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Abstract. In EU countries, knowledge on spatial disparities in overall price level is extremely scarce. When interregional price disparities are large, however, nominal income measures fail to assess prosperity and the catch-up processes of regions. Despite its importance for regional policy, no official regional price statistic is available as a standard. On account of this gap, this paper deals with the econometric estimation of regional price indices for German NUTS 3 regions. Econometric price models for the consumer price index (CPI) and the housing rent index (HRI) are developed on the ground of utility maximization in a two-goods model. The estimated price indices are used to analyse price disparities in the period 1995-2004 across German NUTS 3 regions. Real income comparisons show that the East/West gap is likely to be substantially larger than assessed from incomplete price data in previous studies.

Key words: Regional price level, econometric price models, price disparities, real income disparities

JEL: C21, R13, R31

1. Introduction

Although disparities in cost of living across space play a crucial role in regional economics and policy (Jüssen, 2005), knowledge on regional price levels is scarce in the EU. National statistical offices do not gather price data area-wide. Collections of price data are usually conducted for constructing the consumer price index (CPI) at the national or state level. Although statistical offices of the states provide inflation rates for the sixteen NUTS 1 regions in Germany, the data do not allow for interstate price comparisons. In the United Kingdom the private Reward Group regularly reports cost-of-living indices for the eleven standard (macro-) regions that are used *inter alia* in salary surveys (Johnston et al., 1996). Information on regional price levels at a lower regional level such as for NUTS 2 or NUT 3 regions is not ordinarily available.

On account of this lack of information, regional EU studies must ordinarily rely on nominal indicators. Jüssen (2005) points to the necessity to "analyze convergence of real GDP in order to assess if regional policy is likely to achieve its objective of equalization". In measuring spatial disparities in standard of living, Aten and Heston (2005) estimate regional price levels using spatial-econometric models calibrated with national consumer price indices. The breakdown of country estimations to a regional level is, however, not easy to justify. First, the econometric models built from international studies are primarily demand-orientated and not grounded in economic theory. Second, the calibration with the national consumer price index does not necessarily imply an adequate explanation of regional price levels. Third, there is no *a priori* guarantee that responses of explanatory variables at the national and regional levels are identical.

Roos (2006a) was the first to advance an econometric estimation of regional price levels in Germany. He estimates CPI without housing for all German districts in the period 1993 – 2002. With housing price data from the microcensus survey, however, Roos (2006b) can only calculate overall regional price indices at the state level. On the basis of such aggregated data, West/East comparisons of real income per capita can be shown to result in a too narrow gap when high income regions tend to be high price regions.

Our panel data set enlarges the works of Roos (2006a, 2006b) in several respects. We provide data on overall price levels at a low regional scale of German NUTS 3 for the period 1995 - 2004. The consumer price index without housing does not adequately reflect regional cost of living, as housing rents show considerably larger spatial disparities than prices of other goods and services. Only by employing complete CPI data, real income comparisons can be validly accomplished at the district level. Biases in East/West comparisons of purchasing power are thereby avoided. Adjustments in regional price levels are expected to differ substantially for the CPI with and without housing. The rejection of the law of one price for housing rents has severe consequences with regard to convergence of consumer prices. Moreover, we provide the first insights into the development of local housing prices during the transition period after German unification.

The price and income comparisons are based on econometric regional price models for the consumer price index without housing (CPI-H) and the housing rent index (HRI). They are derived from utility maximization of consumers in a two-goods model. The CPI model without housing is calibrated using data on the latest price comparison of 50 selected German cities in 1993 (Ströhl, 1994). Data on housing rents are available for all 439 German districts at the current fringe of the sample period from the Federal Office for Building and Regional Planning (BBR). Estimates for CPI without housing, housing rents and overall price level at the NUTS 3 level for the period 1995 – 2004 are obtained from numerical specified econometric price models. The panel data set allows for spatial price and income comparisons providing enlarged information for regional policy.

The subsequent sections of this paper are organized as follows. Section 2 presents a model for the price of consumer goods and housing which provides the theoretical basis for econometric price models. Section 3 deals with the construction of cost-of-living and regional price indices. Econometric issues are addressed in section 4, while data are presented in section 5. Estimation results on CPI-H and HRI for German districts are discussed in section 6. A comparison of regional price indices as well as nominal and real income is conducted in section 7. Section 8 concludes.

2. A price model

Reduced-form equations for the price of goods (without housing) and housing services can be derived from a system of supply and demand schemes. Consumer theory states that demand for both kinds of goods, X and H, depends on the prices of housing and other goods, p_H and p_X, income, y, as well as a vector of demographical variables $\mathbf{d} = (d_1\ d_2\ \dots\ d_r)$ (cf. Pollak and Wales, 1981; Goodman, 1990; Hansen et al. 1998; Lee et al., 2001). Olsen (1987) derives demand for housing services from a two-goods model of intertemporal choice based on a utility function of the Stone-Geary type. Goodman (1990) addresses the inclusion of demographic variables on the grounds of tastes or supplements for the lack of knowledge on futures income and prices (cf. Megbolugbe and Cho, 1996; Hansen et al., 1998). He additionally deals with the issue of tenure choice in the demand of housing services.

The model of intertemporal choice allows demand equations for both housing services and all other goods to be derived. For the ease of exposition, we consider housing services from the viewpoint of a renter.[1] Because of a lack of regional disaggregated future data, we restrict the consumer's choice to one period, but include instead demographic variables in the demand functions (see Olsen, 1987).[2]

The representative consumer maximizes the utility function, $U = U(X, H)$, with respect to the budget constraint ($p_H \cdot H + p_X \cdot X = y$). This gives preliminary demand functions for X and H with the price of all goods without housing, p_X, the price of housing serves, p_H, and income, y, as explanatory variables:

(1) $$X^D = X^D(p_X, p_H, y)$$

and

(2) $$H^D = H^D(p_X, p_H, y)$$

Demographical characteristics such as population, age composition or education can be included in the demand system (1) and (2) in different forms (Goodman, 1990; Megbolugbe and Cho, 1996). In all forms a related demand system has to be found such that the first-order conditions of the original equations are retained (Pollak and Wales, 1981). The altered demand system is enriched by additional parameters depending on the demographical variables. A simple form of enrichment is the so-called translation, where interactions between the economic and demographical variables are precluded.[3] Let a_X and b_H be functions of the demographic characteristics:

$$a_X = a_X(\mathbf{d}) \quad \text{and} \quad a_H = a_H(\mathbf{d}).$$

Then translation leads to the related demand system

(1') $$X_T^D = a_X + X^D(p_X, p_H, y - p_X \cdot a_X - p_H \cdot a_H)$$

and

(2') $$H_T^D = a_H + H^D(p_X, p_H, y - p_X \cdot a_X - p_H \cdot a_H)$$

[1] Arevalo and Ruiz-Castilo (2006) apply the rental equivalence approach to include nonrental housing services into the consumer price index (see also Crone et al. 2000).

[2] The supply and demand functions obtained from one-period optimization are shown to be special cases of intertemporal utility maximization. In the general case, the knowledge of future goods prices is necessary that are particularly missing on the regional level. Moreover, in our simplified approach, consumer's decisions are constraint by income instead of wealth.

[3] Interactions can be included by the method of scaling (see Goodman, 1990; Megbolugbe and Cho, 1996).

The parameters a_X and a_H may be interpreted as "subsistence" levels that depend on demographics. The term $y\text{-}p_X \cdot a_X\text{-}p_H \cdot a_H$ reflects a kind of supernumerary income. For the Stone-Gary utility function $U = (H - \eta_H)^{\gamma}(X - \eta_X)^{1-\gamma}$, demand system becomes linear which suggests a linear translation function:

$$a_k = \sum_{j=1}^{r} \eta_j \cdot d_j, \ \ k = X, H .$$

The parameters η_j measure the impacts of the demographic characteristics on goods demand. The generalized CES demand system is not linear in the variables, but in expenditure.

Supply functions for X and H can be easily derived by profit maximization when the two-product technology is assumed to be separable.[4] Then for all goods excluding housing, the standard supply function

(3) $$X^s = X^s(p_X, w, r)$$

comes from a neo-classical production function with labour L and capital K as input factors. Equation (3) explains goods supply X^s as a function of the goods price, p_X, the wage rate, w, and the interest rate, r.

