Shifting on prices of per unit and ad valorem consumption taxes

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Abstract

Economic theory states that on market with imperfect competition, per unit consumption taxes should induce a larger increase of prices than ad valorem consumption taxes. It implies that consumers bear a larger share of the tax burden for per unit consumption taxes than for ad valorem consumption taxes. The present paper aims at testing empirically this theoretical result. It uses the French market for alcoholic beverages, which is submitted to both per unit (excise taxes) and ad valorem (VAT) consumption taxes. Econometrics is implemented on two reforms of consumption taxes affecting two French market for alcoholic beverages, *beers* and *aperitifs*. In 1995, the full rate of VAT increased from 18,6% to 20,6%; excise taxes on alcoholic beverages increased heterogeneously in 1997. Graphical evidence and econometrical results confirm the statements of economic theory. For both classes of alcoholic beverages - *beers* and *aperitifs* - the shifting on prices of per unit excise taxes was significantly larger than the shifting of ad valorem VAT.

Key words: tax incidence, VAT, excise taxes, alcoholic beverages, imperfect competition

JEL codes: H22; H25; D43.

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1 Introduction

The present paper aims at estimating the difference between shifting on prices of per unit and ad valorem consumption taxes, and shows that per unit consumption taxes induce a significantly larger increase of prices than ad valorem consumption taxes. The recent economic crisis, that increases public deficits and generate a new need for fiscal revenue, has reniewed the public debate about increasing consumption taxes. Defenders of this kind of taxes argue that it is a simple way of collecting public revenue, with low collection costs and generating little distortion on the markets. However, consumption taxes are distorting, they induce decreases of production. Incidence of consumption taxes is not obvious either: the burden of these taxes is shared between demanders and suppliers, and the share of suppliers is itself shared between employees and owners of the firms.

Under perfect competition, the shares of suppliers and consumers depend on price elasticities of the demand and the supply; both parts support a share of the tax burden, generally a larger share for the consumers. Imperfect competition changes the sharing of consumption taxes, the consumer share may be lower or larger than under perfect competition, it may even be larger than 100%, which means that the before tax price increases with respect to consumption taxes. This result is very robust as it is valid in the wide range of imperfect competition models (Katz & Rosen 1985, Stern 1987 and Besley 1989 in the Cournot oligopoly model with conjectural variations of Seade (1980); Aderson et al. 2001 in the Bertrand oligopoly model with differentiated goods) and it is confirmed by the few empirical studies testing it (Besley & Rosen 1999 and Carbonnier 2007).

Not only competition has an influence on the sharing of the tax burden between consumers and suppliers. Carbonnier (2008) studied the difference between shifting on prices of tax increases and tax decreases, and empirically confirmed his theoretical results. The way consumption taxes are implemented may also matters, and a large number of authors compare value-added taxes (VAT) to sales taxes (e.g.: Dungan et al. 2008, Smart & Bird 2009, Keen & Lockwood 2010 and Whalley & Kononova 2010).

The present paper aims at understanding the difference of shifting on prices between per unit consumption taxes and ad valorem consumption taxes. Under perfect competition, there should be no difference between both kinds of taxes, but the tax burden is shared differently under imperfect competition. This issue has been studied for a long time on a theoretical point of view. Cournot (1838) already found that per unit and ad valorem consumption taxes operate differently under monopoly: he stated that per unit taxes are always over-shifted on prices as ad valorem taxes may either be over-shifted or under-shifted. Wicksell (1896) also noted the difference between both kinds of taxes under monopoly and found that ad valorem taxes Pareto dominate per unit taxes. Suits & Musgrave (1953) studied monopoly and stated that ad valorem consumption taxes Pareto dominate per unit consumption taxes because tax shifting on prices is larger for per unit than for ad valorem consumption taxes. This last result is confirmed in Cournot oligopoly by Delipalla & Keen (1992). Other authors found the same results using different models of imperfect competition (e.g.: Skeath & Trandel 1994, Denicolo & Matteuzzi 2000 and Grazzini 2006).

All these models also found that ad valorem taxes Pareto dominate per unit taxes. The reason is that the prices are lower with ad valorem taxes for the same tax revenue, and therefore global output is larger. However, all these studies were done under partial equilibrium. Pareto dominance is contradicted if considering general equilibrium (Blackorby & Murty 2007). Myles (1996) calculated an optimal combinaison of both kinds of taxes. In the case of environmental issues, the purpose of a green tax may be to generate a large decrease of the output, and therefore per unit taxes may be prefered to ad valorem taxes (Dröge & Schröder 2009). Nevertheless, if these papers contested the Pareto dominance of ad valorem taxes over per unit taxes, they confirmed that tax shifting on prices of per unit taxes is larger than tax shifting of ad valorem taxes.

One intuitive explanation may be that with imperfect competition, firms own a market power: not only they know the actual demand but also they could anticipate what would be the demand with higher or lower prices. Yet, if they decrease the before tax price after an increase of consumption taxes, it does not change the tax at all if it is per unit but it decreases the tax if it is ad valorem. Therefore, they are more likely to bear a share of the tax burden - by decreasing the before tax price - if it could decrease the proportinal tax, and consequently decrease even more the after tax price than if it is a per unit consumption tax. A modelization of this intuition is presented in section 2.

This result, whose intuition is presented above, is well established in the litterature. Even so, few empirical studies has been implemented in order to test it. Delipalla & O'Donnell (2001) looked at the European tabacco market, comparing ad valorem VAT and excise taxes that are supposed to be per unit consumption taxes. However, the European system of Excise taxes on tabacco is complicated. Some European countries - France for exemple, that is considered in their panel - settle per unit excise taxes for main brands of cigarettes as the amount of ad valorem taxes on the brand of cigarettes leading the market. Therefore, excise taxes on tabacoo are not exactly per unit consumption taxes. Furthermore, addiction changes fundamentally the behavior of consumers and therefore the pricing of suppliers (e.g.: Barnet et al. 1995).

The present paper focuses on the case of alcoholic beverages in France. Alcoholic beverages are of the few markets (with oil and tobacco) on which is collected both ad valorem (VAT) and per unit (special excise duties) consumption taxes. Furthermore, they are sold in a market with imperfect competition: Young & Bielinska-Kwapsisz (2002) studied the market for alcoholic beverages in Washington D.C. and found the taxes over-shifted on prices. The methodolgy consists in comparing responce of prices to two different reforms of consumption taxes for alcoholic beverages. The full rate of VAT (ad valorem consumption tax) increased in 1995 and special excise duties on alcohol (per unit consumption taxes) increased in 1997.

