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**Who pays commodity taxes ?**

**Evidence from French reforms, 1987-1999**

**Clément Carbonnier**

**JEL Codes : D43, H22, H32**

**Keywords : Commodity taxation, tax burden, tax incidence, oligopoly**

# Who pays commodity taxes ?

Evidence from French Reforms, 1987-1999

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## Abstract

The point of this paper is to measure empirically the distribution of the commodity tax burden between consumers and producers. For that purpose, two French reforms are studied. These reforms are steep decreases of the VAT rate on housing repair services on the one hand, and on new car sales on the other hand, the last sector being far more concentrated. The consumer share of the commodity tax burden is 77% in the housing repair services market and 52% in the new car sales market. That confirms the theoretical result of the consumer share increasing with the competition level. This result may influence recommendations about differentiated commodity tax rates.

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**Key Words** : Commodity Taxation ; Tax burden ; Tax incidence ; Oligopoly

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# 1 Introduction

This paper studies the economic impact of commodity tax reforms, and attempts to measure the share of the burden of these taxes between consumers and producers. Commodity taxation is heavily used all around the world, through different kinds of tax. In Europe, a VAT system is in effect and those taxes take up a large part of fiscal incomes. For an example, the 2006 French budget forecasted VAT would represent 48.8% of total fiscal incomes. Indeed, commodity taxes are quite easy to collect and are assumed not to generate distortions as they are paid by consumers.

Classical differentiated taxation recommendations are based on that assumption, and therefore do not take tax shifting matters into account.

However, the commodity tax burden is not paid by consumers only but is shared between consumers and producers. Theoretical studies demonstrated that this share depends on market properties. The question of the value of the consumer share of the tax burden depending on the market may have political implications, as it may affect the optimal commodity tax schedule. For an example, the values of VAT shifting on prices should have an impact on the European debate on reducing VAT rates for labor intensive services. However, few is known about the actual values of the indirect tax burden consumer shares.

The point of this paper is to measure this tax burden share, using price data around the time of two French VAT reforms. The consumer share is found to be 77% in the housing repair service market, and 52% in the new car market. This confirms the theoretical results spelling that the consumer share increases with respect with the competition level in the market.

A number of papers have studied the question of commodity tax shifting on prices theoretically. Katz & Rosen (1985) studied a closed Cournot oligopoly. Stern (1987) and Besley (1989) considered the free-entrance impact, based on the conjectural variation model developed by Seade (1980). Delipalla & Keen (1992) compared consumer shares of specific or ad valorem commodity taxes, and found that the consumer burden is higher in the case of specific commodity taxes. These papers all pointed out the influence of imperfect competition on tax shifting on prices.

From an empirical point of view, Besley & Rosen (1999) tested tax shifting through a number of local commodity tax variations in the United States. They found very few markets with a consumer share of the commodity tax burden significantly different from 100%. The few goods whose tax shifting on prices are found significantly different from 100% are sold through the retail industry. Taxes on these goods are over-shifted, which means that the consumer share is higher than 100%. Delipalla & O'Donnell (2001) tested the theoretical results of Delipalla & Keen (1992) in the case of the European tobacco market and confirmed

the results. These papers pointed out properties on tax shifting, but none actually measured sharply the values of the consumer share of the commodity tax burden, which is the purpose of the present paper.

The rest of the paper is organized as follows.

Section 2 presents the theoretical framework of this study. The parameters that will be estimated are explained - the value of the consumer share depending on prices and tax rate variations. The theoretical results that are tested in the following sections are then presented. An oligopoly model with conjectural variations is used for that purpose. It shows the influence of the competition level on commodity tax shifting on prices. The consumer share is increasing with respect to the competition level in the market.

Section 3 presents the data. The empirical work uses price data at the time of two reforms that induced ample VAT rate variations. July 17th 1987, the French VAT rate on car sales went down from the luxury-rate of 33.33% to the full-rate of 18.6%. September 1st 1999, the French VAT rate on housing repair services went down from the full-rate of 20.6% to the reduced-rate of 5.5%.

Section 4 presents the results of estimates, confirming the theoretical results presented in section 2. Mainly, the consumer share is 77% in the housing repair service market and 52% in the new car market, as the first market is far more competitive than the second one.

Section 5 concludes on the share of the commodity tax burden between consumers and producers, depending of the competition level in the market. A simple model is used to build a Ramsey formula taking into account tax shifting. The optimal commodity tax rate is found decreasing with respect to the demand elasticity and to the consumer share.

## 2 Theoretical framework

The point of the present paper is to measure consumer share. What is called consumer share is the share of the tax burden paid by the consumers. This consumer share is noted  $s$  and also represents the tax shifting on prices.

