Fuel tourism in border regions

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Content

Abstract

The gasoline price differential existing across the border between Switzerland and its neighbouring countries (gasoline price in Switzerland is generally lower than in the neighbouring countries) has encouraged the phenomenon of fuel tourism to develop. People living in the bordering regions of Italy, France and Germany have had an incentive to buy gasoline in Switzerland for several years. This phenomenon increased employment and fiscal revenues from fuel taxes in Switzerland, whereas in the neighbouring countries we observed lower fiscal revenues and a decrease of employment in the gasoline distribution sector. These repercussions on the government revenues have induced the North-Italian province of Lombardy to adopt measures against fuel tourism (in Italy, similar measures have already been adopted in the regions neighbouring Slovenia). For instance, the inhabitants in the regions near the border can take advantage of price rebates at the fuel stations. The reaction to the price decreases was very important: Six months after the introduction of the rebates at the Italian fuel stations, the fuel demand in the Swiss border regions decreased by 20 to 40%. On the other hand, fuel stations in Italy have realised important increases in selling.

The case of fuel tourism gives a good economic example for price responsiveness. The extent to which fuel tourism can be a problem for the border region depends on the sensitivity of car owners to fuel price differentials and on the intensity of cross-bordering movements (density of population). In this paper we analyse the impact of country-specific fiscal policies on gasoline demand using aggregate data at a regional level for three Swiss border regions over the period 1986 to 1997. The data include fuel selling of three main gasoline companies in an area of 10 km from the border. For the area further away form the border, data for a sample of fuel stations are available. A log-log stochastic equation for gasoline consumption was estimated, using fuel price differences as well as regional income and other regional variables (for instance car density, commuters, number of border offices, prices of cigarettes) as independent variables.

Initial estimation results show a very significant impact of price differentials on fuel demand and an important share of fuel tourism on the overall gasoline sales of Swiss border regions. It can be shown that gasoline consumption by consumers in bordering regions is very sensitive to price differentials of standardized goods like gasoline (that is goods, which do not differ from one country to the other). From an energy policy point of view this result implies that, as long as price differentials persist, there is little room in border regions for discouraging residential gasoline consumption using tax increases. Policy measures like those introduced in Italy and in other countries, in order to minimize the negative side-effects of a neighbour with low fuel taxes, seem to be successful in avoiding a loss of taxes as well as losses for owners of gas stations in the border region with higher taxes. Of course, for Switzerland this could imply a restructuring of the fuel-selling sector in border regions.

1 Introduction

The gasoline price differential existing across the border between Switzerland and its neighbouring countries (gasoline price in Switzerland is generally lower than in the neighbouring countries) has encouraged the phenomenon of fuel tourism to develop. People living in the bordering regions of Italy, France and Germany have had an incentive to buy gasoline in Switzerland for several years. This phenomenon increased employment and fiscal revenues from fuel taxes in Switzerland, whereas in the neighbouring countries lower fiscal revenues are observed with a decrease of employment in the gasoline distribution sector. These repercussions on government revenues have induced the North-Italian province of Lombardy to adopt measures against fuel tourism (in Italy, similar measures have already been adopted in the regions neighbouring Slovenia). For instance, the inhabitants in the regions near the border can take advantage of price rebates at the fuel stations. The reaction to the price decreases was very important: six months after the introduction of the rebates at the Italian fuel stations, fuel demand in the Swiss border regions decreased by 20 to 40%. On the other hand, fuel stations in Italy have realised important increases in sales.

2 Cross-border effects of price-differentials

There exists already a broad literature analysing the cross-border effects of price differences. These differentials are usually given by country specific fiscal policies, which can be observed, particularly for alcohol, cigarettes and gasoline. Coats (1995) estimates the effect of state cigarette taxes on the cross-border sales of cigarettes, showing the extent to which inhabitants of the border regions realise the arbitrage opportunities. Garrett and Marsh (2002) analyse cross-border lottery shopping behaviour and show that these revenues cannot be considered a reliable and stable revenue source because of the importance of cross-border lottery competition.

Di Matteo and Di Matteo (1996) analyse the cross-border shopping behaviour between Canada and the USA using the per capita same day automobile trips from Canada to the United States and expenditure. They show that income, the exchange rate, gasoline prices and the Goods and Services Tax as well as seasonality factors can explain over 90% of the variation in same day cross-border trips. Also Merrifield and Storer (1999) analysed the importance of exchange rates on cross-border shopping between Canada and the United States. They circumvent their analysis on the impact of fluctuation in the exchange rates on taxable retail sales of gasoline.

Important differences in the fiscal burden are not only observed between the United States and Canada, but also between different US States. Lilley III and De Franco (1996) have studied the impact of such tax-driven price differentials on cross-border consumer purchasing between US States. Their analysis suggests that tax differentials can have a significant impact on the level of welfare and job creation between neighbouring areas.

