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ABSTRACT

Risk Sharing and Commuting Among US Federal States[*]

Financial markets provide imperfect insurance of labor income risk. However, workers can partly insure against labor market risk by commuting to adjacent regions. Since commuters own wage claims to output produced in adjacent regions, the business cycle in the neighborhood becomes a relevant risk factor at the regional level. In our empirical analysis for US states, we show this effect to be important. State-specific consumption comoves with business cycle shocks that hit adjacent states, in particular if a state is integrated by commuter flows. This labor market perspective on regional risk sharing complements previous studies that investigated risk sharing through financial markets.

JEL Classification: E21, C33, R20

Keywords: risk sharing, consumption smoothing, commuting, labor market risk

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1 Introduction

One key prediction of the neoclassical business cycle model is that idiosyncratic output fluctuations should not fully transmit into income or consumption fluctuations. In fact, if there exists a full set of insurance markets, one for each commodity contingent on each state of the world, households can fully insulate their consumption from idiosyncratic output shocks. This empirical prediction of the neoclassical model under complete markets has been tested using microeconomic data, see e.g. Mace (1991), Cochrane (1991), or Townsend (1994). Aggregate data has been used to examine the international and interregional versions of the "risk sharing" prediction.[1]

A general insight of both approaches is that observed levels of risk sharing fall short of the theoretical prediction under complete markets. This fact may reflect that the model of an economy with a complete set of insurance markets is an abstract idealization. Indeed, the major source of uncertainty originates in human capital and human capital is an asset for which private financial insurance opportunities are almost non-existent, see Drèze and Gollier (1993). Hedging human capital risk would involve a substantial short position in those assets which can be traded on financial markets as Baxter and Jermann (1997) show. It is therefore an important question, whether there are partial substitutes for missing financial insurance markets covering human capital.

Even if *financial* insurance opportunities are non-existent, one option for a household to smooth labor income is to rent out his human capital *physically* into other regions. Plainly speaking, this option is to change ones place of work in response to regional business cycles. In principle, extensive interregional migration, responding to the slightest output shock, would quickly even out small changes in per capita GDP. However, migration is costly. Agents may therefore try to smooth income and consumption by deciding to commute, which is considerably cheaper than migration.

Commuters hold wage claims to output produced outside their place of residence. This separation facilitates risk sharing. For instance, if household members are working in different geographical labor markets, household-level labor market risk is diversified to some extent. An alternative example is that workers commute to adjacent labor markets in response to business cycle shocks that hit their home region. In a nutshell, commuting provides regional risk sharing, because regional output and consumption growth become

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[1] See e.g. Obstfeld (1994), Asdrubali, Sørensen, and Yosha (1996), Sørensen and Yosha (1998), Kalemli-Ozcan, Sørensen and Yosha (2003), and Becker and Hoffmann (2006). In line with this macroeconomic literature, we will use the terms "risk sharing" and "smoothing" interchangeably, meaning any economic activity to disentangle consumption and output, like ex-ante portfolio diversification ("capital market risk sharing") and ex-post adjustment of savings behavior ("credit market risk sharing"), see e.g. Asdrubali, Sørensen, and Yosha (1996).

separated through commuter's income.[2]

Our contribution to the existing literature on regional risk sharing through financial markets is to add a labor market perspective. We run similar regressions that have been used to measure risk sharing through financial markets (see e.g. Asdrubali, Sørensen, and Yosha, 1996), but additionally take into account the effects of commuting on the covariation between regional output and consumption. By definition, commuters do not work in the region they reside in, which means that commuters own wage claims to the output produced elsewhere. Therefore, their income and consumption are related to the business cycle in the neighborhood rather than to the business cycle at their place of residence. At the regional level, this spatial dependency implies that the business cycle at home is not the only idiosyncratic risk factor a region is exposed to. In the presence of commuting, the business cycle in the neighborhood becomes an additional risk factor that drives region-specific consumption.

These considerations, which we elaborate more on in Section 2, motivate us to consider a modification of Asdrubali, Sørensen, and Yosha's (1996) approach to measure risk sharing among regions. In our empirical specification, we allow state-specific consumption to vary with two rather than one risk factors. In our analysis for US federal states it turns out that the business cycle in the neighborhood is an important risk factor for consumption that has been overlooked in previous studies. We are also able to provide evidence that commuter flows correlate with this spatial comovement.

The paper is organized as follows. To fix ideas we provide a brief discussion of the relation between regional risk sharing and commuting in Section 2. In this section we formulate empirical hypotheses which are tested in the remainder of the paper. The data is introduced in Section 3. Section 4 motivates our analysis by illustrating that standard risk sharing regressions yield different estimation results at different levels of regional aggregation. This pattern is consistent with the fact that these regressions neglect commuting linkages. In Section 5, we augment the empirical model by allowing state-specific consumption to vary with the business cycle in the neighborhood. We examine this spatial comovement in terms of commuting linkages in Section 6. The last section concludes the paper.

