Convergence to the Law of One Price: Evidence from European Cities

by

István Szabó

Submitted to

Central European University

Department of Economics

In partial fulfilment of the requirements for the degree of

Master of Science

Supervisor: Katrin Rabitsch

Budapest, Hungary

2012

I, the undersigned [István Szabó], candidate for the degree of Master of Science at the Central European University Department of Economics, declare herewith that the present thesis is exclusively my own work, based on my research and only such external information as properly credited in notes and bibliography. I declare that no unidentified and illegitimate use was made of works of others, and no part the thesis infringes on any person's or intstitution's copyright. I also declare that no part the thesis has been submitted in this form to any other institution of higher education for an academic degree.

Budapest, 4 June 2012

_____

Signature

Acknowledgements

I would like to thank Katrin Rabitsch for her supervision. I am also thankful to Miklós Koren, who gave me the introduction to the topic and helped me with the data. I am grateful to Sergey Lychagin for his help in econometrics. I am also thankful to Thomas Rooney, who helped me finalizing my thesis.

Special thanks to Gábor Nyéki and other participants of the informal master thesis seminar for their good ideas regarding the thesis. All remaining errors are my own.

Abstract

This study examines the price movement between 38 European cities. Using the methods of Arellano and Bond (1991) and Levin et al. (2002) I find evidence for relative convergence of tradable goods prices between 1990 and 2007. The goods used are 211 tradable products, covering a large subgroup of goods. I also measure the effect of the enlargement of the European Union and the creation of Euro Area. The former cause prices increase relative to old members, the latter causes price decrease relative to cities outside Euro Area.

Table of Contents

List of Tables

List of Figures

1 Introduction

It is a fact that the price of a given product, or the price index of a given product category, is rarely equal across stores, cities or countries. The Law of One Price (hereafter LOOP), which is rather an assumption than a law, does not hold. Consequently, if one composes a bundle of goods, the price of that bundle does not, in general, cost the same across locations. If they cost the same, there would be absolute purchasing power parity (hereafter PPP). This empirical observation is theoretically important because some international macroeconomic model implicitly or explicitly assume the LOOP. In neoclassical macro models, there is no price stickiness and the price of good(s) is often omitted as well as there is no trade cost. Nevertheless, these two factors cannot capture price dispersion entirely (Engel and Rogers, 2001).

The failure of LOOP and absolute PPP have become a popular topic among researchers. There are several different factors that can be accounted for the price differences. The first is nominal price stickiness. Prices are normally set in the local currency. A change in the nominal exchange rate would require an immediate change in prices so that the price of a good remains the same in two countries with different currencies. One can find some discussion on the role of nominal exchange rates in Goldberg and Verboven (2005). The second is pricing-to-market. Even a multinational firm operating in several countries does not set their price so that they are equal (Haskel and Wolf, 2001). Alessandria and Kaboski (2011) offer a credible story behind the phenomena. They start from noting that the logarithm of price level is strongly correlated with the

logarithm of real income per capita. Their model, which produces this pattern of prices is based on searching. The third is trade barriers. The basic motivation behind a plausible assumption of the Law of One Price is that if one observes the price of a good in different location, she would want to buy that good at the lowest possible price. In other words, different price for the same good means arbitrage possibility. Existing trade barriers may make this arbitrage impossible to exploit.

In the presence of price convergence, prices are allowed to differ, but following an exogenous shock, prices move so the difference decays over time. Parsley and Wei (1996) provide the first credible results in favour of price convergence in a general setting. Why is price convergence or convergence to PPP so important? A meaningful alternative hypothesis to decreasing price dispersion is that prices follow a random walk. If the latter hypothesis were true, any shock to any price remains permanent. Nevertheless, Parsley and Wei (1996) and other studies (Horváth and Vidovic, 2004; Goldberg and Verboven, 2005) find that prices, in fact, converge. Consequently, the the theoretical models assuming LOOP or absolute PPP does not fail due to that assumption.

If price convergence is a desired goal for policy makers, it is important to know what factors enhance the process. Economic integration is an obvious candidate. Economic integration plays a key role in improving most economic indicators, although neoclassical growth theory does not deal with it. There are several studies about the effect of integration on the behavior of relative prices, most of which work with European data (Beck and Weber, 2001; Goldberg and Verboven, 2005). Beck and Weber (2001) do not only focus on the integration process within the European Union but on the German Economic Unification as well.

It is also worth noting that price convergence have negative consequences. Clearly, if the consumption bundle is cheaper in one country initially, inflation rate is higher during the convergence process. This topic is discussed in Rogers (2001)

In this thesis I follow the studies that measure the rate of convergence with special emphasis on the economic integration of Central and Eastern European countries. I answer the question

if there is a convergence in prices and what the half-life of convergence is. I also provide some evidence for price variability patterns within the sample. The main contribution of this thesis is to find the effect of European Union and Euro Area membership on the pattern of price convergence.

This thesis is structured as follows. In chapter 2 I review the literature of the topic from different perspectives, while Chapter 3 contains the description of the data I use. The methods used for the analysis are in chapter 4. The results of the estimation are presented in chapter 5, and chapter 6 concludes the thesis.

