

Estimate of cross-border cigarette purchases in France 2004-2007

Building and analysing a demand function to measure the volume of cross-border cigarette purchases and subsequent tax evasion.

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The volume and consequences of tobacco purchases that are not locally taxed, i.e., tobacco purchased by French people outside of the traditional French tobacco network, have been the subject of lively debate. Central to this debate is the issue of tobacco prices: should they be increased for the sake of improving public health by decreasing tobacco use, or on the contrary, should the price increases be curtailed to prevent smokers from seeking their tobacco outside of the French supply network (refer to box 1 for current legislation)?

In 1999, 5.3 cigarettes were sold per day and per inhabitant aged 15 to 75 in France; eleven years later, this figure dropped to 3.3 cigarettes. However, this general decrease masks significant geographic variations, since these sales showed a more marked decrease in northern and south-western border *départements* than in French *départements* that are further away from neighbouring countries (see Map 1). Overall, the decrease reached 49% in border *départements* versus 34% in non-border *départements*.

This strong suspicion of tax evasion on tobacco products has been the subject of numerous studies in the United States (Léal *et al.*, 2010). In fact, the American federal structure and the sovereignty of each state regarding tax rates promote tax-driven competition for tobacco products.

In France, several studies have already employed different methods to estimate the extent of tax evasion on tobacco products. The OFDT was able to estimate cross-border tobacco purchases at between 14 and 20% of the French market for 2004 to 2006 (Ben Lakhdar, 2005, 2008). For 2004, the INSEE (French National Institute of Statistics and Economic Studies) evaluated such tobacco purchases at 6% of the French market compared to the 2002 market situation (Besson, 2006). These significantly different estimates can be explained by the empirical methods used and the hypotheses proposed. The variations demonstrate the need for a more elaborate assessment framework.

With a view to improving the robustness of the estimates, this issue of *Tendances* develops a more complex methodological method. This approach, which is based on a theoretical system that describes individual reasons for crossing borders, takes into consideration not only tobacco price differences between France and its border countries, but also the distance that separates individuals from the closest borders. The question that an individual wishing to purchase cross-border tobacco asks himself or herself is therefore the following: is the price difference advantageous enough to offset the transport costs incurred when crossing the border? The econometric analysis used here offers a way to quantify the influence of each determinant of cross-border tobacco purchases, all other things being equal. The analysis also fine-tunes the overall tax evasion estimates. For data availability reasons, and especially since cigarette demand has been greatly distorted due to anti-tobacco measures, the study period ran from 2004 to 2007. The estimated econometric model nevertheless provides an idea of the tobacco tax evasion trends for the most recent years.

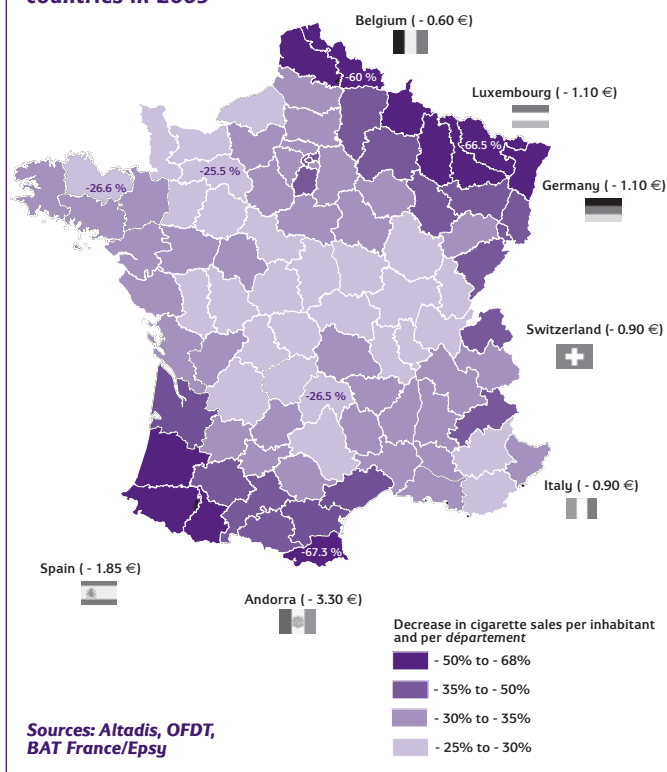
At the same time, a survey on tobacco purchasing behaviours was conducted among smokers. This survey completes the analysis of the econometric model by highlighting the characteristics of users of foreign-purchased tobacco.