The cross-border effects of gasoline price differentials between European countries have been analysed by Rietveld *et al*. (2001), who focused on the consequences of a spatial graduation of fuel taxes in terms of shifts in fuelling patterns, tax receipts and mileage. This analysis demonstrates that the propensity of Dutch households to fill their cars in Germany is high; given a price differential of 5 €-cents, approximately 30% of the Dutch car owners living at the border would fuel in Germany. The trade-off of the average driver of the price difference between the two countries and the distance travelled is about 5 €-cents/l/km.

Based on the methods and results presented in the literature of cross-border purchasing, this study focuses on the cross border behaviour of foreign car drivers choosing to fill their tanks in Switzerland. Actually, the fiscal policy of the Swiss government in relation to fuel taxation differs slightly from the fiscal policies of its neighbouring countries. Fig. 1 shows that for the year 1997, the neighbouring countries had higher gasoline prices than Switzerland. These differences are mainly due to the fact, that Italy, German and France charge significantly higher taxes on leaded and unleaded gasoline than Swiss authorities do. However, the price differences for diesel are less pronounced then these for gasoline.

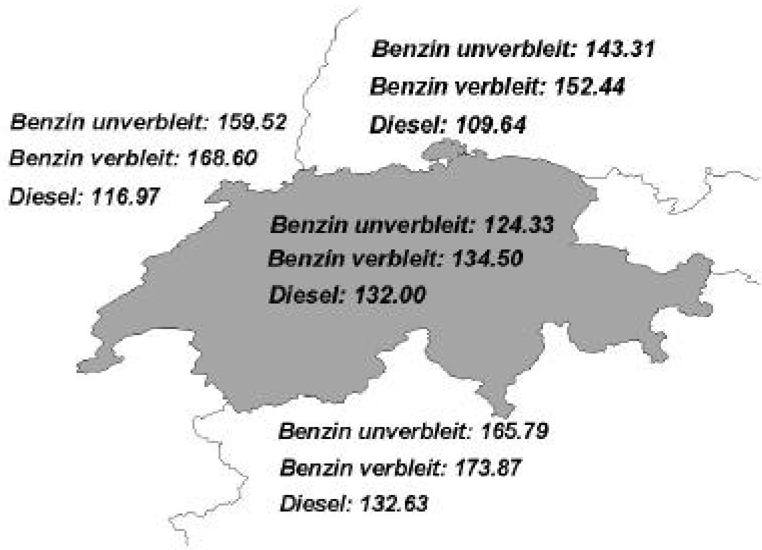

Fig. 1. Gasoline (leaded and unleaded) and diesel prices in the year 1997 for Switzerland and its neighbouring countries, in Swiss Cents (1 € = 1.48 CHF)

Since fuel is an almost homogeneous product, it can be expected that car drivers react rationally to price differences across gas stations. Therefore, the conspicuous price differentials between Switzerland and its neighbouring countries should have led to an important share of cross-border fuelling ("fuel tourism") in Swiss border regions. Actually, people living in the bordering regions of Italy, France and Germany had, for several years, an incentive to buy gasoline in Switzerland. This phenomenon has some positive side-effects for the Swiss economy, since it increased employment and fiscal revenues, whereas the neighbouring countries experienced lower fiscal revenues and a decrease in the employment in the gasoline distribution sector. Because of the very high price differentials (at least in some years), these repercussions were particularly important in the Italian border regions. The negative impact on the government revenues has induced the North-Italian province of Lombardy to adopt measures against fuel tourism (in Italy, similar measures have been already adopted in the regions neighbouring Slovenia). For instance, the inhabitants in the regions near to the border can take advantage of price rebates at the fuel stations. The reaction to the price decreases was very important and show that car drivers react rationally to a price differential; six months after the introduction of the rebates at the Italian fuel stations, the fuel demand in the Swiss border regions has decreased by 20 to 40%.[1] On the other side, fuel stations in Italy have realised important increases in sales.

The comparison of the density of fuel stations in the border cantons and the rest of the country can give some insights on the importance of fuel tourism for the structure of the gasoline retail industry. Actually, it can be found that near the border, the density of fuel stations is higher than in the rest of the country. This holds true particularly for the border region to Italy (Canton Ticino) and for the Canton Basel-City, where the density of fuel station is of about 5.6 and 6.4 stations per 10'000 vehicles respectively, whereas the Swiss average is about 3.1 stations.

The aim of the paper is therefore to identify the impact of price differentials on cross border gasoline fuelling behaviour. This insight is interesting for the fiscal policy of a country and may imply a spatially differentiated fiscal policy, with a spatial graduation of fuel taxes, which should prevent car drivers from fuel-tanking trips abroad. Due to a data problem, we will not consider the demand for diesel.

