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Christian Rühl†

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Abstract

Studies employing micro price data suggest that price dispersion is larger between regions in different countries than between regions in the same country. To investigate the strength of this border effect, deviations from the law of one price are used in most studies to provide statistical evidence on the effect of borders on price dispersion. I propose an alternative measure of the economic costs of borders which has an explicit welfare-theoretic foundation. Employing a unique micro price data set from households in Belgium, Germany and the Netherlands I provide evidence on the economic importance of price differences for households. I find that price dispersion within countries has only small economic importance, but that price dispersion between Belgium and Germany (and Belgium and the Netherlands) has considerable economic importance.

JEL classification: D12, D61, F45, F61
Keywords: Border effects, goods market integration, welfare effects, international price dispersion

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1. Motivation

Prices for identical goods vary considerably across locations. For example Lach (2002) studies prices of four products in different regions in Israel and finds considerable dispersion. Asplund & Friberg (2001) study price dispersion in Scandinavian duty free shops located on ferries and find considerable dispersion in prices paid by different nationalities. Sorensen (2000) studies price dispersion in the market for prescription drugs. In Figure 1, I plot the estimated values for regional indicator variables in a regression of prices paid by consumers for (identical)[1] products which were bought in all 23 *Nuts2* regions of Belgium and the Netherlands on regional indicators and product indicators.[2] The darkness of the red indicates the expensiveness of a region: Lightly red colored regions are less expensive than darkly red colored regions.[3] One can see that there is some price dispersion within a country, i.e. not all regions in the Netherlands (in Belgium) are of the same color. However, there is an even larger degree of price dispersion between regions in different countries: All *Nuts2* regions in Belgium are more expensive (are of a darker red color) than the *Nuts2* regions in the Netherlands.

But not only the prices of identical goods differ between regions. Rather the entire assortment of goods seems to be more expensive in regions of Belgium than in regions of the Netherlands. In Figure 2, I plot the the estimated values for regional indicator variables in a regression of prices paid by consumers for all goods belonging to the category *Candy*.[4] Again one sees the pattern, already visible in Figure 1, of (relatively) small price dispersion within a country, but (relatively) large dispersion between countries. This descriptive evidence is in accordance with a large literature that finds that prices differ between lo-

[1] Identical in the sense that they are sold under the same *European Article Number* (EAN).

[2] A detailed description of the data set underlying Figure 1 is given in Section 3. below.

[3] Prices are expressed in cents, the range is between 118 and 162 cents.

[4] Which consists, mostly, of chocolate bars like *Mars, Snickers, ...*. I use only products with the same volume for the regression so as to avoid problems with potentially different package sizes in different countries.

cations - especially if they belong to different countries. In this paper, I intend to contribute to this literature by providing a new measure for the welfare consequences associated with observed price differences. This measure goes beyond providing statistical evidence that prices are more dispersed across nations than within. Rather it quantifies the importance of these price differences for consumer well-being.

The standard approach in the international economics literature on the integration of markets across countries is based on the seminal work of Engel & Rogers (1996) and has attracted considerable attention in the literature in recent years. In their study Engel & Rogers (1996) use price index data (for the main subcategories of the consumer price index) for 14 cities in the United States and 9 cities in Canada and show that the border between the countries provides a significant source of market segmentation. Most subsequent studies employing different data sets (in particular micro price data sets from various countries) have confirmed the findings of Engel & Rogers (1996) on the importance of borders.[5]

The basic starting point for many studies on market integration is the insight that prices of identical (in their physical characteristics) goods should not differ too much between locations. They can only differ by the transportation costs, which are necessary to ship the goods from one location to the other. If the difference is larger, market participants could transport the goods from the cheaper location to the more expensive location (and sell it there to earn an arbitrage profit). The property that prices of identical goods can not differ too much between locations (or in the absence of transportation costs have to be equal) is the *law of one price*.[6] Based on this insight many authors assess the importance of borders on market integration by regressing differences in prices between locations on a variable capturing transportation cost (usually approx-

[5] Examples of this work include Parsley & Wei (2001), Asplund & Friberg (2001), Engel & Rogers (2004), Crucini et al. (2005), Imbs et al. (2010) or Gopinath et al. (2011). Deviating results are reported by Broda & Weinstein (2008).

[6] Some classical references on the LOOP (and its aggregated version, *purchasing power parity*) are Isard (1977) and Rogoff (1996).

imated by geographical distance) and a border indicator. Then, following Engel & Rogers (1996), they translate the estimated coefficient on the border indicator into a distance equivalence measure: They express the border effect as the additional amount of distance (within one country) that is needed to account for the larger price dispersion between locations on different sides of the border.

While such a quantification is of some interest, one ultimately looks for a measure that can be expressed in pecuniary terms, i.e., one wants to go beyond a statement like *the border is 75000 miles wide* to a statement like *costumers could save* 10 *Euro if there was no border related price dispersion*.[7] [8] Stated differently, the framework of Engel & Rogers (1996) provides statistical evidence on the importance of borders for market segmentation, but it does not provide evidence on the economic importance of this segmentation.

In this article, I propose a new framework to answer the question raised above: Is international price dispersion not only statistically important but also economically important? I start from the idea that in consumer markets for *fast-moving consumer goods* not the price of the individual good but rather the price of the entire basket of goods influences decisions and economic well-being (and hence arbitrage behavior).[9] To compare the welfare-consequences of observed price differences, I borrow form micro-economic theory the concept of the *compensating variation*, which allows one to compare two different price scenarios with respect to consumer well-being. I show that the compensating variation can be approximated by an expression that depends upon expenditure shares, own and cross- price elasticities of the demand for goods and price differences between locations. I obtain empirical measures for these variables using a unique household scanner data set for a panel of over 16000

[7] A related weakness of the approach to express the importance of borders in distance equivalent units is that the estimated border effects depends, in a nonlinear manner, on estimated regression parameters, which makes it very sensitive to estimation errors.

[8] Other authors have employed alternative identification schemes before (such as Gopinath et al. (2011)) or have criticized the methodological approach by Engel & Rogers (1996) (such as Gorodnichenko & Tesar (2009)). But all of these studies nevertheless followed the basic rationale given by Engel & Rogers (1996).

[9] See for example the theoretical study of Bliss (1988) or the work of Bell & Lattin (1998).

households from Belgium, Germany and the Netherlands, who provide detailed information on the goods they buy and what they have to pay from them.[10] I estimate the necessary preference parameters (expenditure shares on a household level and elasticities on a national level) and quantify the price differences between the *Nuts 2* regions of Belgium, Germany and the Netherlands. Then I compute the implied compensating variation for each panel member with respect to prices in all other regions. For example, for each household from Brussels that participates in the panel, I compute the compensating variation with respect to prices from regions in Belgium, Germany and the Netherlands and then investigate if the size of the compensating variation differs if the regions belong to different countries.

In my opinion, the approach suggested in this article offers several important advantages compared to the existing approaches. It allows to assess if price differences actually matter for consumers. While analyzing the difference in the price of an identical good across markets provides important insights into the degree of integration across these markets, I think it can not provide perfect evidence on the degree of market integration: Neither consumers nor retailers in the market for *fast-moving consumer goods* view the price of a single good as a sufficient statistic to influence behavior. They rather view individual goods as components of a larger basket of goods they buy (sell) and they base their buying (selling) decisions on the price of this basket.[11] This effect is missing in the standard approach, which compares the price for each good separately. Furthermore, even if the price difference of a single good provides information on market integration, it usually can not provide evidence on the economic importance of it. My approach of employing the concept of compensating variation to express the welfare consequences can provide evidence on the economic im-

[10]The products reported include food, beverages, personal care and home care products.

[11]For example, it is very likely that a consumer does not care if the price of good toothpaste has a lower price at store A than at store B, if the entire basket (including toothpaste) is cheaper at store B. Neither does retailer A try to set the cheapest price for every good he offers (which is also sold by retailer B, but rather tries to achieve an average price level which makes him attractive to consumers.

portance (and similar techniques are used as a standard approach in the area of public finance to evaluate effects of tax changes).

However, there are two potential drawbacks of my approach. First, I need to make an assumption about the consumers utility function to be able to derive concrete preference parameters. To keep the restrictions of this for the general validity of the results as small as possible I make use of a standard method to estimate the consumers demand parameters. The second drawback is that the data requirements to implement the computations are very high: One needs not only detailed information on prices but also detailed information on typical baskets bought by consumers. Fortunately, I have been able to obtain access to a database which contains detailed information on household shopping behavior in markets for *fast-moving consumer goods.* Unfortunately, the quality of the data comes at a cost: It covers only a small subset of of all consumer purchases. As is the case with many household scanner price data sets the sample is restricted to purchases and prices of goods from retail markets.[12]

The main results of the research described in this article are: Using a unique data set on transaction prices for *fast-moving consumer goods* I document considerable price variation for identical goods between countries (and less price dispersion within countries). Using the standard approach of Engel & Rogers (1996), I show that price dispersion is considerably larger across borders than within. For example, I find that the border effect in a regression of price dispersion on (the logarithm of) distance and a border indicator is statistically significant for the considered country pairs Belgium-Germany, Belgium-Netherlands and Germany-Netherlands.[13] For the new approach I propose, which compares compensating variations between locations, I provide two sets of results. In a first step, I provide descriptive evidence on the size of the compensating variation for households with respect to prices in different regions of their home

[12] Other authors such as Broda & Weinstein (2008) or Gopinath et al. (2011) have derived their results employing similarly limited data.

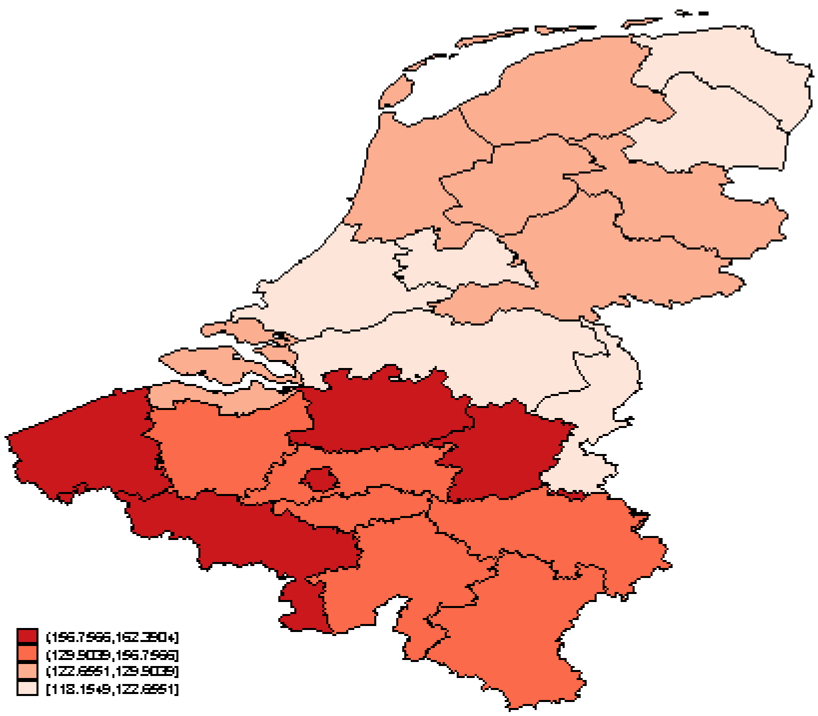
[13] Since the estimated coefficients on distance tend to be very small, this would imply that the border is equivalent to an infinite amount of within-country distance.

country and regions in other countries. For example, I find that an average household living in Belgium could reduce his expenditure by approximately 47 Euro per month if he faced the average prices from Germany. A household living in Germany would need to be compensated with approximately 36 Euro per month if he faced average prices of Belgium.[14] For the case of Germany and the Netherlands the numbers are much lower: German households would need approximately 6 Euro less if they were faced with Dutch prices. This indicates a higher degree of retail market integration between Germany and the Netherlands than between Germany and Belgium (and Belgium and the Netherlands). In a second step, I investigate by how much national borders influence the degree of market integration as measured by the compensating variation. I find, in a regression of the compensating variation (measured at the household level) on (the logarithm of) distance and a border indicator, that the border effect is statistically significant for all considered country pairs. For example, I find that for households from Belgium the border coefficient with respect to Germany is equal to approximately -41 Euro of reduced expenditure, while for the Netherlands it is equal to approximately -96 Euro of reduced expenditure.