Incentives for cross-border purchases and econometric modelling

The incentives for making cross-border purchases, whether of tobacco, alcohol or other goods, can be reduced to a relatively simple cost-benefit question: is it advantageous for an individual to purchase goods in a neighbouring country when that individual can purchase them locally?

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Map 1 - Trends in cigarette sales per inhabitant (%) and per département (1999-2009), as well as price difference for a pack of 20 cigarettes between France and its neighbouring countries in 2009



At the root of cross-border trade are therefore, essentially, tax or price differences for a given good between countries, on the one hand and, on the other hand, transport costs. We understand then that the individual de-

cision to purchase abroad depends on the geographic location of the individual and either the economic situation of the neighbouring country as such or the strategic behaviour of the countries. Indeed, it is possible that the goods in question are less expensive in the neighbouring country because of that country's economic situation: a lower GDP per inhabitant and a lower standard of living can make the goods sold there less expensive than in the domestic country. The neighbouring country may have the same, or even a better economic situation, but the price of the good in question may be lower because of a more advantageous tax strategy. In the case of tobacco, we can think of Spain as an example of the first model. In Spain, cigarettes are less expensive, but wealth per inhabitant is lower. As an example of the second model, Luxembourg's national wealth per inhabitant is clearly higher than that of all its European neighbours, but cigarettes have lower taxes there.

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Following the example of the North American studies that have already been conducted, it is appropriate to model an equation of tobacco demand by factoring in not only the price of French tobacco, but also the various differences that exist between French tobacco prices and the tobacco prices of France's neighbouring countries. In addition to other control variables, distance from the border, either in kilometres or in travel time, assesses the travel costs individuals bear to cross the border. Therefore, distance is a determinant variable of tobacco demand, whether domestic or foreign (see Methodology, p. 6).

This cigarette demand equation has been estimated for the period 2004 - 2007 because a very significant structural shock recently affected French tobacco demand: in 2004 (see Graph 1), the price of cigarettes in France rose dramatically, thereby creating a previously unseen difference when compared to the cigarette prices of neighbouring countries. Furthermore, it was during this period that the fight against tobacco use intensified in France with, for example, a ban on smoking in public places on 1st February 2007¹.

Results of the estimates

The results of the econometric estimates that seek to explain and quantify the determinants of French departmental cigarette sales are shown in Table 1.

The first noteworthy result is that the past sales coefficient, which measures the inertia

Box 1 - Legislation on tobacco possession and transport

In France, articles 575 G and 575 H of the French General Tax Code govern the possession and transport of tobacco by individuals, and the current provisions of these articles were put into effect by the Act of 20 December 2005.

Article 575 G: "After retail sale, manufactured tobacco cannot circulate in quantities of over 1 kilogram without the document mentioned in II of article 302 M [the Simplified Accompanying Document (DSA, or Document Simplifié d'Accompagnement, in French)]."

Article 575 H: "With the exception of suppliers in warehouses, tobacconists at retail points of sale, [...], no one can be in possession of more than 2 kilograms of manufactured tobacco in warehouses or commercial locations, or in means of transport."

Therefore, for personal use, an individual can enter France in possession of up to 5 cartons (or 1 kg) of tobacco without any documentation or declaration. For 6 to 10 cartons (1 to 2 kg), an individual must have a Simplified Accompanying Document granted by the customs authorities. It is strictly prohibited to be in possession of more than 10 cartons (i.e., 2 kg) of tobacco under penalty of confiscation of goods, fines (up to €750) and criminal prosecution. These levels apply per individual travelling in forms of collective transport and per vehicle for individuals travelling in a personal vehicle.

France is the only country of the European Union to apply such strict limits to foreign tobacco pur-

chases, and did so to protect the State monopoly. However, in 2010, the European Commission threatened to go before the European Court of Justice because it believed that the French model does not comply with European Community law. Initially, the French Ministry in charge of the Budget showed its willingness to rectify the situation, adding that the law is not very effective (very few Simplified Accompanying Documents are delivered and the tax losses resulting from foreign purchases have not diminished for tobacconists located near international borders). Anti-tobacco associations and tobacconists (especially) denounced putting this symbolic law to an end, using the same argument: tobacco is a product unlike any other.