2 Literature review

The literature of the Law of One price is very extensive and there is no general cookbook for these articles. In other words, there are many different approaches to assess the price dispersion. There are some theoretical papers in this field, but most of the researches are empirical. These empirical works differ in a few dimensions, which I define as follows. The first is the disaggregation of data. The range of this dimension extends from fairly aggregated price indexes to the retail prices of particular products in different stores. The second is the geographical places the data are collected from. This is defined by the geographical extent and the origin of one particular data point, e.g. store, city, country. The third is methodology. There are several different methods used in the literature, mainly given by the dataset used. Obviously, for cross-sectional datasets, one uses cross-sectional methods. Since long enough time series of prices are available, the usage of panel methods is very common. Some apply simple panel methods like difference-in-differences, some do fairly sophisticated ones, e.g. dynamic panel methods. Also, one can find structural models that serves as a way to explicitly include the way price dispersion is developed. Finally, there are differences in the approach: a large part of the literature search for the cause of price differences, while others address the question of what improves the price convergence.

2.1 Disaggregation

The level of disaggregation is very important when deciding what to research. Haskel and Wolf (2001) examine the pricing decision of one particular firm, IKEA. For this research, they needed true retail prices of products, applied by the stores around the world. Their main interest was to examine the relative price differences of two similar products in different countries. They find that even if this relative price differences exist, thus, a potential arbitrage may take place, the extent to which the LOOP is violated should be large enough for a competitor to exploit it. To sum up, a credible threat of arbitrage is present if the difference of relative prices is large enough.

The other extreme of studies use aggregated prices or price indexes. Allington et al. (2004) make their estimations with comparative price level indexes from Eurostat. Typical products in the data are the following: pasta products; cocoa, excluding cocoa preparations; beer; cigarettes; small electric accessories; photographic and cinematographic equipment and optical instruments. The authors claim that "[t]his is the most disaggregated level at which data is currently held by Eurostat"(p. 9). On the one hand, the definition of these good categories may be too wide to derive a clear pattern of price changes. On the other hand, with these products, they can describe the phenomena for whole economies, not only certain industries.

2.2 Place

Some of the studies compare prices within one country. Two examples are Horváth and Vidovic (2004) and Rátfai (2006). They study prices in Slovakia and Hungary, respectively. Horváth and Vidovic (2004) looked at prices in the regions of Slovakia, an economy in transition. They had access to monthly prices of more than five hundred products from all 38 regions of the country. The products they included in the investigation include tradable goods as well as non-tradable goods and services. Since Slovakia is a relatively small country with an area of 49 thousand square kilometers, it is valid to include non-traded goods in the investigation. The data comes

from the Slovak Statistics Office and it is possible for anybody to go to another region of Slovakia and have a meal in a restaurant or borrow a wedding dress. [1] They examine the variability of prices by constructing measures suggested by Engel and Rogers (2001). [2] and find that the variability of relative prices of products within one region is greater than the variability of the price of one product across regions. They also computed the rate of convergence of priced across regions for most goods. The rate of convergence is identified by a panel unit root test Levin and Lin (1992). and the rate of convergence is expressed as the half life of convergence. Horváth and Vidovic (2004) reports different half lives for different goods categories, e.g. it is 5.68 months for non-perishable goods with Bratislava as benchmark district and demeaned price specification.

One of the supposed causes of price differences is trade costs. Trade costs prevent people to some extent from exploiting the arbitrage possibility given by different prices. This is why economic integration is in the focus of examining price convergence, as it means a reduction in trade barriers. The most obvious example of economic integration is the European Union. Goldberg and Verboven (2005) analyse the price convergence between five European countries from 1970 to 2000. They also used the method of Levin and Lin (1992). Although the authors argue for the importance of this market, and their results are plausible, it does not say anything about the LOOP in general. They find that the typical half life of shocks to prices of cars lies between 1.3 and 1.6 years, which is admittedly lower than 5-6 years what most studies suggest for Purchasing Power Parity. [3]

[1] These two items are part of the product list

[2] Similarly to Horváth and Vidovic (2004), Engel and Rogers (2001) looked at prices in one country, the United States of America.

[3] These estimations of 5-6 years may be upward biased as argued by Imbs et al. (2005)

2.3 Methodology

The panel unit root test of Levin and Lin (1992) [4] is widely used in the literature to analyze panel data and more specifically, to identify the half-life of convergence (Goldberg and Verboven, 2005; Horváth and Vidovic, 2004; Rátfai, 2006). Another popular econometric method is the Arellano and Bond (1991) dynamic panel estimator. A recent paper using this method dealing with similar question is Aker (2010). She examined the effect of mobile phone coverage on the dispersion of grain prices in Niger and found that mobile phone coverage accounts for a $10 - 16$ percent decrease in price dispersion. One can see that this setting captures the effect of other variables in contrast to unit-root tests, where the emphasis is on the time series itself. In addition, this study takes price dispersion as given and contains a channel through which the price dispersion can be reduced.

Even if one has access to panel data, it is not necessary to work with panel methods; ordinary least squares for cross-sectional data is enough. Engel and Rogers (1996) compute the standard deviation of relative prices over time, consequently losing the time dimension. They try to measure the effect of the border between Canada and the United States by examining relative prices between city pairs. Also, they only have thirteen product categories, so it makes sense to identify the border effect for each product category. Clearly, this study seeks to find a cause of price dispersion across countries.