The remainder of the paper is organized as follows. Section 2 presents the theoretical background, defining the parameters that should be estimated, giving the intuition for the theoretical result and explaining the econometrical stategy. Section 3 presents the data: the indirect tax system on alcoholic beverages in France, the reforms used for the econometrics, the times series and graphical evidences. Section 4 presents the results of the estimations. Section 5 concludes.

2 Econometrical framework and methodology

2.1 Intuition of the difference of shifting of per unit and ad valorem taxes

Whatever model is used - partial or general equilibrium, Cournot or Bertrand competition - all theoretical analyses show that per unit consumption taxes shift more fully on prices than ad valorem consumption taxes. These results may be understood intuitively. Let us consider the equilibrium with a per unit tax t. A representative firm sells Q at selling price p^s, with marginal cost c_m. Given the per unit tax t, the before tax price is $P = p^s - t$. In addition, let us consider that at that equilibrium the representative firm faces a demand variating as $\frac{dQ}{dp^s}\Big|_e = -\alpha$. That precise point being an equilibrium means that the potential marginal gains $dG_t = (P - dP - c_m^e)dQ = (P - dp^s - c_m^e)\alpha dp^s$ of decreasing the selling price by dp^s is equal to the potential marginal loss $dL_t = QdP = Qdp^s$. Figure 1a shows it with dG_t in dark grey and dL_t in light grey.

Figure 1:
Intuition of the larger shifting of per unit taxes

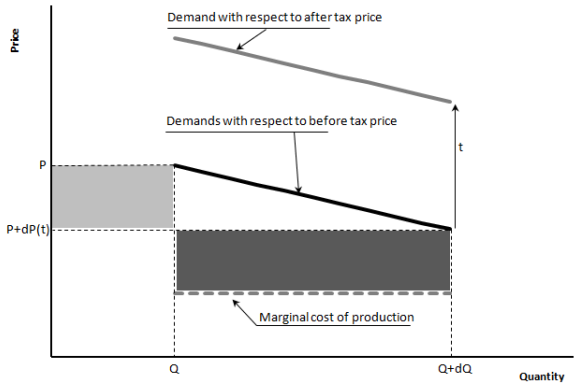


Figure 1a: Per unit taxes

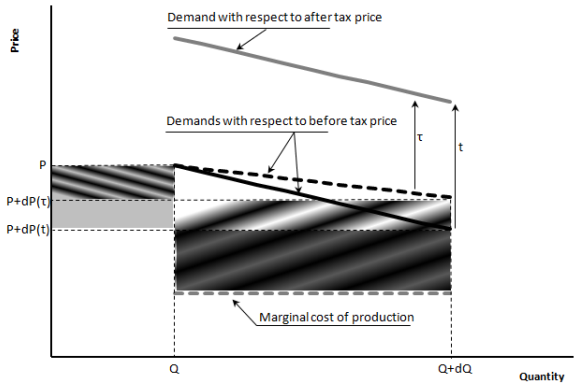


Figure 1b: Ad valorem taxes

Notes: Solid grey line shows the residual demand for products of a given firm with respect to their after tax price. Black lines are the same demand with respect to their before tax price P, the solid line when taxes are per unit t, the dashed line when they are ad valorem τP. The point (P, Q) is assumed to be the equilibrium with per unit taxes. The light gray rectangle represents the marginal loss of decreasing the price such that the output increases of dQ, when taxes are per unit. The dark grey rectangle represent the marginal gain of the same price decrease. The hatched rectangles are the marginal loss and gain of the same selling price decrease when taxes are ad valorem.

Now, it appears that this point (p^s, Q) can not be the equilibrium with an ad valorem tax $\tau = \frac{t}{P}$. Indeed, the marginal gain of decreasing the selling price by dp^s is $dG_\tau = (P - dP - c_m^e)dQ = (P - \frac{dp^s}{1+\tau} - c_m^e)\alpha dp^s$ which is superior to dG_t because $\frac{dp^s}{1+\tau} < dp^s$; the marginal loss is $dL_\tau = QdP = Q\frac{dP}{1+\tau}$ which is inferior to dL_t for the same reason. Figure 1b shows it with dG_τ and dl_τ in hatched black. As $dG_t = dL_t$, $dG_\tau > dG_t$ and $dL_\tau < dL_t$, it appears that $dG_\tau > dL_\tau$ and it is profitable for the representative firm to set a selling price inferior to P.

2.2 Definition of tax shifting on prices

The incidence of consumption taxes is the sharing of the tax burden between suppliers and consumers. This paper focuses on the consumer share of this tax burden, that is the tax shifting on prices. The selling price p (all taxes included) and the before tax price p_w (without any tax) depend on each other as $p = (p_w + t)(1 + \tau)$ where t is the per unit tax and τ the rate of the ad valorem tax. The shifting on prices of per unit taxes is denoted x, the shifting on prices of ad valorem taxes is y. Tax shifting x is the ratio of the effective variation $\frac{\partial p}{\partial t}$ of the tax included price p to the variation $\left.\frac{\partial p}{\partial t}\right|_{p_w}$ that would occur if the before tax price p_w does not vary as taxes vary. As $\frac{\partial p}{\partial t} = (1 + \tau)\left(\frac{\partial p_w}{\partial t} + 1\right)$ and $\left.\frac{\partial p}{\partial t}\right|_{p_w = C^{te}} = 1 + \tau$ the shifting on prices x of the per unit taxes is given by equation (1).

$$x = \frac{\frac{\partial p}{\partial t}}{\left.\frac{\partial p}{\partial t}\right|_{p_w}} = 1 + \frac{\partial p_w}{\partial t} \tag{1}$$

In the same way, $\frac{\partial p}{\partial \tau} = p_w + t + (1 + \tau)\frac{\partial p_w}{\partial \tau}$ and $\left.\frac{\partial p}{\partial \tau}\right|_{p_w = C^{te}} = p_w + t$. Therefore, the shifting on prices y of the ad valorem taxes is given by equation (2).

$$y = 1 + \frac{1 + \tau}{p_w + t}\frac{\partial p_w}{\partial \tau} \tag{2}$$

According to these notations, the aim of the present paper is to test theoretical results forecasting that x should be superior to y. These parameters correspond to those of Dellipalla & O'Donnell (2001), with the difference in the specification of the ad valorem tax. To fit variables of Dellipalla & Keen (1992), they considered $p = \frac{p_w + t}{1 - v}$ as if the ad valorem tax rate v was applied to the selling price p. To reproduce european VAT (the ad valorem tax in the data), I consider the ad valorem tax τ applied to the selling price without VAT $p_w + t$. The correspondance is $v = \frac{\tau}{1+\tau}$. Besley & Rosen did not consider a formula of tax shifting as their goal was to test full shifting against over-shifting and under-shifting. Therefore, they only considered the before tax price and estimated if it increases or decreases with respect to tax changes.

