Interregional Risk Sharing and Fiscal Redistribution in Reunified Germany

Falko Jüßen[*]

University of Dortmund

Department of Economics

Vogelpothsweg 87

D-44227 Dortmund

Phone: +49-231-755-3291, Fax: +49-231-755-3069

(f.juessen@wiso.uni-dortmund.de)

Abstract

This paper provides empirical evidence of interregional risk sharing in reunified Germany. The focus is on two related questions: First, to what extent do private institutions and the public sector provide insurance against asymmetric shocks to individual regions? Second, to what extent does the public sector reduce long-term differences between regions? While the federal government channel is not found to have a stabilizing effect, private factor income flows provide almost complete insurance against short-term shocks. In sharp contrast, the fiscal transfer system achieves a substantial reduction of long-term disparities between regions. These results show that fiscal transfers in reunified Germany are mainly concerned with redistribution in favor of depressed regions rather than providing insurance against idiosyncratic shocks.

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1 Introduction

At the heart of interregional risk sharing stand the fundamental differences between regional Gross Domestic Product (GDP), income, disposable income, and consumption. While GDP corresponds to a region's production, income explicitly includes net factor payments from other regions. By holding claims to output in other regions, individuals can smooth away idiosyncratic shocks to income caused by variations in their home region's production. Following Asdrubali, Sørensen, and Yosha (1996) (henceforth ASY) such insurance is referred to as 'income smoothing' or 'capital market smoothing'. As discussed by ASY (1996) and von Hagen (2000), in a world with imperfect capital markets, further smoothing of incomes can be achieved by the fiscal transfer system, which renders disposable income different from income. This channel of risk sharing is referred to as 'federal government smoothing'. In the extreme case of full risk sharing after capital market and federal government smoothing, idiosyncratic shocks to production do not affect disposable income at all. The desirable effect of this stabilization is that regions can achieve a smooth stream of intertemporal consumption.[1]

In most economies, fiscal transfers are not primarily intended to provide short-term risk sharing. Although fiscal transfers may turn out to have stabilizing effects, the main justification of transfers is to provide systematic and long-term redistribution from persistently rich to persistently poor regions. This is made explicit in the German constitution, which states that the main goal of the fiscal transfer system is to create and secure uniform living standards throughout Germany. In general, any persistent disparities in levels of relative economic prosperity may result from different shocks but also from permanent heterogeneity among regions.

Similar to the smoothing of output shocks by private markets, the smoothing of persistent initial disparities by fiscal redistribution can also be interpreted as a kind of insurance. Rather than providing insurance against shocks, this kind of risk sharing refers to an insurance against unfavorable initial conditions. It is an insurance in a Rawlsian sense, an insurance taken behind a veil of ignorance. Behind a veil of ignorance, individuals could be born in a rich as well as poor region. In the absence of sizeable regional migration, the risk of being born in a poor region can be insured against by redistribution of income by public institutions. The market, by contrast, is not expected to provide sufficient insurance against unfavorable initial conditions.

This implies that one has to distinguish between two kinds of risk sharing: Firstly,

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[1]A region can further smooth its consumption by borrowing and lending on the credit market. Since consumption data are not available at the disaggregated regional level used in this paper, such *ex post* channel of 'consumption smoothing' or 'credit market smoothing' (see ASY, 1996 and Becker and Hoffmann, 2006) is not considered.

private markets and the public sector provide insurance against idiosyncratic *shocks* to regional output. Secondly, the public sector aims at reducing *level* disparities between regions which may result from permanent heterogeneity rather than from short-term shocks.

This paper provides new empirical evidence on both kinds of risk sharing in reunified Germany. One novelty of our study is that it introduces new empirical techniques into the risk sharing literature which rely on nonparametric density estimation. The short term and stabilizing effect of interregional risk sharing is analyzed by conditioning the densities of first-differenced income and disposable income on shocks to regional output. This conditioning allows one to assess if shocks to production are transmitted to shocks to income and disposable income. An advantage of the proposed methodology is that one can address the question of whether the relationship between the different risk sharing channels and idiosyncratic output shocks is more complex than captured by a linear regression model as proposed by ASY (1996). For example, a nonparametric approach may turn out to be useful if high risks are harder to insure than moderate risks.

In order to analyze if redistribution of the public sector contributes to a reduction of level disparities between regions, we adopt a continuous state space method to estimate the transition dynamics and calculate the implied long-run distributions of regional output, income, and disposable income. By comparing the shapes of the long-run distributions we can assess the extent of smoothing of disparities between regions achieved by private factor income flows and public interregional transfers.

The techniques employed are borrowed from the growth econometrics literature and were first introduced by Danny Quah in a number of seminal papers to analyze convergence between countries and regions (Quah, 1996a, b, c, 1997, 2001). This so called 'distribution dynamics' approach facilitates an analysis of evolving distributions which extends panel data and time-series methods and is especially useful in uncovering empirical phenomena like clumping, stratification, and polarization. As already pointed out by Quah himself (Quah 1996c, p. 117), risk sharing is one example where these phenomena are relevant. Surprisingly, the techniques from the growth econometrics literature have not been transferred yet to a risk sharing framework. Our study is the first assigning Quah's ideas to the risk sharing literature by explicitly distinguishing between the distribution dynamics of output, income, and disposable income.

While previous studies for (West) Germany have examined regional risk sharing at the level of the West German federal states (Hepp and von Hagen, 2000, Kellermann, 2001, Buettner, 2002), our study provides a regionally disaggregated analysis at the level of 271 functionally defined labor market regions. For reunified Germany, ours is the first study analyzing interregional risk sharing, most likely because appropriate data have only recently

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become available. The case for reunified Germany is particularly interesting because there are substantial interregional transfers aimed at reducing regional disparities, especially between the Eastern and Western part of the country. These transfers potentially provide insurance of idiosyncratic regional risk.[2]

Before we proceed to present the data and the econometric model, we provide a preview of our results. The results of the short-term risk sharing analysis are surprisingly clear-cut: Shocks to regional output are found to be almost uncorrelated to changes in regional income, a finding which provides strong evidence of almost complete risk sharing after income smoothing. The fact that regional income does not co-move with output implies that there is no scope for further smoothing of income shocks by the federal government. Indeed, the estimation results show that fiscal transfers, which are responsible for the wedge between income and disposable income, provide no additional insurance of idiosyncratic shocks.

Concerning the long-term redistributive properties of fiscal transfers we find that the variance reduction achieved by the fiscal transfer system is substantial. In the long run, the probability that German regions deviate from the average level of disposable income per capita is comparatively low. Since redistribution by the public sector is necessary to achieve a uni-modal distribution of regional incomes, we conclude that the fiscal transfer system reduces disparities between regions significantly. However, this redistributive policy has no short-term stabilizing effects as a by-product.