Some studies build a sophisticated model to create price dispersion and use data to quantify the results. Crucini et al. (2009) build a dynamic stochastic general equilibrium model to analyse the connection between price stickiness, trade costs and price dispersion within one country across cities. The model they use contains three key elements. The first is firms set price for a specific good in a specific city and the firms are in a monopolistic competition. This is mandatory

[4] The revised version of the paper was published as Levin et al. (2002).

to produce intranational price dispersion. The second is transportation costs. The third is Calvo-pricing, which is often used in New-Keynesian macroeconomic models. This latter induces price dispersion. Their main finding is the substitutability between distance and price stickiness. Numerically it can be stated as follows : a one percentage point increase in the price stickiness is equivalent with 15 miles extra distance between cities. [5]

Some of the papers in this field are purely theoretical. Alessandria (2004) develops a model with infinite firms and infinite consumers located in two countries. The source of price dispersion in this paper is searching cost. The searching cost is fixed; nevertheless, the production cost (wage) each firm faces is stochastically changing over time. However attractive this model is, it is completely useless without testing its results. The author argues that the model is the first one to reproduce a U-shaped pass-through–market share relationship.

To sum up, I would say that if one has access to a data of prices and wants to describe the price dispersion, she is bounded by it in terms of methodology and obviously the place under investigation. This is why the data is very important in this field.

[5]The price stickiness measure is the one used in practice, the ratio of firms that cannot change price.

3 Data

The data I use comes from Unit (2007). This survey contains prices of consumption goods and services. Data was collected in 140 cities around the world, for slightly more than 300 goods, covering a large part of typical consumption. Prices are in current US dollars, thus I do not have to deal with exchange rates. A study that use a previous version of this dataset is Rogers (2001)

3.1 Data properties

The places I am interested in are European cities. It is very common in the literature that researchers try to capture the effect of integration by selecting the sample in order that it covers some economic integration process, e.g. integration of the United Kingdom to the European Communities, German Monetary Unification or European Monetary Unification. This is the reason I restrict my sample to contain 38 European cities.

As for the goods, I use only 211 tradable products. The motivation for this is the possibility of trade across countries within the more or less free trade area. Since international trade between countries in the European Union is especially high, my hypothesis is that the convergence rate for this data is higher than, for instance, the convergence rate to absolute PPP worldwide. I do not claim that it is meaningless to include services as well and I know that I identify the price convergence for tradable products only.

The data is given yearly from 1990 to 2007. This time period extends from the fall of so-

cialism in Central and Eastern European countries to the accession of Romania and Bulgaria to the European Union. I would say that the data is perfectly suitable to examine what happened to prices during the integration process in which ten CEE countries become members of the European Union.

I have to mention that the data contains missing values to a large extent. This does not cause a major problem, however, in the estimations. Either the method I use does not require balancedness, as the Arellano–Bond estimator, or I restrict the sample so that I can do the estimation, in the case of the Levin-Lin-Chu panel unit root test.

For the estimations I will also add dummies for European Union and Euro Area membership. For the countries that became members of the European Union on the 1st of May 2004, I decided to use the value 1, indicating that they are members. The other two dates of EU enlargement are 1995 and 2007. As for the Euro Area, the data only covers the creation of Euro Area.

The figure that is most suitable to motivate my thesis is figure 3.1. I produced the figure as follows. First, I calculated mean price for each good and each year. Then I divided each price entry with the appropriate mean. After that, I selected two subgroups of cities based on their accession date to the European Union. Each city that became part of the European Union before the 2004 enlargement were selected to the old members group. The other cities that became part of the European Union in 2004 or in 2007 were selected into the new members group. Finally, I calculated the mean of these normalized prices across goods and then across cities within group. What figure 3.1 displays is two time series, which is able to demonstrate the price convergence. Also, it seems that there is no absolute convergence between the two groups.

3.2 Statistical analysis

The evolution of prices over time is mainly addressed in the next chapter. Here, I provide a cross-sectional analysis of the data. A very effective way to explore the cross-sectional, two

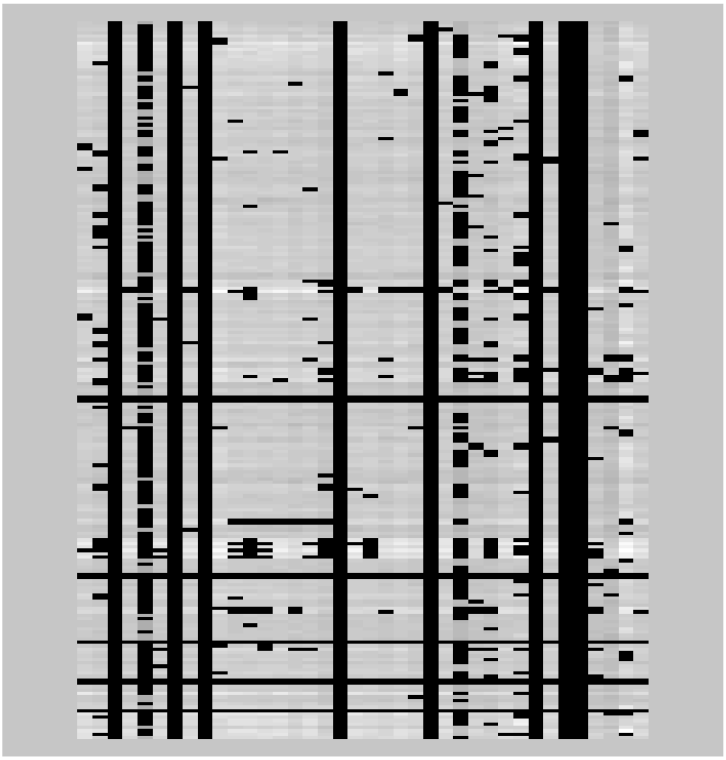
Figure 3.1: The evolution of prices in two groups of countries

