullerton and Metcalf (2002). Thus, the degree of pass-through on such markets is an empirical question and needs to be assessed case by case. In particular little is known about the actual vat share born by consumers in transport, the major market with VAT reduced-rate in the EU, despite the ongoing debate about harmonization of VAT rates across countries and modes.

This paper aims at filing this gap by providing empirical evidence on the pass-through effect in the four main transport modes (airline, railways, road, and waterways) on the EU27 level. We have utilized simple econometric modeling on a unique dataset collected specifically for that research objective. The set contains market level data on prices, outputs, levels of competition, and VAT rates for each country-mode pair for the years 2001-2011. This approach allows us to isolate and quantify VAT pass-through efects for different modes while controlling for changes in input prices, the level of competition, and demand shocks, which all can shift consumer price. With our approach it is also possible to assess how observed differentiation of market concentration affects pass-through levels in EU member states.

2. Theoretical Foundations of tax pass-through

A comprehensive academic presentation of tax incidence is provided by Fullerton and Metcalf (2002). They separate the cases of perfectly and imperfectly competitive markets and consider both ad valorem and specific output taxation for different models of oligopolies. A general conclusion that follows from their work is that the extent of pass-through is very sensitive to particular assumptions about costs, demand and market structure settings. This can be easily seen even in the simplest case of perfect competition. Under the constant returns to scale assumption, Fullerton and Metcalf argue that any unit tax increase will be entirely passed on consumers since producer prices cannot fall below constant marginal cost. The same logic derived from the principle of zero economic profits holds for homogeneous product Bertrand competition, where firms compete in prices. Thus, for the reasons given above, in a long-term equilibrium of perfectly competitive markets, typical full-shifting might be assumed under constant returns to scale. On the other hand, in the short run, under perfect competition with an upward sloping supply curve due to increasing marginal cost, any proportion of tax sharing between consumer and producers is possible, excluding full shifting or over shifting.

Fullerton and Metcalf show that under many imperfectly competitive settings, tax over shifting is possible or sometimes even guaranteed. The interest in over shifting is motivated by the results of several empirical studies, which tend to confirm this phenomenon in various markets. On theoretical grounds, over shifting occurs only under particular assumptions regarding curvature of costs and demand. For example, in static Cournot oligopoly, over shifting of unit tax cannot occur under linear demand and constant marginal cost; however, under constant demand elasticity (or more generally convex demand function), it will always be guaranteed. Moreover, Fullerton and Metcalf show that in a Cournot oligopoly with free entry, positive fixed costs and constant marginal costs, over shifting is more likely because the increase in unit tax has an additional indirect effect on consumer price via reducing equilibrium number of firms. As a consequence, in the long run, pass-through effect and corresponding price reaction will typically be larger than for a fixed number of companies. Altogether the conditions which determine the magnitude of pass-through in imperfectly competitive models are technically rigorous and allow both over and under shifting to occur.[4]

The introduction of product differentiation brings additional paths over which taxes can affect prices. Typically, with differentiated products, firm responses to tax increase might partially have a non-price nature. Under horizontal differentiation, oligopolistic firms can react by reducing product variety (Kay and Keen 1983). On the other hand, in vertically differentiated markets, firms may respond by lowering product quality (Cremer and Thisse 1994). Under the latter scenario, consumer prices might even drop due to a decreased marginal cost, marking negative pass-through. The general conclusion from differentiated product markets is that the pass-

[4] In Appendix 2, we illustrate the impact of changes in taxation on consumer prices in imperfectly competitive market using standard N-firm Cournot oligopoly setting. This analytical exercise aims to provide insights for interested readers into the mechanics of short and long-run pass-through effects.

through will typically be lower as firms can respond to tax increases by reducing the degree of differentiation, which intensifies price competition. Summing up, the indications of the theoretical literature allow drawing a few conjectures regarding the likely pass-through differentiation in multi-modal passenger transport industry:

- Within given mode, the VAT tax pass-through is expected to be larger for more demand inelastic and more competitive markets;
- Markets/corridors with lower inter-modal substitutability are likely to exhibit larger pass-through on consumer prices;
- Advances in the liberalization of formerly vertically integrated markets, such as rail, will likely increase pass-through over time as dominant firms under third party access regulation experience increasing competitive pressure.

As indicated in the second section, the impact taxation on prices is mediated by several factors, which can be interrelated. For example, greater availability of train connections on a given route shall lead to lower pass-through in road mode on that route due to greater demand elasticity for bus trips. On the other hand, greater inter-modal substitutability will raise intra-modal competitive pressure on bus operators, leading to additional competition effect induced by exit of least cost effective operators from a bus mode. This effect is expected to further decrease pass-through in the longer run. This example highlights the need to control not only for direct demand effect but also for competition effect in the regression model for proper isolation of the pass-through. Forming reliable expectations about between-mode differences in pass-through magnitudes is even more demanding, as different modes differ not only with respect to demand characteristics but also idiosyncratic factors such as cost structures which must be controlled for directly or via fixed effects. Before we discuss our estimation strategy we refer to empirical studies of pass-through magnitudes.

