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Price variability and the speed of adjustment to the law of one price: Evidence from Slovakia

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Price variability and the speed of adjustment to the law of one price: Evidence from Slovakia[*]

Abstract

This paper uses a large panel data set of monthly frequency final good and service prices in thirty-eight Slovak districts over a five-year period to study price variability and the working of the law of one price. We concentrate on three issues. First, using simple statistical tools, we investigate the range of price differences across Slovak districts. Second, we measure relative price variability across cities and across products. The variability of relative prices in the same district appears to be higher than the variability of prices of the same good across different districts. We identify the factors likely to be responsible for this fact. Third, using benchmarks we investigate the speed of convergence to the absolute law of one price. While we find evidence for absolute convergence, the speed is lower than that found in US cities. The speed of convergence to the relative law of one price is considerably higher.

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Julius Horvath and Stanislav Vidovic

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Tiivistelmä

Tässä työssä tutkitaan yhden hinnan lain toteutumista ja hintojen vaihtelua laajan hinta-aineiston avulla. Käytössä on kuukausittaisia havaintoja yksittäisten tavaroiden ja palveluiden hinnoista Slovakian 38 hallintoalueesta viiden vuoden ajalta.Ensiksi selvitetään yksinkertaisilla tilastollisilla menetelmillä hintojen vaihtelua Slovakia hallintoalueiden välillä. Seuraavaksi mitataan suhteellista hintavaihtelua tuotteiden ja kaupunkien välillä. Suhteellisten hintojen vaihtelu hallintoalueiden sisällä näyttää olevan suurempi kuin yksittäisten tuotteiden hintojen vaihtelu hallintoalueiden välillä. Tutkimuksessa selvitetään tekijöitä, jotka aiheuttavat tämän. Kolmanneksi, lasketaan kuinka nopeasti hinnat konvergoituvat absoluuttisen yhden hinnan lain määrittämään hintatasoon. Tuloksien mukaan hintakonvergenssia on, mutta sen nopeus on vähäisempi kuin yhdysvaltalaisten kaupunkien välillä. Hintakonvergenssi suhteellisen yhden hinnan lain määrittämään hintatasoon on selvästi nopeampaa.

1 Introduction

The study of the law of one price (LOOP)[1] and its aggregate version, the purchasing power parity (PPP) has a long history in international economics.[2] However, till now, only a small number of papers[3] attempted to tackle the LOOP in the context of transition economies. This paper examines the concept of the law of one price using store level price data in the context of a small open transition economy, Slovakia.

The paper begins with a direct, unconditional description of the behavior of consumer price data across regions in Slovakia and finds that they seem to be for the most part inconsistent with the simple static absolute version of the LOOP. Simply, in a given time period the differences between nominal prices seem to be too large for the LOOP to hold. In a given period of time the differences between non-homogeneous products were in some cases in hundreds of a percent. The differences are lower for homogeneous products, but 30-50 percent differences even for these products are quite common. However, most prices move together across districts and within a band.

Then, we analyze the variability of relative prices across districts and across products. Here we follow the empirical strategy proposed in Engel and Rogers (2001). Our results support the following empirical regularity: the variability of relative prices within the same district is higher than the variability of prices of the same good across different districts. The variability of the price of consumer good i relative to good j in the same district is higher than the variability of consumer good j across different districts. In other words, the price of beef relative to the price of chicken in a given district is more variable than the price of beef across all districts.

[1] The cornestore of the LOOP is consumer arbitrage across different locations. In the long run, adjusted for transportation costs, prices of goods and services measured in the same currency should be identical across all geographic locations. However, there are problems with the understanding of the LOOP even as an empirical proposition. Herrmann-Pillath (2001, p.48) writes: "adherence to the LOOP does not seem to be an empirical issue but a matter of basic beliefs about how the market mechanism works." One can be of the opinion that under market imperfections, imperfect information, prevailing disequilibria, missing contracts and high search costs there may be good reasons for the LOOP not to hold. On the other hand, there is always the argument that these frictions may disappear in the long run.

[2] The most recent discussions include, among others Engel (1993), Parsley and Wei (1996), Engel and Rogers (1996), Cecchetti, Mark and Sonora (1999), Engel and Rogers (2001), Haskel and Wolf (2001), Imbs, Mumtaz, Ravn and Rey (2002), and O'Connel and Wei (2002).

[3] See Conway (1999), Cushman, MacDonald and Samborsky (2001), Wei and Fan (2002), Ratfai (2003) and Vidovic (2003).

Finally, we also investigate relative price reversion to a common mean employing the panel unit root test of Levin and Lin (1992). In the international context it is often demonstrated that mean reversion in relative prices does occur but that it is slow, taking between three and five years. We ask whether these results also hold for regions inside the currency area. In general, one may expect faster price convergence across regions than across countries, as is documented for developed market economies.[4] For Slovakian regions, this is less obvious. On one hand, there are good reasons to expect Slovak regions to be integrated with each other. These regions have the same heritage and language (some exceptions may be found in the southern regions but even there Slovak is widely used), and had largely free capital, labor and product markets during the period under investigation. Also these regions share the same currency and the distance between them is insignificant. On the other hand, there is a tendency in Slovakia toward pronounced economic disparities across regions.[5] The empirical results show that there is evidence of convergence to the LOOP in Slovak data. However, our results indicate that the speed - while faster than typically found in cross-country data - is lower than that found in US cities.

This paper is structured as follows. In Section 2, we describe the price data. In section 3, we take a first glimpse at the data. In Section 4, we measure the variability of relative prices across products and districts. In Section 5, we measure the speed at which prices converge, and in the last Section, we summarize and conclude.

2 The data

Our data set contains monthly frequency nominal prices for more than five hundred final goods and services from 38 Slovak districts over the period from January 1997 to December 2001.[6] The data are thus three dimensional, the dimensions being time, commodity,

[4] However, Cecchetti, Mark and Sonora (1999) find that deviations from city purchasing power parity are more persistent than deviations from international PPP.

[5] This is well documented in Kárász, Kárász and Pala (2000) and World Bank (2002).

6 At this time the Slovak economy had moved away from the monetary overhang that was inherited from the past and possibly impacting on relative prices. Also, as some prices - especially in transportation and utilities - were tightly regulated and the Central Bank of Slovakia pursued a relatively tight monetary policy in this period, the inflation rate was low as compared to the early 1990s.

and district.[7] Store identifiers are not available in the sample. The full data set includes tradable and nontradable goods and services, homogeneous and heterogeneous products.[8] Depending on the aim of the particular investigation, we also select sub-samples from the data. For purposes of the empirical analysis, we calculate district specific cross-store averages from the individual prices.

These data serve as the basis for calculation of the consumer price index by the Slovak Statistics Office (SSO), which provides explicit instructions and data forms to data collectors. The collector typically obtains the data by visiting the premises (shops) by the 20th of the respective month. Then data are sent to a particular branch of the Statistics Office. The explicit instructions of the SSO allow consideration of domestic as well as imported goods and goods of different quality, but not goods of lower than the 'first quality category.' The consumer prices of final goods and services are provided inclusive of value-added tax. Collectors of price data may use sale prices of products that are accessible to all consumers. SSO encourages this, especially if these sales are temporary and it is expected that the products will be sold again at 'normal' price. Importantly, the data set contains actual prices rather than quoted prices or price indices. The stores are selected by the SSO representative and may include privately and publicly owned stores. In case a store is not operating any more, it is replaced by a comparable store in the same district, but only upon prior approval of the SSO branch office. It is important to note that SSO collects prices from at least three different stores in each district. For food and catering in the services sectors, cheaper, middle level, and high price stores are considered. In apartment rent prices, at least two prices are provided: one from the downtown (city center) and the other from the outskirts.

The products in the sample represent basic foodstuff, alcoholic beverages and tobacco, as well as clothing, footwear, housing, water, electricity, gas and other fuels as well as furnishings, household equipment and home maintenance. Finally, the data set also contains

7 We use the regional division in Slovakia with 38 districts. The data collected in the sample are almost exclusively taken from the capital cities of the districts. The districts are the following: Bratislava, Bratislava-vicinity, Dunajská Streda, Galanta, Senica, Trnava, Považská Bystrica, Prievidza, Trenčín, Komárno, Levice, Nitra, Nové Zámky, Topolčany, Čadca, Dolný Kubín, Liptovský Mikuláš, Martin, Žilina, Banská Bystrica, Lučenec, Rimavská Sobota, Veľký Krtíš, Zvolen, Žiar nad Hronom, Bardejov, Humenné, Poprad, Prešov, Stará Ľubovňa, Svidník, Vranov nad Topľou, Košice, Košice-vicinity, Michalovce, Rožňava, Spišská Nová Ves, Trebišov.

8 By homogeneous product we mean an item that consumers may consider as perfectly (or almost perfectly) substitutable across different suppliers.

prices on health; transport; restaurants and hotels catering and accommodation services; personal care; recreation; and culture. Consequently the data set contains low priced items (matches, salt) as well as expensive items (durables). It also contains some nationally recognized Slovak brand names.

3 A first glimpse

In this Section we carry out a preliminary analysis of the degree of deviation from the LOOP. Our data set allows us to abstract from the effects of nominal exchange rates, trade policies, and similar issues arising in an international context. With disaggregated data on actual consumer prices for different types of products, we also avoid aggregation problems associated with using sector level price indices. On the other hand we are aware of the fact that by not using general price indexes, but instead using nominal absolute average prices of selected individual goods, our data set may seem to be too specific. In this respect Haskel and Wolf (2001) note the following: “abandoning price indices for actual transaction prices comes at a cost: by necessity, any group of products selected has some ‘special’ characteristics that may limit the extent to which finding for that group can be generalized.” At the same time, if any version of the law of one price is to hold, it should hold on the individual level if it is to hold at all.