dimensional properties of the data is offered by Engel and Rogers (2001). For each city k and good j I computed the r_{kj} coefficient as follows:

$$r_{kj} = \frac{\frac{1}{210}\sum_{n=1,n\neq j}^{211} sd(\Delta p_{jt}^k - \Delta p_{nt}^k)}{\frac{1}{37}\sum_{m=1,m\neq j}^{38} sd(\Delta p_{jt}^k - \Delta p_{jt}^m)},$$

where p_{jt}^k is the logarithm of price change of good j in city k in year t. The computed coefficients show for each good-city pairs whether the variation of the relative prices within the city or the variation of prices of the product across the cities is greater. The former is true if the coefficient is greater than one, the latter otherwise. Out of the 8018 possible good-city pairs, I could not compute the coefficient for 926 due to missing data. The majority of the remaining 7092 coefficients are greater than one, exactly 4571. This means that, in general, prices vary more within a city across goods than the price of a good across cities. Since the resulting coefficients would require a too large table, I report the coefficients as a grayscale image, where black means missing value. Furthermore, the frame I added stands for value one. If a cell is darker than that, it means it is lower than one.

Figure 3.2: The matrix of r_{kj} coefficients on a grayscale image



4 Methods

My main research question addresses the rate of price convergence across European cities. Taking into account the observation that prices tend to get closer, one would want to make the analysis in a dynamic panel setting. To measure if there is a convergence in prices and what is the rate of convergence, I use two methods, the dynamic panel estimator of Arellano and Bond (1991) and the panel unit root test of Levin et al. (2002).

4.1 Dynamic panel model

In the field of empirical economics the method of Arellano and Bond (1991) or its modified version (Arellano and Bover, 1995; Blundell and Bond, 1998), is used very frequently for dynamic panel estimations. This general method of moments estimator performs well for data with small time dimension and large cross-sectional dimension. Since I have a panel with yearly data between 1990 and 2007 and very large number of pruduct-city pairs, the available dataset is such that this estimator is expected to give meaningful result.

The model can be written in the following form:

$$q_{cgt} = \alpha + \beta q_{cg(t-1)} + \gamma X_{cgt} + \nu_{cgt},$$

where q_{cgt} is the logarithm of the price of good g in city c and year t divided by the price of good

g in a benchmark city in year t. With this transformed relative price, two things are ensured. First, the magnitude of the data points are the same for all goods by design. Thus, I compare apples to apples. Second, interpreting the result in a meaningful way becomes easier. Exogenous control variables are in X_{cgt} and ν_{ctg} is the disturbance term. This disturbance term is assumed to be serially uncorrelated. More formally, $E(\nu_{cgt}) = E(\nu_{cgt}\nu_{cgs}) = 0, t \neq s$ as in Arellano and Bond (1991).

4.2 Panel unit root test

The panel unit root test of Levin et al. (2002) is also a widely used method. Moreover, it is used by Goldberg and Verboven (2005), Horváth and Vidovic (2004) and Rátfai (2006) as it is mentioned in chapter 2. The disadvantage of this test is that it does not allow for controls in the estimated equation. In general, the hypothesis of Levin et al. (2002) is stated as follows:

$$\Delta q_{it} = \delta q_{it} + \sum_{L=1}^{P_i} \theta_{iL} \Delta q_{it-L} + \alpha_i d_t + \varepsilon_{it},$$

where d_t is the deterministic term, that is, zero, constant or time trend. Subscript i stands for cross section. The stochastic process q_{it} is under investigation. In order to perform the test, one has to state three assumptions. The first is the data generation model, it is either one of the following:

$$\begin{aligned}
\Delta q_{it} &= \delta q_{it-1} + \zeta_{it}, \text{ or} \\
\Delta q_{it} &= \alpha_{0i} + \delta q_{it-1} + \zeta_{it}, \text{ or} \\
\Delta q_{it} &= \alpha_{0i} + \alpha_{1i} t + \delta q_{it-1} + \zeta_{it},
\end{aligned}$$

where $-2 < \delta \geq 0$. Clearly, the one with the time trend is not suitable for this study because I use relative prices. The constant term, however, seems plausible if one takes into consideration

the fact that there were cities with systematically lower initial prices. Consequently, I have to test for unit root in both setup. The second assumption is that the disturbance terms have to be independently distributed across individuals and they follow an autoregressive–moving-average process. The third assumption is a set of finite moment conditions for the disturbance terms in the model as well as in the ARMA processes that define the disturbance terms in the model.

The test for unit root hypothesis is simply to decide whether the null, $\delta = 0$, is true. While the statistical significance of δ is important to test, the point estimate for δ is a key to saying something about the process itself. Similarly to the dynamic panel estimation, one can give an estimation for half-life to a shock. Although there are lagged difference terms in the definition of the process, they influence little the half life as their coefficients are usually very small and/or they are not statistically significant.

