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Temporal and Spatial Dependence of Inter-Regional Risk Sharing: Evidence from Russia

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Abstract

We present an analysis of interregional consumption risk sharing in Russia between 1999 and 2009 using novel estimation methods. In addition to standard fixed effects panel estimations, we use system and difference GMM estimators to reflect time dynamic properties and possible endogeneity between output and consumption. Furthermore, we apply spatial models that control for spatial dependence across regions. The results show that regional consumption deviations from the national average are highly persistent in time and space. Nevertheless, regional consumption risk sharing in Russia is relatively high with 70 to 90 per cent of idiosyncratic risk being smoothed. Finally, fiscal policy and the degree of financial development appear to contribute to the consumption smoothing.

JEL-Classification: E32, E21, R12, P25

Keywords: Russia, financial development, risk sharing, spatial models, GMM

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1. Introduction

Consumption risk sharing has been at the research agenda of international finance and economics ever since the seminal contribution by Backus et al. (1992). The early studies concerned with consumption risk sharing focus on bilateral correlations of consumption and output to assess risk sharing on an international scale. Asdrubali et al. (1996) propose a path-breaking panel data approach to estimate risk sharing and established an econometric model, which remains widely-used among risk sharing studies up to the present. Both national and international analyses arrive at the conclusion that some idiosyncratic consumption risk remains unsmoothed across regions, states or countries. The most relevant factors partially explaining the surprisingly low amount of risk sharing were found in trade costs (Obstfeld and Rogoff, 2001) and financial market imperfections (Bai and Zhang, 2012). This paper is motivated by these previous findings and contributes to the existent literature by using an innovative methodological approach as well as a dataset, which has not been used so far in consumption risk sharing studies.

Our findings contribute to several strands of the existing literature on risk sharing. First, while interregional risk sharing has been analyzed for many industrialized countries, such as the US (see, for example, Asdrubali et al., 1996) or Canada (see Crucini, 1999), only few studies have been conducted for Russia (Skoufias, 2003, Notten and de Crombrugghe, 2012) or Eastern European countries (Guo and Puyun, 2017). Given its high degree of centralized administration with deep historic roots reaching not only to the communist period but also to the tsarist time, Skoufias (2003) notes that Russian households use a broad set of insurance strategies including formal and informal borrowing, labor supply adjustment, and asset sales, which result in comparably high risk sharing. Our results show that the level of risk sharing is well above levels reported for developed economies (Asdrubali et al., 1996) but also for other emerging economies, e.g. China (Boyreau-Debray and Wei, 2005, Du et al. 2011).

Secondly, we apply novel estimation methods in our analysis, which are compared with standard models using fixed effect models. The previous literature, including national or international comparisons, did not apply system GMM in order to take temporal persistence into account. Moreover, the system GMM estimator deals also with potential endogeneity problems in classical risk sharing equations.

Finally, no macroeconomic risk sharing study has controlled for potential spatial dependence. It appears meaningful to take spatial dependency into account because we analyze risk sharing at the regional level and Russian regions are likely to be linked through economic and structural characteristics. In fact, previous research has shown that economic development of Russian regions is highly dependent on opportunities for economic cooperation among neighboring regions (Kolomak, 2011). We therefore employ spatial models which allow for spatial correlation of various forms.

We find that approximately 70 to 90 percent of consumption risk is shared across Russian regions. While this is a substantially larger fraction compared to regional risk sharing studies for other countries, it confirms previous results (Skoufias, 2003, and Notten and de Crombrugghe, 2012). The finding of comparatively high risk sharing is also valid throughout all specifications including standard panel models as well as temporal and spatial dependence. The spatial models yield somewhat higher coefficients as compared to the fixed effects regressions, indicating that risk sharing is slightly lower if spatial dependence is considered. The dynamic models estimated with difference and system GMM show that regional consumption deviations from the country average are highly persistent.

Finally, our results show that domestic factors are more important for regional risk sharing than regions' openness to international capital flows. In particular, the degree of development of the banking sector contributes significantly to risk sharing, while foreign investment flows do not seem to exercise any particular influence. The main results are highly robust to the inclusion of additional control variables and the use of subsamples, for example to the exclusion of Moscow and St Petersburg as main economic centers. However, bank credit ceases to have a positive effect on risk sharing if the two cities are excluded.

The rest of the paper is structured as follows. Section 2 reviews permanent income theory as the theoretical foundation of risk sharing and gives an overview of the existing literature about consumption risk sharing, the links between risk sharing and financial integration as well as different channels of risk sharing. Section 3 introduces our dataset and descriptive statistics for the variables. Section 4 presents the standard fixed effects panel regressions in levels and differences, which are compared to the difference and system GMM estimator in section 5 and to spatial models in section 6. Section 7 discusses the results for these methods and concludes.

2. Literature Review

2.1 Estimation Approach

Friedman (1957) developed the permanent income hypothesis, which states that an individual's consumption is consistent with their expected long-term income. By separating income and consumption into a permanent and a transitory component, Friedman argues that only changes in permanent income affect consumption systematically.