The tax analyzed in that study is VAT, which is an ad valorem commodity tax applied on the before tax price. The before tax price is  $\frac{p}{1+\tau}$  where  $p$  is the selling price, and the amount of the tax is then  $\frac{\tau p}{1+\tau}$ . After a variation of the VAT rate, the consumer price variation is  $\frac{dp}{d\tau}$ . The producer price variation - the variation of the before tax price - is  $\frac{d(\frac{p}{1+\tau})}{d\tau}$ , that is equal to  $\frac{\frac{dp}{d\tau}(1+\tau) - p}{(1+\tau)^2}$ .

Consumer share is then :

$$s = \frac{(1 + \tau)}{p} \frac{dp}{d\tau} \left( \frac{1 + \tau}{1 + \tau \left( \frac{(1+\tau)}{p} \frac{dp}{d\tau} \right)} \right) \quad (1)$$

This expression may seem very complicated, but one should note that  $s$  is the image of  $x = \frac{(1+\tau)}{p} \frac{dp}{d\tau}$  by the function  $f : x \mapsto x \frac{1+\tau}{1+\tau x}$ . This function  $f$  is strictly increasing with respect to  $x$ , with only two fixed points 0 and 1. Therefore, if  $x = \frac{(1+\tau)}{p} \frac{dp}{d\tau}$  is inferior to 100%, so is the consumer share  $s$ . Furthermore, if  $x_1$  of good 1 is higher than  $x_2$  of good 2, the consumer share  $s_1$  of good 1 is higher than the consumer share  $s_2$  of good 2. The rest of this section studies the influence of market properties on the proxy  $x = \frac{(1+\tau)}{p} \frac{dp}{d\tau}$  of the consumer share.

Under perfect competition, this proxy is equal to :

$$x = \frac{\epsilon_o}{\epsilon_d + \epsilon_o} \quad (2)$$

Where  $\epsilon_o = \frac{p}{O} \frac{\partial O}{\partial p}$  is the supply elasticity and  $\epsilon_d = -\frac{p}{D} \frac{\partial D}{\partial p}$  is the demand elasticity. Equation (2) shows that the consumer share under perfect competition is always inferior to 100%. It increases with respect to the supply elasticity and decreases with respect to demand elasticity.

Under imperfect competition, over-shifting could happen. What is called over-shifting of the tax is a consumer share superior to 100%, which means that the selling price increase is higher than the amount of the tax. A full-shifted tax induces an increase of the price equal to the amount of the tax increase, and then a consumer share of 100%. The classical case is with consumer shares inferior to 100%, that taxes are under shifted on prices.

In order to understand what happens under imperfect competition, I study an oligopoly model with conjectural variation, as developed by Seade (1980), then Katz & Rosen (1985). The version presented here is close to the Stern (1987) version. Non-constant marginal costs are added, and a direct inclusion of the tax rate is made in order to have more directly interpretable results.

The model considers  $n$  firms producing a unique good at cost  $K + C(q_i)$  where  $K$  is a fixed cost and  $C$  the cost, depending on  $q_i$ , the production of firm  $i$ . With this cost function,  $C(0) = 0$ . This is a model with conjectural variations, what means that when one of the  $n$  firms on the market changes its production  $q_i$ , it anticipates a variation production of the other firms equal to  $\left. \frac{\partial Q_{-i}}{\partial q_i} \right|^a = \alpha \frac{Q_{-i}}{q_i}$  - where  $Q$  is the global production and  $Q_{-i} = Q - q_i$  is the production of all firms except  $i$ .  $\gamma = \alpha + \frac{1-\alpha}{n} = \frac{1}{n} \frac{\partial Q}{\partial q_i}$  is thus a parameter between  $\frac{1}{n}$  and 1, increasing with respect to the market power of firms. With  $\gamma = \frac{1}{n}$ , the model is a Cournot oligopoly, with price determined as a Nash equilibrium, there is no collusion on this market. With  $\gamma = 1$ , the price determined in the market is monopoly price, this case represents the total collusion on the market.

The specification of this model with  $K = 0$  and  $\gamma = 0$  - wich implies  $\alpha = -\frac{1}{n-1}$  - results in equilibrium under perfect competition. Finally,  $p$  is the selling price,  $\epsilon = -p \frac{Q'}{Q}$  the demand elasticity and  $F = p \frac{\epsilon'}{\epsilon}$  the elasticity of the demand elasticity .