This paper is structured as follows: The data are introduced in Section 2. Section 3 focuses on the short-term stabilizing effects of interregional risk sharing. The distribution dynamics analysis of long-term disparities between regions is presented in Section 4. A brief discussion of our empirical approach is presented in Section 5. The last section presents our conclusions.

2 Data

In order to gain an understanding of regional risk sharing it is necessary to measure the regional macroeconomies carefully. Recently, detailed data for reunified Germany have become available, which facilitate a regionally disaggregated analysis at the level of 439 counties. The institution for measuring the counties' economic activity is the National Accounts of the Federal States compiled by the Statistical State Office Baden-Wuerttemberg. Our analysis of interregional risk sharing takes data on GDP, (primary) income, and dis-

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[2]In Germany, there is an explicit, formula-based arrangement for tax revenue sharing and transfers among German federal states which is defined by the German constitution. Moreover, there are separate arrangements for fiscal equalization at the municipal level in all federal states (Hepp and von Hagen, 2000).

posable income into account.[3]

Gross Domestic Product (GDP) is measured in market prices and quantifies the amount of economic production of a particular region. In contrast to Gross National Product (GNP), GDP *ex*cludes interregional income transfers and hence attributes to a region the products generated within it, rather than the incomes received in it.

The income figure used in this study is the so-called primary income of private households.[4] It consists of the received compensation of employees, the incomes of the self-employed, and property income, e.g. interest on wealth. In contrast to GDP, primary income *in*cludes net factor payments (interregional income transfers) from other regions. A priori, the difference between regional GDP and income can be expected to be substantial because regions within a country are highly integrated.

Disposable income is defined as the amount of households' total income left after taxes, plus any transfer payments and grants received from the federal government. We denote the overall balance of levied taxes (e.g. income tax), contributions (e.g. social insurance contributions) and received transfers (e.g. pensions, unemployment benefits, social welfare) as net fiscal transfer. Disposable income is obtained from primary income by substracting the net fiscal transfer.[5] This income figure determines how much private households can consume and save and it is often seen as an indicator of the standard of living in a region.[6]

Since regions differ in size, aggregate measures of output, income, and disposable income need to be normalized by an appropriate reference variable. Usually, total population or total employment are used as a reference.

For income and disposable income, total population is the appropriate reference because income is measured at the place of residence instead of at the workplace. In contrast, total employment appears to be the more appropriate reference for data on production, because both, GDP and the number of employed people refer to the workplace.[7]

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[3] All data can be downloaded from:
http://www.statistik-portal.de/Statistik-Portal/publ.asp.

[4] GNP data for German counties are not available. Moreover, there are no income data for other sectors.

[5] Previous studies on interregional risk sharing and fiscal federalism distinguish between the smoothing effects of different levels of the fiscal equalization system such as taxes, transfers, and grants (Sørensen and Yosha, 1999, Buettner, 2002). Unfortunately, it is not possible to analyze the composition of federal government smoothing at the fine level of regional aggregation used in this paper because these data are not available. Nevertheless, one still can compare incomes before and after redistribution of the fiscal sector, i.e. income versus disposable income.

[6] Official statistics does not report data on consumption at the county level. Therefore, working with disposable income data is the best we can do. It is well-known from other countries that even if consumption data are available they are frequently measured imprecisely and noisily (ASY, 1996). Moreover, as argued by Athanasoulis and van Wincoop (2001), over longer horizons one can expect consumption growth to closely follow the growth rate of income after risk sharing. Unfortunately, official statistics does not provide regional price indices at the county level.

[7] Population or employment data disaggregated for age groups are not available for the whole time period under study.

This difference between data referring to the place of residence and to the workplace might cause problems in our analysis of interregional risk sharing because regions within a country are integrated by commuter flows. If commuting linkages between regions are not accounted for in the employed data, a properly specified risk sharing model needs to isolate the smoothing effects of commuting and suburbanization from other channels such as capital market and federal government smoothing. A further problem associated with the use of disaggregated county data is that the borders of German counties are determined by political and historical rather than economic reasons.

For these reasons we aggregate counties to local labor market regions which are the target areas for the most important regional policy program in Germany, the so called GRW (German 'Gemeinschaftsaufgabe Verbesserung der regionalen Wirtschaftsstruktur'). We use data for 439 German counties to define 271 labor market regions, so that center and hinterland of labor markets are adequately integrated on the basis of commuter flows. Due to this aggregation the employed data on GDP, income, and disposable income already account for the most important commuting linkages between regions and we can express all variables in terms of per capita as is usually done in the risk sharing literature.[8]

To account for the potential role of German-wide shocks (time-specific effects) that may create uninsurable output variability, we have formulated the data for each labor market region relative to the German-wide aggregate. This normalization also accounts for common changes in inflation. The key variables in our study are the region's logarithmic or percentage deviations from the national average per capita values of production, income, and disposable income. To save on notation, we denote relative variables with lower-case letters, so relative output per capita is $gdp = \log \frac{GDP}{GDP*}$, relative income is $inc = \log \frac{INC}{INC*}$, and relative disposable income is $dinc = \log \frac{DINC}{DINC*}$, whereas the variables indicated with a star denote the population-weighted national average values. In the following, we use the term 'relative' as equivalent to 'idiosyncratic'.

These relative variables do not only reflect the influence of shocks but also include the permanent heterogeneity among regions. This means that the levels of gdp, inc, and $dinc$ include the fixed effect of each region. In order to measure idiosyncratic shocks, we will work with first differences of our key variables gdp, inc, and $dinc$ which by construction no longer include the fixed effects of the variables in levels. The first differences of the relative variables measure the deviation of a region's growth rate from the average growth rate in Germany as a whole.