Initial legislation abolishing the limitations was subsequently submitted to the French Council of Ministers in mid-November 2010. However, members of French Parliament (motivated by tobacconists) defended these two articles in their original form, i.e., with the strict limits. In early December, the government foresaw an alternative, highlighting the unmeasurable concept of "personal use". After several trips between the French National Assembly and the French Senate, sometimes entertaining the idea of removing the limits, sometimes entertaining the idea of keeping them, the legislation was finally adopted by the two parliamentary bodies on 20 December 2010: France would thus continue to apply the same limits for tobacco transport and possession.

Box 2 - The data used

The cigarette sales per French administrative département (excluding Corsica) were provided by Altadis. The price of cigarettes in France was provided by the French Official Journal. The prices of cigarettes in foreign countries were obtained using Euromonitor (Belgium, Germany, Italy and Spain), Statec (Luxembourg) and OFS (for Switzerland). Information on tobacco prices in Andorra could be obtained only for 2010 (€2.40). We regenerated the series of prices by comparing it to the Spanish price (€3.90 in 2010), and by assuming that the differential rate remained constant (61.5%) during the observation period². The per-département population and the per-département tax data came from the INSEE (French National Institute of Statistics and Economic Studies)

1. Decree 2006-1386 of 15 November 2006 relating to the conditions of application for the ban on smoking in public places. NOR SANX0609703D, JORF (French Official Journal) of 16 November 2006.

2. It is noteworthy that the price per Spanish pack is relatively low compared to other countries. This can be explained by the large numbers of Spanish tobacco brands, which are sold there at very low prices.

Table 1 - 2004-2007 results of the estimates of cigarette sales equations

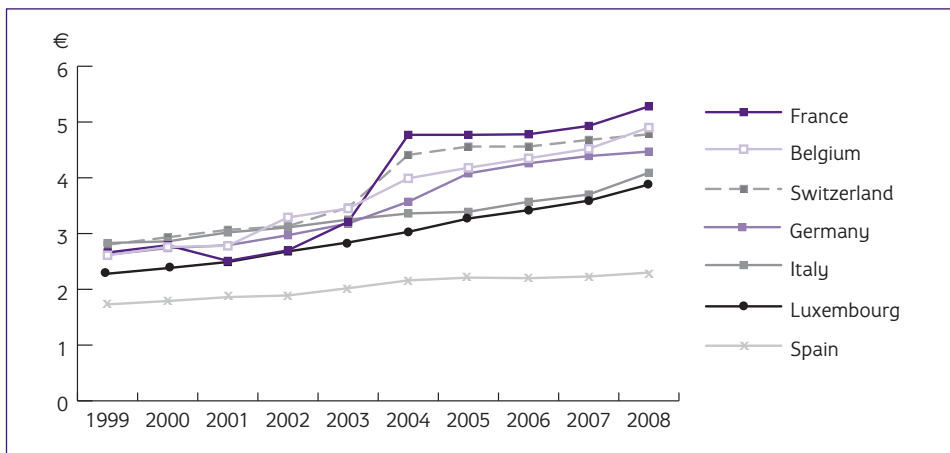
(Dependent variable: natural logarithm of departmental cigarette sales). (1)

	[Distance from the border]	[Time from the border]
Sales concluded	0.139*	0.141*
French price	-0.349*	-0.349*
Taxable income	0.003	0.005
Population	0.177*	0.154*
Price differential	-1.059*	-1.067*
Distance	0.179*	.
Time	.	0.170*
Constant	8.716*	9.013*
Wald chi2(6)	7,827.30*	7,896.21*

(1) All explanatory variables are expressed as natural logarithms

Significance of coefficients: * p < 0.01 (Z-test)

Significance of model: Wald Chi2 at six degrees of freedom * p < 0.01

Graph 1 - Price of a pack of 20 cigarettes in France and in neighbouring countries, 1999-2008

Sources : Euromonitor, Statec, OFS

of cigarette sales and - as an indirect result - the addictive behaviour of users, is relatively low (+ 0.139).

Indeed, we might have expected this variable to have a more important explanatory weight. This result may be considered an offshoot of the "de-trivialisation" of tobacco use in recent years, as suggested by Costes *et al.* (2010).

However, this coefficient helps calculate long-term price elasticity, which is obtained by dividing the French price coefficient by 1 minus the past price coefficient. The subsequently calculated elasticity is - 0.4, meaning that, in the long term, a 10% increase in the

price of cigarettes causes an average reduction in sales of 4%, all other things being equal³.