[1] Information of „Bundesverband freier Tankstellen e. V." (Association of the independent gas stations) www.bft.de/bft/aktuell/dittert.htm

The next section of the paper starts with a description of the data, giving more detailed information on the development of fuel demand in the Swiss border regions and on the magnitude of price differentials between Switzerland, Germany, Italy and France over the sample period. The following section describes the model applied for estimating fuel demand in border regions and the variables used. In section 5 the estimation results are presented and interpreted with a brief summary conclusion presented in section 6.

3 Data used to measure the importance of fuel tourism in Swiss border regions

3.1 Gasoline demand

The importance of fuel tourism in the Swiss border regions can be shown by the development of gasoline sales. For this study we assume that the border region influenced by fuel tourism behaviour is defined by a territory within 5 kilometres from the border.

The data on gasoline demand were collected by the "Swiss Oil Association" ("Erdölvereinigung") for the three most important fuel companies (ESSO, BP and Shell) and include the sales of around 190 fuel stations located in an area of about 5 kilometres from the border (for this area we have the sales of all fuel stations). In Switzerland, the gasoline stations of these three companies account for approximately 30% of all Swiss gasoline stations (in the year 2001 these companies owned approximately 1240 gasoline stations out of a total of 4140). It can be assumed that the selling of these stations are representative of the selling of all other gasoline stations. The choice to analyse the demand patterns of the border regions is based on the assumptions that in these regions foreign drivers choosing to fill the tanks of their cars in Switzerland significantly determine the fuel demand.

For the area between 5 and 20 kilometres from the border, the demand data were only collected for a sample of fuel stations. Due to the small amount of stations, these data have not been used for the estimation of the cross-border gasoline demand. Additionally, because of the longer distance from the border, it can be assumed that fuel tourism is only of negligible importance in explaining the overall gasoline demand of the region.

The demand data distinguish between leaded and unleaded gasoline as well as diesel, although the distinction between leaded and unleaded gasoline is available only from 1991. After 1991, a rapid shift from leaded to unleaded gasoline can be observed. This structural break has the consequence that selling of leaded gasoline experience a significant decrease in the period between 1985 and 1997. On the contrary, the demand for unleaded gasoline shows an important increase. Because of this shift in the demand for the different gasoline types, the estimation uses the aggregated demand for leaded and unleaded gasoline.

Fig. 2 shows the development of fuel sales in the three Swiss border regions considered in the analysis. The border region to Austria has not been considered, since the number of gasoline stations for this border region is not large enough.

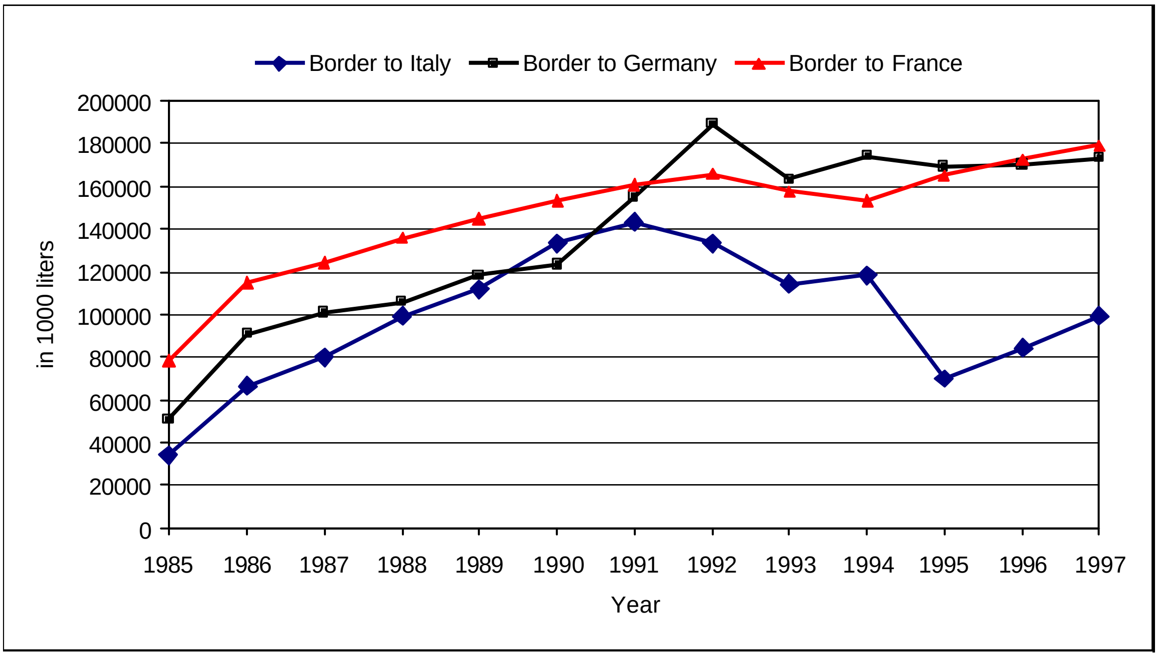

Fig. 2. Development of gasoline demand of the three main companies in the border regions of Switzerland for the years 1985 to 1997

Fig. 2 shows that since 1985 gasoline demand has increased in every border region of Switzerland. This development is not surprising, since incomes, car densities and kilometres driven also rose, in part substantially, in all the countries considered. Moreover, it is interesting to note that the development wasn't smooth but was characterised, especially in the Italian and partially also in the German part of Switzerland, by phases of increasing consumption and as well as phases of decreases in quantities sold. These sudden changes in fuel demand are arguably explained by the high price differentials between countries that have induced car drivers towards cross-border fuelling.