3. Review of Empirical Studies

Numerous empirical studies have dealt with tax incidence of specific and ad-valorem taxes (including VAT). This literature focuses on several aspects that impact tax pass-through, such as intensity of competition, demand elasticity and type of taxation. Interestingly, instances of over shifting and long-term versus short-term impact have also been reported. In general, empirical studies confirm most of the theoretical findings highlighted in section 2.

Some studies found smaller shifting on less competitive or more demand elastic markets. The most widely cited among them are Poterba (1996), Carbonnier (2007), and Alm et al. (2009). In light of these two findings, Carbonnier (2007) argues that sales tax may serve as an effective redistribution instrument on markets with lesser competition. Increased tax rate will capture a greater portion of oligopoly rent due to the strategic inclination of firms to maintain an undistorted level of demand.

Tax shifting to consumers on imperfectly competitive markets, is larger for specific tax than for ad-valorem tax (Delipalla and Keen 1992). This theoretical result is relevant for the study of VAT incidence and has been empirically confirmed by Delipalla and O'Donnell (1998), who compared consumer shares of specific and ad-valorem sales taxes on the European cigarette market. Carbonnier (2007) points also to the interesting issue of scale of tax changes. He speculates that large changes in tax rates tend to be less shifted than small changes because of consumer perception bias.

In contrast to perfectly competitive structure which exhibits full shifting, oligopolistic markets tend to show under or over shifting. As discussed earlier, both possibilities are theoretically plausible, because the extent of pass-through is determined jointly by several cost, demand, and competition parameters (Delipalla and O’Donnell 2001). Interestingly, few studies, such as (Karp and Perloff 1989) and Alm et al. (2009), obtained clear evidence of tax over shifting. Others, especially multiproduct papers, found under shifting (Besley and Rosen 1999; Poterba 1996). Controlling for market structure is particularly important for unbiased assessment of tax incidence (Karp and Perloff 1989). In reduced-form models, utilized in majority of studies, this can be done with variables measuring market concentration and input costs, provided availability of such data. Several studies, like Harris (1987), missed important price shifters, risking potential overestimation of pass-through effect.

The contribution of our study is clear cut, as we have not found any empirical studies relating directly to VAT pass-through in transport markets. Some studies provide estimates of demand elasticity for particular transportation modes. For example Litman (2013) shows that those elasticities vary between -2 and close to 0, depending on the purpose and time of travel. Fouquet (2012) documents that aggregate land transport elasticities in UK have been decreasing since the 19th century, due to real price decline and real income rise, reaching -0,6 in 2010. Those papers however do not make any reference to the tax pass-through effect.

4. Modeling Framework for VAT Pass-Through

To estimate the impact of VAT rate changes on price levels we utilized a standard, reduced-form pricing model. This framework has reasonable data requirements and therefore is frequently adopted in empirical studies of tax incidence.

Our core data set contains observations on changes in VAT regimes in four modes of passenger transport for EU-27 countries for the period 2001-2011. Additionally we use price indices and output volumes of respective modes as well as numerous control variables for competition intensity as well as supply and demand shifters. Although our dataset has a panel structure we treat it as a cross-sectional data because changes in VAT rates have been introduced infrequently throughout the decade (see Table A.1 in the Appendix 1). Hence no fixed effects can be sensibly disentangled from the data. The general model is in the following form:

$$\{dP = f(dQ(L),\ m(i)dvat,\ dP(L),\ dY(L), dvathhi\} \qquad (1)$$

where:

- dQ(L) – lag of annual rate of change in the demand level, measured by the change of passengers (for air and water transport) and passenger-kilometers (for road and rail transport) volumes. Data source: EUROSTAT and World Bank.
- $m(i)dvat$ are mode-specific changes in VAT liabilities, where $m(i)$ are dummy variables for particular modes,[5] multiplied by $dvat$ variable explained below.
- $dvat$ – the first difference in theoretical liability from changing VAT rates. The $dvat$ was calculated in the following form:

$$dvat = \frac{VAT_t}{(1+VAT_t)}P_t - \frac{VAT_{t-1}}{(1+VAT_{t-1})}P_{t-1} \qquad (2)$$

  VAT_t denotes the rate of VAT in the time *t* (after the change of rate) and VAT_{t-1} is the rate of VAT for the previous year (before the change of rate). P_t and P_{t-1} are the levels of corresponding consumer price indices (HICP). Importantly, if VAT rate remained unchanged between two successive periods, $dvat$ variable is set to zero. Data source: own calculations based on VAT rates database collected in Barbone et al. (2014).

[5] Mode index: $i \in (1, \dots, 4)$, where: 1 - passenger transport by air (CP0733); 2 - passenger transport by railway (CP0731); 3 - passenger transport by road (CP0732), and 4 - passenger transport by sea and inland waterway (CP0734).

- dP(L) – lag of annual rate of change in a harmonized index of consumer price (HICP). Data source: EUROSTAT.
- $dvathhi$ - interaction variable which captures the impact of competition intensity on the pass-through, measured by Herfindahl-Hirschman concentration index (HHI). Data source: own calculations based on industry data.
- dY(L) – lag of the annual rate of GDP growth which controls for shifts in demand. Data source: EUROSTAT.