The empirical analysis employs annual data in the period from 1995 to 2002. Data

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[8]Since all our measures—output, primary income, and disposable income—are in per capita terms we often omit 'per capita' for the sake of brevity. Population data are reported by the Federal Office for Building and Regional Planning.

from earlier years are only available for GDP but not for primary and disposable income. Thus, our database consists of a balanced panel of 271 regions observed over 8 years.[9]

3 The short-term stabilizing effects of interregional risk sharing

In this section to what extent private markets and the public sector provide insurance against idiosyncratic shocks to regional output is analyzed. As summarized by Asdrubali and Kim (2004), most of the theoretical literature on risk sharing considers a world of open endowment economies with complete markets lasting infinite periods. Each economy is populated by a representative risk-averse consumer who maximizes his expected utility in the face of an exogenous stochastic output process. Standard time- and leisure-separable utility functions imply that every representative agent will insure his future income stream in any contingency. If markets are complete, agents can pool their risk and insure fully against the idiosyncratic uncertainty in their resources. Consequently, one important empirical implication of risk sharing theory is that consumption should not co-move with idiosyncratic variables, such as regional output. Rather, changes in consumption should move parallel to aggregate changes in consumption (given that preference shocks and measurement error are absent).[10]

The study of risk sharing *channels* was introduced by ASY (1996) and adds to the analysis the correlation between GDP and additional national accounts measures, such as income, disposable income, and ultimately consumption. As discussed in the last section, we can only work with data on disposable income because consumption data are not available at the disaggregated regional level used in this paper. We follow the ideas of ASY (1996) and Sørensen and Yosha (1998) and consider the following identity of per capita output, income, and disposable income:[11]

$$gdp_i = (gdp_i - inc_i) + (inc_i - dinc_i) + (dinc_i). \tag{1}$$

In order to obtain a simple measure of smoothing from the identity, one manipulates it by taking differences and multiplying both sides by Δgdp_i :

$$\Delta gdp_i \cdot \Delta gdp_i = (\Delta gdp_i - \Delta inc_i) \cdot \Delta gdp_i + (\Delta inc_i - \Delta dinc_i) \cdot \Delta gdp_i + (\Delta dinc_i) \cdot \Delta gdp_i. \tag{2}$$

[9]The database only covers a rather short time period but one has to keep in mind that a richer database is simply not available for reunified Germany.

[10]For more details on risk sharing theories we refer to Cochrane (1991), Sørensen and Yosha (1998), Crucini (1999), and Crucini and Hess (2000).

[11]The decomposition suggested in the cited studies also includes consumption $cons_i$ and reads as (in logs): $gdp_i = gdp_i - inc_i + inc_i - dinc_i + dinc_i - cons_i + cons_i$.

Finally, one takes expectations and arrives at the following decomposition of the cross-sectional variance in Δgdp (see ASY, 1996, Sørensen and Yosha, 1998, and Mélitz and Zumer, 1999 for further details):

$$var\left\{\Delta gdp_i\right\} = cov\left\{\Delta gdp_i, \Delta gdp_i - \Delta inc_i\right\} \qquad (3)$$
$$+cov\left\{\Delta gdp_i, \Delta inc_i - \Delta dinc_i\right\}$$
$$+cov\left\{\Delta gdp_i, \Delta dinc_i\right\}.$$

Divide by the variance of Δgdp_i to get

$$1 = \beta_C + \beta_G + \beta_U, \qquad (4)$$

where β_C is the ordinary least squares estimate of the slope in the regression of $(\Delta gdp_i - \Delta inc_i)$ on Δgdp_i. The dependent variable $(\Delta gdp_i - \Delta inc_i)$ reflects changes in capital income flows between regions (e.g. equity returns) and β_C is interpreted as the percentage of smoothing of a GDP shock carried out by capital markets.[12]

Similarly, the coefficient β_G is the slope in the regression of $(\Delta inc_i - \Delta dinc_i)$ on Δgdp_i. The $(\Delta inc_i - \Delta dinc_i)$ differential measures the net change in fiscal transfers and we can interpret β_G as the percentage of smoothing of a GDP shock carried out by the federal government. Finally, β_U is the coefficient in the regression of $\Delta dinc_i$ on Δgdp_i and measures the amount not smoothed. In practice, the third regression needs not be estimated because the β coefficients sum to unity.

At the practical level, the typical parametric risk sharing regressions implied by the variance decomposition method are specified as panel regressions and can be summarized as follows (all variables are in stacked form):

$$\Delta gdp - \Delta inc = \beta_C \Delta gdp + u_1 \qquad (5)$$
$$\Delta inc - \Delta dinc = \beta_G \Delta gdp + u_2,$$

whereas β_C and β_G measure the average degree of capital market and federal government smoothing, respectively. The β coefficients will be weighted averages of the year-by-year cross-sectional regressions (see ASY, 1996, footnote 5). In both regressions, the right-hand side variable is the idiosyncratic shock to output and the slope parameters measure the percentage of shocks to output which are absorbed at each level of smoothing. Full risk

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[12]One has to keep in mind that the $gdp - inc$ differential also captures retained earnings. There are no data available which can be used to disentangle the effects. Athanasoulis and van Wincoop (2001) argue that retained earnings do not alter the economic interpretation of capital market risk sharing substantially because retained earnings reflect an investment that contributes to dividends in the future.

sharing is present if β_C and β_G sum to unity.[13]

This paper suggests an alternative method of analyzing risk sharing which is based on nonparametric density estimation as proposed by Quah (1997) in the context of convergence studies. Our basic idea is to combine ASY's (1996) regression specification as summarized in (5) and Quah's (1997) distribution dynamics approach.

Quah's original approach is concerned with mapping whole distributions sequentially in time. This procedure will turn out to be especially useful in estimating the long-term redistributive effects of interregional risk sharing and is introduced in more detail in the next section. In this section, we suggest a slight modification of Quah's dynamic approach to analyze the short-term stabilizing effects of risk sharing.

By estimating the conditional densities $f(\Delta gdp - \Delta inc | \Delta gdp)$ and $f(\Delta inc - \Delta dinc | \Delta gdp)$ we can test if shocks to regional output are transmitted to shocks to income and disposable income. This means that instead of mapping the distributions of single variables (gdp, inc, and $dinc$) sequentially in time,[14] we estimate the (contemporaneous) conditional densities of variables in first differences. These densities show the likelihood of changes in private factor income flows (or net fiscal transfers, respectively) given that a region is subject to an idiosyncratic shock to its production. In a nutshell, such analysis is the nonparametric equivalent à la Quah (1997) to the parametric risk sharing regressions as displayed in (5). To compare the results obtained with our method to those of linear techniques we will also perform a simple regression-based risk sharing analysis.

The conditional densities $f(\Delta gdp - \Delta inc | \Delta gdp)$ and $f(\Delta inc - \Delta dinc | \Delta gdp)$ are estimated using adaptive kernel techniques (Silverman, 1986, Pagan and Ullah, 1999).[15] We briefly explain how to estimate the conditional densities using the density $f(\Delta gdp - \Delta inc | \Delta gdp)$ as an example. First, we have to estimate the joint density of $(\Delta gdp - \Delta inc)$ and Δgdp using adaptive kernel techniques. Then, we compute the marginal density of Δgdp by integrating over $(\Delta gdp - \Delta inc)$. The ratio of the joint density to the marginal density provides the estimate of $f(\Delta gdp - \Delta inc | \Delta gdp)$.

