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Cross-border commuting and consuming: an empirical investigation

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CROSS-BORDER COMMUTING AND CONSUMING AN EMPIRICAL INVESTIGATION

Thomas Y. Mathä, Alessandro Porgiglia
and Michael Ziegelmeyer

**HOUSEHOLD FINANCE AND
CONSUMPTION NETWORK**

NOTE: This Working Paper should not be reported as representing the views of the European Central Bank (ECB). The views expressed are those of the authors and do not necessarily reflect those of the ECB.

Household Finance and Consumption Network

This paper contains research conducted within the Household Finance and Consumption Network (HFCN). The HFCN consists of survey specialists, statisticians and economists from the ECB, the national central banks of the Eurosystem and a number of national statistical institutes.

The HFCN is chaired by Gabriel Fagan (ECB) and Carlos Sánchez Muñoz (ECB). Michael Haliassos (Goethe University Frankfurt), Tullio Jappelli (University of Naples Federico II), Arthur Kennickell (Federal Reserve Board) and Peter Tufano (University of Oxford) act as external consultants, and Sébastien Pérez Duarte (ECB) and Jiri Slacalek (ECB) as Secretaries.

The HFCN collects household-level data on households' finances and consumption in the euro area through a harmonised survey. The HFCN aims at studying in depth the micro-level structural information on euro area households' assets and liabilities. The objectives of the network are:

- 1) understanding economic behaviour of individual households, developments in aggregate variables and the interactions between the two;
- 2) evaluating the impact of shocks, policies and institutional changes on household portfolios and other variables;
- 3) understanding the implications of heterogeneity for aggregate variables;
- 4) estimating choices of different households and their reaction to economic shocks;
- 5) building and calibrating realistic economic models incorporating heterogeneous agents;
- 6) gaining insights into issues such as monetary policy transmission and financial stability.

The refereeing process of this paper has been co-ordinated by a team composed of Gabriel Fagan (ECB), Pirmin Fessler (Oesterreichische Nationalbank), Michalis Haliassos (Goethe University Frankfurt), Tullio Jappelli (University of Naples Federico II), Sébastien Pérez Duarte (ECB), Jiri Slacalek (ECB), Federica Teppa (De Nederlandsche Bank), Peter Tufano (Oxford University) and Philip Vermeulen (ECB).

The paper is released in order to make the results of HFCN research generally available, in preliminary form, to encourage comments and suggestions prior to final publication. The views expressed in the paper are the author's own and do not necessarily reflect those of the ESCB.

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Abstract:

This paper analyses empirically how cross-border consumption varies across product and services categories and across household characteristics. It focuses on the part of cross-border sales that arise due to work-related cross-border crossings; it analyses the cross-border consumption behaviour of cross-border commuter households residing in Belgium, France and Germany and working in Luxembourg. In total, it is estimated that these households spend €925 million per annum in Luxembourg, reflecting about 17% of their gross annual income from Luxembourg and contributing about 10% to total household final consumption expenditure in Luxembourg. Cross-border consumption expenditure is shown to depend on individual and household characteristics, such as total household income, the number of cross-border commuters in the household, distance between home and work, as well as price level (index) differences between Luxembourg and its neighbouring countries. Cross-border commuters take advantage of existing arbitrage opportunities.

Keywords: cross-border shopping, commuting, consumption, expenditure, households
JEL Codes: F15, R12, R23, J61

Non-technical summary

In the economic literature, cross-border shopping is predominantly analysed in the fiscal or tax induced context, where tax and excise duty differences translate into consumer price differences. As a result, cross-border shopping arises so as to exploit these price differences across jurisdictions. This paper adds to the literature and presents results on aggregate and product-related consumption. In contrast to much of the existing economic literature, it focuses on the part of cross-border sales that arise due to cross-border crossings for work purposes. This setting implies that the time- and transport-cost-related trade-off with price savings from cross-border purchases is (quasi-)controlled for. Analysing cross-border commuting households takes care of other obstacles related to cross-border shopping, such as language barriers, insecurity regarding consumer rights and informational asymmetries.

For the purpose of this study, we use data from a representative household survey among cross-border commuters residing in Belgium, France and Germany and working in Luxembourg. The survey asks households about their consumption behaviour for various product and services categories, spanning from fuel, alcohol and tobacco products to eating in and outside home, clothes shopping to car purchases or furniture. This allows us to provide quantifications for both specific categories as well as aggregate cross-border consumption, and to link them to the respective corresponding category for household final consumption expenditures (HFCE) in the national accounts. Second, we are able to relate the cross-border consumption to household characteristics, such as their economic and financial situation, for which to date little to nothing is known.

The cross-border consumption is shown to be related to various household characteristics. In general, cross-border consumption tends to be negatively related to the distance between home and work, with the coefficient estimate being much smaller than usual (this being likely to be related to the sampled population consisting of cross-border commuter households instead of cross-border resident households) and positively related to household income and the number of cross-border commuters per household. Furthermore, cross-border commuter households' consumption expenditure is related to price level index (PLI) differences across the neighbouring countries. This is in particular the case with regard to *tradables* and *durables*, such as *food* and *non-alcoholic beverages*, *alcohol*, *tobacco*, *clothing*, *furnishing* and *household equipment*. For services, the expenditures of cross-border commuter households are not systematically related to price level differences, which may also be linked to their limited cross-country substitutability with respect to consumption.

Our results also show that cross-border commuter (households) contribute significantly to the Luxembourg economy. In 2010, they spent on average about €9,300 in the Grand-Duchy, representing about 17% of their gross income from Luxembourg, thereby contributing about 10% (6%) to the household final consumption expenditure (HFCE) in Luxembourg excluding (including) *housing*, *water*, *electricity*, *gas* and *other fuels*, which roughly accounts for about 24% of total HFCE, and to which cross-border commuter households per definition quasi do not contribute. The highest expenditure categories *fuel*, *food* and

non-alcoholic beverages and *catering services* contribute 21%, 11% and 10% to the final total consumption expenditure for the respective category in the Luxembourg National Accounts for 2010.

As cross-border commuters are very important for the Luxembourg economy in employment terms (in 2011, they represented about 44% of Luxembourg's domestic employment), it is evident that at the aggregate level our consumption estimates represent an upper bound to these effects in an international setting. At individual household level, however, there is no reason to suspect that the behavioural relationship with consumption would not be broadly applicable across countries where cross-border commuting flows take place.

1 Introduction and motivation

Many of Europe's regions are international border regions, i.e. they border with regions from other countries, and many Europeans do not live far from such a border. Due to different institutional and regulatory environments, price and wage discontinuities arise at these international borders, giving rise to arbitrage opportunities, which are consequently exploited by workers and consumers (of border regions) alike. These international wage and price differences are well documented; it is equally well documented that, in cross-border regions in particular, this leads to cross-border economic activity, be it cross-border shopping, commuting or migration or all of them combined. For both types of cross-border economic activity the fundamental driving forces are existing differences in prices and wages.

The literature of regional commuting and cross-border commuting has identified pull and push factors such as wage differences, unemployment differences between regions, as well commuting obstacles such distance, travel time, the quality of public infrastructure, and language differences. Due to increased economic integration in the EU and improved public infrastructure, cross-border commuting has markedly increased over the years (e.g. MKW and Empirica, 2009). The literature on both regional and cross-border commuting behaviour and their determinants supports that wage differences are a major explanatory factor for the observed commuting flows (e.g. Cameron and Muellbauer, 1998; Marvakov and Mathä, 2009; Mathä and Winttr, 2009). The economically most important cross-border region in Europe is the Grande-Region, covering 5 regions (Saar, Lorraine, Luxembourg, Rhineland-Palatinate and Wallonie) at the intersection between France, Germany, Luxembourg and Belgium, which makes it a prime candidate for a detailed case study with the possibility of generalisation. Out of the estimated 750,000 cross-border commuters in the EU15/EEA/EFTA counties, 200,000 cross-borders within the Grande-Region make it, in numbers, the most important cross-border commuter region in Europe (MKW, Empirica, 2009).

Cross-border shopping has been analysed in various contexts. Cross-borders shopping is for example analysed in the tourism, marketing and retail literature examining and identifying demographic and socio-psychological factors. Timothy and Butler (1995) analyse the cross-border shopping between Canada and the U.S. within the tourism literature and conclude that it is as much a leisure activity as it is an economic one. Guo et al. (2006) report Hispanic consumers shopping in the U.S. to be motivated by product and services quality, fashion consciousness and fashion shopping. The most prominent context is however the fiscal or tax induced context, where tax and excise duty differences translate in consumer price differences and cross-border shopping arises as to exploit of those across jurisdictions. Thus cross-border shopping is seen in the context of the regional and international economics literature, the law of one price and arbitrage of consumers.

One strand of the literature looks upon cross-border shopping from a (optimal) tax revenue perspective. In the literature on international tax competition, optimal taxation is complicated by the fact that that cross-border shopping arises endogenously as reaction to tax differences. Theoretical approaches have emphasised the role of country size differences between economies and views cross-border shopping traditionally with focus on tax differences across countries (regions) and tax competition between them. A rather robust results of this literature in light of cross-border shopping is that smaller countries have an incentive to set lower taxes than larger countries; by attracting cross-border shoppers, the smaller country is effectively able to tap into the tax base of the larger country (e.g. Kanbur and Keen, 1993; Ohsawa, 1999 and Nielsen, 2001 among others).¹ Egger, Pfaffermayr and Winner (2005a,b) show for example in two separates studies, one using gasoline, beer, wine and tobacco prices across U.S. states and the second using average effective tax rates on consumption for 22 OECD countries, that indeed tax rates tend to vary inversely with the size of jurisdictions. In particular, i) countries set lower tax rates, if their neighbouring countries do, ii) smaller countries tend to set lower tax rates, and iii) countries with smaller neighbours do so too.

A different strand of the literature looks at cross-border shopping in terms of market segmentation and cross-border arbitrage possibilities and analyses the determinants of cross-border shopping flows. The approach typically taken in the empirical cross-border shopping literature is to estimate a demand function, where cross-border sales are regressed upon prices, taxes, income, transport costs and some other destination and origin specific controls, bearing resemblance to a gravity type approach. Prominent products under investigation are those with fiscally induced price differences, i.e. products with excise duties, which typically vary greatly between countries or jurisdictions (e.g. Banfi, Filippini and Hunt, 2005 for fuel, Asplund, Friberg and Wilander, 2007 for alcohol, and Thursby, Jensen and Thursby, 1991 for cigarettes). Not surprisingly, empirical studies show overwhelming support for consumers exploiting existing price differences and shopping across borders. Yet, as for example argued by Asplund, Friberg and Wilander (2007, p. 142) it seems that despite a relatively sizeable literature for particular products little is known about the general extent of cross-border shopping.