The profit of firm  $i$  is :

$$\Pi_i = \frac{p}{1 + \tau} q_i - C(q_i) - K_i \quad (3)$$

Because of the conjectural variations, the anticipated price variation with respect to its own production variations is for firm  $i$  :

$$\left. \frac{\partial p}{\partial q_i} \right|^a = p \left( \frac{\partial p}{\partial Q} \frac{Q}{p} \right) \frac{\partial Q}{\partial q_i} \frac{1}{Q} = -\frac{\gamma}{\epsilon} p \frac{n}{Q} \quad (4)$$

Looking at symmetrical equilibrium, equation (5), and (6) follow. Equation (5) is the firm profit maximization condition and equation (6) is the stability condition :

$$\frac{p}{1 + \tau} \left( 1 - \frac{\gamma}{\epsilon} \right) - \frac{\partial C(q)}{\partial q} = 0 \quad (5)$$

$$F > -2 \frac{\epsilon}{\gamma} + 1 + \epsilon - \epsilon_c \left( \frac{\epsilon}{\gamma} - 1 \right) \quad (6)$$

Where  $c = \frac{\partial C(q)}{\partial q}$  is the marginal cost and  $\epsilon_c = \frac{q}{\frac{\partial C(q)}{\partial q}} \frac{\partial^2 C(q)}{\partial q^2}$  the elasticity of the marginal cost  $c$  with respect to the production  $q$ . There is no solution if  $\epsilon$  is not superior to  $\gamma$ . Moreover, the stability condition (6) restricts the possible values for  $F$ . However,  $F$  can take every positive value, and some negative values. The more the marginal cost increases with respect to the production the less condition (6) is constraining.

Differentiating equation (5) on an equilibrium path, with  $n$  fixed, and  $p$  and  $\tau$  as variables, results in price shifting proxy  $x_{cgo}$  in a Cournot Generalized Oligopoly. The results are given by equation (7).

$$x_{cgo} = \frac{1 + \tau}{p} \frac{dp}{d\tau} = \frac{1 - \frac{\gamma}{\epsilon}}{1 + (\epsilon - \gamma)\epsilon_c - \frac{\gamma}{\epsilon} + \frac{\gamma}{\epsilon} F} \quad (7)$$

As  $\epsilon_c = \frac{1}{\epsilon_o}$  under perfect competition, equation (7) with  $\gamma = 0$  gives the perfect competition consumer share. The point is to understand the influence of collusion on the consumer share. Equation (8) gives the sign of the differentiate of the price shifting proxy -  $x_{cgo}$  - with respect to the collusion parameter  $\gamma$ .

$$sgn \left( \frac{\partial x_{cgo}}{\partial \gamma} \right) = sgn \left( -\frac{F}{\epsilon} \right) \quad (8)$$

Condition (8) states that oligopolistic consumer share is inferior to perfect competition consumer share if  $F > 0$ , and superior if  $F < 0$ . In the market for non-addicting goods, consumer share of the tax burden decreases relative to collusion.

The point of the following sections is to emplement empirical measures, in order to test if it is consistent with reality.

### 3 data

In order to test the theoretical results presented in the previous section, two tax reforms are studied. The point is to study tax rate variations large enough to get sharp measures of the consumer share. There have been few large tax rate changes, and the only reforms that can be studied are those changing the commodity tax category of one kind of good<sup>1</sup>. There have been two such reforms. September 17th 1987, the VAT rate on new car sales went down from the luxury-rate of 33.33% to the full-rate of 18.6%. September 1st 1999, the VAT rate on housing repair services went down from the full-rate of 20.6% to the reduced-rate of 5.5%.

The comparison of tax shifting in these two markets is meaningful as the new car market is a closed oligopoly and the housing repair market is close to perfect competition. Obviously, there are very few new car producers, and fixed costs to enter the new car producing market are very high. Between 1992 and 2002 the mean ratio of fixed capital on value added for the car industry was 455%, which is indeed very high.

In addition, the 1999 reform applied to housing repair services only and not to housing building. Fixed costs to enter the market are low. Housing repair service firms are for the most part very small firms, often with only a few employees. The mean ratio of fixed capital on value added for personal and domestic services between 1992 and 2002 was 32%, which indeed is low.

Moreover, table 1 gives the number of firms by size for each of those two economic sectors. In this table is also included an index calculated on this data with a Herfindahl-Hirschman formula.

The Concentration index is found equal to 0.02% for the housing repair service industry and 8.96% for the new car sales industry. This confirms the assumption that the new car sales industry represents oligopoly and housing repair service industry represents perfect competition.

In order to study these reforms, I use the time series of price index, IPC, build by INSEE<sup>2</sup>. The new car index and the dwelling repair index are used to measures the consumer share of commodity tax burden.