We begin with some simple data checks. First, Slovakia consists of eight basic regions. The World Bank (2002) compares regional GDP per capita at purchasing power and finds that in 1999 the Bratislava region was approximately 100% of the EU average, and all other regions were at 50% or below. Of the remaining seven regions, the Prešov region was the poorest, at 32% of the EU average. In light of this difference, one might expect that Bratislava-region prices would be higher than prices in the Prešov-region, especially for key products in daily consumption. Figure 1 gives boneless chunk roast prices for Bratislava and Svidnik (a district in the Prešov region). Despite the significant income gap, price levels in the two locations seem to move together quite closely. Prices in Svidnik are in some periods even higher than prices for the same product in the Bratislava district. One can find other food products displaying the similar patterns. For instance, Figure 2 showing the price behavior of wooden coffins, a more heterogeneous product, makes the picture even bleaker; it is more expensive to get a coffin in Svidnik than in Bratislava. Though these observations are arguably a bit naïve, there are still lessons to be learned here. First, massive income differences across regions may not imply higher prices of particular products in richer regions, even if one expects higher price levels in the more advanced regions. In richer districts one finds increased competition, which may push retail prices down as compared to poorer districts where small shops are still prevalent.

Second, the search costs may be particularly high if the product is inexpensive and not bought repeatedly, so that consumers may stop searching for the lowest price before buying. Thus the factors that would support LOOP may be less effective with homogeneous *and* relatively inexpensive products. This seems to be confirmed for example by Figure 3, which describes the behavior of the retail price of matches in the 38 districts. The price differences between regions are huge and hence it seems that arbitrage is not prevalent. The emerging picture is quite different for gasoline prices, for instance, shown on Figure 4.[9] The search cost for gasoline is presumably small, as it accounts for a substantial chunk of the consumer's budget, and is bought repeatedly.Third, search costs may be high for heterogeneous products because of the time it takes to compare the different alternatives on the market. During the period studied, catalogue sales and computer shopping were not standard. Thus for heterogeneous products such as men's leather sport-type footwear (or ladies stockings) one would expect that the factors supporting the LOOP would be weak. Evidence in support of this statement is provided in Figure 5.

Fourth, international chains of retail stores are moving gradually into the Slovakian market. Intuitively, one may expect convergence in price levels for products sold by these chains, especially for brand-name products. We do not have such products in our data set. However, our data set contains some products, which are brand names across Slovakia. These are Alpa Francovka (cosmetic alcohol used in Slovak households, inexpensive and not bought repeatedly), Cigarette Mars (widely consumed, especially by lower income individuals), Cigarette Dalila (widely consumed, especially by middle income individuals) and Cheese Niva (a popular cheese brand name). Figures 6 and 7 plot the time paths of some of these national brand name prices in Slovak districts. As with many other prices, eyeballing these graphs suggests that some product prices move within a band. The widths of the bands however differ across products. In some cases the width is very narrow and not increasing, in other cases it is large and seems to widen. This issue is taken up in a more detail in Section 5.

3.1 The static absolute law of one price

To take a snapshot of product prices at different locations at a given point in time, we introduce the notion of the *static absolute law of one price (SALOOP)*. Let p_i^A and p_i^B represent the given-period price of the *i*th commodity in districts A and B, respectively. If SALOOP holds, these two prices are equal. Using simple descriptive statistics, we evaluate the validity of SALOOP. [10] As transport costs, price stickiness in local currency prices, non-competitive markets and other obstacles to arbitrage do exist even in national markets, our prior is that SALOOP will not hold. But even if there are differences between the prices, we still would like to know how large these differences are in the data.

To assess the extent of these differences we initially chose a set of 44 goods and divided them into food products (including tobacco) and non-food products. Most of the food and tobacco products represent homogeneous and tradable goods. They include rice, sugar, potato, milk, butter, eggs, oranges, poppy-seed, cheese 'Niva', wheat flour, white rolls, white bread, corn flakes, beef, pork, chicken, salami, coffee, candies, cigarettes and lettuce. Our second set of products involves some homogeneous non-food products such as Alpa Francovka, matches, children game *Človeče Nehnevaj sa*, cement, synthetic blanket Larisa, storage can Omnia, drivers license fee, and video-tape rentals. For illustration purposes, we also include products in this group, for which homogeneity is unlikely to hold. This latter group includes linen bed-sheet, ladies stockings, men's sport leather shoes, wooden coffin, men's boxer shorts, wedding dress rentals, meal in restaurant, apartment rent for 2 and 3 bedrooms, apartment painting, and ticket for classical theater performance.

The descriptive statistics for the forty-four products are presented in Table 1. Two relative prices are given, as measured in April 2001: the difference between maximum and

[9] Figures 3 and 4 each contain more than 2000 observation (60 times 38). To ease visualization, the graphs do not contain a legend.

[10] It may be that the concept of SALOOP holds only as equilibrium and thus when characterizing conditions for it to hold one should refer to all basic laws of equilibrium analysis as consumer utility maximization and optimization. This fact is obscured in the empirical analysis, which considers only the movement of prices. Herrmann-Pillath (2001, p. 48).

minimum price observations (*max-min*) and the difference between maximum and mean price observations (*max-mean*) among the thirty-eight districts. The deviations in *max-min* relative price are on the order of 10 to 100 per cent. This *max-min* relative price is lowest for tobacco products and highest for white bread, white rolls, and rice.[11] The *max-mean* relative price ratio is understandably less variable; it fluctuates between 4 and 70 percent. The results presented in Table 1 do not change significantly if we look at the *max-min* and *max-mean* relative prices over time. For example Figure 8 plots the corresponding *max-mean* price ratio for boneless chunk roast.

Differences among non-food products are more pronounced. This must be partly due to the fact that heterogeneous goods are included in the sample. Large differences in *max-min* and *max-mean* relative prices obtain for lady's apparel, men's shoes, and wooden coffins. On the other hand, the market for gasoline – homogeneous product in a highly competitive oligopolistic market - is extremely integrated, the difference between maximum and minimum average price across districts being only around 3 per cent, and the *max-mean* relative price ratio around one per cent.

Observing these differences also begs the question: what accounts for them? Our prior is that distance would not play a major role in explaining these differences.[12] One might also consider location-specific and goods-specific factors. If location-specific factors prevail, and if they are the sole reason for price differences across districts, then we may find similar patterns in the behavior of relative price pairs in each district and each product in the sample. To evaluate this conjecture we calculate pairwise relative prices for each district and each product in April 2001. For example, for the Bratislava district we calculate the relative price as compared to other districts for each product, thus obtaining 2580 pairwise relative price observations. Of these almost 75 percent were higher than one (price in Bratislava higher than that in the other district) as reported in Table 2. This ratio was highest in Bratislava followed by Kosice. While the correlation between this measure of pair-

[11] Note that these differences are lower than differences reported by Haskel and Wold (2001) for identical IKEA products across different countries. For some specific products in their sample they report the max-min relative price ratio to be higher than nine.

[12] Evidence in Engel and Rogers (1996) suggests that distance explains much of the price variability of similar goods in the United States and Canada. We do not expect distance to contribute significantly to the explanation of the price variability in Slovakia. Slovakia is a small country - less than 50 thousand square kilometers. The furthest distance between most eastern and western parts of the country is less than 700 km, between most northern and southern parts considerably less. The average distance between pairs of capitals of the 38 Slovakian districts used in this study is around 190 km. Thus, while expecting distance to play some role in explaining the behavior of prices across districts it is our prior that this role will be rather limited.

wise relative prices and distance from benchmark city (Bratislava, Banska Bystrica) is insignificant, there is high positive correlation between pairwise relative prices and size of district, the latter measured as population of the district's capital. This indicates that there is a tendency for prices to be the higher, the larger the city, suggesting the existence of location (city) specific effects in pricing patterns across districts.[13]

4 Relative price variability in districts and individual price variability across districts

Engel (1993) - studying sources of real exchange rate volatility across six developed countries[14] - uncovers an interesting empirical regularity: "the consumer price of a good relative to a another good within a country tends to be much less variable than the price of that good relative to a similar good in another country." Engel (1993, p. 35). In other words, comparing the volatility of prices of the same (similar) goods across borders to volatility of different goods inside the same country, Engel (1993) presents empirical evidence that the volatility of the former is higher than the volatility of the latter. Engel and Rogers (2001) performed a similar investigation within the United States, and the results show that there is a tendency for prices of the same product across different cities to be less volatile than the prices of different products in a city. In other words relative prices of different goods in a city are more volatile than price of the same good across cities. The analysis in this section is inspired by the approach developed in Engel and Rogers (2001). However, our data comprise actual (average) monthly prices for 501 final goods and services over a five year period, whereas Engel and Rogers used monthly price indexes for 43 different goods and services over some ten years. Thus, we investigate two sources of variability in prices. First, we look at the variability of each individual price across districts; second, in each individual district we look at the variability of prices of all products. Before we present the empirical analysis we provide some justification for this approach.

[13] This may also reflect the price levels in these districts. Note that according to our knowledge there are no data on regional price levels in Slovakia.

[14] The countries included the United States, Japan, Germany, Italy, France and Canada.