This paper adds to the above literature and presents aggregate and product related consumption estimates of cross-border commuter households based on a representative survey. Our approach, thus, differs in important aspects to the approach typically taken in the cross-border shopping literature, which is to estimate some kind of (inverse) demand function, relating aggregate cross-border sales of specific products to aggregate region- or country-specific characteristics, such as different prices, taxes, income, distance and other controls (e.g. Asplund, Friberg and Wilander, 2007). Also, it is not concerned with cross-border sales due to tourism, where people's border-crossing sole or main purpose is to take advantage of existing arbitrage opportunities.

¹ See also Keen (2002) and Leal, López-Laborda, Rodrigo (2010) for a survey of the literature.

This paper focuses on the part of cross-border sales that arise quasi naturally by people who cross the border for work purposes; it analyses the cross-border consumption (shopping) behaviour of cross-border commuter households. While still small in absolute numbers, cross-border commuting is on the rise in Europe, and in some border regions it gives rise to a lot of cross-border economic activity. Thus, by focusing on cross-border commuter households, we analyse a hitherto somewhat neglected economic group, which offers several advantages: In contrast to cross-border shopping due to tourism or transit, which has been the focus of much of existing literature, the time and transport cost related trade-off with price savings associated with cross-border purchases is (quasi-)controlled for in this setting. This extends to other obstacles to cross-border shopping, such as language barriers, insecurity regarding consumer rights and informational asymmetries that exist but for the lack of appropriate controls are very difficult to take into consideration and therefore plague making inferences.

For the purpose of this study, we use data from a representative household survey among cross-border commuters residing in Belgium, France and Germany and working in Luxembourg. Cross-border commuters are immensely important for the Luxembourg economy; in 2011, they represented about 44% of the Luxembourg's domestic employment (Statec, 2012b). Due to this importance it is likely that at aggregate level our estimates represent an upper bound to the effects of this activity in an international setting. At individual household level, however, there is no reason to suspect that the behavioural relationships with consumption would not be broadly applicable across countries where cross-border commuting flows take place.

Luxembourg is mentioned more or less *en passant* in various empirical studies on cross-border shopping, may it relate to fuel tourism or cross-border cigarettes sales (e.g. Rietveld Bruinsma and Van Vuuren, 2001; Cnossen, 2006). Yet, with the exception of a couple of studies by the Luxembourg statistical office STATEC (Allegrezza et al., 2005; Genevois and Zanardelli, 2008), relatively little is known about the magnitude of cross-border shopping in Luxembourg and its economic and fiscal importance. This paper aims to fill some of those gaps. Luxembourg may serve as a good case in point, since it is geographically located very centrally in (Western) Europe, is very small in size and has borders with three much larger economies. It is the destination of the second highest number of in-commuters in Europe, which indicates a substantial extent of cross-border economic activity. The cross-border commuters in the sample originate from the neighbouring countries (regions) Belgium (Wallonie), France (Lorraine) and Germany (Saar and Rhineland-Palatinate) to Luxembourg. Thus, the present paper comprises both international and regional dimensions. Urban and metropolitan elements are present in that most cross-border commuters live in very narrow rim in close proximity to the Luxembourg border. The mean and median travel distance is between 40–50 kilometres from home to work. Taken together, the Luxembourg labour market is a regional labour market that spans across countries, with about 44% of total employment in Luxembourg stemming from the inflow of cross-border commuters.

First, this paper explores how cross-border consumption varies across product and services categories and across household characteristics. The survey asks households about their consumption behaviour for various product and services categories, spanning from fuel, alcohol and tobacco products to eating in and outside home, clothes shopping to car purchases or furniture. This allows us to provide quantifications for both specific categories as well as aggregate cross-border consumption and to link them to the respective corresponding category for household final consumption expenditures (HFCE) in the national accounts. Second, we are able to relate the cross-border consumption to household characteristics, such as their economic and financial situation, for which to date little to nothing is known. The survey provides information on the complete household member matrix and educational attainment, age, marital status, household size, employment status (working hours, work contract type, years of work abroad), household income abroad and in the country of residence, asset and liability structure of the household, distance to the border, travel mode to work, etc... The richness of the survey provides an unprecedented opportunity for an in-depth analysis of how cross-border consumption varies across household characteristics. For the lack of data availability, the latter presents a novelty in the cross-border shopping literature.

Our results show firstly that cross-border commuter (households) contribute significantly to the Luxembourg economy. On average, they spent about €9,300 in the Grand-Duchy in 2010, representing about 17% of their gross income from Luxembourg, thereby contributing about 10% (6%) to the household final consumption expenditure (HFCE) in Luxembourg excluding (including) *Housing, water, electricity, gas and other fuels*, which roughly accounts for about 24% of total HFCE, and to which cross-border commuter households per definition quasi do not contribute. The highest expenditure categories *fuel, food and non-alcoholic beverages* and *catering services* contribute 21%, 11% and 10% to the final total consumption expenditure for the respective category in the Luxembourg National Accounts for 2010. The cross-border consumption is shown to be related to various household characteristics. In general, cross-border consumption tends to be negatively related to the distance between home and work, with the coefficient estimate being much smaller than usual (this being likely to be related to the sampling population consisting of cross-border commuter households instead of cross-border resident households) and positively related to household income, the number of cross-border commuters per household and to price level index (PLI) differences. Other individual and household specific characteristic contribute significantly to various expenditure items, but in a rather sporadic fashion, not allowing drawing conclusions of general validity. For example, tobacco expenditures tend to decrease with increasing income and educational attainment, which may make sense from a sociological point of view, but runs counter to results for consumption expenditure of other product categories.

Section 2 briefly presents the survey, the data and main sample characteristics. Section 3 discusses their consumption pattern. Section 4 provides the various estimates of cross-border consumption and their covariates. Section 5 concludes.

2 Cross-border shopping in the literature

International literature

Cross-border shopping behaviour has been analysed in a number of countries, most prominently the U.S. Walsh and Jones (1988) for example focus on sales of taxed products in West Virginia (USA) and report that, for counties of West Virginia sharing a common border with a neighbouring state, a 1% reduction in sales taxes results in about 1% reduction in the after-tax sales price, increasing grocery store sales by about 5.9%, thereby confirming that sales tax differentials between states lead consumers to exploit lower after tax prices in low tax states and to shop across state boundaries. Di Matteo and Di Matteo (1996) examine the determinants of Canadian cross-border shopping, which rose tremendously between 1986-1991, by using data on same day automobile trips and expenditures from 7 Canadian provinces bordering the U.S. They report that 90% of the variation is due to income, exchange rate, gasoline price differences, the Goods and Services Tax plus seasonal factors.

The vast majority of studies, however, focus on fiscally induced price differences across state and provincial borders of very specific products, most notably excise products, such as fuel, alcohol and tobacco (see Keen 2002 or Leal, López-Laborda and Rodrigo, 2009 for a review). Manuszak and Moul (2009) analyse for example the retail gasoline activity in Southeast Chicagoland and report a sharp discontinuity in activity across regions that coincides with the political boundary and a decline in activity in the high tax region as the low tax border is approached. Stehr (2007) analyses the effect of Sunday sales bans on spirits and tax variation across U.S. states and reports that about 80% and 20% of increases in spirit sales following the repeal of Sunday sales ban are due to own-state drinking and cross-border shopping, respectively. In particular, cross-border shopping of tobacco has been analysed extensively in the U.S. in the context of casual smuggling across state and province borders and to the concern of fiscal authorities. Examples of this research are Coats (1995), Thursby, Jensen and Thursby (1991), Thursby and Thursby (2000), Chiou and Muehlegger (2008) or Lovenheim (2008). The latter for example reports 13-25% of cigarettes to be purchased in a lower-price state or Native American Reservation. According to Leal et al. (2009), a robust result in these types of studies is that 2% to 6% of cigarettes consumed in the U.S. are smuggled.

Similarly in Europe, most studies concentrate on fuel, alcohol and tobacco, and thus on products subject to excise duties. Cross-border shopping of fuel is a rather common phenomenon where borders meet and has consequently been studied for a number of European countries. For Irish counties bordering Northern Ireland, Fitzgerald et al. (1988) report consumers purchasing 2/3 thirds of their petrol and almost all alcohol north of the border, accounting for about 1/10th of their total expenditure and resulting in an estimated inland revenue loss of about 5% of all commodity taxes. Thus not surprisingly, good knowledge about factors and magnitudes are of interest of fiscal and tax authorities aiming to assess losses or gains due to cross-border shopping. For example, in a report to the Irish exchequer, the value of cross-border shopping between Ireland and Northern Ireland

was estimated to be €350-550 million in 2008, with an estimated resulting VAT and excise duty revenue loss of €58-90 million plus an additional possible corporation tax revenue loss of €15-24 million (Office of the Revenue Commissioners and the Central Statistics Office, 2009).

For Spain, recent studies have exploited regional variations in the Hydrocarbon Retail Sales Tax (HRST). Leal, López-Laborda and Rodrigo (2009) show fuel purchases of diesel fuel in Aragon to be sensitive to price differences to adjacent regions. Similarly, Romero-Jordána, García-Inés and Álvarez García (2013) demonstrate the impact of the diesel price differences at the border of two Spanish provinces (Lugo with and Leon without HRST). They report less intensive variations in diesel prices at the border of Lugo and point toward service stations in regions with higher excise duties using price policy to alleviate the negative effects from fuel tourism. Banfi, Filippini and Hunt (2005) provide empirical evidence on fuel price differences and on cross-border refuelling for three Swiss regions bordering France, Germany and Italy. Using counterfactual simulations, they estimate for the period 1985 to 1997, that on average about 9% of total gasoline sales are due to fuel tourism from these countries. Using survey evidence, Rietveld, Bruinsma and van Vuuren (2001) report for the Netherlands that about 30% of Dutch car owners residing close to the German border would refuel across the border if the price differences were €0.05 per litre.

Recent cross-border studies on alcohol price differences include Asplund, Friberg and Wilander (2007) who analyse per capita sales of alcohol (beer, wine and spirits) in Swedish municipalities and their sensitivity to foreign prices and the distance to the border of Denmark and Germany. They report that the distance is important in explaining cross-border arbitrage by consumers. Importantly, they are able to show that this affects not only sales of bordering municipalities but also interior regions. Their estimates suggest that the sales elasticity with respect to the foreign price is 0.3 in border regions, which reduces to 0.2 (0.1) for regions 100 (400) kilometres further inland.