The rest of this article is organized as follows. Section 2.2 presents the framework to evaluate price differences across markets using the concept of compensating variation. Section 2.3 introduces the data set and provides descriptive evidence on purchasing behavior. Section 2.4 contains preliminary evidence on the consequences of price dispersion. Section 2.5 provides further detail on the econometric implementation and Section 2.6 provides descriptive evidence on the size of the compensating variation across regions. Section 2.7 considers the effect of national borders and Section 2.8 concludes.

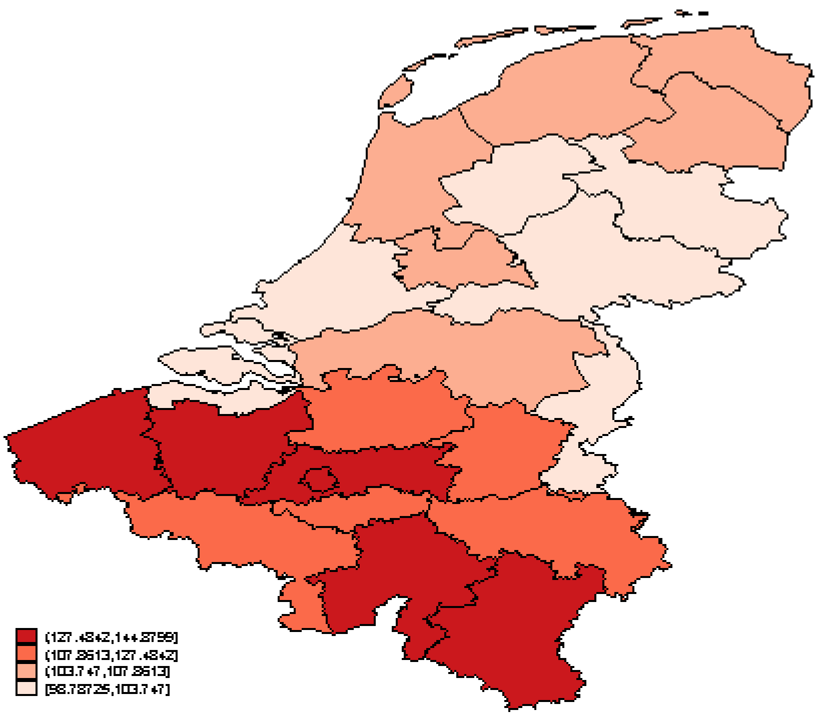
[14]If all other prices for, i.e., flats and electronic products, would be the same.

Figure 1: Regional price dispersion: Belgium and Netherlands
(Identical Goods)



Notes: This graph contains the results of a regression of transaction prices for goods on regional indicator variables, focusing only on *EAN*-identical goods. The darkness of the red indicates different levels of expensiveness: Lightly red colored regions are cheaper, dark red colored regions are more expensive. For the regression prices for goods which are sold in all 23 Nuts2 regions of Belgium and the Netherlands in January 2005 are used.

Figure 2: Regional price dispersion: Belgium and Netherlands
("Candy" category)



Notes: This graph contains the results of a regression of transaction prices for goods on regional indicator variables. The darkness of the red indicates different levels of expensiveness: Lightly red colored regions are cheaper, dark red colored regions are more expensive. For the regression prices for goods (with the same package size and volume) in the category *Candy* which are sold in both Belgium and the Netherlands in January 2005 are used.

2. Conceptional Framework

The basic starting point for many studies on market integration is the law of one price, which postulates that the price of an identical (in its physical characteristics) good in two locations has to be equal for a market to be in equilibrium. If the price for, lets say, toothpaste a is lower in location location i than in location j, it would be profitable (abstracting from any kind of transaction and transportation costs) to buy the toothpaste a in location i, ship it to location j and sell it there to earn an arbitrage profit. This arbitrage activity would led to an upward pressure on the price of the toothpaste in location i and a downward pressure in location j. This tends to equalize the prices of the toothpaste in locations i and j. Dropping the extreme assumption of no transactions costs, there would still be a tendency for prices to be equalized until the price difference $p_i^a - p_j^a$ is smaller than the transaction and transportation costs between the locations. To the extent that transactions and transportation costs are functions of the (geographical) distance between locations i and j, one thus should observe a positive correlation between price dispersion and distance: Prices in locations further apart can differ by a greater amount than prices in locations close to each other.

2.1. The Law of one Price and International Market Integration

In a seminal study Engel & Rogers (1996) extend the concept of the law of one price to an international setting and try to identify, if national borders have a negative effect on market integration (even after controlling on transaction and transportation cost). Following them a large literature has emerged, which is focusing on basic regression equations of the form

$$q_{i,j}^a = \alpha_i + \alpha_j + \beta \ln d_{i,j} + \delta B_{i,j} + u_{i,j}, \tag{1}$$

where $q^a_{i,j}$ is a measure of the price dispersion for good a between locations i and j. (Prices are converted to the same currency if locations i and j use different currencies).[15] The distance variable $\ln d_{i,j}$ enters the regression equation as a proxy variable for transportation and transaction costs between locations i and j, which are assumed to increase (at a decreasing rate) with the distance between locations i and j. The variable $B_{i,j}$ is an indicator variable taking on the value $B_{i,j} = 1$ if locations i and j belong to different countries. If $\delta > 0$, then national borders lead to an increase in market disintegration as measured by price dispersion.

Studies using the framework of equation (1) usually find that both distance and national borders increase price dispersion, i.e. both β and δ are statistically significant and positive. However, it is difficult to interpret the size of the coefficients in economic terms. Therefore the following statistic

$$\textit{distance equivalent of crossing border} = \exp\left(\frac{\delta}{\beta}\right) \tag{2}$$

is often used, which translates the estimated border coefficient into a distance measure (expressed in miles of kilometers). Using this measure and consumer price index data for regions in the United States and Canada, Engel & Rogers (1996) find that the border between the United States and Canada is equivalent to 75.000 miles of within country distance.[16] Parsley & Wei (2001) report evidence that the border between the United States and Japan is equivalent to distances only seen in space travel. While these numbers provide some evidence on the economic cost of borders, they are still not readily interpreted in terms of monetary units (and to some degree unbelievably large).

[15] Common measures of dispersion are the squared percentage difference of prices $q^a_{i,j} = \left(\ln p^a_i - \ln p^a_j\right)^2$ or the absolute difference $q^a_{i,j} = |\ln p^a_i - \ln p^a_j|$).

[16] There are recent studies claiming that this overstates the size of the border effect due to the omission of regional specific variables.

2.2. Compensating Variation and International Market Integration

Studies using the framework of the previous section find that markets tend to be less integrated between countries than within countries. Since they are based on the law of one price they all assume that the price difference of good a between locations i and j is a sufficient statistic for arbitrage behavior: As soon as the price difference gets too large, someone will act and cash in on it by transporting the good form the cheaper location to the more expensive one. It is very likely that this behavior can be observed for large scale and (or) very expensive products like cars. For example, when buying a new car the price difference between locations i and j can either induce the buyer to order his car at low-price location j (and travel there to collect the car). Or it can induce an entrepreneur to start a new business, which offers consumers a lower price than the one prevailing in region i by importing the car from location j and keeping a part of the price difference as their profit.[17]

However, this kind of arbitrage activity is less likely for other goods. For example, Gopinath et al. (2011) use, in their study of market integration between the United States and Canada, price data from a retailer operating both in the United States and Canada. Most products in their sample are relatively cheap (and are often bought together with other products at a single shopping trip). For such products, for example a pack of toothpaste, it is hard to imagine arbitrage activity as described above. For most products form the group of so-called *fast-moving consumer goods* not the price of a single good is determining the shopping behavior, but rather the price of the entire shopping basket. (See for example Bliss (1988), who proposes a model of retail outlet choice, and Bell & Lattin (1998) who empirically investigate determinants of retail outlet choice). Therefore I think that for such a data situation (i.e. scanner data from retailers

[17] A prominent example of such a strategy is the market for re-imported cars, in which, for example, specialized German firms buy cars in other EU countries (where they tend to be cheaper) and sell them to German car buyers.

or demand side data on households purchases) a new measure for market integration has to be developed. This measure should be, firstly, based on a solid theoretic grounding and should, secondly, provide a more meaningful interpretation of the border effects than the ones obtained from regressions like (1) (and the transformation in (2)).

To develop this measure, think of a consumer facing a price list $\mathbf{p}_i = (p_i^a, p_i^b, \ldots)$ (for goods $a, b, \ldots$) offered to him in location i and a price list (of the same/similar) goods offered in location j, $\mathbf{p}_j = (p_j^a, p_j^b, \ldots)$. Also assume that the consumer has an amount of money y that he wants to spend on the goods. The maximum amount of utility that the consumers in location i faced with prices $\mathbf{p}_i$ and income y can obtain is denoted by $V(\mathbf{p}_i, y)$, where V denotes the indirect utility function.[18] The *compensating variation* is the amount of additional income that the household h needs to be given if instead of facing prices $\mathbf{p}_i$ he faces prices $\mathbf{p}_j$ while remaining at the initial utility level. It is implicitly defined by

$$V(\mathbf{p}_j, y + CV_{h,i}^j) = V(\mathbf{p}_i, y). \tag{3}$$

If, for example, all prices are higher in location j than in location i, the compensating variation would be positive ($CV_{h,i}^j > 0$): The consumer needs to be given additional income to reach the same level of well-being if he is forced to switch from prices $\mathbf{p}_i$ to prices $\mathbf{p}_j$.

Employing the concept of the expenditure function, denoted by $e(\cdot)$ an alternative expression for the compensating variation is given by:

$$CV_{h,i}^j = e(\mathbf{p}_j, V_i) - e(\mathbf{p}_i, V_i). \tag{4}$$

$e(\mathbf{p}_j, V_i)$ denotes the expenditure necessary to obtain the level of well-being $V_i = V(\mathbf{p}_i, y)$ given prices in location i and $e(\mathbf{p}_j, V_i)$ denotes the expenditure necessary to obtain the level of well-being V_i given prices in location j. Hence the

[18]Formally $V(\mathbf{p}_i, y)$ is defined as $V(\mathbf{p}_i, y) = \max_{\mathbf{x}} u(\mathbf{x}) s.t. \mathbf{p}_i x \leq y$, where $\mathbf{x}$ is a vector containing the quantities of goods $a, b, \ldots$ as elements and u is a utility function.

compensating variation also indicates by how much expenditure would have to change so that the consumers remains on the same utility level if he relocates from location i to location j.