Based on the Arrow-Debreu assumption of complete markets where agents can trade claims on assets, macroeconomic theory predicts that countries can trade idiosyncratic risk. Consequently, consumption growth rates should be highly correlated across countries, since idiosyncratic income shocks should not have strong effects on domestic consumption (Lewis, 1999). However, Backus et al. (1992) find that international consumption growth rates are less strongly correlated than output. They show that the discrepancy between international output and consumption correlations remains robust even if they control for transport costs. Hence, this revealed a puzzling contradiction between the data and the theory in that international correlations for per capita consumption are lower than for per capita income. Obstfeld and Rogoff (2001) rank this particular inconsistency between stylized facts and theory as one of the six major puzzles in international macroeconomics.

A considerable number of studies have aimed to find explanations for the international consumption correlations puzzle: Obstfeld and Rogoff (2001) assert that low risk sharing can partially be explained by introducing trade costs. In their model, Obstfeld and Rogoff (2001) not only include transport costs but also tariffs and other barriers to trade. Trade costs have become a popular explanation, which extends the early observations by Backus et al. (1992) that transport costs alone cannot alone account for the puzzle. Moreover, Obstfeld and Rogoff (2001) argue that comparing output with consumption correlations is somewhat misleading as only output less investment and government consumption can be shared by private consumers. Hence, they compare international consumption correlations with international correlations of output after investment and government consumption. As predicted, they find the *net* output correlations to be substantially lower (0.17) than the consumption correlations (0.40). Stockman and Tesar (1995) suggest another explanation for low international consumption correlations: they argue that the data can be replicated very well with a model accounting for non-traded goods and allowing for a combination of shocks to technologies and tastes.

A now-common approach for estimating the amount of consumption risk sharing was developed by Asdrubali et al. (1996), who estimate the amount of interstate risk sharing in the United States. Moreover, their results strengthen the conclusion that consumption risk sharing, that is income and consumption smoothing, is far from perfect. In their seminal work, the authors decompose US interstate risk sharing into three distinct channels using panel regressions in varied differencing frequencies. Firstly, they find that economic agents in the US can share risk ex-ante via the cross-ownership of assets by using capital markets. Secondly, the federal government's tax-transfer system is identified as another instrument for income smoothing. Lastly, credit markets can facilitate ex-post consumption smoothing by enabling members of the federation to lend or borrow after shocks to the gross state product. Their results are consistent with permanent income theory in the sense that states hit by more persistent output shocks are found to experience less consumption smoothing through saving.

A substantial part of the risk sharing literature aims to identify specific channels through which shocks are smoothed. In order to understand how countries achieve consumption insurance, finding distinct channels of risk sharing is crucial for explaining the puzzlingly low amount of international risk sharing. Asdrubali et al. (1996) try to distinguish between different channels of consumption risk sharing. Firstly, countries or regions can share risk by trading claims to their output. These claims are exchanged previous to the occurrence of a shock, hence the name ex-ante risk sharing. Such claims can, for instance, persist in the form of fiscal transfer arrangements or equity holdings. Since the cross-holdings enable countries or regions to stabilize their income when facing an income shock, the channel can also be called income smoothing. For that to work, countries need to receive higher net transfers during recessions than during growth periods (Becker and Hoffmann, 2006). Asdrubali et al. (1996) estimate that shocks to the gross state product are smoothed ex-ante by 39 per cent through capital markets in the US. The federal government's tax-transfer system smoothens another 13 per cent of shocks to state output ex-ante. Becker and Hoffmann (2006) estimate that around 50 per cent of consumption risk in the US is shared ex-ante and thereby confirm the previous findings by Asdrubali et al. (1996).

Secondly, countries or regions can share consumption risk by buying or selling foreign assets or via borrowing and lending. Since this means that a shock has already occurred, and current income is observed, this consumption smoothing channel can also be referred to as the ex-post channel of risk sharing. For the US, Asdrubali et al. (1996) show that 23 per cent of output shocks are smoothed ex-post via credit markets. Asdrubali et al. (1996) and Sørensen and Yosha (1998) show that highly persistent shocks which are not insured ex-ante are unlikely to be smoothed ex-post on credit markets, since it is implausible that borrowers would be able to repay. They observe for OECD countries that cross-country consumption smoothing is mostly negligible via personal saving and dissaving.

The extent of risk sharing is highly dependent on the persistence of output shocks. Becker and Hoffmann (2006) show that transitory and permanent shocks are two entirely different types of risk corresponding with distinct smoothing mechanisms. Asdrubali et al. (1996) already observe that the so called “corn states” rely more heavily on consumption smoothing via credit markets whereas “oil states” are more reliant on income smoothing through capital markets. In the context of the persistence of shocks, this appears to be reasonable since an exceptionally bad harvest is likely to have only transitory effects on output. In the long run, however, credit constraints are likely to be more severe and credit markets cannot emulate capital markets. Correspondingly, Asdrubali et al. (1996) find that consumption smoothing through saving is relatively low for US regions with more persistent shocks to output.

Sørensen and Yosha (1998) find consumption risk sharing at a one-year differencing frequency to be higher (40 per cent) compared to a three-year frequency (25 per cent). This implies that persistent shocks to GDP are harder to smooth than transitory shocks. Artis and Hoffmann (2008) do not alter differencing frequencies but use a risk sharing equation in levels in order to observe risk sharing in the medium and long term. In contrast to the majority of the literature, they observe a strong increase in risk sharing, specifically during the 1990s, by differentiating between permanent and transitory fluctuations in their empirical specification. More specifically, they report for OECD countries that the share of permanent country-specific risk, which is shared internationally, increased from under 30 per cent until the 1980s to more than 60 per cent in the 1990s. They argue that the reason why previous studies have failed to capture this increase is related to the global decline in business cycle volatility: country-specific consumption mainly reacts to permanent shocks, but the permanent component of output has been affected to a lesser extent by the decline in volatility. Thus, the volatility of consumption growth conditional on current output growth has increased Therefore, risk sharing regressions will suffer from an upward bias that understates the actual amount of risk sharing.

