Regional price levels in Germany

Michael W. M. Roos
University of Dortmund

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Abstract

Cross-sectional evidence on price levels is scarce in all countries. However, several studies suggest that there might exist considerable differences in price levels within countries, which has obvious welfare implications. I use a sample of price levels in 50 German cities in 1993 to analyze the determinants of inter-city price level differentials. The most important factors driving price level differentials are population size and the average wage level. Using this information, I predict the price levels in all 440 German districts and aggregate them to the state level. On the state level I find convergence of the price levels to a common mean, but at a very low speed. The estimated half-life is about 15 years.

Keywords: price levels, regional price differentials, convergence
JEL classification: E31, R00, R10,

1 Introduction

Geographic price differentials are intensely studied in the economic literature. There are two different but closely related foci on this topic: one on inflation and one on price levels. First, there is the research on international purchasing power parity (PPP) which compares price movements across international borders (see Engel 1993, Froot/Rogoff 1995, Frankel/Rose 1996, Engel/Rogers 1997, Engel/Rogers 2001). The general result of this literature is that there are deviations from PPP, which are fairly persistent. To get a better understanding of the sources of theses deviations from PPP, several researchers studied the price movement within a country where trade barriers are expected to be lower and the influence of the nominal exchange rate is eliminated (see Parsley/Wei 1996, Cecchetti et al. 2002). Again, deviations from PPP are found.

Moreover, these deviations from city PPP are more persistent than the deviations from international PPP (Cechetti et al. 2002, p. 1094).

The second strand of research focuses on price levels instead of inflation. The analysis of geographic price level differentials complements the inflation differential studies and is important for its own sake. National and regional inflation rates are calculated from price indices which are normalized in a base year. The problem is that the actual price levels in the base year typically are unknown. This means that there might exist permanent deviations from PPP even if we observe identical inflation rates in two countries or regions because of unobserved price level differences in the base year. But deviations from PPP are not only interesting from a theoretical point of view. Regional price level differentials indicate differences in regional costs of living and thus may have important welfare implications. There exists some direct evidence that even within countries price level differentials are common and a permanent feature rather than a transitory one necessary as an adjustment process following shocks (McMahon 1991, Walden 1998, Koo et al. 2000, Tabuchi/Yoshida 2000, Kakwani/Hill 2002, Emery/Levitt 2002, Slesnick 2002).

In this paper, I provide new evidence on intra-country regional price level differences in Germany. In all countries data on consumer price levels at a single point in time are scarce since they are not collected by the official statistics offices on a regular basis. In general, the only data available are infrequently collected official data or data from private sources. However, this privately produced information, such as the well-known ACCRA index for U.S. cities, might not be well suited for scientific uses (see Koo et al. 2000).

In Germany, the Federal Statistical Office and the Statistical Offices of the states collected cross-sectional data on prices of consumer goods and services (except housing) only in 1978 and in 1993. The 1978 sample (Rostin 1979) covers 31 cities and the 1993 sample (Ströhl 1994) covers 50 cities, 32 in the former FRG and 17 in the former GDR and the two parts of Berlin. Surprisingly, this data source has been totally ignored by economic researchers. To the best of my knowledge, this paper is the first in-depth analysis and application of the 1993 data set.

The paper has three goals. First, I analyze the determinants of the observed inter-city price level differentials. Second, I estimate the price levels for all 440 German districts (Kreise) in 1993 and the 16 states (Bundesländer). Finally, I use the CPI inflations rates of the states to calculate the 2002 price level differences on the state level and to analyze if we observe price level convergence between the states.

The analysis has produced the following results. The regional average

wage level and the population size are the most important determinants of a city's consumer price level. Regional income is a good predictor, too, but inferior to population. The local rental rate of retail outlets as a component of retailing costs is irrelevant. Although the econometric model fits best for the price index of services, the price index of goods and especially the index of non-durable goods can be explained as well. Altogether, the estimation results are very convincing and seem to be even better than those obtained in the two studies for the U.S. which are closest to my study (McMahon 1991, Walden 1998). The good model fit and the comparison of out of sample predictions with in sample estimates indicate that the predicted price levels for the districts not included in the original sample are fairly reliable. They could thus be used for tests of theoretical models, e.g. from the New Economic Geography (see Fujita et al. 1999) or from migration theory[1]. Finally, I find convergence of price levels within states. This contrasts to McMahon (1991) and Slesnick (2002) reporting permanent and even widening price level differentials over time for U.S. regions. However, with a half-life of about 15 years the convergence is rather slow compared to the estimated half-lives from the PPP studies[2].

Section 2 describes a very simple supply and demand framework as the theoretical foundation for the choice of regressors. Section 3 presents the data and the econometric model. In Section 4, I estimate several versions of the model, perform some robustness checks, and discuss the model that I use for prediction. Section 5 contains the prediction results including the estimation of the speed of convergence. A final section summarizes the main results and discusses issues to be treated in future work.

2 Model

I use a very simple supply and demand framework in order to explain the regional consumer price level. From standard consumer theory the demand for a good i should be mainly a function of its price p_i, the prices of other goods j such as substitutes and complements $\mathbf{p}_j$, and the expenditure level, which is a function of income per capita y and the

[1] Tests of New Economic Geography models have been somewhat unsatisfactory so far. A reason for this is the lack of regional price level data (see Hanson 1998, Roos 2001). The same is true for studies analyzing the determinants of migration flows (see Decressin 1994).

[2] Cecchetti et al. (2002) estimate a half-life of price level differentials between European cities of nine years. For U.S. cities and individual commodities Parsley and Wei (1996) estimate half-lifes between four to five *quarters* (tradable goods) and fifteen *quarters* (services).

population size n. Hence we can formulate

$$q_i^d = q_i^d(p_i, \mathbf{p}_j, y, n). \tag{1}$$

Since I want to analyze the aggregate price level p of a region, I have to aggregate all goods available in a region to total demand

$$q^d = q^d(p, y, n). \tag{2}$$

Of course, demand depends negatively on p and positively on y and n.

From the theory of the firm we know that the supply of a good should depend on prices, costs and degree of competition in the market, which is likely to be a function of the number of suppliers s. Therefore, total supply in a region can be written as

$$q^s = q^s(p, \mathbf{c}, s). \tag{3}$$

The relevant costs $\mathbf{c}$ are the costs of local factors, since the costs of traded intermediate goods should be the same in all regions if trade costs are negligible. For consumer goods the relevant costs should depend on the regional wage level w and the rents of retail outlets r. Supply should rise in p and s and fall in w and r.