5 Results

5.1 Dynamic panel method

Table 5.1: Estimation results : Arellano-Bond dynamc panel method, Budapest as base city

Variable	**Coefficient** (Std. Err.)			
L.logrelprice	0.575**	0.635**	0.583**	0.644**
	(0.005)	(0.004)	(0.004)	(0.004)
eu	-0.061**	-0.068**		
	(0.008)	(0.009)		
euro	-0.110**		-0.110**	
	(0.004)		(0.004)	
Intercept	0.302**	0.249**	0.258**	
	(0.007)	(0.007)	(0.003)	
N	106849	106849	106849	106849
$\chi^2_{(3)}$	26809.558	24365.654	26543.638	24073.698

The estimated coefficients can be interpreted in two different ways. First, regarding that the panel has a time series dimension, which is modeled as autoregressive processes, one can identify the half life of the convergence. In other words, it is possible to predict how prices respond to a shock. Second, the combination of the estimated parameters gives the expected change in price movement as a consequence of economic integration. Assuming that there is steady state, one can also compute the steady state relative price that reflects systematic differences across cities.

Table 5.2: Estimation results : Arellano-Bond dynamc panel method, Brussels as base city

Variable	**Coefficient** (Std. Err.)			
L.logrelpricebru	0.553**	0.555**	0.563**	0.564**
	(0.011)	(0.011)	(0.011)	(0.011)
eu	0.100**	0.100**		
	(0.006)	(0.006)		
euro	0.012*		0.014**	
	(0.005)		(0.005)	
Intercept	-0.110**	-0.108**	-0.044**	
	(0.005)	(0.005)	(0.002)	
N	106761	106761	106761	106761
$\chi^2_{(3)}$	2979.759	2972.351	2432.727	2424.574

The impulse response of the estimated model is simply an exponential decay. This results from the single lagged dependent variable among the explanatory variables. The half-life can be computed as follows: $\frac{log(0.5)}{log(\beta)}$, where β is the coefficient of lagged dependent variable. According to my estimations, which can be seen in tables 5.1 and 5.2 for base cities Budapest and Brussels, respectively, the half-life of a shock is between 1.28 and 1.55 years. This result is in line with the convergence literature; the estimated half-life is roughly the same as in Goldberg and Verboven (2005) and somewhat larger than in Horváth and Vidovic (2004). The latter is not surprising, since that result comes from a small country. Since the number of locations is large enough, one might estimate the Arellano-Bond estimator as well for each product separately.

The estimated coefficients of the exogenous controls contain very important information. The two controls I included in the regressions are dummies for European Union membership and Euro Area membership. Taking into account that the disturbance terms are zero in expectation,

one can write the following equation:

$$E\left[q_{cgt}|q_{cgt-1}, X_{cgt}\right] = E\left[\alpha + \beta q_{cgt-1} + \gamma X_{cgt}|q_{cgt-1}, X_{cgt}\right] = \alpha + \beta q_{cgt-1} + \gamma X_{cgt}.$$

So far, there has only been one-way change in the value of the dummies: no country has left the Euro Area or European Union. Therefore, for each city in the sample there is at most one change in the vector of dummies over time. Therefore, it is interesting to see what happens at the change. It is also worth noting that Euro Zone membership always comes after accession to the European Union.

Suppose that there is a city that becomes part of the European Union in a given year covered by the sample time period. On average, the price of a good relative to the price in Brussels increases 10 percent if the country the city is located in becomes member of the European Union. I chose Brussels as a base city to identify this effect because it belonged to the European Union in 1990, the earliest year in my sample and its dummy series did not change. Considering that nine cities in the sample changed membership status, this change in price struck those cities.

The same analysis can be done for Euro Area membership. In this case it is better to work with the Budapest basis since Hungarian Forints was the legal currency used there throughout the whole sample. There is much less variability for Euro Area membership; I can only identify the effect of its introduction. Somewhat interestingly, the estimated coefficient in table 5.1 implies an average of 11 percent decrease of relative prices for cities which adopted euro as a currency in 2001.

I would like to add that the fact that the intercept is significantly different from zero where it is included in the model means strong support for the hypothesis that prices will not converge in absolute terms. That is, in the long run, or steady state, prices in European cities other than Budapest are 25 to 30 percent higher than in Budapest on average. It would be also interesting

Table 5.3: **P**anel unit root test results

	Budapest		Brussels	
	with constant	without constant	with constant	without constant
δ	-.38983052	-.04862533	-.33034955	-.00976703
s.e.	.00289684	.00083297	.00283525	.00048553
N	79845	79845	80790	80790
t	-1.3e+02	-58.3755	-1.2e+02	-20.1163
t^*	-36.9762	-55.8700	-4.0605	-19.3251
p	0.0000	0.0000	0.0000	0.0000
half-life	1.4	13.5	1.73	69

to examine specific bilateral price differences, but I will no deal with them in this thesis.

5.2 Panel unit root test

Table 5.3 contains the estimation results of the four specifications: columns 1 and 2 with Budapest as base city, columns 3 and 4 with Brussels as base city; columns 1 and 3 with constant, column 2 and 4 without constant. The half-life of the convergence is calculated from the point estimate in a slightly modified way than in the dynamic panel case. The estimated results for δ with constant imply somewhat higher half-lives than the dynamic panel estimator. The implied half-lives in the regressions without constant are also statistically significant, but they are a magnitude larger than the ones without constant. This is evidence for the phenomenon seen in figure 3.1, that the price between the two groups does not seem to converge to a common value. Test statistics are t and t^*. The latter, the adjusted one is appropriate for testing both models. Also, I report the p-values for the adjusted t-statistics. This adjusted t-statistic is asimptotically normally distributed, thus each estimate is significant.