Luxembourg and the Grande-Région

The Grande-Région comprises the regions Luxembourg, Wallonie (Belgium), Lorraine (France), Sarre and Rhineland-Palatinate (both Germany). The Grande-Région is a highly integrated cross-border area in the midst of Europe with high cross-border economic activity, counting more than 200,000 cross-border commuters in total (MKW and Empirica, 2009). Luxembourg is its geographic centre and stands for the lion's share of these cross-border commuters, which is mainly due to its attractive wages (e.g. Mathä and Wintr, 2009). In the last ten years, the number of cross-border commuters increased by 77% and, in 2011, they represented about 44% of the Luxembourg's domestic employment (154,000 of 347,000) (Statec, 2012b). Combined with the high share of foreigners residing and working in Luxembourg (>40%), the Luxembourg economy and labour market is truly international. Almost the total entirety of cross-border commuters arrive in Luxembourg from its three neighbouring countries France (~50%), Belgium (~25%) and Germany (~25%). With a geographical size of 2,586 km² and an estimated total population of slightly more than 0.5

million inhabitants in 2011 (Statec, 2012a) Luxembourg is the second smallest country in both dimensions in the EU. Still, Luxembourg is the country with the second highest number of cross-border in-commuters recorded in the European Economic Area (EEA), second only to Switzerland (see for example MKW and Empirica, 2009).

Despite their huge importance to the Luxembourg labour market, surprising little systematic research on cross-border commuters' economic situation and cross-border shopping behaviour has been undertaken. While plenty of information is available on numbers, country of origin, the employment or the gender distribution of cross-border commuters, mainly stemming from administrative data sources, such as the social register of Luxembourg, the Inspection Générale de la Sécurité Sociale (IGSS), little to nothing is known about the cross-border consumption of cross-border commuter households and in particular how they vary with household characteristics, such as income and wealth. A number of surveys conducted by CEPS/INSTEAD in cooperation with STATEC in 2002, 2003 and 2007 among cross-border commuters provide information on their consumption expenditures in Luxembourg and the types of products they tend to consume (Allegrezza et al., 2005; Genevois and Zanardelli, 2008). According to these surveys, cross-border commuters contribute very substantially to Luxembourg's GDP; in 2007 cross-border commuter households spent an estimated average of €9,076 per year in the Grand Duchy. However, for the lack of adequate data questions concerning income and wealth their relationship with consumption could hitherto not be explored. Our estimates referring to 2010 support these estimates; cross-border commuter households pour on average €9,300 per annum into the Luxembourg economy, representing about 17% of their gross household income from Luxembourg (see also Mathä, Porpiglia and Ziegelmeier, 2012).

Table 1 shows the importance of consumption expenditure of non-residents for the Luxembourg economy. It has increased by 10.5 percentage points in the last 15 years and accounted for 27% of total household final consumption expenditure in 2010.

Table 1: Final household consumption expenditure (current prices)

	1995	2000	2005	2010	2011
On Luxembourg territory, total	7,195	10,249	12,583	14,926	15,899
By Luxembourg residents, abroad	350	477	899	971	993
By non-resident households, on Luxembourg territory	1,181	2,059	3,233	3,856	4,284
By Luxembourg residents, on Luxembourg territory and abroad	6,364	8,667	10,248	12,041	12,608

Source: Statec (2012) National Accounts. http://www.statistiques.public.lu/stat/TableViewer/tableView.aspx?ReportId=1440&IF_Language=eng&MainTheme=5&FldrName=2&RFPPath=22

Table 2 shows various price level indices (PLIs) from the Eurostat-OECD Purchasing Power Parity programme, corresponding to the final expenditure classification in the European Standard of Accounts (ESA95). It illustrates a rather well known fact; Luxembourg tends to have lower *fuel*, *tobacco* and to a lesser extent *alcohol* prices than neighbouring countries, whereas the general price level is more elevated. We will analyse in the multivariate analysis whether these price level index differences affect cross-border commuter

households' consumption expenditures for specific product categories. For example, is the consumption expenditure of Belgian cross-border commuters on *alcohol* larger than French or German cross-border commuters' expenditure, all else equal, as might be expected from the price level indices in Table 2.

Table 2: Price level indices, 2010

2010	Belgium	France	Germany	Luxembourg
Household final consumption expenditure	111.2	110.7	104.4	122.0
Food & non-alcoholic beverages	114.9	108.9	109.8	115.4
<i>Food</i>	114.9	110.4	110.7	117.0
<i>Non-alcoholic beverages</i>	115.0	95.1	104.1	106.6
Alcohol, Tobacco and narcotics	99.0	109.2	98.8	88.1
<i>Alcoholic beverages</i>	97.7	92.7	88.0	91.9
<i>Tobacco</i>	103.2	130.3	112.4	84.0
Clothing and footwear	114.4	104.6	103.3	105.9
<i>Clothing</i>	115.0	106.5	103.7	104.7
<i>Footwear</i>	111.8	96.6	102.8	108.7
Furnishings, housh. equip. & maintenance	104.8	110.2	98.1	109.2
Health	129.7	115.2	101.9	131.8
Personal transport equipment	100.7	102.3	100.8	95.2
Fuel	101.5	99.3	103.5	85.7
Transport services	98.3	111.5	112.3	112.3
Recreation and culture	102.6	106.6	104.4	108.1
Education	139.5	118.9	101.8	295.5
Restaurants and hotels	112.7	103.0	102.3	106.4
Miscellaneous goods and services	115.7	111.1	101.1	124.4

Source: Price level indices (*prc_ppp_ind*) are taken from the Eurostat-OECD Purchasing Power Parity programme and are expressed relative to EU27=100 (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=prc_ppp_ind&lang=en download from 18 February 2013). Fuel prices refer to consumer prices of petroleum products inclusive of duties and taxes and are taken from the European Commission, Statistics & Markets Observatory Oil Bulletin (downloaded on 18 February 2013 from http://ec.europa.eu/energy/observatory/oil/bulletin_en.htm). Fuel price indices are calculated as averages of weekly prices in 2010 combining both euro super 95 and diesel prices (with equal weights).

Scattered evidence exists for Luxembourg in the literature, in particular with respect to existing differences in price levels and cross-border arbitrage in form of tank refuelling tourism and cross-border shopping of alcohol, tobacco and coffee. Rietveld, Bruinsma and van Vuuren (2001) report that Luxembourg's fiscal competition attracts foreign motorists to generate tax revenues from international sales of fuel in the range of 1–2% of Luxembourg GNP. They argue that the attraction is so strong that freight transporters and coach operators as far away as the Netherlands detour to refuel. Thöne (2006) reports that fuel sales in Luxembourg strongly correlate with price differences to neighbouring countries.² In 2010, tax receipts from mineral fuel amounted to €813 million (Statec, 2012), accounting for 8% of total fiscal revenues (excl. social contributions) and 17% on total tax revenues from production and imports.

² For a detailed case study on cross-border fuel tourism at the Luxembourg-German border (in the commune of Merttert-Wasserbillig) see Naumann (2005).

Furthermore, Thöne (2006) also reports that tobacco prices in Luxembourg are substantially lower than in neighbouring countries, owing much to low excise duties, reduced VAT (12% instead of the regular 15%) and increased tobacco taxes in all neighbouring countries, such that they can be regarded as own motive for tax arbitrage. Accordingly, he regards the tobacco tax as the secret star of Luxembourg taxes. Similarly, Cnossen (2006) shows for example that Luxembourg had the second lowest prices for cigarettes among the EU15 countries, with a retail price €2.88 for the most popular price category of a pack of 20 cigarettes, whereas retail prices in its neighbouring countries were substantially higher in 2006 (Belgium: €3.56; France: €5.00 and Germany: €4.47) and argues that “Luxembourg is a prime example of a major bootlegging country due to the much higher total tax rates on tobacco products in neighbo[u]ring states. If annual consumption per adult in Luxembourg were the same as average consumption in Belgium, France, and Germany, then only 10% of cigarettes bought in the duchy would be consumed there”. Cnossen reports that Luxembourg generates €1,353 of tax revenue per capita, which is about 5 times as high as the average for the EU15. In total, in 2010 tobacco taxes generated €492 million in fiscal revenue, contributing alone about 5% to total fiscal revenues (excl. social contributions) and 10% of total revenues on production and imports.

However, while this paper analyses the cross-border expenditures of cross-border commuters in Luxembourg, we hasten to add that cross-border shopping activity is not a unidirectional phenomenon in this highly integrated cross-border area. The national statistics institute of Luxembourg estimates that, in 2009, Luxembourg resident households spend over €1 billion or over €6,000 each abroad, representing 11% of their total final consumption expenditure (STATEC, 2011). This level of expenditure is similar in magnitude than that of cross-border commuters’ expenditures in Luxembourg. While these figures do not specify the geography of foreign expenditure, it is clear that the bulk of it can be attributed to cross-border shopping in neighbouring regions, also as the typical “basket of goods and services” purchased abroad differs; Luxembourg resident households tend to spend important share of their expenditure abroad on restaurants and hotels (30%), clothing and footwear (17%), leisure activities (13%) and home furnishings (13%) (STATEC, 2011). As regards the motivation for shopping abroad, it is mainly cheaper prices and the larger number of goods on offer, as survey results commissioned by the Luxembourg trade association (Confédération Luxembourgeoises du Commerce, 2008, 2010) among Luxembourg resident consumers indicate.

3 Data and methodology

For the purpose of this paper, we use a survey of cross-border commuter households, conducted by the Central Bank of Luxembourg together with CEPS/INSTEAD in 2010. The survey centers on the household as the unit of analysis and targets households living in adjacent regions of Luxembourg and within the Grande-Région, where at least one household member works in Luxembourg at the date of data collection. The Xross-Border Household Finance and Consumption Survey (XB-HFCS) was designed to investigate the income, wealth and consumption pattern of the cross-border commuter households. In

this paper, we focus on explaining the cross-border commuters' expenditures in Luxembourg and their motives for doing so.

The questionnaire contains an array of questions concerning cross-border commuter households' expenditures in Luxembourg (For the complete questionnaire see Mathä, Porpiglia and Ziegelmeier, 2012). Combined these questions cover about 71% of total household final consumption expenditures in Luxembourg. Excluding the product category *Housing, water, electricity, gas and other fuels* (~24% of HFCE), which is linked to residency in Luxembourg and to which cross-border commuter households per definition do not contribute, the coverage increases to 94%. The questions in the survey were designed such that they correspond closely to main aggregates of household final consumption expenditure in the ESA95. Questions were worded, such that they are understandable in layman's terms. To give a specific example, the question related to expenditure item *CP110 Catering services* in the national accounts was phrased as:

7.11 *What was the average monthly expenditure that your household incurred on food and drinks outside home during the last 12 months? This is expenditure that you made in restaurants, snacks, cantinas, coffee shops and other establishments of this kind.*
!__!__!__!__!__!__! Euro/month

The sampling contains 42 strata along three dimensions: country of residence, gender and income of the cross-border worker. To account for the right skewness of the wealth distribution wealthy households were oversampled. Within each stratum individuals are randomly selected. The field phase spanned from November 2010 to the end of January 2011. In November 2010, the questionnaire was sent by mail to the sampled households. It was accompanied by an official introduction letter of the institutions BCL and CEPS/INSTEAD, an information leaflet and a blank return envelope to send back the completed questionnaire. The final sample size is 715 households. With about 15% the response rate can be considered relatively high taking the complexity, sensitivity and survey mode of this survey into account.