To implement this test, both tax shifting x and y should be estimated. That for, new parameters x' and y' are defined as $p = (p_0 + x't) * (1 + y'\tau)$ where p_0 is the price that would occur if there was no consumption taxes at all. Hence, it appears that $\frac{\partial p}{\partial t} = (1 + y'\tau)x'$. Because the before tax price is equal to $p_w = \frac{p}{1+\tau} - t$, its derivative with respect to t is equal to $\frac{\partial p_w}{\partial t} = \frac{\frac{\partial p}{\partial t}}{1+\tau} - 1 = \frac{1+y'\tau}{1+\tau}x' - 1$. Thus, the shifting on prices x of per unit taxes may be written as a function of the proxy parameters x' and y' as in equation (3).

$$x = \frac{1 + y'\tau}{1 + \tau}x' \tag{3}$$

In a similar way, $\frac{\partial p}{\partial \tau} = (p_0 + x't)y'$ and consequently $\frac{\partial p_w}{\partial \tau} = \frac{\partial\left(\frac{p}{1+\tau} - t\right)}{\partial \tau} = \frac{p_0 + x't}{1+\tau}y' - \frac{p}{(1+\tau)^2}$. Thus, the shifting on prices y of ad valorem consumption taxes may be written as a function of the proxy parameter y' as in equation (4).

$$y = \frac{1 + \tau}{1 + y'\tau}y' \tag{4}$$

These relationships between x' and x and between y' and y will be usefull as the parameter of interest are x and y and the econometrical strategy is based on x' and y'.

2.3 The econometrical strategy

The main data base used to estimate tax shifting x and y is a price index time series, whose properties are presented in section 3. Appart from correction of collection biases, the price index I_i at period i is linked to the mean price p_i by the formula $I_i = Cp_i = C(p_i^0 + x't_i)(1 + y'\tau_i)$, with C the constant term equalizing the price index to 100 on January 1998. This price index should be regressed differently to estimate shifting on prices of per unit consumption taxes (x) and shifting on prices of ad valorem consumption taxes (y). The simpliest case is the case of ad valorem consumption taxes, for which no information on the actual level of prices is necessary. The dependant variable should be the logarithm of the price index $\ln I_i = \ln C + \ln(p_i^0 + x't_i) + \ln(1 + y'\tau_i)$. Considering operator $\delta_i(Z) = Z_i - Z_0$, the VAT part $\ln(1+y'\tau_i)$ of this formula is equal to $\ln(1+y'\tau_0)+\ln(1+\frac{y'\delta_i(\tau)}{1+y'\tau_0})$. As $\frac{y'\delta_i(\tau)}{1+y'\tau_0}$ is small compared to one (an order of magnitude of $\frac{1}{100}$ for the reforms considered in the present analysis), the Taylor expansion of this logarithm is $\ln(1 + \frac{y'\delta_i(\tau)}{1+y'\tau_0}) = \frac{y'}{1+y'\tau_0}\delta_i(\tau) + r_i$ with the order of magnitude of r_i equal to $\frac{1}{10000}$. Therefore, the logarithm of the price index is as presented in equation (5).

$$\ln I_i = \underbrace{\ln C + \ln(1 + y'\tau_0)}_{constant\ terms} + \underbrace{\ln(p_i^0 + x't_i)}_{controls\ term} + \underbrace{\frac{y'}{1 + y'\tau_0}\delta_i(\tau)}_{tax\ shifting\ term} \tag{5}$$

The coefficient of the linear regression of $\ln I_i$ by the tax rate variations $\delta_i(\tau)$ is therefore the estimate of a function of the shifting on prices of ad valorem consumption taxes as presented by equation (6).

$$\beta_1 = \frac{y'}{1 + y'\tau_0} = \frac{y}{1 + \tau_0} \tag{6}$$

In the linear regression of $\ln I_i$, the other independent variable should control for the variations of $\ln(p_i^0 + x't_i)$. It could be the logarithm of the production costs (wages, payroll taxes, energy prices, rents, etc.) or the logarithm of the transportation costs.

Shifting on prices of ad valorem consumption taxes such as VAT may be estimated only with IPC time series. However, another data base should be used to estimate shifting on prices of per unit consumption taxes such as the excise taxes on alcoholic beverages. For those taxes, the actual mean price of the goods should be used, at least for one period. To estimate shifting on prices of per unit consumption taxes, the dependant variable of the linear regression should be the absolute increase of the price index from one period to another $\Delta_i(I)$ (where the operator $\Delta_i(Z)$ is equal to $Z_i - Z_{i-1}$). The value of that absolute variation over a period is given by equation (7).

$$\Delta_i(I) = \underbrace{C(1 + y'\tau)\Delta_i(p^0)}_{constant\ and\ control\ terms} + \underbrace{C(1 + y'\tau)x'\Delta_i(t)}_{tax\ shifting\ term} \tag{7}$$

The shifting on prices of per unit consumption taxes is estimated through the coefficient β_2 of independant variable $\Delta_i(t)$, as shown by equation (8). Given any period $i = u$, it is possible to calculate the actual tax shifting on prices because $I_u = p_u C$.

$$\beta_2 = C(1 + y'\tau)x' = C(1 + \tau)x = (1 + \tau)\frac{I_u}{p_u}x \tag{8}$$

In the actual estimation, the period u is chosen as the last period before the reform of the excise taxes. Furthermore, delays of independant variables $\Delta_{i-1}(t)$, $\Delta_{i-2}(t)$ and $\Delta_{i-3}(t)$ are added as regressors to take into account the delays in the tax shifting. I tested similar regressions with more delays and chose to limit to three months delay because no tax shifting appears in regressions later than three months after the reform. As for the ad valorem tax shifting estimation, independant variables are added in to control for $\Delta_i(p^0)$: it could be the absolute variation over one period of the production costs (wages, payroll taxes, energy prices, rents, etc.) or the absolute variation over one period of the transportation costs. Given the results of these two linear regressions, the comparison of shifting on prices of per unit and ad valorem consumption taxes may be done by comparing the estimated tax shifting $x = \frac{\beta_2 p_u}{(1+\tau)I_u}$ and $y = \frac{\beta_1}{1+\tau_0}$.