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[2] The only paper we are aware of which addresses the issue of regional risk sharing and commuting is Borge and Matsen (2004). In their risk sharing study for Norway, Borge and Matsen (2004) attempt to control for the effects of commuting by using data at different levels of regional aggregation. We provide a similar experiment in Section 4. However, Borge and Matsen (2004) do not introduce explicit data on commuting linkages as we do.

2 Theoretical considerations

One way to measure regional income risk sharing is a regression of region-specific (idiosyncratic) income growth rates on region-specific output changes, see e.g. Demyanyk, Ostergaard, and Sørensen (2007). Under full income risk sharing, idiosyncratic income does not comove with idiosyncratic output shocks. Ultimately, however, agents care about a smooth stream of intertemporal *consumption*. The overall amount of consumption risk sharing that is achieved after all levels of smoothing is revealed by a regression of idiosyncratic consumption growth rates on idiosyncratic output fluctuations. If output risk is fully diversified, consumption moves one-to-one with aggregate consumption, whilst being independent of idiosyncratic risk factors, such as region-specific output shocks.

These empirical implications are derived from models that highlight the role of financial claims to income derived from various forms of capital. However, financial markets provide little hedging of wage income, since human capital is nontradable. In consequence, a household may be induced to smooth shocks to the productivity of his home region by deciding to rent out his human capital *physically* into other regions. Changing ones place of work by commuting to an adjacent region is one important way of doing so.

To illustrate the relation between risk sharing measured at the regional level and commuting, we consider two regions, region i and an adjacent region j. Productivity across regions is imperfectly correlated. We first consider an extreme scenario in which there are no financial markets and there is no mobility of labor. In this scenario, there is no regional risk sharing at all and we will, therefore, observe a perfect comovement of region i's income, consumption, and output (the same holds for region j). Now we assume that some workers living in region j decide to work in region i. Thus region i experiences in-commuting from region j.

How does in-commuting affect the covariation between idiosyncratic output, income, and consumption in region i?[3] Region i's output movements no longer translate fully into changes in region i's income and consumption, because workers, who commute from the adjacent region j to region i, bear a part of region i's output risk. Effectively, commuters export a part of region i's output risk to their place of residence in region j by owning wage claims to region i's risky output. At the same time, however, commuting also goes into the other direction, i.e. some workers living in region i will own wage claims to region j's output. Before discussing these effects in more detail, we can formulate a first, general, hypothesis, which refers to the simple fact that commuting is a more important phenomenon the smaller we define regions. In turn, this implies that *ignoring* commuting in

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[3] It should be emphasized that this study investigates the relation between risk sharing and commuting measured at the level of *regions*, not at the individual or household level.

the empirical analysis altogether should have different effects at different levels of regional aggregation.

Hypothesis 1 Standard risk sharing regressions yield different estimation results at different levels of regional aggregation, since commuting is more important the smaller the regional entities are.

As a motivating experiment, we provide a test of Hypothesis 1 by estimating risk sharing regressions for 48 US federal states as well as for 8 BEA Regions.[4] Using explicit data on commuting, we can provide a more direct test of the effects we are after. If region i experiences in-commuting from the adjacent region j, a part of region i's output risk is exported to the neighborhood by commuters holding wage claims to region i's risky output. From the perspective of region i, this effect can be summarized as follows.

Hypothesis 2 Commuting helps to smooth state-specific income and consumption, because state-specific income and output growth become separated through commuters' income.

Of course, commuting goes into both directions, which means that some workers living in region i will decide to work in the adjacent region j. These workers receive and spend their labor incomes at their place of residence in region i, while they contribute to the output produced in region j. Effectively, commuters import the business cycle risk of the adjacent region to the region in which they reside. From the perspective of region i, this implies that aggregate income and consumption will vary with the business cycle in region j.

In reality, there are more than two regions and workers cannot commute to every region likewise. This fact implies that human capital risk and with it income flows derived from labor cannot be diversified all over the country as perfect risk sharing would suggest. Rather, labor income flows between regions will be "biased" towards the neighborhood, in a sense that workers hold a disproportionately high fraction of claims to the output produced in adjacent regions. Consequently, region-specific aggregate variables will comove with output changes in neighboring regions. We will seek empirical evidence for this effect, which is summarized by the following hypothesis.[5]

Hypothesis 3 State-specific income and consumption comove with output fluctuations in adjacent states, as commuters own wage claims to the output produced in the

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[4] Since there is neither data on production nor on consumption at the county level, we cannot analyze risk sharing at finer levels of regional aggregation.

[5] Note that we are not refering to a spatial correlation in *output* across regions, which could be due to production externalities or various forms of linkages other than risk sharing. Hypothesis 3 refers to the relation between neighbor-specific output changes and state-specific income and consumption changes (not between neighbor-specific *output* and state-specific *output*).

neighborhood.