Our initial data sample consisted of 1112 observations (country-year pairs). Due to missing data, especially in output variable ($Q_{j,t-1}$) and HHI ($dvathhi_{j,t}$), the final sample had 863 observations. Summary statistics of variables used in the model are shown in Table 1 below.

Table 1. Descriptive statistics.

variable	*N (# obs.)*	*Mean*	*Std. Dev.*	*Min*	*Max*
dP	944	4.01	7.44	-24.66	67.70
dY	1120	0.02	0.04	-0.19	0.10
m(1)dvat	1110	0.04	0.47	-7.51	5.57
m(2)dvat	1110	0.09	0.88	-3.47	22.22
m(3)dvat	1110	0.08	0.82	-3.04	22.12
m(4)dvat	1110	0.02	0.20	0.00	4.45
dQ	1066	0.01	0.13	-0.86	0.81
HHI	1132	0.40	0.34	0.00	1

The annual rate of price changes in passenger transport varied between -25 and 68 percent points. The average rate was slightly above 4 points. High standard deviation can be explained by the presence of emerging market and years of financial crisis. These both factors cause more volatility in changes the prices. Herfindahl–Hirschman index for EU transport markets exhibits full range of variability, varying from 0.001 (nearly perfect competition) to 1 (perfect monopoly). Demand for passenger transport services in the EU-27 between 2001 and 2012 increased on average by almost 1% per year. The largest changes in the VAT rate were observed in the road and rail transport.

Unlike Carbonnier (2007), who models consumer share in the total VAT amount, we measure pass-through as the ratio of two variables: $dP/dtax^{vat}$. This ratio can be directly estimated as one of the coefficients in equation (1) and has interpretation both in terms of elasticities and monetary changes.[6] Note that the value of $dtax^{vat}$ coefficient exceeding one is an indication of tax over shifting. In following sections, we explain in detail the underlying econometric model and the estimation results.

5. Econometric model and estimation strategy

[6] Since price is an index, both nominator and denominator of $dP/dtax^{vat}$ ratio are expressed in percent changes. However if the price was measured in levels, the ratio would remain unaffected.

Our estimated model has the following specification, with subscript *j* denoting country and *t* denoting time in years:

$$dP_{j,t} = \beta_0 + \beta_1 dP_{j,t-1} + \beta_2 dY_{j,t-1} + \beta_2 dQ_{j,t-1} + \beta_3 m(1) dvat_{j,t} + \beta_4 m(2) dvat_{j,t} + \beta_5 m(3) dvat_{j,t} + \beta_6 m(4) dvat_{j,t} + \beta_6 dvathhi_{j,t} + \varepsilon_{j,t} \quad (3)$$

In order to address endogeneity in the model, we decided to include the lagged GDP and the lagged output. Presence of endogenous variables would require using instrumental variable regression. However, we lacked proper instruments for demand-related variables that would be both relevant and exogenous from price. The lagged output can play a role in price movements due to imperfect competition, lack of information and other market failures which lead to the delayed price adjustments as a response to changes in demand.

Before model estimation we perform various correctness checks for general specification in Eq. (3). First, we determine, how we should approach the panel-type data and the error term of the regression equation. Since we include lagged dependent variable in the model, we violate the assumption of strict exogeneity and thus the model with fixed effects cannot be taken into consideration. We perform Breusch-Pagan LM test for random effects. With probability p=0.16, we fail to reject the null hypothesis that there is a significant difference across units. Given this result we decided to ignore the panel structure of our data sample.

Second, we check whether all relevant variables are included in the model using link test as described in Pregibon (1980).[7] Test results (shown in Table A.2 in the Appendix 1) give significant result for a predictor variable and insignificant for a squared predictor, which indicates that the model specification is correct. In addition we apply Ramsey RESET in order to detect the possible omitted variable bias. With F(3, 851) = 1.42, we fail to reject the null hypothesis that the model has no omitted variables.

Next, we test for non-linearity using a simple NLCHECK procedure described in Jann (2008).[8] All test results are insignificant with 5% level (see Table A.3 in Appendix 1), which indicates that linearity assumption is not violated. We also test for possible multicollinearity in the regression with variance inflation factor (VIF). The average VIF amounts to 5.29, while results above 10 are usually considered as high. Excluding *dvathhi* from the model significantly reduces VIF to 1.06. This finding might indicate possible multicollinearity between *dvathhi* and other explanatory variables. Therefore finally we estimate two different specifications with and without *dvathhi* variable.

In the regression model presence of heteroscedasticity and autocorrelation was detected. Thus, we decided to use Newey-West estimator with HAC standard errors corrected for both autocorrelation and heteroscedasticity. Due to the annual granularity of the data sample, one lag of dependent variable is included. Using Shapiro-Wilk test (with p=0.00), we reject hypothesis that error terms are distributed normally. We do not consider this result as a potential cause of estimation bias as that the presence of possible outliers might be the reason for violation of this assumption. Hence, in the next step, we tried to detect possible outliers and estimate regression coefficients on a reduced sample. We test, whether there are significant differences between models with and without outliers.