Table 2 - Estimates of volumes of cigarettes purchased in neighbouring countries of France in 2005-2007

Year	[Distance]	Sales difference compared to effective sales (in %)	[Time]	Sales difference compared to effective sales (in %)
	Gross sales difference (in tonnes)		Gross sales difference (in tonnes)	
2005	11,685	21.32%	12,438	22.70%
2006	10,352	18.56%	11,134	19.96%
2007	10,093	18.37%	10,865	19.77%
Total	32,131		34,437	

Note 1: In the [Distance] estimate, the kilometric distance variable is used like an explanatory variable. The [Time] estimate represents time expressed in minutes.

Table 3 - Estimates of tax losses due to cross-border purchased cigarettes in neighbouring countries in 2005-2007

Year	[Distance]	Tax evasion (in thousands of euros)	[Time]	Tax evasion (in thousands of euros)
	Gross sales difference (in tonnes)		Gross sales difference (in tonnes)	
2005	11,685	2,240,344	12,438	2,384,803
2006	10,352	2,000,132	11,134	2,153,069
2007	10,093	1,989,021	10,865	2,139,132

Note 1: In the [Distance] estimate, the kilometric distance variable is used like an explanatory variable. The [Time] estimate represents time expressed in minutes.

3. The calculation of price elasticity of long term demand is as follows: $(-0.349)/(1 - 0.139) = -0.405$

4. More precisely, our estimates show that a more populated *département* sells noticeably more cigarettes than a less populated one, but also that a *département* which has experienced a growth of its population over the study period would see its cigarettes sales increase. It is impossible to differentiate between the two effects.

5. It is worthy to note that these are relative prices (technically necessary given that our variables are expressed into a natural logarithm) and that an increase of 10% of the price gap presupposes an important increase in prices at national level.

In the short term, the current direct elasticity of the price is approximately - 0.35 in both estimated equations, indicating that a 10% increase in the price of cigarettes causes a 3.5% decrease in sales on average. These results correspond perfectly to the results of past research in different time periods (Anguis and Dubeau, 1997; Godefroy, 2003; Étilé, 2006). The wealth effect, measured by taxable income, is not far from zero. In other words, individual wealth, measured on a French departmental level, does not affect cigarette sales in any way. Finally, the population variable indicates that sales increase less than proportionally to the increase in population size (+ 0.18% in the distance equation and + 0.15% in the time equation). In other words, the more populated French *départements* are⁴, the higher cigarette sales are, but at a rate that is less than proportional (an increase of 10% in population size would lead to an increase in sales in the region of +1.5% to + 1.8%).

The crucial point of our research is related to the attractiveness of cross-border sales. Two results are clearly revealed. The first is that, on average, a 10% increase in the distance separating a *département* from the closest bordering country causes an increase in local sales of 1.79%. If we consider time as an explanatory variable, the results are nearly the same (+1.7%). In other words, distance coherently acts as a filter for the attractiveness of foreign prices.

The second result is that the relative price differential effectively influences departmental cigarette sales: when the relative difference between the French price and the neighbouring country price grows by 10%, the sales drop by about 10.6%, i.e., slightly more than proportionally⁵. Rationally, users react to incentives generated by tax advantages (see Box 3 for the location and sociodemographic profile of these users).

Box 3 - 2009-2010 Survey on how French smokers supply themselves with tobacco

A survey conducted at the request of the OFDT on French smokers in order to understand how they supply themselves in tobacco also helped shed light on the issue of tobacco purchased outside of the French tobacconist network. The INPES (National Institute for Prevention and Health Education) conducted this survey using telephone interviews integrated into an omnibus survey conducted by BVA in two phases. Each phase had two periods (21-22 May and 28-29 May for the first period and 25-26 June and 2-3 July 2010 for the second period). The surveyed smokers came from four, 1,000-person representative samples of the French population aged 15 and over (quota sampling method).

In total, 767 current smokers aged 20 to 54 were surveyed, whether they were occasional or regular (at least one cigarette per day) smokers.

No significant differences were observed between the two periods for most of the questions. Subsequently, the analysis was performed on all surveyed smokers.