6 Conclusion

In this thesis I presented an empirical analysis of the prices in European cities. The study was focusing on the period of enlargement of the European Union and the creation of Euro Area, between 1990 and 2007. I find strong evidence for price convergence. Also, I find that becoming member the of the European Union has an immediate effect of price increase, while introducing the Euro as a currency affected the prices of Euro Area to a negative direction relative to non-Euro Area members.

As a main method, I used the Arellano and Bond (1991) dynamic panel estimator , allowing the inclusion of control variables. Other studies in the field have not used this method extensively, an example for that does Aker (2010). Therefore, to my knowledge, no-one has used this method to evaluate the effect of European Economic Integration on European prices. The most common method to measure the rate of price convergence is performing the Levin et al. (2002) panel unit root test and make use of the estimated coefficient. To compare my data to the existing literature, I also performed the the test. I found that my estimated half-lives are in line with the literature.

Since the data I had access to does not extend to recent years, it would be definitely worth performing the dynamic panel test on more recent data in the future. It is also worth noting that European Economic Integration has not finished and it will still be interesting what happens after more Central and Eastern European countries adopt Euro.

References

Aker, Jenny C., "Information from Markets Near and Far: Mobile Phones and Agricultural Markets in Niger," *American Economic Journal: Applied Economics*, 2010, *2* (3), pp. 46–59.

Alessandria, George, "INTERNATIONAL DEVIATIONS FROM THE LAW OF ONE PRICE: THE ROLE OF SEARCH FRICTIONS AND MARKET SHARE*," *International Economic Review*, 2004, *45* (4), 1263–1291.

_ **and Joseph P. Kaboski**, "Pricing-to-Market and the Failure of Absolute PPP," *American Economic Journal: Macroeconomics*, January 2011, *3* (1), 91–127.

Allington, Nigel F., Paul A. Kattuman, and Florian A. Waldmann, "One Market, One Money, One Price? Price Dispersion in the European Union," *SSRN eLibrary*, 2004.

Arellano, Manuel and Olympia Bover, "Another look at the instrumental variable estimation of error-components models," *Journal of Econometrics*, 1995, *68* (1), 29 – 51.

_ **and Stephen Bond**, "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations," *The Review of Economic Studies*, 1991, *58* (2), 277–297.

Beck, Guenter W. and Axel A. Weber, "How Wide Are European Borders? New Evidence on the Integration Effects of Monetary Unions," *SSRN eLibrary*, 2001.

Blundell, Richard and Stephen Bond, "Initial conditions and moment restrictions in dynamic panel data models," *Journal of Econometrics*, 1998, *87* (1), 115 – 143.

Crucini, Mario J., Mototsugu Shintani, and Takayuki Tsuruga, "The Law of One Price Without the Border: The Role of Distance Versus Sticky Prices," Working Paper 14835, National Bureau of Economic Research April 2009.

Engel, Charles and John H. Rogers, "How Wide Is the Border?," *The American Economic Review*, 1996, *86* (5), pp. 1112–1125.

_ **and** _ , "Violating the Law of One Price: Should We Make a Federal Case Out of It?," *Journal of Money, Credit and Banking*, 2001, *33* (1), pp. 1–15.

Goldberg, Pinelopi K. and Frank Verboven, "Market integration and convergence to the Law of One Price: evidence from the European car market," *Journal of International Economics*, 2005, *65* (1), 49 – 73.

Haskel, Jonathan and Holger Wolf, "The Law of One Price - A Case Study," Working Paper 8112, National Bureau of Economic Research February 2001.

Horváth, J. and S. Vidovic, "Price variability and the speed of adjustment to the law of one price : evidence from Slovakia," Helsinki 2004// 2004. working paper.

Imbs, Jean, Haroon Mumtaz, Morten O. Ravn, and Hlne Rey, "PPP Strikes Back: Aggregation And the Real Exchange Rate," *The Quarterly Journal of Economics*, 2005, *120* (1), 1–43.

Levin, Andrew and Chien-Fu Lin, "Unit Root Tests in Panel Data: Asymptotic and Finite-Sample Properties: Asymptotic and Finite-Sample Properties, unpublished manuscript," Discussion paper, University of California San Diego 1992.

_ , _ , **and Chia-Shang James Chu**, "Unit root tests in panel data: asymptotic and finite-sample properties," *Journal of Econometrics*, 2002, *108* (1), 1 – 24.

Parsley, David C. and Shang-Jin Wei, "Convergence to the Law of One Price Without Trade Barriers or Currency Fluctuations," Working Paper 5654, National Bureau of Economic Research July 1996.

Rátfai, A., "How fast is convergence to the law of one price? Very," *Economics Bulletin*, 2006// 2006, *6*, 1 – 12. exported from refbase (http://www.bibliography.ceu.hu/show.php?record=1356), last updated on Tue, 23 Jun 2009 13:52:57 +0200.

Rogers, John H., "Price Level Convergence, Relative Prices, and in Europe," *SSRN eLibrary*, 2001.

Unit, Economist Intelligence, "Worldwide Cost of Living Survey," 2007. .