Using the test described in Grubbs (1969), we detect several outliers in the sample. The presence of these outliers can be related to the fact that the changes in VAT rate occurred relatively rarely in our data (only in 10% of observations). In order to determine, whether the presence of the outliers, might have affected estimation results, we estimated the model using the reduced sample of 88 observations with changes in VAT rate. The outcomes

[7] The general idea of this test is to check whether additional significant independent variables can be found. If the model is specified correctly, regression $dP_{j,t}$ on the prediction would give significant results, while regression on prediction squared would be insignificant.

[8] First, predictors are categorized into bins. Then, the model is fitted again using dummy variables of these bins. Finally, the joint Wald test is performed.

of major tests in restricted sample are similar in comparison to the full sample model. First, no random effects are detected. Second, both link test and Ramsey RESET test indicate that the reduced sample model's specification is correct. Third, the linearity assumption could not be rejected. Finally, in the reduced sample VIF dropped significantly (from 5.29 to 2.67) and only heteroscedasticity, but no autocorrelation was detected. Lack of autocorrelation can be justified by the small sample and no actual time-series data. Taking all of these findings into consideration, the Newey-West estimator with HAC standard errors without lagged variables was used in the regression on reduced sample. No significant differences between estimated coefficients were found (see Table A.3 in Appendix 1 for estimates of restricted sample model). Adjusted R-squared increased from 0.18 in the full sample model to 0.36. Importantly, as we have expected, excluding outliers altered results of Shapiro-Wilk test. At 5% significance level we now fail to reject the null hypothesis that the error terms have normal distribution.

Since there is no significant differences in the estimated coefficients between the full sample model and the reduced sample model, in the next section, the results of the full sample model are presented in detail.

6. Results

The results of our estimations are presented in Table 2. Model 1 provides total pass-through coefficients for each of the main transport modes. Model 2 includes additional interaction variable $dvathhi$ which captures the effect of market competition (measured by HHI) on the overall magnitude of pass-through in passenger transport.

In Model 1, the pass-through effect is captured by the coefficients of $m(i)dvat$ variables which reflect the mode-specific magnitude of tax shifting. Those estimates indicate by how consumer price can be expected to increase (in €) as a result of €1 increase in VAT liability, induced by VAT rate increase. Altogether the pass-through magnitudes are high, ranging from 0.62 to 1.17. The strongest effects are observed for air and rail modes where both coefficients indicate respectively nearly full shifting and small over shifting. Partial shifting for road mode (0.619) looks rather striking, as this type of passenger transport has no concertation as indicated by the low value of HHI (see Table 3).[9] On the other hand, partial shifting can be explained with low demand elasticity and hence at least some extent of market power. With an exception of major inter-urban corridors, carriers are not exposed to severe intra and inter-modal competition because they operate on different routes without overlaps.[10] In such situation carriers might still choose not to distort output to much for strategic reasons which explains why the pass-through coefficient is sharply below one. Nearly full shifting in the air mode also looks striking, given relatively high demand elasticities reported in Table 3. This result however can be explained by intensive intra-modal competition from low-cost carriers on particular routes inside EU which drives margins down and hence reduces strategic inclinations of carriers to absorb tax changes. Altogether, our findings for air and road modes suggest that the intensity of inter and intra-mode competition is an important factor that influences the magnitude of pass-through. Overshifting in case of rail mode can be explained with low demand elasticity and a rise of intra-modal competition resulting from advancements in liberalization.

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[9] HHI takes values from a range between zero and one, capturing in a synthetic way all possible states of competition from perfect competition (HHI=0) to monopoly (HHI=1).

[10] Some methodological concerns can be risen with regards to utilizing HHI as a measure of competition in road mode. When using country level HHI for assessing competition in particular transport modes one must be careful, because country level markets are usually too broad compared to the scope of relevant markets. Especially, country-level HHI might provide an upward biased assessment of competition on fragmented markets organized around particular corridors, where different companies operate on different routes without overlaps.

Table 2. Estimation Results: pass-through and competition effect.

Model 1. Dep = dP		Model 2. Dep = dP	
Variable	**Coefficient** (Std. Err.)	**Variable**	**Coefficient** (Std. Err.)
dP(L)	0.367** (0.056)	dP(L)	0.364** (0.056)
dY(L)	34.048** (6.855)	dY(L)	35.602** (6.931)
m1dvat (air)	0.925* (0.382)	m1dvat (air)	1.651** (0.475)
m2dvat (rail)	1.173** (0.306)	m2dvat (rail)	3.316** (0.855)
m3dvat (road)	0.619** (0.212)	m3dvat (road)	0.833** (0.232)
m4dvat (water)	0.799 (0.752)	m4dvat (water)	2.761* (1.125)
dQ(L)	-1.899 (2.310)	dQ(L)	-2.042 (2.367)
Intercept	1.697** (0.284)	Intercept	1.651** (0.290)
.		dvathhi	-2.348* (0.937)
N	883	N	863
$F_{(7,875)}$	18.791	$F_{(8,854)}$	17.575
Prob > F	0.000	Prob > F	0.000
R-squared	0.182	R-squared	0.183
***, **, * Significance at 1 %, 5%, 10% level		***, **, * Significance at 1 %, 5%, 10% level	

Table 3. HHI and elasticities

Mode	Air	Rail	Road	Waterways
HHI (EU-27 Average)	0.19	0.67	0.09	0.19
Own elasticities[(a)]	-0.8/-1.12/-1.96	-0.65/-1.2	-0.45/-0.69	Na
Coefficient of variation of pass-through among EU28 due to HHI variability[(b)]	0.37	0.50	0.54	0.56

(a) Based on Litman (2013) and InterVISTAS (2007) for air mode.