How do our hypotheses relate to the standard approach to measure regional risk sharing? The standard approach is solely concerned with the covariation between region-specific aggregates, i.e. only state-specific output shocks are assumed to drive income and consumption. Typically, the wedges between regional aggregate variables (such as output, income, and consumption) are attributed to financial markets (and fiscal redistribution). Our previous discussion suggests that these wedges actually reflect *combined* effects of financial markets and commuting linkages. Moreover, standard risk sharing regressions neglect one potentially relevant risk factor—the business cycle in the neighborhood.

3 Data and notation

The state-level data used in the analysis is the data constructed by Asdrubali, Sørensen, and Yosha (1996), but for an extended period of time. We employ annual data on Gross State Product (GSP), state-level personal income, and state consumption during the period 1970-1998.[6] All data is deflated by the common consumer price deflator. Since we prefer a consistent concept of neighbors in our spatial analysis, we exclude Hawai, Alaska, and D.C. and focus on the 48 continental federal states.

Data on GSP is provided by the Bureau of Economic Analysis (BEA). GSP is defined as the value added of the industries of a state and is thus measured at the place of work. By contrast, state-level personal income is measured at the place of residence and consists of the sum of earnings (wages and proprietors‘ income) and distributed profits (including interest and rent) of residents of the state.

Since data on actual private consumption at the state level is not available, Asdrubali, Sørensen, and Yosha (1996) use per capita annual retail sales, by state, as a proxy for per capita private state consumption. Retail sales are then rescaled by the ratio of total private consumption to total US retail sales.

Consumption per capita in federal state k in period t is denoted by C_t^k and the US-wide per capita consumption is C_t^*. Lower-case letters denote logarithms, so that Δc_t^k is the growth rate of consumption. Similarly, the growth rates of income and GSP are Δy_t^k and Δx_t^k, respectively.

Throughout the paper we will work with idiosyncratic (state-specific) growth rates,

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[6] While this data is available for the period 1963-1998, data on interstate commuter flows is not available before 1970. We therefore have to restrict the analysis to the period 1970-1998.

which are defined as

$$\begin{aligned}
\Delta\tilde{c}_t^k &= \Delta c_t^k - \Delta c_t^* \quad \text{(consumption)}\\
\Delta\tilde{y}_t^k &= \Delta y_t^k - \Delta y_t^* \quad \text{(income)}\\
\Delta\tilde{x}_t^k &= \Delta x_t^k - \Delta x_t^* \quad \text{(output).}
\end{aligned}$$

Removing US-wide aggregate growth rates is crucial for the analysis of risk sharing, because aggregate shocks cannot be diversified.

In the estimations, we quantify by how much state-specific income and consumption growth vary with state-specific output shocks. Moreover, we examine whether the business cycle in adjacent states is a driving force for state-specific consumption. To quantify this spatial comovement, we need to measure, for each state, the average output fluctuation in the neighborhood.

Output per capita in the neighborhood of state k in period t is denoted by Z_t^k. This variable is calculated as

$$Z_t^k = \frac{\sum_{m \epsilon N_k} \text{output}_m}{\sum_{n \epsilon N_k} \text{population}_n} = \frac{\mathbf{W} \cdot \mathbf{out}_t}{\mathbf{W} \cdot \mathbf{pop}_t}, \tag{1}$$

where N_k comprises all neighbors to state k, $\mathbf{W}$ is a 48×48 binary contiguity matrix, and $\mathbf{out}_t$ and $\mathbf{pop}_t$ are stacked vectors of output and population, respectively.

The symmetric matrix $\mathbf{W}$ contains the binary contiguity relationships among states. This means that in the matrix $\mathbf{W}$ values of unity are placed in positions i, j, where j indicates states that have borders touching state i. Thus $\mathbf{W}$ has entries of zeros for non-neighbors and ones for neighbors, with zeros on the main diagonal. Pre-multipyling the stacked vectors of output and population by matrix $\mathbf{W}$ yields Z_t^k.

We experimented with several procedures to construct $\mathbf{W}$ and it turned out that our results are not very sensitive to the particular choice for $\mathbf{W}$.[7] To illustrate the sparsity of $\mathbf{W}$, Table 1 displays some summary statistics for the number of neighbors according to our choice for $\mathbf{W}$. States in the center of the US, such as Missouri or Tennesse, have up to eight neighbors, while other states, such as Washington or Florida, have only two

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[7] The entries of $\mathbf{W}$ can be determined on the basis of polygon centroid coordinates using a procedure called Voronoi tesselation, see Anselin (1988). An alternative procedure is to find a given number of nearest neighbors to each state. A third possibility is to use a map and to construct $\mathbf{W}$ by hand. The estimations reported in the paper are obtained using a neighborhood matrix $\mathbf{W}$ that was generated using polygon centroid coordinates. We found it prudent to compare this matrix to a map and we verified that the neighboring relations are indeed reasonable.