Of the surveyed smokers, 56% were men, with a mean age of 38. 71% were employed, 63% had at least finished high school (and obtained the French baccalauréat), 20% had a monthly income per person of under €900 and 37% had a monthly income of over €1,500. A total of 82% were cigarette smokers, 34% were rolled tobacco smokers and 2.6% used other tobacco products (mainly cigars). Approximately 40% smoked over 10 cigarettes per day and 55% are not dependent, or are only slightly dependent, on tobacco⁶. Finally, 12% of the smokers lived in a border *département* of France.

Regarding tobacco supply methods, nearly 75% of the surveyed smokers made their most recent tobacco purchase at a French tobacconist's. Nearly three-quarters of the smokers who did not make their most recent tobacco purchase at a French tobacconist's (or approximately 15% of all surveyed people) went to a tobacconist's in a neighbouring country. The other smokers made their most recent purchase in duty-free (2% of all surveyed people), at a tobacconist's in a country that is not a neighbour of France (1.7%) or by Internet (0.3%). Furthermore, 0.5% responded by saying they had purchased their last pack of cigarettes on the street and 0.5% had received their last pack from someone they knew (occasional smokers). Finally, 5% of the surveyed smokers did not want to or could not answer this question. If we consider that these non-responders made their purchase at a French tobacconist's, then one out of every five smokers stated going outside of the French tobacconist network to make their most recent tobacco purchase⁷.

In the last 12 months, more than half of these smokers stated they had never gone abroad to purchase their tobacco, 22% had gone abroad once or twice, and 2.6% stated going abroad nearly every day or every day.

Of the smokers who had bought their tobacco abroad at least once in the last 12 months (335 smokers), 12.5% only bought one pack, 22.4% bought two to ten packs and 8.4% bought more than 5 cartons.

Cross-border purchasers were characterised by geographic location: they are far more numerous in the northern, eastern and south-western regions of France. Departmentally speaking, cross-border buyers are mainly concentrated in border areas (39% vs. 12% in non-border *départements*, $p < 0.01$). Among the smokers making cross-border purchases, twice as many of them had an average income (€900 to €1,500 per month per person) when compared with low income smokers ($p < 0.01$), while high income smokers are somewhere in the middle. There is no significant relationship between daily use and cross-border purchases. However, 18% of dependent smokers bought their last pack in a neighbouring country vs. 13% of non-dependent or slightly dependent smokers ($p < 0.01$).

Those purchasing abroad in the last year were more numerous in border areas (68% vs. 43%, $p < 0.01$). Smokers for whom the head of household is in a high SPC and retired people were more inclined to make this kind of purchase than less well-off categories, which is confirmed by the monthly income per person: of those earning above €900, 50% purchased tobacco abroad in the last year versus 31.5% for those earning below €900 ($p < 0.01$). Regular purchasers (at least 10 purchases in the last year) had the same characteristics, but we also observed an over-representation of dependent smokers (15.3% vs. 7.6% of non-dependent smokers, $p < 0.01$). These regular purchasers are distinguished by a stronger tendency to buy more than 5 cartons or only one pack (16.7% vs. 5.6% of occasional buyers and 16.7% vs. 11.2%, $p = 0.02$).

In contrast to other studies, this sample did not reveal a significant relationship between daily tobacco use and supply strategies. However, dependent smokers make more cross-border, grey-market and international purchases, and buy in larger quantities, than slightly dependent or non-dependent smokers.

In summary, smokers' means of supply vary mainly due to their geographic location (border areas more affected by purchases outside of the French tobacconist network), their degree of tobacco dependence and their income (lower income smokers buy more often in French tobacco shops, thereby confirming that they are the ones most affected by price increases). Finally, although the relationship is not very significant, it seems that rolling tobacco smokers make more cross-border purchases and travel abroad more frequently for their tobacco purchases than cigarette smokers.

Estimates of cross-border purchases and tax evasion

Since the tobacco demand function has been estimated, we can now proceed with an approximation of the tax evasion related to cross-border cigarette purchases. In fact, to perform this estimate, we need to answer a counterfactual question: to what extent would the French sales have increased if the prices had been harmonised at European level, i.e., if there had not been a difference in price between France and its neighbouring countries?

Technically, the value of the tobacco demand equation needs to be determined with all of the estimated parameters, except for the price differential. We then obtain the tobacco sales that would have been recorded in France if the price of a French pack of cigarettes had been identical to that of neighbouring countries. This volume must then be subtracted from the sales that actually occurred in French tobacco shops in order to obtain an estimation of the tax evasion due to cross-border cigarette purchases.