3 Data

3.1 The time series

Different data sources are used to implement these regressions. First of all, the fiscal legislation gives the rates τ_i of ad valorem consumption taxes (actually, it is the full-rate of VAT, a value added tax) for each period. Furthermore, alcoholic beverages are submitted in France to per unit excise taxes, which constitute the tax t_i for each period. Concerning the prices, two data bases are used, both provided by INSEE, the French statistical agency. The main one is IPC[2], the second one is time series of mean prices. IPC is a monthly price index time series harmonized at the european level. The classification of goods is based on the international standard COICOP (Classification of Individual Consumption According to Purpose), with some more details. Consumption goods are classified in twelve divisions, 86 groups and 161 classes. Montlhy price indexes are calculated from the monthly collection of the actual prices of 1000 different goods in 2000 different selling points in 106 cities of more than 2000 inhabitants. Indexes are calculated as a linked chain of Laspeyres. This IPC time series is more accurate and corrected from collection biases than the mean prices time series, and is therefore used for the regressions. However, the mean prices are also needed to calibrate the estimation of the shifting on prices of per unit consumption taxes, as presented in section 2.3: only the value at one period - the last period before the reform - is used.

Two alcoholic beverages are chosen among the categories for which the French IPC time series gives a specific monthly price index. From the different price indexes for classes of alcoholic beverages, the one called *brandy and liquors* has been rejected from the empirical study. The beverages whose prices are collected to built this price index are very different in terms of consumption as in terms of excise taxes. In particular, it is not possible to calculate a global excise tax for those kind of alcoholic beverages. The index called *champagne, sparkling wine and ciders* has been rejected for the same reasons, so as the *rhum* price index. Rhum beverages are submitted to different legislations depending mainly on two facts: the

[2] *Indice des prix à la consommation*: consumption price index

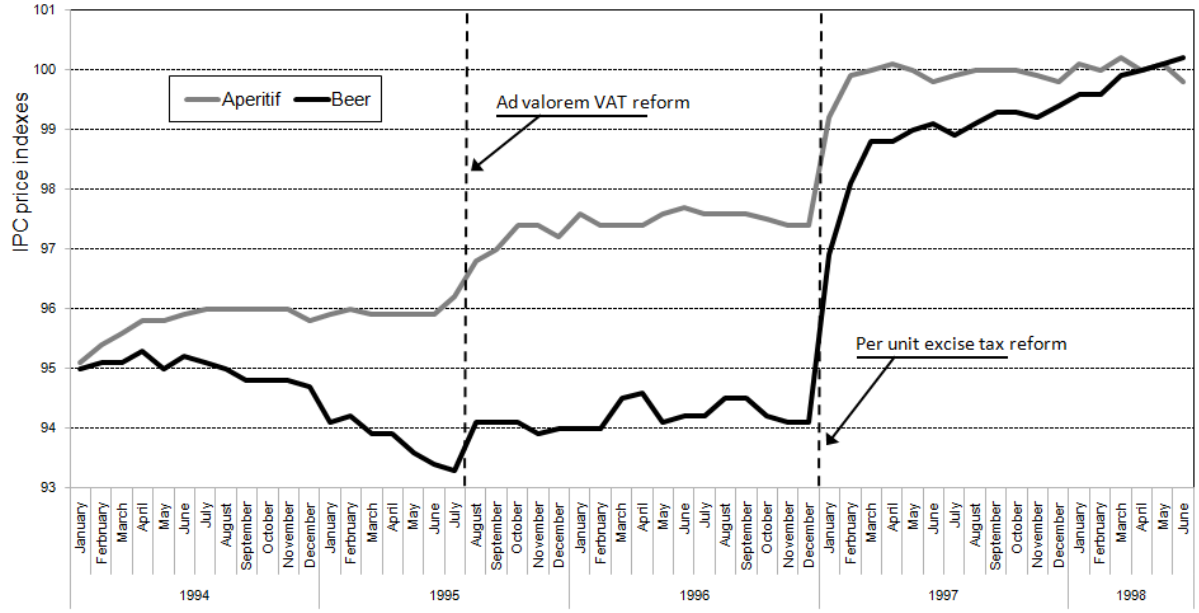
region of production - there is smaller excise taxes for rhum produced in the French antilles or in the Réunion island - and the quantity imported in continental France. Last, *wine* index has been rejected: this index collects prices of actual wine, but also of different beverages made of wine - fortified wine for exemple - that are submitted to different excise taxes. Furthermore, less reforms occured on wine excise taxes.

The remaining two time series of price indexes are studied to compare incidence of ad valorem VAT and per unit excise taxes. First of all, the *beer* index corresponds to usual blond beers, sold in pack of 6*33 centillitres (a little more than 6*11oz) for a total of two litres (a little less than 68oz). They are beers with a low degree of alcohol (inferior to 4.5% in volume). As excise taxes on beers are proportional to the degree of alcohol, over-estimating the degree of alcohol leads to an over-estimation of excise taxes and an under-estimation of the excise tax shifting on prices. As the purpose of this paper is to test if excise tax shifting is indeed larger than VAT shifting on prices, a safety margin is taken to be sure not to over-estimate excise tax shifting, and that for not to under-estimate excise taxes and degree of alcohol. Hence, the maximal degree of alcohol of 4.5% in volume is considered for *beers*.

Second, the time series of price index called *aperitif* is used for the econometrics. It consisted in the index of prices of *anise aperitif* and *whisky*. Those beverages are quite different the one from the other. However, they are submitted to similar excise taxes. For both beverages, the same excise tax is settled by hectolitre of pure alcohol. The degree of alcohol of anise aperitif is 45% in volume, and the collected prices are for bottles of one litre. The degrees of alcohol of whiskies depend on the brands, but are close from one brand to another and close to the degree of alcohol of anise aperitif (a degree of alcohol of 42% in volume is considered for the econometrics). INSEE collects prices of bottles of 75 centilitres. Figure 2 shows the price index of both kinds of goods all along the global period considered.

Another time series data base is available at INSEE, which gives each month the mean prices instead of price indexes. Only one value of these time series is used for each kind of beverages. Whatever month may be used to calibrate the IPC time series; actually, the last month before reform is chosen. This unique value is used to measure the value of the variation of excise taxes due to the reform proportionally to the actual price of the good. Three time series are used: on one hand time series for *beer* is used to calibrate price index for *beer*, on the other hand both times series for *anise aperitif* and *whisky* are used to calibate price index for *aperitif*. If the calibration of the excise tax reform for *beer* is done exactly by the *beer* mean price series, it is more complicated for *aperitif*. As I can not know the proportion of prices of whisky and anise aperitif in the *aperitif* IPC time series, I use two calibrations to bound the actual excise tax reform. The lower bound of the excise tax variation - and consequently the upper bound of the tax shifting - is calculated with the *whisky* mean price. The upper bound of the excise tax variation - and consequently the lower bound of the tax shifting - is calculated with the *anise aperitif* mean price. Indeed, whisky and anise aperitif are submitted to the same excise tax, calculated by hectolitre of pure alcohol, and bottles of *anise aperitif* contain more alcohol than bottles of *whisky*: IPC times series collects prices of one liter bottles of anise aperitif with a degree of alcohol of 45% in volume - that is bottles containing 45 centiliter

Figure 2:
Price indexes of alcoholic beverages during the late 1990's in France



Source: Consumption price index (IPC, Indice des prix à la consommation), a monthly price index series built by INSEE, the French statistics agency.

of pure alcohol - as it collects prices of 75 centiliter bottles of whisky with a degree of alcohol of 42% in volume, that is bottles containing 31.5 centiliter of pure alcohol.