Table 1: Descriptive statistics

	Mean	**Std. Dev.**	**Min.**	**Max.**
Number of neighbors in **W**	4.46	1.60	1	8
In-commuter rate IN^k_{1970}	.0236	.0210	.0006	.0970
Out-commuter rate OUT^k_{1970}	.0256	.0295	.0005	.1320
In-commuter rate IN^k_{1980}	.0282	.0221	.0023	.1055
Out-commuter rate OUT^k_{1980}	.0292	.0278	.0027	.1356
In-commuter rate IN^k_{1990}	.0317	.0261	.0021	.1293
Out-commuter rate OUT^k_{1990}	.0343	.0345	.0020	.1757
In-commuter rate IN^k_{2000}	.0357	.0289	.0026	.1509
Out-commuter rate OUT^k_{2000}	.0389	.0364	.0028	.1634

Notes: Matrix **W** contains the binary contiguity relationships among states. Thus **W** has entries of zeros for non-neighbors and ones for neighbors, with zeros on the main diagonal. The baseline data for commuter rates is the total number of workers commuting between counties of residence and counties of work in 1970, 1980, 1990, and 2000. This data is derived from the Census Bureau decennial censuses (US Census Bureau, Population Division, Journey-To-Work and Migration Statistics Branch). The Census Bureau estimates commuting patterns from two questions: "Where do you live?" and "Where did you work last week?". Given this information, the Census estimates the number of persons working in a county by county where they reside and the number of persons living in a county by county where they work. We have aggregated the bilateral county-level commuter flows to the state level. Only commuting among the 48 continental federal states has been considered. The variable IN^k_t denotes commuting from other states to state k, relative to state k's employment. The variable OUT^k_t denotes the out-commuter rate for state k.

neighbors. The average state has between 4 and 5 neighbors.

With Z_t^k given by (1), idiosyncratic output growth in the neighborhood of state k is calculated as

$$\Delta \tilde{z}_t^k = \Delta z_t^k - \Delta x_t^*.$$

State- and neighbor-specific output shocks are positively correlated, but the correlation coefficient between $\Delta \tilde{x}_t^k$ and $\Delta \tilde{z}_t^k$ is with 0.544 not too high. Since our data set is fairly large, we can thus separate the impact of both risk factors in our estimations.

The key question of our analysis is whether risk sharing depends on the extent of commuting linkages between states. Unfortunately, consecutive time-series data on commuter flows between US states is not available. The only data that is available are special tabulations from the decennial Censuses of 1970, 1980, 1990, and 2000, which show bilateral commuter flows between counties, i.e. the total number of workers commuting between counties of residence and counties of work.[8] We aggregate the county data to the federal-state level and calculate commuter flows into and out of each state. In the aggregation, we only consider commuting among the 48 continental states, i.e. we exclude commuters from and to foreign countries and workers at sea. Commuter flows are then normalized by state-level employment in order to determine commuter rates. We denote the in-commuter rate for federal state k at time t by IN_t^k, and OUT_t^k denotes the out-commuter rate ($t = 1970, 1980, 1990, 2000$).

Table 1 reports descriptive statistics for commuter rates. It can be seen that commuting has become more important over time. In 2000, the mean values of commuter rates indicate that more than 3.5% of workers do not reside in the state they work in.

4 Risk sharing among states and BEA regions

We quantify deviations from perfect income and consumption risk sharing using panel data regressions:

$$\Delta \tilde{y}_t^k = \mu_K^k + \beta_K \Delta \tilde{x}_t^k + \varepsilon_{K,t}^k \tag{2}$$

$$\Delta \tilde{c}_t^k = \mu_U^k + \beta_U \Delta \tilde{x}_t^k + \varepsilon_{U,t}^k . \tag{3}$$

Regression (2) measures interstate income risk sharing. Risk is shared if state-level income reacts less than one-to-one to idiosyncratic shocks to output ($\beta_K < 1$). We refer to $(1 - \beta_K) \cdot 100\%$ as the percentage of risk shared at the income smoothing level. Long-lasting differences in growth performances across states are controlled for by including state fixed-effects, μ_K^k and μ_U^k. In regression (3), $(1 - \beta_U) \cdot 100\%$ measures the overall amount of

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[8] See `http://www.census.gov/population/www/socdemo/journey.html`. The data can be downloaded from `http://www.bea.gov/bea/regional/reis/jtw/default.cfm`.

consumption risk sharing that is achieved after all levels of smoothing. Regressions like (2) and (3) are often interpreted to measure the amounts of risk sharing provided by capital and credit markets. The discussion in Section 2 suggests that such regressions actually reflect the *combined* smoothing effects provided by financial markets and labor markets, i.e. commuting.

To motivate our subsequent analysis, we estimate regressions (2) and (3) for 48 US federal states and 8 BEA regions, where the data for BEA regions is aggregated from the state-level data. The moderate aim of this exercise is to examine whether risk sharing differs between states and BEA regions when commuting linkages between states are ignored, see Hypothesis 1.