Unfortunately, the value function $V(\cdot)$ and the expenditure function $e(\cdot)$ are not observable and thus equations (3) and (4) cannot directly be used to construct a measure of the welfare consequences resulting from price differences between locations i and j. However, using results form consumer demand theory, one can derive the following approximation[19]

$$\frac{CV_{h,i}^{j}}{y} \approx \sum_{n=1}^{N} w_n \Delta \ln p^n + \frac{1}{2} \sum_{n=1}^{N} \sum_{l=1}^{N} w_n \epsilon_{n,l} \Delta \ln p^n \Delta \ln p^l. \tag{5}$$

$\frac{CV_{h,i}^{j}}{y}$ is the percentage change in expenditure (of expenditure y in the baseline situation with prices $\mathbf{p}_i$) necessary to be as well of with prices $\mathbf{p}_j$ than with prices $\mathbf{p}_i$. The size depends upon price difference for the $n = 1, \ldots, N$ products between locations i and j ($\Delta \ln p^n = \ln p_j^n - \ln p_i^n$) and preference parameters w_n and $\epsilon_{n,l}$. w_n is the share of expenditure devoted to product n and $\epsilon_{n,l}$ is the compensated cross price elasticity of the demand for good n with respect to good l.[20] One can interpret this equation as consisting of two parts: The first, linear, part shows how expenditure would change if price p^n would change but the consumption pattern (i.e. the share devoted to good n) would remain constant. The second, quadratic, part shows the potential effect of price changes on demand.

To interpret (5) in more detail, suppose that the price of good n increases (and the price of all other goods remain constant). This size of the compensating variation with respect to this price change will depend upon three parts: First, for a given consumption pattern, an increase in the price of good n would

[19] The detailed derivation is delegated to the appendix.

[20] One can find such an approximation already in Hicks (1946). It is also used in Friedman & Levinsohn (2001) to investigate the effect of financial crisis on consumer well-being in Indonesia. Similar expressions for evaluating welfare changes arise in many demand models - for example also in the model of Lewbel & Pendakur (2009).

require the consumer to spend $w^n(p_j^n - p_i^n)$ units more to implement his old consumption pattern. Second due to the price increase the consumer, depending upon the size of the own-price elasticity $\epsilon_{n,n}$, maybe will reduce his consumption demand of good n. This would tend to lower the compensating variation. Thirdly, due to the change in relative prices the consumer might shift to less expensive substitutes. This reallocation effect depends upon the size of the cross-price elasticity of good n with respect to the other goods. In terms of equation (5) the first aspect is captured by the linear part and the second and third aspects are captured by the quadratic part. In situations where the price changes are small, the first order effect will play a dominant role (since the second order effect will depend upon the product of the price changes, which in such a situation will be small). The second order effect will only become important if either the considered price changes are large or the own- and cross-price elasticity take on large values.

Summarizing, equation (5) illustrates that the preference-based assessment of a given price difference for a good depends on the importance of the good to the consumer (as measured by the expenditure share devoted to it), on the percentage price change and the response of the consumer to price changes (as measured by the elasticity parameters). Whereas the second of these effects is captured by the standard approach of measuring border effects (i.e. the one focusing just on deviations from the law of one price) both the first and the third are neglected. Therefore this approach to measure the is more general and has a more meaningful economic interpretation.

To implement the approach outlined in this section, one needs to be able to estimate the preference parameters given in equation (5) and one needs to be able to construct the relevant price differences. For the purpose of estimating preference parameters, a detailed data set on demand behavior would be optimal, while for constructing the price difference supply side data would be optimal. However, to the best of my knowledge, no such data set containing both detailed demand and supply data is available. Therefore, I here focus on a demand side data set, which allows me to estimate the preference parameters and construct also price differences between regions. I think that this is a valid approach, since the data set, which is described in more detail below, is constructed to be representative of the purchasing behavior in the respective countries and thus the price information I obtain from it should be a good approximation to a more detailed data set containing supply side information on prices.

3. Data

To implement the econometric approach outlined in the previous section I use a high quality micro price data set, which is based upon detailed purchase reports for so-called *fast-moving consumer goods*[21] by a representative panel of households from Belgium, Germany and the Netherlands.[22] In this section I first provide general information about the organization and size of the data set, then provide descriptive statistics on the purchase behavior of the households in the panel and describe the classification system for goods that I will use in the econometric implementation below.

3.1. Description of the data set

The data set used in this study is provided by AiMark[23] which is a non-profit cooperation that promotes research in the area of retail markets. The underlying information is collected by households in Belgium, Germany and the Netherlands. Panelists are chosen so as to provide a representative sample of cos-

[21] *Fast-moving consumer goods* are goods that are sold quickly (from the perspective of the seller) and at relatively low cost - i.e. goods sold at a typical supermarket or discounter like grocery products, home and personal care products and beverages.

[22] I also have access to purchase information of households from Poland, however I do not include it in the analysis of this paper. The main reason for this exclusion is that, at least for rural regions from Poland, the purchasing behavior seems to be different from the one in Belgium, Germany and the Netherlands.

[23] Advanced International Marketing Knowledge

tumers of the considered retail markets. The data sets consists not only of purchase data (as described in more detail in the next paragraph) but also of selected household information. The data set is provided to AiMark by various commercial providers (like the *Gesellschaft für Konsumforschung* (GfK) in Germany, Kantar Worldpanel and IRI), which employ the data to offer advice to the retail and marketing industry.[24]

Each household is endowed with a scanning technology which it uses to scan all the purchases of *fast-moving costumer goods* at retail outlets including all major supermarket chains (such as Rewe or Aldi in Germany or Albert Heijn and C1000 in the Netherlands).[25] For each product bought the household scans the bar-code which uniquely identifies the product via the Global Trade Item Number (GTIN) and enters the volume and the price it paid for the product.[27] The data providers add to this information a detailed description of the products and a classification system of the goods into different (more aggregate) product categories, to which I also have access.[28] In addition to the detailed data on the individual transactions, I also have access to information on household characteristics such as the location of the household (at the postal code level), its income group and its age.

To obtain a better insight into the data set I report in Table 1 some descriptive statistics.[29] Entries in Table 1 refer January 2005. The first row of the table shows the number of panelist reporting purchases, it ranges from around 2500

[24]As will be outlined in more detail below the data is best comparable to the data from Symphony IRI which is used by Coibion et al. (2013), who use U.S. data.

[25]This scanning technology is similar to the one underlying the Nielsen HomeScan database which has been, e.g., used at the Chicago Booth School of Management as a basis for research in the area of marketing[26] but also other questions such as the welfare effects of new shopping centers (Hausman & Leibtag (2007)).

[27]The GTIN-12 code corresponds to the Universal Product Code (UPC) which is used in the U.S. and Canada. In Europe, the GTIN was formerly known as European Article Number (EAN).

[28]In case the product does not have a bar-code, the household enters information on product characteristics manually.

[29]Before using the data for any computations, I cleaned the reported purchases. All purchases where the reported price deviated by more than 200 percent from the national average price for the same good were discarded. I also excluded all purchases with prices above the 95th percentile of the price distribution from further computations.

households in Belgium to about 10500 households in Germany. The second column contains the average age of the panelist (in households with multiple members, this is the age of household head), which is in the range of 50 to 52.[30] The third column contains average income.[31] The fourth row contains the number of unique products sold, it ranges from around 23000 goods in Belgium to over 70000 goods in Germany. The following three rows contain summary information about shopping behavior of households. I report their monthly expenditure on *fast-moving consumer goods* (in the row *Monthly Expenditure*), the average number of expenditure per shopping trip (*TripExpenditure*) and the total number of trips undertaken in January 2005 (given by the row N_{Trips}). A shopping trip is defined as a unique combination of household, store and day. The final row N_{Obs} shows how many purchases where recorded in total in January 2005.

3.2. Purchasing behavior of consumers

Further information about consumer behavior is contained in Figure 3, where I show histograms of total monthly expenditure for each of the three countries. For Germany and the Netherlands most of the expenditure per month is concentrated in a the range of 150 to 300 Euro. For Belgium there tend to be more monthly expenditures in the range above 300 Euro (reflecting the large mean value reported for Belgium in Table 1). The expenditure reported in Figure 3 will be used later on to convert the percentage expression of the compensating variation, given in equation (5), to monetary units. One thus can already see here that the absolute level of compensating variation will tend to be high for Belgian households, since they tend to have the highest expenditure. (As Figures 1 and 2 indicate that Belgian households also tend to face highest prices, one should expect the compensating variation of Belgian households with respect to prices

[30] For some countries, I am not given the exact age but only age brackets. For these countries, I use the middle of the age brackets to compute the average age.

[31] I am not given the exact income, but only income brackets. I use the middle of the income brackets to compute the average income. Income brackets are not identical across countries.

Table 1: Sample Information

	Belgium	Netherlands	Germany
Households	2548	3672	10580
Age	51	50	52
Income	1926	1918	2384
N_{EAN}	23960	27616	74774
Monthly Expenditure	231	155	183
N_{Trips}	29206	54202	180990
Trip Expenditure	41	21	22
N_{Obs}	189154	403149	1204789

Notes: All numbers are for January 2005. Households is the number of panelists, Age is the average age of households in the panel, Income is the average income of households in the panel. N_{EAN} denotes the number of (unique) goods bought. N_{Trips} denotes the number of shopping trips per month, Monthly Expenditure is the total amount spent on goods and Trio Expenditure is the amount spent per trip. N_{Obs} is the number of purchases.

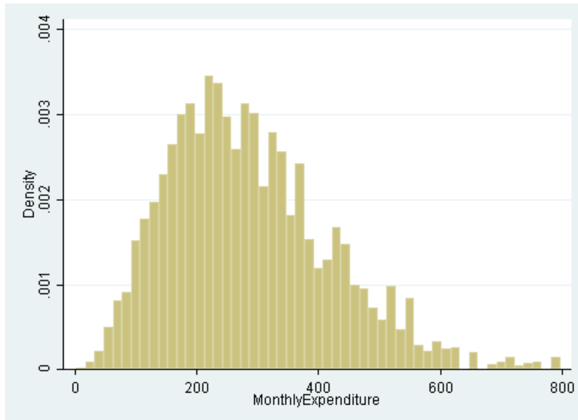
from regions in other countries to be negative - i.e. Belgian households could reach the same level of well-being with less expenditure).