Using the market equilibrium condition we can eliminate the quantity and write the price level as a function of the demand and supply determinants

$$p = p(y, n, w, r, s). \tag{4}$$

A simple linear specification of the equilibrium price in region k could be

$$p_k = \alpha_0 + \alpha_1 y_k + \alpha_2 n_k + \alpha_3 w_k + \alpha_4 r_k + \alpha_5 s_k \tag{5}$$

where all parameters should be positive.

3 Data and estimation

Data For the dependent variable I use the data provided in Ströhl (1994). This is one of the two cross-section samples collected by the Federal Statistical Office Germany and contains price indices for 50 German cities in 1993. Of these 50 cities 32 are located in the western part of Germany and 17 in the former GDR. Since Berlin was divided, two indices are calculated for the western and the eastern part respectively so that in total 51 observations are available. It is important to mention that the price indices are not cost of living indices for two reasons. First, they do not contain prices of housing. Second, they have been constructed using the national expenditure shares as weights so that the

indices do not represent local expenditure patterns. The index is based on a basket of 367 goods and services. In total, about 70000 prices were collected.

Ströhl (1994) also provides subindices for several commodity groups of which I use the subindices for goods and services and of durable and non-durable goods. All price levels are expressed relative to the base city Bonn whose price level is normalized to 100. Table 1 contains some summary statistics of all observations. The coefficient of variation and the range between the minimum and the maximum show that there is considerable geographic variation in consumer price levels. Not surprisingly, the differentials are larger for services than for tradable goods. It is also very plausible that there is almost no variation in the price levels of consumer durables since these goods are likely to be traded interregionally[3].

	(1) Total	(2) Goods	(3) Services	(4) Non-durables	(5) Durables
Mean	97.4	98.9	93.4	99.3	98.5
CV	0.036	0.018	0.091	0.033	0.007
Min	91.4	95.4	78.1	93.5	97.0
Max	103.7	102.9	109.1	106.0	100

Table 1: Summary statistics of price levels 1993 in 51 German cities

However, looking at summary statistics for all cities in the sample might be misleading because of the special conditions in East Germany. For this reason, I present the statistics for the two parts of Germany separately in Table 2 for the West German cities and Table 3 for the East German cities. These tables show that within each part of the country the price differentials are lower. Interestingly, the coefficients of variation are almost equal in the West and the East for each index. Although the variation is much lower in each part, especially the difference of 9 percentage points between the cheapest city (Nordhorn) and the most expensive city (Munich) in the West are considerable.

It is also very interesting to have a closer look at the price levels in the two parts of Berlin. One could presume that the price levels should

[3]However, compared to the variation of other economic variables, the coefficients of variation are rather low as the following table shows:

	Wages	Rental rates	GDP	Population
Total	0.201	0.460	1.347	1.340
West	0.080	0.420	1.165	0.680
East	0.073	0.457	1.039	1.295

	(1) Total	(2) Goods	(3) Services	(4) Non-durables	(5) Durables
Mean	99.6	99.9	98.8	101.2	98.6
CV	0.019	0.013	0.045	0.022	0.008
Min	94.9	97	89.2	96.8	97.1
Max	103.7	102.9	109.1	106.0	100

Table 2: Summary statistics of price levels 1993 in 33 West German cities

	(1) Total	(2) Goods	(3) Services	(4) Non-durables	(5) Durables
Mean	93.4	97.0	83.5	95.8	98.3
CV	0.015	0.008	0.046	0.013	0.006
Min	91.4	95.1	78.1	93.5	97.0
Max	96.5	98.3	92.1	97.8	99.2

Table 3: Summary statistics of price levels 1993 in 18 East German cities

be fairly similar due to the relatively short distances within the city. If the price level in East Berlin were considerably lower than the price level in West Berlin, Westerners could easily shop in the East. This increase in demand should drive up the price level in the East. However, this did not happen. At least, there was no price level convergence until 1993. This can be seen in Table 4. The price indices of all goods excluding housing differed by 6.4 percentage points. Since this is aggregate data it is likely that prices of some individual goods differed even more.

Now, I turn to the discussion of the independent variables. A major problem is the availability of appropriate data for the theoretical variables. In order to measure the degree of competition in each city, I could use the number of retail outlets and relate it to the number of inhabitants. The number of outlets is available form the outlet census 1993 ("Handels- und Gaststättenzählung"), but I chose not to acquire the data for two reasons. First, it is likely that the number of outlets is a poor measure of competition if suppliers are heterogenous. A more adequate variable would be concentration measure based on market share

	(1) Total	(2) Goods	(3) Services	(4) Non-durables	(5) Durables
West	102.9	101.9	105.7	103.6	100
East	96.5	98.1	92.1	97.4	98.8

Table 4: Price levels in Berlin

which is not available. Second, the data is not available from a single source, but would have to be acquired from each of the 16 states' statistical offices. Given the doubts concerning the adequacy of this variable this seems too costly. Furthermore, there is some evidence that the empirical relation between prices and market structure variables is weak (Asplund/Friberg 2002). Therefore, I will not introduce a competition variable in the estimation equation.

The second variable which is problematic is income. Ideally, disposable income should be used but data for disposable income is not available for the cities in the East. The second best solution would be GNP which is not available at all on a disaggregate geographical level. GDP data is available, but only for 1992. Since the regions in East Germany had enormous growth rates in the first years after the German reunification[4], the error caused by using the 1992 data would be large. I interpolate the values for 1993 in region r with the formula

$$GDP_{93,r} = 0.5 \left(GDP_{92,r}(1 + \gamma_{93}) + \frac{GDP_{94,r}}{(1 + \gamma_{94})} \right), \tag{6}$$

where γ_{93} and γ_{94} are the growth rates of GDP on the state level.

Similar problems arise with wages. It would be ideal to have the wage rate in the retail sector on the city or district level. What is available are average annual wages per capita in districts. Again, there are no observations for 1993 but only for 1992 and from 1995 to 1997. I use these observations to interpolate the 1993 values using a quadratic time trend[5]. The interpolation is necessary because as with GDP, the growth rates of wages in Eastern regions were very high.