To enable insurance against countrywide shocks, financial flows need to be able to move freely across borders. Incomplete capital markets therefore constitute a crucial factor for explaining imperfect risk sharing. The connection between risk sharing and financial integration has thus shown to be a worthwhile object of investigation. Regarding the relationship between risk sharing and financial integration, there are divergent findings in the literature.

Kose et al. (2009) find no evidence for financial integration to improve consumption risk sharing between 1960 and 2004. In turn, equity investment and foreign direct investment (FDI) appear to have modestly favorable effects on risk sharing for industrialized countries in a period of financial globalization (starting in 1987). Applying threshold analysis to more than 60 countries from the 1980s to 2000s, Malik (2015) shows that risk-sharing is negligible for low levels but significant for high levels of financial integration.

It is well established that investors are home-biased as they hold more assets in their home countries than abroad (Tesar and Werner, 1995). Artis and Hoffmann (2006) attempt to empirically connect the two phenomena. They show that, particularly after the 1990s, a smaller home bias leads to more portfolio diversification and to more consumption risk sharing. Sørensen et al. (2007) also demonstrate that the decreased home bias in equity and debt holdings, a sign for increasing financial integration, goes along with a rise in consumption risk sharing.

2.2 Intra-National Risk Sharing

Previous literature has found that risk sharing tends to be higher between sub-national regions than across countries. In an international setting with industrialized economies, most papers report consumption risk sharing rates of approximately 40 per cent (Sørensen and Yosha, 1998). Asdrubali et al. (1996) estimate that about 75 per cent of shocks to gross state product in US states have been smoothed for the period from 1963 to 1990. Moreover, they draw attention to the issue of measurement error when using regional data. According to the authors, aggregate consumption data for individual states is more prone to measurement error than national data. Contributions by Asdrubali et al. (1996) and Sørensen and Yosha (1998) have demonstrated that cross-holdings of claims to capital and the resulting capital income flows are a far more substantial source of risk sharing across regions than across countries.

Crucini (1999) estimates consumption risk sharing across G7 countries, Canadian regions and US states and finds that risk sharing across the G7 countries is lower in every specification. He proposes an explanation for these results based on real interest rates and the assumption that aggregate consumption can be used as a proxy for permanent income: fluctuations of real interest rates (Mark, 1985) induce intertemporal substitution leading to fluctuations in consumption, which may engender consumption co-movements over time. Furthermore, Crucini (1999) mentions the home bias in portfolio diversification (Becker and Hoffmann, 2006; Sørensen et al., 2007) as another explanation for lower international risk sharing.

Mélitz (2004) and Kalemli-Ozcan et al. (2004) study the special importance of risk sharing for EMU countries. In a monetary union, monetary policy cannot be used as a short-term instrument to smooth adverse output shocks of single member states. However, this process can be mitigated if risk sharing across member countries is in place. Demyanyk et al. (2008) find that EMU members were the only countries within the EU with increased risk sharing in the five years after the implementation of the euro. Kalemli-Ozcan et al. (2014) analyze risk sharing in light of the European sovereign debt crisis using recent data. They find that fiscal austerity programs have diminished risk sharing over the course of the crisis years - especially in the peripheral countries (Greece, Ireland, Italy, Portugal and Spain).

There is only a little and mixed evidence for intra-national risk sharing in emerging economies, which in general also show a lower degree of risk sharing. Kose et al. (2009) suggest that emerging and developing economies' risk sharing capabilities are restrained by external debt. Guo and Puyun (2017) find a lower degree of risk sharing especially in new EU member states in Eastern Europe as compared to the earlier member states. Risk sharing is especially low for China. Boyreau-Debray and Wei (2005) and Xu (2008) document that consumption correlation was lower than income correlations between regions. More recently, Du et al. (2011) find that only about 40 percent of the income shocks at the provincial level are smoothed between regions between 1980 and 2007. Ho et al. (2015) find that income components account for a large share of consumption variation in Chinese cities, which confirms a low degree of risk sharing. Contrary to this, Skoufias (2003) and Notten and de Crombrugghe (2012) report a relatively high importance of risk sharing in Russia.

3. Data

Russia has been hit hard by the transformation recession at the beginning of the 1990s. Moreover, Russia's output development in the second half of the 1990s was low compared to other emerging economies. During the analyzed period, 1999 to 2008, Russia experienced rapid economic growth. Since Russia's economy is heavily dependent on raw materials, particularly oil and gas, the increases in commodity prices until 2008 were another crucial factor for its economic success (see Eller et al., 2016; Berglof and Lehmann, 2009).

Russia is comprised of more than 80 highly heterogeneous regions (oblast). Their heterogeneity makes them particularly interesting for regional analysis (see Eller et al, 2016, Fidrmuc et al., 2015). However, we have to exclude some regions due to missing data or because they are seriously affected by military conflicts.[1] The macroeconomic data, that is gross regional product (GRP) per capita, final household consumption per capita, government expenditures, foreign direct investment and total foreign investment, are retrieved from the Russian Federation Federal Statistics Service (Rosstat). The data on personal and corporate credit at the regional level come from the Bank of Russia.