3.3. Classification scheme for goods subcategories

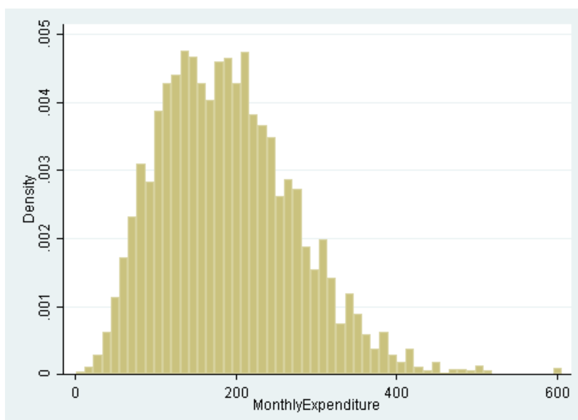
I constructed a common classification scheme for products in Belgium, Germany and the Netherlands. This was achieved by using the classification system of the data provider, who normally uses the data for providing consultancy services to companies in the area of marketing. Therefore the basic classification system is intended to serve the same objectives as the ones of this study, i.e. to investigate consumer demand behavior. As the grouping systems differ slightly across countries, I constructed comparable categories of goods by using the classification scheme of Germany as a basis. For Belgium and the Netherlands I then assigned the categories provided in the source data to their German

Figure 3: Monthly expenditure

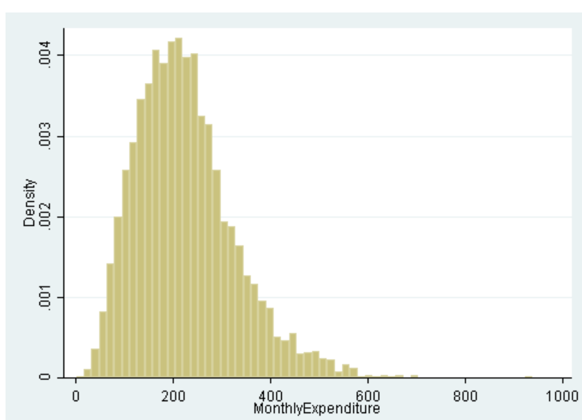
(a) Belgium



(b) Netherlands



(c) Germany



Notes: Histogram of monthly expenditure on fast-moving consumer goods for Belgium, the Netherlands and Germany. On the x-axis monthly expenditure is expressed in Euro, on the y-axis the share of households is plotted. Results are for January 2005.

counterpart. This was done using the assistance of country representatives of the data provider as well as using the extensive documentation of the different classification schemes, to which I had access at the data providers offices. This documentation provides a detailed description of the goods to be included in each sub-category using a system of key words. For each of the sub-categories in the Belgian and Dutch documentation, I searched for the best match in the German classification system by focusing on the key words. In case there was no clear assignment possible, I excluded the data from further computations. The classification system I constructed allows me to group together the products in 31 categories covering different parts of the consumer good market. [32]

4. Evidence at the Goods Level

As a first step to investigate the importance of price dispersion on consumer well-being, I here evaluate the approximation to the compensating variation at the level of individual goods (as defined by their *EAN*). However, at this very dis-aggregated level I am not able to evaluate the effects of within country price dispersion and hence I treat i and j in equation (5) as countries and focus only on cross country price dispersion. It is also not feasible to estimate own- and cross-price elasticity parameters at this fine level of aggregation and hence I will only look at a first-order approximation to the compensating variation.

To compute the (first-order approximation of the) compensating variation for consumers from country i with respect to prices from country j I proceed as follows: In a first step, I identify all products which are sold both in country i and country j (by comparing their *EAN*). Then I construct national average prices for these products. In a next step, I compute for each household the total

[32] The name of the categories are *Meat, Snacks, Fresh Products, Vegetables, Dairy White, Dairy Yellow, Fat and Oils, Delicasees, Preserved Food, Basic Food, Hot Drinks, Candy, Baby Products, Spreads, Ready-made Food, Cereals, Frozen Products, Alcohol, Liquor, Beer, Champagne, Wine, Alcohol-free drinks (without CO2), Alcohol-free drinks (with CO2), Bodycare, Mouth and Tooth, Hygiene Products, Household Cleansers, Laundry, Animalcare, Rest.*

value of expenditure he devotes to these good (using the prices he actually paid)

$$\textit{Actual Basketprice}_h = \sum_{u=1}^{U} q_{h,u} p_{h,u}$$

where $q_{h,u}$ is the amount of good u that household h has bought and $p_{h,u}$ is the price he paid for it. U is the number of goods which are sold both in country i and j. Then I compute what the same bundle would have cost using the average prices from country i and country j respectively. Formally,

$$\textit{Hypothetical Basketprice}_h^j = \sum_{u=1}^{U} q_{h,u} \bar{p}_u^j,$$

where now $\bar{p}_u^j$ is the average price of good u in country j.

The compensating variation (up to a first-order) is then approximated by

$$CV_{h,i}^j = \textit{Hypothetical Basketprice}_{h,i}^j - \textit{Actual Basketprice}_{h,i}, \tag{6}$$

i.e. the change in expenditure if prices change from actual prices paid to average prices from country j. Positive (negative) values indicate that the household would need to increase (decrease) his expenditure to remain at the same level of well-being as before the price change. [33]

The results of this exercise are summarized in Figure 4 and Table 2. In Figure 4, I show for the three country pairs Belgium-Netherlands, Belgium-Germany and Netherlands-Germany the histogram of (percentage) price differences for identical goods sold in each country of each pair. For example, the top panel shows the histogram for the case Belgium-Netherlands, where the percentage deviation is computed by subtracting from the average price for a good in Belgium the average price for the same good in the Netherlands (prices are first

[33] This is equivalent to the formulation appearing in equation (5) above: Holding consumption patterns constant (i.e. neglecting second order substitution effects) the compensating variation is just the difference in the price of bundles evaluated with prices in region i and region j.

converted to logarithms). Positive values indicate that the considered good is more expensive in Belgium. As one can see, this is the case for a large share of goods: Both the mean and the median are above zero, indicating that, on average, goods tend to be more expensive in Belgium. Similar evidence is contained in the middle panel, covering the case of Belgium-Germany. The lower panel, covering the case of Netherlands-Germany, is not so clear cut: There are many goods for which the Netherlands is more expensive, but there are also many goods for which the Netherlands are cheaper. (Mean and median are close to 0).

What these price difference imply for average consumer baskets is spelled out in Table 2. The columns cover the three country pairs Belgium-Netherlands, Belgium-Germany and Netherlands-Germany and the table is split into two parts. The upper part, under the heading **Aggregate Level**, contains information on how many goods (out of the total number of goods) are common to each country pair and various statistics on how affected different sample measures are. Focusing on the country pair Belgium-Netherlands, one can see that out of around 27500 good in Belgium (27600 goods in Netherlands) only 2745 goods are sold in both countries - i.e only around 10 percent of goods for Belgium.[34] Even though only a small number of goods is sold in both countries, most households buy one of these goods. This is likely due to the fact that many of these common goods come from large multinational producers and have famous brand names. However the number of times these goods are bought is small relative to the overall number of goods bought: Only about 9 (5) percent of all transactions in Belgium (the Netherlands) involve goods which are also sold in the Netherlands (Belgium). Even more pronounced is this effect if one looks at the amount of expenditure. In total, Belgian (Dutch) households report expenditure of close to 380000 Euro (412000 Euro). But only about 2900 Euro

[34] The actual number of common goods might be higher, since I only have demand side data and observe only the goods which are actually purchased. There might be goods, which are sold in both countries, but which where not bought by the panelist in my data set. However, even with supply-side data from a single retailer operating in the United States and Canada Gopinath et al. (2011) report that only about 5 percent of all goods are sold in both countries.

(71000 Euro) (i.e. less than 12 (6) percent) is devoted to expenditure on goods which are sold in both countries.

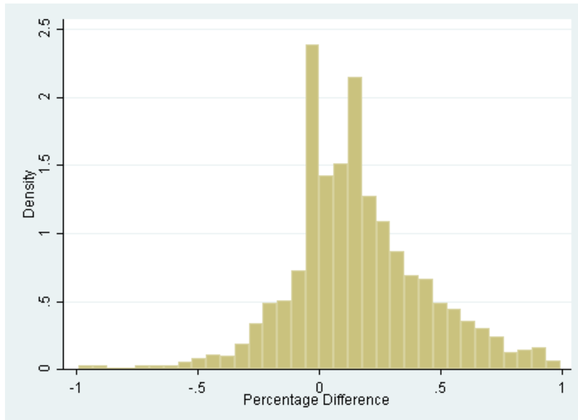
The lower part of Table 2, under the heading **Household Level**, provides information on how (on average) households are affected by the price differences displayed in Figure 4. For each of the affected households, I compute the (monthly) expenditure share that is devoted to goods, which are also sold in the other country of the considered country pair. The mean of this statistic is contained in the row *Expenditure Share*: The highest values are obtained for the country pair Belgium-Netherlands (9 percent for Belgian households and 19 percent for Dutch households), while the lowest values are obtained for the country pair Belgium-Germany (4 percent for Belgian households and 3 percent for German households). I also report, in the row *Goods share*, the share of goods affected for each household: Again the highest values are obtained for the pair Belgium-Netherlands and the lowest for the pair Belgium-Germany. The final two rows contain the results from the computations underlying equation (6), i.e. the (mean) change in expenditure if instead of facing the actual transaction prices, consumers would be faced with the average price from either their home country or from a foreign country. Focusing on the country pair Belgium-Netherlands, one can see that (on average across all households from Belgium) Belgian households would need to pay around 1.5 Euro less, if they faced the (average) prices from the Netherlands. Dutch households, on the other hand, would need to pay (on average) 5.4 Euro more, if they faced the prices from Belgium. While these numbers are relatively small, it should be noted that for a Belgian household (on average) only 11 percent of the goods he buys are included in these computations. If the price level for all the other goods he buys (but to which there is no *EAN* identical match in the Netherlands) is also lower in the Netherlands, than one could expect that, considering all goods, on average Belgian households could save around $10 \cdot 1.54 = 15.4$ Euro per month if they faced faced the prices from the Netherlands. [35]

[35] The interpretation for the other country pairs is similar.

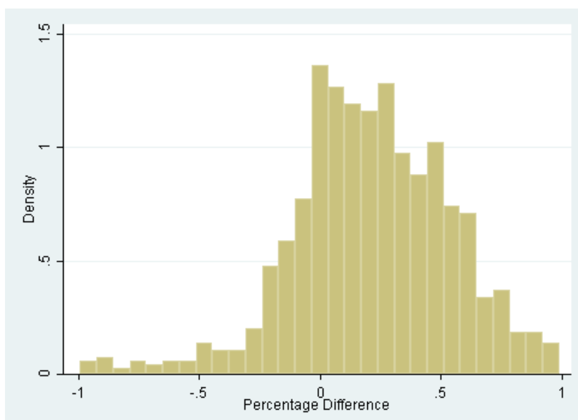
As one can see there is some effect of cross-country price dispersion on consumer well-being: Dutch and German households would need to be compensated if they were faced with Belgian prices. Belgian households could reach the same well-being with lower expenditure if they faced German or Dutch prices. However, this effect seems to be small - mainly because the share of expenditure devoted to goods which are sold (under the same EAN) in both countries is small. However as indicated in Figure 2, the price dispersion is not only observable at the level of *EAN* identical goods (as shown in Figure 4) but seems to be present for all goods belonging to a particular product category: Not just *EAN* identical goods are, according to Figure 2, more expensive in Belgium. Therefore I now develop an approach to implement the computation of equation (5) at the higher aggregation level of product categories. At this level of aggregation I am then also able to compare the effect of within to cross country price dispersion on consumer well-being by computing (average) price levels at the level of *Nuts 2* regions. The econometric details to implement equation (5) are explained in the next section.