The supply of housing may, *inter alia*, depend on the price of housing services, construction costs, costs of financing and land supply (Ho and Ganesan, 1998; Ge et al., 2006). Tse et al. (2006) use the change in housing prices as the only influencing factor. With the housing price, p_H, a measure of other influences of profitability i_P and land supply, l, as explanatory variables, the supply function reads

(4) $$H^s = H^s(p_H, i_P, l) .$$

In equilibrium, demand and supply in both markets must match. After aggregating (1') and (3) over all households and firms, respectively, and solving for the goods market price p_X, one obtains the relation

(5) $$p_X = p_X(p_H, Y, w, r, \mathbf{D}) ,$$

while the price of housing services, p_H, is achieved analoguously from equating (2') and (4):

(6) $$p_H = p_H(p_X, Y, i_P, l, \mathbf{D}) .$$

The equations (5) and (6) render equilibrium prices in the goods and housing market as functions of the determinants of the respective aggregate supply and demand equations. Note, that the vector **D** consists of aggregate demographical characteristics. In both price functions,

[4] The two-product technology is said to be separable if inputs can be split up. A part of input is used in production of X and the other part in production of H.

individual income y is also replaced by aggregate income Y. This means that income in the price level equation (5) can no longer be treated as exogenous. The same applies to the wage rate w which not only affects the price level p_X but depends itself on expected future prices.

3. Cost of Living and Regional Price Index

Since the Boskin commission concluded that the consumer price index (CPI) overstates US inflation (Boskin et al., 1998), a discussion on price index concepts used in official statistics has taken place. The overrating of inflation by the CPI with a fixed basket of goods arises from neglecting substitutions and changes in product quality between base periods. Changes in cost of living result both from changes in commodity prices and quantities, for example, necessary to achieve a constant utility level. The traditional Laspeyeres price index falls short of measuring the cost of living as it is based on constant quantities. Thus, it is not – or at least very insufficiently - a cost-of-living index (COLI), but a cost-of-goods index (COGI) (Schultze and Mackie, 2002, pp. 38, 40 and 74).

While knowledge on the development of the CPI over time is needed for shaping monetary policy, interregional price comparisons are necessary in revealing differences in standards of living (Rao, 2004). They are more related to the COLI than to the COGI approach. A comprehensive cost-of-living index has to control for all sorts of environmental conditions that affect utility besides the prices of goods and services in different areas. Such a complete COLI is an extremely ambitious index approach (Schultze, 2003; Diewert, 2004b). Leaving the augmentation aside,[5] a regional cost-of-living index compares the minimum expenditures $C(\mathbf{p}_r, U_b)$ and $C(\mathbf{p}_b, U_b,)$ necessary to attain the same utility level in region r as in a base area b, U_b, given the price vectors $\mathbf{p}_r$ and $\mathbf{p}_b$:[6]

$$(7) \qquad P_r^{COL} = \frac{C(\mathbf{p}_r, U_b)}{C(\mathbf{p}_b, U_b)}.$$

Instead of imputing a fixed bundle of goods and services, a COLI demands a fixed level of utility. Let $\mathbf{q}_b^*$ and $\mathbf{q}_r^*$ be the optimal bundles of commodities. Then the cost of living index can be written in the form

[5] In this case, the index is also termed “conditional” COLI (see Schulze and Mackie, 2002, pp. 65 and pp. 95)
[6] Cf. Schultze and Mackie, 2002, pp. 46; Diewert, 2004a; Diewert, 2004b. For a critical assessment of the COLI approach see von der Lippe (2004).

$$(8) \qquad P_r^{COL} = \frac{\sum_{i=1}^{n} p_{ir} \cdot q_{ir}^*}{\sum_{i=1}^{n} p_{ib} \cdot q_{ib}^*} \text{ with } U_r = U_b.$$

The COLI measures the necessary compensation in income for a consumer in region r to be well off as a consumer in base region b facing a price vector $\mathbf{p}_r$ instead of $\mathbf{p}_b$. A positive compensation is tantamount to a deadweight loss, while a negative compensation comes along with a gain in welfare. As the optimal bundles $\mathbf{q}_b^*$ and $\mathbf{q}_r^*$ are unobservable, the COLI formulae (7) and (8) are not operational. They may be approximated by a superlative price index like the Fisher, Törnquist or Walsh index that weights the prices of both regions in a symmetric fashion.[7]

Spatial consumption patterns are – if any – in most countries only known at a highly aggregated level. Although a consumer price index is available for nearly all German states, price rates are weighted with national expenditure shares. At a higher disaggregated level, regional price indices are *a fortiori* constructed using national weights. In both larger German price comparisons on the city level, the price index of Laspeyres is applied in a modified form (Rostin, 1979; Ströhl, 1994). The original spatial Laspeyres price index is defined by (Neubauer, 1996, 151) as

$$(9) \qquad P_{br}^{L} = \sum_{i=1}^{n} \frac{p_{ir}}{p_{ib}} \cdot \frac{p_{ib} \cdot q_{ib}}{\sum_{j=1}^{n} p_{jb} \cdot q_{jb}} = \frac{\sum_{i=1}^{n} p_{ir} \cdot q_{ib}}{\sum_{i=1}^{n} p_{ib} \cdot q_{ib}}.$$

In general, an actual or fictive area may be chosen as the base region. When only national consumption patterns are available, the use of national average prices would be in accordance with the “pure” Laspeyres approach.

In his price comparison across 50 German cities, Ströhl (1994) uses the modified formula (see also Rostin, 1979)

$$(10) \qquad P_{br}^{RS} = \sum_{i=1}^{n} \frac{p_{ir}}{p_{ib}} \cdot \frac{p_{ib} \cdot q_{iG}}{\sum_{j=1}^{n} p_{jb} \cdot q_{jG}} = \frac{\sum_{i=1}^{n} p_{ir} \cdot q_{iG}}{\sum_{i=1}^{n} p_{ib} \cdot q_{iG}},$$

[7] A price index is called „superlative“ if it proves to be a second-order approximation to an arbitrary utility function. A basic characteristic of superlative indices is that they are symmetric (Diewert, 2004c, p. 348).

where b indicates the base city Bonn and G Germany as a whole. In (10) the price rates are formed by relating the prices of goods and services of the reporting city r to the respective prices of the base city Bonn. The weights are, however, fictive expenditure shares as prices of the base city Bonn are multiplied by national average quantities.

The axiomatic approach to index theory assesses the usability of price indices with respect to their formal properties. Axioms used in temporal comparisons may, but need not have spatial counterparts and *vice versa*. We will restrict our discussion of the above price indices (9) and (10) to the three important properties

- region reversal,
- transitivity,
- characteristicity

that are accessible to an economic interpretation.[8] Different test results give reason for some caveats calling the price index of Rostin and Ströhl Laspeyres index.

A price index P is said to be region reversal if it is invariant to the choice of s or r as the base region in a bilateral comparison:

(11) $P_{sr} = (P_{rs})^{-1}$.

In international studies of purchasing power parities, the check of property (11) is called country reversal test (Diewert, 1993, p. 311; von der Lippe, 2001, ch. 2, p. 9 and ch. 3, p. 8). In spite of some difficulties in interpretation of (10), P^{RS} possesses this desirable property. Using P^{RS}, the relative price level of regions is bilaterally uniquely determined. As opposed to P^{RS}, the original Laspeyres price index (9) fails the region-reversal test.

As to consistent measurement, the property of transitivity of spatial price indices plays an outstanding role. Under the axiom of region reversal, R(R-1)/2 price index numbers can be meaningfully calculated across R areas. On the one hand, the relative price level between two regions r and s can be measured directly by comparing r and s. On the other hand, it can be computed indirectly by interposing a third region t, i.e. by successively comparing r with t and t with s. If both comparisons give the same index number for any regions r, s and t of the regional system, the underlying price index P is said to be transitive:

(12) $P_{rs} = P_{rt} \cdot P_{ts}$.

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[8] Usually axioms or tests for spatial price indices are discussed in the context of international comparisons of purchasing power parities. See Diewert, 1993, ch. 12; von der Lippe, 2001, ch. 8; Rao, 2004, pp. 498.

The property of transitivity ensures internal consistency in the sense of a unique ordering of the regions with respect to spatial price levels. The R(R-1)/2 price indices in multilateral comparisons can then be reduced without loss of information to R-1 indices. It is easily shown that the price index P^{RS} is transitive, while the Laspeyres price index P^{L} is not. The differences between P^{L} and P^{RS} give reason for not labelling the latter as a Laspeyres index.