3.2 The reforms on consumption taxes on alcoholic beverages

Given these time series, a special attention is given to the different reforms. Alcoholic beverages are submitted to two different kinds of consumption taxes. First of all, they are submitted to the general consumption tax, VAT. In addition, they are submitted to excise taxes, defined per unit for hectolitre of product - or hectolitre of pure alcohol depending on the kind of alcoholic beverage. There is also another per unit consumption tax whose revenue is directly allocated to public health insurance, but there has not been any change of this tax during the period considered for the empirical study. The reforms studied in the present analysis are summarized in table 1.

On August 1^{st} 1995, the full rate of VAT increased from 18.6% to 20.6%. It also affected the market for alcoholic beverages as alcoholic beverages are submitted to this full rate of VAT. The tax increase with respect to retail price is then 1.69% (0.02/1.186), which is of the same order of magnitude as the variations of excise taxes in 1997 - 2.50% for *beer*, 2.22% for *anise aperitif* and 1.66% for *whisky*.

After looking at the impact of ad valorem VAT on prices, I focuse on the impact of per unit excise taxes on prices. On January 1^{st} 1997, excise taxes increased for alcoholic beverages. For beers, it was 12.5 francs per degree of alcohol and per hectolitre of beverage and became 17 francs per degree and hectolitre.

Table 1:
Reforms of VAT and excise duties on alcoholic beverages

Beverage	Beer	Anise aperitif	Whisky
Packaging	2L 4.5%	1L 45%	0.75L 42%
August 1^s 1995		18.6%→20.6%	
VAT rate reform		1.69%	
January 1^s 1997	12.5F→17F/°*hL	9060F→9510F/hL of pure alcohol	
Excise taxes reform	6.17¢/€2.47	30.87¢/€13.93	21.61¢/€13.01
% of selling price	2.50%	2.22%	1.66%

Sources: Data come from consumption price index (IPC, *Indice des prix à la consommation*), a monthly price index series built by INSEE, the French statistics agency.
Notes: For both the reforms which occurred in 1995 and 1997, the first line indicates the variation in fiscal law and the last line gives the variation of the tax as a percentage of the after tax price before the reform. For the 1997 excise taxes reform, an intermediate line gives the variation in amount of the excise taxes for the packaging of the beverages whose price is collected to built the price index.

As we considered packs of 6*33cL of beer whose degree is 4.5% in volume, it corresponds to an increase of 6.17 cents of euro per pack[3]. As the mean price of *beer* the last month before the reform was 2.47 euros, it is an increase of the excise tax of 2.50% of the actual price, which corresponds to an increase of 2.35 of the price index of *beer* (as the price index of *beer* is 94.1 the last month before the reform).

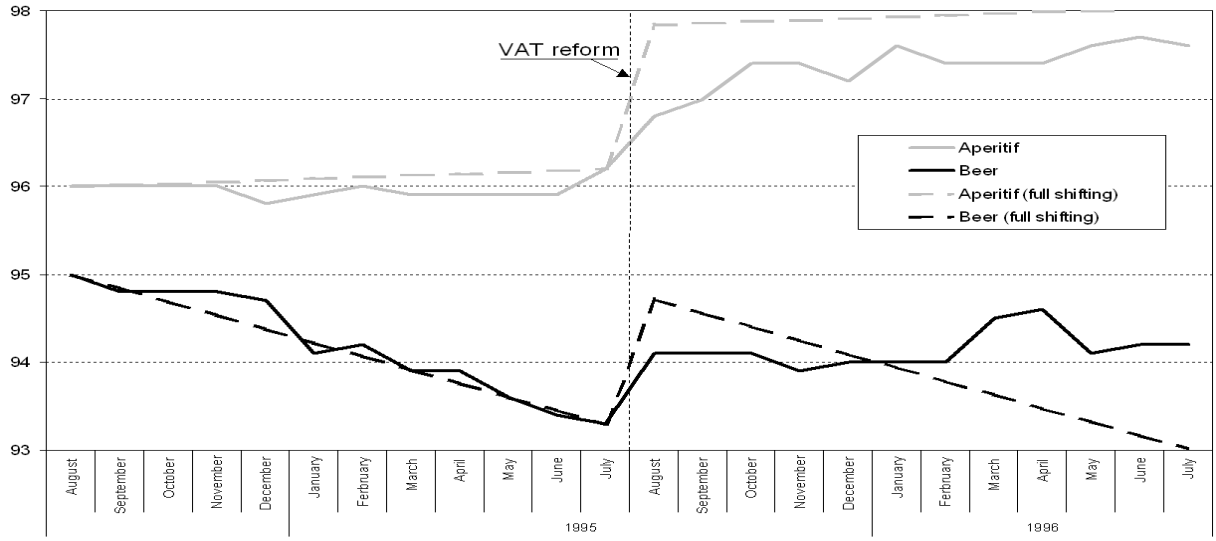
For distilled alcoholic beverages, the excise duty was 9,060 francs per hecolitre of pure alcohol and became 9,510 francs per hectolitre of pure alcohol. For *anise aperitif* (which gives the upper boundary of the full shifting as it has an alcoholic degree of 45% in volume and the time series gives the mean price of bottles of one litre), it is an increase of the excise taxes of 30.87 cents of euro per bottle. The mean price was 13.93 euros the last month before the reform, thus the tax increase represents 2.22% of the price, which corresponds to an increase of 2.16 of the price index as it was 97.4 the last month before the reform. For *whisky* (which gives the lower boundary of full-shifting as it has a mean alcoholic degree of 42% in volume and the time series gives the mean price of bottles of 75 centilitres), it is an increase of the excise tax of 21.61 cents of euro per bottle. The mean price was 13.01 euros the last month before the reform, thus the tax increase represents 1.66% of the price, which corresponds to an increase of 1.62 of the price index as it was 97.4 the last month before the reform.

3.3 Graphical evidence

To show on a figure (figure 3) the magnitude of the tax shifting, we report on the same figure the actual price indexes around the 1995 reform and the price indexes that would occur if VAT shifted fully on prices. The calculation of that simulated indexes for full shifting is made by measuring the mean rate of inflation before the reform then applying this rate of inflation of prices all along the new time series. The only change to that linear time series is the multiplycaton by 1.0169 ($= \frac{1.206}{1.186}$) of the indexes the months after the VAT reform.