Consider two goods i and j, and two locations A and B and the following simple example of the real exchange rate between the two locations. Let capital letters denote price indexes and small letters prices of specific goods. Then

$$P^A = \alpha p_i^A + (1-\alpha) p_j^A$$
$$P^B = \gamma p_i^B + (1-\gamma) p_j^B$$

and their difference is

$$P^A - P^B = \alpha p_i^A + (1-\alpha) p_j^A - \gamma p_i^B - (1-\gamma) p_j^B \qquad (1)$$

These can be rewritten as

$$P^A - P^B = \alpha(p_i^A - p_i^B) + (1-\alpha)(p_j^A - p_j^B) + (\alpha-\gamma)(p_i^B - p_j^B) \qquad (2a)$$

$$P^A - P^B = \gamma(p_i^A - p_i^B) + (1-\gamma)(p_j^A - p_j^B) + (\alpha-\gamma)(p_i^A - p_j^A) \qquad (2b)$$

Equations (2a) and (2b) contain two types of expressions. The first compares the price of the same good (i or j) in two different locations (A and B). These are the first two expressions on the right hand side of equations (2a) and (2b). The second compares the prices of different goods (i and j) in the same location (A or B).

Comparing $p_i^A, p_j^A, p_i^B, p_j^B$ in the static environment we may assume the following.

- Assuming that the law of one price holds, or there is a tendency for it to hold, then prices of similar goods converge across different districts, i.e. there is a tendency for $p_i^A = p_i^B$ and $p_j^A = p_j^B$. Then, if V represents volatility, one can expect $V(p_i^A - p_i^B)$ to be low and thus $V(p_i^A - p_j^A) > V(p_i^A - p_i^B)$. In other words, volatility of relative prices in the same district is higher than the volatility of prices of the same good across districts. However, this result may be obtained also if one assumes the same (similar) degree of price stickiness of an individual good across districts; then again $V(p_i^A - p_j^A) >$ $V(p_i^A - p_i^B)$.
- Assuming that the law of one price does not hold for some reason (markets are segmented, producers have different pricing strategies for different locations, etc.), then one can expect that the same product would be priced differently in two locations, i.e. $p_i^A \neq p_i^B$ and $p_j^A \neq p_j^B$, and consequently one expects $V(p_i^A - p_j^A) < V(p_i^A - p_i^B)$. The same expectations hold if the distance between locations A and B is significant, and transportation costs or other trade barriers prevent the convergence of prices. Then again one can expect $V(p_i^A - p_j^A) < V(p_i^A - p_i^B)$.

Thus $V(p_i^A - p_j^A)$ is a measure of volatility of relative prices in the same location and $V(p_i^A - p_i^B)$ a measure of volatility of the price of the same good in different locations. Following Engel and Rogers (2001) we define ratio r_i^k as

$$r_i^k = \frac{\frac{1}{l-1}\sum_{n=1,n\neq i}^{l} sd(\Delta p_{i,t}^k - \Delta p_{n,t}^k)}{\frac{1}{h}\sum_{m=1,m\neq k}^{h} sd(\Delta p_{i,t}^k - \Delta p_{i,t}^m)} \qquad (3)$$

where *sd(.)* denotes standard deviation, *l* the number of products in the data set, and *h* the number of districts. $p_{i,t}^k$ is the *log* of the price of good *i*, at time *t*, at location *k*. Also,

$$\Delta p_{i,t}^k = \ln\frac{p_{i,t}^k}{p_{i,t-1}^k}$$

$$\Delta p_{i,t}^k - \Delta p_{i,t}^m = \ln\frac{p_{i,t}^k}{p_{i,t-1}^k} - \ln\frac{p_{i,t}^m}{p_{i,t-1}^m} = \ln(\frac{p_{i,t}^k / p_{i,t-1}^k}{p_{i,t}^m / p_{i,t-1}^m}).$$

The r_i^k coefficient is the ratio of sums of standard deviations.

The numerator in (3) represents the average of the standard deviations of the first log difference of the price of good *i* relative to the price of each other good at location *k*. Thus, the numerator represents the volatility of relative prices of different goods in the same location.

The denominator in (3) represents the average of the standard deviations of the first log difference of good *i* at different locations, *k* and *m*. Thus, it is the denominator in (3) which measures the deviation from the LOOP. More precisely we may call it the measure of the *relative law of one price,* since here we really consider variation of log differences of two prices. If the relative LOOP holds, then the denominator is expected to be small. Engel and Rogers (2001) mention that there are actually three cases where one can expect the denominator to be small. First, when the 'law of one price holds', so that the differences between the prices of good *j* in two locations are small. Second, if the price of good *j* at location *A* is proportional to the price of good *j* at location *B*, the difference is almost constant. Third is the case where the price of good *j* at both locations is hardly changing.

We now turn to the analysis of the variability of prices in our data set. In reporting the results we divide the data set according to the following classification: Table *1* Bread, Cereals, Meat and Fish; Table *2* Milk, Cheese, Eggs, Oils and Fats; Table *3* Fruit, Vegetables and Other Food Products; Table *4* Non-Alcoholic and Alcoholic Beverages and Tobacco; Table *5* Clothing; Table *6* Footwear; Table *7* Housing, Water, Electricity, Gas and Other Fuels; Table *8* Furnishings, Household Equipment and Routine Maintenance of the House; Table *9* Health; Table *10* Transport; Table *11* Recreation and Culture, Major Durables for Recreation and Culture; Table *12* Restaurants and Hotels Catering and Accommodation Services; Table *13* Personal Care. A general picture of the data set is provided in Table 3.

These results for coefficient r_i^k are summarized in Table 4.[15] The data show that the r_i^k coefficient is above one for all thirteen groups of products. In the sample of 501 individual products the r_i^k coefficient is greater than one in about 92 per cent of the cases. In the remaining cases – where it was smaller than one - the smallest value was 0.74.[16] When we weight the coefficients (with weights equal to the weights assigned for each particular good in the consumer price index in 2002), the r_i^k coefficient is still, in more than 92% of the cases, higher than one. The results in Table 4 also show that the unweighted average of all r_i^k ratios equals 1.47. Taking a weighed average across products, the average r_i^k increases to 1.86.[17]

There seem to be certain regularities in these results. The variability of relative prices in the same district is higher than the variability of the price of the same good across different districts. In other words the price of a consumer good relative to a different good in the same district is more variable than the price of the same good across districts. This observation suggest that the variability in real exchange rate is affected more by movements in the last factor on the right hand side of equations *2a* and *2b* than in the first two factors.

Columns *2* and *3* of Table 4 give the results calculated for monthly differences in the logs of prices. Columns *5* and *6* of Table 4 give the corresponding statistics for twelve-month differences. One may expect convergence to the relative LOOP to hold more as time passes, and a corresponding increase in the value of the r_i^k coefficient. The data show

[15] Detailed results are available from the authors upon request.

[16] Engel (1993) found that for most of the goods the intra-country relative price changes are much smaller than the failures of the inter-country LOOP. If these results were valid for the case of intra-country data, then the reported coefficients r_i^k would be small. Engel and Rogers (2001) wrote that average values would need to be around 0.15 to replicate the Engel (1993) finding. Results of Engel and Rogers (2001) as well as our results challenge this expectation.

[17] In the sample used by Engel and Rogers (2001), the weighted average value of the coefficient was greater than two.

a slight increase in the un-weighted value of the r_i^k coefficient, from 1.47 to 1.59, and a more significant increase in the weighted-value, from 1.86 to 2.59. This result to a certain extent differs from Engel and Rogers (2001) who reported that the twenty-four-month ratios "actually are slightly lower, which is the opposite of what one would expect." (p.6).

As the next step we analyze the denominator of the r_i^k coefficient.[18] These results are summarized in Table 5. Again, the denominator measures the average standard deviation of the difference in the price of the same good across cities, what we call the relative law of one price. In Engel and Rogers (2001), the weighted average of the denominator of the r_i^k coefficient equals 2.87; in our sample it is 4.47. This suggests that either the 'absolute law of one price' holds to a lesser extent in our sample than in theirs, i.e. prices are less proportional across districts in Slovakia than they are across the US cities, or the prices of the same good across Slovak districts are less sticky. An additional reason may be that our data contain individual actual prices whereas Engel and Rogers used price indexes, and the individual prices can be more volatile.[19]

The lowest denominator values in the calculations of Engel and Rogers (2001) are for 'food away from home' and 'used cars', where the relative variabilities are less than one. In our sample the lowest variability is for Aspirin (1.04), gasoline 91-octane (0.94), gasoline 95-octane (1.09), and oil fuel (0.97). We find the highest volatility for tomato (41.95), parsley (32.37), kiwi (22.81), ignition module (17.82), apples (15.22), mandarins (13.94), fruit-based soft drink (13.69). This measure of variability is very high for fruit and vegetables in both countries. But high volatility was also found among such non-tradables as services provided with apartment renting (13.31).

[18] Engel and Rogers (2001) argued that the numerator is similar to the numerator analyzed in Engel (1993), so that the larger r_i^k ratios in Engel and Rogers (2001), as compared to Engel (1993) stem from the smaller value of denominator. Subsequently they concentrate on explanation of the value of the denominator. We follow their strategy with the following caveat. In Engel and Rogers (2001) the numerator measures the volatility of relative prices in 29 large U.S. cities. One needs to make an assumption that the competitiveness of local markets in these cities for different products is similar. This assumption excludes the following situation: there is no tendency for the law of one price to hold, but the variation which this causes is smaller then the variation caused by the differences in market structures in different cities (regions). Thus, even if the law of one price does not hold, we may still obtain an r_i^k coefficient greater than one. We also assume away this possibility for the Slovak regions.