For some cities, I have no data for the rental rate of retail outlets. They are missing for small cities, especially in the East. I approximate these data by using the average rental rate in cities of comparable size in the respective part of the country. This approximation seems justified as the simple correlation between the rental rate and a city's population is about 0.67.

As already mentioned, in some cases the geographical reference unit differs between the dependent and some of the independent variables. This is due to the administrative structure of Germany consisting of urban and rural districts ("kreisfreie Städte" and "Landkreise"). The larger cities are urban districts whereas some of the small cities belong to larger a rural district. The problem is that most data is only available on the district level but not on the city level. In the case of the rural

[4]The average growth rate of the Eastern länder in 1993 was 21.2 %.

[5]The fitted trend lines have high values of R^2. In general, they are larger than 0.9.

districts, which are larger than the city, the income variable overstates the city's income and the wage is the average wage of the whole district which does not need to be identical with the average wage in the city. On the other hand, to concentrate on a city's income and population in the case of the urban districts might not be appropriate either, since it is likely that large cities also serve some of the demand of their hinterland belonging to the surrounding rural districts. In addition, I have the conceptual difficulty that the demand for local goods does not come from local residents only but also from tourists and travelers. Their demand might not be important for large cities but it is probable that it does have an impact on local prices in small resorts. In these cases, the actual demand is larger than the demand measured by the local population and the local income. Accordingly, the estimated coefficients of income and population will be biased upwards. In order to cope with this problem, I include a dummy in the estimation equation which takes on the value of one if the city is an urban district. In addition, a variable which captures the demand from outside the region should be included. Since I do not have the numbers of tourists and travelers in each city in 1993, I construct another dummy variable. This dummy is one in regions in which the ratio of hotel beds to residents is larger than the average of all regions[6]. Both the urban district dummy and the tourism dummy are expected to have positive coefficients because the actual demand in the respective regions is likely to be higher than the measured one. In the same line of thinking, I include a dummy for cities that are classified as central places and expect its coefficient to be positive.

Econometric issues Two econometric problems might arise. The first is multicollinearity. As Table 5 shows, some of the independent variables are highly correlated. Especially wage and GDP per capita and total GDP and population have very high positive correlations. Hence I will not include these variables in one estimation equation but rather estimate one equation with population and another with GDP. Since I want to have the wage as a cost factor in my regressions, I do not include GDP per capita at all.

The second problem is more severe than multicollinearity. For theoretical reasons one might expect that the wage is endogenous and therefore correlated with the error term. Standard labor market theory predicts that the wage rate is a function of the expected price level and vice versa. In order to avoid the resulting endogeneity bias, I instrument the average wage by variables describing the average qualification

[6] The number of overnight stays is available from 1995. Since this number is fluctuating strongly, there is no easy way of predicting the needed values. The classification of regions in tourist and non-tourist regions seems more robust against these errors.

	Wage	GDP	GDP p.c.	Population
GDP	0.5149	1		
GDP p.c.	0.8065	0.5488	1	
Population	0.3126	0.9129	0.3077	1
Rental rate	0.5865	0.7600	0.6018	0.7353

Table 5: Correlation of independent variables

and other characteristics of the local labor force. According to the AIC and likelihood ratio tests the following specification seems to be best to instrument the wage[7]:

$$\widehat{w} = \underset{(2.5)}{17.810} - \underset{(-11.3)}{13.088}\, d^{east} - \underset{(-1.51)}{5.627}\, f^{unsk} + \underset{(2.15)}{15.499}\, f^{sk} + \underset{(5.76)}{72.103}\, f^{for} + \underset{(4.52)}{73.855}\, f^{old},$$

where d^{east} is a dummy for East Germany, f^{unsk} is the fraction of workers without vocational training, f^{sk} is the fraction of workers with vocational training, f^{for} is the fraction of workers of foreign nationality, and f^{old} is the fraction of workers older than 50 years. The values in parentheses are t-statistics.

In the light of what has been said before, I estimate two equations. In (7) I use total district GDP Y as a measure for the size of demand. The other independent variables are the estimated wage $\widehat{w}$, the rental rate r, and the three dummies for tourism, urban districts, and central places:

$$p_k = \beta_0 + \beta_1 Y_k + \beta_2 \widehat{w}_k + \beta_3 r_k + \beta_4 d_k^{tour} + \beta_5 d_k^{city} + \beta_6 d_k^{cent} + \epsilon_k. \quad (7)$$

The second estimation equation (8) differs from the first one only in that I measure demand by the population of the city (not the district):

$$p_k = \gamma_0 + \gamma_1 n_k + \gamma_2 \widehat{w}_k + \gamma_3 r_k + \gamma_4 d_k^{tour} + \gamma_5 d_k^{city} + \gamma_6 d_k^{cent} + \varepsilon_k. \quad (8)$$

Again, all coefficients are expected to be positive.

[7]The adjusted R^2 of this regression is 0.93. Other specifications also included the unemployment rate, the ratio of male workers, and the ratio of workers with a college degree.

4 Estimation results

Basic results Table 6 contains the first regression results of equation (7) in columns (1) and (3) and of equation (8) in columns (2) and (4). In the estimations of columns (3) and (4) I excluded the observations of West Berlin because West Berlin proved to be an outlier in the first estimations. Especially in the estimation of (7) Berlin had a very large residual with an actual price level much lower than predicted. In addition, $\widehat{\beta}_1$ and $\widehat{\gamma}_1$ decrease by approximately one standard deviation if the model is estimated without the observation of West Berlin. Compared to its population and GDP, West Berlin's wage level is far too low[8] which leads to the upward bias of the GDP and population coefficients. Since one goal of the paper is to estimate the missing price levels in other regions and no other city is comparable to Berlin, I exclude West Berlin from the further analysis.

The results in columns (3) and (4) show that my simple model can explain the regional price level differences very well. The adjusted R^2 is high[9], there is no indication that the residuals are not normal and the important variables are significant at least at the 10%-level and have the correct signs. In addition, the Hausman-Wu test shows that the wage rate is indeed endogenous[10].

The most important determinants of the local price level are the wage level and demand, either measured by income or by population. From both estimations follows that a rise in the regional average wage by 1000 DM p.a. would increase the price level approximately by 0.37 points. A rise in a city's GDP by 1 billion DM would increase the price level by 0.03 points and a population increase of 100.000 inhabitants would raise the price level by 0.15 points.