Furthermore, the general index is used in order to implement a double difference regression. At that point, I construct a new index that is the index for all goods except the one

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<sup>1</sup>Some smaller reforms occurred, they are studied in Carbonnier (2005). The sources of variation are not enough to estimate sharply the consumer share values. However, they are enough to point out short run asymmetrical effects in tax shifting.

<sup>2</sup>INSEE : *Institut National de Statistiques et d'Etudes Economique*, the French statistic agency. IPC : *Index des Prix à la consommation*, it is build with a classification near the international reference COICOP, with more details. There is 12 divisions, 86 groups and 161 classes. It is calculated every month. More than 1 000 different goods representing the 161 classes are included, their prices are observed all along the month in 27 000 saling points in 106 cities with more than 2 000 inhabitants. IPC is a annually chain-linking Laspeyres index.

Firm classes (by nb. of employees)	Housing repair services		New car sales	
	Number of Firms of that class	Percent. of empl. in firms of that class	Number of Firms of that class	Percent. of empl. in firms of thas class
0	124 347	47.82%	74	34.74%
1 to 2	65 649	25.25%	34	15.96%
3 to 5	35107	13.50%	18	8.45%
6 to 9	18 116	6.97%	20	9.39%
10 to 19	11 021	4.24%	14	6.57%
20 to 49	4 804	1.85%	18	8.45%
50 to 99	663	0.25%	8	3.76%
100 to 199	221	0.08%	5	2.35%
200 to 249	34	0.01%	2	0.94%
250 to 499	44	0.02%	7	3.29%
500 to 999	17	0.01%	2	0.94%
1000 to 1999	12	0.00%	2	0.94%
2000 to 4999	10	0.00%	6	2.82%
5000 & more	0	0.00%	3	1.41%
Overall	260 045	100%	213	100%
<b>Concentration</b>	<b>0.02%</b>		<b>8.96 %</b>	

Table 1: Concentration in the car and the housing repair sectors

Data presented here come from the French data base SIRENE.

The concentration parameter is calculated as an Herfindahl-Hirschman index, taking the number of employees as proxy of the size of the firms. As data do not give the exact number of employees in each firm, the number of employees used for a firm is the lower limit of the segment it belongs to.

studied, using for that purpose the weight coefficient of the studied index in the general index.

In order to control the regression, production costs are also used. The proxies of production costs are the price index of rents on the one hand and of energy on the other hand.

Figure 1 and 2 show the general price index and the new car price index around the time of the 1987 reform - figure 2 shows this data sharply around the time of the reform as figure 1 shows longer time series. Figure 4 shows the general price index and the housing repair service price index around the time of the 1999 reform - figure 4 shows this data sharply around the time of the reform as figure 3 shows longer time series.

Figure 2 shows that the 1987 VAT shifting in new car prices was strictly positive. Even if the new car price volatility seems quite high, one can clearly see a huge new car price fall at the time of the reform. At the same time the overall price index seems not to have undergone shocks.



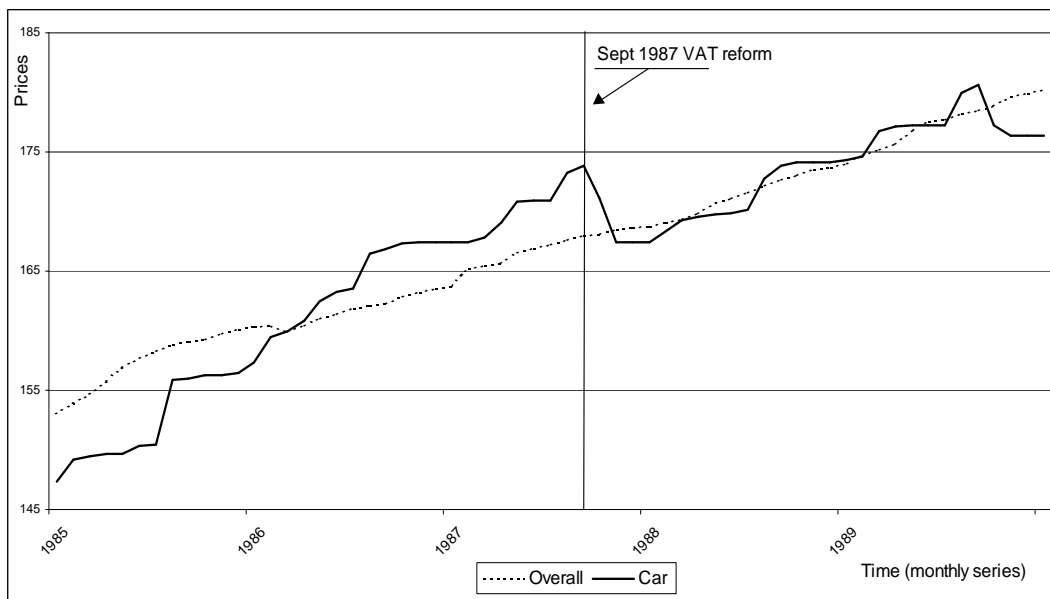


Figure 1: Car prices around September 1987 tax reform, long time series

The continuous curve is the INSEE price index - base 100 : 1980 - for new cars.