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[13]This can be seen more clearly by rewriting the first regression $\Delta gdp - \Delta inc = \beta_C \Delta gdp + u_1$ as $\Delta inc = (1 - \beta_C)\Delta gdp + u_1$. If β_C equals 1, income does not co-move with output. Similarly, if full risk sharing is achieved at the federal government level, $dinc$ should not co-move with gdp. As in previous studies, we do not impose any restrictions on the estimated coefficients.

[14]This will be done in the next section.

[15]Adaptive estimators with a varying rather than fixed bandwidth have the desirable effect of separating different modes of the density more clearly. The adaptive kernel estimator adapts to the sparseness of the data by varying the bandwidth inversely with the density. This means that a broader bandwidth is used for observations located in regions with low density, and vice versa. Thus, adaptive estimators are able to recover more details of the density where data concentrate because the window width decreases in those regions while it increases in areas of only low data densities. Silverman's (1986, Section 3.4.2) rule of thumb is used to determine the bandwidth of the pilot density estimate in the two-step adaptive kernel estimation. All computations are performed using MATLAB.
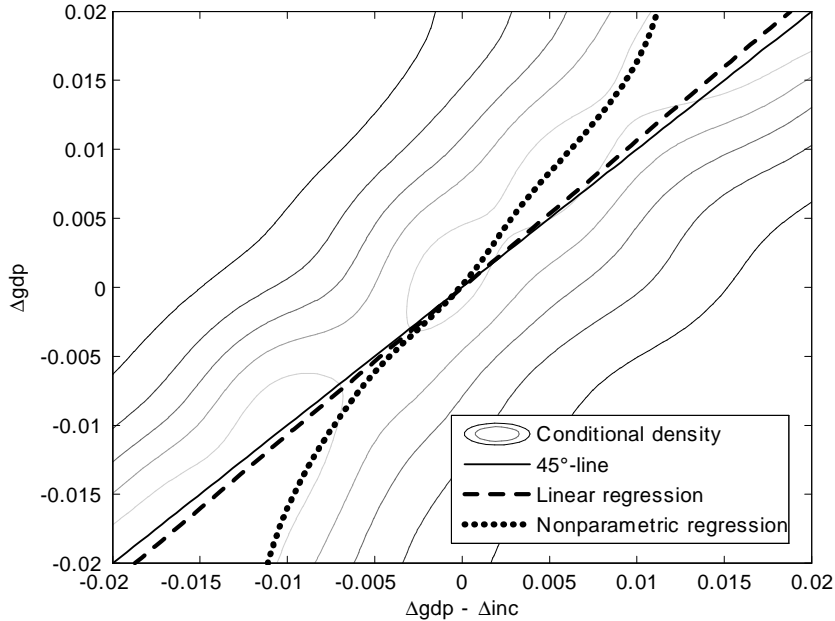
Figure 1: Contour plot of $f(\Delta gdp - \Delta inc | \Delta gdp)$ (capital market smoothing of idiosyncratic output shocks)

Figures 1 and 2 show the contour plots of the surface of the conditional densities $f(\Delta gdp - \Delta inc | \Delta gdp)$ and $f(\Delta inc - \Delta dinc | \Delta gdp)$ which were estimated using pooled data for all years (1897 observations). The thin lines in Figures 1 and 2 connect points at the same density on the three-dimensional graph of the conditional densities (output omitted). The displayed regression lines will be explained later.

To illustrate how to interpret the figures, we can consider the conditional density $f(\Delta gdp - \Delta inc | \Delta gdp)$ as an example (Figure 1). If all mass of this density were concentrated only parallel to the Δgdp axis at a value of 0 for ($\Delta gdp - \Delta inc$), idiosyncratic output shocks would not be insured at all. Such density shape would indicate that given that a region has a certain output shock, there would be a high likelihood that this shock were perfectly transmitted to a change in income of similar magnitude. Risk sharing would be absent because there would be no adjustment in net factor income flows between regions ($\Delta gdp - \Delta inc$) in response to an idiosyncratic output shock Δgdp. In other words, there would be no difference between the change in relative output and the change in relative income, regardless of the size of shocks to output.

In contrast, perfect risk sharing already at the capital market level manifests itself in the kernel if most probability mass were concentrated around the 45°-diagonal. In this case,
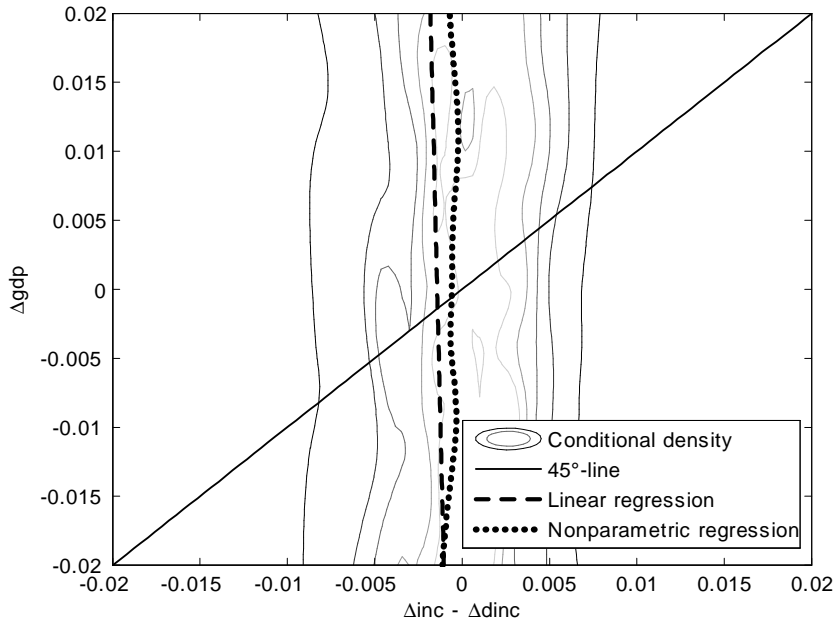
Figure 2: Contour plot of $f(\Delta inc - \Delta dinc | \Delta gdp)$ (federal government smoothing of idiosyncratic output shocks)

relative income would not co-move with relative output. To examine the smoothing effects of the federal government, the shape of the conditional density $f(\Delta inc - \Delta dinc | \Delta gdp)$ as displayed in Figure 2 is interpreted analogously.