All descriptive statistics are appropriately weighted to make the sample representative of the population of cross-border commuter households to Luxembourg. The XB-HFCS is representative of 99,181 households residing outside Luxembourg and within in the "Grande-Région" (representing 294,772 individuals and 127,186 cross-border commuters) where at least one household member works in Luxembourg at the time of the data collection.³ Furthermore, all variables have been multiply stochastically imputed to address item non-response. For a detailed description of the XB-HFCS, including an English translation of the questionnaire, sample selection, weighting and imputation, as well as some basic descriptive household statistics on income, wealth and consumption expenditures on the Luxembourg territory see Mathä, Porpiglia and Ziegelmeier (2012).

³ Figures indicating the number of individuals and households are calculated using cross-border commuter individual and household level weights, respectively.

Table 3: Socio-economic characteristics of cross-border commuters

		BE	FR	DE	Total
Country of residence	Observations	192	353	170	715
	Percentage	26.9	49.4	23.8	100
	Percentage weighted	25.4	49.1	25.5	100
Country of birth in %	Belgium	83.1	1.4	1.2	22.1
	France	6.0	91.5	0.2	46.5
	Germany	1.1	1.0	86.2	22.8
	Luxembourg	3.9	1.8	7.0	3.7
	Rest EU	2.2	1.7	3.9	2.4
	Rest of the world	3.7	2.5	1.4	2.5
Gender	Male	74.5	65.7	70.9	69.3
Age	Mean	40.9	39.3	41.3	40.2
	Median	41	38	40	40
Marital Status	Single/never married	21.0	22.8	23.4	22.5
	Married/partnered	68.6	71.7	61.9	68.4
	Widowed/divorced	10.4	5.6	14.7	9.1
Education	Primary/low secondary	10.6	3.9	16.8	8.9
	Secondary	38.9	50.8	48.0	47.1
	Tertiary	50.5	45.3	35.2	44.1
Household size	Mean	3.2	3.0	2.7	3.0
	Median	3	3	2	3

Source: own calculations based on the XB-HFCS 2010; data are multiply imputed and weighted.

Table 3 shows socio-demographic characteristics of cross-border commuters. Almost one half of cross-border commuters in Luxembourg reside in France, the other half is almost equally divided between Belgium and Germany. As expected the majority of cross-border workers are natives (defined here as country of birth) of their respective country of residence. More than 80%, 90% and 85% of cross-border workers from Belgium, France and Germany are born in their respective country of residence.⁴

According to administrative data sources from the Luxembourg social security register (Inspection Générale de la Sécurité Sociale, IGSS), about 67% of cross-border commuters are male (Statec, 2012b). This gender gap is also reflected in the XB-HFCS. 69% of all of cross-border commuter are male. Note that our figures are *strictu sensu* not comparable to those from the IGSS, as we refer to household level aggregates as opposed to individual level aggregates used by the IGSS (the corresponding number not shown with cross-border commuter level weights would be 63%). This is as expenditure questions concern the whole household and not individuals. The share of males varies across countries of residence, the respective shares being 75% for cross-borders commuters from Belgium, 66% from France and 71% from Germany. The average age of cross-border commuters is similar in all three countries: 41 years for cross-border commuters from Belgium; the corresponding ages for France and Germany are 39 and 41 years. These figures correspond

⁴ The sample characteristics match the characteristics published by STATEC well. STATEC (2012) estimates the respective share of Belgian, French and German cross-border commuters from Belgium, France and Germany to be 90%, 96% and 92%.

closely to those survey based figures from in Allegrezza et al. (2005) where male and female cross-border commuters were estimated to be on average 37.4 and 34.7 years of age (data referring to 2002).

Table 4: Employment related characteristics

		BE	FR	DE	Total
Employment status	Self-employed with and without employees	3.7	2.0	1.8	2.4
	Employee	96.3	98.0	98.2	97.6
	thereof with permanent contract	96.8	97.3	97.8	97.3
Employment status spouse	Employed	71.7	77.7	75.4	75.7
	in Luxembourg	52.6	45.9	35.4	44.9
	in country of residence	47.4	54.1	64.6	55.1
Sector of company (incl. NACE code liv.2)	Industry (B, C, D, E)	19.7	18.4	13.0	17.4
	Construction (F)	6.8	11.0	15.0	11.0
	Wholesale & retail trade; repair (G)	12.9	10.5	12.3	11.6
	Financial & insurance act. (K)	17.9	15.7	24.2	18.4
	Market services (H, I, J)	18.9	19.3	7.6	16.2
	Non market services (L-S)	23.8	25.1	27.8	25.5
Working hours/week	Mean	39.5	39.7	39.9	39.7
	Median	40	40	40	40
Working years in Luxembourg	Mean	12.1	10.0	9.3	10.3
	Median	9	10	7	9
Means of transport	By car only	84.5	76.8	87.0	81.3
	By public transport only	2.6	4.5	3.7	3.8
	Both	12.9	18.7	9.3	14.8
Distance to workplace in km	Mean	48.3	46.1	47.3	47.0
	Median	42	40	47	43

Source: own calculations based on the XB-HFCS 2010; data are multiply imputed and weighted.

The civil status is similar across countries; the mode is “married or living together with a partner”, with relative frequencies of 69% in Belgium, 72% in France, and 62% in Germany; the second most frequent category is “single” with a share of around 21-23% in all three countries. The data shows that cross-border commuters tend to have a high level of education regardless of the country of residence. The distribution of educational levels is as follows: For Belgian cross-border commuters, the mode is to have achieved a first stage tertiary education, while for cross-border commuters from France and Germany, it is to have achieved a (upper) secondary education degree. The median household size is 3 for workers resident in France and Belgium. It is 2 for cross-border commuters residing in Germany. In summary, even if there are differences in detail with respect to the socio-demographic descriptive statistics over the three neighbouring countries, cross-border workers tend to be natives in the residence country, are relatively young, and highly educated.

With about 98%, almost all cross-border commuters are employees, of whom 97% have a permanent contract. The variation across countries of residence is negligible. The share of employed spouses/partners is rather high regardless of the country of residence considered. On average, 76% of spouses/partners are in employment, of whom almost 45% work across the border as well. For Belgian cross-border commuter household this is also the

modal outcome. In France and Germany it is more common that one partner commutes across the border whilst the other is employed in the country of residence. Having said this, the fraction of cross-border's spouses/partners being cross-border commuters themselves is rather substantial (France: 46% and Germany 35% of those being in employment). Concerning the sectors of employment, by far the most important sector for cross-border commuters is the Services sector, where almost two thirds of jobs are. At a more disaggregate level, the main sectors of activity are Non-market Services and Financial Services followed by Industry and Market Services. The median and mean number of working hours is 40 and 39.7 hours per week. The median number of years working in Luxembourg is 9 years; the mean is 10.3 years.

The average and median commuting distance are 46 and 43 kilometres, with German commuters having a slightly longer median commute (47 km) than commuters from Belgium (42 km) or France (40 km). Cross-border commuters predominantly arrive by car. For an estimated 81% of cross-border commuters, it represents the sole mode of transport. The respective share for commuters from Belgium, France, and Germany are 85%, 77% and 87%. 15% are estimated to use both car and public transport and a low 4% use public transport only.

4 How much do cross-border commuters spend across the border?

According to the estimates from the XB-HFCS, cross-border commuter households spent on average €9,300 in Luxembourg in 2010. The highest expenditures are incurred by cross-border commuter households from Belgium (€10,000), followed by cross-border commuter households from France (€9,900) and Germany (€7,600). These figures are line with those reported for 2007 by Genevois and Zanardelli (2008); total consumption expenditures increased by 3% in nominal terms, which is lower than the 7.6% cumulated increase of the Luxembourg HICP during the same time span (see Mathä, Porpiglia and Ziegelmeier, 2012 for further details). In total, cross-border commuter households' expenditure accounts for about 10% of household final consumption expenditure on the Luxembourg territory for the selected items. If we were to include *Housing, water, electricity, gas and other fuels* (~24% of total HFCE in 2010) then their contribution would shrink to about 6%.

Table 5: Consumption expenditures of cross-border commuter households in 2010

Product category	Expenditure per household in €										National accounts	
	Absolute					In Percent					HFCE in € million	
	Belgium	France	Germany	Total	Belgium	France	Germany	Total	Total LU	Share XB		
Food and non-alcoholic beverages	1,971	1,411	1,025	1,455	20	14	14	16	1,293	11		
Alcoholic beverages, tobacco and narcotics	789	927	538	793	8	9	7	9	1,248	6		
<i>Alcoholic beverages</i>	335	239	109	230	3	2	1	2	319	7		
<i>Tobacco</i>	455	688	429	563	5	7	6	6	929	6		
Clothing	1,030	794	447	765	10	8	6	8	564	13		
Furnishings, housh. equipment & maintenance	580	590	122	468	6	6	2	5	1,385	3		
Health	191	162	161	169	2	2	2	2	299	6		
Transport	3,496	4,199	3,783	3,914	35	42	50	42	2,700	14		
<i>Vehicles</i>	865	1,590	1,000	1,256	9	16	13	13	896	14		
<i>Energy - fuel</i>	2,468	2,392	2,583	2,460	25	24	34	26	1,167	21		
<i>Maintenance and repair of vehicles</i>	107	152	121	132	1	2	2	1	522	3		
<i>Transport services</i>	55	65	80	66	1	1	1	1	115	6		
Recreational and cultural services	64	55	45	55	1	1	1	1	299	2		
Package holidays, travel	607	450	343	463	6	5	5	5	230	20		
Education	5	27	121	46	0	0	2	0	111	4		
Catering services	1,076	1,115	911	1,053	11	11	12	11	888	12		
Miscellaneous goods and services	191	151	54	136	2	2	1	1	1,596	1		
<i>Durables</i>	1,445	2,181	1,122	1,724	14	22	15	19	2,280	7		
<i>Services</i>	2,296	2,177	1,836	2,120	23	22	24	23	4,059	5		
Total in survey	9,999	9,882	7,551	9,317	100	100	100	100	10,612	9		
Total household final consumption expenditure in LU national accounts										14,951	6	

Source: own calculations based on the XB-HFCS 2010; data are multiply imputed and weighted. Share denotes the share of household final consumption expenditures (HFCE) on Luxembourg territory accounted for by cross-border commuter households taken from Luxembourg national accounts as published by STATEC (downloaded from http://www.statistiques-public.lu/stat/TableViewer/tableView.aspx?ReportId=1442&IF_Language=eng&MainTheme=5&FldrName=2&RFPPath=22).