3.2 Gasoline prices

The data set contains the annual average gasoline prices for Switzerland and the neighbouring regions (the prices are collected by the border officers every month). There are some missing data for single months, which have been interpolated using the price of the previous and the following month.

Fig. 3 illustrates the differences of the leaded gasoline price between Switzerland and its neighbouring countries. It is worth noting that in Italy during the 1980s and at the beginning of the 1990s the prices were significantly higher than in the other countries, but since 1993 an adjustment towards the price of other countries has occurred. The differences between Swiss and German prices are smaller; and between 1985 and 1989 prices were actually lower in Germany than in Switzerland.

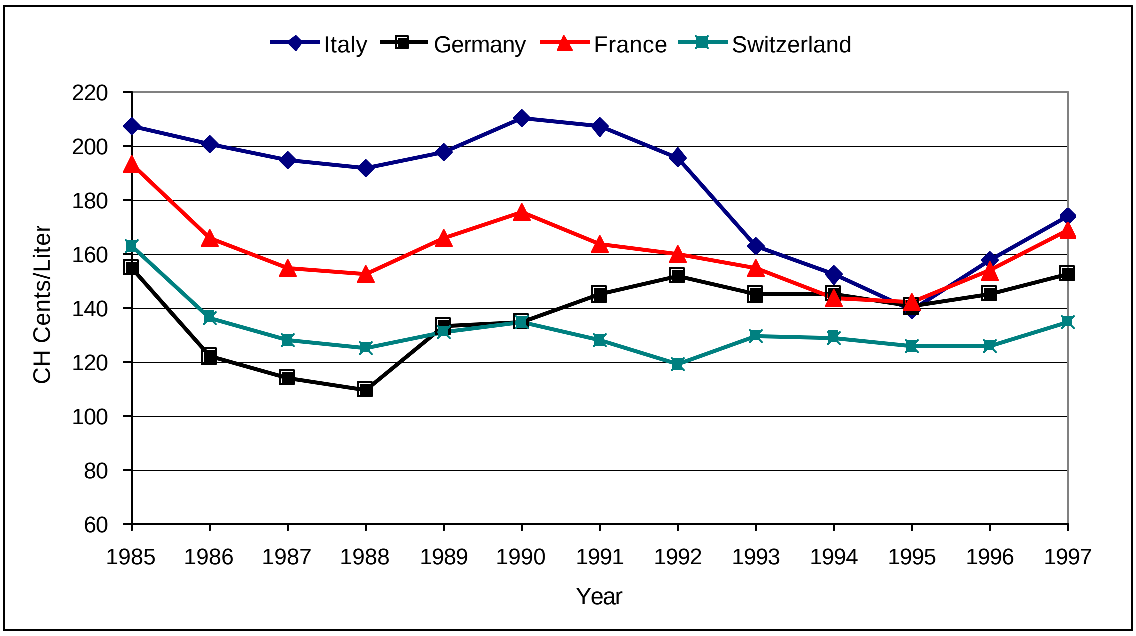

Fig. 3. Development of the price of leaded gasoline (in Swiss Cents/litre) between 1985 and 1997

It can be observed that the price differences between countries for diesel are smaller. Switzerland has, in comparison to its neighbours, the highest prices (excluding the period between 1990 and 1992, when Italy had the highest prices).

Because of the switch of demand from leaded to unleaded gasoline, it was decided to use the data for aggregated gasoline sales. The distinction between unleaded and leaded gasoline sales has been introduced since 1991, therefore it has been decided to use leaded gasoline prices for all countries in order to determine the price differences between countries. Nevertheless, Fig. 4 illustrates the development of different fuel type prices showing quite similar patterns over the sample period. Therefore the leaded price is used to approximate the average relative price of gasoline consumed during the period 1985 - 1997.