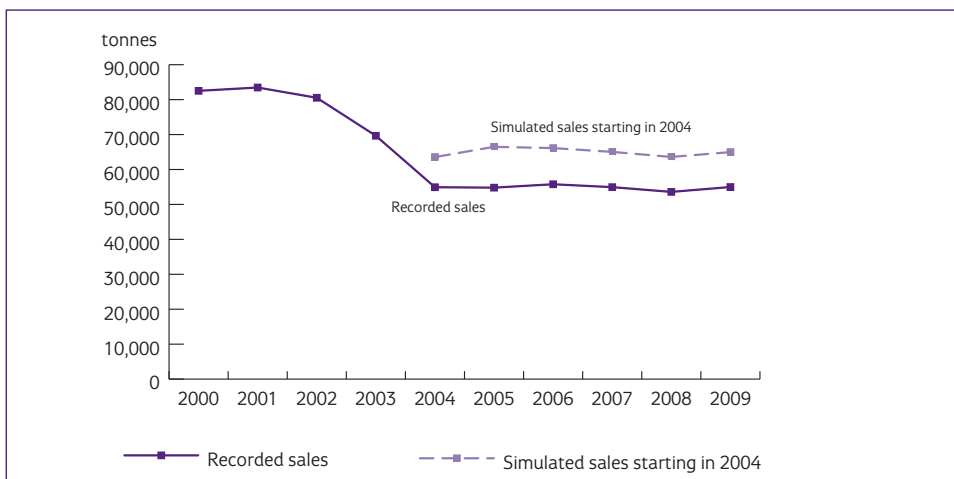
The results of these simulations are shown in Table 2. If the difference in price between French cigarettes and cigarettes across the border had been zero in 2005, then 11,684 tons of cigarettes would have been sold in France instead of abroad. In other words, depending on the equation under consideration (distance or time), cigarettes purchased in all countries neighbouring France represented between 21.3% and 22.7% of the sales recorded in tobacco shops in 2005, i.e., approximately one of every five cigarettes⁸. It should be noted that this difference in simulated sales and actual sales diminished in 2006 and 2007. This could be explained by the fact that individuals may have gotten fed up with the travelling required to cross the border, as well as, and probably more so, by the fact that the price difference diminished in favour of France between 2006 and 2007. This confirms the importance of this variable.

Considering that a pack contains 20 cigarettes, that a cigarette weighs 0.8 grams (Hill and Laplanche, 2003) and the tax rate on a pack of cigarettes is 80.39%, the amount in lost tax revenue can be estimated. This estimation is shown in Table 3.

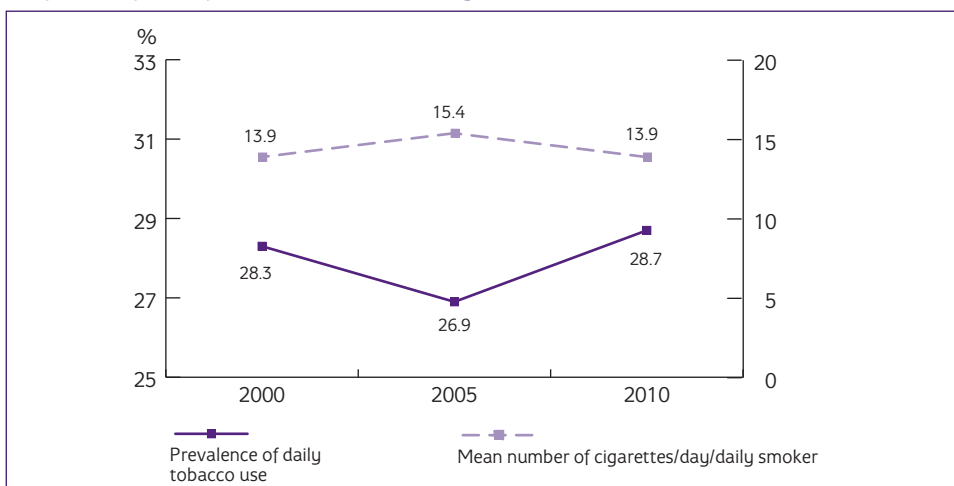
6. For this survey, tobacco dependence was calculated using the simplified Fagerström test designed around two questions about daily use and the time that lapses between awakening and smoking the first cigarette of the day.

7. It appears that the proportion of smokers who purchased their tobacco outside of the French tobacconist network and the proportion of cigarettes procured through cross-border purchases are identical. However, this is just a simple coincidence. We currently have no information confirming a link between these two figures.