A property that gains special significance with respect to economic interpretation is that of characteristicity. It means that bilateral comparisons should possible be representative as far as for both regions and not distorted by characteristics of other regions. Characteristicity and transitivity are, obviously, not independent from one another. A price index sharing the property of transitivity must be influenced by characteristics of all possible intermediary regions. Thus, it always violates the property of characteristicity in its strict sense (see Balk, 2001). From the viewpoint of the axiomatic approach, it is preferable for a price index to preserve most of the regional characteristics without losing its transitivity. As is seen from formulae (9) and (11), P^{RS} depends on the average quantities q_{jG} that may not be typical for two regions actually compared. This acts as a potential source of distortion. Note, however, that in P^{L}, the consumption pattern of the reporting region is missing as well. While in the former case the representativity of the average shares of expensives plays a crucial role for characteristicity, it is the representativity of the base region that matters in the latter case.

4. Econometric issues

In order to establish an econometric model for the consumer price index without housing (CPI-H) and the housing price index (HRI), we refer to equilibrium relationships (5) and (6) the supply and demand andsupply scheme. As prices for both kinds of goods have to be estimated for the whole sample period, they cannot be used as mutual determinants in the price models themselves. Moreover, we have to abstract from the interest rate in virtue of its constancy across regions.[9] Thus, empirically, regional price level of the X-goods has to be explained by purchasing power, wage and potential demographical influences. Purchasing power is usually measured by disposable income (Y). In some areas, however, demand from tourists and travellers may additionally affect local prices. On this account, we introduce the hotel overnight stays (HOS) as a measure for the effect of 'foreign' purchasing power on

[9] Regional differentiated investment allowances are not available for the consumption sector of the economy.

regional price level. As demand is more concentrated in densely populated areas, we make use of population density (DENS) as an influence factor.

Using these explanatory variables, the econometric model for the consumer price index (without housing), CPI-H, reads

(13) $CPI - H = \alpha_0 + \alpha_1 \cdot Y + \alpha_2 \cdot HOS + \alpha_3 \cdot w + \alpha_4 \cdot DENS + u$,

where u is an identically normally distributed error term with E(u) = 0 and V(u) = σ_u^2. As income and prices are simultaneously determined, Y cannot be viewed as exogenous. The well-known price-wage spiral suggests that the same applies to the wage rate (w). Thus, in order to eliminate the endogeneity bias, both y and w should be instrumented. This can be carried out by two-stage least-squares (TSLS) instead of OLS estimation. Besides hotel overnight stays and population density, population and human capital may serve as additional instruments. Roos (2006a) showed population to have quite the same explanatory power as income. Human capital is often used as a control variable in international econometric price level models (cf. Aten and Heston, 2005).

In explaining housing prices, purchasing power is captured by regional disposable income (Y). At least in the long run, charges for tourist accommodation may exert pressure on housing rents as usage may become interchangeable. On this account, hotel overnight stay (HOS) can be viewed as a potential influence of profitability. As land prices are highly variable, we measure scarcity of housing space by dwelling capacity (DWELL). We additionally explain prices for H-goods by demographic variables such as population density (DENS), human capital (HUM) and the growth rate of population (GPOP):

(14) $HRI = \beta_0 + \beta_1 \cdot Y + \beta_2 \cdot HOS + \beta_3 \cdot DWELL + \beta_4 \cdot DENS + \beta_5 \cdot HUM + \beta_6 \cdot GPOP + v.$

v is an identically normally distributed error term with E(v) = 0 and V(v) = σ_v^2. In housing price models, Y is usually viewed to be exogenous (cf. Goodman, 1990; Lee et al., 2001; Ge et al.., 2006) as housing rents account for only a small part of disposable income. Thus, the HRI model can be estimated without instrumenting Y.

As outliers may adversely affect regression coefficients, they should be accounted for in the final price models. Not all outliers are, however, harmful. Leverage points will only distort regression coefficients if they come along with large residuals. A useful diagnostic for identifying influential observations is provided by Cook's distance that combines residuals and extreme values in the x-space. According to Fox (1991), we consider a data point with a CD value larger than the cut-off value of 4/(n-k) as an influential observation.

5. Data

Data of the dependent variables, CPI-H and HRI, of the econometric price models stem from two sources. CPI data without housing used to calibrate an econometric price model for X-goods are available from the latest city survey by the German Federal Statistical Office in 1993 (Ströhl, 1994). The price comparison is conducted for 50 selected German cities. Rent data used to estimate a price for H-goods are provided by the Federal Office for Building and Regional Planning (BBR) for 439 German districts in 2004. Time series of the independent variables for all 439 German districts are obtained from German regional statistics and the Federal Employment Agency.

Using these series, a panel data set of the consumer price index without housing (CPI-H) and the housing rent index (HRI) for the period 1995-2004 is gained in two steps. First, preliminary price indices are estimated on the basis of regression models (13) and (14). Secondly, the regional price indices are adjusted using inflation rates of the German states. For Schleswig-Holstein, Hamburg and Bremen no inflation rates are provided by official statistics. However, we can adjust the regression estimates by a common inflation rate for all three states that can be calculated from the national and state inflation rates. The overall regional price level (CPI) is gained by linearly combining both sub-price indices:

$$\text{(15a)}\quad \text{CPI} = \begin{cases} 0.81498 \cdot \text{CPI - H} + 0.18502 \cdot \text{HRI} & \text{for West German districts} \\ 0.87895 \cdot \text{CPI - H} + 0.12105 \cdot \text{HRI} & \text{for East German districts} \end{cases} \quad \text{for 1995-1999}$$

and

$$\text{(15b)}\quad \text{CPI} = 0.78783 \cdot \text{CPI - H} + 0.21217 \cdot \text{HRI} \quad \text{for 2000-2004}$$

The coefficients of the linear combinations in (15a) and (15b) denote the weights of the X- and H-goods in the respective baskets of commodities (Statistisches Bundesamt, 1998, 2003). In the base year 1995, the population-weighted price indices take a value of 100 for Germany as a whole.

Demand-effective income is preferably operationalised by disposable income. However, complete time series of this variable are not available for all German states on the district level. For Rhineland Palatinate data for the years 1993 and 1994 are missing. For the Saarland and all East German states except Berlin highly disaggregated data on disposable income are only available for the period 1995–2004 ("National Accounts of the States", Statistical Office Baden-Württemberg). As balanced panel data on this income variable is available for 1992 to

2004 at the state level, we use the information on the state growth rates to calculate 1993 data for the CPI-H regression.

Gross domestic product (GDP) is a poorer indicator for demand-effective income. However, GDP data is available for the whole period of investigation, 1995-2004, at the district level by the working group "National Accounts of the States" (Statistical Office Baden-Württemberg). All eastern states except Saxony and five western states (BW, BY, HB, HE, NW) additionally report GDP figures for 1993. For the CPI-H regression we estimate GDP in cities of these states by using 1994 district and 1993 state data. We employ GDP data for assessing robustness of estimation results. This can also be done by proxying demand by population, which is available for all years.

Particularly in tourist districts, income and population are expected not to capture whole local demand. Demand for goods does not only come from residents, but also from tourists and travellers. In tourist regions, 'foreign' demand may significantly impact local goods prices. We use hotel overnight stays as a proxy for external demand. Data on this variable are only incompletely available from the "Statistik regional" CD. Gaps are closed by interpolating as well as by using other variables of the tourism statistic.[10]

The supply side of price determination is involved by the costs of the production factor labour. Data on wages on the district level are made available by the Institute for Employment Research (IAB) for the period 1993 - 2004. More specifically, the labour costs are measured by average gross wages and salaries of full-time employees subject to the social security system. They include taxes and payroll deductions of the employees, but no social security contributions of the employers. Wage data are provided for all German districts.

We use population density to capture the impact of agglomeration on goods and housing prices. In particular in the HRI regression, the ratio of population to the floor area of building and open space is preferable to the ratio of population to district area as it captures scarcity more adequately. Attractiveness of living and working conditions on housing rents is proxied by population growth. Higher living claims of skilled workers are measured by the proportion of employees with a university degree or degree from an advanced technical college. Descriptive statistics for all variables are reported in Table 1 for the margins of the period of investigation.

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[10] Roos (2006a) approximated external demand by using a dummy variable constructed from hotel beds.