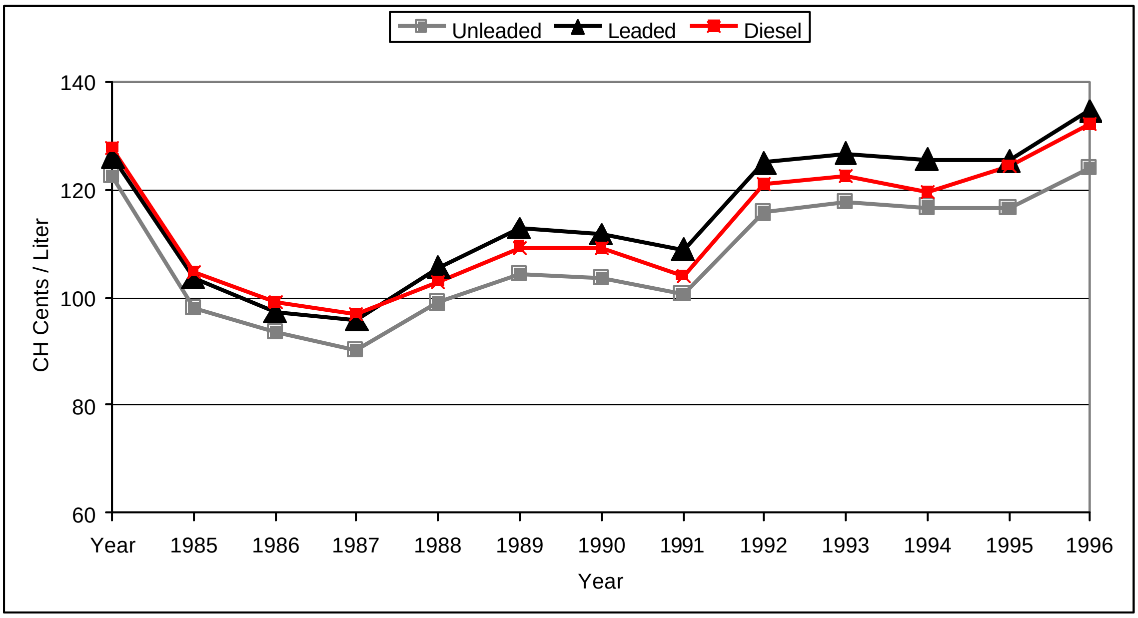

Fig. 4. Development of different gasoline prices in Switzerland (in Swiss Cents/litre)

3.3 Further socio-economic variables

Other variables considered that might help to explain fuel demand in the border regions are national and regional income (regional income available only for the Switzerland), length of the border, number of custom stations and of cross-border commuters. Table 1 gives an overview on the minimum, maximum and median value of the variables used in the model.

Table 1: Description of data

Variable	Measure	Min.	Max.	Median
Gasoline demand				
Border region to Italy	1000 litres/y	34’471	143’721	98’994
Border region to Germany	1000 litres/y	51’131	189’136	155’181
Border region to France	1000 litres/y	78’698	179’062	153’350
Gasoline price				
Switzerland	CHF/l	1.19	1.63	1.29
Italy	CHF/l	1.39	2.10	1.94
Germany	CHF/l	1.10	1.55	1.45
France	CHF/l	1.42	1.93	1.60
Swiss regional income				
Border regional to Italy	CHF/y	35’935	41’557	40’275
Border regional to Germany	CHF/y	47’473	55’504	52’568
Border regional to France	CHF/y	46’561	54’207	49’945
Foreign income				
Italian regional income	CHF/y	17’798	37’541	27’942
German regional income	CHF/y	25’867	41’055	34’774
French regional income	CHF/y	22’246	33’267	28’912
Commuters				
From Italy	Persons/y	18’876	44’476	38’486
From Germany	Persons/y	18’876	37’493	31’469
From France	Persons/y	49’526	84’557	74’005
Regional population				
Switzerland - Italy	Persons	9’118’425	9’279’388	9’173’330
Switzerland - Germany	Persons	22’489’075	24’906’736	23’795’115
Switzerland - France	Persons	7’352’878	7’949’127	7’709’970

4 Model

The household demand for gasoline is generally explained using the basic framework of household production theory.[2] It is assumed that the household combines purchased market goods and its time to produce the commodity providing the utility:

$$U = U(S(G, C, T), X; D, R) \tag{1}$$

where S is the transport service, G is gasoline, C is the capital stock (car), T is time, X is a purchased composite numeraire good that directly yields a utility while D and R represent demographic and geographic/regional characteristics which determine the household's preferences. The production function assumes a time period during which the household's automobile stock is not affected by the price of gasoline.

In this framework the household's decision can be thought of as a two-stage optimisation problem (see Deaton and Muellbauer 1980). In the first stage, the consumer minimizes the costs of producing S, whereas in the second stage of the optimisation problem, the household maximizes its utility. As a result, the derived demand for gasoline can be obtained as:

$$G = G(P, I, C, D, R) \tag{2}$$

and depends on the gasoline price (P), household's income (I), the car availability (C), and the demographic (D) and spatial (R) characteristics of the household. Assuming a constant stock of vehicles, a gasoline price increase affects only the mileage of households. Of course, in a longer run, an increase in gasoline prices affects the choice of the type of car providing an incentive to buy more fuel-efficient vehicles.