Figure 4: Price differences at the level of individual goods

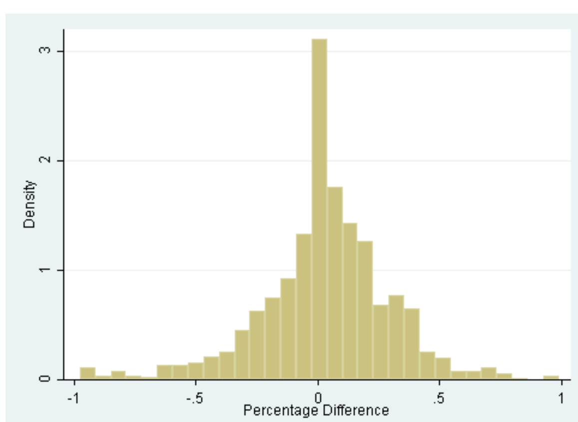
(a) Belgium and Netherlands



(b) Belgium-Germany



(c) Netherlands-Germany



Notes: Histogram of percentage price differences between Belgium-Netherlands, Belgium-Germany and Netherlands-Germany. For example, positive values in the top panel indicate that the average price of a good is larger in Belgium than in the Netherlands. On the x-axis the percentage difference is plotted. Results are for January 2005.

Table 2: Price dispersion and consumer well-being at the level of individual goods

	Pair 1		Pair 2		Pair 3	
	Belgium (1)	Netherlands (2)	Belgium (1)	Germany (2)	Netherlands (1)	Germany (2)
			Aggregate Level			
Goods	27463	27616	27463	74774	27616	74774
Common Goods	2745	2745	1016	1016	1319	1319
Households	2549	3672	2549	10580	3672	10580
Affected	2392	3633	1800	7572	2852	9261
Transactions	208144	403149	208144	1204789	403149	1204789
Affected	22982	74718	6332	22269	10510	44747
Expenditure	379222	411951	379222	1300000	411951	1300000
Affected	29363	71253	10628	26208	12211	45199
			Household Level			
Expenditure Share	0.09	0.18	0.04	0.03	0.04	0.04
Goods Share	0.11	0.19	0.03	0.02	0.03	0.04
CV: Prices from (1)	0.00	5.40	0.00	0.76	-0.00	0.22
CV: Prices from (2)	-1.54	-0.00	-0.80	0.00	0.36	0.00

Notes: This tables contains results on the effects of price differences (at the level of individual goods) on consumer expenditure. The top part (under the heading Aggregate Level) provide information on the number of goods sold in both countries and the amount of expenditure covered. The lower part (under the heading Household Level) reports results on the mean value for the compensating variation and the mean value of goods affected at the household level. Results are for January 2005.

5. Econometric Implementation

In this section, I provide details on the implementation of equation (5), i.e. the measurement of the expenditure shares w_n, the own-price elasticities $\epsilon_{n,n}$, the cross-price elasticities $\epsilon_{n,l}$ and the price differences $\Delta \ln p_n$.

In a first step, I have to take a stance on the level of regional aggregation (i.e. the meaning attached to the subscripts i and j appearing in equation (5)). I choose to work at the level of *Nuts 2* regions.[36] For each household I observe the postal code of his residence address and use it to match him to one of the 62 *Nuts 2* regions in Belgium, Germany and the Netherlands.[37] The level of regional aggregation was chosen to satisfy two criteria: Allowing for enough within county heterogeneity while at the same time having large enough sample to compute the relevant parameters appearing in equation (5).[38]

In a second step, I have to take a stance at the appropriate level of aggregation for the products included in the data set. Since estimating demand parameters at the level of individual goods is, at least in the set-up considered here, in-feasible, I decided to use the aggregation level of *product categories* as my baseline specification. This means that I suppose that all products belonging to a given category share enough common characteristics, so as to be treated the same for the perspective of estimating the demand system. Since the categories are still vary narrow, I think that this level of aggregation is appropriate. The reason for choosing this level of aggregation was again twofold: Allowing for enough detail on the number of products while at the same time having large enough sample to compute the relevant parameters appearing in equation (5).[39]

[36] Nuts stands for *Nomenclature des units territoriales statistiques* and is commonly used in regional studies and also by Eurostat to provide regional specific statistics. The 2 stands for the level of aggregation within a country, for Germany it corresponds to the so-called *Regierungsbezirke*.

[37] The assignment is done using matching tables provided by Eurostat, available at http://ec.europa.eu/eurostat/en/web/nuts/correspondence-tables/postcodes-and-nuts.

[38] Another reason for choosing the Nuts 2 regions is the availability of regional specific information from Eurostat.

[39] As explained below, I use the Almost Ideal Demand System to estimate parameters. In such

5.1. Preference parameters

Given the choice of product categories, there are two sets of preference parameters that need to be estimated in order to implement equation (5): Expenditure shares on product categories $n = 1, \ldots, N$, w_n, and the (compensated) own- and cross-price elasticities between goods n and l, $\epsilon_{n,l}$. In a first step, I obtain household specific expenditure shares by dividing, for each household, (monthly) expenditure on product category n by total (monthly) expenditure. This gives me, for each household, a vector of expenditure shares $\mathbf{w}_h = (w_h^1, \ldots, w_h^N)$. In a second step, I estimate an *Almost Ideal Demand System* as introduced by Deaton & Muellbauer (1980), using monthly expenditure shares (and average monthly prices paid). I then recover the elasticities $\epsilon_{n,l}$ from the estimated demand system. Formally I suppose that the share of expenditure devoted to category n by household h can be expressed as

$$w_n = \alpha_n + \sum_{k=1}^{N} \gamma_{nk} \ln p_k^h + \beta_n \ln \left[\frac{x^h}{a(\mathbf{p})} \right] + u_n^h \tag{7}$$

where N is the number of categories considered. p_k is average price of products in category k paid by household h and x^h is the total monthly expenditure on *fast-moving consumer goods* and $a(p)$ is a price index. I estimate equation (7) for each country separability.[40] [41] [42]

5.2. Prices

In a final step, I need to compute for each region pair (i, j) the price differences for the N different product categories. I construct these difference in the fol-

studies, it is common to use relatively broad categories of goods.

[40]If a household has $w_n^h = 0$ for some n, then I use the average price in his region for product category n as the price variable.

[41]Estimation is undertaken using the Stata routine *quaids*.

[42]In principle, one could also estimate, in most cases, the model at a regional level (i.e. for each Nuts2 region separately). However, since I am interested in the welfare consequences arising from price differences I think that imposing a common elasticity structure across regions is suitable.

lowing way. For a given country pair, I first identity all common goods (by comparing the *EAN* assigned to goods) and then compute the average price for each region and for each category for these goods. I then compute the difference between the (logarithm) of the average price per category in region k and region i. This method of computing the average price has the benefit that only identical goods are used to quantify price difference , i.e. there should be no effects of different product quality (i.e. meat could be of higher quality in Belgium than in Germany) or package size. One drawback of this method to compute average prices is that a larger share of goods are not considered in computing the average price.[43]

6. Descriptive Evidence

In this section, I provide descriptive statistics on the compensating variation for households of Belgium, Germany and the Netherlands. For each household, 62 compensating variations are computed (with respect to the prices in the 61 other *Nuts 2* regions and with respect to his home region - where the compensating variation is 0 by construction) according to equation (5). I start, in the next subsection with a first-order approximation covering a large number of categories and then investigate the importance of adding the second-order terms by focusing on the case of beverages for Belgium and the Netherlands.

6.1. First-order approximation

In this section, I work, for each country pair, at the level of product categories. I include only those product categories in the computation of the compensating variation, for which I am able to compute average prices in all *Nuts 2* regions of the considered country pair. The first set of evidence is provided in

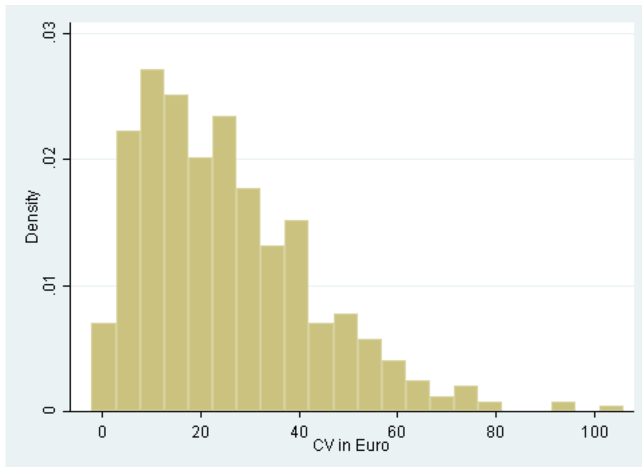
[43]As a robustness check, I also compute price differences by using all products (with the same package size and volume) in order to compute the mean price for category n in region j. The results using this measure for price differences tend to be larger than the ones reported here.

Figure 5, where I consider panel members from Berlin. In the top panel of Figure 5, I show the histogram of the compensating variation for panel members from Berlin with respect to prices in Brussels. As one can see, for almost all panel members the compensating variation is positive - i.e. they would need to increase their expenditure if they were faced with prices from Brussels (and would stick to their consumption patterns). For most panel members the compensating variation is in the range of 15 to 40 Euro. As I am working at a monthly frequency, one can conclude (if consumption patterns are stable over time) that the annual effect is in the range of 180 to 480 Euro of additional expenditure that a household from Berlin would need to incur, if he faced the prices from Brussels. The variation in the size of the compensating variation is attributable to the fact that different households have different expenditure shares (and different overall expenditures) and thus are affected differently by price differences. The lower panel of Figure 5 contains the average values (across all panel members) of the compensating variation (expressed in percentage points of initial expenditure) from households from Berlin with respect to the other regions in Belgium and Germany. For each region, I split up the total compensating variation into the contribution of the different product categories - where different categories are indicated by different colors. While there does not seem to be a clear pattern for the contribution of the different categories for comparison regions from Germany (the relatively low values on the right part of the figure), there is clear evidence that all categories tend to be more expensive in Belgium (and hence contribute to a larger compensating variation). The biggest contribution comes from the categories of (fresh) meat and vegetables.

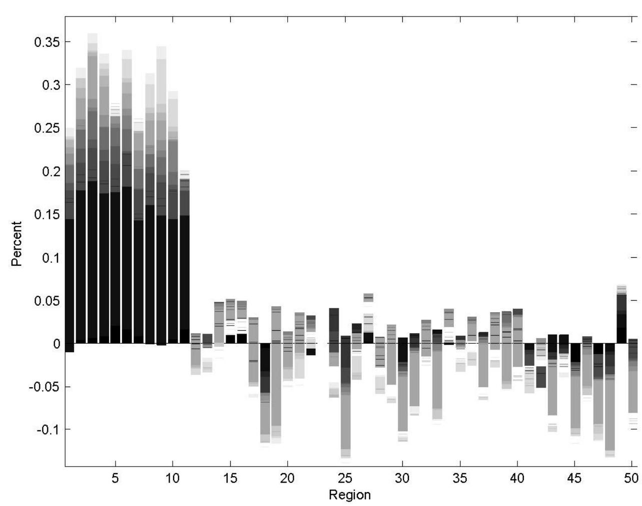
As a second example, I consider the *Nuts 2* regions to which Amsterdam, Berlin and Brussels (i.e. the capitals of the three countries under consideration) belong and show on a color-map in Figure 6 the (mean across all households from the regions to which the capital belongs) compensating variation with respect to prices from the other *Nuts 2* regions. I do this, for each capital region, with respect to the prices in the two other countries separately. The rea-

Figure 5: Compensating Variation: Households from Berlin

(a) Households from Berlin, Prices from Brussels



(b) Contribution to Compensating Variation



Notes: The top panel shows the compensating variation for households from Berlin with respect to prices from Brussels, when only common goods are used to quantify price differences. The lower panel shows the average compensating variation for households from Berlin with respect to prices from other regions in Belgium and Germany and shows the contribution of different product categories to the compensating variation.