Fuel purchases represent the largest share of consumption expenditure in Luxembourg, representing almost €2,500 on average. Together with *tobacco* and *alcohol*, these products subject to special excise duties represent roughly 1/3 of all consumption expenditures of cross-border households on the Luxembourg territory. They represent 21%, 6% and 7% of household final consumption expenditure in Luxembourg for these categories. With regard to fuel this is about 15 percentage points less than the share of about 35% for cross-border commuter households in the combined number of Luxembourg resident and cross-border commuter households (186,440+99,181). Much of the difference must therefore be accounted for by fuel tourism of other non-residents and detouring freight transporters. The second place goes to *food and non-alcoholic beverages*, i.e. supermarket shopping (16%) or *catering services*, i.e. eating out (11%). The third and fourth place got to *vehicle purchases* (13%) and *clothing* (8%). The respective share of *tobacco* and *alcohol* are somewhat surprising and lower than what we would have expected a priori. The rather high share of *package holidays* (Q: booking travels, train or aeroplane tickets) deserves mention; cross-border commuter households account for about 20% of this category in the HFCE, which is likely to be linked to the international airport in Luxembourg.

How does the total consumption expenditure of cross-border commuter households vary over the income distribution? Table 6 displays how much of the gross income earned in Luxembourg is consumed in Luxembourg. If a household earned a yearly gross income between €0-10,000, the household spend on average €5,900 for consumption in Luxembourg. Whereas absolute consumption expenditures increase with higher income brackets, the share between consumption in Luxembourg and gross income earned in Luxembourg shrinks, e.g. households in the lowest income bracket consume according to Table 6 more in Luxembourg than their income. However, this likely to be due to the way we had to approximate income, i.e. due to taking the midpoint of each income bracket, which for this category may simply reflect that most households' income in this bracket is closer to the upper end than to the lower end of the bracket. The fraction of income consumed in the highest income bracket of €500,000-1,000,000 is only 6%. On average, approximately 17% of the gross income received from Luxembourg is also consumed in Luxembourg, representing about €925 million per annum.

Table 6: Consumption in Luxembourg as a fraction of income

€/year	Mean consumption	Income LU midpoint bracket	Consumption in % of income LU	Total income	Consumption in % of total income
€0-10,000	5,877	5,000	118	18,631	32
€10,001-25,000	7,869	17,500	45	26,897	29
€25,001-50,000	7,942	37,500	21	46,051	17
€50,001-75,000	8,784	62,500	14	71,966	12
€75,001-100,000	14,045	87,500	16	97,013	14
€100,001-250,000	16,116	175,000	9	179,639	9
€250,001-500,000	24,944	375,000	7	382,212	7
Total	9,317	53,501	17	62,405	15

Source: own calculations based on the XB-HFCS 2010; data are multiply imputed and weighted.

Next, we provide some descriptive statistics to explore how cross-border consumption varies across household characteristics. Table 7 and Table 8 provide the participation rates and the mean expenditure for the product categories. In the discussion, we limit ourselves to the most important categories and note first that, indeed, it is not easy to distil bivariate relationships of general validity for participation rates and (conditional) mean expenditures that in addition also hold across expenditure items. Clearer answers can only be expected from multivariate estimations, which are subject of the next section. Still, we want to provide some selective but noteworthy first impressions.

With respect to *food and non-alcoholic beverages*, the participation rates are very high, and in the same magnitude as fuel, with negligible variation across household characteristics, at least from what can be deduced from these summary statistics. With regard to *alcohol*, the participation rate tends to be higher for the young, middle and high educated, as well as larger households, and households with 2 or more cross-border commuters and commuting by car (exclusively or not). It is not surprising to see that the transport mode has an effect on tobacco and alcohol purchases, as fuel, tobacco, and alcohol are often purchased in bundles. When refuelling the car in Luxembourg, tobacco and alcohol are stocked up as well. 40% of cross-border commuter households buy *tobacco* products in Luxembourg. Here, we notice a clear variation across household characteristics. Younger, less educated households, households commuting to work by car only and lower income from Luxembourg and French households seem to have higher participation rates. The high participation rate among cross-border commuter households from France may also relate to tobacco being priciest in France, whilst it is cheapest in Luxembourg.

With regard to clothing, 65% of cross-border households buy clothing in Luxembourg. The participation rate tends to be higher among women, better educated households and households with more than one cross-border commuter and households with higher income from Luxembourg. Cross-border households from Germany tend to have a lower participation rate than their counterparts from Belgium or France, which may also be related to price differences.

As expected, with a participation rate of 41%, the probability of buying *durables* is generally on the lower side. On average, 38% of cross-border commuter households bought *furnishings and household equipment*, such as furniture, TV, computer etc... in Luxembourg during the last 12 months. This is related to the fact that these types of products are bought infrequently. Additionally, these goods are commonly associated with delivery charges (being typically bulky products), and thus cross-border activity may be constrained by this factor.

Table 7: Participation rates for product categories, by household characteristics

Participation rates	# obs	Services										Durables				Total			
		Food & non-alc. beverages	Alcohol	Tobacco	Clothing	Total	Furnishings & household equip.	Vehicles	Fuel	Total services	Maintenance and repair of vehicles	Transport services	Health	Culture	Package holidays, travel	Education	Catering services	Other	
Male																			
no	264	100	98	48	43	81	37	35	6	97	78	17	15	52	27	27	6	93	11
yes	451	100	97	46	39	58	44	40	8	96	63	17	10	34	25	20	2	91	11
Age																			
<30 years	73	100	95	57	53	63	38	37	9	97	63	10	10	33	39	23	5	94	9
30-39 years	262	100	97	43	39	67	44	40	9	94	70	17	13	41	30	21	3	96	10
40-54 years	313	100	99	50	38	66	43	40	6	97	69	19	10	42	18	21	3	91	12
>54 years	67	100	98	29	37	54	30	27	7	96	60	17	11	30	19	27	0	80	16
Education																			
Primary/lower secondary	46	100	100	25	50	44	22	20	3	97	52	10	5	42	11	17	3	87	15
Upper secondary	269	100	97	50	47	60	37	34	6	98	60	18	9	36	18	19	3	89	9
Tertiary	400	100	98	48	32	74	50	47	9	93	78	17	15	43	37	26	4	96	13
Civil status of household																			
single	143	100	99	50	39	57	34	31	7	94	70	13	14	36	36	22	5	94	15
married/partnered	506	100	97	47	41	69	47	43	8	97	66	18	11	38	23	23	3	91	11
widowed/divorced	66	100	96	35	42	55	21	19	1	96	75	17	5	54	20	12	0	99	8
Household size																			
1	102	100	99	44	36	46	30	27	6	92	74	17	11	41	33	16	5	96	13
2	167	100	98	44	46	69	37	35	6	98	70	10	14	41	35	29	3	95	16
3	157	100	94	49	47	67	41	38	8	98	59	20	9	37	21	21	4	92	6
4 or more	289	100	98	48	35	69	49	44	8	95	69	19	11	39	19	19	2	88	11
Income in Luxembourg																			
0 - 25,000	105	100	97	48	50	52	29	26	7	96	47	9	5	28	13	17	2	83	7
25,001 - 50,000	213	100	97	42	44	62	39	36	8	96	66	19	10	34	23	20	4	92	12
50,001 - 75,000	142	100	97	52	31	70	50	48	4	95	77	17	17	46	39	21	3	95	9
75,001 - 100,000	125	100	99	57	38	82	60	54	11	95	88	22	17	58	34	32	4	99	21
More than 100,001	130	100	98	40	16	85	47	45	8	98	92	23	20	61	36	36	5	100	13
Number of cross-border workers																			
1	502	100	97	43	42	57	36	33	6	95	60	13	8	33	22	19	3	90	11
2 or more	213	100	98	55	37	83	55	51	11	98	87	27	21	56	34	29	5	97	12
means of transport - workplace																			
by car only	563	100	98	49	43	63	40	37	7	96	63	17	3	37	22	20	3	92	10
by public transport	34	100	93	28	28	79	37	33	8	92	86	4	33	45	42	29	9	98	19
both of the above	118	100	94	41	31	72	50	48	9	98	86	19	51	52	42	30	1	91	15
Country of residence																			
Belgium	192	100	99	59	33	72	49	49	4	93	64	14	13	36	26	23	3	91	14
France	353	100	97	50	48	69	50	46	9	97	68	20	11	32	25	23	4	94	12
Germany	170	100	97	29	34	50	18	12	6	98	70	14	12	56	25	18	3	89	8
Total	715	100	97	47	40	65	41	38	7	96	68	17	11	39	25	22	3	92	11

Source: own calculations based on the XB-HFCS 2010; data are multiply imputed and weighted.

Table 8: Mean expenditure for selected product categories over household characteristics, in €