In this study we are interested in analysing household aggregate gasoline demand in three border areas of Switzerland. Therefore, households living in these border areas are confronted with the gasoline price in Switzerland and the price in the neighbouring country. Moreover, the aggregate gasoline demand in these regions should be influenced by the following factors: income in Switzerland, income abroad, population and daily commuters[3].

Unfortunately, we do not have data on total gasoline sales in these border regions but only the data of the three main companies (ESSO, BP and Shell). However, assuming that these three companies are representative of the gasoline sales (in terms of sale volumes and location of gasoline stations), we are able to estimate the aggregate gasoline demand for the border regions. In principle, we are assuming that the market shares of these companies on total gasoline sales are constant over time. Because gasoline can be considered a homogeneous product (in terms of quality and price), households should not have a preference in buying this good in a specific gasoline station or in another one. For this reason market shares are assumed to be constant over the sample period.

As stated above, we are not interested in the absolute level of aggregate gasoline demand, but on the changes of demand due to changes in the price differential between the countries. Therefore, assuming that the development of gasoline sales of the three companies in our sample is representative, we can estimate the impact of the price changes on demand. The

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[2] For a clear presentation of the household production theory, see Becker (1965), Muth (1966) and Deaton and Muellbauer (1980). See Lin *et al*. (1985) for an application of household production theory on gasoline demand.

[3] Daily commuters travel every day to Switzerland for working purposes.

empirical model for households' aggregate gasoline demand, based on equation (2), can be specified as follows:

$$G_{it} = G\left(\left(\frac{P_{GCH}}{P_{GAbr}}\right)_{it}, I_{CHit}, I_{Abrit}, Pop_{it}, Comm_{it} \right) \qquad (3)$$

where

i = border region,

t = year (1985 – 1997),

G_{it} = gasoline demand in the Swiss border area *i* in year *t* (5 km from the border to Italy, Germany and France) approximated by the gasoline sales of the three main companies SHELL, BP, ESSO.

$\left(\frac{P_{GCH}}{P_{GAbr}}\right)_{it}$ = Relationship between the gasoline price in Switzerland and the border region *i* in year *t*,

I_{CHit} = Income in the Swiss border region *i* in year *t*,

I_{Abrit} = Income of the neighbouring countries in the border areas *i* in year *t*,

Pop_{it} = Total population living in the border area *i* in year *t* (population in the Swiss border region and abroad),

$Comm_{it}$ = Foreign persons coming to Switzerland every day to work (daily commuters).

It is expected, that a decrease in the ratio of the Swiss gasoline price to the foreign gasoline price will lead to an increase in the demand for gasoline in the border regions. Similarly, an increase in the income is expected to have a positive impact on gasoline demand. It is expected that population growth will have a positive effect on the demand for transport services and hence an increase in overall gasoline demand. In addition, it is likely that commuters have an important positive role in explaining the level of gasoline demand in border regions, since they regularly travel to work in Switzerland and can therefore choose the gasoline station in the country with the lowest prices without incurring additional opportunity costs. It is likely that during the observation period (1985-1997) commuters will have chosen to fill their cars in Switzerland, since the Swiss price was lower than the price in the neighbouring countries.[4]

Estimation of demand function (3) requires the specification of a functional form. The popular log-log form used in many energy demand studies is chosen, giving constant estimates of the required price and income elasticities. Therefore the equation to be estimated is:

$$\ln G_{it} = a_0 + a_1 \ln\left(\frac{P_{GCH}}{P_{GAbr}}\right)_{it} + a_2 \ln(I_{CH})_{it} + a_3 \ln(I_{Abr})_{it} + a_4 \ln(Pop)_{it} + a_5 \ln(Comm)_{it} + m_{it} \qquad (4)$$

[4] With exception of four years, were the German gasoline price was lower than the Swiss one.

5 Results

A panel data set characterized by a relatively small number of cross-sectional units and a relatively long time period is used to estimate equation (4). Therefore traditional panel data estimation approaches (fixed and random effects models) are not appropriate. For this reason, the estimation of equation (4) was carried out using a GLS estimation procedure for pooled time-series and cross-sectional data suggested by Kmenta (1986) and Greene (2003).[5]

For comparison purposes, we estimated the model with two different assumptions on the distribution and process of the disturbances[6]:

1. the first model assumes homoskedasticity and nonautocorrelated disturbances. The coefficients corresponds to those of OLS estimation,

2. the second model corrects for group specific autocorrelation, this implies that the model allows for different AR(1) for each region.

The model is not corrected for heteroskedasticity since the Lagrange Multiplier and Likelihood Ratio statistics did not reject the hypothesis of homoskedastic disturbances. Since the results of the Wald statistic were less clear, a White's general heteroskedasticity test was conducted, which suggested that the disturbances are not heteroskedastic at the 1% significance level.[7]

The results of the estimated equations are presented in Table 2.[8]

[5] For a general presentation of this econometric procedure see Greene (2003). The estimation has been performed using the econometric software "Limdep version 8".