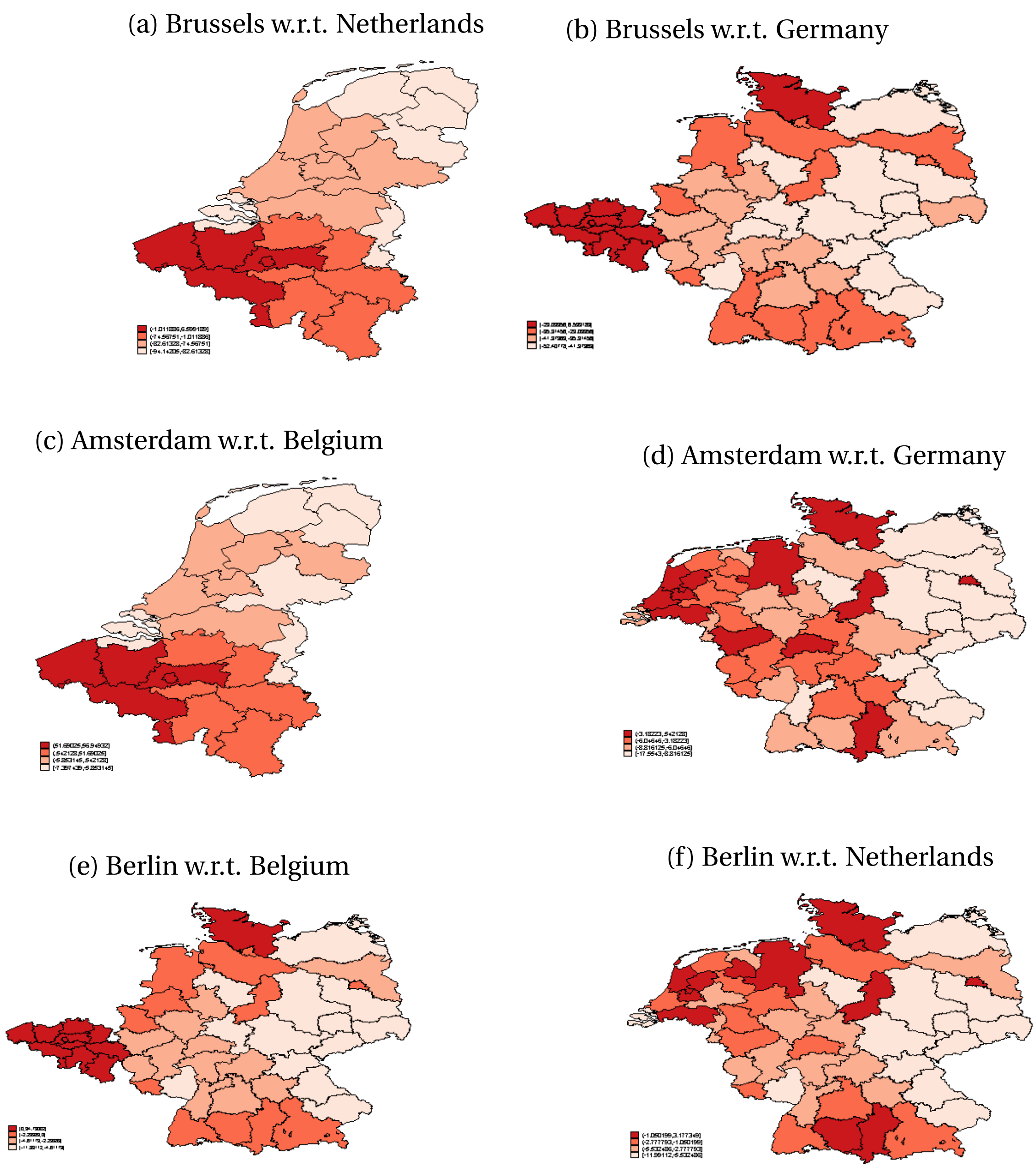
son for this is the fact that the compensating variation is computed for different product categories for the the different country pairs: For the case of Belgium and the Netherlands more categories are included in the computations than for Germany and Belgium and Germany and the Netherlands. Therefore the overall size of the compensating variation differs between country pairs. Regions which are colored with a darker red are regions for which the absolute value of the compensating variation is larger. For example, the top right panel of Figure 6 covers the case of households from Brussels and prices from different regions in Belgium and the Netherlands. While the compensating variation is relatively low (in absolute values) for regions in Belgium, the compensating variation becomes very large for regions in the Netherlands. Households from Brussels could save substantially if they were faced with prices from regions in the Netherlands.

In Table 3 I provide information about the mean value of the compensating variation. The average compensating variation for Belgian households with respect to price in other Belgian regions is very close to 0, indicating a strong degree of within country market integration. However, the average compensating variation is quite large, if one considers the case of German or Dutch prices. On average a Belgian household could reduce his expenditure by 46 Euros if he faced prices form Germany prices and by 82 Euro if he faced prices from the Netherlands.[44] [45] This indicates that markets for retail goods are considerably less integrated across nations than within. Comparing these numbers to average monthly expenditure, one sees that Belgian households could decrease their expenditure by about 40 percent if they faced German prices. Given that, in our sample, the average Belgian income is lower than the average German income, one can conclude that Belgian households (viewed from the perspective of the *fast-moving consumer good* market) are facing a retail market which

[44]The value for the Netherlands is lager since it covers a larger number of product categories.

[45]And, to the extent that the consumption patterns are similar across months, they could spend $12 \cdot 46 = 552$ Euro less per year and have the same level of well-being if they faced German prices.

Figure 6: Compensating Variation: Capital Regions



Notes: Each panel shows the average compensating variation for households from a capital region with respect to prices in other regions. The darkness of the red indicates of a region indicates the (mean) absolute size of the compensating variation of the considered capital region with respect to that region.

is not very beneficial to them.

Table 3: Average Compensating Variation

	Prices from region in					
	BE	**NE**	**BE**	**GER**	**GER**	**NE**
BE Households	-1.27	-82.52	-1.66	-46.76	.	.
GER Households	.	.	36.40	-0.38	0.01	-5.91
NE Households	51.97	-1.69	.	.	4.79	-0.46

Notes: Average compensating variation, for households from Belgium (BE), Germany (GER) and the Netherlands (NE) with respect to prices in the other regions of Belgium, Germany and the Netherlands. Each row considers households from one country, and each column covers the different price scenarios. For example, in the row for Belgian households the first element is the average compensating variation for households from Belgium w.r.t. prices in regions of Belgium and the second element w.r.t. prices in regions of the Netherlands.

In summary, one can already see from Table 3 that within country price dispersion and the associated compensating variation is small compared to the effect of cross country price dispersion. This indicates that retail markets tend to be more integrated within countries than across. The low values within countries are probably due to the presence of large nationwide retailers, who tend to follow a national pricing strategy so as to avoid competition between different outlets. Also one can note that the effects of price dispersion on compensating variation are not symmetric (i.e. the effect for a Belgium household with respect to German prices is larger than the effect for a German household with respect to Belgian prices). This reflects to a large degree different purchases patterns across countries. For example, Belgian households tend to devote a large share on expenditure categories that are very expensive in Belgium but cheap in Germany and thus could save a lot if they faced German prices.

In Figure 7, I show the mean of compensating variation for different *Nuts 2* regions. To construct the plots, I compute, for example, for Belgian households the average compensating variation for each of the 11 regions in Belgium. Then

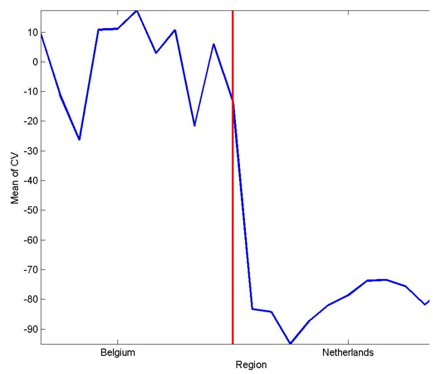
I compute for Belgian households the average compensating variation for each of the 12 regions in the Netherlands. The result of this computation appears in the top left panel of Figure 7. The x-axis covers all 23 regions, belonging to the Belgium and the Netherlands. The border is indicated by a vertical red lines. One sees, as already documented in Table 3, that within country the compensating variation is low. But as soon as prices from other countries are used, the compensating variation becomes more negative. The lower right panel of Figure 7 contains the results for German households and regions in Germany and the Netherlands. One sees that for this situation the difference between the compensating variation for regions in Germany and regions in the Netherlands is much smaller than for the cases where Belgium is considered. This indicates (even though there are, as documented in Figure 4, substantial differences in prices) a relatively higher level of market integration between Germany and the Netherlands than between Germany and Belgium. The reason for the low values of the compensating variation for this case are that some goods are more expensive in Germany and some are more expensive in the Netherlands. But for an average consumer basket these price effects tend to offset each other. This is an insight which could not be obtained in a setting of equation (1), where only price differences for single goods are considered.

The jumps in the compensating variation at the borders, indicated by the red lines in Figure 7, as well as the relatively large (in absolute value) elements off the main diagonal in Table 3 indicate that national markets for *fast moving consumer goods* are not as well integrated across countries than within.[46] In the next section, I therefore perform a simple regression analysis (which is inspired and similar to the regression given in equation (1)) relating compensating variation to borders and (to capture transaction costs) a distance measure.

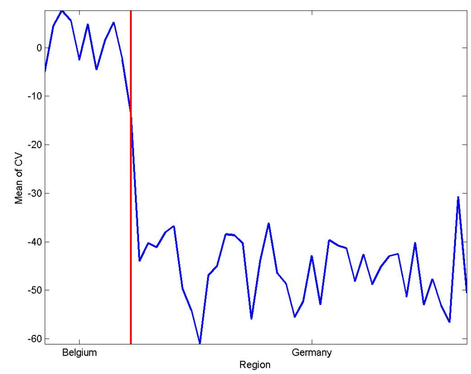
[46]With the possible expectation of Germany and the Netherlands, for which compensating variations tend to be lower.