We use annual data between 1999 and 2009. This time period is chosen for several reasons. First, initial conditions and adopted policy reforms played a crucial role for economic development during the early 1990s. From the 2000s onward, banks have largely stabilized and the implementation of market reforms had already progressed (see Berkowitz and DeJong, 2011). In line with that, Ahrend (2012) detects a break in 1998 in the determining factors of Russian GRP. In order to avoid this structural break and the corresponding distortion of results, we do not include data before the year 1999 in the analysis. Several variables are also not available before 1999, and the methodology for calculating regional consumption changed in 2009. Finally, military conflicts and the subsequent economic sanctions recently imposed on Russia are likely to influence current data in a way that would render our results hard to interpret (Dreger et al., 2016). Despite these data restrictions, our data set includes 75 regions yielding 825 observations in the baseline specification.

[1] We exclude Chechnya, Dagestan, Ingushetia and Ossetia since they are subject to military conflicts. Mansiysky, Nenetsky, Yamalo and Zabaikalsky are excluded due to missing data.

The key variables are regional consumption, *C*, and income, *Y*, which are measured in real and per capita terms. Several control variables may influence the size of risk sharing, and therefore, they are taken as interaction terms with income per capita. Thus, we include government size, *G*, the oil price, *oil*, and a linear time trend as control variables. Following earlier literature, we analyze the impact of several measures of financial integration and development on risk sharing (Artis and Hoffmann, 2006, and Kose et al., 2009). On the one hand, capital flows from abroad are approximated by foreign direct investment (*FDI*) and total foreign investment (*TFI*) as shares of GRP. On the other hand, domestic credit supply (Fidrmuc et al., 2017, Kapounek 2017) is approximated by personal loans, *LP*, and corporate loans, *LC*, as shares of GRP.[2]

Most regions did not experience any significant foreign investment during the observed period. Only about ten regions have received considerable foreign investment. All regions that have experienced foreign investment, also faced significant capital flight after the financial crisis. In contrast to that, personal and corporate loans as shares of GRP have experienced a steady increase despite some regional variation. In 2001, the country average of personal loans amounted to about 1 per cent of GRP and increased to 12.7 per cent in 2009. Corporate loans increased from an average of 12.7 per cent as a share of GRP in 2001 to 24.6 per cent of GRP in 2009. Berkowitz and DeJong (2011) find that bank-issued credit has significantly contributed to economic growth after 2000 whereas the main driver for growth in the 1990s, entrepreneurial activity, ceased to boost growth in the 2000s.

[2] Descriptive statistics are presented in Table A.1 in appendix. Moreover, Table A.2 shows the correlation matrix of the untransformed variables.

4. Baseline Panel Estimations of Risk Sharing

4.1 Fixed Effect Models Regressions

The early literature related bilateral correlations of consumption to bilateral output correlations (see, for example, Backus et al., 1992). Asdrubali et al. (1996) propose an alternative approach based on panel regressions, which exploits directly both cross-sectional and time variation in the available data. Furthermore, this approach allows for the inclusion of additional control variables for financial development as well as interactions observing specific regional characteristics, such as oil production. As reviewed in the previous section, the main part of the risk sharing literature has used risk sharing equations in differences and thereby concentrated on a short-term view. Artis and Hoffmann (2008) focus on a long-term view and estimate risk sharing in levels using time-series panel data methods. Similarly, we estimate the risk sharing equation both in differences and levels using fixed effects panel estimations, dynamic panel regressions, and spatial models.

Asdrubali et al. (1996) define the extent to which changes in GDP determine contemporaneous changes in consumption. Thus, the risk sharing equation measures co-movements between idiosyncratic components of growth rates of aggregate private consumption and output. The model can be formalized as follows: c_{it} and y_{it} denote region and time-specific per capita consumption and output in logarithms, respectively. Risk sharing is assumed to be perfect if $c_{it} - \bar{c}_t = 0$, that is if there is no difference between the regional and the country aggregate component of the variable. The regression variables are modelled as $\Delta\tilde{C}_{it} = \Delta c_{it} - \Delta\bar{c}_t$ and $\Delta\tilde{Y}_{it} = \Delta y_{it} - \Delta\bar{y}_t$. Finally, the risk sharing equation can be formulated as

$$\Delta\tilde{C}_{it} = \alpha_i + \theta_t + \beta\Delta\tilde{Y}_{it} + \sum_{k=1}^{K}\gamma_k x_{itk}\tilde{Y}_{it} + \varepsilon_{it} \tag{1}$$

where β is an estimator for the fraction of idiosyncratic risk that is not shared nationally, α_i denoting region fixed effects and θ_t as time effects. It is assumed that the error term, ε_{it}, is identically and independently distributed.

Regional consumption and income deviations from the rest of the country are the core variables of the risk sharing equation. Population-weighted “rest of the country” averages, $\bar{c}_i$ and $\bar{y}_i$, are defined as $\bar{c}_i = \sum_{j=1}^{R} w_{it}c_{it}$ and $\bar{y}_i = \sum_{j=1}^{R} w_{jt}y_{jt}$, with $w_{jt} = pop_{jt}/\sum_{j=1}^{R} pop_{jt}$ denoting the population weight of region i at time t with population pop_{it}. The average consumption and income data used for a particular region i exclude this region from the aggregation, $i \neq j$. Consumption and income are measured in real and per capita terms.