[19] It seems that this last reason is not born out by the data. There are disaggregated product prices in our sample with significantly higher volatility than the price indexes in Engel and Rogers (2003), but our data set also contains prices considerably less volatile than their more aggregated data.

Engel and Rogers (2001) also compare the value of the denominator of non-traded to traded goods; they simply classify goods as traded and services as non-traded. One may expect the value of the denominator of (3) to be lower for traded goods, but they find that it is substantially lower for the non-traded goods. In their sample the weighted-average value of the denominator for non-traded goods is 1.74 and for traded goods 4.35.[20] We also divide our sample into tradable and non-tradable goods. We classify 88 products as non-tradables. These products represent 17.5% of all products and their total weight is 12.7% in the sample. The results reported in Table 6 indicate differences between tradables and non-tradables that are much smaller than those reported in Engel and Rogers (2001). The weighted average for non-traded goods is 5.37, for traded goods 4.35.

A concern arises here whether the results produced by first differences are not artifacts produced by rapidly adjusting prices. Engel and Rogers (2001) point out that the variance of first differences for prices that adjust quickly might be larger than for prices that adjust slowly. For this reason we calculate standard deviations for twelve-month differences as well. The pattern is similar to that obtained in the one-month difference case: the value of the denominator is higher for non-traded goods than for the traded goods. Thus our results seem to be more in the line with the standard assumption that the (relative) LOOP holds more for traded goods than for non-traded goods.

Engel and Rogers (2001) argued that their results are to a large extent explainable by stickiness of prices. We also - in Figure 9 - depict the relationship between the deviation of the relative LOOP (the denominator of the r_i^k coefficient) and the stickiness of prices as measured by the standard deviation of the nominal price of each individual good across all districts. The correlation between these two series is 0.763, and the positive relationship is clearly seen in Figure 9. The smaller the standard deviation of the nominal price, the smaller the denominator of the r_i^k coefficient.

[20] Herrmann-Pillath (2001, p. 55) comments in this respect. “Engel/Rogers (1999) show that relative-relative price movements seem to manifest a violation of the LOP for tradables, and just the opposite for non-tradables which flies in the face of any sensible understanding of LOP.”

5 The speed of adjustment

In this Section we estimate the speed of adjustment of prices to the law of one price. As suggested by Parsley and Wei (1996), we start by estimating

$$\Delta q_{i,k,t} = \beta q_{i,k,t-1} + \sum_{m=1}^{s(k)} \gamma_m \Delta q_{i,k,t-m} + \varepsilon_{i,k,t} \tag{4}$$

where $q_{i,k,t} = \ln(\frac{p_{i,k,t}}{p_{j,k,t}})$, i is the benchmark district, j is the respective district, k is commodity, and t is the time period. In this section Bratislava and Banska Bystrica served as benchmark districts. These two cities provide a natural benchmark, Bratislava because of its importance as a political and economic capital of the country, and Banska Bystrica because of its being another large city in the middle of the country.[21] Our estimation procedure is based on the work of Levin and Lin (1992).

The findings in Section 3 show that there are large differences in nominal prices across districts. These differences may make the test of convergence as described in (4) somewhat unrealistic, since it does not account for any district-specific effect. For this reason, we perform the panel unit root analysis also for de-meaned data as follows.

$$\Delta \tilde{q}_{i,k,t} = \beta \tilde{q}_{i,k,t-1} + \sum_{m=1}^{s(k)} \gamma_m \Delta \tilde{q}_{i,k,t-m} + \varepsilon_{i,k,t} \,,$$

$$\tilde{q}_{ij,k,t} = \ln \frac{p_{i,k,t}}{p_{j,k,t}} - \frac{1}{T} \sum_{b=1}^{T} \ln \frac{p_{i,k,b}}{p_{j,k,b}} \tag{5}$$

where $b = 1, 2, \ldots. 60$.

Thus while (4) informs us on the absolute LOOP, (5) speaks to the speed of convergence to the relative LOOP. In both specifications, the main parameter of interest is β, related to the speed of convergence. Under the null hypothesis of no convergence, β is to equal to zero, meaning that shocks to $q_{i,k,t}$ are permanent. Convergence implies a negative value of β, with the approximate half-life of a shock given by $-\frac{\ln 2}{\ln(1+\beta)}$.

[21] The last natural option for the benchmark city would be Košice, because of its size and economic importance. We opted against Košice as a benchmark because of its geographical location on the very east of the country. We believe that Bratislava and Banska Bystrica represent the only natural choice for benchmark district, and while the convergence results may not be invariant to the choice of benchmark, choosing another benchmark city would not make much sense from the economic point of view.

We perform the analysis for 157 non-perishable final products, 49 perishable products and 24 services. These products are listed in Tables 8-10, with Bratislava serving as benchmark. These tables display the β coefficients from equations (4) and (5). To obtain the auto-regressive coefficient, one would need to add one to the value of β. The closer the estimate of β to zero, the longer the estimated half-life of a disturbance and the more likely it is that the data contain a unit root.

In Table 7 we report the summary of the results for the sample of non-perishable goods, perishable goods and services. The adjustment among Slovakian cities is slower for non-perishable goods and for services than the corresponding results obtained in Parsley and Wei (1996) for the respective groups of products, 15.84, 12.18 and 46.21. However, adjustment is faster for perishable goods not depending on the benchmark.

Median values for the half-life of price convergence are considerable lower if we use specification (5). We also note that the β coefficient using specification (4) is positive in 34 out of 157 cases for non-perishable goods, 6 out of 49 cases for perishable goods and 8 out of 24 cases for services. However, using specification (5), the β coefficient is always negative and the presence of the unit root is rejected in all cases.

Finally, we calculate the mean log-difference for all the commodities and regress it on the distance to the benchmark and the size of the individual city. We control for non-linearity by adding quadratic terms. The results are presented in Tables 11 and 12. These results show that the size variable is an important determinant of the level of mean log-differences in prices. It has a negative coefficient and is almost always statistically significant, except for a couple of cases where the quadratic terms are added. This means that the higher the population of the main city in the district, the higher the level of prices. The quadratic term of population is almost always statistically insignificant. The distance from the benchmark district does not seem to be a determinant, except for the nonperishable commodities group with the benchmark district Bratislava.[22]

[22] One may suggest the following explanation. First, non-perishable goods can be easily transported and therefore produced only at a couple of locations in a country (unlike perishable goods). Second, economic activity, which is greater in the western part of Slovakia, seems to be an important determinant of equilibrium price level. With Bratislava being in the most western part of Slovakia, the distance variable works as a proxy for the level of economic activity.

6 Conclusions

This paper uses a large panel data set for final goods and services across 38 Slovakian districts over the period 1997:01-2001:12 to examine the nature of deviations from the law of one price in the context of the small transition economy. In this paper we provide three type of investigations. First, we document the range of price differences across Slovak districts. Second, we find that the variability of relative prices in the same district is higher than the variability of the prices of the same good across different districts. We investigate the factors, which may be deemed responsible for this finding. Third, we investigate the speed of convergence to the LOOP in the spirit of Parsley and Wei (1996). We find evidence for convergence; however its speed - while faster than typically found in cross-country data - is lower than that found for the US cities. The speed of convergence in panel unit root tests increases considerably if we condition on district-specific factors by using de-meaned relative price data.

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Table 1: Basic relative prices of selected final goods and service across Slovak districts

Product	Maximum to Minimum Relative Price Ratio	Maximum to Mean Relative Price Ratio	Coefficient of Variation
Rice	1.697	1.465	0.091
Sugar	1.192	1.087	0.034
Potato	1.854	1.366	0.141
Milk	1.302	1.160	0.057
Butter	1.254	1.145	0.052
Eggs	1.365	1.183	0.068
Oranges	1.398	1.214	0.077
Poppy Seed	1.589	1.115	0.077
Cheese 'Niva'	1.237	1.098	0.047
Wheat Flour	1.348	1.149	0.065
White Roll	1.630	1.244	0.114
White Bread	2.012	1.698	0.140
Oat Flakes	1.402	1.203	0.078
Boneless Chunk Roast	1.340	1.120	0.067
Boneless Beef Rear	1.369	1.150	0.069
Boneless Pork Shoulder	1.224	1.113	0.049
Chicken Fryer	1.208	1.106	0.039
Ham Salami	1.214	1.081	0.040
Coffee	1.566	1.200	0.091
Lentilky Candies	1.211	1.108	0.039
Cigarette ‘Dalila’	1.179	1.041	0.029
Cigarette ‘Mars’	1.098	1.051	0.024
Vlassky Salad	1.600	1.296	0.111
Alpa Francovka	2.250	1.363	0.128
Linen Bed Sheet	1.405	1.179	0.070
Lady's Stockings	3.232	2.367	0.353
Men’s Sports Leather Shoes	2.266	1.542	0.256
Wooden Coffin	3.076	1.724	0.224
Matches	1.511	1.313	0.092
Children Game	2.551	1.198	0.155
Men’s Boxer Shorts	2.399	1.821	0.227
Cement	1.273	1.113	0.058
Gasoline 91	1.031	1.010	0.006
Cover Sheet Larisa	1.498	1.270	0.091
Storage Cane 'Omnia'	1.495	1.251	0.093
Meal in Restaurant – Schnitzel	1.861	1.262	0.136
Wedding Dress Borrowing	2.304	1.347	0.192
Drivers License Fee	1.633	1.315	0.115
Videotape Borrowing	1.986	1.375	0.159
Apartment Rent 2 Bedrooms	3.406	1.377	0.203
Apartment Rent 3 bedrooms	2.625	1.136	0.138
Apartment Rent – Services	6.109	2.257	0.422
Apartment Painting	5.424	2.150	0.407
Classical Theater Ticket	7.415	2.045	0.460

Data are from April 2001. Results in Table 1 calculated from nominal prices expressed in Slovak korunas. Maximum (minimum) is the highest (lowest) price observed in any of the thirty-eight districts. If the static law of one price holds, our threshold would be 1.00 both for max-min as well as for max-mean ratios.