Figure 7: Compensating Variation: Mean per Region

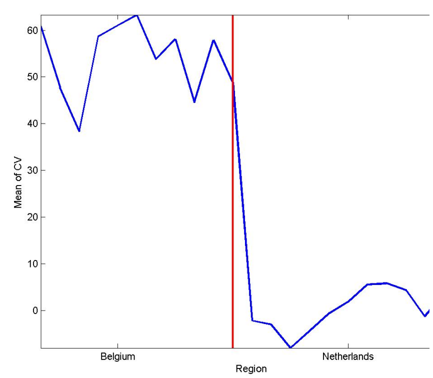
(a) BE (compared to NE)



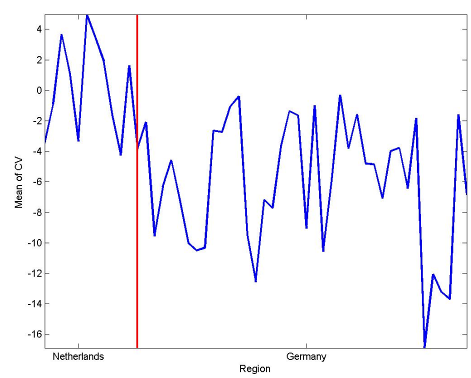
(b) BE (compared to GER)



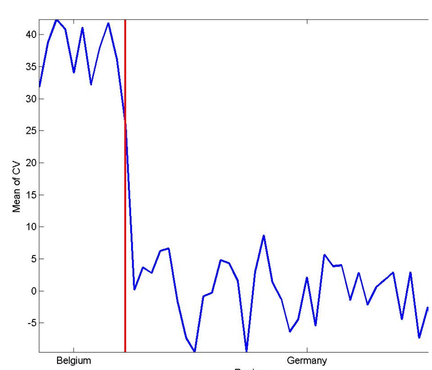
(c) NE (compared to BE)



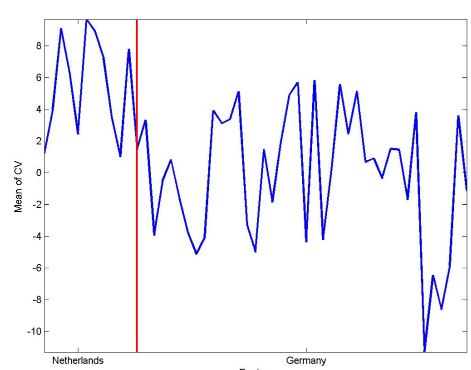
(d) NE (compared to GER)



(e) GER (compared to BE)



(f) GER (compared to NE)



Notes: Average compensating variation for households from Belgium (BE), the Netherlands (NE) and Germany (GER) with respect to prices in the other Nuts regions of the three countries. Red lines indicate where a new country starts, whose name is given on the x-axis. On the y-axis the compensating variation is plotted in Euro.

6.2. Second-order approximation using beverage categories

The results described in the previous section were based upon a first-order approximation to the compensating variation - i.e. they were based on the implicit assumption that consumers do not change their behavior if (relative) prices change. In this section I investigate the implications of allowing for such changes in behavior: Consumers can either reduce their demand (an effect captured by the own price elasticity $\epsilon_{n,n}$ in equation (5)) or they can substitute to cheaper product categories (captured by the cross price elasticity in equation (5)). I do this by focusing on beverages and the country pair Belgium-Netherlands. In a first step, I compute own- and cross-price elasticities for 6 beverage categories by estimating an Almost Ideal Demand System for the budget shares devoted to the six categories. I then use the estimated elasticity estimates (together with the expenditure shares and price differences) to evaluate equation (5).

Elasticity estimates are reported in Table 4. The top panel contains the estimation results for Belgium and the lower panel the results for the Netherlands. All own price elasticities $\epsilon_{n,n}$ (the elements on the main diagonal) are, as one would expect, negative: Higher prices for a category tend to lower demand. Cross-price elasticities $\epsilon_{n,l}$ (the elements not on the main diagonal) are (in most cases) positive, indicating that most of the goods are substitutes. However the size of the substitution effect tends to be small. (This is due to the level of aggregation considered in the estimation. Consumers view Beer and Champagne not as very good substitutes. Studies using similar levels of aggregation find similar values for substitution elasticities. See, for example, Tiffin et al. (2011)).

Using the elasticity estimates appearing in Table 4 I then compute the compensating variation according to equation (5). I here only present a few results indicating that first- and second order approximations are highly correlated. The correlation coefficient between the first-order approximation and the second-order approximation is (across all households from Belgium and the Netherlands) is around 0.82 - indicating a strong dependence between the two

Table 4: Elasticity estimates

(a) Belgium

Alc. free (No CO2)	Alc. free	Beer	Hot Drinks	Champagne	Liquor	Wine
-0.7516	0.2681	0.1501	0.2067	0.0156	0.0522	0.0590
0.3757	-1.3338	0.3391	0.3927	0.0462	0.0112	0.1689
0.2149	0.4694	-1.4550	0.4312	0.0323	0.0977	0.2094
0.1360	0.1442	0.1423	-0.4818	0.0170	0.0200	0.0222
0.2096	0.5994	0.3001	0.4990	-0.2439	0.0844	-1.4485
0.7014	0.2082	1.0929	0.3164	0.1052	-2.2512	-0.1729
0.1534	0.3700	0.3317	0.1333	-0.2542	-0.0429	-0.6913

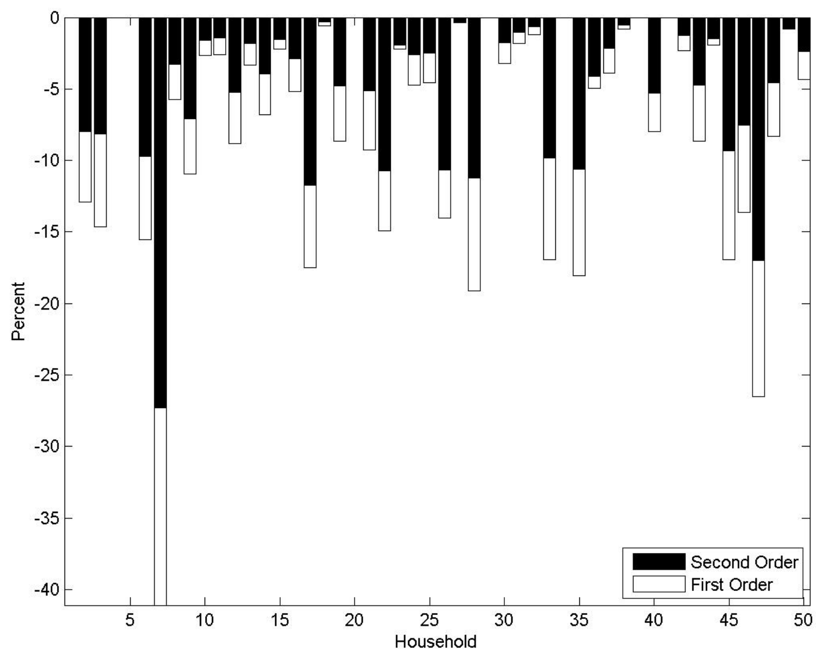
(b) Netherlands

Alc. free (No CO2)	Alc. free	Beer	Hot Drinks	Champagne	Liquor	Wine
-0.8223	0.1698	0.1960	0.4224	0.0052	0.0334	-0.0044
0.2007	-1.0564	0.3025	0.2598	0.0265	0.0377	0.2293
0.4602	0.4032	-1.2894	0.1431	0.0262	0.1426	0.1141
0.1775	0.0840	0.0863	-0.3676	0.0096	0.0131	-0.0029
0.1181	0.3447	0.1730	0.3566	-1.5590	0.7013	-0.1346
0.5961	0.4220	1.4080	0.1638	0.6886	-5.1638	1.8854
0.1382	0.4881	0.2465	-0.2376	-0.0123	0.3302	-0.9532

Notes: Own- and cross price elasticities for six beverage categories from Belgium and the Netherlands. Based upon estimates of an Almost Ideal Demand System.

measures. This evidence is also confirmed in Figure 8, where I plot for a random sample of households from Brussels the compensating variation with respect to prices from Amsterdam. While the second-order approximation leads to lower (in absolute value) measures for the compensating variation, there is a noticeable positive relationship between first- and second order approximation.

Figure 8: Compensating Variation: First-order versus Second-order approximation



Notes: First- and second-order approximation (expressed as a share of initial expenditure) to the compensating variation for a sample of households from Brussels with respect to prices of beverage products from Amsterdam.

7. The Effect of Borders

In this section, I provide evidence on how national borders affect the level of compensating variation between two regions (using the first-order approximation described above). But before doing this, I first present results from the standard regressions based upon simple price differences between regions.

7.1. Engels-Rogers Approach

In Table 5 I present the results of a regression of type outline in Section 2. above. I estimate

$$q^a_{i,j} = \alpha_0 + \alpha_j + \beta \ln d_{ij} + \delta B_{i,j} + u_{i,j} \tag{8}$$

and report the estimated coefficients β and δ in Table 5. To obtain these results, I first identify common products for the country pairs Belgium-Netherlands, Belgium-Germany and Germany-Netherlands and then construct the percentage price deviation for each of these products between the regions in which it is sold.[47] One can see that borders do significantly affect the observed degree of

Table 5: Effect of Borders on Price Dispersion

	(BE-NL) Dispersion	(BE-GE) Dispersion	(NL-GE) Dispersion
distance	-0.00121*	0.00386***	0.00343***
	(-2.14)	(7.73)	(10.67)
border	0.188***	0.414***	0.119***
	(132.21)	(292.56)	(118.99)
Region 1 f.e.	Yes	Yes	Yes
Region 2 f.e.	Yes	Yes	Yes
Observations	2327077	1130278	3032412

t statistics in parentheses,* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

price dispersion. However, as argued above, it is hard to understand and quantify the economic importance of these results and, in addition, it is difficult to

[47] Not all of the products are sold in all of the regions of the considered country pairs.

compare them between the considered country pairs. (I.e. it is not sensible to say things like *The border between Belgium and Germany is three times as important as the border between Belgium and the Netherlands*). Therefore I now turn to an investigation of the importance of borders using the new measure developed above.[48]

7.2. Compensating Variation

In this section I investigate if and how the fact that two regions i and j belong to different countries affects the size of the compensating variation for a consumer living in region i with respect to prices from region j (and vice versa). More precisely, let $CV_{h,i}^{j}$ be the compensating variation for consumer h from region i with respect to prices from region j. Then I estimate the equation

$$CV_{h,i}^{j} = \alpha_0 + \alpha_j + \beta \ln d_{ij} + \delta B_{i,j} + u_{i,j}^{h} \tag{9}$$

where $\ln d_{i,j}$ is the logarithm of the distance between regions i and j and $B_{i,j}$ is an indicator variable taking on the value 1 if regions i and j belong to different countries.[49] For each country, I estimate the equation for each of the other two country separately. In total I thus obtain 6 sets of estimates for equation (9). For example, I estimate the equation for households from Belgium and consider the compensating variation with respect to the different regions in Germany and the Netherlands. In the case of households from Belgium and regions in Germany, the estimated coefficient on the border indicator thus summarizes the average effect of the border on the size of the compensating variation between regions in the two countries. The estimated coefficient δ thus has an easy interpretation in monetary terms (compared to the difficult interpretation as-

[48]Translating the estimated border coefficient into distance equivalents as explained in equation (2) is here not possible, since the estimated distance coefficients are too small relative to the border coefficients.