Figure 1 provides strong evidence of almost complete risk sharing after capital market smoothing. Most of the mass of the conditional density is concentrated around the main diagonal which indicates that shocks to regional production have no substantial influence on changes in income. This means that shocks to output Δgdp induce a change in factor income flows ($\Delta gdp - \Delta inc$) in the same direction and of similar magnitude. However, the shape of the density also suggests that large positive or negative output shocks are partly transmitted to changes in income.[16] This visual impression will be confirmed below.

By sharp contrast, there is almost no evidence for a smoothing effect of the federal government (Figure 2). Since the mass of the conditional density $f(\Delta inc - \Delta dinc | \Delta gdp)$ is concentrated parallel to the Δgdp axis there is no evidence for an additional insurance effect of the public sector. In other words, shocks to regional output Δgdp do not induce a change in net fiscal transfers ($\Delta inc - \Delta dinc$).

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[16]With (absolutely) large shocks we mean those values of Δgdp which are close to the left or right boundary of the grid interval.

Table 1: OLS estimates of risk sharing channels (percent)

	1996-2002	
Capital markets (β_C)	0.937	(0.007)
Federal government (β_G)	-0.019	(0.005)
Not smoothed (β_U)	0.082[1]	

Percentage of shocks to Gross Domestic Product absorbed at each level of smoothing. Standard errors are in parentheses. Number of observations: 1897.

[1]Calculated as $1 - \beta_C - \beta_G$

In order to test if these strong results are confirmed by a parametric regression analysis, we also estimate the risk sharing regressions (5). If β_C is estimated close to 1 and β_G close to zero (or insignificant), we would obtain a similar pattern of almost complete risk sharing after capital market smoothing and virtually no risk sharing after federal government smoothing.

Indeed, this is the pattern found in the data (see Table 1). While a simple OLS regression yields an estimate of $\beta_C = 0.937$, the estimated coefficient for β_G is found to be negative (-0.019).[17] The results of this estimation indicate that only 8% of idiosyncratic output shocks are not smoothed after both channels of risk sharing. The federal government, however, is found to have a (slight) destabilizing function. Hence, the results of the parametric regression analysis are well in line with our nonparametric density analysis.

The examination of Figure 1 suggests that a parametric regression approach possibly hides important information which could be detected in a nonparametric regression framework. Fortunately, the estimated conditional densities $f(\Delta gdp - \Delta inc|\Delta gdp)$ and $f(\Delta inc - \Delta dinc|\Delta gdp)$ already incorporate a simple nonparametric regression. We simply have to multiply the estimated conditional densities with the grid points at which the density was evaluated.[18]

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[17]Both coefficients are significantly different from zero at the 1% level. Controlling for region-specific fixed-effects in the idiosyncratic growth rates by removing region-specific means from all variables has close to no influence on the estimation results obtained with plain OLS.

[18]The same equi-spaced grid is used on both axis. A deeper nonparametric regression analysis (e.g. local polynomial regression or average derivative estimation) is beyond the scope of this paper. Such analysis could shed more light on the exact nature of the nonlinearities detected with our simple nonparametric

In order to facilitate a comparison of a) the nonparametric conditional density approach, b) the parametric regression approach, and c) the nonparametric regression approach, we display both regression lines in the same graph as the conditional densities.

From Figure 1 it can be seen that the nonparametric regression indeed reveals some nonlinearities which cannot be detected with the linear model. The shape of the nonparametric regression indicates that moderate risks are almost completely insured. However, large positive or negative shocks on the grid interval are partly transmitted to changes in income. This pattern indicates that these risks are harder to insure on the capital market than small risks.

The shape of the conditional density and the nonparametric regression line show the advantage of the nonparametric approach suggested in this paper. As argued by Danny Quah in the context of convergence studies, by focusing on the average behavior of a representative region, a linear regression model potentially suppresses important distributional patterns the researcher is interested in (see the arguments in Quah, 1996a, 1997). Our results suggest that this problem may also apply for interregional risk sharing studies. In our application, the linear regression for capital market smoothing is flatter than the nonparametric regression. Hence, the linear framework overstates the degree of risk sharing for those risks which are measured on the grid interval.

For federal government smoothing (Figure 2), however, the nonparametric regression is not substantially different from the linear regression line.

That much is certain, the most important feature is that both the nonparametric as well as the parametric approach suggest a consistent result concerning short-term interregional risk sharing: While private markets provide almost complete insurance against shocks, the federal government does not contribute to a stabilization of regional incomes. According to the results of our estimation, fiscal transfers in reunified Germany can hardly be justified with reference to a potential stabilizing effect on regional incomes. Such insurance effect cannot be found in the data.

However, as discussed in the Introduction, fiscal transfers are not only intended for stabilization, but mainly for long-term redistribution. We argued that such redistribution can also be interpreted as a kind of risk sharing: Rather than being concerned with the smoothing of idiosyncratic shocks, the public sector can provide a smoothing of permanent heterogeneity among regions. In order to analyze if fiscal transfers achieve a long-term reduction of regional disparities by systematic redistribution of incomes, we analyze the distribution dynamics of relative output, income, and disposable income. In contrast to the short-term risk sharing analysis performed in this section, a long-term analysis of risk

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regression, which is motivated by Quah's distribution dynamics approach.

sharing is concerned with the levels of relative variables rather than their first differences.

4 The long-term redistributive effects of interregional risk sharing

In this section we analyze to what extent the public sector reduces long-term differences in the relative position of a region, reflecting its economic development relative to the national average. In other words, we provide evidence whether long-term differences in relative production are also reflected in long-term differences in income and disposable income. To do so, we adopt the distribution dynamics approach to economic convergence which was proposed by Quah (1997).

In a first step, we estimate a probability model of transitions which captures a distribution's law of motion. This means that we examine how a given individual of the distribution of *gdp*, *inc*, and *dinc* at time t transits to another part of the distribution by the time $t + \tau$. In a second step, we follow recent developments in the growth convergence literature (Johnson, 2000, 2005) and calculate the densities of the implied ergodic distributions on the basis of the estimated distributional dynamics in a continuous framework. As explained below, a comparison of the ergodic densities of *gdp*, *inc* and *dinc* allows one to assess the degree of (level) smoothing achieved by private and fiscal institutions.

4.1 Estimating distribution dynamics and the implied ergodic density

One possibility of estimating transition probabilities is to discretize the state space and then count the observed transitions out of and into distinct discrete cells of a Markov transition probability matrix (Quah, 1993). However, Bulli (2001) has shown that an arbitrary discretization of the state space alters the probabilistic properties of the data. A better approach is to use no discretization but instead to allow the number of cells of the Markov transition probability matrix to tend to infinity (Quah, 1997). In this continuous case, the transition probability 'matrix' becomes a stochastic kernel. Such a kernel is a huge non-negative matrix whose rows sum to unity, satisfying regularity conditions to ensure that a limiting distribution exists (Quah, 2001).