Table 1: Descriptive statistics

Variable	Year	Mean	Standard deviation	Minimum	Maximum
Consumer price index	1995	89.9	1.2	88.4	97.6
without housing[a]	2004	102.5	1.8	97.8	107.6
Housing rent index (HRI)[a]	1995	79.6	9.9	62.6	111.3
	2004	87.5	8.9	73.1	124.4
Consumer price index	1995	88.7	1.9	86.0	97.5
(CPI)[a]	2004	99.3	2.8	95.4	111.2
Disposable income[b]	1995	11.3	0.7	9.5	14.3
	2004	14.4	0.6	13.0	16.6
Gross domestic product	1995	14.3	3.3	10.1	23.7
(GDP)[b]	2004	18.6	4.4	12.9	35.0
Population[b]	1995	156.4	321.9	45.4	3471.0
	2004	149.2	314.3	44.1	3387.5
Population density	1995	3366.8	1818.3	1573.8	10057.5
[b,c]	2004	3159.1	1400.1	1520.0	9447.6
Wage[d]	1995	52.0	3.8	45.0	70.8
	2004	63.0	5.9	50.9	82.2
Hotel overnight stays[c]	1995	269.5	655.3	9.2	6720.0
	2004	383.8	1131.6	14.4	11504.4
Dwelling capacity[c]	1995	81.9	109.6	16.5	1770.3
	2004	89.7	116.5	17.7	1878.5
Human capital[c]	1995	0.092	0.031	0.047	0.228
	2004	0.094	0.033	0.050	0.250

Sources
a Own calculations, b National Accounts of the States (*Volkswirtschaftliche Gesamtrechnung der Länder*), State Statistical Office Baden Württemberg, c Statistik regional (CD), Federal Statistical Office Germany, d Federal Employment Agency, Nuremberg,

6. Estimation results

Data for the consumer price index without housing (CPI-H) are available from the price comparison across 50 German cities in 1993. In a preliminary step, we aimed at identifying outliers by calculating Cook's distance from OLS estimation of the price model (13). The city of Mainz is a potential outlier as its standardized residual is larger than 2. However, none of the CD values exceed the cut-off value of 0.089. As no influential observation is identified, we calibrate the econometric model for the X-goods using the complete sample data set.

Table 2 reports the results of two-stage least-squares estimation (TSLS) of variations of the CPI model (13). In all regression, population, population density, hotel overnight stays, human capital and an east dummy are used as instruments. Hotel overnight stays are related to regional population. Population density is measured by relating population to the living and open space. First, the original model (13) is estimated by instrumenting disposable income and wage. 93.4% of the CPI variance is explained by the employed explanatory variables. The White test does not point to the presence of heteroscedasticity.

All regression coefficients are significant with the expected signs. The first CPI-H regression model is run with disposable income, which exerts a positive impact on regional price level. Moreover, the higher the population density, the higher the consumer price index. This effect may result from stronger local demand for consumer goods in densely populated areas. The positive correlation between CPI and wages can be explained well by the wage-price spiral. The positive response of regional prices on hotel overnight stays is expected to capture the demand of tourists and travellers for local goods. In the second and third CPI-H models, disposable income is substituted by GDP and population, respectively. Both variables show quite the same explanatory power as disposable income.

Table 2: Estimation result for CPI-H models

	TSLS of CPI (without housing)		
Instruments	Population, population density, hotel overnight stays, human capital, east		
Const.	82.173 (119.784)	82.470 (110.844)	81.999 (124.208)
Disposable income	0.049 (2.470)		
GDP		0.029 (2.394)	
Population			0.710 (2.515)
Population density	16.537 (2.470)	14.824 (2.079)	16.213 (2.429)
Wage	0.215 (19.158)	0.212 (18.079)	0.218 (20.011)
Hotel overnight stays	0.222 (2.112)	0.196 (1.840)	0.226 (2.166)
R^2	0.934	0.932	0.935
SER	0.931	0.941	0.921
SSR	38.981	39.826	38.210
White (p-value)	6.601 (0.949)	7.292 (0.923)	6.985 (0.935)

Notes:
t-values for the regression coefficients in parenthesis
R^2: coefficient of determination, SER: Standard error of regression, SSR: Sum of squared TSLS residuals, White: White heteroscedasticity test

The housing rent models are estimated by employing the complete data set covering 439 German districts. As the Federal Office for Building and Regional Planning (BBR) collecting data on housing rents since quite recently, the regressions are carried out for the latest year of investigation 2004. Because no endogeneity bias comparable with the CPI-H model is present with the housing rent index, the regression models can be estimated by ordinary least-squares (OLS) or, in case of heteroscedasticity, weighted least-squares (WLS).

In a preliminary step, the HRI model is estimated by OLS for the purpose of outlier detection. With n=439, the cut-off value of Cook's distance amounts to 0.0093. With this critical value, 29 districts are identified as influential observations. 20 outlying districts are located in West Germany and 9 in East Germany. Their effect on parameter estimation is controlled for by dummy variables in the final model.

Although there are some changes in absolute values of the estimated coefficients between the regressions with and without outliers, all signs are as expected. Table 2 shows that the coefficient of determination increases from 71.8% in the regression model with outliers to 82.9% in the regression model where outliers are controlled for by dummy variables. As the White test accepts the null of homoscedastictiy in the latter case, the final housing rent model is estimated by OLS.

Table 2: Estimation results for HRI models

	Regression with outliers		Regression with outlier dummies	
	Coefficient	t-value	Coefficient	t-value
Const.	2.517	5.263	2.989	6.906
Disposable income	0.180	11.307	0.130	8.567
Population density	0.015	5.598	0.015	6.204
Population growth rate	13.923	2.717	24.044	4.978
Dwelling capacity	-4.210	-5.207	-3.396	-4.693
Hotel overnight stays	0.062	6.505	0.049	5.617
Human capital	14.180	14.621	14.429	15.571
R^2	0.718		0.829	
SER	0.576		0.464	
SSR	143.185		86.775	
White (p-value)	93.583 (0.000)		45.746 (0.282)	

Notes:
R^2: coefficient of determination, SER: Standard error of regression, SSR: Sum of squared TSLS residuals, White: White heteroscedasticity test

While the impact of population density on housing rents does not differ in both regressions, the effect of population growth turns out to be considerably stronger when outliers are controlled for. While the positive influence of the former variable is expected to result from stronger local demand, the significant positive coefficient of the latter variable may due to the influx of ‘foreign’ citizens attracted by regional job opportunities or amenities. The most significant impact on the housing rent index (HRI), however, comes from disposable income; albeit its estimated regression coefficient decreases noticeably in the final model. The latter effect is also observed for hotel overnight stays and dwelling capacity. An increasing number of overnight stays puts pressure on rents because of higher opportunity costs.

On the other hand, housing demand relative to housing supply slackens with increasing dwelling capacity thereby reducing pressure on housing rents. The positive regression coefficient of human capital is well in line with the hypothesis that the demand of academics and skilled workers is mainly focused on the high-quality market segment of housing.

7. Regional price and income variation

The consumer price indes (CPI) exhibits a considerable spatial variation of regional price level (Figure 1). In 1995, the overall price level in Frankfurt/Main was about 25% higher than in Stendal. The difference between the highest and lowest CPI districts, Munich and Mittlerer Erzgebirgekreis, enlarged in 2004 to 37.5%. Without housing, the differences narrow to about 13% in 1995 and 16.5% in 2004. This is in line with the tendency to the law of one price for tradable goods. Notice, however, that non-tradable goods, particularly services, in the CPI without housing may preserve perceptible price disparities. Districts like Munich, Frankfurt, Stuttgart and Cologne are found at the top independently whether housing rents are included or not. With the exception of Hamburg, the districts with the ten largest CPI values are concentrated in South Germany, the Main-Rhine area and the Lower Rhine area. By contrast, all districts with the ten lowest CPI values are located in East Germany.