Additional control variables denoted by x_{itk} are interacted with $\tilde{Y}_{it}$. The risk sharing coefficient β measures the extent to which output deviations from the country average explain present consumption deviations, besides past consumption deviations and γ_k which is the coefficient for x_{itk} for each of the k control variables. We observe the interactions in order to identify channels that contribute to risk sharing. A negative sign of γ_k indicates that a specific interaction is conducive to risk sharing. Since the risk sharing parameter now is a function of x_{itk}, the marginal effect of $\tilde{Y}_{it}$, that is the degree of consumption risk sharing achieved by region i, amounts to $1 - \beta - \gamma_k x_{itk}$. We also include x_{itk} without $\tilde{Y}_{it}$ as interaction for the sake of avoiding misspecification.

Without any control variables, the degree of risk sharing achieved by region i amounts to $1 - \beta$. Intuitively, in a model with complete markets and perfect risk sharing, β yields zero as consumption growth rates are equalised across all regions. To see the contribution of the individual channels to risk sharing, we compute also the contributions of *k* control variables, *x*, which is evaluated at the average of variable *x*,

$$1 - \beta - \gamma_k \bar{x}_{itk}. \quad (2)$$

Artis and Hoffmann (2006) show that the results of regressions in differences may be subject to the specific type of a shock to output: if those shocks change over time, estimations using differences may fail to detect risk sharing. They propose estimating risk sharing in levels, which shows the extent of risk sharing in the long-term. Following this approach, we estimate the risk sharing equation in levels,

$$\tilde{C}_{it} = \alpha_i + \theta_t + \beta \tilde{Y}_{it} + \sum_{k=1}^{K} \gamma_k x_{itk} \tilde{Y}_{it} + \varepsilon_{it}. \quad (3)$$

4.2 Baseline Results in Differences and Levels

Table 1 shows the results for the panel fixed effects estimations of risk sharing equation (1) in differences. We find that only about 10 per cent of idiosyncratic consumption risk remains unsmoothed across regions and the coefficient is statistically significant at the 5 per cent level. After the inclusion of further control variables, the direct impact of income shocks on consumption level remains nearly unchanged. However, the income coefficient becomes insignificant in the specification with oil prices and only marginally significant (at the 10 per cent level) if personal loans are included.

The control variables have nearly no impact on regional risk sharing both in statistical and economic terms. Actually only income multiplied by corporate loans is significant, but the coefficient is very low in absolute value. We report the average degree of risk sharing in the last line of all tables. We can see that the risk sharing remains similar to the level in the basic specification of around 90 per cent in all specifications in Table 1.

Table 1: Consumption Risk Sharing, First Differences

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\Delta\tilde{Y}_{it}$	0.100***	0.144**	0.073	0.105***	0.137***	0.121***	0.090*	0.104**
	(0.039)	(0.059)	(0.102)	(0.035)	(0.040)	(0.037)	(0.048)	(0.039)
$\Delta\tilde{Y}_{it} \times G_{it}$		–0.158						
		(0.202)						
$\Delta\tilde{Y}_{it} \times Oil_{it}$			0.001					
			(0.002)					
$\Delta\tilde{Y}_{it} \times Trend_t$				–0.015				
				(0.018)				
$\Delta\tilde{Y}_{it} \times TFI_{it}$					0.004			
					(0.010)			
$\Delta\tilde{Y}_{it} \times FDI_{it}$						0.001		
						(0.006)		
$\Delta\tilde{Y}_{it} \times LP_{it}$							–1.064	
							(2.215)	
$\Delta\tilde{Y}_{it} \times LC_{it}$								–0.773***
								(0.132)
Constant	–0.001	–0.013	–0.022	–0.013	–0.011	–0.009	0.010	–0.002
	(0.010)	(0.025)	(0.014)	(0.010)	(0.010)	(0.010)	(0.013)	(0.011)
No of obs.	750	750	750	750	690	666	675	675
No. of regions	75	75	75	75	74	74	75	75
R^2	0.164	0.138	0.169	0.142	0.026	0.009	0.024	0.016
Implied risk sharing	90.0%	82.2%	97.4%	89.7%	87.0%	88.0%	83.9%	77.0%

Notes: *, ** and *** indicate statistical significance at the 10 per cent level, 5 per cent level, and 1 per cent level. Robust standard errors are given in parentheses. Time and region effects as well as the control variables without interaction are included in the estimations but not reported.

The pass-through of income shocks to consumption in levels, as specified in equation (2), is slightly higher than the coefficients estimated for the difference specification (see Table 2). Thus, almost 30 per cent of the idiosyncratic income shocks are not smoothed. Other findings remain largely similar to the previous results: The interaction variables remain insignificant, and the level of risk sharing in extended specifications remains largely similar to that of the basic specification.

These estimations indicate a comparably high degree of risk sharing. For example, Asdrubali et al. (1996) find (using a difference specification) that about 25 per cent of consumption risk is not shared across US states. The degree of long-run income smoothing (that is, estimated in levels) is also remarkably high when compared with the US where Artis and Hoffmann (2006) find only about 50 per cent is shared using an equation in levels. However, taking into account Russia's tradition of central administration, high national risk sharing is not so surprising. For instance, the federal government still redistributes oil revenues across regions to a high degree (see, for example, Eller et al., 2016). Using individual consumption data, Skoufias (2003) and Notten and de Crombrugghe (2012) show that income shocks are only weakly transmitted to consumption in Russia.