(b) Own calculations.

Estimation results for Model 2, bring one additional insight to our knowledge of European transport market. The coefficient for interaction variable $dvathhi$ is negative (-2.34) as expected by theoretical literature. Hence, the more competitive the market is, the larger the pass-through of VAT on customers.[11] Taking the strength of competition impact on pass-through magnitude obtained from Model 2, we are able to assess differentiation of (unknown) pass-through rates at a country–level related to this specific factor. We utilize data on market concentration in each country-mode to obtain coefficient of variation in pass-through rates induced by HHI differentiation (see Table 3). It looks that differences in competitive conduct among member states might, ceteris paribus, generate significant variation in pass-through magnitudes amounting to almost 50% of average levels. Smaller variation among member states can be expected only in air mode due to greater integration of this market at the European level.

7. Summary and Conclusions

There is little empirical evidence from transport markets on the sensitivity of final prices to the changes in VAT rates. In our empirical analysis we adopt a pass-through measure which is defined as the portion of monetary tax liability resulting from an increased tax rate that is shifted to consumer price. In our estimation we controlled for input prices, market structure and various demand shifters, which possibly determine consumer prices. Our study offers two main findings. First, not all changes in VAT rates will be fully passed on consumers from operators liable for the VAT. The largest price reactions are expected in air and rail modes, while in road transport and waterways we estimate only partial, albeit greater than 50%, shift on customers. Second, the magnitude of pass-through magnitudes depend on the intensity of inter and intra modal competition. We have captured competition effects only through simple concentration index. In future research, it is recommended to analyze this relationship more accurately and disentangle the impact of both types of competition via own and cross price elasticities of demand. Altogether, our results suggest that, changes in passenger fares and demand on transport markets resulting from change in VAT cannot be reliably extrapolated from perfectly competitive case.

What are the policy implications of such estimates? First, for the two modes with full pass-through, the mostly negative impact of VAT harmonization on passengers (implying an increase in tax rates) is maximized, while the impact on operators is restricted only to the demand response. On the other hand, for the less-than-full pass through modes the impact of any VAT scenario on fares and consumer demand is smaller, at the expense of operators who absorb some of the tax increase.[12]

Our findings imply that changes in the level and structure of VAT levied on passenger transport will tend to induce consequences on the structure of both supply and demand. For instance, given the wide dispersion of VAT regimes across the EU (with many countries zero-rating all or many modes), attempts to rationalize the system by, for instance, setting uniform standard VAT rates would result in reduction in demand, while lowering slightly the profitability of operators in selected modes, and presumably leading to consolidation in the number of active market participants. This would probably be most felt in the most atomistic markets, such as intercity bus transport. To the extent that our estimates capture the behavior of operators faced with generally low demand elasticities, expected demand response will be low. Hence, harmonization of VAT system in passenger transport (implying an increase in rates) will impose only small distortion on output, employment and GDP effects, while being good news for national treasuries.

For a more in-depth discussion of policy scenarios and quantitative impacts of various VAT scenarios, see Barbone et al. (2016) and Barbone et al. (2014).

[11] An increase of VAT liability by €1 on the market with a concentration lower by 0.1 increases consumer prices by additional €0.23 compared to the market with 0.1 higher HHI score.

[12] In the latter case, an interesting side-effect arises for business passengers, for whom a reduced fare implies a net reduction in price, pushing the demand up. This effect is probably negligible due to minimal share of business demand for trips in road and waterways modes.

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Dr Luca Barbone (1961-2015), sadly passed away on September 1, 2015, leaving his friends and collaborators with a sense of great loss and inconsolable emptiness. We would like to honor him as a brilliant economist, respected colleague and our friend,: l'*onore e la gloria Amico!*

8. References

Alm, J., Sennoga, E., & Skidmore, M. (2009). Perfect competition, urbanization, and tax incidence in the retail gasoline market. *Economic Inquiry, 47*(1), 118-134.

Barbone, L., Breemersch, T., Carruthers, R., & Zenz, H. (2016). VAT-induced Distortions in the Passenger Transport System in the European Union: Assessment and Options for Reform. *Transportation Research Procedia, 14*, 333-342.

Barbone, L., Carruthers, R., Sobolewski, M., Zenz, H., Pohl, A., Schnabl, A., et al. (2014). The economic effects of the current VAT rules for passenger transport. Final Report for DG TAXUD.