8. If all cigarette purchases made by French smokers (both in French tobacco shops and across the border) are considered, this percentage of foreign cigarettes was 18% in 2005, thereby confirming the prior estimates.

Graph 2 - Cigarette sales and simulated sales, France (2000-2009)

Sources : Altadis, OFDT

Graph 3 - Reported prevalence and mean daily use of tobacco (2000-2010)

Source : Baromètres Santé 2000, 2005, 2010 (Inpes)

Note: in 2000, data are for daily smokers aged 12 to 75 years old, whereas in 2005 and 2010 data are for daily smokers aged between 15 and 75 years old.

The simulations indicate that the loss in tax revenue related to cross-border purchases was 2.24 billion euros in 2005 and nearly 2 billion euros in 2006 and 2007 when the distance from the border was used as an explanatory variable for the estimate.

If the time required to cross the border is considered as an explanatory variable for sales, then the results are slightly higher: nearly 2.4 billion euros in 2005, 2.1 billion euros in 2006 and the same for 2007.

In addition to their usefulness with respect to lost tax revenues, these estimates raise a legitimate question regarding the trends in tobacco use in France. On Graph 2, we present the cigarette sales recorded between 2000 and 2009 and add the estimates for cross-border purchases from 2004 to 2009. For 2004, we used the OFDT estimate results of 8,635 tonnes (Ben Lakhdar, 2005); for 2005 to 2007, we used the distance model estimates presented in Table 3, and for 2008 and 2009 we considered that 10,000 tonnes of cigarettes had been purchased abroad (since the

cigarette price differential between France and its neighbouring countries remained relatively stable for these two years).

Graph 2 appears to be consistent with the INPES 2010 Baromètre santé (health survey) results, which, for all tobacco products, concluded that there was an increase in tobacco use by French people between 2005 and 2010 (Beck et al., 2010), but that this increase was accompanied by a decrease in the average number of cigarettes smoked per day (see Graph 3). In fact, since the 2003 and 2004 major tax hikes on tobacco products in France - tax hikes which led to a clear decline in tobacco use compared to the early 2000s - it seems that nothing has managed to effectively modify French tobacco use.

Discussion

Of course, such work is not without its limitations. First of all, the phenomenon is

not easy to observe or quantify. Furthermore, there were limitations regarding the choice of methodology employed or factors that could not be taken into consideration.

Methodologically, the choice of distance or time from the departmental prefecture to the border was deliberate. It mechanically erases certain geographic particularities of ease or difficulty in accessing borders, although the time model was designed to specifically take these characteristics into account.

Regarding the elements not integrated into the model, considering cross-border employment-related travel would have been quite useful. In such situations, travel is no longer motivated by the difference in tobacco prices, but rather by an obligation for individuals to cross the border. In these cases, even if the price differential is only minimal, foreign tobacco importation can take place.

Likewise, hand-rolled tobacco sales could not be taken into consideration in our econometric model due to the non-existence of these data for the study period on a departmental level. We cannot assess the impact that this omission could have on our estimates. It appears that cigarette price increases promote a substitution effect that favours hand-rolled tobacco sales. Hence, when cigarette sales fall, hand-rolled tobacco sales tend to experience the reverse effect, giving the impression that some of these smokers turn to hand-rolled tobacco instead. However, as our supply survey shows (see Box 3 on page 4), hand-rolled tobacco users also resort to cross-border purchases: therefore, the net effect remains indeterminate.

Finally, the development of contraband tobacco can be suspected, since customs confiscations were higher than ever in 2010. This is certainly an element that interferes with our estimates, but it is extremely difficult to determine how. The form of the econometric equation used (particularly its departmental nature and the consideration of population size) enables our estimates to incorporate contraband tobacco-related items that could diminish the estimates of cross-border purchases. However, for this phenomenon, no explanatory variable (such as the number of customs agents or the volume of confiscated tobacco products per *département*) could be incorporated into the equation, since there was a lack of available data. Subsequently, it is once again difficult to discuss this point.

Finally, it is unfortunate to only have yearly data to deal with this issue. Monthly data could have helped us reveal a seasonal phenomenon. Not only would monthly data have helped us better understand the impact of price hikes, but it also would have helped us isolate tourist tobacco purchases, which can be considerable at certain times of the year.