Table 2: Consumption Risk Sharing, Levels

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\tilde{Y}_{it}$	0.292***	0.262**	0.369***	0.331***	0.362***	0.305***	0.289***	0.306***
	(0.103)	(0.129)	(0.079)	(0.074)	(0.091)	(0.115)	(0.078)	(0.066)
$\tilde{Y}_{it} \times G_{it}$		0.159						
		(0.232)						
$\tilde{Y}_{it} \times Oil_{it}$			–0.002					
			(0.001)					
$\tilde{Y}_{it} \times Trend_t$				–0.015				
				(0.011)				
$\tilde{Y}_{it} \times TFI_{it}$					–0.009			
					(0.008)			
$\tilde{Y}_{it} \times FDI_{it}$						–0.001		
						(0.008)		
$\tilde{Y}_{it} \times LP_{it}$							–0.206	
							(0.229)	
$\tilde{Y}_{it} \times LC_{it}$								–0.355
								(0.271)
Constant	–0.222***	–0.241***	–0.213***	–0.196***	–0.179	–0.175***	–0.224***	–0.214
	(0.026)	(0.043)	(0.040)	(0.025)	(0.022)	(0.023)	(0.026)	(0.027)
No of obs.	825	825	750	825	770	752	750	750
No. of regions	75	75	75	75	74	74	75	75
R^2	0.750	0.733	0.750	0.749	0.726	0.732	0.753	0.638
Implied risk sharing	70.8%	77.2%	53.7%	67.1%	62.2%	69.4%	69.7%	63.6%

Notes: *, ** and *** indicate statistical significance at the 10 per cent level, 5 per cent level, and 1 per cent level. Robust standard errors are given in parentheses. Time and region effects as well as the control variables without interaction are included in the estimations but not reported.

5. Dynamic Panel Models

5.1 GMM Panel Models

As an alternative to standard fixed effect models, we apply difference and system GMM (Arellano and Bond, 1991, Arellano and Bover, 1995, and Blundell and Bond, 1998). This approach has become a widely used method in various fields of empirical macroeconomics (Roodman, 2009). However, it has not been used so far in the risk sharing literature. Since the dependent variable is found to exhibit serial correlation, the risk sharing equation in levels is estimated in a dynamic specification including the lagged dependent variable as a regressor. In this way, we can see the persistence of regional consumption relative to the country's average. This approach also reflects the permanent income hypothesis, which postulates that lagged consumption is the most important variable to predict current consumption, since only permanent changes in income affect consumption systematically. The dynamic version of the risk sharing equation can be stated as

$$\tilde{C}_{it} = \rho \tilde{C}_{i,t-1} + \beta \tilde{Y}_{it} + \sum_{k=1}^{K} \gamma_k x_{itk} \tilde{Y}_{it} + \vartheta x_{itk} + \theta_t + \alpha_i + \varepsilon_{it}, \qquad (4)$$

where fixed effects, $\alpha_i \sim IID(0, \sigma_\mu^2)$, and the error term, $\varepsilon_{it} \sim IID(0, \sigma_v^2)$, are independent of each other and among themselves. Control variables are again defined as they are in fixed effect estimations (1) and (2).

We use the one-step difference and system GMM estimator (Roodman, 2009) and instrument $\tilde{C}_{it}$, $\tilde{Y}_{it}$ and the controls as they are suspected to be endogenous. Since this produces a large number of instruments, we restrict the number of instruments to contain one to six lags, depending on the specification for difference GMM, or apply the collapse option recommended by Roodman (2009). The time effects θ_t are used as exogenous variables. Estimates of the standard errors are robust to heteroskedasticity and serial correlation. We report the Hansen *J*-statistic to test for overidentifying restrictions, which fails to reject the null of instrument exogeneity. Moreover, we report also the Arellano-Bond tests for residual second-order autocorrelation. The null hypothesis of no residual autocorrelation is rejected for all specifications. Moreover, we exclude the main economic hubs Moscow and Saint Petersburg from the sample in order to confirm the robustness of the results.

In robustness analysis, we apply an alternative estimator proposed by Han and Phillips (2010) for dynamic panel data models, which avoids the weak moment condition problem affecting conventional GMM estimation when the autoregressive coefficient is near unity. Their simulations show that the estimator has little bias even in very small samples. However, this approach assumes that additional regressors are exogenous.

5.2 Risk Sharing Estimated with System GMM

Tables 3 presents results for risk sharing using dynamic models estimated by system GMM.[3] In all specifications, the coefficients of the lagged dependent variable is highly significant and lies between 0.8 and 0.9, but it is below unity which confirms that consumption shocks are transitory. A region's consumption deviation from the country average in one year is largely carried over to the following year. According to the basic specification in Table 3, column (1), it takes approximately four years until a consumption shock is reduced by half. This may correspond well to the general properties of macroeconomic shocks such as employment, as this period is about a half of a typical business cycle. Thus, the persistence of consumption patterns is in line with the conjecture that regional consumption deviations may reflect structural economic underdevelopment.