Besley, T. J., & Rosen, H. S. (1999). Sales taxes and prices: an empirical analysis. *National Tax Journal, 52*(2), 157-158.

Brander, J. A., & Zhang, A. (1990). Market conduct in the airline industry: an empirical investigation. *The RAND Journal of Economics, 21*(4), 567-583.

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

Cole, S. (2005). *Applied Transport Economics: Policy, Management & Decision Making*: Kogan Page Publishers.

Cremer, H., & Thisse, J.-F. (1994). Commodity taxation in a differentiated oligopoly. *International Economic Review, 35*(3), 613-633.

Delipalla, S., & Keen, M. (1992). The comparison between ad valorem and specific taxation under imperfect competition. *Journal of Public Economics, 49*(3), 351-367.

Delipalla, S., & O'Donnell, O. (1998). The comparison between ad valorem and specific taxation under imperfect competition: Evidence from the European cigarette industry. *Discussion Paper*(9802).

Delipalla, S., & O'Donnell, O. (2001). Estimating tax incidence, market power and market conduct: the European cigarette industry. *International Journal of Industrial Organization, 19*(6), 885-908.

Fischer, T., & Kamerschen, D. R. (2003). Price-cost margins in the US airline industry using a conjectural variation approach. *Journal of Transport Economics and Policy, 37*(2), 227-259.

Fouquet, R. (2012). Trends in income and price elasticities of transport demand (1850–2010). *Energy Policy, 50*, 62-71.

Fullerton, D., & Metcalf, G. E. (2002). Tax incidence. In A. J. Aurebach, & M. Feldstein (Eds.), *Handbook of Public Economics* (Vol. 4, pp. 1787-1872): Elsevier.

Grubbs, F. E. (1969). Procedures for detecting outlying observations in samples. *Technometrics, 11*(1), 1-21.

Harris, J. E. (1987). The 1983 increase in the federal cigarette excise tax. In L. H. Summers (Ed.), *Tax Policy and the Economy* (Vol. 1, pp. 87-112): MIT Press.

InterVISTAS (2007). Estimating Air Travel Demand Elasticities

Jann, B. (2008). NLCHECK: Stata module to check linearity assumption after model estimation.

Karp, L. S., & Perloff, J. M. (1989). Estimating market structure and tax incidence: the Japanese television market. *The Journal of Industrial Economics, 37*(3), 225-239.

Katz, M., & Rosen, H. S. (1985). Tax analysis in an oligopoly model. National Bureau of Economic Research Cambridge, Mass., USA.

Kay, J. A., & Keen, M. J. (1983). How should commodities be taxed?: Market structure, product heterogeneity and the optimal structure of commodity taxes. *European Economic Review, 23*(3), 339-358.

Litman, T. (2013). Understanding transport demands and elasticities. Victoria Transport Policy Institute.

Poterba, J. M. (1996). Retail price reactions to changes in state and local sales taxes. *National Tax Journal*, *49*(2), 165-176.
Pregibon, D. (1980). Goodness of Link Tests for Generalized Linear Models. *Journal of the Royal Statistical Society. Series C (Applied Statistics), 29*(1), 15-14.
Varian, H. (1992). *Microeconomic Analysis* (3ed.): W.W. Norton & Company.

APPENDIX 1. TESTS AND ESTIMATION RESULTS

Table A.1. Data Summary.

	Number of changes in VAT rates 2001-2011					Averages for the period 2001-2011					HHI index (2011)		
	total	_air	_railway	_road	_sea and inland waterway	VAT rate	VAT Change	Unempl. Rate	GDP (million Euro)	Passenger transport output	_air	_railway	_road
Croatia	2	0	1	1	0	23.0%	1.0%	9.3	37,698	278	n.a	n.a	n.a
Cyprus	1	1	0	0	0	15.0%	2.0%	4.2	12,515	318	0.06	n.a	0.00
Czech Republic	8	2	2	2	2	9.5%	2.5%	5.9	120,618	501	0.16	0.97	0.10
Estonia	8	2	2	2	2	9.5%	1.0%	15.7	11,057	151	0.20	0.43	0.56
Finland	4	1	1	1	1	9.0%	1.0%	8.5	163,754	1,080	0.55	1.00	0.28
Germany	1	1	0	0	0	19.0%	3.0%	8.8	2,387,132	17,462	0.25	0.92	0.01
Greece	12	3	3	3	3	9.7%	1.0%	11.3	194,602	927	0.14	1.00	0.02
Hungary	15	3	4	4	4	21.3%	2.7%	8.9	88,663	360	0.10	0.45	0.01
Latvia	10	4	3	3	0	8.4%	1.4%	11.4	12,243	40	0.39	1.00	0.15
Lithuania	6	2	2	2	0	20.5%	5.8%	16.0	23,375	50	0.30	1.00	0.08
Poland	3	1	1	1	0	8.0%	1.0%	9.8	319,798	1,656	0.27	0.27	0.00
Portugal	8	2	2	2	2	5.8%	0.5%	12.4	156,956	1,301	0.40	0.84	0.01
Romania	8	2	2	2	2	22.8%	2.5%	7.7	91,110	460	0.28	0.94	0.00
Slovakia	12	3	3	3	3	17.7%	3.3%	16.5	40,028	77	0.70	0.98	0.06
Slovenia	4	1	1	1	1	8.5%	0.5%	6.1	25,723	92	0.43	1.00	0.06
Spain	4	1	1	1	1	7.6%	0.6%	20.2	947,374	4,160	0.12	0.85	0.04
Total	106	29	28	28	21								

Table 1A. Link test results.