Of course, these limits represent the basis of an agenda for research to be undertaken to estimate French tobacco demand as accurately as possible and, subsequently, to specifically assess the impact of enacted public anti-tobacco policy.

Conclusion

French tobacco supply methods and use have significantly changed in the last few years. Of course, tobacco demand is increasingly restricted: laws, measures, information on the health consequences or tax hikes reduce incentives to use tobacco. However, at the same time, circumvention strategies have arisen: although smokers use relatively fewer cigarettes, they smoke hand-rolled tobacco more often, or if possible, they go abroad to buy their tobacco (see Box 1 on page 2 regarding the recent debate on tobacco possession and transport).

Regarding the latter point, we have demonstrated that cross-border purchases, which amount to one out of every five cigarettes smoked, lead to 2 billion euros in tax evasion each year. This clearly reduces the impact of price hikes, but only up to a certain extent. The increase in taxes therefore remains a public policy lever for decreasing tobacco use.

Given that a European harmonisation in

Credits

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The accepted methodology for estimating cross-border cigarette purchases is based on the econometric estimation of a tobacco demand function. The latter aims to explain cigarette sales using different variables according to mainland French administrative *départements* (excluding Corsica due to special taxation rules there) and for the purposes of determining potential incentives for cross-border cigarette purchases. This will be done on the one hand through the price differential that exists between France and neighbouring countries and on the other hand by considering the distance (or travel time) separating the mainland French *départements* from the nearest borders. This can be modelled as follows:

$$Y_{it} = \alpha + \beta_1 Y_{it-1} + \beta_2 P_{it} + \beta_3 R_{it} + \beta_4 POP_{it} + \beta_5 (P_{it} - P_{jt}) + \beta_6 D_{it}^{\min} + \epsilon_{it}$$

Y_{it} represents cigarette sales per *département* i for year t . We are seeking to explain departmental sales not only through the previous year's sales Y_{it-1} , since there could exist a certain inertia in sales behaviour, but also through cigarette prices. Since individual income can also affect tobacco demand, we consider the mean taxable income per *département* R_{it} to express this wealth variable. On a departmental level, the population size is also an explanatory factor for departmental tobacco sales: in fact, it is expected that a more populated *département* has higher tobacco sales; likewise, a *département* experiencing a population increase will certainly witness an increase in cigarette sales. The variable for the number of individuals aged 15 to 75 is denoted by POP_{it} .

For each French *département*, we calculated the difference between the prices within the *département* and those in the closest foreign country j ($P_{it} - P_{jt}$). The higher this differential, the more incentive there is to go across the closest border to purchase cigarettes. This price differential variable (which is expressed in relative prices for methodological reasons) is expected to be negative, thereby taking into account the cigarette sales per *département* that did not occur due to the attractiveness of purchasing them in the closest neighbouring country. In addition to the latter variable, we used a variable for travelling to the border, which could influence departmental cigarette sales. D_{it}^{\min} therefore represents either the minimum time or distance required to travel to the border for each *département*. Two variables were constructed here, since the closest neighbouring countries for a *département* are not always the ones reached the fastest (the accepted criterion is the quickest route by motorway). We subsequently measured the distance for each departmental prefecture from the closest neighbouring country using two variables: the first is a measure of distance expressed in kilometres; the second is a measure of time by car expressed in minutes. These measurements, supposedly fixed for the sampling period, were calculated using <http://maps.google.fr/>. With the exception of Luxembourg, Switzerland (Geneva) and Andorra, several border cities (with over 20,000 inhabitants) were used to determine the minimal distance. These cities were Saarbrücken, Karlsruhe and Freiburg im Breisgau for Germany, Turin and San Remo for Italy, and Figueres, Vielha and Irun for Spain.

α is the constant of the equation and captures the standard error of the mean, while ϵ_{it} is a random term with the usual properties of independence and distribution. β_1 and β_6 are the coefficients of the model to be estimated. All of the variables are expressed as natural logarithms to facilitate the interpretation of the coefficients. This is the Generalised Method of Moments (GMM estimator) developed by Arellano and Bond (1991) and used to estimate the studied tobacco demand. An advantage of the GMM method is that it is adapted within the scope of linear dynamic models, whose explanatory variables are endogenous and predetermined, and when the panel sample is characterised by a weak temporal range.

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Printing
Imprimerie Masson / 69, rue de Chabrol 75010 Paris
ISSN 1295-6910
Legal publication registration

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