[6] The estimation of a model corrected for common autocorrelation are omitted since the results do not vary significantly from those of the model with group specific autocorrelation.

[7] To use the White test, we regressed the squared OLS residual on a constant, the variable, the variable squared and the cross-products of the variables. The R2 in this regression was 0.7, the chi-squared statistic was 30.03. The 1% critical value is 34.81 (with 18 degrees of freedom).

[8] In preliminary modelling dummy variables for the border regions were included. However, given their poor fit the results are not presented here.

Table 2: Estimation of equation (4), dependent variable: G (gasoline demand in the border region)

Variable	**Model 1** Homoskedastic regression and nonautocorrelated disturbances [a)]	**Model 2** Model with correction for group specific autocorrelation[b)]
Constant	-17.799*** (-7.103)	-18.659*** (-5.898)
$\ln(\frac{P_{GCH}}{P_{GAbr}})$	-0.766*** (2.857)	-0.672* (2.090)
$\ln(I_{CH})$	1.112* (2.070)	1.123 (1.745)
$\ln(I_{Abr})$	0.949*** (5.532)	0.985*** (4.211)
$\ln(Pop_{Tot})$	0.164 (0.975)	0.166 (0.839)
$\ln(Comm)$	0.465** (2.286)	0.496* (2.114)
Log-Likelihood function	20.66	22.94
No. of obs.	39	39
Pooled OLS residual variance (SS/nT)	0.0203	0.0179

t-statistics are in parenthesis

***, ** and *: coefficients are significantly different from zero at the 99%, 97% and 95% confidence levels respectively.

a) Adjusted R-squared: 0.83

b) Individual autocorrelation coefficients: 0.423, 0.195, 0.413.

The coefficient of the price ratio, in both models is negative and significant and varies between 0.67 and 0.77. This suggests that a decrease of the price ratio by 10% would increase the gasoline demand in the Swiss border regions by approximately 6.7 to 7.7%. The income variables have all the expected signs. The coefficients for the foreign income are highly significant and show a (surprising) high level, whereas the coefficient for the Swiss income is significant at the 5% confidence level only in the model without correction for autocorrelation. The coefficient for the population is not significant in any of the models. Finally, as expected the variable for commuters seems to explain some of the fluctuations in gasoline demand in border regions - suggesting that an increase of 10% in the number of daily commuters to Switzerland increases the demand for gasoline in the border regions by approximately 5%.

A comparison of the coefficients resulting from the different estimations shows that the differences are only small, the results can be therefore considered to be quite robust with respect to the econometric approach.

Based on model 2 in Table 2, it is possible to make a first simple approximation of the share of fuel tourism on the overall gasoline demand in the border regions. For this purpose the ratio of the Swiss gasoline price to the price abroad is set equal to 1 and then, using the other explanatory variables included in the model 2, the 'predicted' gasoline demand for each year and border region is calculated. These 'predictions', which reflect the gasoline demand that would have existed without a gasoline price differential between the four countries, are compared with the actual gasoline demand data. The differences between the 'predicted' and actual values give an approximation of the effect of the phenomenon of cross-border fuel tourism and are illustrated in Fig. 5.

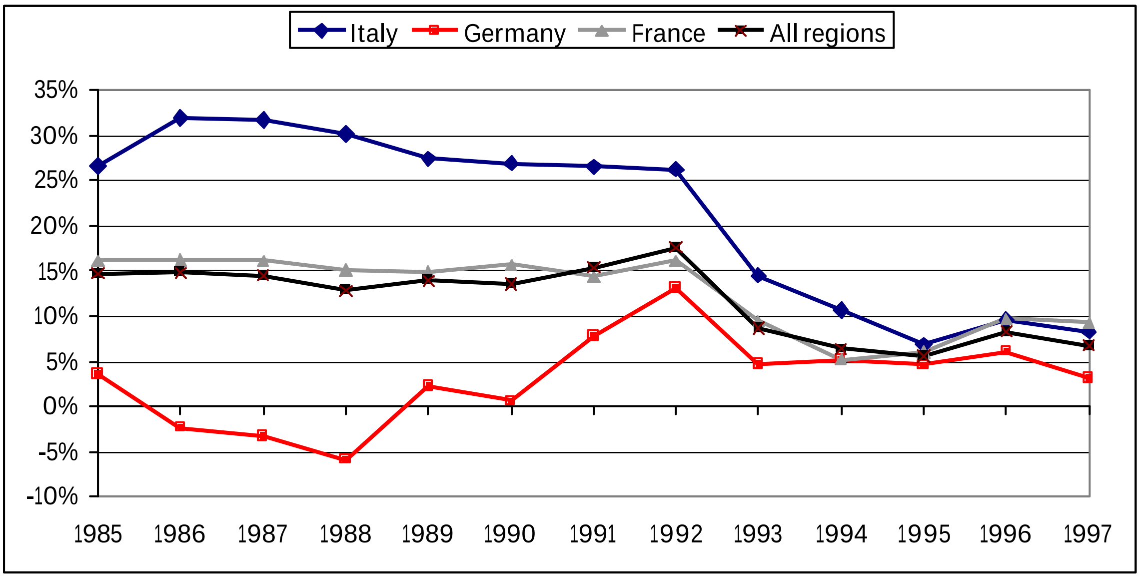

Fig. 5. Simulation of fuel tourism in percent of total gasoline demand in the border regions between 1985 and 1997