Table 2: Share of pairwise relative prices higher than one

District Name	Coefficient	District Name	Coefficient
Bratislava	74.67	Banská Bystrica	50.03
Bratislava-vicinity	49.96	Lučenec	51.79
Dunajská Streda	61.47	Rimavská Sobota	40.10
Galanta	43.11	Veľký Krtíš	41.92
Senica	51.41	Zvolen	40.72
Trnava	43.48	Žiar nad Hronom	42.17
Považská Bystrica	47.20	Bardejov	48.39
Prievidza	35.38	Humenné	41.79
Trenčín	49.71	Poprad	46.00
Komárno	49.34	Prešov	44.50
Levice	52.04	Stará Ľubovňa	43.05
Nitra	54.17	Svidník	46.13
Nové Zámky	54.74	Vranov nad Topľou	46.95
Topolčany	43.62	Košice	63.10
Čadca	42.30	Košice-vicinity	41.48
Dolný Kubín	52.37	Michalovce	48.58
Liptovský Mikuláš	62.22	Rožňava	53.80
Martin	50.09	Spišská Nová Ves	52.79
Žilina	54.61	Trebišov	50.09

Data for April 2001. Pairwise relative price calculated as a simple ratio of nominal prices for each product for two districts. Thus for each district this measure contains 2580 relative pairwise prices. Coefficient in the Table 2 provides a percentage value for the number of observations for which this relative pairwise price is higher than one.

Table 3: Description of data

	Size	Weight in CPI	Weight in our sample
T1: Bread, Cereals, Meat and Fish	45	106.0	168.31
T2: Milk, Cheese, Eggs, Oils and Fats	19	53.6	79.63
T3: Fruit, Vegetables and Other Food	58	54.1	85.29
T4: Beverages and Tobacco	21	92.0	150.76
T5: Clothing	61	54.3	59.13
T6: Footwear	12	20.7	28.10
T7: Housing, Water, Electricity, Gas	24	215.3	47.60
T8: Furnishings, Household Equipment and Maintenance	80	51.8	56.53
T9: Health	16	14.5	11.04
T10: Transport	31	125.5	106.41
T:11: Recreation and Culture	61	72.1	88.21
T12: Restaurants and Hotels Services	33	72.2	45.48
T:13: Personal Care	40	67.9	73.48
Total	501	1000.0	1000

Size: number of products in the sample in each group of products;
Weight of the group of products in the consumer price index in 2002, and in our sample.

Table 4: The ratio of relative price variability across districts and cross-district variability of the relative law of one price deviations

	r_i^k (un)	r_i^k (w)	r_i^k <1	r_i^k (un)12	r_i^k (w)12	r_i^k <1 (12)
T1: Bread, Cereals, Meat and Fish	1.59	1.62	---	1.99	2.14	---
T2: Milk, Cheese, Eggs, Oils and Fats	1.80	1.92	---	2.25	2.45	---
T3: Fruit, Vegetables and Other Food	1.34	1.35	8	1.61	1.68	4
T4: Beverages and Tobacco	1.88	2.08	---	2.32	2.79	---
T5: Clothing	1.39	1.33	1	1.29	1.21	4
T6: Footwear	1.34	1.32	----	1.20	1.18	---
T7: Housing, Water, Electricity, Gas	1.29	1.30	5	1.28	1.39	6
T8: Furnishings, Household Equipment and Maintenance	1.46	1.52	6	1.34	1.40	11
T9: Health	1.83	1.88	1	2.67	2.84	1
T10: Transport	1.57	3.99	10	2.42	8.58	13
T:11: Recreation and Culture	1.25	1.24	7	1.13	1.12	15
T12: Restaurants and Hotels Services	1.52	1.39	2	1.39	1.52	3
T:13: Personal Care	1.44	1.51	---	2.62	1.44	2
Total	1.47	1.86	40	1.59	2.59	59

r_i^k (un): un-weighted average of the r_i^k coefficient; prices are measured as one-month log difference

r_i^k (w): weighted average across the group of products of the r_i^k coefficient

r_i^k <1: number of cases in the group where the coefficient was lower than one

r_i^k (un)12: like r_i^k (un) except that prices are measured as twelve-month log differences

r_i^k (w)12: like r_i^k (w) except that prices are measured as twelve-month log differences

r_i^k <1 (12): number of cases in the group where the coefficient was lower than one.

Table 5: Measure of the relative law of one price

	den (un)	den (w)
T1: Bread, Cereals, Meat and Fish	3.85	3.65
T2: Milk, Cheese, Eggs, Oils and Fats	3.94	3.73
T3: Fruit, Vegetables and Other Food	9.45	9.90
T4: Beverages and Tobacco	4.01	3.45
T5: Clothing	4.43	4.48
T6: Footwear	4.42	4.51
T7: Housing, Water, Electricity, Gas	5.68	5.78
T8: Furnishings, Household Equipment and Maintenance	4.23	3.95
T9: Health	4.36	4.70
T10: Transport	6.07	2.79
T:11: Recreation and Culture	5.28	5.56
T12: Restaurants and Hotels Services	4.20	3.63
T:13: Personal Care	4.38	4.13
Total	5.13	4.47

den (un): un-weighted average of the denominator of the r_i^k coefficient multiplied by 100

den (w): weighted average of the denominator of the r_i^k coefficient multiplied by 100

Table 6: Values based on division of products to tradables and non-tradables

	r_i^k	den	r_i^k	den
	Unweighted average		Weighted average	
Non-traded Goods	1.32	5.46	1.33	5.37
Traded Goods	1.50	5.07	1.93	4.35
Total	1.47	5.13	1.86	4.47

For explanation, see Tables 4 and 5.

Table 7: Half-life of price convergence in months

	Specification (4)		Specification (5)	
	Benchmark District			
	Bratislava	Banska Bystrica	Bratislava	Banska Bystrica
Non-Perishable	29.56	21.81	5.68	5.24
Perishable	9.82	6.18	1.98	2.78
Services	79.62	49.35	7.34	6.40

Half-life calculated as $-\frac{\ln 2}{\ln(1+\beta)}$. In the table we report the median value.

Table 8: Panel unit root test: non-perishable goods

Product	β (4)	Half-life	β (5)	Half-life
Rice	0.015	-46.041	-0.084	7.907
Wheat Flour Half-Fine	0.002	-310.605	-0.271	2.192
Farina	0.016	-44.407	-0.205	3.028
Wafers without Flavor	-0.032	21.440	-0.228	2.677
Pasta	-0.003	237.273	-0.091	7.280
Dough	-0.078	8.508	-0.199	3.124
Oat Flakes without Flavor	-0.029	23.534	-0.225	2.720
Dried Milk for Babies	-0.149	4.305	-0.195	3.203
Dried Milk Half-Fat	-0.037	18.138	-0.177	3.566
Dried Grapes	0.005	-146.725	-0.149	4.288
Peanuts Peeled Salted	0.008	-86.677	-0.092	7.146
Beans White Dried	-0.010	68.480	-0.112	5.817
Lentils	-0.029	23.236	-0.166	3.808
Soya Meat	-0.028	24.315	-0.154	4.145
Sour Cabbage	-0.024	28.415	-0.282	2.093
Peas in Salty Water	-0.014	48.711	-0.186	3.371
Leco	-0.023	29.206	-0.235	2.591
Granulated Sugar	-0.066	10.201	-0.401	1.352
Ground Sugar	-0.047	14.271	-0.361	1.550
Cooking Chocolate	0.004	-174.745	-0.268	2.221
Salt	0.008	-89.006	-0.216	2.842
Ground Sweet Paprika	-0.019	36.176	-0.167	3.787
Ground Pepper	-0.003	250.490	-0.217	2.827
Caraway not Ground	-0.034	19.999	-0.146	4.379
Vinegar	-0.060	11.138	-0.254	2.365
Baking Powder	-0.126	5.152	-0.358	1.566
Cocoa Powder	0.057	-12.546	-0.163	3.885
Table Mineral Water	-0.031	21.663	-0.044	15.243
Fruit Sirup	-0.025	27.369	-0.195	3.201
Rum 38-40%	0.001	-721.684	-0.203	3.048
Vodka 38-40%	-0.022	30.830	-0.111	5.896
Brandy 38-40%	-0.002	424.387	-0.147	4.360
Wine Red Bottled	-0.021	32.746	-0.245	2.468
Wine White Bottled	-0.020	34.174	-0.159	4.006
Wine Sparkling	0.027	-25.837	-0.304	1.910
Cotton Dress Material for Ladies	-0.021	32.577	-0.084	7.904
Ladies Synthetic Dress Material	-0.010	71.390	-0.099	6.677
Ladies Woolen (Partly) Dress Material	-0.007	102.763	-0.108	6.046
Short Underwear for Men	0.000	-6078.16	-0.098	6.712
Long Underwear for Men	-0.006	122.495	-0.150	4.250
Undershirt for Men	0.008	-83.127	-0.132	4.908
Pyjamas for Men	0.007	-98.983	-0.096	6.864
Shorts for Men	0.019	-37.061	-0.079	8.417
Men Bathroom Gown	-0.045	14.995	-0.099	6.637
Panties for Women	-0.005	134.331	-0.082	8.094
Night Dress for Women	0.006	-115.318	-0.104	6.315
Underwear for Women	0.008	-88.940	-0.121	5.355
Pyjamas for Women	-0.013	51.032	-0.196	3.186
Bra	-0.013	51.326	-0.079	8.416
Home Dress for Women	-0.020	34.039	-0.099	6.642

This table lists 50 products and is continued.