[49]Distance between regions is computed using the Haversine formula. The required latitude and longitude data for each region i are computed as the average of the latitude and longitude data of the households (and their zip code ares) in region i.

sociated with the border coefficient in the standard approach given by equation (1)).[50] I report estimate for the case of the first order approximation described above (and adding, for comparison, the case where I compute the price difference between regions by using all goods instead of just *EAN* identical goods).

The results for this estimation are contained in Table 6 and 7. Starting with the top panel of Table 6, which covers the case of Belgian households, one sees that for an average household from Belgium the border with respect to the Netherlands is equivalent to a reduction in expenditure of 96 Euro (while remaining at the same level of well-being as with Belgian prices). If all goods are used to quantify price differences, the value changes to 98 Euro. For the case of German prices, the estimated border coefficient is also negative - i.e. Belgian household could reach the same level of well-being with less expenditure if they faced German prices. The interpretation for the remaining cases is similar. One think to note is that, although most of the distance coefficients are statistically significant, they are either very small (or in many cases even negative). This is somewhat surprising, since one should expect that price differences (and hence their welfare consequences) of regions further apart should increase with distance. However, as alluded to above, the retailers selling these goods are often national wide retail chains that (potentially) follow a nation wide pricing strategy, thus reducing (or maybe even eliminating) the effect of distance on the degree of compensating variation due to distance.[51]

8. Conclusions

In this paper I propose a new approach towards measuring the effect of national borders on market integration. While the traditional approach, as introduced by Engel & Rogers (1996) and used in many studies afterwards, focuses on the

[50] Implicitly, I assume here - as is done in many studies employing the standard approach - that only the distance and border indicator are responsible for differences between regions.

[51] In further work, I will investigate if and how the degree of within country compensating variation changes when focusing on a single retail chain.

Table 6: Effect of Borders on Compensating Variation

(a) Belgian households

	Common goods		All goods	
	w.r.t. NE	w.r.t. GER	w.r.t. NE	w.r.t. GER
distance	0.0255***	0.00380	0.0117*	0.00381
	(4.69)	(1.35)	(2.36)	(0.74)
border	-96.21***	-41.98***	-98.40***	-102.7***
	(-53.66)	(-55.38)	(-60.12)	(-74.05)
Region 1 f.e.	Yes	Yes	Yes	Yes
Region 2 f.e.	Yes	Yes	Yes	Yes
Observations	58627	127450	58627	127450

(b) Dutch households

	Common goods		All goods	
	w.r.t. BE	w.r.t. GER	w.r.t. BE	w.r.t. GER
distance	-0.00455**	0.000115	-0.00593***	-0.00206***
	(-2.91)	(0.31)	(-3.49)	(-4.73)
border	59.58***	-6.124***	67.81***	-6.079***
	(94.25)	(-22.27)	(98.72)	(-19.04)
Region 1 f.e.	Yes	Yes	Yes	Yes
Region 2 f.e.	Yes	Yes	Yes	Yes
Observations	84456	187272	84456	187272

Table 7: Effect of Borders on Compensating Variation 2

(a) German households

	Common goods		All goods	
	w.r.t. BE	w.r.t. NE	w.r.t. BE	w.r.t. NE
distance	-0.00105***	-0.00104***	-0.00256***	-0.00118***
	(-8.31)	(-16.70)	(-11.57)	(-17.71)
border	32.77***	-2.067***	86.92***	3.411***
	(219.97)	(-27.32)	(332.97)	(42.16)
Region 1 f.e.	Yes	Yes	Yes	Yes
Region 2 f.e.	Yes	Yes	Yes	Yes
Observations	529000	539580	529000	539580

t statistics in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

(regional) price differences of goods one at a time, I develop an approach that tries to measure the ”costliness” of borders to consumers by looking at all prices that enter a consumers shopping basket. This approach starts with the concept of the compensating variation, which is the amount to be given to a household (taken away from a household) if prices he has to pay increase (decrease) so as to leave him as well off after the price change as he was before.

I apply this concept to regional price differences between *Nuts 2* regions of Belgium, Germany and the Netherlands. In a first step, I provide evidence on the importance of price dispersion (at the national level) and show, in Table 2, that only a small part of a typical consumers shopping basket is devoted to goods that are sold in more than one country. Focusing on this small part of the basket, I provide evidence that Belgium is more expensive than the Netherlands and Germany. I then argue that one can use the price differences of identical goods to calibrate overall price differences between regions. To do this I develop an econometric framework which allows me to implement the computation of the compensating variation at the level of individual households. (The framework involves the estimation of own- and cross- price elasticities in an *Almost Ideal Demand System*). Using this framework I estimate the relevant parameters (namely expenditure shares, own- and cross-price elasticities and price differences between regions) for a sample of 62 *Nuts 2* regions of Belgium, Germany and the Netherlands.

I report that markets tend to be more integrated within countries than between countries as measured by the compensating variation: The compensating variation tends to be lower if one compares prices from regions in one country compared to comparisons, where regions belong to different countries. I also find considerable disintegration between the markets of Belgium and Germany and Belgium and the Netherlands. This is surprising, since these markets should by law, regulation, language (for the case of Flandern and the Netherlands) and currency be very integrated: There exist free movement of persons between these countries, there are no restrictions on importing goods from the other countries, regulations and value added tax rates are similar and all prices are expressed in the same currency. Therefore, I will in further research investigate possible reasons for this observed degree of disintegration.

Finally, from a theoretical viewpoint one of the benefits of my new approach can be seen by comparing the results on the importance of the border between Germany and the Netherlands in my approach (as given in equations (5) and (9)) and the traditional approach (as given in equation (1)). While the traditional approach finds a strong effect of borders on price difference I do find that these price differences are only of modest economic importance. Even though the border coefficient in (9) (as reported in Table 6) is statistically significant, the implied effect on consumer well-being is relatively small: The price differences are associated with modest values for the compensating variation. As alluded to above, these small values arise because the pattern of price differences is not uniform: Some goods are more expensive in Germany, some are more expensive in the Netherlands and the effects cancel in a typical consumer basket. This is not the case for Belgium, where prices tend to be, for most goods, higher than in either Germany or the Netherlands. This is reflected in the high values of the border coefficient in equation (9) (as reported in Table 6).

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Appendix: Derivation of equation (5)

To derive the approximation to the compensating variation provided in equation (5) we start with the definition of the compensating variation

$$CV_{h,i}^{j} = \underbrace{e(\mathbf{p}_j, V_i)}_{a} - \underbrace{e(\mathbf{p}_i, V_i)}_{b},$$

which can be interpreted as a function of $\mathbf{p}_j = (p_j^1, p_j^2, \ldots, p_j^N)$.

Taking a second-order Taylor expansion of this function around $\mathbf{p}_i$ yields

$$\begin{aligned} CV_{h,i}^{j} \approx\ & \underbrace{e(\mathbf{p}_i, V_i) + \sum_{n=1}^{N} \frac{\partial e(\mathbf{p}_i, V_i)}{\partial p_i^n} \left(p_j^n - p_i^n\right) + \frac{1}{2} \sum_{n=1}^{N} \sum_{l=1}^{N} \frac{\partial^2 e(\mathbf{p}_i, V_i)}{\partial p_i^n \partial p_i^l} \left(p_j^n - p_i^n\right) \left(p_j^l - p_i^l\right)}_{a} \\ & \underbrace{- e(\mathbf{p}_i, V_i)}_{b}, \\ \approx\ & \sum_{n=1}^{N} \frac{\partial e(\mathbf{p}_i, V_i)}{\partial p_i^n} \left(p_j^n - p_i^n\right) + \frac{1}{2} \sum_{n=1}^{N} \sum_{l=1}^{N} \frac{\partial^2 e(\mathbf{p}_i, V_i)}{\partial p_i^n \partial p_i^l} \left(p_j^n - p_i^n\right) \left(p_j^l - p_i^l\right). \end{aligned}$$

The derivative of the expenditure function is equal to the Hicksian demand function (known as Shephard's Lemma, see for example Mas-Colell et al. (1995, Proposition 3.G.1, p. 68)):

$$\frac{\partial e(\mathbf{p}_i, V_i)}{\partial p_i^n} = h^n(\mathbf{p}_i, V_i), \quad \frac{\partial^2 e(\mathbf{p}_i, V_i)}{\partial p_i^n \partial p_i^l} = \frac{\partial h^n(\mathbf{p}_i, V_i)}{\partial p_i^l},$$

where h is the Hicksian demand function which expresses the demand for good n as a function of prices $\mathbf{p}_i$ and desired utility level V_i. Inserting this gives

$$CV_{h,i}^{j} \approx \sum_{n=1}^{N} h^n(\mathbf{p}_i, V_i) \left(p_j^n - p_i^n\right) + \frac{1}{2} \sum_{n=1}^{N} \sum_{l=1}^{N} \frac{\partial h^n(\mathbf{p}_i, V_i)}{\partial p_i^l} \left(p_j^n - p_i^n\right) \left(p_j^l - p_i^l\right). \quad \text{(A1)}$$

Using the duality theorems summarized in Figure 3.G.3 of Mas-Colell et al. (1995) we can replace the Hicksian demand functions by the Marshallian demand functions $x^n(\mathbf{p}_i, y)$ to get

$$CV^j_{h,i} \approx \sum_{n=1}^{N} x^n(\mathbf{p}_i, y)\left(p^n_j - p^n_i\right) + \frac{1}{2}\sum_{n=1}^{N}\sum_{l=1}^{N} \frac{\partial x^n(\mathbf{p}_i, y)}{\partial p^l_i}\left(p^n_j - p^n_i\right)\left(p^l_j - p^l_i\right).$$

Expanding the term

$$\frac{\partial x^n(\mathbf{p}_i, y)}{\partial p^l_i} = \frac{\partial x^n(\mathbf{p}_i, y)}{\partial p^l_i}\frac{p^l_i}{x^n}\frac{x^n}{p^l_i} = \epsilon_{n,l}\frac{x^n}{p^l_i} = \epsilon_{n,l}x^n\frac{1}{p^l_i},$$

where $\epsilon_{n,l}$ is the demand elasticity of good n with respect to the price of good l, and replacing yields

$$CV^j_{h,i} \approx \sum_{n=1}^{N} x^n(\mathbf{p}_i, y)\left(p^n_j - p^n_i\right) + \frac{1}{2}\sum_{n=1}^{N}\sum_{l=1}^{N} \epsilon_{n,l}x^n\frac{1}{p^l_i}\left(p^n_j - p^n_i\right)\left(p^l_j - p^l_i\right).$$

Finally dividing both sides by expenditure in the initial situation y, we get

$$\frac{CV^j_{h,i}}{y} \approx \sum_{n=1}^{N} \frac{x^n(\mathbf{p}_i, y)p^n_i}{y}\frac{1}{p^n_i}\left(p^n_j - p^n_i\right) + \frac{1}{2}\sum_{n=1}^{N}\sum_{l=1}^{N} \epsilon_{n,l}\frac{x^n p^n_i}{y}\frac{1}{p^n_i}\frac{1}{p^l_i}\left(p^n_j - p^n_i\right)\left(p^l_j - p^l_i\right)$$

where $w_n = \frac{x^n p^n}{y}$ is the expenditure share devoted to good n. Noting that $\frac{p_j - p^n_i}{p^n_i}$ is the percentage change in price for good n between region i and j, we can replace it with the logarithmic difference of the prices and arrive at equation (5) in the main text.

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