Figure 1: Consumer Price Index 1995 and 2004

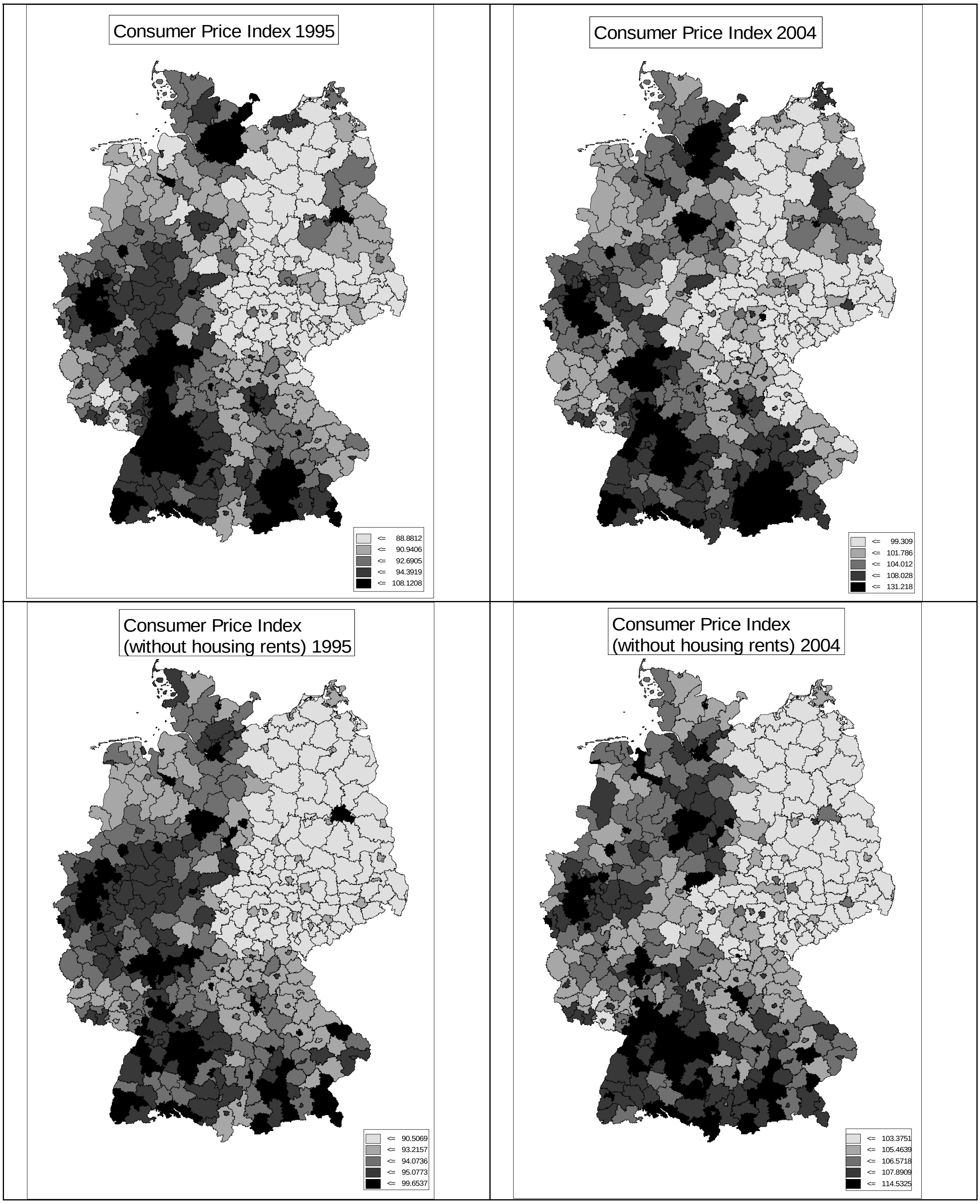


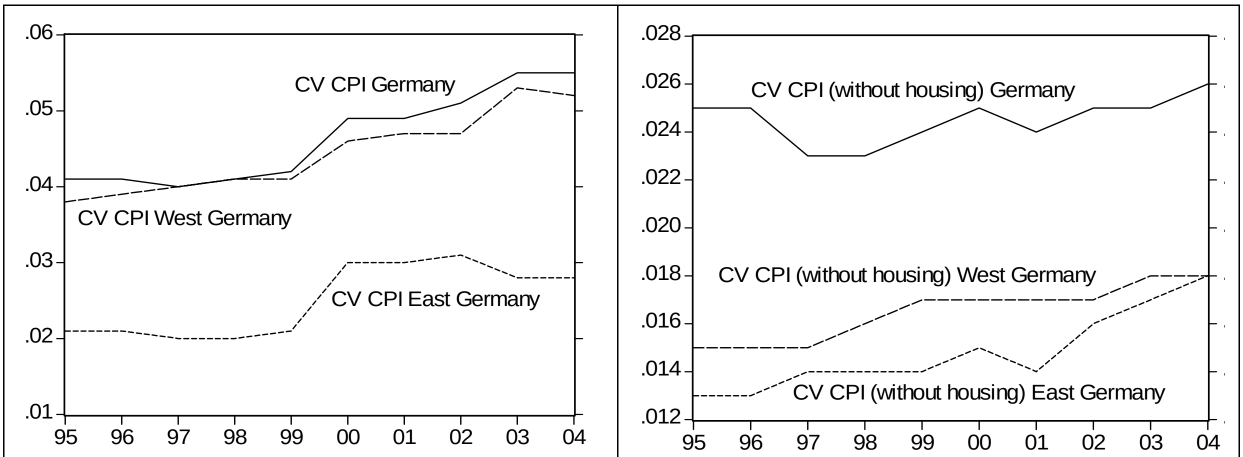
Figure 2 shows an increase in price dispersion during the period of investigation across German districts. While the coefficient of variation of the CPI increases from 4.1% in 1995 to 5.5% in 2004, it only rises from 2.5% to 2.6% for the CPI without housing. A rise of relative price dispersion is also observed within the West and East German regions. CPI price

Table 4: Districts with largest and lowest CPI

1995		2004		1995		2004	
CPI (10 largest values)				CPI without housing (10 largest values)			
Frankfurt/M	108.1	Munich city	131.2	Munich city	99.7	Munich city	114.5
Munich county	107.4	Munich county	127.3	Frankfurt/M	99.6	Munich county	113.4
Munich city	107.0	Frankfurt/Main	124.7	Stuttgart	98.9	Stuttgart	113.4
Heidelberg	105.5	Starnberg	122.9	Erlangen	98.4	Erlangen	113.1
Hochtaunuskreis	105.4	Stuttgart	121.9	Munich county	98.1	Frankfurt/M	112.3
Starnberg	105.1	Heidelberg	120.0	Düsseldorf	98.2	Hamburg	112.3
Stuttgart	104.0	Hamburg	119.9	Ludwigshafen	98.1	Böblingen	112.3
Garmisch-Patenk.	102.9	Cologne	119.6	Leverkusen	98.0	Düsseldorf	112.0
Cologne	102.8	Hochtaunuskreis	119.4	Cologne	97.8	Ludwigshafen	111.5
Fürstenfeldbruck	102.8	Ebersberg	118.7	Böblingen	97.7	Cologne	111.2
CPI (10 lowest values)				CPI without housing (10 lowest values)			
Stendal	86.0	Mittlerer Erzgebirgekreis	95.4	Mittlerer Erzgebirgskreis	88.4	Uecker-Randow	97.8
Uecker-Randow	86.1	Torgau-Oschatz	95.6	Demmin	88.5	Demmin	98.5
Mittl. Erzgebirgskreis	86.1	Vogtlandkreis	95.6	Uecker-Randow	88.6	Parchim	99.1
Prignitz	86.4	Uecker-Randow	95.6	Stollberg	88.6	Ludwigslust	99.2
Mansfelder Land	86.4	Mecklenburg-Strelitz	95.6	Vogtlandkreis	88.8	Güstrow	99.4
Aschersleben-Staßfurt	86.4	Zwickauer Land	95.7	Zwickauer Land	88.8	Mecklenburg-Strelitz	99.5
Vogtlandkreis	86.5	Löbau-Zittau	95.8	Löbau-Zittau	88.9	Nordvorpommern	99.7
Torgau-Oschatz	86.5	Demmin	95.8	Chemnitzer Land	88.9	Mittlerer Erzgebirgskreis	99.8
Demmin	86.6	Ludwigslust	95.9	Prignitz	88.9	Nordwestmecklen burg	99.9
Kyffhäuserkreis	86.6	Niederschles. Oberlausitzkreis	96.2	Elbe-Elster	88.9	Stollberg	100.3

disparities within East Germany are, however, relatively small compared with those in West Germany. Neither in Germany as a whole nor in the two former German states is evidence for σ-convergence is found.

Figure 2: Coefficient of variation for CPI



a) Coefficient of variation (CV) CPI

b) Coefficient of variation (CV) CPI without housing

CPI convergence regressions largely corroborate results on σ-convergence (Table 5).[11] β-divergence is found for West and East Germany with the CPI with and without housing. For Germany as a whole, the coefficient of the lagged CPI is positive with housing and negative without housing. In view of the low speed of convergence of 0.9% in the latter case, both results imply persistent price disparities. Although Roos (2006a) states that price level differentials cannot exist over a long period across German states, the estimated half-life of about 15 years for the CPI without housing does not give rise for rapid price adjustments. Persistency of regional price levels has also been established for other countries. Cechetti et al. (2002), for instance, found a unit root in US city price levels with an implied half-life of 9-10 years over a very long sample period. According to Busetti et al. (2006) three quarters of price levels across Italian regional capitals are not converging. Dayanandan and Ralhan (2005) estimate CPI half-lives of 7-8 years for Canadian provinces and cities.