The discontinuous curve is the INSEE price index - base 100 : 1980 - for everything except new cars.

September 17<sup>th</sup> 1987, the VAT tax rate on new car sales went down from the luxury-rate of 33.33% to the full-rate of 18.6%.

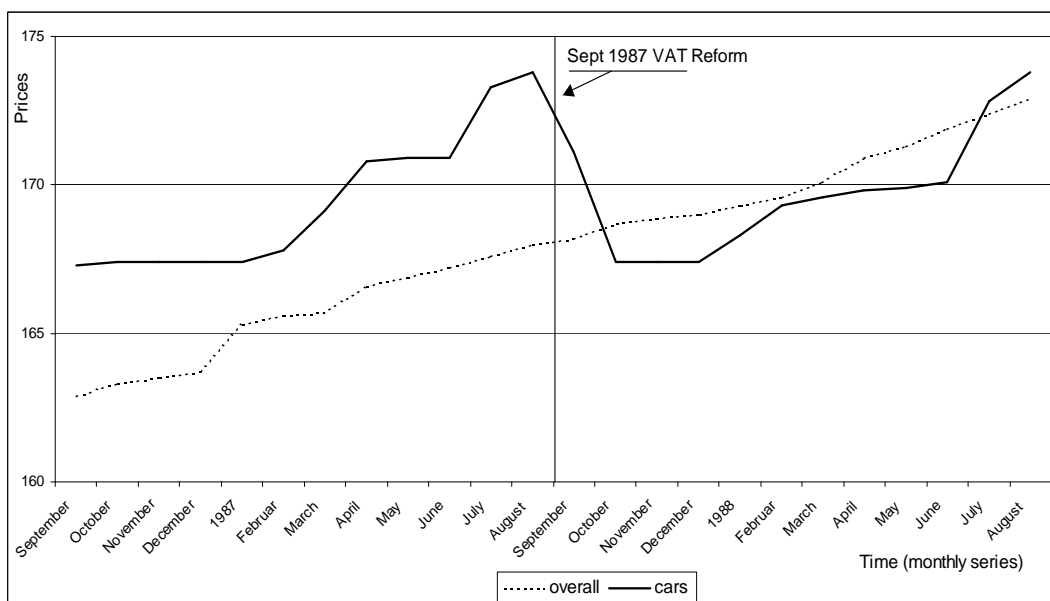


Figure 2: Car prices around September 1987 tax reform, short time series

The continuous curve is the INSEE price index - base 100 : 1980 - for new cars.

The discontinuous curve is the INSEE price index - base 100 : 1980 - for everything except new cars.

September 17<sup>th</sup> 1987, the VAT tax rate on new car sales went down from the luxury-rate of 33.33% to the full-rate of 18.6%.

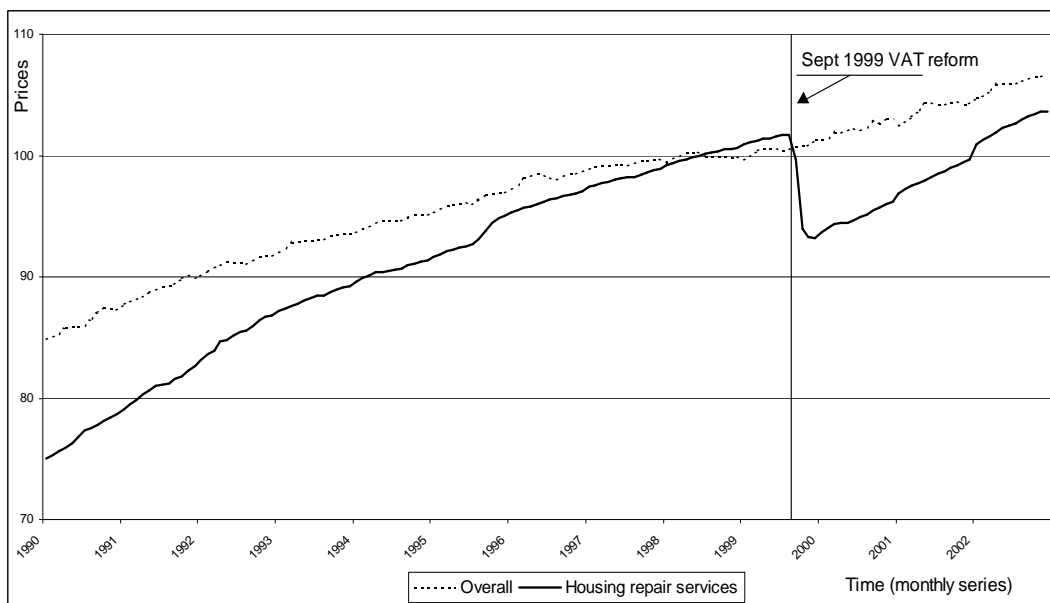


Figure 3: Housing repair service prices around September 1999 tax reform, long time series