Average expenditure	# obs	Total	Food & non-alc. beverages	Alcohol	Tobacco	Clothing	Total	Furnishings & household equip.	Vehicles	Field	Total services	Maintenance and repair of vehicles	Transport services	Health	Culture	Package holidays, travel	Education	Catering services	Other	
Male																				
no	264	9,775	1,377	241	628	968	1,531	523	1,008	2,533	1,411	136	108	177	56	595	114	1,087	225	
yes	451	9,114	1,489	225	533	675	1,809	444	1,365	2,428	915	131	48	166	54	404	15	1,038	97	
Age																				
<30 years	73	8,241	978	267	637	674	1,512	373	1,139	2,205	861	78	87	91	85	383	12	1,006	126	
30-39 years	262	8,947	1,273	165	541	674	1,799	437	1,362	2,406	886	124	81	175	52	314	31	1,204	108	
40-54 years	313	10,208	1,780	287	553	891	1,754	566	1,188	2,630	1,310	165	51	206	43	609	79	1,003	156	
>54 years	67	8,369	1,423	148	566	673	1,659	291	1,368	2,138	958	102	45	109	69	468	0	806	165	
Education																				
Primary/lower secondary	46	6,759	1,046	117	841	541	717	223	494	2,596	427	64	18	77	17	176	6	475	70	
Upper secondary	269	8,820	1,493	253	662	690	1,534	443	1,091	2,473	911	158	52	172	41	394	4	804	90	
Tertiary	400	10,364	1,497	229	400	890	2,130	544	1,586	2,419	1,363	119	91	185	77	594	98	1,436	199	
Civil status of household																				
single	143	8,310	1,177	216	497	694	1,506	222	1,284	2,211	1,025	71	91	187	78	373	11	984	214	
married/partnered	506	10,027	1,578	244	588	826	1,977	593	1,384	2,575	1,140	156	59	165	50	529	63	1,100	118	
widowed/divorced	66	6,468	1,219	158	532	485	360	140	220	2,218	623	110	54	154	34	188	1	874	82	
Household size																				
1	102	7,085	1,146	140	421	426	1,227	118	1,109	1,904	748	104	69	100	58	223	15	1,074	178	
2	167	9,347	1,361	240	642	844	1,504	406	1,098	2,338	1,242	59	104	230	89	562	12	1,176	184	
3	157	9,212	1,328	245	643	776	1,968	526	1,442	2,491	902	179	46	121	39	407	42	860	68	
4 or more	289	10,230	1,710	250	520	840	1,918	612	1,306	2,739	1,175	164	52	184	41	524	81	1,077	129	
Income in Luxembourg																				
0 - 25,000	105	7,693	1,217	275	771	597	1,288	180	1,108	2,405	627	129	10	152	28	211	4	513	93	
25,001 - 50,000	213	7,942	1,206	182	584	599	1,512	478	1,035	2,298	748	119	71	103	47	298	7	811	103	
50,001 - 75,000	142	8,784	1,591	225	419	793	1,118	515	602	2,482	1,002	102	91	206	78	453	6	1,155	67	
75,001 - 100,000	125	14,045	2,122	286	497	1,300	3,071	778	2,294	2,753	1,903	195	101	289	80	793	24	2,113	421	
More than 100,000	130	16,750	2,336	287	225	1,409	3,842	780	3,062	3,074	3,201	203	108	336	92	1,723	507	2,377	233	
Number of cross-border workers																				
1	502	7,714	1,253	196	575	613	1,165	370	795	2,289	733	102	44	112	47	314	9	889	106	
2 or more	213	13,312	1,957	316	532	1,143	3,117	712	2,404	2,887	1,899	209	121	312	75	832	138	1,461	212	
Means of transport - workplace																				
by car only	563	9,251	1,469	250	607	731	1,660	473	1,188	2,549	992	136	13	159	47	457	54	993	125	
by public transport	34	7,242	965	85	432	704	1,501	116	1,384	1,461	974	16	279	113	104	349	16	1,121	97	
both of the above	118	10,215	1,503	161	355	970	2,129	534	1,595	2,232	1,502	140	304	238	83	525	5	1,363	206	
Country of residence																				
Belgium	192	9,999	1,971	335	455	1,030	1,445	580	865	2,468	1,220	107	55	191	64	607	5	1,076	191	
France	353	9,882	1,411	239	688	794	2,181	590	1,590	2,392	1,062	152	65	162	55	450	27	1,115	151	
Germany	170	7,551	1,025	109	429	447	1,122	122	1,000	2,583	925	121	80	161	45	343	121	911	54	
Total	715	9,317	1,465	230	563	765	1,724	468	1,256	2,460	1,067	132	66	169	55	463	46	1,053	136	

Source: own calculations based on the XB-HFCS 2010; data are multiply imputed and weighted.

Not surprisingly then, a low 7% of cross-border commuter households bought a vehicle in Luxembourg in that given year. However, conditional on purchase the mean expenditure is sizeable. Noticeable is the much lower participation rate in durables and the related unconditional mean expenditure among cross-border commuter households from Germany (18% and €1,222), whilst participation rates reach about 50% and unconditional higher mean expenditures (€1,445 and €2,181) for cross-border commuter households from Belgium and France. It is in particular the much lower participation rate (12%) in buying *furnishings and household equipment* compared to cross-border commuters from Belgium (49%) and France (46%) that makes the difference. The conditional mean is, in contrast, rather similar across countries (BE: €1,185, FR: €1,275, DE: €1,009). However, concerning vehicles cross-border commuter households from Belgium have the lowest participation rate (4%), but the highest conditional mean expenditure (€21,633). Furthermore, *durables* seem more likely to be bought and at higher expense if cross-border commuter households live, loosely speaking, closer to Luxembourg (smaller distance between home and workplace), the larger the household, the better educated the reference person and if there are more than one member working in Luxembourg. With regard to age there seems to be hump-shaped pattern discernible for the participation rate but not for the conditional mean expenditure. Furthermore, participation and mean expenditure seems to be positively related to income in Luxembourg (except for the highest income earners), but not with income in the country of residence. Differences in the participation rates do not always carry over to differences in mean expenditure.

Turning to *fuel*, we notice first the high participation rate in buying fuel in Luxembourg. It seems that variation across household characteristics is negligible. Virtually every cross-border commuter household buys fuel in Luxembourg, which of course was to be expected given the previous discussion on prices differences and cross-border arbitrage. Notable in this context is that, it does not seem to matter how cross-border commuters take themselves to work, by car or public transport. The participation rate remains very high (96% for households using the car only, 92% for those taking public transport and 98% for those using both modes). A more useful characteristic here would possibly be whether or not households have (own) a car. In essence, this means that regardless of the transport mode cross-border commuter households refuel in Luxembourg, where fuel prices are knowingly much cheaper than in the neighbouring countries.

Lastly, with regard to services, descriptive statistics tend to suggest that participation in services expenditure increases with household income in Luxembourg, the number of cross-border commuters in the household, the educational attainment. With respect to *catering services*, the participation rates are very high, and in the same magnitude as fuel. This again, is a very expected result and likely to be much related to meals at lunch time and other catering expenses. Some variation across household characteristics tends to be present. Older and larger cross-border households tend to have a slightly lower participation rate whereas households with a higher income from Luxembourg tend to have higher

participation rates. The participation rate and expenditure incurred for other services categories is on the low side. We leave the discussion of those to the multivariate analysis.

5 Econometric analysis

5.1 Econometric model

We analyse cross-border consumption expenditures and relate it to various socio-economic and employment related characteristics of the household, as well as price differences across countries and product categories. We adopt the following estimation strategy: First, we provide estimates for the pooled expenditure set of household i over different product categories j (excluding the unspecific *other* category), thereby obtaining $i \times j = 715 \times 14 = 10,100$ observations. Second, we provide separate coefficient estimates for each individual product category, and third for aggregate expenditure items, such as *total* expenditure, expenditure of *durables*, *transport* and *services*. *Total* expenditures are non-censored, meaning that we are able to use linear regression techniques. The results of a Box-Cox model for total expenditures indicates that a log-linear model is to be preferred over a linear model ($\theta = 0.078$). We will thus transform the dependent variables in natural logarithms.

For most product categories, and this also being the case for the two aggregate categories *durables* and *services*, the expenditure distribution function is censored at the lowered tail, i.e. at zero, resulting in biased estimated in case of using ordinary least squares. For the pooled estimations, as well as categories affected in the individual estimations, we therefore opt for a tobit model. The observed expenditures are $y_{ijk} = y_{ijk}^*$ if $\ln(y_{ijk}^*) > 0$ and $\ln(y_{ijk}^*) \leq 0$ otherwise. This model can be estimated with tobit, where the dependent variable is $\ln(y)$ rather than y , and the threshold equals the minimum uncensored value of $\ln(y)$ (see Cameron and Trivedi, 2009).

Consider the log-linear regression model with panel-level random effects for the pooled dataset (i.e. combining both expenditures across households and product categories):

$$\ln(y_{ijk}^*) = \exp(\mathbf{x}_{ijk}\boldsymbol{\beta} + \alpha_j + \phi_k + v_i + \varepsilon_{ijk}),$$

where y_{ijk}^* is the underlying latent variable. The random effects v_i are assumed to be i.i.d with $N(0, \sigma_v^2)$ and the error term ε_{ijk} is assumed to be i.i.d. with $N(0, \sigma_\varepsilon^2)$ and independent of v_i . α_j and ϕ_k represent product and country fixed effects, respectively. We report weighted average marginal effects, i.e. marginal effects are calculated first for every household. Then they are the averaged and weighted. All estimates are based on 5 sets of multiply imputed datasets. The coefficients and standard errors are calculated following Rubin's rule (1987).

The vector of explanatory variables includes an array of variables related to individual and household related information of cross-border commuters, which we expect to influence whether or not and how much is spent on the product category in question. The first group of variables is related to the employment of the cross-border commuter in the household. This is the logarithm of the *distance* from home to work, whether or not the cross-border commuter is *full-time* working, his/her *duration* in years of working in Luxembourg, the dominant transport mode (*car, mixed, public transport*), the *number of household members working* in Luxembourg, as well as the logarithm of total *household income*. Second, we include a number of other household control factors, such as the *household size*, the civil status (*single, married/partnered or widowed/divorced*), *gender, age* and educational attainment (*primary, secondary, tertiary*) of the cross-border commuter.⁵ Finally, we include the *price level index* (relative to Luxembourg) for specific product items and aggregates to analyse how price differences affect the expenditure of cross-border commuter households in Luxembourg, as well as some dummy variables for the residence for the household (*Belgium, France or Germany*). The higher the difference the more attractive is buying in Luxembourg. In case of prices being higher in Luxembourg, the less negative the price index difference to the respective neighbouring country, the less the cost penalty of buying the item in Luxembourg. Thus, the expenditure is expected to monotonically increase in the price level index difference.

5.2 Econometric analysis

We first discuss estimates for the pooled dataset (Table 9), followed by a brief discussion of the estimates for each individual product category (Table 10) and selected aggregates of total, durable, transport and services expenditures (Table 11). In the discussion, we will focus on distance, income and PLI differences. Coefficient estimates of other covariates are discussed selectively.

Pooled estimates

Both estimation techniques use either pooled tobit estimates with clustered household id or a random effects tobit on the households id yield very similar results (Table 9) and are discussed together. Increasing distance between home and work contributes significantly negative to consumption expenditure in Luxembourg. The elasticity is less than $-1/3$, which is contrast to most international studies on trade flows, which consistently report distance elasticities of above -1 . In our case, this may be related to the particular focus of the study – i.e. the fact that we analyse cross-border commuters, which by definition regularly cross the border, and as such do not incur any additional transport costs when shopping in Luxembourg. Still, we would expect distance to matter. This is as households living in close proximity of the border may cross the border more frequently for shopping purposes. To provide a specific example some Luxembourg supermarkets are open on Sundays (this is also marketed in the media, such as the local radio stations), whereas supermarkets in Germany are generally shut on Sundays. Households living in very close

⁵ We included also the inverse hyperbolic sinus transformation of total household net wealth. Since this variable was not significant, we excluded it from our specifications.

proximity to such a supermarket make use of this amenity whereas households living farther away, say close to Saarbrücken, would generally not be expected to make use of this possibility.

Total household income has a significantly positive effect on cross-border consumption, with an income elasticity which is about 0.20. In addition, it matters profoundly whether more than one household member is a cross-border commuter. Similarly, the duration of working in Luxembourg and working full-time (≥ 40 hours) as opposed to part-time have a positive effect on consumption; each year and working full-time increase consumption by an estimated 1.5% and 20% respectively. For part-time workers, this strong reduction in consumption expenditure in Luxembourg may also be related to fewer cross-border crossings, simply as they work fewer days (e.g. two or three out five days) in Luxembourg. With regard to the transport mode, the coefficient estimates indicate that cross-border commuter households using public or mixed modes of transport incur higher expenditure in Luxembourg than household exclusively using the car to get from home to work estimations.