As discussed by Asdrubali, Sørensen, and Yosha (1996) and Demyanyk, Ostergaard, and Sørensen (2007), simple OLS estimations of equations (2) and (3) are likely to suffer from problems of heteroscedasticity because small states typically have higher residual variance than large states. We therefore follow their suggestion and estimate equations (2) and (3) using a two-step Generalized Least Squares (GLS) procedure.[9]

The estimation results are reported in Table 2. We find that states and regions do not differ significantly with respect to the degree of income risk sharing they achieve. About $100\% - 53\% = 47$ percent of output risk is laid off at the income smoothing level. This magnitude for income risk sharing is similar to what has been reported in previous studies for the US, see e.g. Demyanyk, Ostergaard, and Sørensen (2007).

There is, however, a pronounced difference in the total amount of consumption risk sharing that is achieved. For states, we find that only 22.08 percent of output risk remains unsmoothed after all levels of smoothing. For BEA regions, the point estimate is with $\beta_U = 42.93$ about twice that large. Thus states tend to achieve a higher degree of consumption risk sharing than BEA regions.

A candidate explanation for this difference is that the analysis at the federal-state level does not take into account all relevant risk factors a state is exposed to. If states are integrated by commuter flows, state-level consumption varies not only with state-specific shocks to output, but also with output changes in adjacent states, see Hypothesis 3. Since the analysis at the state-level does not take the business cycle in the neighborhood into account, regression (3) tends to over-estimate the effective degree to which state-specific consumption is separated from output risk. The regression only measures by how much consumption depends on state-specific output shocks. In the presence of commuting, however, also output fluctuations in the neighborhood are a driving force for state-level

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[9] The first step is a panel Ordinary Least Squares (OLS) estimation. From the residuals we estimate the variance of the error terms in the regression assuming that it varies by state. In the second step the variables for each state are weighted by the estimated standard error for the state.

Table 2: Income and consumption risk sharing among 48 federal states and 8 BEA regions

	48 Federal States		**8 BEA Regions**	
1970-1986	*Coeff.*	*Std. err.*	*Coeff.*	*Std. err.*
Income risk sharing (β_K)	52.88	(1.11)**	55.86	(2.28)**
Consumption risk sharing (β_U)	22.08	(3.07)**	42.93	(5.16)**

Note: Results are from the following GLS regressions:

$$\Delta \tilde{y}_t^k = \mu_K^k + \beta_K \Delta \tilde{x}_t^k + \varepsilon_{K,t}^k$$
$$\Delta \tilde{c}_t^k = \mu_U^k + \beta_U \Delta \tilde{x}_t^k + \varepsilon_{U,t}^k.$$

Δx_t^k is the growth rate of output per capita in state k in period t, and $\Delta \tilde{x}_t^k$ is Δx_t^k minus the US-wide output growth rate. $\Delta \tilde{y}_t^k$ and $\Delta \tilde{c}_t^k$ are defined similarly using state-level income and consumption. Fixed-effects are denoted by μ_K^k and μ_U^k. The method of estimation is a two-step Generalized Least Squares (GLS) procedure. The first step is a panel Ordinary Least Squares (OLS) estimation. From the residuals of this regression the variance of the error terms is estimated assuming that it varies by state. In the second step the variables for each state are weighted by the estimated standard error for that state. Alaska, District of Columbia, and Hawai are excluded. Coefficients and standard errors (in parentheses) are multiplied by 100. The number of observations is 1392 for the state-level analysis and 232 for the BEA-level analysis. $^{**},^{*}$ denotes significance at the 5 and 10 percent levels, respectively.

consumption.

If we use regressions like (2) and (3) to measure risk sharing among BEA regions, by contrast, we measure risk sharing among regional entities that are quite independent in terms of labor mobility. Or to put it differently, aggregate data for BEA regions already comprises the relevant neighborhood. Consequently, the observed differences between states and regions may stem from the fact that there is not much commuting between BEA regions, while commuting between states is important.[10]

The differences between states and BEA regions are more pronounced for consumption than for income risk sharing, see Table 2. This empirical observation can be rationalized by the fact that income data, by construction, only comprises realized components of income, while consumption data additionally reflects those returns to assets that are dominated by yet-to-be-realized gains, see Sørensen et al. (2007, p. 589) for a related argument. The option to commute *is* such an asset. To illustrate this with an example, we can assume that the neighborhood experiences a boom. Then the option to commute to the neighborhood increases in value and workers can borrow in the short term in anticipation of higher labor incomes. Higher incomes can actually be realized by taking the option to commute. Thus forward-looking agents may adjust their consumption even before the boom in the neighborhood manifests itself in higher (realized) incomes.