Surprisingly, the rental rate of retail outlets is not significant and has the wrong sign. A reason for this might be that rents are a relatively unimportant cost component in retailing and in some of the service industries. In West Germany in 1993, wages and salaries accounted for 12.3% of total costs whereas rents accounted for only 3.4% in food retailing. In restaurants, the respective figures are 28.3% and 9.7% (StBA 1997, pp. 133-135).

Of the dummies, the tourism dummy only matters in the estimation with the population variable. This is plausible because it is designed to control for cities in which the number of people buying goods is con-

[8] The average annual wage in West Berlin is 46015 DM compared to 51695 DM in Hamburg and to 54005 DM in Munich which are the second and third largest cities.

[9] The R^2 is considerably higher than in McMahon (1991) and Walden (1998).

[10] The t-statistics of the wage estimation residuals in the original regressions are larger than 4 (-4.43 and -4.27).

p^{total}	(1)	(2)	(3)	(4)
$const$	81.928***	81.315***	81.581***	81.215***
	(0.8696)	(0.7640)	(0.8268)	(0.7499)
y	0.05054***		0.0331*	
	(0.0182)		(0.0181)	
n		2.1192***		1.5496**
		(0.5075)		(0.5851)
$\widehat{w}$	0.3500***	0.3731***	0.3619***	0.3753***
	(0.0239)	(0.0225)	(0.0229)	(0.0221)
r	-0.0069	-0.0153	-0.0100	-0.0145
	(0.0110)	(0.0104)	(0.0104)	(0.0101)
d^{tour}	0.4130	0.5798*	0.5013	0.5954*
	(0.3373)	(0.3162)	(0.3165)	(0.3090)
d^{city}	0.6845	0.5488	0.7677*	0.6394
	(0.4633)	(0.4310)	(0.4342)	(0.4239)
d^{cent}	-0.1060	-0.0671	-0.0287	-0.0353
	(0.5186)	(0.4790)	(0.4858)	(0.4683)
$\overline{R}^2$	0.9046	0.9171	0.9138	0.9184
$RMSE$	1.073	1.000	1.004	0.977
$p(JB)$	0.615	0.108	0.183	0.666
#	51	51	50	50

Table 6: Dependent variable is total price level in all cities; standard errors in parentheses,*** significant at 1 percent, ** significant at 5 percent, * significant at 10 percent, RMSE is the root mean squared error of the predicted values; P(JB) is the empirical significance level of the Jarque-Bera test on normality of the residuals

siderably larger than the resident population. The insignificance of this dummy in the equation with GDP is also plausible because in these estimations measured demand is larger than the city's demand anyway in the cases of rural districts. The size of the dummy coefficient is considerable as the classification of a city as a tourist resort is equivalent to the price level effect of 400,000 inhabitants more.

In order to learn more about the determinants of the price level, I also estimate models (7) and (8) with some of the subindices as dependent variable. I want to find out whether the results for the price index of all goods are strongly driven by the prices of services and other non-traded goods. Table 7 presents the results of the estimations with GDP as demand variable. First of all, in none of these estimations the GDP coefficient is significant. Second, the model can explain the price level of services much better than the price level of goods. Especially the price level of consumer durables cannot be explained by this model since an F-test on the joint significance of all regressors rejects the model at the 10% level. This last finding is not surprising given the low interregional variation of these price levels. Since durable consumer goods are likely to have the highest degree of tradability this result is in line with conventional reasoning. Last, the wage coefficient in the services regression is 2.5 times larger than in the regressions with the total price index or the price index of non-durable goods. This confirms the expectation that labor costs are much more important in service industries than in goods retailing industry.

The results in Table 7 are corroborated by estimations with the population as demand measure, which are shown in Table 8. The main difference is that the population coefficient is significantly different from zero in column 1. For the price level of services the local demand is much more important than for the total price level as the population coefficient in Table 8 is 2.3 times larger than in Table 6.

Prediction equations For the prediction of the total price level, I remove all insignificant variables from the estimation equation in order to have more degrees of freedom. With GDP as independent variable, I also exclude the dummy for urban counties, because the inclusion of any dummy makes the GDP coefficient insignificant even at the 10% level. Table 9 contains the estimation results. Column (1) shows the results with the counties' GDP as demand measure whereas in columns (2) and (3) the population size measures local demand. In (2) n stands for the population of the city and in (3) for the population of the district. The estimates in (2) and (3) are very similar.

The coefficient estimates are similar to the estimations before. The GDP coefficient implies an elasticity of 0.005 and the population coef-

	(1) $p^{services}$	(2) p^{goods}	(3) $p^{non-durables}$	(4) $p^{durables}$
$const$	54.062***	91.706***	85.848***	97.967***
	(2.0457)	(0.7728)	(1.2767)	(0.5493)
y	0.0637	0.0217	0.0418	0.0000
	(0.0448)	(0.0169)	(0.0280)	(0.0120)
$\widehat{w}$	0.8837***	0.1700***	0.3211***	0.0087
	(0.0566)	(0.0214)	(0.0353)	(0.0152)
r	-0.0077	-0.0114	-0.0157	-0.0070
	(0.0256)	(0.0097)	(0.0160)	(0.0069)
d^{tour}	0.4655	0.5373*	0.5802	0.4720**
	(0.7831)	(0.2958)	(0.4887)	(0.2102)
d^{city}	1.2916	0.6118	0.6263	0.5987**
	(1.0744)	(0.4059)	(0.6705)	(0.2885)
d^{cent}	0.5525	-0.2380	-0.4348	-0.0118
	(1.2021)	(0.4541)	(0.7502)	(0.3228)
$\overline{R}^2$	0.9127	0.7215	0.7690	0.0802
$RMSE$	2.483	0.938	1.550	0.667
$p(JB)$	0.590	0.961	0.660	0.745
#	50	50	50	50

Table 7: Dependent variable is the respective subindex in all cities except for West Berlin; standard errors in parentheses,*** significant at 1 percent, ** significant at 5 percent, * significant at 10 percent, RMSE is the root mean squared error of the predicted values; P(JB) is the empirical significance level of the Jarque-Bera test on normality of the residuals