The continuous curve is the INSEE price index - base 100 : 1998 - for housing repair services.

The discontinuous curve is the INSEE price index - base 100 : 1998 - for everything except housing repair services.

September 1<sup>st</sup> 1999, the VAT tax rate on housing repair services went down from the full-rate of 20.6% to the reduced-rate of 5.5%.

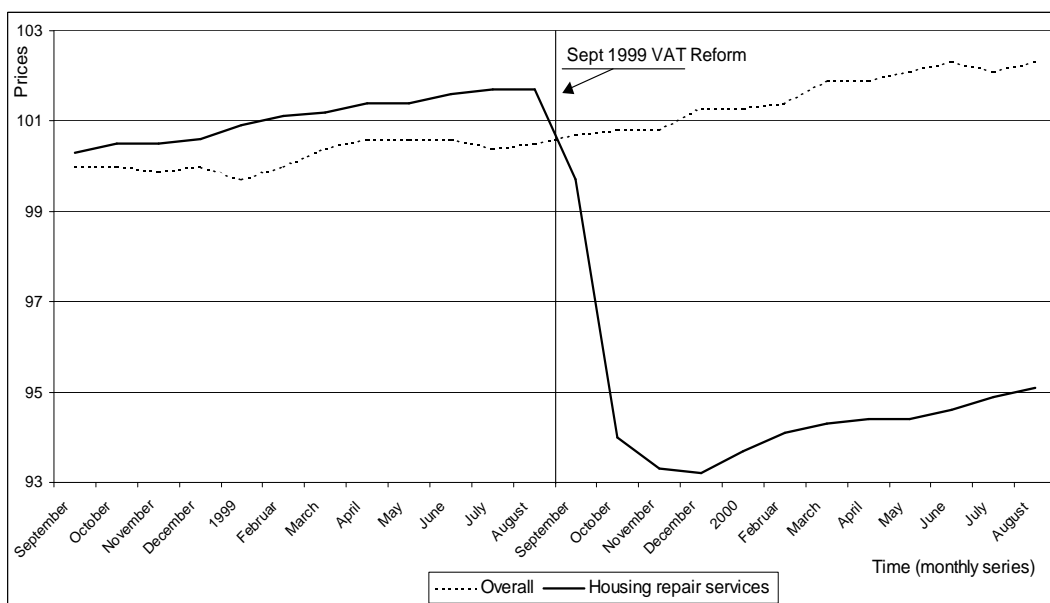


Figure 4: Housing repair service prices around September 1999 tax reform, short time series

The continuous curve is the INSEE price index - base 100 : 1998 - for housing repair services.

The discontinuous curve is the INSEE price index - base 100 : 1998 - for everything except housing repair services.

September 1<sup>st</sup> 1999, the VAT tax rate on housing repair services went down from the full-rate of 20.6% to the reduced-rate of 5.5%.

The 1999 VAT shifting was also strictly positive. Figure 4 shows that the 1999 VAT rate decrease shifted strongly on housing repair service prices. Housing repair price index underwent very small fluctuations, except at the time of the reform, when it fell. At the same time the overall price index seems to remain quite linear.

## 4 Tax shifting Measures

The point of this section is to calculate the values of the consumer share. Preliminary estimates may be done. With the values presented in figure 2 and not taking in account the inflation trend, the fall was of 3.7% for new car prices in the four months following the 1987 reform (the new car price index is 1738 for August 1987 and 1674 for December 1987). Inflation of new car prices was 4.2% in the year preceding the reform, which leads to a new car price fall adjusted for inflation of 5.3% of the price in four months. The VAT rate decreased from 33.33% to 18.6%, which represents a fall of 11%. A preliminary estimate of tax shifting on new car prices is thus 48%.

With the values presented in figure 4 and not taking in account inflation, the fall was 8.4% for housing repair service prices in four months (the housing repair service price index is 1017 for August 1999 and 932 for December 1999). Inflation for housing repair service prices was 1.5% in the year preceding the reform, which leads to a housing repair service price fall adjusted for inflation of 8.8% of the price in four months. The VAT rate decreased from 18.6% to 5.5%, which represents a fall of 11%. A preliminary estimate of tax shifting on housing repair service prices is thus 80%.