5 Incorporating the neighborhood

We now test Hypothesis 3, which states that state-specific consumption growth varies with the business cycle in the neighborhood. Thereafter, we examine this spatial comovement in terms of commuting linkages between states.

The evidence presented in the last section has revealed that the effects we are after should show up more strongly in the consumption than in the income risk sharing channel. For this reason, we restrict ourselves to the analysis of consumption risk sharing in the following. The augmented consumption risk sharing regression we estimate reads as

$$\Delta \tilde{c}_t^k = \mu_U^k + \beta_U \Delta \tilde{x}_t^k + \gamma_U \Delta \tilde{z}_t^k + \varepsilon_{U,t}^k. \tag{4}$$

The difference to our previous regression (3) is that idiosyncratic consumption growth is

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[10] A similar interpretation has been offered by Borge and Matsen (2004). They estimate a set of risk sharing regressions for 19 Norwegian counties and 5 regions, respectively. At the county level, they find a very high estimate for income risk sharing in the order of 80 percent. In their long-run regressions, this coefficient is much lower at the level of regions. These results lead them to conjecture that commuting may be an important part of the high estimate for income risk sharing at lower levels of regional aggregation. A different but related explanation is provided by Kalemli-Ozcan, Sørensen and Yosha (2003). They show that better insurance of production risk entails higher specialization in production. Since large regions are less specialized, the amount of risk sharing and the size of regions may be inversely related.

Table 3: Consumption risk sharing and spatial comovement

Consumption risk sharing, 1970-1998, 48 US federal states

	Baseline		**Spatial Comovement**	
	Coeff.	*Std. err.*	*Coeff.*	*Std. err.*
$\Delta\tilde{x}_t^k$ (state-specific shock)	22.08	$(3.07)^{**}$	13.21	$(3.79)^{**}$
$\Delta\tilde{z}_t^k$ (neighbor-specific shock)	—	—	19.48	$(5.04)^{**}$

Notes: Results are from the following GLS regression:

$$\Delta\tilde{c}_t^k = \mu_U^k + \beta_U \Delta\tilde{x}_t^k + \gamma_U \Delta\tilde{z}_t^k + \varepsilon_{U,t}^k.$$

The table displays the coefficients β_U and γ_U. Δx_t^k is the growth rate of output per capita in state k in period t, and $\Delta\tilde{x}_t^k$ is Δx_t^k minus the US-wide output growth rate. $\Delta\tilde{c}_t^k$ is defined similarly using state-level consumption. $\Delta\tilde{z}_t^k$ denotes the average idiosyncratic output shock that hits adjacent states to state k at time t. μ_U^k denotes state fixed effects. Estimation is carried out using GLS. Alaska, District of Columbia, and Hawai are excluded. For further details see the notes to Table 2 and the main text. Coefficients and standard errors (in parentheses) are multiplied by 100. Number of observations is 1392. **,* denotes significance at the 5 and 10 percent levels, respectively.

allowed to vary with two rather than one kind of output risk. Besides state-specific output shocks, $\Delta\tilde{x}_t^k$, also output shocks that hit the neighborhood, $\Delta\tilde{z}_t^k$, are accounted for. The γ_U-coefficient measures how strongly state-specific consumption growth is influenced by output shocks that hit the neighborhood.[11]

Table 3 summarizes the estimation results obtained using GLS. The column labeled "Baseline" displays the results for a benchmark specification, in which the spatial co-

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[11] In an alternative specification, we build on Demyanyk, Ostergaard, and Sørensen (2007) in controlling for the effects of US banking deregulation on risk sharing. During the 1980s, states relaxed restrictions on intrastate and interstate banking, i.e. statewide branching by mergers and aquisitions and entry by out-of-state bank holding companies was permitted. From Demyanyk, Ostergaard, and Sørensen (2007) we know that these structural changes in the banking industry had a considerable effect on the level of interstate income risk sharing. To control for this effect, we followed Demyanyk, Ostergaard, and Sørensen (2007) and interacted the risk sharing coefficients using a dummy variable that becomes one from the year in which both interstate and intrastate deregulation took place. It turned out that these interaction terms have almost no influence on the estimate for γ_U, which is the coefficient we are primarily interested in.

movement is omitted, $\gamma_U = 0$. Only 22.08 percent of state-specific output risk remains unsmoothed. This magnitude for β_U is similar to estimates reported in previous studies which examine consumption risk sharing among all 51 federal states. For instance, Asdrubali, Sørensen, and Yosha (1996) find that about 25 percent of shocks to GSP remain unsmoothed after all levels of smoothing during the period 1963-1990.

From the column labeled "Spatial Comovement" it can be seen that consumption is highly dependent on the business cycle in the neighborhood. A substantial amount of 19.48 percent of business cycle fluctuations in the neighborhood is transmitted to state-specific consumption. At the same time, accounting for $\Delta\tilde{z}_t^k$ has reduced the point estimate for β_U substantially (from 22.08 to 13.21). Apparently, the additional risk factor has reclassified an important part of the variance of consumption growth from state-specific to neighbor-specific output fluctuations.