Table 5: CPI convergence regression

	Germany	West Germany	East Germany
	Coeff. (t-value)	Coeff. (t-value)	Coeff. (t-value)
	Consumer price index (CPI)		
Const.	-0.8455 (-8.116)	-0.9706 (-7.019)	-0.2958 (-0.819)
CPI 1995	0.2135 (9.269)	0.2410 (7.906)	0.0912 (1.133)
R^2	0.164	0.161	0.012
White	7.863 (0.020)	0.470 (0.791)	17.648 (0.000)
	Consumer price index without housing (CPI-H)		
Const.	0.4723 (5.452)	0.0535 (0.339)	-1.0135 (-2.127)
CPI-H 1995	-0.0763 (-3.994)	0.0157 (0.452)	0.2544 (2.402)
R^2	0.035	0.001	0.050
White	6.201 (0.045)	1.692 (0.193)	2.731 (0.098)

The disparities in housing rents across German regions are extremely large (Table 6). In 1995, the Munich HRI exceeds that of Stendal by around 137%. The gap between the highest and lowest HRI district widens during the period of investigation reaching a value of 284% in 2004. While all ten regions with the highest housing rents are located in West Germany, the

[11] In all convergence regressions, the total growth rate in the period 1995-2004 of the variable under analysis is used as the dependent variable.

Figure 3: Housing rent index 1995 and 2004

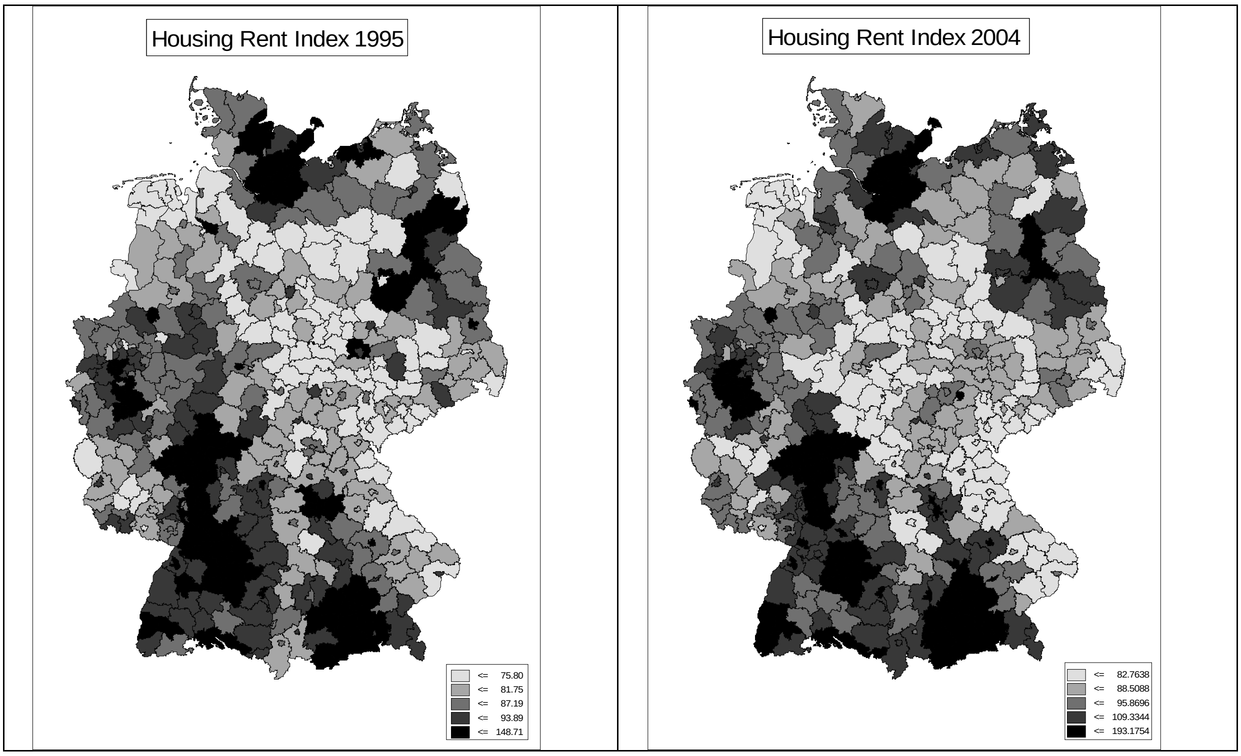
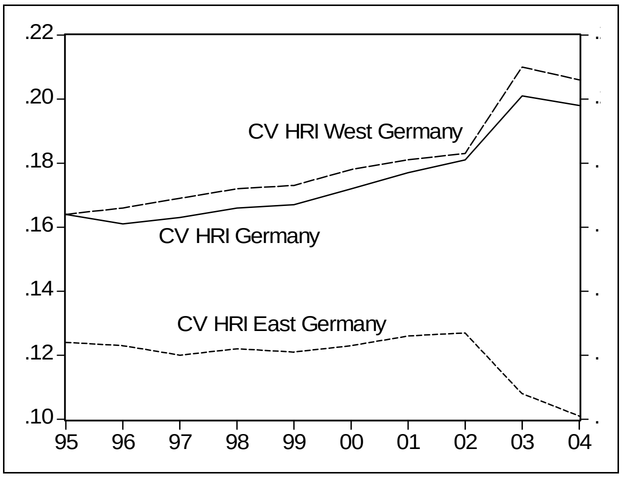


Table 6: Districts with largest and lowest HRI

1995		2004	
HRI (10 largest values)			
Munich county	148.7	Munich city	193.2
Frankfurt/M	145.9	Munich county	178.8
Starnberg	145.7	Starnberg	175.0
Hochtaunuskreis	143.9	Frankfurt/M	170.6
Heidelberg	142.6	Fürstenfeldbruck	158.0
Munich city	139.5	Ebersberg	157.3
Fürstenfeldbruck	136.4	Hochtaunuskreis	157.1
Ebersberg	134.9	Heidelberg	156.6
Dachau	131.4	Stuttgart	153.5
Freising	127.7	Main-Taunus-Kreis	152.4
HRI (10 lowest values)			
Stendal	62.6	Tirschenreuth	68.0
Wittmund	64.5	Hof city	71.1
Plauen	64.7	Regen	71.5
Wilhelmshaven	65.7	Werra-Meißner-Kreis	71.8
Emden	66.2	Wunsiedel	72.7
Aschersleben	66.4	Hof county	72.9
Lüchow-Dannenberg	67.1	Görlitz	73.1
Mansfelder Land	67.2	Neustadt a.d.Waldnaab	73.4
Uecker-Randow	67.5	Plauen	73.6
Halberstadt	67.5	Bremerhaven	74.1

geographic distribution of the ten districts with lowest housing rents is mixed. Figure 3 shows that low-rent regions are situated in both German parts.

Figure 4: Coefficient of variation for housing rent index (HRI)



The great disparities in the HRI are reflected by large CV values. In both Germany as a whole and West Germany, the coefficient of variation rises from 16.4% in 1995 to about 20% in 2004 (Figure 4). This tendency clearly indicates σ-divergence of housing rents in both areas. By contrast, the declining CV values during the sample period in East Germany point to σ-convergence. These findings are largely corroborated by convergence regressions (Table 7). The coefficient of lagged HRI is, however, not significant for Germany as a whole. For East Germany, the rate of HRI convergence is estimated by 6.3% which implies a half-life of 11 years.