Continued Table 8

Product	β (4)	Half-life	β (5)	Half-life
Shirt for Babies	-0.045	14.965	-0.099	6.654
Cotton Napkins for Babies	-0.038	18.055	-0.179	3.517
Short Sleeved Shirt for Children	-0.011	60.936	-0.118	5.517
Panties for Girls	0.004	-158.048	-0.115	5.678
Underwear for Boys	0.003	-210.946	-0.074	8.989
Pyjamas for Children	-0.011	63.033	-0.180	3.485
Undershirt for Children	0.009	-78.412	-0.104	6.307
Long Winter Coat for Men	-0.044	15.499	-0.135	4.796
Winter Jacket for Men	-0.019	35.788	-0.143	4.485
Baby Stockings	-0.019	36.439	-0.066	10.109
Ladies Stocking	-0.001	594.060	-0.088	7.486
Socks for Children	0.005	-130.492	-0.123	5.283
Stockings for Children	-0.014	50.423	-0.126	5.148
Handkerchief for Women	0.003	-230.991	-0.071	9.480
Knit Cap for Children	-0.008	90.625	-0.066	10.124
Knit Gloves for Children	-0.023	29.563	-0.046	14.872
Knit Thread	-0.014	50.110	-0.150	4.267
Rubber Strap	-0.020	34.015	-0.095	6.967
Metal Zipper	-0.030	22.703	-0.097	6.818
Repair of Heels for Women	-0.013	51.570	-0.081	8.210
Latex Paint Universal	-0.076	8.727	-0.082	8.128
Paint	-0.102	6.445	-0.215	2.859
Basic Synthetic Paint	-0.008	85.677	-0.064	10.476
Synthetic and Oil Paint	-0.060	11.149	-0.180	3.489
Cement SPC 325	-0.032	21.071	-0.236	2.580
Lime	-0.008	88.388	-0.143	4.502
WC Bowl with Flusher	0.006	-121.781	-0.071	9.450
Painting Services	-0.013	53.765	-0.068	9.844
Painting of Wooden Products	-0.016	43.338	-0.055	12.358
Propan-Butan	-0.047	14.421	-0.358	1.565
Curtains	-0.003	212.155	-0.058	11.677
Bed Sheet	-0.003	219.648	-0.111	5.876
Bed Linen for Children	0.000	2063.035	-0.120	5.402
Bed Linen for Adults	0.000	3679.961	-0.099	6.619
Turkish Towel	0.002	-319.224	-0.095	6.925
Table Cloth	0.009	-79.517	-0.083	8.037
Dish Cloth	0.002	-292.052	-0.135	4.790
Synthetic Cover Larisa	-0.001	624.599	-0.091	7.288
Comforter, Synthetic Material	0.031	-22.429	-0.047	14.515
Quilt Feather Filling	-0.016	44.105	-0.117	5.558
Glass without Holder	-0.023	29.754	-0.102	6.410
Crystal Glass Leaden with Holder	-0.013	54.796	-0.083	7.999
Plate Set for 6 People	-0.003	260.687	-0.119	5.480
Porcelain Cup with Decorations	-0.022	31.082	-0.078	8.515
Glass Bowl from Silex with Cover	-0.027	25.750	-0.129	5.002
Thermos with Pump 1 Liter	-0.006	108.706	-0.135	4.766
Kitchen Pot 4 Liters	0.007	-96.760	-0.114	5.739
Tea Kettle	0.004	-197.772	-0.057	11.841
Cutlery for 6 Persons	-0.021	33.306	-0.038	17.877
Kitchen Knife with Plastic Handle	-0.010	68.567	-0.100	6.604

This table lists 51-100 products and is continued in the next page.

Table 8 Continued

Product	β (4)	Half-life	β (5)	Half-life
Soup Ladle – Rustles	-0.006	118.677	-0.096	6.874
Infant Bottle from Plastic	-0.029	23.207	-0.262	2.286
Kitchen Scales	0.007	-101.393	-0.067	10.021
Wooden Ladle	-0.011	61.673	-0.146	4.380
Plastic Bucket	-0.006	116.571	-0.105	6.244
Flat Light Switch	-0.022	31.080	-0.082	8.078
Electric Adapter	-0.019	35.992	-0.097	6.803
Regular Light Bulb	0.007	-92.879	-0.123	5.276
Roll-on Meter	-0.006	124.797	-0.066	10.179
Combination Pliers	-0.002	312.137	-0.065	10.238
Screw Driver	-0.020	34.990	-0.101	6.493
Metal Rake without Handle	-0.067	9.947	-0.204	3.040
Aluminum Double Ladder	-0.019	35.323	-0.121	5.354
Household Scissors	-0.019	35.861	-0.102	6.464
Drier for Laundry	-0.106	6.161	-0.133	4.848
Ironing Board	-0.016	43.976	-0.103	6.408
Construction Nails	-0.007	95.893	-0.104	6.281
Chamomile	-0.082	8.086	-0.251	2.397
Herb Tea	-0.096	6.881	-0.156	4.091
Thermometer	-0.077	8.647	-0.149	4.283
Adhesive Plaster in a Pack	-0.039	17.447	-0.192	3.256
Bandage Material	-0.048	14.077	-0.168	3.776
Protection Means	-0.004	165.714	-0.088	7.561
Disk Brake Slabs	-0.009	80.105	-0.072	9.334
Accumulator	-0.003	211.088	-0.074	8.985
Halogen Light Bulb	-0.004	184.421	-0.060	11.113
Gasoline 91 Octane	-0.540	0.892	-0.719	0.547
Gasoline 95 Octane	-0.222	2.760	-0.391	1.399
Oil Fuel	-0.441	1.192	-0.723	0.539
Motor Oil	-0.002	302.862	-0.048	13.997
Gear Box Oil	-0.005	139.864	-0.072	9.324
Non-Freezing Liquid for Cooler	-0.023	29.734	-0.087	7.582
Electronic Pocket Calculator	0.007	-99.376	-0.082	8.124
Ball for Children	-0.072	9.245	-0.106	6.170
Clovece Nehnevaj Sa	-0.006	110.496	-0.153	4.185
Plastic Bob Sled with Brakes	-0.038	18.030	-0.114	5.727
Volleyball	-0.006	120.482	-0.124	5.229
Videotape – Clean	-0.026	26.362	-0.058	11.551
Tape for Sound Recording – Clean	-0.018	38.837	-0.142	4.520
Colored Postcard	-0.013	55.084	-0.074	9.025
Spiral Calendar	-0.035	19.469	-0.109	6.006
Notebook – Halfthick 40 Sheets	-0.076	8.806	-0.139	4.614
Note Book A4	-0.012	57.070	-0.098	6.706
Black Pencil	-0.004	173.537	-0.121	5.374
Celluloid Ruler	-0.018	38.597	-0.110	5.932
Design A4	-0.026	26.442	-0.144	4.447
Color Pencils	-0.014	48.196	-0.124	5.258
Razor Blade – 5 Pieces in a Pack	0.002	-353.988	-0.055	12.303
Francovka Alpa – Cosmetic Alcohol	-0.007	94.006	-0.135	4.777
Folded Bandage Absorbant Cotton	-0.047	14.491	-0.149	4.290

This table contains products 101-150.

Continued Table 8

Product	β (4)	Half-life	β (5)	Half-life
Paper Handkerchiefs 10 Pieces	-0,003	247,008	-0,047	14,257
Toilet Paper 400 Slips	0,002	-315,891	-0,116	5,602
Paper Napkins	-0,003	274,748	-0,121	5,356
Umbrella for Women	-0,016	42,191	-0,087	7,623
School Bag	-0,016	44,070	-0,105	6,252
Matches	-0,009	77,469	-0,195	3,201
Wooden Coffin	-0,001	478,826	-0,057	11,859

Table 8 lists 157 products; the benchmark district for this data is Bratislava.

β (4) is the coefficient from equation (4).

β (5) is the coefficient from equation (5).

Half-life in both cases calculated as $-\frac{\ln 2}{\ln(1+\beta)}$.