To estimate the transition dynamics of *gdp*, *inc*, and *dinc* in a continuous framework, we suppose that the distribution of a variable x can be described by the density function $f_t(x)$, where x is variously *gdp*, *inc*, and *dinc*.[19] In general, this distribution will evolve over time so that the density prevailing at time $t + \tau$ for $\tau > 0$ is $f_{t+\tau}(x)$. Assuming that the process describing the evolution of the distribution is time-invariant and first-order Markov, the relationship between the two densities can be written as

$$f_{t+\tau}(z) = \int_0^\infty g_\tau(z|x) f_t(x) dx, \tag{6}$$

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[19]This simplified presentation of Quah's (1997) methodology was proposed by Johnson (2000, 2005).

where $g_\tau(z|x)$ is the $\tau-$period ahead density of z conditional on x. For example, z could be relative GDP in 2002 and x the same variable in 1995. The transition probabilities $g_\tau(z|x)$ encode all information about the evolution of the sequence of distributions over time and map the distribution from period t to period $t + \tau$.

Similar to the last section, the stochastic kernel $g_\tau(z|x)$ is a conditional density. However, there is an important difference between the conditional densities $g_\tau(z|x)$ for *gdp*, *inc*, and *dinc* and the conditional densities $f(\Delta gdp - \Delta inc | \Delta gdp)$ and $f(\Delta inc - \Delta dinc | \Delta gdp)$. The former densities map a single variable sequentially in time. This means that the kernel $g_\tau(z|x)$ shows the probability that a given region transits to a certain state of relative GDP (income, disposable income) given that it is in a certain state of relative GDP (income, disposable income) in the starting period.

The estimated transition probability kernel $g_\tau(z|x)$ describes the distribution's law of motion. If one assumes that this law of motion is stable over time, the transition probabilities can be projected further into the future, to calculate the implied stationary (or ergodic) distribution. While actual densities at a given point in time may reflect a (historical) disequilibrium due to structural shocks in the past, the ergodic density shows a future equilibrium in the absence of structural changes. An analysis of the long-term properties of risk sharing is therefore concerned with the ergodic rather than actual point-in-time densities.

Given an estimate for $g_\tau(z|x)$, the implied long-run density $f_\infty(z)$, given that it exists, is the solution to

$$f_\infty(z) = \int_0^\infty g_\tau(z|x) f_\infty(x) dx. \tag{7}$$

We suggest two methods to solve for the ergodic density, $f_\infty(z) = f_\infty(x)$. An intuitive approach is to multiply the transition probability kernel $g_\tau(z|x)$ multiple times by itself until the density has converged, which means, until all rows of the transition probability kernel are equal. Using this iterative procedure, observed transition probabilities are projected further into the future.

The second way is related to an eigenvector and eigenvalue problem. Johnson (2005) has shown that the stationary distribution can be represented as an eigenvector of $g_\tau(z|x)$ corresponding to the eigenvector one.[20] We checked that both approaches yield the same

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[20]For an elaborate presentation of this idea see the webappendix of Johnson (2005), downloadable from `http://irving.vassar.edu/faculty/pj/pj.htm`. The author explains how to solve numerically for $f_\infty(z) = \int_a^b g_\tau(z|x) f_\infty(x) dx$, where a and b define the interval where the density is evaluated. In the numerical implementation, the stochastic transition probability kernel $g_\tau(z|x)$ is estimated as a $p \times p$ matrix Q, where p is the number of grid points at which the conditional density is evaluated. If the largest eigenvalue of this matrix is unity then the Markov chain is ergodic. The left eigenvector ϕ corresponding

result.

Before introducing the economic interpretation of the ergodic densities of *gdp*, *inc*, and *dinc* it is important to note that the limiting distribution is, by construction, independent of initial conditions. This property becomes evident if one recalls that the ergodic density can be calculated by multiplying the distribution's law of motion multiple times by itself. If there are sufficient iterations the influence of the starting positions of particular regions becomes more and more negligible.

Keeping this important property in mind, one can interpret the ergodic density from the perspective of a *single* region. The underlying assumption of the ergodic density is that a single region has moved many times between the states of the Markov chain according to the unchanged law of motion $g_\tau(z|x)$. By construction, the ergodic density shows how often the region realizes the distinct states, asymptotically independent of the starting position of the particular region. This means that for a single region, the ergodic density shows the *likelihood* of certain outcomes.

For example, if the density of the ergodic distribution of one of our relative variables is uni-modal with a peak at 0 (in logs), there is a very high likelihood that a region realizes the average outcome. In other words, such pattern of the ergodic density would imply that in the long run the likelihood is highest that a region *becomes* one with an average outcome.

Besides the number of distinct peaks, one also has to examine the dispersion of the ergodic density. If the dispersion is small it is unlikely that extreme values are realized. By contrast, a large standard deviation indicates a pronounced variation.

A comparison of the implied long-run distributions of relative output, income, and disposable income allows one to assess the extent of smoothing achieved by private and public interregional transfers. One could also say that the ergodic distributions show the 'risk' of becoming a poor or rich region in terms of *gdp*, *inc*, and *dinc*. To illustrate this, consider an extreme case. If regions were not integrated by factor movements and if there were no fiscal transfer system, regions would be completely isolated and there would be no interregional risk sharing. In such a setting, differences in production would be fully mirrored in both, income as well as disposable income. Consequently, the shape of the ergodic densities of *gdp*, *inc*, and *dinc* would be equal. By contrast, if private institutions absorb differences in regional production and if there is significant redistribution of regional incomes by the public sector, the long-run distributions of output, income, and disposable income will differ.

In our methodological framework of distribution dynamics one finds evidence for a

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to this eigenvalue has the property $\phi = Q\phi$ and ϕ is the implied ergodic density.

reduction of disparities achieved by risk sharing if the ergodic density of relative income has smaller dispersion than the ergodic density of relative output. Similarly, the extent of redistribution achieved by the federal government is revealed by the shape of the ergodic density of *dinc* in comparison to *inc*. The former density should have a smaller dispersion than the latter.

If there is a large cross-section of regions, the ergodic densities also have a cross-sectional interpretation. If it is assumed that the distribution of a cross-section of regions has evolved for a very long time according to the unchanged law of motion $g_\tau(z|x)$, the influence of the starting positions of different regions will have vanished. In such a setting, the ergodic density shows the shape of the distribution if past dynamics continue operating unchanged in the future.