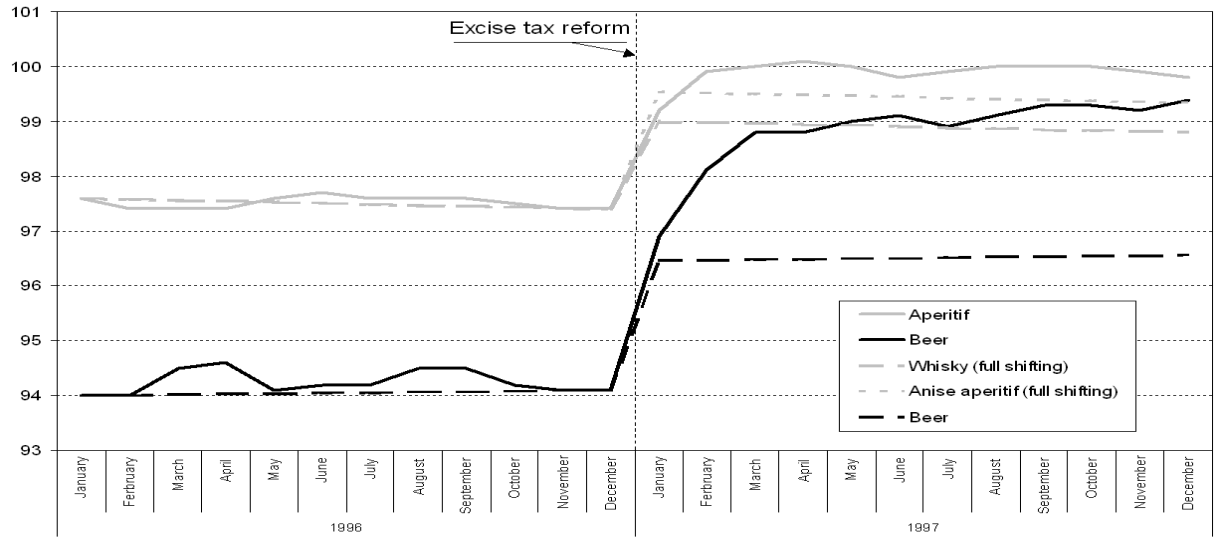
[3]All prices are converted in euro because the time series of the mean prices built by INSEE are fully converted in euros.

Figure 3:
Prices of alcoholic beverages around the reform of the full rate of VAT in august 1995



Sources: Data for the solid curves come from consumption price index (IPC, Indice des prix à la consommation), a monthly price index series built by INSEE, the French statistics agency. Dashed curves are calculated with the trend of IPC before the reform and the change of consumption tax, as if taxes shift fully in prices.

Figure 4:
Prices of alcoholic beverages around the reform of excise taxes on alcohol in january 1997



Sources: Data for the solid curves come from consumption price index (IPC, Indice des prix à la consommation), a monthly price index series built by INSEE, the French statistics agency. Dashed curves are calculated with the trend of IPC before the reform and the change of consumption tax, as if taxes shift fully in prices.

It appears clearly that VAT is under shifted on prices, for both alcoholic beverages studied, *beer* and *aperitif*. Concerning *aperitif*, the inflation rate of prices is close to zero before and after the reform - apart the last month before the reform. Therefore, the increase of prices due to the increase of the full rate of VAT is obvious, and stays obviously under the curve simulating full-shifting on prices. Concerning *beer*, the rate of inflation of prices is negative before the reform, but stays close to zero after the reform. Therefore, the curve simulating full-shifting on prices passes under the curve of the actual price of *beer* six month after the reform. Nevertheless, this seems due to a modification of the inflation rate of the price of *beer* and not to an over-shifting of VAT.

The same graphical exercice is done for the reform of excise taxes on alcoholic beverages in 1997. Figure 4 presents the curves of the actual price indexes for *beer* and *aperitif*, and the curves simulating full-shifting for *beer*, *anise aperitif* and *whisky*.

It appears clearly that excise taxes are over-shifted on prices of both alcoholic beverages studied: *beer* and *aperitif*. Hence, shifting on prices of per unit excise taxes in 1997 was doubtlessly larger than shifting on prices of ad valorem VAT in 1995 which was under-shifted on prices. Econometrics confirms these results in section 4, and gives the level of significance of the difference between tax sifting on prices of ad valorem VAT and per unit excise taxes.

4 Empirical results

4.1 Autocorrelation of the residuals

The econometrical strategy is explained in section 2. In addition, the time series are slightly smoothed because of the collection duration: the prices of all goods in all selling points are collected each month, but they are collected at different times within each month. This induces heteroscedasticity on data because residuals are autocorrelated at first order. Indeed, let us suppose that a permanent exogenous shock occurs on March 15th. Among the prices used to build an index of prices for March, some are collected after March 15th - and the permanent hexogenous shock is taken into account in the index of March - while some are collected before March 15th - and the permanent hexogenous shock is taken into account in the index of April. Therefore, the residuals of the regression for March and April are correlated because they are both impacted by the same permanent hexogenous shock (even if considering first differenciate of price indexes instead of price indexes themselves). As a consequence, autocorrelation is tested with the Durbin-Watson test. Results of these tests for each time series are presented in table 2.

If the test for autocorelation states that residuals are independant, estimations are implemented with Ordinary Least Scare (OLS) regressions. If the Durbin-Watson test states that residuals are autocorrelated, different methods are used to correct this heteroscedasticity. First of all, OLS regressions are implemented with standard errors estimated with the Newey-West method (OLS_{NW})[4]. Then, Feasible

[4]Different lags are used, from 0 (equivalent to the white method for estimating standard erros) to 4. Results are very close the ones to the others using different lags, I present the results with lag equals to 1, the most appropriate to correct

Table 2:
Tests for autocorrelation of the residuals

	1995	1997
Critical values	1.35 - [1.59 - 2.41] - 2.65	1.05 - [1.84 - 2.16] - 2.95
Biers (result)	0.295192 (autocorrelated)	2.07042 (independant)
Aperitif (result)	0.887916 (autocorrelated)	2.653798 (undeterminated)

Notes: the first line presents the critical values of the Durbin Watson test for autocorrelation of the residuals. The residuals are independant if the statistics of test is between the number between brackets. The residuals are autocorrelated if it is lower than the lowest number or higher than the highest number. The test gives an undeterminated results for other values of the statistics of test.