	(1) $p^{services}$	(2) p^{goods}	(3) $p^{non-durables}$	(4) $p^{durables}$
$const$	53.450***	91.436***	85.305***	97.988***
	(1.8368)	(0.7204)	(1.1968)	(0.5107)
n	3.650**	0.7799	1.3034	0.1937
	(1.4333)	(0.5621)	(0.9339)	(0.3985)
$\widehat{w}$	0.9117***	0.1779***	0.3354***	0.0096
	(0.0540)	(0.0212)	(0.0352)	(0.0150)
r	-0.0230	-0.0119	-0.0149	-0.0089
	(0.0248)	(0.0097)	(0.0161)	(0.0069)
d^{tour}	0.6792	0.5877*	0.6681	0.4807**
	(0.7568)	(0.2968)	(0.4931)	(0.2104)
d^{city}	1.0026	0.5426	0.5055	0.5865**
	(1.0384)	(0.4072)	(0.6766)	(0.2887)
d^{cent}	0.6105	-0.2675	-0.5124	0.0089
	(1.1469)	(0.4498)	(0.7473)	(0.3189)
$\overline{R}^2$	0.9189	0.7214	0.7662	0.0842
$RMSE$	2.393	0.938	1.559	0.665
$p(JB)$	0.481	0.956	0.438	0.769
#	50	50	50	50

Table 8: Dependent variable is the respective subindex in all cities except for West Berlin; standard errors in parentheses,*** significant at 1 percent, ** significant at 5 percent, * significant at 10 percent, RMSE is the root mean squared error of the predicted values; P(JB) is the empirical significance level of the Jarque-Bera test on normality of the residuals

ficient an elasticity of 0.004. In each case the wage elasticity is about 0.145. This means that interregional wage differentials are the most important explanation for price level differentials. In both estimations, the model fit does not change when the insignificant variables are removed. However, in the estimation with GDP (column 1) the RMSE is considerably higher than in the respective estimation in Table 6 (column 3). This is unfortunate because I want to have predictive power. In contrast, the RMSE in the population equation (column 2) is even lower than before.

p^{total}	(1) *city*	(2) *city*	(3) *district*
const	81.509***	81.377***	81.344***
	(0.8482)	(0.7459)	(0.7516)
y	0.0274*		
	(0.0148)		
n		1.2090***	1.2130**
		(0.4355)	(0.4682)
$\widehat{w}$	0.3660***	0.3625***	0.3622***
	(0.0213)	(0.0188)	(0.0191)
d^{tour}		0.5448*	0.5269*
		(0.3061)	(0.3084)
$\overline{R}^2$	0.9100	0.9189	0.9173
$RMSE$	1.026	0.973	0.983
$p(JB)$	0.300	0.119	0.098
#	50	50	50

Table 9: Dependent variable is total price level in all cities; standard errors in parentheses,*** significant at 1 percent, ** significant at 5 percent, * significant at 10 percent, RMSE is the root mean squared error of the predicted values; P(JB) is the empirical significance level of the Jarque-Bera test on normality of the residuals

Figure 1 is a scatter plot of the predicted price levels against the actual values. The plot confirms that the predictive power of the model seems acceptable. There are no obvious cases in which the predicted value is very far off the actual one. The largest residual in the GDP estimation is 2.17 points which corresponds 63% of the total price level's standard deviation. In the population regression (2) the largest deviation is 1.93 point corresponding to 56% of the standard deviation. Altogether, figure 1 illustrates the message of the RMSE that the population models seem more suitable for prediction than the GDP model. In 25 out of the 50 cases the population model has a smaller residual and in 4 cases the residuals are basically identical. Given all these results, I will only use

the figures in column (3) of Table 9 for the prediction.

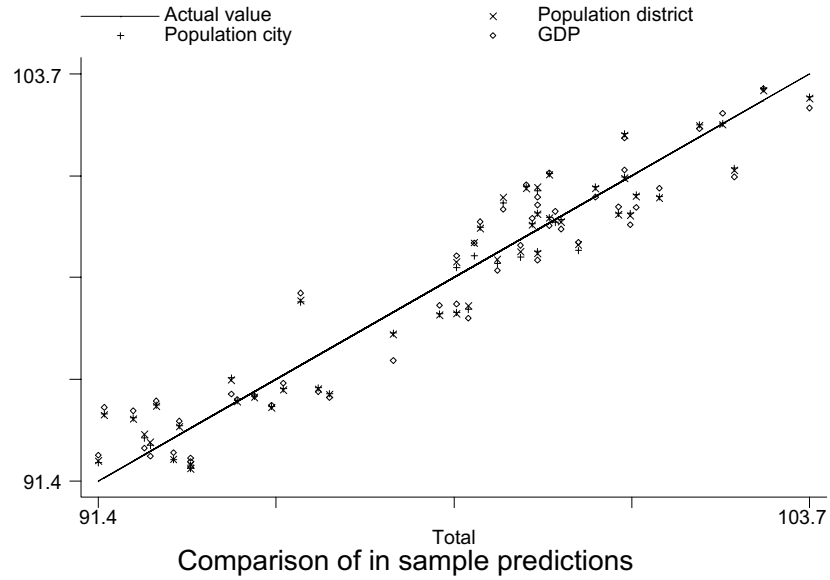

Figure 1: In sample predictions using all 50 observations

An important question is how reliable the estimated price levels are in regions that are not in the sample. In order to get an impression of the predictive performance of the model, I compare in sample estimates with out of sample predictions. I do this by the following procedure: First, I exclude one city from the sample. Then, I estimate the model from Table 9, columns (2) and (3) again with the remaining 49 observations. Finally, I use the estimated coefficients to predict the price level of the excluded city using the population, the instrumented wage and the tourism dummy. I do this for all cities in the sample.

Figure 2 shows both the in sample estimates from column (2) in Table 9 and the out of sample predictions from (2) and (3) obtained from the procedure described before. With one observation excluded the out of sample predictions are very similar to the in sample estimates. In Figure 2, no systematic differences are discernible. As a measure of the out of sample performance of the model I compute the RMSE for all 50 out of sample predictions. Surprisingly, in both cases the out of sample RMSE (0.967 in (2) and 0.977 in (3)) is even lower than the in sample RMSE (0.973 in (2) and 0.983 in (3)). Although this is no proof that the following results of the out of sample predictions are reliable, it demonstrates that the out of sample predictions are not completely unrealistic. Given that the sample includes most of the large

cities and an acceptable number of small towns as well and given its high explanatory power I think that the predicted price levels are unlikely to be very wrong.