For example, suppose that the ergodic density of the relative income variable turns out to be bi-modal; one peak corresponds to a high relative income and the other one to a low income. This pattern would imply that in the long run there are both, relatively rich as well as poor regions in the cross-section. Hence, one would find evidence for the existence of inequality in the long run which usually is referred to as 'convergence clubs'.

4.2 Estimation results

The estimated distribution dynamics of *gdp*, *inc*, and *dinc* are based on one-year transitions taking place between 1995 and 2002. This means that we pool the observed transitions 1995-1996, 1996-1997 and so on. The use of annual transitions instead of longer time intervals is strongly recommended by Quah because taking transition steps with long time intervals instead of annual frequencies is likely to be 'correspondingly noisy, with even fewer observations informing the estimate' (Quah, 2001, p. 308). The sample consists of 1897 observations (271 labor market regions multiplied by 7 observed transitions).

Based on the estimated transition probability kernels $g_\tau(z|x)$ (see equation (6)) we calculate the ergodic densities of regional output, income, and disposable income (see equation (7)).[21] Figure 3 displays the estimation results. All densities have been normalized so that the densities show the likelihood of a realization of *gdp*, *inc*, and *dinc* in the grid interval.

4.2.1 GDP vs. income

Although private markets are not expected to provide substantial insurance against unfavorable initial conditions, it is nevertheless instructive to compare the long-run distributions of output (*gdp*) and income (*inc*). As the literature points out, the capital market

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[21] The transition probability kernels $g_\tau(z|x)$ are conditional densities. To estimate these densities we can use the same econometric toolkit as developed in the last section. Again, we use adaptive kernel techniques.
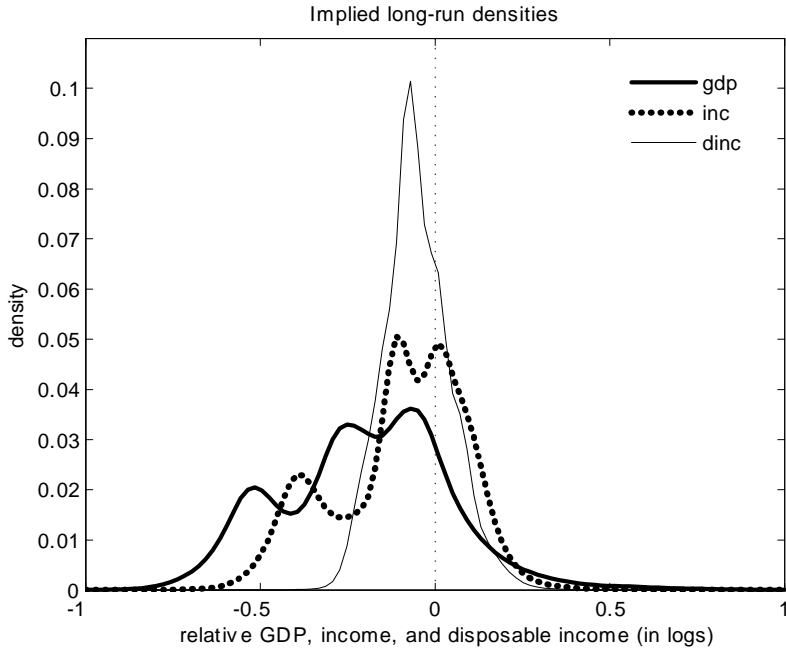
Figure 3: Ergodic densities of relative output, income, and disposable income, calculated on the basis of $g_1(z|x)$ for *gdp*, *inc*, and *dinc* (yearly transitions between 1995-2002)

may provide insurance, not only against transitory, but also against permanent shocks (Becker and Hoffmann, 2006).[22] If stochastic shocks to output and income differ, it is well possible that the long-run distribution of income is smoother than the output distribution. Moreover, convergence in income may be expected to occur faster than convergence in output, because convergence in income can be achieved by trade in financial assets. By contrast, convergence in output requires a flow of productive factors themselves.

Indeed, there is some evidence for these hypotheses. Both densities (*gdp* vs. *inc*) show a three-peaked pattern. However, the peaks of the relative GDP distribution are located at lower values than the peaks of the relative income distribution. For the relative GDP distribution, the peaks correspond to 60%, 78%, and 93% of the German average while they correspond to 67%, 89%, and 101% for the relative income distribution. This means that a single region faces a higher likelihood of realizing a low value of relative production than realizing a low value of relative income. Hence, the shapes of the ergodic densities suggest that in the long run there are fewer differences in regional income than in regional output.

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[22] The methodology suggested in the last section cannot distinguish between transitory and permanent shocks. Such distinction would require a cointegrated VAR framework. Due to the short time-period spanned by our database for reunified Germany, a sophisticated analysis of the persistence of shocks is not possible.

This pattern is consistent with a certain smoothing effect of capital market linkages even if the variables are formulated in levels rather than in first differences as in the last section.

To further illustrate that the income distribution is smoother than the GDP distribution we compare the standard deviations of the two distributions. Since there are no sample observations of the ergodic density, one has to calculate the standard deviation directly from the estimated density. The standard deviation of the relative output distribution is 0.246 while it is 0.190 for the relative income distribution.

Taking a cross-sectional perspective of economic convergence, the multimodal pattern of both *gdp* and *inc* indicates that German labor market regions will not become equal to one another in terms of output or income. Rather, there will be convergence clubs of both regional output and income if the past dynamics of the regional distributions remain unchanged. Since the market does not fully equalize regional income disparities, there can be scope for further income smoothing provided by fiscal redistribution.

4.2.2 Income vs. disposable income

To analyze the long-term redistributive function of fiscal transfers we compare the ergodic densities of income (*inc*) and disposable income (*dinc*).

As can be seen from Figure 3 , the long-run distribution of disposable income is strongly uni-modal with a peak corresponding to 93% percent of the German average. This means that becoming a region with a slightly below-average disposable income is associated with the highest likelihood. Remarkably, in the long run, the probability that a region has a disposable income smaller than about 0.75 times the German average (-0.3 in logs) is effectively zero.

The shape of the ergodic density of *dinc* suggests that German regions do not deviate much from the average disposable income per capita. The figure clearly illustrates that the ergodic distribution of disposable income has considerably smaller dispersion than the income distribution. The standard deviation of the former is 0.098 while it is 0.190 for the latter. These numbers show that the variance reduction achieved by the fiscal transfer system is substantial. About half of the dispersion of the income distribution is smoothed away by the federal government.