In order to get sharper measures of the tax burden share, regressions are implemented. The parameter that has to be measured is the parameter  $s$  defined by equation (1) in section 2. Therefore, using the operator  $\Delta_t$  defined by equation (9), double difference regressions are implemented following equation (10) :

$$\Delta_t(X) = \frac{X_t - X_{t-1}}{X_{t-1}} \quad (9)$$

$$\Delta_t(p_{dependant}) = \sum_{i=1}^4 \alpha_i \Delta_{t+1-i}(1 + \tau) + \beta \Delta_t(p_{overall}) + \sum_i \gamma_i \Delta_t(p_{control_i}) + \epsilon_t \quad (10)$$

Where  $p_{overall}$  is the general price index, and the controls are the rent index and the energy price index. According to equation (1), this regression gives the consumer share as presented by equation (11) :

$$Consumer\ share = f\left(\sum_{i=1}^4 \alpha_i\right) = \left(\sum_{i=1}^4 \alpha_i\right) \left(\frac{1 + \tau}{1 + \tau \sum_{i=1}^4 \alpha_i}\right) \quad (11)$$

These regressions are implemented for both the new car market around 1987 and the housing repair market around 1999. The regressions take into account the three years around the reforms. Results are compiled in table 2.

	(1)	(2)
	Housing repair services	New car sales
Number of observations	36	36
$R^2$	99%	67%
VAT rate shifting during the 1 <sup>st</sup> month ( $\alpha_1$ )	0.169*** (0.009)	0.173*** (0.043)
VAT rate shifting during the 2 <sup>nd</sup> month ( $\alpha_2$ )	0.472*** (0.009)	0.272*** (0.045)
VAT rate shifting during the 3 <sup>rd</sup> month ( $\alpha_3$ )	0.072*** (0.009)	0.025 (0.044)
VAT rate shifting during the 4 <sup>th</sup> month ( $\alpha_4$ )	0.024*** (0.009)	0.032 (0.044)
<b>Consumer share<sup>+</sup></b>	<b>77%***</b> (2%)	<b>52%***</b> (6%)

Table 2: Consumer share measures

This table presents the results of the regressions of housing repair service prices in the one hand and of new car sale prices in the other hand, on VAT rate changes.

\*\*\* : 1% significant

+ : Calculated as the sum of the coefficients until the last significant, according to equation (11)

As it appears from figure 2 and figure 4, results are very sharp and the tax rate variations explain the main part of the price variations. The  $R^2$  of these regressions are therefore very high : 99% for the housing repair services and 67% for new car sales.

In addition, these results are very significant (1% significant). The standard errors are very small and so the measures of the consumer shares are very sharp. The values themselves - and not only their signs - are meaningful.

A first result is the very rapid rate of tax shifting. For both goods, taxes shifted almost entirely during the first two months following the reforms. The ratio between tax shifting during the first two months and tax shifting during the two following months is 7.8 for the 1987 reform on new car sales and 6.7 for the 1999 reform on housing repair services.

Because of the small standard errors, the difference between the two measures is also significant. The difference between consumer shares in the housing repair service market and in the new car sales market is 25%, with a standard error lower than 7%. The difference between the two tax shiftings is then 1% significantly positive.

This results are shown in figure 5. This figure shows the price reaction of both the new car sales and the housing repair services as estimated by the regressions. The error bars indicate the 95% confidence intervals as estimated by the regressions.