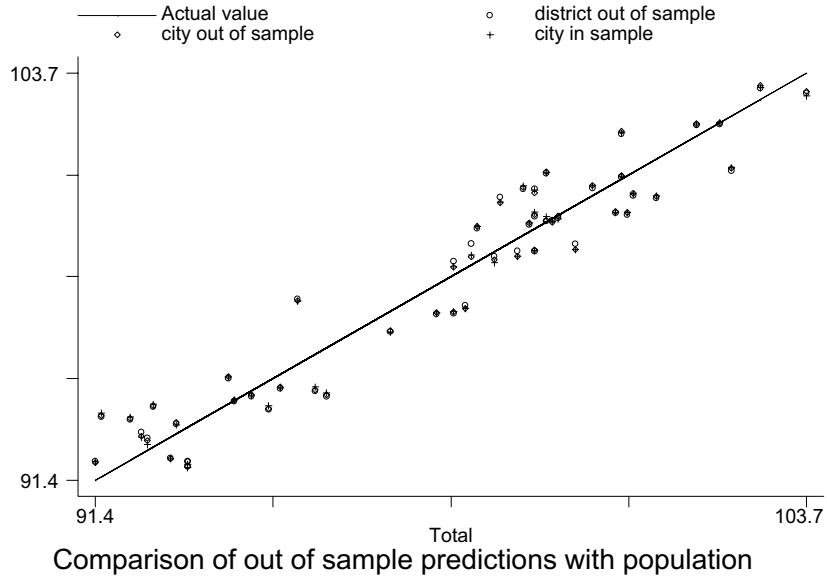

Figure 2: In sample prediction using all 50 observations and out of sample predictions with 49 observations.

5 Prediction results

Districts In this section, I will present several results from the prediction experiments. First, I provide the predicted price levels on the district level. Second, I aggregate the price levels on the district level to the state level. Although it is more interesting to have the data geographically as disaggregated as possible, many other variables are only available on the state level. Third, I use inflation rates on the state level to predict the states' price levels in 2002.

Figure 3 shows the predicted price levels in 1993 for all districts[11]. The predicted price levels are based on the parameter estimates in column 3 of Table 9 and the predicted wage, the population figure, and the tourism dummy in each district[12]. Table 10 contains summary statistics of the estimates and the actual price levels.

[11] The actual price level from the sample was used instead of the predicted price level. A spreadsheet with the estimated price levels is available from the author upon request.

[12] In the case of Eisenach, the actual wage was used instead of the predicted wage.

	Total	West	East
Mean	97.31	98.76	93.09
CV	0.029	0.014	0.008
Min	90.88	94.90	90.88
Max	103.7	103.7	96.50
Q25	94.90	97.74	92.69
Q75	99.27	99.64	93.50
#	441	328	113

Table 10: Summary statistics of the estimated district price levels

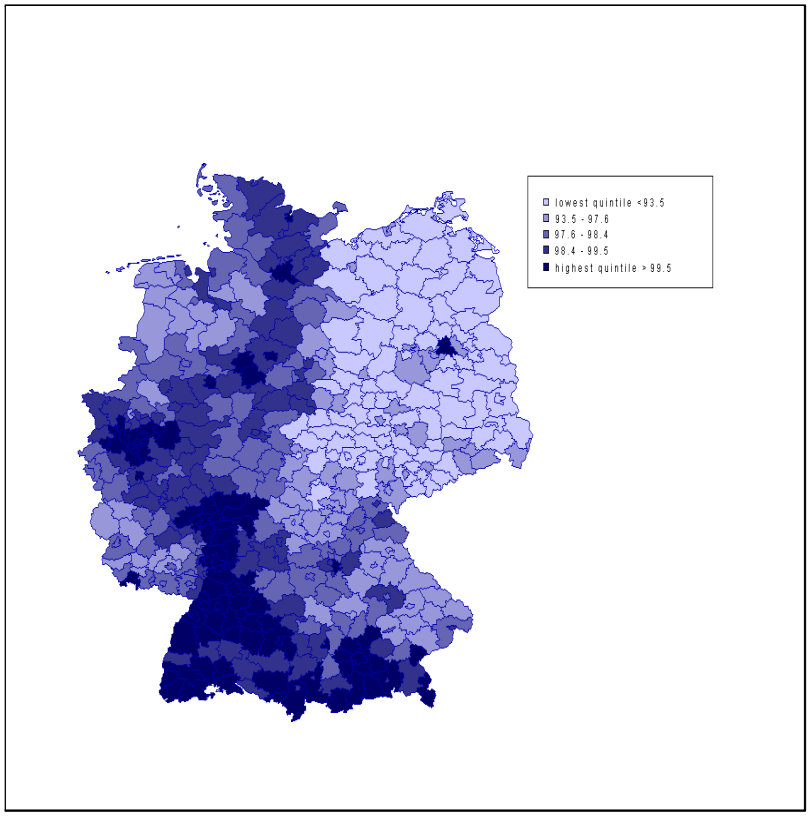

Figure 3: Predicted price levels in Germany on the district level

State	Price level	State	Price level
Berlin (West)	102.9	Rheinland-Pfalz	98.35
Hamburg	102.01	Niedersachsen	98.19
Berlin	100.51	Saarland	97.92
Baden-Württemberg	100.35	Berlin (East)	96.5
Hessen	99.90	Sachsen	93.37
Bremen	99.49	Sachsen-Anhalt	93.22
Nordrhein-Westfalen	99.35	Thüringen	93.20
Bayern	99.06	Brandenburg	93.04
Schleswig-Holstein	98.76	Mecklenburg-Vorpommern	92.76

Table 11: Price levels in 1993

Almost all districts in the East are in the lowest quintile of the distribution. Only some districts close to Berlin and some in Sachsen and Thüringen have price levels in the second quintile. In the West, there are several high price centers. Especially the South West is very expensive, with all districts around Frankfurt and Stuttgart lying in the highest quintile. Other high price regions are the Rhein-Ruhr area and Munich and its hinterland. Price levels are low in the North West and the South East. Altogether, the map mirrors closely the spatial distribution of economic activity in Germany.