For the cross-section of regions we find strong evidence of long-term convergence of disposable income because there are no convergence clubs apparent.[23] The persistent polarization in regional output and income is not transmitted to the long-run distribution of disposable income. This finding implies that fiscal redistribution strongly contributes to an

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[23]The term 'convergence' should not be interpreted as a dynamic catching-up process of poor regions. Rather, 'convergence' of disposable income only refers to a reduction of disparities through systematic redistribution by the public sector.

equalization of incomes among regions in reunified Germany. To put it differently, income smoothing by federal fiscal institutions is necessary to achieve a uni-modal distribution of regional incomes.

On the side of the econometrics, the estimated shape of the densities of the long-run distributions of *gdp*, *inc*, and *dinc* show the advantage of the nonparametric approach proposed in this paper. Obviously, the distribution patterns are non-normal. A standard parametric regression analysis could not detect the long-term polarization outcome in *gdp* and *inc*. Therefore, this paper has shown that Quah's (1997) distribution dynamics approach is not only a powerful framework to analyze GDP convergence or divergence but it is also extremely useful to discriminate between the long-run outcomes of output, income, and disposable income.

5   Discussion

Besides having provided new empirical evidence on interregional risk sharing in reunified Germany, another contribution of this paper is to have introduced new empirical techniques into the risk sharing literature inspired by established techniques originally proposed in the growth econometrics literature. We think that the application of the distribution dynamics approach in a risk sharing framework is an advance in itself and it would be interesting to compare the results for Germany with other countries. In order to point out potential drawbacks and opportunities of the distribution dynamics framework to other researchers, we present a critical discussion of our analysis before we summarize our main results.

One caveat of our analysis is that we did not directly examine the effects of labor mobility on smoothing of GDP shocks. Interregional smoothing of earnings can be the result of commuting across the borders of a region (ASY, 1996) and commuters income may also make up a fraction of the smoothing effect attributed to the capital market. Therefore, it is an important task for future research to incorporate commuter flows in the risk sharing framework, an issue which has gained only minor attention in the literature so far.

Moreover, due to the short time period available for reunified Germany, we did not examine the time-series properties of the data used. For other countries, however, longer time series are available and researchers should carefully examine the persistence the data display. The concept of distribution dynamics is only applicable if the employed *relative* variables are stationary. In other words, if the *absolute* per capita levels of regional output, income, and disposable income are integrated processes, one has to assume that there is a cointegrating relationship between regional variables and the respective national average values with cointegrating vector $(1, -1)$. Only if there is such long-run relationship between regional and aggregate variables, can one interpret the ergodic densities of *relative* variables

also in terms of a cointegrating relationship, as we did in the present paper. By contrast, if the relative data series are integrated processes, an ergodic density in the sense of a long-run equilibrium simply does not exist because a non-stationary series is not ergodic.

Another important aspect is that our analysis does not account for spatial effects. Throughout the present paper the cross-sectional observations on regional output, income, and disposable income were treated as if they represent a random sample, that is, a collection of observations from independent and identically distributed random variables. In reality, however, regional data often display a high degree of spatial autocorrelation as well as various forms of spatial heterogeneity. Unfortunately, there is no study as of today which explores the implications that spatial effects can hold for the application of the continuous variant of the distribution dynamics approach used in this paper.

Of course, there are alternative estimation strategies which could be used to overcome the discussed limitations of the nonparametric distribution dynamics approach. For example, there are both panel data and time-series models that can account for spatial interdependence. The advantage of the approach pursued in the present paper comes about if the distribution is not single-peaked and high moments have to be estimated for proper inference. We fully agree with Rey and Dev's (2006) call that 'a fruitful avenue of future research is adopting a perspective where the outputs from the spatial econometric analysis become inputs into a higher order study in which the dynamics of both the income distribution and the level of spatial clustering are treated jointly'. The methodological issues on spatial regional income convergence examined in Rey (2001), Egger and Pfaffermayr (2006), and Rey and Dev (2006) can have relevance for the study of interregional risk sharing, especially the recent developments in the analysis of spatial σ-convergence. The cited studies may serve as a starting point to develop a unified modelling strategy for spatial dependence and the dynamics of the whole income distribution.

However, before adopting spatial econometric techniques to the issue of risk sharing, researchers should extend existing theoretical models to directly incorporate spatial linkages of capital, federal government, and credit market smoothing, so that testable empirical implications can be derived from a sound theoretical basis. In growth theory, the connection between spatial econometric techniques and theoretical (structural) models including spatial linkages is beginning to attract increased attention (see for example Fingleton and López-Bazo, 2006). For the issue of risk sharing, we leave these interesting tasks to future research.

6 Conclusion

This paper focused on two related questions: First, to what extent do private institutions and the public sector provide insurance against idiosyncratic output shocks to individual

regions? Second, to what extent do private institutions and the public sector reduce long-term differences in the relative position of a region reflecting its economic development relative to the national average?

It is unnecessary to emphasize that the aim of this study was not to draw conclusions about whether the existing federal transfer system redistributes too much or too little. Moreover, it is beyond the scope of this paper to analyze any negative incentive effects that can result from the fiscal transfer system. Instead, we were only interested in analyzing the stabilizing effects and predicting the long-term redistributive effects of fiscal transfers in reunified Germany.

Our empirical results suggest that private factor income flows provide almost complete insurance against region-specific shocks. A co-movement of income and output is only found for high and low idiosyncratic output risk. This pattern could not be detected within a linear regression approach which, in our application, tends to overstate the degree of insurance provided by private markets.

By sharp contrast, the federal government channel is not found to have a stabilizing effect on regional incomes. Rather than providing insurance against idiosyncratic shocks, fiscal transfers in reunified Germany are mainly concerned with redistribution in favor of depressed regions. The fiscal transfer system achieves a substantial reduction of long-term disparities between regions. If past distribution dynamics continue operating unchanged in the future, a uni-modal distribution of regional incomes will not be achieved without redistribution by the public sector. These findings imply that the public sector provides insurance against that type of risk which cannot be completely insured on private markets: The risk of being a permanently poor region.

Our paper shows that the patterns of short-term risk sharing (smoothing of shocks) and long-term redistribution of the public sector (smoothing of differences in levels) can differ substantially. Under the current law in Germany, it is hard to argue that short-term risk sharing is the main justification of the federal transfer mechanism. Though, previous studies on interregional risk sharing argue that even a redistributive policy may turn out to have stabilizing effects. In the US, 13 percent of shocks to gross state product are smoothed by the federal government (ASY, 1996). Using a similar approach as ASY (1996) to estimate the smoothing of state-specific shocks to West German states from 1970 to 1997, Buettner (2002) finds that the share of shocks to state income absorbed by fiscal flows is roughly at the same level as in the US. In reunified Germany, however, stabilization is not a by-product of fiscal redistribution at all, at least at the disaggregated regional level used in this paper.

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