Table 7: Housing rent convergence regression

	Germany	West Germany	East Germany
	Coeff. (t-value)	Coeff. (t-value)	Coeff. (t-value)
Const.	-0.0240 (-0.192)	-0.3504 (-2.411)	1.9817 (8.575)
HRI 1995	0.0306 (1.092)	0.1046 (3.223)	-0.4317 (-8.162)
R^2	0.003	0.031	0.377
White	4.573 (0.102)	1.470 (0.479)	13.148 (0.001)

The highest nominal income per capita districts are situated in South Germany. Starnberg, Hochtaunuskreis, Baden-Baden and Munich county are ranked first in 1995 and 2004 (Table 8). In all sample years there is a clear West/East divide of the regions with highest and lowest nominal income per capita. The maximum West/East gap narrowed during the period of investigation from 136% in 1995 to 112% in 2004. This development is consistent with a

Figure 5: Nominal disposable income 1995 and 2004

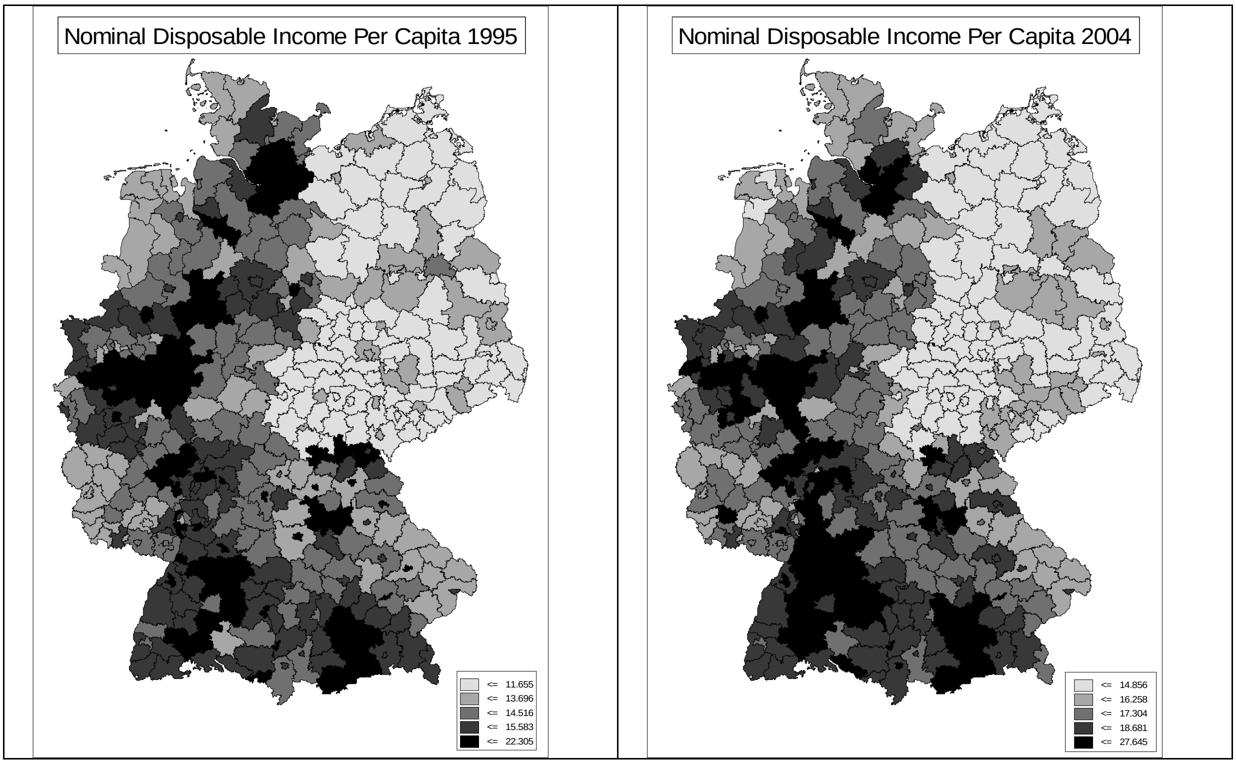


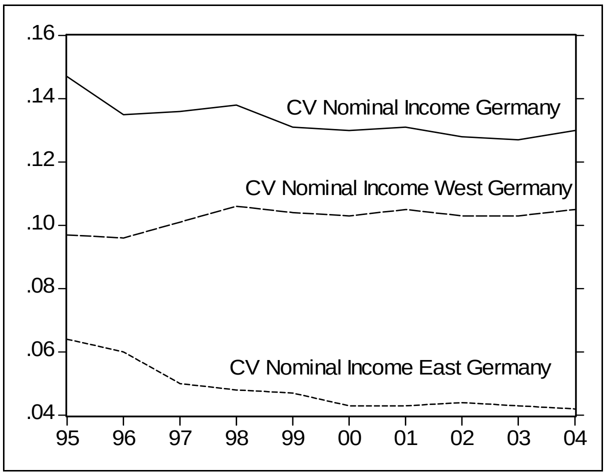
Table 8: Districts with largest and lowest nominal income per capita

1995		2004	
Nominal income per capita (10 largest values)			
Starnberg	22305	Starnberg	27645
Hochtaunuskreis	19806	Hochtaunuskreis	26873
Baden-Baden	19306	Munich county	23670
Munich county	19154	Baden-Baden	23590
Erlangen-Höchstadt	18566	Hamburg	23054
Munich city	18319	Munich city	22436
Düsseldorf	18269	Sankt Wendel	22421
Stormarn	17894	Main-Taunus-Kreis	21865
Herford	18092	Mettmann	21732
Rheinisch-Bergischer Kreis	17832	Pforzheim	21699
Nominal income per capita (10 lowest values)			
Uecker-Randow	9463	Weimar	13023
Aschersleben-Staßfurt	9591	Uecker-Randow	13150
Quedlinburg	9643	Kyffhäuserkreis	13220
Schönebeck	9656	Ostvorpommern	13245
Stendal	9808	Demmin	13460
Demmin	9977	Weimarer Land	13522
Weimarer Land	9990	Köthen	13550
Mecklenburg-Strelitz	10197	Eichsfeld	13591
Unstrut-Hainich-Kreis	10259	Mecklenburg-Strelitz	13617
Schmalkalden-Meiningen	10436	Nordvorpommern	13629

reduction of the coefficient of variation from 0.147 to 0.130. σ-convergence is also found across East German but not across West German regions (Figure 6).

With state data, the East/West ratio increases from 0.80 in 1995 to 0.85 in 2002 (Roos, 2006b). It can be shown, however, that this ratio is overestimated with highly aggregated data when high-income regions tend to be high-price regions. This explains the lower East/West ratios of 0.756 in 1995 and 0.810 in 2004 calculated from district data. Moreover, across German states, relative income dispersion turns out to be considerably smaller. Roos (2006b) estimated a decline of the CV coefficient from 0.12 in 1995 to about 0.10 in 2002. Although

Figure 6: Coefficient of variation for nominal income



the true extent of regional disparities is somewhat hidden with state data, σ-convergence in nominal income is revealed for Germany as a whole at both regional scales.

Table 9: Nominal income convergence regression

	Germany	West Germany	East Germany
	Coeff. (t-value)	Coeff. (t-value)	Coeff. (t-value)
Const.	0.7440 (19.340)	0.2814 (3.933)	1.5542 (12.784)
CPI 1995	-0.2090 (-14.297)	-0.0390 (-1.473)	-0.5392 (-10.732)
R^2	0.319	0.007	0.512
White	17.528 (0.000)	1.794 (0.408)	0.815 (0.665)

β-convergence in all Germany takes place with a rate of 2.6% per annum (Table 9). This means that the income gap is halved in about 27 years. While there is no significant relationship between income growth and initial income across West German districts, income disparities are reduced by a rate of 8.6% in East Germany. The fast rate of convergence estimated for East Germany implies a half-life of about 8 years.