Fig. 5 illustrates the development of fuel tourism in the Swiss border regions (this is an area of 5 km from to border). Until 1992, according to our estimates fuel tourism accounted for approximately 15% of overall gasoline demand in these regions. Since 1992, its importance decreased to around 7% of the overall regional demand. Within this there is some variation between the different regions. In the area near to Italy, until 1992, more than 25 % of gasoline sales accounted for people coming from abroad. In the same period, the fuel tourism in the border region to Germany was very small and in fact negative between 1986 and 1988, when the Swiss gasoline price exceeded the German price. Cross-border fuelling in the border region to France seemed to be very similar to the Swiss average. Finally, it is worth noting that since 1993, the difference between the regions has become less important because of the smaller differences in gasoline prices; the overall share of people benefiting from cross-border arbitrage is diminishing.

Generally, the results suggest that price differentials of homogeneous goods, like gasoline, does induce important cross-border movements. Consequently, these revenue sources cannot be considered very stable, since they depend mostly on the foreign fiscal policies.

6 Summary and Conclusion

This paper explores the issue of 'Fuel Tourism' in Switzerland. Using a panel data set for the three regions of Switzerland bordering Italy, Germany, and France, over the period 1985–1997 it is shown that there is a significant impact of the gasoline price differential on fuel demand. The estimated price elasticity suggests that a decrease of 10% in the ratio of the Swiss gasoline price to the price in the bordering country will lead to a reduction in demand of between 6.7 to 7.7%. Moreover, the estimated equation is utilised to simulate the effect of fuel tourism; the simulations indicate that from 1985 to 1992 fuel tourism accounted for about 15% of overall gasoline sales in the three regions, falling to about 7% from 1992 to 1997.

From an energy policy perspective, the results presented in this paper imply that, as long as the gasoline price differentials persist, the scope for gasoline tax increases in the bordering regions are extremely limited. For example, a policy aimed at discouraging residential gasoline consumption (say for environmental reasons) by raising taxes is unlikely to be successful. Whereas, policies to counter the negative side-effects of fuel tourism, like those introduced in Italy and in other countries, appear to be reasonably successful in avoiding a loss of taxes as well as losses for owners of gas stations in the border region with higher taxes. In Switzerland, this implies that there might be a need to restructure the fuel-selling sector in border regions.

References

Becker, G.S., (1965), A Theory of the Allocation of Time, *Economic Journal*, Vol. 75, pp. 493-517.

Coats, R. M., (1995), A note on estimating cross-border effects of state cigarette taxes, *National Tax Journal*, Vol. 48, No. 4, December, pp. 573-584.

Deaton, A., Muellbauer, J., (1980), *Economics and Consumer Behaviour*, Cambridge University Press, Cambridge, UK.

Di Matteo, L., Di Matteo, R., (1996), An Analysis of Canadian Cross-Border Travel, *Annals of Tourism Research*, Vol. 23, No. 1, pp. 103-122.

Garrett, T. A., Marsh, T. L., (2002), The revenue impacts of cross-border lottery shopping in the presence of spatial autocorrelation, *Regional Science and Urban Economics*, Vol. 32, pp. 501-519.

Greene, W. H., (2003), *Econometric Analysis*, Prentice Hall, New Jersey.

Kmenta, J., (1986), *Elements of Econometrics*, Macmillian Publishing Company, New York.

Lilley III, W., De Franco, L. J., (1996), *Impact of Retail Taxes on the Illinois-Indiana Border*, paper presented at the workshop "Designing State-Local Fiscal Policy for Growth and Development", Federal Reserve Bank, Chicago.

Lin, A.-I., Botsas, E. N., Monroe, S. A., (1985), State gasoline consumption in the USA – An econometric analysis, *Energy Economics*, Vol. 7, No. 1, January, pp. 29-36.

Merrifield, D. E., Storer, P., (1999), *Cross-Border Shopping and Economics Activity in Whatcom County, Washington: Gasoline Service Stations 1988-98*, paper presented at the Pacific Northwest Regional Economic Conference, Boise Idaho, April 1999.

Muth, R.F., (1966), Household production and consumer demand functions, *Econometrica*, Vol. 34, pp. 699-709.

Rietveld, P., Bruinsma, F.R., van Vuuren, D.J., (2001), Spatial graduation of fuel taxes; consequences for cross-border and domestic fuelling, *Transportation Research Part A* 35, pp. 433-457.