Appendix A

List of Goods

Table A.1: Goods in the sample

Beer, local brand (1 l) (mid-priced store)

Beer, local brand (1 l) (supermarket)

Beer, top quality (330 ml) (mid-priced store)

Beer, top quality (330 ml) (supermarket)

Cognac, French VSOP (700 ml) (mid-priced store)

Cognac, French VSOP (700 ml) (supermarket)

Gin, Gilbey's or equivalent (700 ml) (mid-priced store)

Gin, Gilbey's or equivalent (700 ml) (supermarket)

Liqueur, Cointreau (700 ml) (mid-priced store)

Liqueur, Cointreau (700 ml) (supermarket)

Scotch whisky, six years old (700 ml) (mid-priced store)

Scotch whisky, six years old (700 ml) (supermarket)

Vermouth, Martini & Rossi (1 l) (supermarket)

Vermouth, Martini & Rossi (1 l) (mid-priced store)

Wine, common table (1 l) (mid-priced store)

Wine, common table (1 l) (supermarket)

Wine, fine quality (700 ml) (mid-priced store)

Wine, fine quality (700 ml) (supermarket)

Wine, superior quality (700 ml) (mid-priced store)

Wine, superior quality (700 ml) (supermarket)

Boy's jacket, smart (chain store)

Boy's jacket, smart (mid-priced/branded store)

Business suit, two piece, medium weight (chain store)

Business suit, two piece, medium weight (mid-priced/branded store)

Boy's dress trousers (chain store)

Boy's dress trousers (mid-priced/branded store)

Child's jeans (chain store)

Child's jeans (mid-priced/branded store)

Child's shoes, dresswear (mid-priced/branded store)

Child's shoes, dresswear (chain store)

Dress, ready to wear, daytime (chain store)

Dress, ready to wear, daytime (mid-priced/branded store)

Girl's dress (chain store)

Girl's dress (mid-priced/branded store)

Men's shoes, business wear (chain store)

Men's shoes, business wear (mid-priced/branded store)

Business shirt, white (chain store)

Business shirt, white (mid-priced/branded store)

Mens raincoat, Burberry type (chain store)

Men's raincoat, Burberry type (mid-priced/branded store)

Child's shoes, sportswear (chain store)

Child' s shoes, sportswear (mid-priced/branded store)

Socks, wool mixture (mid-priced/branded store)

Socks, wool mixture (chain store)

Tights, panty hose (chain store)

Tights, panty hose (mid-priced/branded store)

Women's cardigan sweater (chain store)

Women's cardigan sweater (mid-priced/branded store)

Women's raincoat, Burberry type (chain store)

Women's raincoat, Burberry type (mid-priced/branded store)

Women's shoes, town (chain store)

Women's shoes, town (mid-priced/branded store)

Apples (1 kg) (mid-priced store)

Apples (1 kg) (supermarket)

Bacon (1 kg) (mid-priced store)

Bacon (1 kg) (supermarket)

Beef: ground or minced (1 kg) (mid-priced store)

Beef: ground or minced (1 kg) (supermarket)

Bananas (1 kg) (mid-priced store)

Bananas (1 kg) (supermarket)

Beef: roast (1 kg) (mid-priced store)

Beef: roast (1 kg) (supermarket)

Beef: stewing, shoulder (1 kg) (mid-priced store)

Beef: stewing, shoulder (1 kg) (supermarket)

Butter, 500 g (mid-priced store)

Butter, 500 g (supermarket)

Cocoa (250 g) (mid-priced store)

Cocoa (250 g) (supermarket)

Cornflakes (375 g) (mid-priced store)

Cornflakes (375 g) (supermarket)

Cheese, imported (500 g) (mid-priced store)

Cheese, imported (500 g) (supermarket)

Coca-Cola (1 l) (mid-priced store)

Coca-Cola (1 l) (supermarket)

Carrots (1 kg) (mid-priced store)

Carrots (1 kg) (supermarket)

Chicken: fresh (1 kg) (mid-priced store)

Chicken: fresh (1 kg) (supermarket)

Chicken: frozen (1 kg) (mid-priced store)

Chicken: frozen (1 kg) (supermarket)

Drinking chocolate (500 g) (mid-priced store)

Drinking chocolate (500 g) (supermarket)

Eggs (12) (mid-priced store)

Eggs (12) (supermarket)

Frozen fish fingers (1 kg) (mid-priced store)

Frozen fish fingers (1 kg) (supermarket)

Fresh fish (1 kg) (mid-priced store)

Fresh fish (1 kg) (supermarket)

Flour, white (1 kg) (mid-priced store)

Flour, white (1 kg) (supermarket)

Beef: filet mignon (1 kg) (mid-priced store)

Beef: filet mignon (1 kg) (supermarket)

Ground coffee (500 g) (mid-priced store)

Ground coffee (500 g) (supermarket)

Ham: whole (1 kg) (mid-priced store)

Ham: whole (1 kg) (supermarket)

Instant coffee (125 g) (mid-priced store)

Instant coffee (125 g) (supermarket)

Lamb: chops (1 kg) (mid-priced store)

Lamb: chops (1 kg) (supermarket)

Lemons (1 kg) (mid-priced store)

Lemons (1 kg) (supermarket)

Lamb: leg (1 kg) (mid-priced store)

Lamb: leg (1 kg) (supermarket)

Lamb: Stewing (1 kg) (mid-priced store)

Lamb: Stewing (1 kg) (supermarket)

Lettuce (one) (mid-priced store)

Lettuce (one) (supermarket)

Margarine, 500g (mid-priced store)

Margarine, 500g (supermarket)

Mushrooms (1 kg) (mid-priced store)

Mushrooms (1 kg) (supermarket)

Milk, pasteurised (1 l) (mid-priced store)

Milk, pasteurised (1 l) (supermarket)

Mineral water (1 l) (mid-priced store)

Mineral water (1 l) (supermarket)

Orange juice (1 l) (mid-priced store)

Orange juice (1 l) (supermarket)