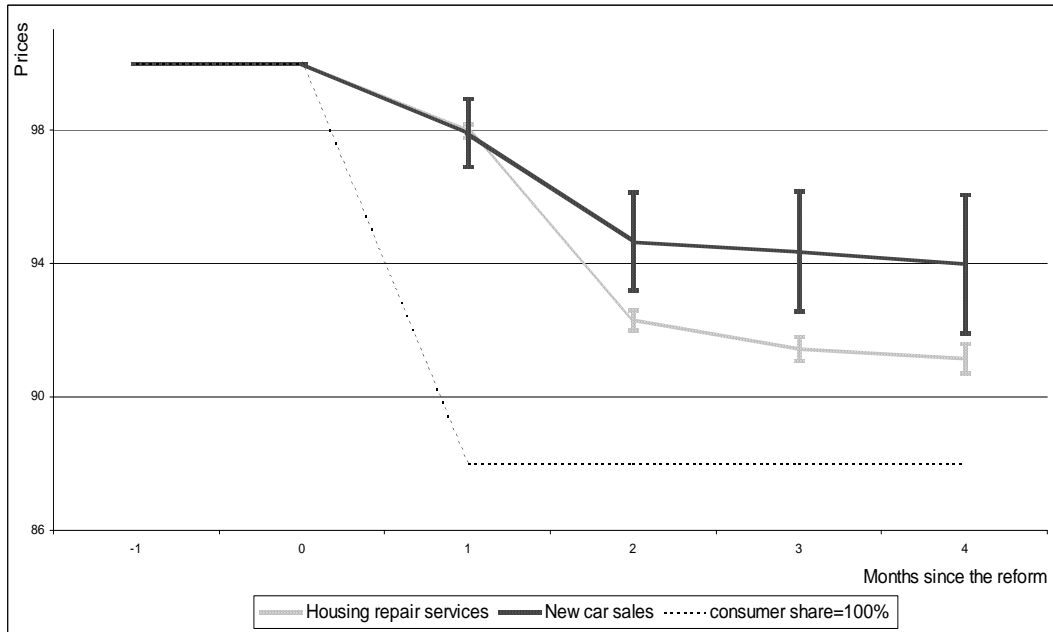


Figure 5: Price reaction simulation

The curves are the prices - base 100 before the reforms - as they appear out of the regressions.

Error bars indicate the 95% confidence intervals.

The discontinuous curve - "consumer share=100%" - shows the prices that would occurred if the consumer share was 100%.

Figure 5 show clearly that the 95% confidence intervals of the prices new car sales and housing repair services do not cross. Hence, this figure illustrates that tax shifting on housing repair service prices is higher than tax shifting on new car sales.

## 5 Conclusions

Analyzing huge VAT variations, this study provides sharp measures of the consumer shares in two very different markets. As Delipalla & O'Donnell (2001), only under-shifting of taxes are found. Moreover, the consumer share in the housing repair service market - a close to perfect competitive market - is very significantly higher than the consumer share in the car market - a quite closed oligopoly with very few firms competing.

These empirical results are consistent with the hypothesis that tax shifting is increasing with respect to competition level in the market. This result is quite intuitive: because the price is close to the marginal cost in perfect competition, firms can not pay a large part of commodity taxes. On the opposite, oligopoly firms already capture a part of the consumer

surplus without commodity taxes, they thus have to support a large part of the commodity tax burden.

This dependence of tax shifting with respect to competition level may have political implications as to fiscal decisions. For example, it should influence the decision to choose which kind of goods has to be taxed to the full-rate or to the reduced-rate. Firms acting in low competition markets pay a bigger part of commodity taxes than firms acting on competitive markets. Therefore, commodity taxes can be a mean for States to capture a part of oligopoly rents.

Including these results in a simple model produces a version of the famous Ramsey formula. Let us consider a single consumer - which reflects the case with preference homogeneity - and two goods 1 and 2. The consumer utility is  $u(q_1, q_2)$  depending on the quantities  $q_i$  of good  $i$  consumed. This utility function is assumed to be separable, and linear with respect to money. The prices of these goods are  $p_i = 1 + s_i t_i$ , where the prices with no taxes are normalized at 1,  $t_i$  is the tax on good  $i$  and  $s_i$  the consumer share of this tax. The consumer maximization results in :

$$\frac{\frac{\partial u}{\partial q_1}}{p_1} = \frac{\frac{\partial u}{\partial q_2}}{p_2} = 1 \quad (12)$$

The State wants to earn a minimum income  $R$  with commodity taxes. Its objective is to maximize the consumer utility. The State maximization first order conditions are :

$$\frac{\partial u}{\partial q_i} \frac{\partial q_i}{\partial p_i} \frac{\partial p_i}{\partial t_i} + \lambda q_i + \lambda t_i \frac{\partial q_i}{\partial p_i} \frac{\partial p_i}{\partial t_i} = 0 \quad (13)$$

Where  $\lambda$  is the Lagrange parameter of this maximization associated to the State budget constraint. As the elasticity of good  $i$  demand is  $\epsilon_i = -\frac{p_i}{q_i} \frac{\partial q_i}{\partial p_i}$ , the tax rate - for ad valorem taxes - is  $\tau_i = \frac{t_i}{p_i}$ , and  $\frac{\partial p_i}{\partial t_i} = s_i$ , the first order conditions (13) result in the optimal tax rate :

$$\tau_i = -\frac{1}{\lambda} + \frac{1}{s_i \epsilon_i} \quad (14)$$

The optimal tax rate is not such that taxes more the goods for which demand is less elastic, but to tax the goods for which the effect of the consumer share through demand elasticity is weak. For two goods with the same demand elasticity, it is optimal to tax more the less competitive one.

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