Table 9: Panel unit root test: perishable goods

Product	β (4)	Half-life	β (5)	Half-life
Rye Bread	0.000	-1510.71	-0.111	5.911
White Roll	-0.045	15.148	-0.107	6.136
Christmas Cake	0.003	-255.313	-0.131	4.928
Dumplings	-0.022	31.265	-0.133	4.838
Chunk Roast with the Bone	-0.020	34.771	-0.244	2.473
Boneless Chunk Roast	-0.035	19.253	-0.284	2.075
Beef Rear Boneless	-0.037	18.445	-0.339	1.675
Pork Meat with Bone	-0.112	5.858	-0.428	1.241
Pork Neck with Bone	-0.005	151.484	-0.426	1.247
Pork Side	-0.131	4.946	-0.462	1.117
Pork Leg Boneless	-0.083	7.960	-0.416	1.288
Pork Shoulder Boneless	-0.140	4.594	-0.467	1.103
Chicken Fryer	-0.081	8.220	-0.295	1.984
Chicken Portioned	-0.044	15.300	-0.338	1.683
Diet Salami Pork	-0.027	25.446	-0.200	3.106
Stewed Ham Pork	-0.027	24.964	-0.227	2.696
Smoked Bacon with Skin	0.004	-187.37	-0.030	23.090
Fish Fillet not Breaded	-0.033	20.929	-0.266	2.238
Smoked Fish	-0.072	9.233	-0.172	3.679
Fish Salad with Mayonnaise	-0.058	11.659	-0.144	4.469
Half-Fat Milk	-0.015	45.728	-0.172	3.673
Sweet Cream	-0.048	14.015	-0.121	5.385
Sour Cream	-0.068	9.820	-0.144	4.462
Sheep Cheese	-0.005	132.309	-0.243	2.489
Cheese Edam	-0.027	25.362	-0.356	1.573
Eggs	-0.020	33.572	-0.447	1.169
Fresh Butter	-0.008	83.203	-0.282	2.089
Oil	0.023	-30.941	-0.163	3.897
Pork Lard	-0.032	21.137	-0.156	4.087
Oranges	-0.054	12.530	-0.762	0.483
Lemons	-0.120	5.430	-0.546	0.877
Kiwi	-0.244	2.474	-0.619	0.719
Banana	-0.363	1.537	-0.832	0.388
Celery	-0.211	2.917	-0.544	0.882
Carrot	-0.183	3.439	-0.321	1.791
Parsley	-0.206	3.005	-0.773	0.467
Cabbage	-0.082	8.149	-0.531	0.914
Salad Cucumber	-0.578	0.804	-0.985	0.165
Pepper	-0.171	3.699	-0.790	0.444
Onion	-0.187	3.347	-0.240	2.523
Vegetable Mixed Frozen	-0.014	48.806	-0.101	6.496
Spinach Stew Frozen	-0.045	14.993	-0.461	1.121
Potato	-0.124	5.216	-0.674	0.618
Fresh Yeast	-0.004	175.689	-0.054	12.600
Garlic	-0.183	3.432	-0.343	1.652
Beer 10% Bottled	0.016	-42.477	-0.081	8.230
Beer 12 % Bottled	0.003	-210.59	-0.155	4.124
Karafiat	-0.023	29.149	-0.356	1.575
Rose	-0.052	12.863	-0.309	1.877

This table lists 49 perishable products; for explanations see Table 8.

Table 10: Panel unit root test: Services

Product	β (4)	Half-life	β (5)	Half-life
Videotape Borrowing	0.013	-54.317	-0.100	6.545
Veterinary Service	0.014	-50.473	-0.069	9.762
Beef Bouillon with Meat	-0.004	158.437	-0.103	6.402
Beef Goulash	0.006	-118.730	-0.047	14.462
Roasted Pork Meat	-0.010	70.604	-0.120	5.439
Fried Pork Meat	0.000	146059.816	-0.100	6.610
Grilled or Baked Chicken	0.004	-196.288	-0.086	7.686
Pancakes with Jam	0.014	-48.584	-0.042	16.218
Sheep cheese with dumplings	-0.005	151.156	-0.096	6.891
Fried Cheese	-0.001	711.037	-0.112	5.810
French Fries	-0.005	135.254	-0.098	6.699
Dumpling	-0.009	79.062	-0.061	10.956
Stewed Rice	-0.009	75.505	-0.081	8.250
Stewed Cabbage	-0.009	80.195	-0.094	7.031
Coffee	0.003	-237.238	-0.135	4.780
Mineral Water	-0.003	220.524	-0.084	7.859
Cola Soft Drink	-0.002	411.966	-0.092	7.186
Beer 12% Draft	-0.002	363.552	-0.117	5.573
Beer 12% Bottle	-0.002	326.486	-0.081	8.160
White Wine	-0.018	37.953	-0.074	9.053
Red Wine	-0.013	51.277	-0.089	7.478
Dessert Wine	-0.002	295.915	-0.046	14.832
Slovak Juniper Brandy	-0.001	876.009	-0.096	6.903
Brandy, Domestic Production	0.003	-241.867	-0.083	7.956

This table lists 24 services; for explanations see Table 8.

Table 11: Regression results; Benchmark district: Bratislava

Non-perishable Goods					
	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Constant	0.149089	0.009337	16.0	0.000	0.8823
Distance	8.37840e-005	2.802e-005	2.99	0.005	0.2083
Size	-6.69507e-007	1.094e-007	-6.12	0.000	0.5240
Perishable Goods					
	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Constant	0.114386	0.007220	15.8	0.000	0.8807
Distance	-1.12414e-005	2.166e-005	-0.519	0.607	0.0079
Size	-1.20886e-007	8.461e-008	-1.43	0.162	0.0566
Services					
	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Constant	0.419822	0.03306	12.7	0.000	0.8259
Distance	8.39962e-005	9.919e-005	0.847	0.403	0.0207
Size	-1.45096e-006	3.874e-007	-3.74	0.001	0.2920
Non-perishable Goods					
	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Constant	0.148912	0.01732	8.60	0.000	0.6980
Distance	0.000130376	0.0001259	1.04	0.308	0.0324
$Distance^2$	-9.06631e-008	2.259e-007	-0.401	0.691	0.0050
Size	-8.00781e-007	3.315e-007	-2.42	0.022	0.1542
$Size^2$	5.91354e-013	1.436e-012	0.412	0.683	0.0053
Perishable Goods					
	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Constant	0.105050	0.01325	7.93	0.000	0.6628
Distance	1.28072e-005	9.628e-005	0.133	0.895	0.0006
$Distance^2$	-3.49382e-008	1.728e-007	-0.202	0.841	0.0013
Size	1.03429e-007	2.536e-007	0.408	0.686	0.0052
$Size^2$	-1.04183e-012	1.098e-012	-0.948	0.350	0.0273
Services					
	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Constant	0.421492	0.05828	7.23	0.000	0.6204
Distance	0.000617852	0.0004236	1.46	0.154	0.0623
$Distance^2$	-1.04356e-006	7.602e-007	-1.37	0.179	0.0556
Size	-3.07193e-006	1.116e-006	-2.75	0.010	0.1915
$Size^2$	7.31453e-012	4.833e-012	1.51	0.140	0.0668

Table 12: Regression results benchmark district: Banska Bystrica

Non-perishable Goods					
	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Constant	0.0881491	0.01138	7.74	0.000	0.6381
Distance	7.65461e-005	6.435e-005	1.19	0.242	0.0400
Size	-4.44690e-007	6.306e-008	-7.05	0.000	0.5939
Perishable Goods					
	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Constant	0.0489891	0.008178	5.99	0.000	0.5135
Distance	-3.11559e-005	4.622e-005	-0.674	0.505	0.0132
Size	-2.26109e-007	4.530e-008	-4.99	0.000	0.4229
Services					
	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Constant	0.104178	0.03801	2.74	0.010	0.1809
Distance	-7.26732e-005	0.0002148	-0.338	0.737	0.0034
Size	-1.09583e-006	2.105e-007	-5.20	0.000	0.4434
Non-perishable goods					
	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Constant	0.103220	0.02270	4.55	0.000	0.3925
Distance	3.47927e-005	0.0002868	0.121	0.904	0.0005
$Distance^2$	8.42534e-008	8.359e-007	0.101	0.920	0.0003
Size	-7.81805e-007	2.248e-007	-3.48	0.001	0.2743
$Size^2$	8.47542e-013	5.387e-013	1.57	0.125	0.0718
Perishable Goods					
	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Constant	0.0297011	0.01574	1.89	0.068	0.1002
Distance	8.52280e-005	0.0001988	0.429	0.671	0.0057
$Distance^2$	-3.09256e-007	5.794e-007	-0.534	0.597	0.0088
Size	8.79523e-008	1.558e-007	0.564	0.576	0.0099
$Size^2$	-7.95892e-013	3.734e-013	-2.13	0.041	0.1243
Services					
	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Constant	0.233107	0.07353	3.17	0.003	0.2390
Distance	-0.00147228	0.0009290	-1.58	0.123	0.0728
$Distance^2$	4.05641e-006	2.707e-006	1.50	0.144	0.0655
Size	-2.03591e-006	7.282e-007	-2.80	0.009	0.1963
$Size^2$	2.46794e-012	1.745e-012	1.41	0.167	0.0588