Compared to static results reported in the previous subsection, some control variables exhibit a statistically and also economically significant influence on regional risk sharing. All coefficients are negatively signed. Higher oil prices improve risk sharing, which is in line with Eller et al. (2016), who find that the federal government redistributes oil revenues to a large extent. However, the relatively small coefficient implies that oil prices do not have a substantial effect on risk sharing. The negative and significant coefficient of the linear time trend in column (5) indicates that risk sharing has improved over time, but the coefficient's size is again very small. As a result, the amount of estimated risk sharing is not decisively affected by the control interactions since they are either insignificant or very small in size.

Further columns in Table 3 displays the link between financial integration and risk sharing by using flows of foreign capital and domestic credit as interactions. TFI as a share of GRP in column (6) has the expected negative sign but does not affect risk sharing significantly. The

[3] The main results are similar also for difference GMM especially for all control variables. The main difference is that income shocks have a weaker impact if difference GMM is used, which corresponds to the interpretation of difference GMM as short-run risk sharing. System GMM includes the level equation, which can be associated with the long-run income smoothing, whereas difference GMM explains mainly the risk sharing in the short run. The results for difference GMM are reported in Table A.3 in appendix.

coefficient of FDI as a share of GRP in column (7) is statistically significant at the 10 per cent level and also negative. In terms of economic significance, however, FDI appears to be negligible on average, although it may be important for some regions.

Table 3: Consumption Risk Sharing, System GMM

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\tilde{C}_{it-1}$	0.847***	0.885***	0.825***	0.828***	0.926***	0.900***	0.765***	0.781***
	(0.057)	(0.111)	(0.048)	(0.050)	(0.072)	(0.081)	(0.097)	(0.133)
$\tilde{Y}_{it}$	0.108***	0.177**	0.132***	0.128***	0.150***	0.153**	0.213**	0.255**
	(0.035)	(0.091)	(0.034)	(0.032)	(0.058)	(0.066)	(0.077)	(0.113)
$\tilde{Y}_{it} \times G_{it}$		–0.161						
		(0.143)						
$\tilde{Y}_{it} \times Oil_{it}$			–0.0005**					
			(0.0003)					
$\tilde{Y}_{it} \times Trend_t$				–0.004**				
				(0.002)				
$\tilde{Y}_{it} \times TFI_{it}$					–0.007			
					(0.009)			
$\tilde{Y}_{it} \times FDI_{it}$						–0.023*		
						(0.012)		
$\tilde{Y}_{it} \times LP_{it}$							–0.448**	
							(0.216)	
$\tilde{Y}_{it} \times LC_{it}$								–0.282***
								(0.110)
Constant	–0.001	0.021	–0.045**	–0.008	0.002	–0.008	–0.030	0.062***
	(0.015)	(0.047)	(0.018)	(0.014)	(0.023)	(0.016)	(0.059)	(0.023)
No. of obs.	750	750	750	750	699	683	750	750
Hansen *p*-value	0.133	0.296	0.101	0.110	0.394	0.369	0.237	0.168
No. of regions	75	75	75	75	74	74	75	75
AR(1) *p*-value	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000
AR(2) *p*-value	0.208	0.229	0.191	0.205	0.590	0.492	0.171	0.212
Implied risk sharing	89.2%	78.9%	84.4%	87.2%	83.8%	83.1%	75.7%	69.9%

Notes: *, ** and *** indicate statistical significance at the 10 per cent level, 5 per cent level, and 1 per cent level. Robust standard errors are given in parentheses. Time and region effects as well as the control variables without interaction are included in the estimations but not reported. The endogenous variables include risk sharing, income deviations and income interacted with the control variables. The instruments include all collapsed available lags.

Table 4: Consumption Risk Sharing in Levels, Spatial Error Model

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\tilde{Y}_{it}$	0.091**	0.113*	0.084	0.089***	0.117**	0.120***	0.100	0.150***
	(0.038)	(0.062)	(0.099)	(0.035)	(0.046)	(0.043)	(0.061)	(0.038)
$\tilde{Y}_{it} \times G_{it}$		–0.062						
		(0.194)						
$\tilde{Y}_{it} \times Oil_{it}$			0.000					
			(0.002)					
$\tilde{Y}_{it} \times Trend_{t}$				–0.002				
				(0.014)				
$\tilde{Y}_{it} \times TFI_{it}$					0.004			
					(0.005)			
$\tilde{Y}_{it} \times FDI_{it}$						0.004		
						(0.005)		
$\tilde{Y}_{it} \times LP_{it}$							–0.209	
							(0.736)	
$\tilde{Y}_{it} \times LC_{it}$								–0.173
								(0.139)
lambda	0.149***	0.149***	0.145***	0.151***	0.079*	0.070	0.149***	0.128***
	(0.039)	(0.038)	(0.040)	(0.040)	(0.047)	(0.047)	(0.046)	(0.042)
sigma	0.007***	0.007***	0.007***	0.007***	0.006***	0.006***	0.007***	0.007***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
No of obs.	720	720	720	720	610	610	720	720
No of regions	72	72	72	72	61	61	72	72
Log-Likelihood	773.7	773.9	774.4	773.7	708.3	709.0	773.7	782.9
Implied risk sharing	90.9%	87.4%	91.6%	91.1%	89.0%	88.3%	88.6%	82.2%

Notes: *, ** and *** indicate statistical significance at the 10 per cent level, 5 per cent level, and 1 per cent level. Robust standard errors are given in parentheses. Weight matrix is defined for three closest neighbors. Time effects, regional fixed effects, and control variables without interaction are included in the estimations but not reported.