Concerning other household controls, it appears that household size, status and age do not exert any significant effect, whereas women tend to spend significantly more than men. Furthermore, less educated cross-border commuter households tend to incur significantly lower expenditures. Cross-border commuter households from in Germany tend to spend significantly less than cross-border commuter households from Belgium or France.

Price level index (PLI) differences contribute positively significant to cross-border expenditure. Distinguishing between PLI differences for tradables and services reveals that it is the PLI differences for tradables that are the driving factor. PLI differences for services are not significant in contributing to more/less cross-border consumption expenditure. Distinguishing further between PLIs for each product category corroborates this finding. PLI differences are significantly positive for the tradable product categories *alcohol, tobacco, clothing, furnishings and household equipment, vehicles and fuel*. PLI differences for individual services related product categories are either insignificant or significant with wrong sign. Thus, these results indicate that cross-border commuters take advantage of existing arbitrage possibilities. For services, results are likely to be linked to limited substitutability possibilities, as some expenses can hardly be avoided, such as expenditure for food and drinks at lunch time.

Estimates for individual product categories

Distance has a significantly negative effect on consumption expenditure for the majority of product categories. There is no significant effect on tobacco, fuel, maintenance and repairs of vehicles, education and catering services. With regard to tobacco, fuel and catering services, these results are not surprising. The distance coefficient estimate for tobacco is insignificant, a result that is likely to be linked to the insignificance of distance estimate for fuel. Tobacco can be bought anywhere in Luxembourg, at big petrol stations or smaller

newspaper shops in town. Often tobacco purchases are bundled with refuelling. The insignificance of the distance coefficient for fuel is not unexpected; fuel is purchased by virtually all cross-border commuters, regardless of the transport mode usually used. The insignificance of the coefficient estimate may relate to missing variability, as the price difference between Luxembourg and the neighbouring regions is such that all commuters always try to refuel in Luxembourg, and this is regardless of the predominant transport mode. Anecdotal evidence (i.e. from one of the authors) suggests that commuters usually using public transport use their car once or twice a month for their commute (either in part or entirety) in order to refuel their car at a Luxembourg petrol station. Descriptive statistics do not show a marked difference between fuel consumption and transport mode, a result which is also supported by the multivariate estimation (specification 7). Also, a larger distance between home and work may actually be expected to result in higher fuel expenditures, as the car has to be refuelled more often; this effect may be counterbalanced by increased use of public transport or mixed transport modes for larger distances.

The total household income is significantly positive for 6 out of 14 product categories. In addition, it matters whether or not more than one household member is a cross-border commuter (sign. for 7/14 categories). The coefficient estimates are for example positively significant for clothing, fuel, transport services, catering services, and thus significant for those product categories that we would primarily expect to be affected. Price level index (PLI) differences are positively significant for a number of product categories, notably food and non-alcoholic beverages, alcohol, tobacco, clothing furnishings and household equipment, and thus those product categories that can be considered tradables, thus by large corroborating the results from the pooled estimates. The PLI differences are generally not significant for product categories related to services (and if so with wrong sign). In part this is related to missing substitutability. Being located in Luxembourg for work purposes implies certain expenditures that hardly can be avoided, such as expenses for meals in restaurants or canteens. Again the results from these product specific regressions suggest that cross-border commuter households systematically use the existing arbitrage possibilities for consumer purchases.

With regard to the transport mode, the estimations return mixed signals. As would be expected the expenditure on transport services in Luxembourg is larger if the transport mode includes a public transport component; the coefficient estimates for both mixed and public transport mode are positively significant. Cross-border commuting households exclusively using public transport tend to spend less expenditure on vehicles and on maintenance & repairs of vehicles, as would be expected. Female gender is a positively contributing factor for expenditure on tobacco, clothing, health, education and package holidays. A higher educational attainment goes together with higher expenditure on clothing, culture and catering services and lower expenditure on tobacco. Other household characteristics have sporadic significant effect on expenditure, which are hard to generalise.

Table 9: Tobit expenditure estimates across product categories

Tobit estimates	Pooled (clustered household id)						Cont'd table	Pooled (clustered on household id)						Random effects on household id		
	1	2	3	4	5	6		1	2	3	4	5	6			
Household characteristics on travel, employment, residency, etc.																
ln(distance)	-0.319 *** (-4.66)	-0.318 *** (-4.68)	-0.319 *** (-4.68)	-0.317 *** (-4.74)	-0.317 *** (-4.74)	-0.317 *** (-4.74)	over all products (2.84)	0.0159 *** (2.84)					0.0161 *** (3.38)			
mixed transport	0.356 *** (3.86)	0.355 *** (3.87)	0.356 *** (3.88)	0.349 *** (3.69)	0.349 *** (3.70)	0.350 *** (3.71)	tradables	0.0595 *** (7.44)					0.0592 *** (8.64)			
public transport	0.425 ** (2.25)	0.427 ** (2.26)	0.428 ** (2.25)	0.436 (1.35)	0.437 (1.35)	0.438 (1.35)	services	-0.0104 (-1.36)					-0.0102 (-1.56)			
ln(total income)	0.220 *** (3.24)	0.221 *** (3.26)	0.219 *** (3.24)	0.223 *** (3.59)	0.224 *** (3.61)	0.222 *** (3.58)	food & non-alcoholic beverages	0.00229 (0.10)					0.00229 (0.10)			
length	0.0154 ** (2.54)	0.0153 ** (2.53)	0.0153 ** (2.53)	0.0158 *** (2.62)	0.0157 *** (2.62)	0.0158 *** (2.63)	alcohol	0.104 *** (3.12)					0.104 *** (3.12)			
full-time	0.206 * (1.83)	0.207 * (1.85)	0.205 * (1.82)	0.202 * (1.74)	0.204 * (1.75)	0.201 * (1.73)	tobacco	0.0408 *** (3.55)					0.0408 *** (4.59)			
>1 cross-border commuter in househ.	0.428 *** (4.85)	0.425 *** (4.82)	0.426 *** (4.83)	0.428 *** (4.91)	0.425 *** (4.88)	0.425 *** (4.89)	clothing	0.0674 *** (3.43)					0.0674 *** (2.95)			
household size	-0.0382 (-1.10)	-0.0382 (-1.11)	-0.0382 (-1.11)	-0.0381 (-1.11)	-0.0383 (-1.11)	-0.0384 (-1.12)	furnishings & househ. equip.	0.193 *** (7.19)					0.191 *** (7.81)			
single	-0.0370 (-0.36)	-0.0366 (-0.35)	-0.0354 (-0.34)	-0.0320 (-0.29)	-0.0315 (-0.29)	-0.0305 (-0.28)	vehicles	0.561 ** (2.13)					0.548 *** (2.86)			
widowed/divorced	-0.191 (-1.46)	-0.186 (-1.42)	-0.186 (-1.42)	-0.187 (-1.37)	-0.182 (-1.33)	-0.183 (-1.33)	fuel	0.0584 * (3.10)					0.0581 * (1.76)			
age	-0.000106 (-0.02)	-0.000156 (-0.03)	0.0000164 (-0.00)	-0.000276 (-0.05)	-0.000323 (-0.06)	-0.000206 (-0.04)	maint. & repair of vehicles	-0.0353 (-1.45)					-0.0351 * (-1.80)			
female	0.218 *** (2.67)	0.218 *** (2.67)	0.217 *** (2.67)	0.225 *** (2.70)	0.224 *** (2.69)	0.224 *** (2.69)	transport services	0.0197 (0.73)					0.0201 (0.90)			
prim. / lower secondary education	-0.426 ** (-2.40)	-0.425 ** (-2.39)	-0.431 ** (-2.41)	-0.429 ** (-2.54)	-0.428 ** (-2.54)	-0.435 ** (-2.57)	health	-0.0222 ** (-2.04)					-0.0218 ** (-2.10)			
upper secondary education	-0.0694 (-0.81)	-0.0688 (-0.81)	-0.0701 (-0.82)	-0.0721 (-0.86)	-0.0718 (-0.86)	-0.0734 (-0.88)	culture	-0.00236 (-0.03)					-0.00176 (-0.03)			
France	0.0334 (0.38)	-0.0699 (-0.75)	-0.155 (-1.21)	0.0341 (0.39)	-0.0678 (-0.74)	-0.150 (-1.24)	package holidays, travel	0.0362 (0.54)					0.0367 (0.66)			
Germany	-0.266 *** (-2.63)	-0.346 *** (-2.75)	-0.259 * (-1.73)	-0.260 ** (-2.50)	-0.338 *** (-2.84)	-0.252 * (-1.76)	education	-0.0287 * (-1.77)					-0.0291 ** (-2.13)			
Product fixed effects included	yes	yes	yes	yes	yes	yes	catering services	-0.0335 ** (-2.19)					-0.0331 (-1.50)			
# observations													10,100	10,100	10,100	10,100

Note: own calculations based on the XB-HFCS 2010; data are multiply imputed and weighted. Base category: Belgian, married/partnered, part-time, male, tertiary education, transport mode car. Tobit estimates refer to weighted average marginal effects of the latent expected value of $\ln(y^*)$. t-statistics in ().