These results help us to understand why we observed different amounts of consumption risk sharing at the state- and BEA-level, see Table 2. In equation (3), the neighborhood is excluded from the analysis, while the augmented regression (4) has revealed that the business cycle in the neighborhood is in fact an important risk factor. We now corroborate our economic interpretation that commuter flows are an explanation for the observed dependency on the neighborhood.

6 Accounting for commuter flows

Our general strategy to corroborate our economic interpretation is to allow for heterogeneity in the risk sharing coefficients by interacting them with data on commuter flows. Though we face the problem that there is no consecutive time-series data on commuter flows between US states. The fact that we only have cross-sectional data for 1970, 1980, 1990, and 2000 limits the scope of our analysis. While this data allows us to control for cross-sectional variation in commuting patterns, we can only imperfectly account for variation in commuting patterns over time. Keeping this limitation in mind, we first consider a specification that highlights cross-sectional variation in commuter rates. Thereafter, we attempt to exploit the limited information on time variation by using use spline interpolation techniques to generate a consecutive time-series on commuter rates.

In- and out-commuting have different effects on the pattern of regional risk sharing. The spatial comovement that we have documented in the last section is expected to be driven by workers who commute out of a state, see Hypothesis 3. By contrast, the degree to which commuting drives a wedge between state-specific consumption and state-specific output growth should increase with the extent of in-commuting, see Hypothesis 2. Consequently, we interact the spatial regressor, $\Delta\tilde{z}_t^k$, with the average out-commuter rate, $\overline{OUT}^k$, and use the average in-commuter rate, $\overline{IN}^k$, to parametrize the influence of state-specific output risk, $\Delta\tilde{x}_t^k$:

$$\Delta\tilde{c}_t^k = \mu_U^k + \nu_{U,t} + \beta_U^0 \cdot \Delta\tilde{x}_t^k + \beta_U^1 \left(\overline{IN}^k \cdot \Delta\tilde{x}_t^k\right) + \gamma_U^0 \cdot \Delta\tilde{z}_t^k + \gamma_U^1 \left(\overline{OUT}^k \cdot \Delta\tilde{z}_t^k\right) + \varepsilon_{U,t}^k.$$

Although all variables are already formulated relative to their US-wide counterparts, we additionally include time effects, $\nu_{U,t}$, since they may have an influence if interaction terms are included in the regressions. In an alternative specification, we replace time-averaged commuter rates, $\overline{IN}^k$ and $\overline{OUT}^k$, by spline interpolated commuter rates, IN_t^k and OUT_t^k.[12] While the former specification is more robust given the data limitations, the pure cross-sectional variation in commuting patterns may correlate with many other factors which we do not intend to measure. Using spline-interpolated commuter rates is an attempt to test whether there is (still) evidence for a fundamental relation between risk sharing and commuting once commuter rates are allowed to change over time.

The estimation results are summarized in Table 4. Our main interest is in the interaction terms with commuter rates, $\overline{IN}^k \cdot \Delta\tilde{x}_t^k$ and $\overline{OUT}^k \cdot \Delta\tilde{x}_t^k$. A first important result is that both interaction terms have the expected sign. There is a negative interaction between the degree of pass-through of state-specific output shocks to consumption growth and the in-commuter rate, i.e. β_U^1 is negative. This implies that states, which are more integrated by commuting linkages, are more successful in decoupling their consumption from state-specific output fluctuations as conjectured by Hypothesis 2. While the negative coefficient for the interaction term is statistically significant in the more robust specification using time-averaged commuter rates, the effect is measured imprecisely if spline-interpolated commuter rates are used. To illustrate the quantitative effects implied by the coefficient for $\overline{IN}^k \cdot \Delta\tilde{x}_t^k$, we consider a one standard-deviation increase in the average in-commuter rate. Such change decreases the correlation between state-specific consumption and output growth by 7.40 percentage points.

There is strong and robust evidence for Hypothesis 3, which states that the comovement between output shocks that hit the neighborhood and state-specific consumption growth depends on the number of workers who commute out of a state. In both specifications, the interaction term with the out-commuter rate is positive and highly significant. At the same time, the implied quantitative effect is sizeable. A one standard-deviation increase in the average out-commuter rate increases the spatial comovement by 18.12 percentage points. Further evidence for our hypotheses is provided by the coefficient for non-interacted output risk in the neighborhood, γ_U^0. This coefficient measures the magnitude of the spatial comovement when the out-commuter rate is zero. It is insignificant in both specifications,

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[12] In order to make sure that the interaction terms do not capture pure level effects, we include IN_t^k and OUT_t^k in non-interacted form as control variables in this alternative specification.