States From the price levels of each district, I calculate population weighted average price levels on the state level. Table 11 contains the results for 1993. The most expensive state which is not a city state is Baden-Württemberg. Its price level is 2.4 points higher than the price level of the least expensive state in the West (Saarland). The five eastern states (excluding East Berlin) are very close together. The difference between the most expensive eastern and the cheapest western state of 4.4 points is larger than the difference within the group of the western states. The price level in Baden-Württemberg is 8.2 percent larger than in Mecklenburg-Vorpommern. The population weighted averages (including the respective parts of Berlin) is 99.45 in the West and 93.45 in the East. The average Westerner thus had to pay about 6.4 percent more for the same basket of goods and services than the average Easterner in 1993.

Even more interesting than the price level in 1993 are the price levels in 2002, twelve years after the reunification of Germany. Our understanding of the transition process would be improved if we knew whether there is a clear tendency for the price level differential between East and West Germany to vanish. I use the official inflation rates of the consumer price index on the state level to calculate the price levels in 2002. Un-

fortunately, for some states (Hamburg, Bremen, and Schleswig-Holstein) inflation rates are not available at all and for some other states (Niedersachsen, Rheinland-Pfalz, and Sachsen) the available time series start later than 1993. Therefore, I cannot calculate the price levels for the former states. For the latter states, I use the GDP deflator instead of the consumer price index for the missing years. Another problem of this procedure might be that the inflation rates based on the CPI and the GDP deflator include the changes of the housing prices, which are not contained in the estimated price levels. It is difficult to assess the error caused by this incongruity because we do not know the inflation rates of housing prices. Some states provide the inflation rates of total housing cost, i.e. including energy and water. Others separate these costs and provide the inflation rates of housing prices only. Since in my sample energy and water costs are included, I would like to know how housing prices alone change over time in order to assess whether the CPI inflation rate overstates or understates the inflation rate of the price index used here. Not having the necessary data I simply assume that housing prices on average changed proportionately to the total price index. Whether this assumption is adequate might be the issue of a further study.

Table 12 shows the calculated price levels in the states for which inflation rates are available. Compared to Table 11, Hamburg, Bremen, and Schleswig-Holstein are missing. The most important change occurred in East Berlin, whose price level is now even higher than the one in West Berlin. This is not really surprising because the social, political, and economic center of Berlin shifted from the western to the eastern part (Berlin Mitte) since Berlin was made the German capital. Another interesting observation is what happened in Saarland. In 1993, there was almost no difference between the price levels in Saarland and its surrounding state Rheinland-Pfalz; Rheinland-Pfalz was only 0.4% more expensive than Saarland. Up to 2002, the difference had increased remarkably to 2.5%. In fact, Saarland's price level in 2002 is closer to most of the price levels in the eastern states than to the levels in the western states. With respect to the ranking of all states, only minor changes took place. The difference between the most expensive state Baden-Württemberg and the least expensive state Mecklenburg-Vorpommern decreased slightly; in 2002 Baden-Württemberg is 7.5 percent more expensive than Mecklenburg-Vorpommern.

Convergence Table 12 gives the impression that there might be price level convergence. Whether this is really the case can be tested formally. In order to check if there is price level convergence meaning that states with a low price level in 1993 had high inflation rates later on, I estimate a β-convergence equation known from growth theory (see Barro/Sala-i-

State	Price level	State	Price level
Baden-Württemberg	116.45	Berlin	112.20
Nordrhein-Westfalen	115.36	Saarland	111.63
Niedersachsen	115.09	Sachsen-Anhalt	111.34
Hessen	115.06	Thüringen	110.88
Bayern	114.66	Sachsen	110.65
Rheinland-Pfalz	114.43	Brandenburg	108.64
Berlin (East)	114.32	Mecklenburg-Vorpommern	108.29
Berlin (West)	113.62		

Table 12: Price levels in 2002

Martin 1995):

$$\pi_k = \beta_0 - \left(\frac{(1 - e^{-\beta_1 T}}{T} \right) \ln(p_{k,0}) + \varepsilon_k, \tag{9}$$

where π_k is the average annual inflation rate in state k, T is the time period over which the inflation rate is calculated, and $p_{k,0}$ is the price level in state k at the beginning of the time period. The non-linear OLS estimation of this convergence equation for the 14 states in Table 11 (with the two parts of Berlin, but without total Berlin) and $T = 9$ gives the following result[13]:

$$\pi_k = \underset{(0.064)}{0.277} - T^{-1} \underset{(0.009)}{(1 - e^{-0.046T})} \ln(p_{k,0}), \ \overline{R}^2 = 0.539. \tag{10}$$

The convergence coefficient β_1 is significantly negative and implies a half-life of about 15 years. Figure 4 also demonstrates that the states with lower price levels in 1993 in general had high inflation rates. This basically means that within Germany large price level differential cannot exist over a long time. This contrasts to the Slesnick (2001) and McMahon (1991) who find fairly persistent regional price level differentials over time in the U.S.. On the other hand, the estimated speed of convergence is very slow compared to the estimates obtained in PPP studies such as Parsley/Wei (1996) or Cecchetti et al. (2002).

6 Conclusions

This study is the first analysis of regional consumer price levels in Germany. I exploit one of the two data sets provided by the statistical offices, which did not have much attention by researchers so far. The analysis shows that regional differences in price levels are primarily determined by regional wage differences and population sizes. I interpret

[13] The values in parentheses are the standard errors.