Table 10: Tobit expenditure estimates for specific product categories

	Tradables							Services							Summary of coefficients				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	Negativ	positive	sign.		
	food & non-alcoholic beverages	alcohol	tobacco	clothing	furnishings & househ. equip.	vehicles	fuel	maint. & repair of vehicles	Transport services	health	culture	package holidays, travel	education	caterring services	insign.	insign.	sign.		
ln(distance)	-0.283 *	-0.582 **	0.110	-0.620 **	-0.637 **	-0.450 **	0.00771	0.00900	-0.297 **	-0.187	-0.422 **	-0.679 ***	-0.0568	-0.0997	8	3	3	0	
	(-1.76)	(-2.39)	(0.32)	(-2.14)	(-2.19)	(-2.14)	(0.05)	(0.03)	(-2.27)	(-0.79)	(-2.31)	(-2.95)	(-0.78)	(-0.49)					
mixed transport	-0.103	-0.450	-0.958 **	0.401	0.237	0.219	-0.0418	0.0228	1.436 ***	0.382	0.511 **	0.786 ***	-0.295 **	0.0779	2	3	6	3	
	(-0.42)	(-1.27)	(-2.06)	(1.16)	(0.67)	(0.89)	(-0.27)	(0.09)	(8.56)	(1.48)	(2.47)	(2.69)	(-2.31)	(0.30)					
public transport	-0.161	-0.331	1.262 *	0.418	1.179	-6.676 ***	0.0390	-0.870 ***	1.110 ***	0.312	0.576	-0.124	0.380 ***	0.630 **	2	3	5	4	
	(-0.86)	(-0.57)	(1.85)	(0.68)	(1.52)	(-4.85)	(0.18)	(-3.06)	(5.30)	(0.48)	(1.43)	(-0.36)	(3.18)	(2.46)					
ln(total income)	0.0914	-0.123	-0.874 ***	0.255	0.457 *	0.0624	0.119	0.262 *	0.0443	0.468 ***	0.437 ***	0.586 ***	0.0515	0.816 ***	1	1	6	6	
	(0.80)	(-0.53)	(-3.02)	(0.98)	(1.85)	(0.36)	(0.62)	(1.76)	(0.42)	(2.59)	(2.99)	(2.80)	(1.06)	(4.72)					
length	0.0173	0.0422 *	0.0255	0.0395	0.0375	-0.0154	0.0159	0.00621	-0.00699	0.0764 ***	-0.0110	0.00246	-0.00431	0.0326	0	4	8	2	
	(1.44)	(1.68)	(0.78)	(1.42)	(1.55)	(-0.67)	(1.45)	(0.30)	(-0.51)	(4.04)	(-0.63)	(0.11)	(-0.58)	(1.50)					
full-time	0.159	0.217	0.866	0.141	0.0884	-0.0744	0.0655	0.254	-0.0137	-0.285	0.461	0.305	0.0803	0.495	0	3	11	0	
	(0.86)	(0.46)	(1.58)	(0.30)	(0.20)	(-0.16)	(0.26)	(0.70)	(-0.08)	(-0.83)	(1.40)	(0.72)	(0.78)	(1.40)					
>1 cross-border commuter in household	0.324 *	0.500	-0.00204	1.061 ***	0.245	0.209	0.418 **	0.646 ***	0.394 **	0.865 ***	0.242	0.266	0.129	0.486 **	0	1	6	7	
	(1.84)	(1.45)	(-0.00)	(3.01)	(0.76)	(0.76)	(2.43)	(2.58)	(2.17)	(2.97)	(1.11)	(0.84)	(1.39)	(2.35)					
household size	0.139 **	-0.0483	-0.234	0.116	0.218	0.0628	0.0397	-0.0667	-0.00372	-0.178	-0.189 **	0.0480	-0.0508	-0.245 **	3	6	4	1	
	(2.20)	(-0.33)	(-1.24)	(0.71)	(1.54)	(0.57)	(0.47)	(-0.59)	(-0.05)	(-1.48)	(-1.99)	(0.39)	(-1.14)	(-2.20)					
single	0.392 *	0.244	-0.741	-0.454	-0.464	-0.312	-0.215	-0.416	0.158	-0.149	0.549 *	0.383	-0.00663	-0.106	0	9	3	2	
	(1.69)	(0.53)	(-1.33)	(-0.89)	(-0.92)	(-0.68)	(-1.07)	(-1.16)	(0.67)	(-0.37)	(1.89)	(0.89)	(-0.06)	(-0.32)					
widowed/divorced	0.108	-0.555	-0.719	-0.336	-0.435	-0.861 *	-0.219	0.184	-0.558 *	0.688 *	0.0473	-0.461	-0.300 **	0.246	3	6	4	1	
	(0.35)	(-0.88)	(-1.06)	(-0.54)	(-0.92)	(-1.66)	(-0.76)	(0.50)	(-1.71)	(1.80)	(0.15)	(-1.08)	(-2.39)	(0.82)					
age	0.0312 **	-0.0342	-0.0407	0.0102	-0.0117	-0.00386	-0.00620	0.00731	0.0153	-0.0196	0.00421	0.0478 **	-0.00345	-0.0234	0	8	4	2	
	(2.49)	(-1.47)	(-1.40)	(0.36)	(-0.52)	(-0.19)	(-0.40)	(0.40)	(1.28)	(-1.07)	(0.30)	(2.49)	(-0.64)	(-1.21)					
female	-0.00850	-0.110	0.932 ***	1.603 ***	-0.305	-0.263	0.181	-0.186	0.0705	0.549 **	-0.0813	0.531 **	0.255 ***	-0.148	0	7	2	5	
	(-0.06)	(-0.34)	(2.66)	(5.23)	(-0.95)	(-0.96)	(1.18)	(-0.79)	(0.45)	(2.30)	(-0.40)	(1.97)	(2.96)	(-0.73)					
prim./lower secondary education	-0.212	-1.329	1.784 **	-2.084 **	-1.282	-3.494	0.373	-0.828	-0.443	-0.00288	-0.939 **	-0.775	-0.000374	-1.015 *	3	8	2	1	
	(-0.73)	(-1.53)	(2.28)	(-2.23)	(-1.34)	(-0.81)	(0.84)	(-0.96)	(-1.28)	(-0.00)	(-2.00)	(-1.28)	(-0.00)	(-1.78)					
upper secondary education	0.139	0.382	1.199 ***	-0.665 *	-0.532	0.0206	0.440 *	0.0847	-0.153	-0.385	-0.553 **	-0.374	-0.0930	-0.521 **	3	5	4	2	
	(0.84)	(1.13)	(2.86)	(-1.74)	(-1.52)	(0.09)	(1.92)	(0.35)	(-0.80)	(-1.34)	(-2.49)	(-1.23)	(-0.87)	(-2.13)					
PLI difference	0.0750 ***	0.149 ***	0.0560 **	0.102 ***	0.200 ***	0.190	0.0342	-0.0300	0.00707	-0.0242 *	-0.0177	0.0295	-0.00274	-0.0274	1	4	4	5	
	(3.05)	(3.30)	(2.35)	(2.65)	(5.71)	(1.25)	(1.35)	(-1.49)	(0.48)	(-1.95)	(-0.34)	(0.49)	(-0.96)	(-1.09)					
# observations	715	715	715	715	715	715	715	715	715	715	715	715	715	715	715	715	715	715	715

Note: own calculations based on the XB-HFCS 2010; data are multiply imputed and weighted. Base category: Belgian, married/partnered, part-time, male, tertiary education, transport mode car. Tobit estimates refer to weighted average marginal effects of the latent expected value of $\ln(y^*)$. *t*-statistics based on robust standard errors in ().

Estimates for selected aggregates

Next, we discuss the estimates of selected aggregates. Again, distance has a negative effect on total expenditure and the expenditure of durables. A higher total household income and more than one cross-border commuter in the household increase the total expenditure, as well as expenditure on services. Additionally, the former increases expenditures on durables and the latter expenditure on transport. Age and the number of years working in Luxembourg have a positive (0.8% and 0.7% per year) impact on total expenditures, as well as being female.

Table 11: Expenditure estimates for selected aggregates

	Aggregates			
	(16)	(17)	(18)	(19)
	total expenditure	durables	transport	total services
ln(distance)	-0.138 ** (-2.48)	-0.770 ** (-2.49)	-0.0626 (-0.37)	-0.248 (-1.27)
mixed transport	0.0523 (0.78)	0.386 (1.01)	0.199 (1.43)	0.335 (1.64)
public transport	-0.0328 (-0.19)	1.013 (1.22)	-0.0854 (-0.39)	0.317 (1.17)
ln(total income)	0.249 *** (4.93)	0.510 * (1.89)	0.152 (0.79)	0.754 *** (5.01)
length	0.00714 * (1.65)	0.0284 (0.98)	0.0151 (1.13)	0.0267 (1.31)
full-time	0.166 ** (2.05)	-0.170 (-0.33)	0.115 (0.42)	0.254 (0.87)
>1 cross-border commuter in househ.	0.283 *** (4.34)	0.332 (0.91)	0.528 *** (2.75)	0.539 *** (2.89)
household size	0.0312 (1.15)	0.255 (1.60)	0.0310 (0.35)	-0.202 * (-1.92)
single	-0.0218 (-0.28)	-0.533 (-0.93)	-0.223 (-1.02)	0.0576 (0.22)
widowed/divorced	-0.155 (-1.62)	-0.621 (-1.17)	-0.317 (-1.09)	0.0582 (0.25)
age	0.00813 ** (2.04)	-0.0103 (-0.39)	-0.00242 (-0.15)	-0.00357 (-0.19)
female	0.158 *** (2.73)	-0.593 (-1.63)	0.174 (1.10)	0.0607 (0.35)
prim. / lower secondary education	-0.195 * (-1.69)	-1.649 (-1.48)	0.192 (0.41)	-1.113 ** (-2.09)
upper secondary education	0.0357 (0.59)	-0.460 (-1.19)	0.382 * (1.67)	-0.385 ** (-2.00)
PLI difference	0.0304 *** (3.20)	0.384 *** (4.82)	0.106 * (1.68)	0.0142 (0.59)
# observations	715	715	715	715

Note: own calculations based on the XB-HFCS 2010; data are multiply imputed and weighted. Reference category is married/partnered, part-time, male, tertiary education, transport mode car. Total expenditures is estimated by OLS. Tobit estimates for durables, transport and total services refer to weighted average marginal effects of the latent expected value of y^ . t -statistics based on robust standard errors in (). For definitions of aggregates see Table 8. Transport comprises the sum of vehicles, fuel, maintenance & repair of vehicles and public transport*

Education affects expenditure aggregates in different ways. Upper secondary education increases services and transport expenditure. Total expenditure is significantly lower for cross-border commuter households with primary education than for households with either secondary or tertiary education. The more educated the cross-border commuter household the more is spent on total services. Price level index differences contribute to cross-border commuter household total expenditure, expenditure on durables and transport, but not on services. These results support the results from pooled estimation and individual product categories.

6 Final remarks

International borders usually go hand in hand with price and wage discontinuities, which are caused by different institutional and regulatory environments (e.g. taxes), thereby giving rise to arbitrage opportunities, which in turn are exploited by workers and consumers; they engage in cross-border shopping. This phenomenon is well known, but it seems, as for example argued by Asplund, Friberg and Wilander (2007, p. 142), little is known about magnitudes. This paper hopes to contribute to the existing cross-border shopping literature in several ways. First, it seeks to quantify the extent of cross-border shopping in a specific geographical environment for a well defined population. We present consumption estimates of cross-border commuter households based on data of a representative survey, thereby exploiting the fact of natural cross-border crossings. In total, it is estimated that cross-border commuter households spend €925 million per annum in Luxembourg, reflecting about 17% of their gross annual income from Luxembourg and contributing about 10% to household final expenditure in Luxembourg. Second, cross-border expenditure is shown to generally depend on various individual and household characteristics, such as total household income, the number of cross-border commuters in the household, distance between home and work. Furthermore, cross-border commuter households' consumption expenditure is related to price level index differences across the neighbouring countries. This is in particular the case with regard to tradables and durables, such as food and non-alcoholic beverages, alcohol, tobacco, clothing, furnishing and household equipment. For services, the expenditures of cross-border commuter households are not systematically related to price level differences, which may also be linked to the limited cross-country substitutability of these services with respect to consumption.

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