Table 4: Consumption risk sharing and commuting

Consumption risk sharing, 1970-1998, 48 US federal states

	Time-averaged commuter rates[1]	**Interpolated commuter rates**[2]
State-specific output shock:		
$\Delta\tilde{x}_t^k$	22.22**	19.32**
	(5.84)	(5.88)
$\Delta\tilde{x}_t^k \cdot \overline{IN}^k$	-334.35**	—
	(160.39)	
$\Delta\tilde{x}_t^k \cdot IN_t^k$	—	-229.88
		(164.34)
Neighbor-specific output shock:		
$\Delta\tilde{z}_t^k$	6.85	8.98
	(6.68)	(6.71)
$\Delta\tilde{z}_t^k \cdot \overline{OUT}^k$	455.58**	—
	(164.14)	
$\Delta\tilde{z}_t^k \cdot OUT_t^k$	—	426.82**
		(163.35)

Notes: [1] Results displayed in column one are from the GLS regression

$$\Delta\tilde{c}_t^k = \mu_U^k + \nu_{U,t} + \beta_U^0 \cdot \Delta\tilde{x}_t^k + \beta_U^1 \left(\overline{IN}^k \cdot \Delta\tilde{x}_t^k\right) + \gamma_U^0 \cdot \Delta\tilde{z}_t^k + \gamma_U^1 \left(\overline{OUT}^k \cdot \Delta\tilde{z}_t^k\right) + \varepsilon_{U,t}^k,$$

where $\overline{IN}^k$ and $\overline{OUT}^k$ are time-averaged in- and out-commuter rates, respectively.
[2] This specification uses spline-interpolated commuter rates, IN_t^k and OUT_t^k:

$$\begin{aligned}\Delta\tilde{c}_t^k =& \mu_U^k + \nu_{U,t} + \zeta_1 \cdot IN_t^k + \zeta_2 \cdot OUT_t^k \\ &+\beta_U^0 \cdot \Delta\tilde{x}_t^k + \beta_U^1 \left(IN_t^k \cdot \Delta\tilde{x}_t^k\right) + \gamma_U^0 \cdot \Delta\tilde{z}_t^k + \gamma_U^1 \left(OUT_t^k \cdot \Delta\tilde{z}_t^k\right) + \varepsilon_{U,t}^k.\end{aligned}$$

The table displays the coefficients β_U^0, β_U^1, γ_U^0, and γ_U^1, respectively; all other coefficients are suppressed. $\Delta\tilde{c}_t^k$ is the idiosyncratic growth rate of consumption, $\Delta\tilde{x}_t^k$ is the idiosyncratic output growth rate in state k, and $\Delta\tilde{z}_t^k$ is the idiosyncratic output growth rate in the neighborhood to state k. μ_U^k and $\nu_{U,t}$ are state and time fixed-effects, respectively. Estimation is carried out using GLS. For further details see the notes to Tables 2 and 3 and the main text. Coefficients and standard errors (in parentheses) are multiplied by 100. The number of observations is 1392. $^{**},^{*}$ denotes significance at the 5 and 10 percent levels, respectively.

which indicates that controlling for heterogeneity in commuting patterns can almost fully explain the spatial comovement that we have documented in the last section.[13]

7 Conclusion

This paper has re-examined US interstate risk sharing. Interstate risk sharing has been measured by the extent to which state-level consumption growth is separated from output shocks. We have pointed to commuting as an alternative smoothing mechanism to missing financial insurance opportunities covering human capital. Specifically, we have tested three empirical hypotheses concerning the relation between risk sharing and commuting.

A first hypothesis was that commuting can explain why the amount of regional risk sharing depends on the definition of regions. In the presence of commuting, the business cycle risk of the neighborhood becomes a driving force for region-specific consumption. For comparatively small regions, commuting is important and the neighborhood is thus an important risk factor. For large regions, by contrast, commuting is of lesser importance and the data already reflects the effect that commuting has on risk sharing. We have provided evidence on these relations by demonstrating that the 48 US federal states achieve better consumption risk sharing than the 8 BEA regions.

Starting from this empirical observation, we have incorporated the neighborhood in the analysis at the federal-state level. This extension allowed us to provide more direct evidence for our hypothesis that state-specific consumption comoves with output fluctuations in adjacent states. We found the spatial comovement to be highly significant and important in economic terms.

In a final step of the analysis we introduced explicit data on commuting linkages between states in order to test whether the aforementioned spatial comovement does indeed correlate with commuter flows. We found that controlling for cross-sectional heterogeneity in commuting patterns can almost fully explain the spatial comovement between consumption and output in the neighborhood.

From a more general perspective, our paper has illustrated that regional risk sharing is not only a phenomenon attributable to financial markets, but that labor markets also play an important role for risk sharing and consumption smoothing.

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[13] These results concerning the relation between risk sharing and commuting are robust to whether we account for banking deregulation or not. We also examined the effect of including a quadratic trend in the parametrizations as in Demyanyk, Ostergaard, and Sørensen (2007). This has no substantial effect on our results either.

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