Figure 1: Boneless chunk roast prices

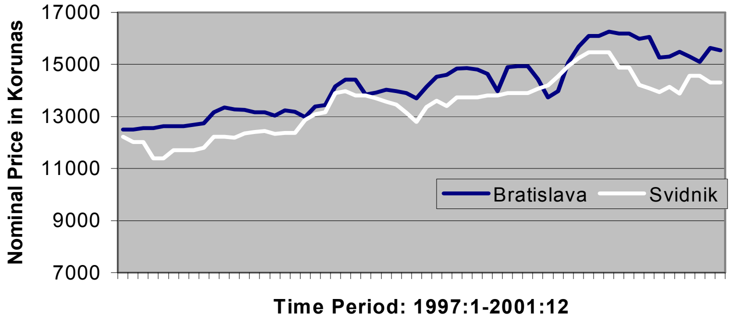


Figure 2: Wooden coffin prices

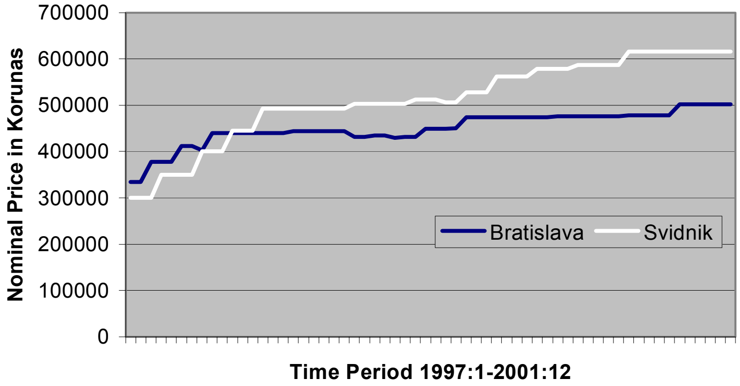


Figure 3: Matches prices across Slovak districts

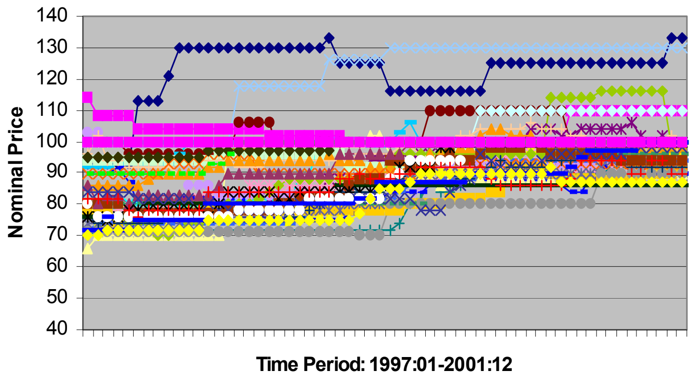


Figure 4: Gasoline 91-octane prices across Slovak districts

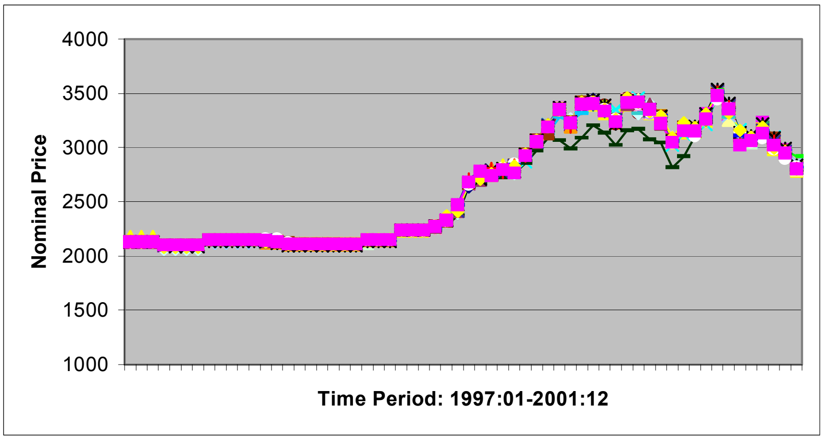


Figure 5: Mens sports leather shoes prices across Slovakia

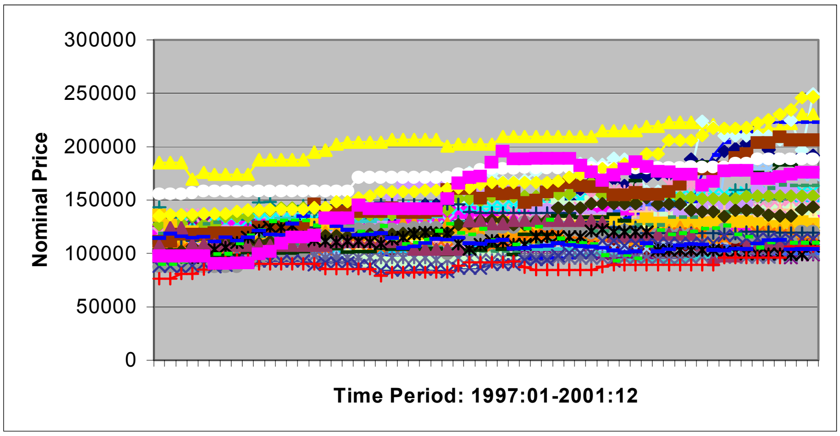


Figure 6: Price of Cigarette-Mars across Slovakia

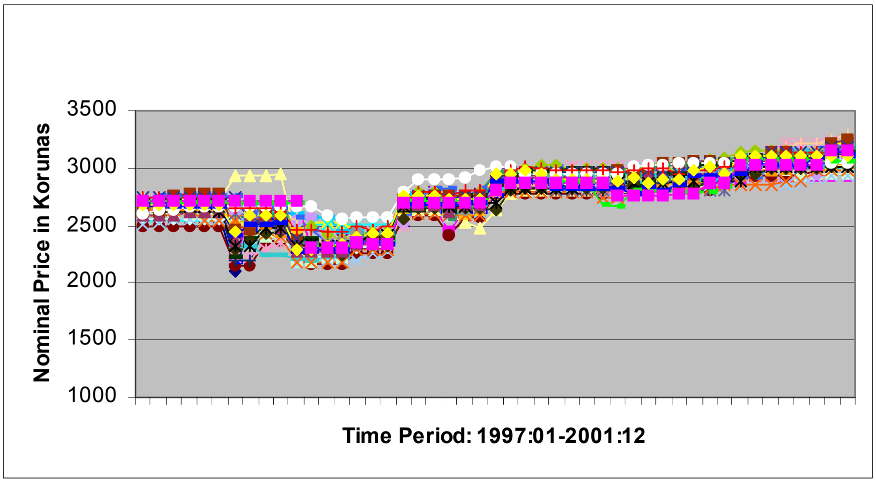


Figure 7: Cheese 'niva' price across Slovakia

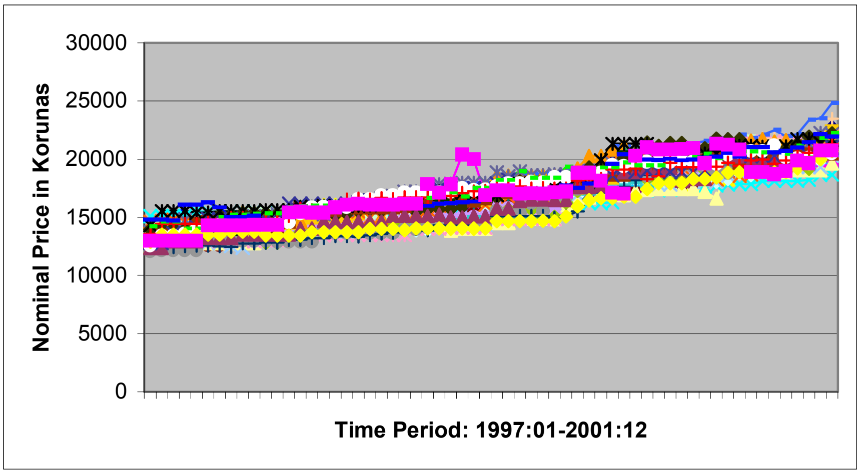


Figure 8: Boneless chunk roast, max-mean price

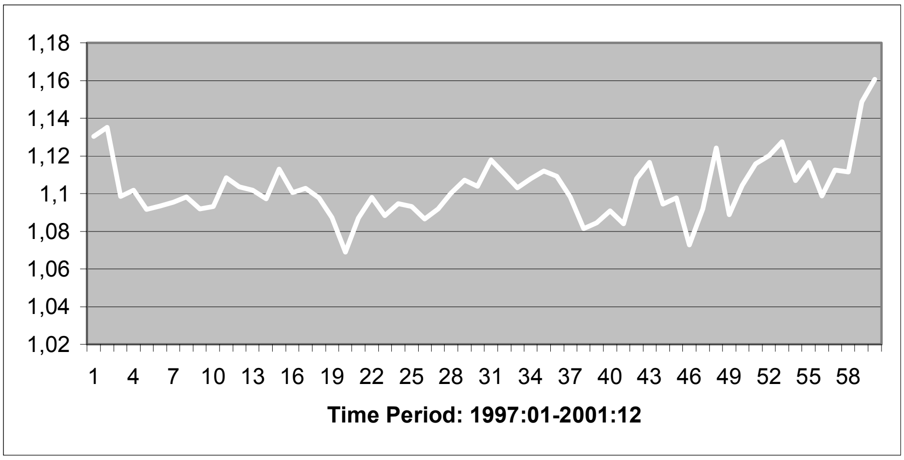
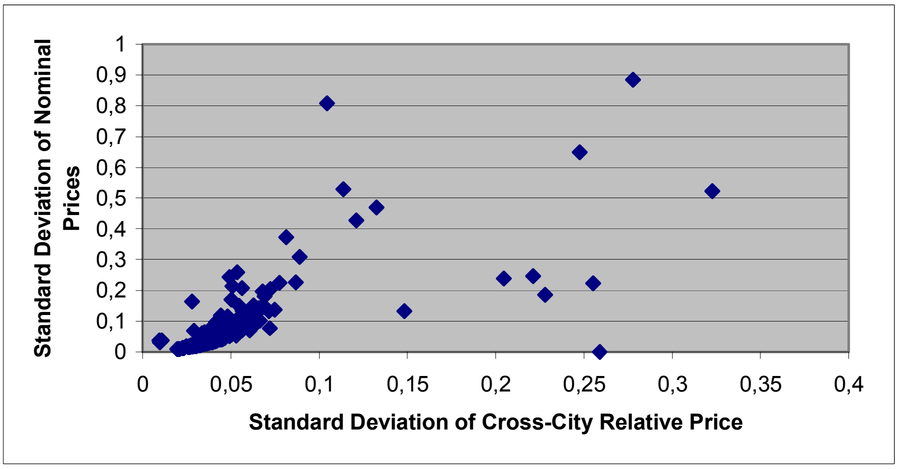


Figure 9: Law of one price deviations versus volatility of nominal prices



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