Figure 7: Real disposable income 1995 and 2004

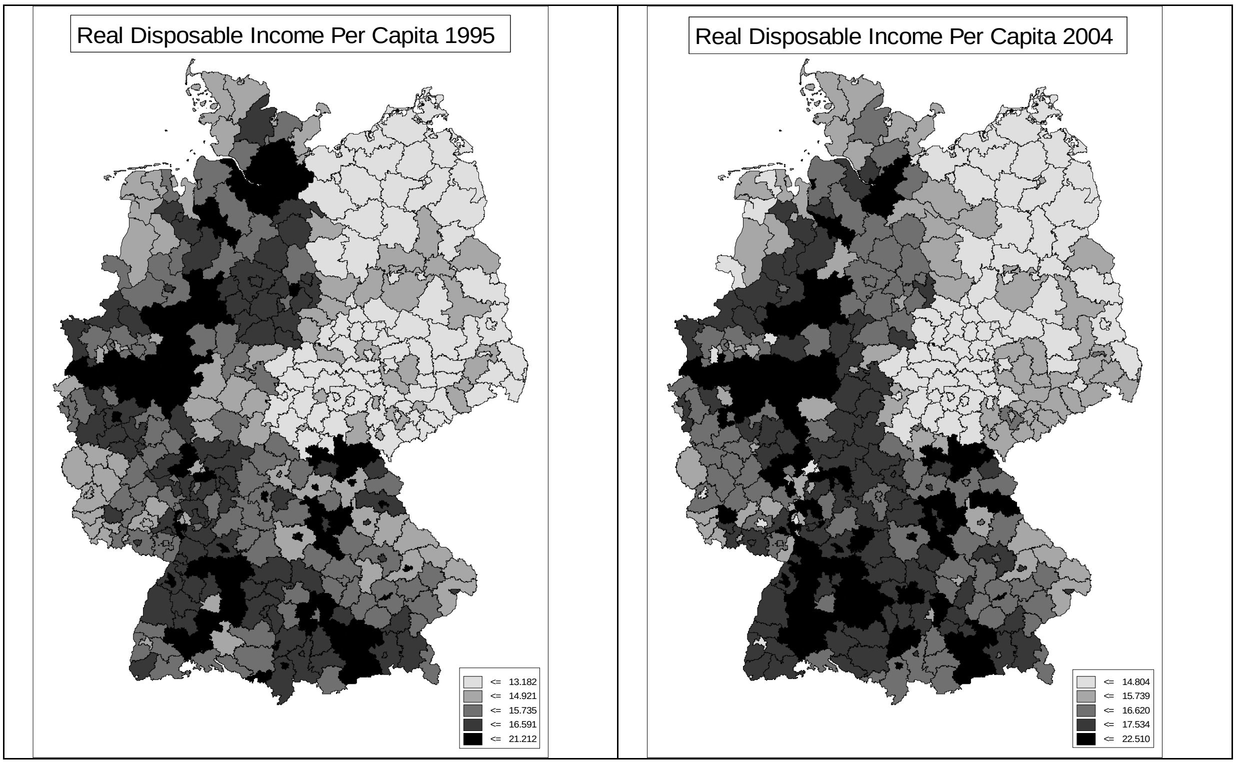


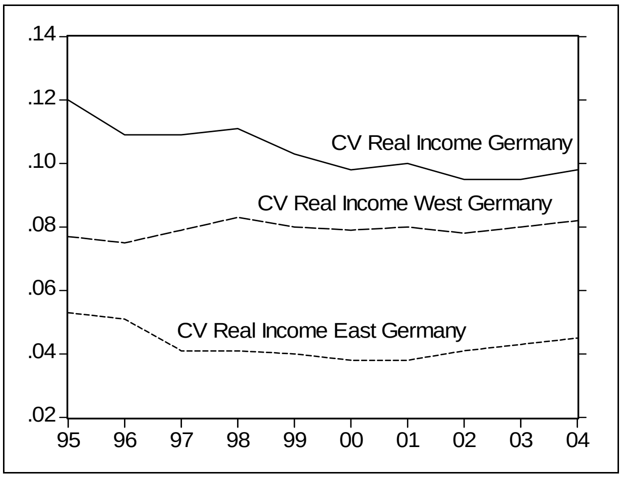
Table 10: Districts with largest and lowest real income per capita

1995		2004	
Real Income per capita (10 largest values)			
Starnberg	21.212	Hochtaunuskreis	22.510
Erlangen-Höchstadt	19.710	Starnberg	22.492
Baden-Baden	19.540	Sankt Wendel	22.300
Herford	19.540	Baden-Baden	20.967
Solingen	19.084	Olpe	20.523
Gütersloh	19.014	Zollernalbkreis	20.288
Harburg	18.963	Pforzheim	20.173
Remscheid	18.854	Gütersloh	20.095
Coburg	18.841	Schwabach	19.596
Hochtaunuskreis	18.793	Solingen	19.577
Real Income per capita (10 lowest values)			
Uecker-Randow	10.996	Weimar	12.509
Quedlinburg	11077	Jena	12.739
Aschersleben-Staßfurt	11101	Rügen	13.092
Schönebeck	11120	Ostvorpommern	13.113
Weimarer Land	11318	Potsdam	13.405
Stendal	11399	Kyffhäuserkreis	13.486
Mecklenburg-Strelitz	11473	Weimarer Land	13.500
Demmin	11519	Wismar	13.655
Rügen	11674	Ilm-Kreis	13.693
Ostvorpommern	11773	Uecker-Randow	13.757

As high-income regions tend to be high-price-level regions as well, disparities in purchasing power are somewhat levelled off. However, real-income gaps between highest and lowest income districts are still large. In 1995, the highest ratio in real income per capita between two districts was 1.9 and in 2004 1.8 (Table 10).

With district data, the East/West ratio fell from 0.796 in 1995 to 0.863 in 2004. Thus, the real income gap between East and West Germany is estimated by short 14% at the fringe of the period of investigation. According to Roos' estimates, the West/East gap with respect to real income per capita is already closed in 2002 (Roos, 2006b). The estimate of an East/West ratio of unity in 2002 is, however, likely an artefact resulting from aggregation and thus strongly upwardly biased. Our finding is close to the finding of the IWH (2003) which reports a real income gap of 0.91 in 2002, although its reliability is criticized by Roos (2006b) on account of its unclear calculation

Figure 8: Coefficient of variation for real income



As with nominal income per capita, σ-convergence can be proved for Germany as a whole as well as within East Germany, while σ-divergence arises for West Germany (Figure 8). Using highly disaggregated data the CV decreases from 0.120 in 1995 to 0.098 in 2004, while it falls off from 0.04 in 1995 to 0.03 in 2002 with state data (Roos, 2006b). As with nominal income, the variation is considerably less within both parts of the German economy.

β-convergence is established for Germany as a whole and the Eastern and Western part of the country (Table 11). Real income convergence across all German districts turns out to be stronger than nominal income convergence. For all German districts the rate of real income convergence increases by the factor 1.6 to a value of 4.1%. This rate of convergence implies a half-life of about 17 years. In contrast to nominal income, the coefficient of lagged initial

Table 11: Real income convergence regression

	Germany	West Germany	East Germany
	Coeff. (t-value)	Coeff. (t-value)	Coeff. (t-value)
Const.	0.9190 (17.984)	0.4622 (4.727)	1.5356 (8.541)
CPI 1995	-0.3115 (-16.537)	-0.1477 (-4.181)	-0.5507 (-7.782)
R^2	0.385	0.051	0.355
White	2.682 (0.262)	0.354 (0.838)	2.417 (0.299)

income is significant for West Germany. The rate of convergence of 1.8% implies a half-life of 39 years. As with nominal income, lagging regions within East Germany caught up to wealthier regions relatively quickly during the period 1995-2004. On average, the real income gap across East German districts is halved in 8 years.

8. Conclusion

In this paper a model for prices of consumer goods and housing is used for estimating the consumer price index (CPI) with and without housing as well as the housing rent index (HRI) for all 439 German NUTS 3 regions in the period 1995-2004. Regional CPIs are calibrated with the aid of a price comparison of 50 German cities by the Federal German Statistical Office in 1993. The HRI model is econometrically estimated using rent data surveyed by the Federal Office for Building and Regional Planning (BBR) in 2004. Both econometric price models are able to explain a high percentage of regional variation. In particular the goodness of fit of the CPI model without housing proves to be very high. Overall regional price levels are obtained by weighting both sub-indices with the shares of consumer expenditures. As consumption patterns are not available at the district level, regional CPIs should not be interpreted as cost-of-living indices (COLI) but Laspeyres-type regional price indices.

The spatial CPI pattern is found to be relatively stable during the period of investigation. Clusters of high-price-level districts are in particular located in South Germany around the cities of Munich and Stuttgart, in the Rhine-Main area, in the Lower Rhine area alongside the centre line Cologne/Düsseldorf and around the city of Hamburg. As expected, most East German districts are low-price-level regions. Districts with low price levels are, however, also found alongside the Czech border in Bavaria and scattered in Rhineland-Palatinate, the Saarland and Hesse. While the CPI without housing converges with an annual rate of 0.9% across all German regions, the total overall price index tends to diverge during the period of investigation. This behaviour is in line with a relatively high rate of convergence of tradable goods which are more strongly weighted in the former price index.

Disparities in housing rents are extremely large. High HRI regions are not only located in West Germany, but also in East Germany - particularly in the surrounding area of Berlin. There is no evidence of HRI convergence across all German districts. However, the development of the HRI is completely different in both former German nations. While HRI disparities have increased in the period 1995-2004 in West Germany, the housing rents tend to converge across East German regions.

Although income disparities are significantly reduced in real terms, high-nominal-income regions are usually high-real-income regions as well. While in 1995 some districts with highest income are located in Northern Germany as well, in 2004 nearly all high-income-districts are situated in Southern Germany. Districts with the lowest income per capita are without exception scattered across East Germany.

Real income per capita converges faster to the unique steady state than nominal income per capita. The West/East gap is reduced by about 7 percentage points during the period of investigation. Across East German regions, the speed of convergence is extremely high. By contrast, no significant regression coefficient of initial nominal income is found for West Germany. In real terms, income per capita nearly converges with the "natural rate" of 2% across West German regions. σ-convergence, however, can only be proved for Germany as a whole and East Germany.

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