Variable	Coef.	(Std. Err.)
hat	0.91	(0.12)
hatsq	0.01	(0.01)
constant	0.19	(0.42)

Table A.3. Joint Wald test for nonlinearity.

Variable	F (9, 60) -	Prob > F
dP(L)	0.86	0.5675
dP(L)	1.25	0.2815
m(1)dvat	1.86	0.0760
m(1)dvat	0.73	0.6836
m(1)dvat	0.70	0.7034
m(1)dvat	0.69	0.7019
dQ(L)	1.28	0.2663
dvathhi	0.61	0.7830

Table A.4. Estimation results on the reduced sample.

Variable dP	**Coef.**	**(Std. Err.)**
dP(L)	0.26*	(0.10)
dY(L)	33.61***	(12.84)
m(1)dvat	1.52**	(0.43)
m(2)dvat	3.70***	(0.94)
m(3)dvat	1.54***	(0.47)
m(4)dvat	3.80***	(1.44)
dQ(L)	1.10	(7.60)
dvathhi	-2.22**	(1.11)
const	1.14	(1.03)
Significance levels: *** 1%, **5% *10%		
#Obs	78	
F-test	6.36	
Adj. R-squared	0.36	

APPENDIX 2. DETERMINANTS OF TAXATION PASS-THROUGH ILLUSTRATED IN COURNOT OLIGOPOLY FRAMEWORK

We illustrate the impact of changes in taxation on consumer prices in imperfectly competitive markets by utilizing standard N firm Cournot model. The primary objective of this analytical exercise is to gain insight into the most important elements which increase or decrease ad-valorem pass-through effect.[13] The choice of this particular analytical framework can be motivated by its adequacy to transport industry (Cole 2005). Moreover empirical studies in airline industry tend to confirm consistency of market conduct with Cournot outcome (Brander and Zhang 1990) and (Fischer and Kamerschen 2003).

We start our illustration from specification of model assumptions. Market demand is linear: $p(Q) = a - bQ$ where $Q = \sum_1^n q_i$. Firms use identical technologies with increasing returns to scale so that the cost function of each firm writes: $C(q_i) = cq_i$+f. The fixed cost is $f > 0$. We set $a > c$. Initially, there is no tax imposed. It can be shown that in long-run Cournot-Nash equilibrium in this market:

$$\left\{\begin{array}{c} q_i^* = \frac{a-c}{(n+1)b} \\ p^* = \frac{a+nc}{n+1} \\ n^* = \frac{(a-c)^2}{\sqrt{bf}} - 1 \end{array}\right\} \tag{A.1}$$

The number of firms in equilibrium is determined by zero profit condition under free entry. According to the above equation the number of firm in equilibrium increases with the positive (and persistent) demand shocks a and decreases with marginal costs c and fixed costs f .

In industrial economics, the notion of competition intensity is understood in terms of market power firms exercise over customers. Market power of firm i is usually measured by relative markup known as Lerner index $L = \frac{p-c}{p}$. The higher the market power firm poses the higher the price level set by firm above marginal costs and thus market is less competitive. In the Cournot-Nash model there exists a formal link between market power and market concentration:

$$\left\{\begin{array}{c} L_i = \frac{p^*-c}{p^*} = \frac{s_i}{|\varepsilon|} \\ L^M = \sum_1^n s_i L_i = \frac{HHI}{|\varepsilon|} \\ HHI = \frac{1}{n} + nD^2(\boldsymbol{s}) \end{array}\right\} \tag{A.2}$$

Market power of individual firm is proportional to its market share s_i and inversely proportional to the elasticity of market demand Ɛ. The second equation in formula (A.2) establishes a link between the measurement of average market power in a given industry L^M, and level of market concentration (HHI, Herfindahl-Hirschman Index). Thanks to low data requirements, HHI is often used as yet another, albeit inaccurate, measure of market competitiveness.[14] Third equation indicates that market concentration increases when the number of firms drops or, for a given number of market players, increases with the variance of their market shares $D^2(\boldsymbol{s})$. Symmetric oligopolies will be more competitive then markets with dominant firms. Now, we will show how introduction of ad valorem tax changes the equilibrium in Cournot market.

AD VALOREM TAX PASS-THROUGH

With introduction of tax a distinction is needed between producer and consumer price the latter being tax inclusive: $p_c = (1+t)p_p$ where t is tax rate ($t < 1$). Imposition of tax does not affect demand curve of customers but is reflected in profit function of particular firm via producer price p_P.[15]

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[13] We consider our exercise useful also because existing theoretical literature focuses mostly on unit tax pass-through.