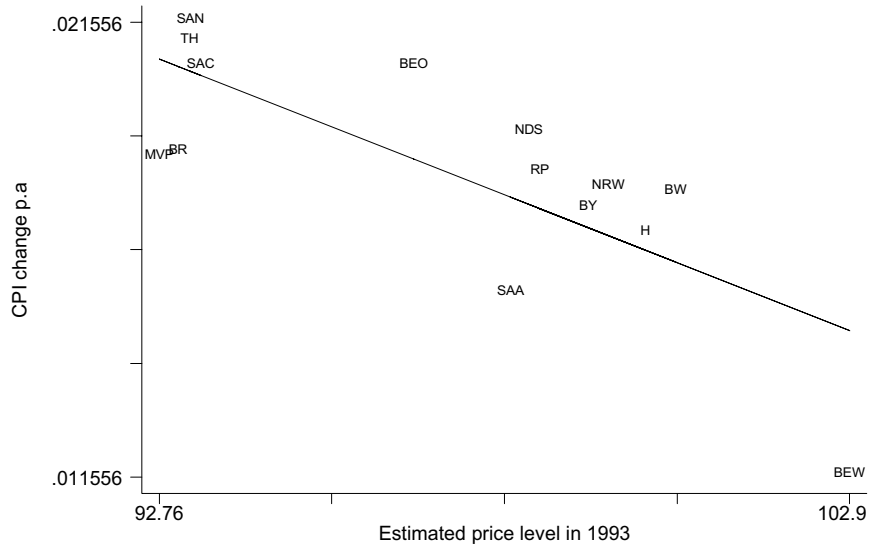

Figure 4: Average inflation rates p.a. versus estimated price levels in 1993

this finding as evidence for a simple supply and demand explanation of price level differences asserting that the price level is high where local retail costs and local demand are high. The local wage is seen as the most important local cost factor of retailing and the population of a city or district is interpreted as a measure of the size of local demand. Finding that the estimated model has acceptable predictive power, I use the model to predict the 1993 price level for all 440 German districts. This gives a detailed picture of the purchasing power of money in Germany. In particular, it allows me to calculate that the same basket of goods and services (excluding housing) was 6.4 percent more expensive in former West Germany than in former East Germany. In the most expensive city Munich, a consumer had to pay 14.1 percent more for the basket than in the least expensive district Hoyerswerda. The actual costs of living might differ even more if the costs of housing are considered.

Then, I aggregate the district price levels to the state level for which CPI inflation rates are available. With these inflation rates I can extrapolate the state price levels from 1993 to 2002. The most interesting result of this exercise is that the price level differential between the two parts of Berlin has vanished. Within the same city arbitrage seems to work well. The estimation of a convergence equation shows that inflation was higher in states with a lower price level in 1993. The implied half-life until all price levels have converged to a common mean is about

15 years which is rather long compared to the figures obtained in studies of PPP.

This first work on regional price levels in Germany can be extended in several ways. First, it should be complemented by an analysis of prices for housing which are not included in the original sample. It is likely that housing rents are much more variable than the prices of consumer goods and services (see Tabuchi 2001). With an index of housing rents it would be possible to construct an overall price index which would provide a more exact picture of the regional cost of living. Second, it would be useful to update the original sample to check whether the predictions are valid. For any individual researcher or even a group of researchers, the costs of repeating the data collection in all 50 cities of the original sample would be prohibitive. However, it might be possible to collect data in a smaller subset of cities. Third, one might try to obtain inflation rates on the district level rather than on the state level. This would allow to perform a more accurate analysis of the convergence question.

Another interesting alley to go would be to do similar analyses in other European countries or even cross-border studies. So far very little is known about price level differences between regions in the euro area. If the current price level differences are large and convergence is slow, the ECB might be confronted with a long transition period with large inflation differentials. As Cecchetti et al. (2002) observe, this causes a number of problems. The most important problem is likely to be the implied difference of real interest rates when nominal rates are fixed by the ECB. Countries with high price levels and low inflation rates might have to suffer high real interest rates compared to other countries with low price levels and high inflation rates. If the convergence to a common EU wide price level takes a long time this situation is likely to harm the high price level countries. More evidence on the relation between price levels and inflation rates in EU countries could provide the informational basis for a monetary policy that reacts adequately to these transition problems.

Finally, the price level estimates could be used in formal tests of theoretical hypotheses. One theory which makes strong predictions about regional price levels is Krugman's New Economic Geography (Krugman 1991, Fujita et al. 1999). A central hypothesis of this theory is that in agglomerations the price level of tradable consumer goods should be lower than in peripheral regions. A very preliminary inspection of the map in Figure 3 does not corroborate this hypothesis. It rather seems to be the case that price levels are higher in agglomerations which would contradict the NEG. However, a reliable answer to this question can

only be given after a formal analysis. Another literature for which price level data might be useful is the empirical literature on the determinants of migrations flows. Going back to Harris/Todaro (1970) the real wage differential between regions is generally seen as an important explanatory variable in migration studies. However, data on real wages are not available without having regional price indices. This is a common problem in migration studies using macro data (e.g. Pissarides/McMaster 1990, Decressin 1994). Since it has been notoriously difficult to demonstrate a significant effect of real wage differentials on migration flows (Alecke/Untiedt 2000) it could be worthwhile to repeat some migration studies correctly controlling for price level differences.

Appendix

In this appendix, I describe the variables used and the data sources.

- Y : GDP on the district level for 1992 and 1994 is available on the CD-ROM "Statistik regional 2002" published by the German statistical offices. In the regressions it is measured in billions of DM.

- γ : The growth rates of GDP on the state level for 1993 and 1994 are taken out of the "Statistisches Jahrbuch 1999" published by the Federal Statistical Office.

- w : The wage level in a district is the average annual earnings of a full time employee subject to social security contributions measured in thousands of DM. This data were provided by the IAB Nürnberg. The instruments for the wage are taken from "Statistik regional 2001" (employees older than 50 years in 1995, employees of foreign nationality in 1996) and from the IAB data set (employees with and without vocational training (Berufsausbildung) in 1992).

- r : The rental rate of business space was taken from the "RDM-Preisspiegel 1993". The RDM (Ring Deutscher Makler) is a state organization of German estate agents. It annually collects data on prices related to real estate in more than 100 German cities, which are published in the "Preisspiegel". Figures on rents of retail outlets are provided in 8 categories of size and location of which I computed an unweighted average. This average rental rate used is measured in DM per m^2.

- n : The population sizes of cities in 1993 were taken from the "Statistisches Jahrbuch 1995". The figures for the districts are from "Statistik regional". Population sizes are measured in millions.

- d^{tour} : The tourism dummy was constructed as follows. I took the number of tourist beds in 1995 from "Statistik regional" and computed the ratio of tourist beds to inhabitants in a district. If a districts beds-to-inhabitants ratio was larger than the average in the 50 city sample, the dummy was set to one.

- d^{cent} : The centrality dummy was set to one if a city is classified as a central place ("Oberzentrum") in the usual classification of the BBR.

- π : The inflation rates of the states were calculated using the CPI price indices ("Preisindex für die Lebenshaltung, alle privaten Haushalte") provided by the respective statistical offices. For Niedersachen, Sachsen, and Rheinland-Pfalz no price indices in 1993 are available. I computed the GDP deflator using the time series of nominal GDP and GDP in constant 1995 prices of the states provided by the "Arbeitskreis VGR der Länder".

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