Generalized Least Square ($FGLS$) regressions are implemented. Different methods are used to estimate the coefficient of autocorrelation: Cochrane-Orcutt ($FGLS_{CO}$), Prais-Winston ($FGLS_{PW}$), Hildreth-Lu ($FGLS_{HL}$) and Hildreth-Lu ajusted with Cochrane-Orcutt iterated method ($FGLS_{HLCO}$). If the Durbin-Watson test gives undeterminated results, the model is estimated with all the different methods (OLS, OLS_{NW}, $FGLS_{CO}$, $FGLS_{PW}$, $FGLS_{HL}$ and $FGLS_{HLCO}$).

4.2 Results of the estimations

Estimations of tax shifting on prices are implemented separetly for each reform. First, the shifting on prices of the variation of the full-rate of VAT in 1995 is estimated according to regression (5), which gives coefficient β_1. VAT shifting on prices is calculated from this coefficient β_1 according to equation (6). The results of these regressions and calculations of tax shifting for both *beer* and *aperitif* are reported in table 3.

The results of these regressions confirm graphical evidences presented in section 3. Estimates of the tax shifting are significant, and their value is significantly lower than 100%. VAT is under-shifted on prices of both alcoholic beverages, *beer* and *aperitif*. The producers bear a substantial share of the burden of VAT.

Concerning the estimation of the shifting on prices of per unit excise taxes, the regressions are implemented according to equation (7). For regressions with the time series of price index for *aperitif* as dependent variable, two estimations are made with two different values for the variation $\Delta_i(t)$ of the excise taxes. The two values constitute boundaries for the variation of excise taxes for the class called *aperitif*: the upper boundary is the variation of excise taxes for anise aperitif, the lower boundary is the variation of excise taxes for whisky. Tax shifting is calculated from the estimate of the coefficient of the $\Delta_i(t)$, $\Delta_{i-1}(t)$, $\Delta_{i-2}(t)$ and $\Delta_{i-3}(t)$ independent variables according to equation (8). The results of these regressions and calculations for both alcoholic beverages studied *beer* and *aperitif* are presented in table 4.

autocorrelation of the residuals at first order.

Table 3:
Estimation of the shifting on prices of the VAT reform in 1995

	OLS_{NW}	$FGLS_{CO}$	$FGLS_{PW}$	$FGLS_{HL}$	$FGLS_{HLCO}$
Beers					
Tax shifting	41.14%	52.67%***	52.76%***	52.67%***	52.67%***
	(25.62%)	(14.17%)	(13.86%)	(14.17%)	(14.17%)
Coefficient β_1	0.3468	0.4441***	0.4448***	0.4440***	0.4441***
	(0.2160)	(0.1194)	(0.1169)	(0.1194)	(0.1195)
R^2	44.0%	84.5%	85.1%	84.5%	84.5%
Number of observations	36	35	36	35	35
Durbin-watson statistics	0.2952^{-}	2.0873^{+}	2.1007^{+}	2.0864^{+}	2.0873^{+}
Aperitifs					
Tax shifting	63.83%***	48.70%***	39.10%***	48.60%***	48.60%***
	(9.48%)	(8.95%)	(9.69%)	(8.96%)	(8.96%)
Coefficient β_1	0.35382***	0.4106***	0.3297***	0.4098***	0.4098***
	(0.07989)	(0.07547)	(0.08166)	(0.07552)	(0.07552)
R^2	95.2%	97.2%	97.0%	97.2%	97.2%
Number of observations	36	35	36	35	35
Durbin-watson statistics	0.8879^{-}	1.9911^{+}	1.8792^{+}	1.9919^{+}	1.9919^{+}

Notes: β_1 is the coefficient of the independant variable $\delta_i \tau$ in the linear regression according to equation (5). These regressions are implemented with different models: OLS_{NW} are ordinary least square regressions with standard errors estimated with the Newey-West method truncated at first order. Other regressions are feasible generalized least square models where the coefficient of autocorrelation is estimated with different method: Cochrane-Orcutt ($FGLS_{CO}$), Prais-Winston ($FGLS_{PW}$), Hildreth-Lu ($FGLS_{HL}$) and Hildreth-Lu ajusted with Cochrane-Orcutt iterated method ($FGLS_{HLCO}$). Tax shifting is calculated from this coefficient β_1 according to equation (6). ***: estimate significant at the level of 1%; **: estimate significant at the level of 5%. According to Durbin-Watson test for autocorrelation of the residuals; $^{+}$: residuals independent; $^{-}$: residuals autocorrelated; ^{o}: autocorrelation of the residuals undeterminated.

The results are all significant at a level of 1%. Furthermore, robustness tests have been implemented, with changing the window of the time series for the regressions or the number of delays: the results stand. For *beer*, the shifting on prices of the excise tax reform was substantially larger than 100%, and therefore substantially larger than the shifting on prices of the increase of the full-rate of VAT in 1995. For *aperitif*, the increase of excise taxes in 1997 was also over-shifted on prices. The upper boundary of tax shifting (estimation with excise taxes for *whisky*) is significantly (at the level of 1%) larger than 100%. The lower boundary of tax shifting (estimation with excise taxes for *anise aperitif*) is also larger than 100%, but not significantly. However, the standard errors are small enough to be sure that this lower boundary of tax shifting, even if lower than 100%, is close to full-shifting and significantly larger than shifting of VAT.

To check if the differences between the shifting on prices of the ad valorem VAT and the per unit excise taxes are significant, the differences between the estimates are calculated as well as the standard errors of these differences. The results are presented in table 5.

For both *beer* and *aperitif*, the shifting on prices of the increase of excise taxes in 1997 was significantly larger than the shifting on prices of the increase of the full-rate of VAT in 1995. It confirms the theoretical result that per unit consumption taxes should induce a larger increase of prices than ad valorem consumption taxes. For *aperitif*, even the lower boundary of the shifting of excise taxes (the estimation

Table 4:
Estimation of the shifting on prices of the change of excise taxes in 1997