[14] HHI can serve as comparative measure of competitiveness in relevant market provided that it is properly defined in terms of geographical outreach and product scope.

[15] The profit function of a single firm now writes: $\pi_i = \frac{(a-bQ)}{1+t} q_i - cq_i - F$.

With ad-valorem tax the equilibrium consumer price given in formula (A.1) changes now to:

$$p_c^* = \frac{a+cn(t+1)}{n+1} \tag{A.3}$$

The impact of ad valorem tax on consumer price can be measured by derivate of consumer price with respect to tax rate:

$$\frac{dp_c^*}{dt} = \frac{cn}{n+1} \tag{A.4}$$

It can be shown that this derivate increases with the number of firms in the market.[16] This result is robust to various model specifications and has clear economic interpretation. With more firms, equilibrium price decreases driving down price-cost margins. Hence firms have less space to absorb any tax increase and shift larger part of tax burden on consumers. On the other hand, when price-cost margins are high (indicating large market power) firms recognize that large fall of demand would be harmful for their profits and strategically tend to absorb more tax to minimize output distortion. This strategy will be profitable especially when market demand is elastic.

To show the impact of demand elasticity (ϵ) on the tax pass-through we first utilize general expression of price elasticity for linear demand assumed in this exercise: $e = |\epsilon| = \frac{p}{a-p}$ to substitute parameter (a) in formula (A.3). After rearranging we obtain a new expression for equilibrium price in Cournot model with explicit account for absolute value of demand elasticity (e):

$$p_c^* = \frac{cen(t+1)}{en-1} \tag{A.5}$$

The impact of demand elasticity on the magnitude of pass-through can be assessed by evaluating the following double derivative:

$$\frac{d}{de}\frac{dp_c^*}{dt} = -\frac{cn}{(en-1)^2} \tag{A.6}$$

This expression is always negative, hence with the growing elasticity of demand (in absolute terms) the impact of tax on consumer prices decreases. This result is intuitive and robust to different model specifications (Fullerton and Metcalf 2002).

As the last element, we illustrate how pass-through changes in the long-run compared to the short run. Note that with tax, long-run equilibrium number of firms, obtained from zero profit condition now writes:

$$n^* = \frac{a-c(t+1)}{\sqrt{bf(t+1)}} - 1 \tag{A.7}$$

It can be shown that n^*decreases with (t) indicating that increase of a tax rate will affect market structure in the long-run and hence indirectly also consumer price.[17] This is an additional avenue over which tax passes-through on to customers compared to the short run equilibrium. To assess the long term pass-through we take again price equation (A.5) and substitute parameter n with its long-run value provided in expression (A.7). Like before, the evaluation is done for derivative of long-run consumer price with respect to tax rate. Unfortunately $\frac{dp_c^{*LR}}{dt}$ has complex algebraic form and we will evaluate it only for a special case of no entry costs:

$$\frac{dp_c^{*LR}}{dt}\Big|_{f=0}\Big| = c \tag{A.8}$$

A quick look on formulas (A.4) and (A.8) showing tax pass-through in short and long-run brings about conclusion that the latter is always larger. For monopoly case short-run pass-through is twice smaller than in the long-run, while for low concentrated oligopoly the difference between both diminishes and the case of perfect competition ($n \to \infty$).

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[16] Formally, derivative of formula (A.4) $\frac{d}{dn}\frac{dp_c}{dt} = \frac{c}{(n+1)^2}$ is always positive.

[17] Formally, derivative of formula (A.7): $\frac{dn^*}{dt}$ is always negative.

Overshifting of ad-valorem tax is little bit tricky and cannot be assessed simply by requiring derivative of price with respect to tax to be greater than 1 (as is the case of unit tax). Instead overshifting of ad-valorem tax requires that an increase in consumer equilibrium price p_c^* exceeds an increase in tax liability L. This condition translates to:

$$\frac{dL}{dt} < \frac{dp_c^*}{dt} \quad \text{or} \quad \frac{dp_p^*(t)t}{dt} < \frac{dp_p^*(t)[1+t]}{dt} = \frac{dp_p^*(t)}{dt} + \frac{dp_p^*(t)t}{dt} \qquad \text{(A.9)}$$

Inequality (A.9) has an empty space of solutions, because $\frac{dp_p^*(t)}{dt}$ is negative in this model. This result is compliant with conclusions from Fullerton and Metcalf (2002) for the case of linear demand and cost (see their expression 3.10). Thus we note that overshifting cannot occur in this simple analytical framework regardless of the parameters' values.[18]

[18] As noted by Fullerton and Metcalf (2012, page 1825): "Overshifting can occur because of the existence of market power and strategic behavior among firms. Firms recognize that forward shifting of the tax will decrease demand for their product. Thus, under some circumstances, they will wish to raise the price more than the increase in tax to compensate for the revenue loss from decreased demand". In other words, overshifting requires an increase of producer price after a tax rise: $\frac{dp_p^*(t)}{dt}>0$, which is never optimal in the discussed setting. Instead firms prefer to strategically absorb some of the tax to mitigate demand response.