Onions (1 kg) (mid-priced store)

Onions (1 kg) (supermarket)

Olive oil (1 l) (mid-priced store)

Olive oil (1 l) (supermarket)

Oranges (1 kg) (mid-priced store)

Oranges (1 kg) (supermarket)

Peanut or corn oil (1 l) (mid-priced store)

Peanut or corn oil (1 l) (supermarket)

Peaches, canned (500 g) (mid-priced store)

Peaches, canned (500 g) (supermarket)

Pork: loin (1 kg) (mid-priced store)

Pork: loin (1 kg) (supermarket)

Pork: chops (1 kg) (mid-priced store)

Pork: chops (1 kg) (supermarket)

Peas, canned (250 g) (mid-priced store)

Peas, canned (250 g) (supermarket)

Potatoes (2 kg) (mid-priced store)

Potatoes (2 kg) (supermarket)

Beef: steak, entrecote (1 kg) (mid-priced store)

Beef: steak, entrecote (1 kg) (supermarket)

Sliced pineapples, canned (500 g) (mid-priced store)

Sliced pineapples, canned (500 g) (supermarket)

Spaghetti (1 kg) (mid-priced store)

Spaghetti (1 kg) (supermarket)

Sugar, white (1 kg) (mid-priced store)

Sugar, white (1 kg) (supermarket)

Tea bags (25 bags) (mid-priced store)

Tea bags (25 bags) (supermarket)

Tomatoes, canned (250 g) (mid-priced store)

Tomatoes, canned (250 g) (supermarket)

Tomatoes (1 kg) (mid-priced store)

Tomatoes (1 kg) (supermarket)

Tonic water (200 ml) (mid-priced store)

Tonic water (200 ml) (supermarket)

Veal: chops (1 kg) (mid-priced store)

Veal: chops (1 kg) (supermarket)

Veal: fillet (1 kg) (mid-priced store)

Veal: fillet (1 kg) (supermarket)

Veal: roast (1 kg) (mid-priced store)

Veal: roast (1 kg) (supermarket)

White bread, 1 kg (mid-priced store)

White bread, 1 kg (supermarket)

White rice, 1 kg (mid-priced store)

White rice, 1 kg (supermarket)

Yoghurt, natural (150 g) (mid-priced store)

Yoghurt, natural (150 g) (supermarket)

Batteries (two, size D/LR20) (mid-priced store)

Batteries (two, size D/LR20) (supermarket)

Dishwashing liquid (750 ml) (mid-priced store)

Dishwashing liquid (750 ml) (supermarket)

Electric toaster (for two slices) (mid-priced store)

Electric toaster (for two slices) (supermarket)

Frying pan (Teflon or good equivalent) (mid-priced store)

Frying pan (Teflon or good equivalent) (supermarket)

Insect-killer spray (330 g) (mid-priced store)

Insect-killer spray (330 g) (supermarket)

Light bulbs (two, 60 watts) (mid-priced store)

Light bulbs (two, 60 watts) (supermarket)

Laundry detergent (3 l) (mid-priced store)

Laundry detergent (3 l) (supermarket)

Soap (100 g) (mid-priced store)

Soap (100 g) (supermarket)

Toilet tissue (two rolls) (mid-priced store)

Toilet tissue (two rolls) (supermarket)

Cost of six tennis balls eg Dunlop, Wilson (average)

Aspirins (100 tablets) (mid-priced store)

Aspirins (100 tablets) (supermarket)

Facial tissues (box of 100) (mid-priced store)

Facial tissues (box of 100) (supermarket)

Hand lotion (125 ml) (mid-priced store)

Hand lotion (125 ml) (supermarket)

Lipstick (deluxe type) (mid-priced store)

Lipstick (deluxe type) (supermarket)

Razor blades (five pieces) (mid-priced store)

Razor blades (five pieces) (supermarket)

Shampoo & conditioner in one (400 ml) (mid-priced store)

Shampoo & conditioner in one (400 ml) (supermarket)

Toothpaste with fluoride (120 g) (mid-priced store)

Toothpaste with fluoride (120 g) (supermarket)

Compact disc album (average)

Television, colour (66 cm) (average)

Daily local newspaper (average)

International foreign daily newspaper (average)

Kodak colour film (36 exposures) (average)

Personal computer (64 MB) (average)

Paperback novel (at bookstore) (average)

International weekly news magazine (Time) (average)

Cigarettes, local brand (pack of 20) (mid-priced store)

Cigarettes, local brand (pack of 20) (supermarket)

Cigarettes, Marlboro (pack of 20) (mid-priced store)

Cigarettes, Marlboro (pack of 20) (supermarket)

Pipe tobacco (50 g) (average)

Regular unleaded petrol (1 l) (average)

Appendix B

List of Cities

Table B.1: Cities in the sample

AMSTERDAM
ATHENS
BAKU
BARCELONA
BELGRADE
BERLIN
BRATISLAVA
BRUSSELS
BUCHAREST
BUDAPEST
COPENHAGEN
DUBLIN
DUSSELDORF

FRANKFURT

GENEVA

HAMBURG

HELSINKI

KIEV

LISBON

LONDON

LUXEMBOURG

LYON

MADRID

MANCHESTER

MILAN

MOSCOW

MUNICH

OSLO

PARIS

PRAGUE

REYKJAVIK

ROME

SOFIA

ST PETERSBURG

STOCKHOLM

VIENNA

WARSAW

ZURICH