	OLS	OLS_{NW}	$FGLS_{CO}$	$FGLS_{PW}$	$FGLS_{HL}$	$FGLS_{HLCO}$
Beers						
Tax shifting	158.30%***					
	(15.12%)					
Coefficient $\beta_{2,t=0}$	44.6188***					
	(3.4703)					
Coefficient $\beta_{2,t=1}$	18.6268***					
	(3.4715)					
Coefficient $\beta_{2,t=2}$	10.4508***					
	(3.4744)					
Coefficient $\beta_{2,t=3}$	-0.9644					
	(3.4789)					
R^2	89.56%					
Number of observations	29					
Durbin-Watson statistics	2.0760^{+}					
Anise aperitifs						
Tax shifting	102.88%***	102.88%***	101.97%***	101.96%***	101.97%***	101.97%***
	(12.11%)	(1.85%)	(11.80%)	(11.54%)	(11.81%)	(11.80%)
Coefficient $\beta_{2,t=0}$	5.8171%***	5.8248%***	5.8245%***	5.8249%***	5.8249%***	5.8248%***
	(0.5100)	(0.0765)	(0.4823)	(0.4715)	(0.4823)	(0.4823)
Coefficient $\beta_{2,t=1}$	2.2511***	2.2511***	2.2362***	2.2360***	2.2360***	2.2361***
	(0.5102)	(0.0769)	(0.5120)	(0.5007)	(0.5122)	(0.5120)
Coefficient $\beta_{2,t=2}$	0.3048	0.3048***	0.3641	0.3693	0.3644	0.3641
	(0.5106)	(0.0783)	(0.5120)	(0.5007)	(0.5122)	(0.5120)
Coefficient $\beta_{2,t=3}$	0.3020	0.3020***	0.1733	0.1732	0.1729	0.1733
	(0.5112)	(0.0806)	(0.4837)	(0.4731)	(0.4837)	(0.4837)
R^2	86.4%	86.4%	88.3%	88.4%	88.3%	88.3%
Number of observations	29	29	28	29	28	28
Durbin-Watson statistics	2.6656^{o}	2.6656^{o}	1.9577^{+}	2.0417^{+}	1.9558^{+}	1.9577^{+}
Whiskies						
Tax shifting	137.26%***	137.26%***	136.05%***	136.03%***	136.04%***	136.05%***
	(16.15%)	(2.47%)	(15.75%)	(15.40%)	(15.75%)	(15.75%)
Coefficient $\beta_{2,t=0}$	8.3102%***	8.3102%***	8.3212%***	8.3207%***	8.3213%***	8.3212%***
	(0.7285)	(0.1092)	(0.6890)	(0.6736)	(0.6890)	(0.6890)
Coefficient $\beta_{2,t=1}$	3.2159***	3.2159***	3.1945***	3.1943***	3.1943***	3.1945***
	(0.7288)	(0.1098)	(0.7314)	(0.7153)	(0.7317)	(0.7314)
Coefficient $\beta_{2,t=2}$	0.4354	0.4354***	0.5201	0.5199	0.5206	0.5201
	(0.7294)	(0.1118)	(0.7314)	(0.7153)	(0.7316)	(0.7314)
Coefficient $\beta_{2,t=3}$	0.4314	0.4314***	0.2476	0.2474	0.2470	0.2476
	(0.7303)	(0.1151)	(0.6910)	(0.6758)	(0.6910)	(0.6910)
R^2	86.4%	86.4%	88.3%	88.4%	88.3%	88.3%
Number of observations	29	29	28	29	28	28
Durbin-Watson statistics	2.6656^{o}	2.6656^{o}	1.9577^{+}	2.0417^{+}	1.9558^{+}	1.9577^{+}

Notes: $\beta_{2,t=j}$ are the coefficients of independant variables $\Delta_{i-j}(t)$ in regression (7), tax shifting are calculated according to equation (8). OLS are OLS regressions; OLS_{NW} OLS with standard errors estimated with the Newey-West method at first order. Others are GLS regressions with coefficient of autocorrelation estimated with: Cochrane-Orcutt ($FGLS_{CO}$), Prais-Winston ($FGLS_{PW}$), Hildreth-Lu ($FGLS_{HL}$) and Hildreth-Lu ajusted with Cochrane-Orcutt ($FGLS_{HLCO}$). ***: estimate significant at 1%; **: estimate significant at 5%. $^{+}$: residuals independent; $^{-}$: residuals autocorrelated; ^{o}: undeterminated.

Table 5:
Differences between shifting on prices of per unit and ad valorem consumption taxes

	OLS	OLS_{NW}	$FGLS_{CO}$	$FGLS_{PW}$	$FGLS_{HL}$	$FGLS_{HLCO}$
Beers		117.16%***	105.63%***	105.54%***	105.63%***	105.63%***
		(29.75%)	(20.72%)	(20.51%)	(20.72%)	(20.72%)
Anise aperitifs	39.05%**	39.05%***	53.27%***	62.86%***	53.37%***	53.37%***
	(15.38%)	(9.66%)	(14.81%)	(15.07%)	(14.82%)	(14.82%)
Whiskies	73.43%***	73.43%***	87.35%***	96.93%***	87.44%***	87.45%***
	(18.73%)	(9.80%)	(18.12%)	(18.19%)	(18.12%)	(18.12%)

Notes: This table presents the differences between the estimates of shifting on prices of reforms of excise taxes in 1997 and VAT in 1995. The different columns present these differences depending on the method used to estimate tax shifting on prices: OLS are ordinary least squares, OLS_{NW} are ordinary least squares with standard errors estimated with the Newey-West method truncated at first order, $FGLS_{CO}$ are feasible generalized least squares where the coefficient of autocorrelation is estimated with Cochrane-Orcutt method, $FGLS_{PW}$ with Prais-Winston method, $FGLS_{HL}$ with Hildreth-Lu method and ($FGLS_{HLCO}$) Hildreth-Lu ajusted with Cochrane-Orcutt iterated method. ***: estimate significant at the level of 1%; **: estimate significant at the level of 5%.

with the excise taxes for *anise aperitif*) is significantly larger than the shifting of VAT in 1995.

5 Concluding comments

Economic theory states that on market with imperfect competition, per unit consumption taxes should induce a larger increase of prices than ad valorem consumption taxes. Thus, consumers should bear a larger share of the tax burden for per unit consumption taxes than for ad valorem consumption taxes.

The present papers aims at testing this theoretical result. It uses the French market for alcoholic beverages, which are submitted to both per unit (excise taxes) and ad valorem (VAT) consumption taxes. Econometrics is implemented on two reforms of consumption taxes affecting the French market for alcoholic beverages. In 1995, the full rate of VAT increased from 18,6% to 20,6%; excise taxes on alcoholic beverages increased in 1997. The econometrical results confirm economic theory. For both *beer* and *aperitif* (a class of beverages including whisky and anise apritif), the shifting on prices of per unit excise taxes was significantly larger in 1997 than the shifting on prices of ad valorem VAT in 1995.

Furthermore, it appears that VAT was under-shifted on prices in 1995 as excise taxes were over-shifted on prices in 1997. The under-shifting of VAT is significant at the level of 1% for both *beer* and *aperitif*. However, the over-shifting of excise taxes is significant at the level of 1% only for *beer*. For *aperitif*, the upper boundary of tax shifting (tax shifting estimated with excise taxes of *whisky*) is significantly larger than 100% (at the level of 1%) but the lower boundary of tax shifting (tax shifting estimated with excise taxes of *anise aperitif*), even if slighlty superior to 100%, is not significantly superior to that threshold.

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