By contrast, the degree of financial development has a stronger influence on regional risk sharing. Access to personal loans, column (8), is significant at the 5 per cent level and has a negative sign. Even though the coefficient is not estimated with high precision, its size suggests that personal credit is of great economic importance. This indicates that ex-post consumption smoothing plays an important role in the sense that personal credit enables individuals to borrow in the aftermath of an economic shock. However, credit markets typically only smooth temporary shocks since lenders are disinclined to give loans to regions that are hit by persistent shocks. Complementary to personal loans, corporate credit improves risk sharing as it is highly significant and also negative. Since companies usually use loans for investments, a plausible interpretation of the coefficient in column (9) is that companies in regions hit by a shock continue to be able to invest, which may benefit employment and ultimately private consumption.

According to the Hansen J-test of overidentifying restrictions, the included instruments are exogenous since the null hypothesis of no correlation between the error term and the instruments cannot be rejected. The p-values of the Arellano-Bond tests for residual autocorrelation show that, as expected, the null hypothesis of no first order autocorrelation is rejected in all specifications. Thus, all estimations are free from second order serial correlation.

Table 5: Consumption Risk Sharing in Levels, Spatial Lag Model

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\tilde{Y}_{it}$	0.090**	0.119**	0.070	0.091***	0.119***	0.121***	0.093	0.151***
	(0.037)	(0.058)	(0.097)	(0.034)	(0.044)	(0.042)	(0.059)	(0.036)
$\tilde{Y}_{it} \times G_{it}$		–0.089						
		(0.180)						
$\tilde{Y}_{it} \times Oil_{it}$			0.000					
			(0.002)					
$\tilde{Y}_{it} \times Trend_t$				0.001				
				(0.013)				
$\tilde{Y}_{it} \times TFI_{it}$					0.004			
					(0.005)			
$\tilde{Y}_{it} \times FDI_{it}$						0.004		
						(0.005)		
$\tilde{Y}_{it} \times LP_{it}$							–0.087	
							(0.702)	
$\tilde{Y}_{it} \times LC_{it}$								–0.180
								(0.135)
rho	0.149***	0.149***	0.144***	0.149***	0.088*	0.082*	0.007***	0.135***
	(0.038)	(0.037)	(0.039)	(0.038)	(0.045)	(0.045)	(0.001)	(0.040)
sigma	0.007***	0.007***	0.007***	0.007***	0.006***	0.006***	0.147***	0.007***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.041)	(0.001)
No of obs.	720	720	720	720	610	610	720	720
No of regions	72	72	72	72	61	61	72	72
Log-Likelihood	773.7	774.0	774.4	773.7	708.6	709.4	773.8	783.5
Implied risk sharing	91.0%	86.2%	93.0%	90.9%	88.8%	88.2%	90.1%	82.0%

Notes: *, ** and *** indicate statistical significance at the 10 per cent level, 5 per cent level, and 1 per cent level. Robust standard errors are given in parentheses. Weight matrix is defined for three closest neighbors. Time effects, regional fixed effects, and control variables without interaction are included in the estimations but not reported.

Furthermore, we apply a novel approach proposed by Han and Phillips (2010) which is also consistent for variables with possibly high autoregressive coefficients (close or even equal to unity). As before, this approach confirms a modest transmission of income shocks to consumption and no influence of control variables.[4] As an additional robustness check, we repeated selected estimations excluding Russia's largest urban, economic and financial hubs of Moscow and Saint Petersburg. In fact, there are hardly any substantial changes in the risk sharing coefficients in this robustness check.

[4] These results are available upon request from authors (see also Table A.4 in appendix).

6. Spatial Models

6.1 Spatial Error Model and Spatial Lag Model

While system GMM controls for temporal persistence by estimating a dynamic panel model, spatial econometric methods are aimed at incorporating the geographic distance between regions. Spatial dependence models were initially applied in cross-sectional studies where aggregate units, such as countries, regions or states, are presumed to exhibit cross-sectional correlation. Regression models can account for spatial dependence in two ways: either by including a spatially lagged variable as an additional regressor (spatial lag model), or through the regression error term (spatial error model). The spatial error model is appropriate if shocks are correlated between regions. The spatial autocorrelation of the error term can potentially bias the estimation results and has to be corrected (Arbia, 2014).

$$\tilde{C}_{it} = \eta\tilde{Y}_{it} + u_{it} \text{ with } u_{it} = \lambda W u_t + \varepsilon_{it}, \tag{5}$$

In addition, the spatial lag model reflects that consumption is affected by the consumption levels in neighboring regions,

$$\tilde{C}_{it} = rW\tilde{C}_{it} + \eta\tilde{Y}_{it} + \varepsilon_{it}, \tag{6}$$

In both model types, W is a matrix containing the spatial weights. We use a *five-nearest-neighbor* matrix. The disturbances ε_{it} are assumed to be $IIN(0, \sigma_{\mu}^2)$. The weights matrix is created with a geo-dataset including longitudes and latitudes of the regions using the Stata package *spwmatrix* (Jeanty, 2010b). In order to create proportional weights and comparable spatial parameters, we row-standardize the weight matrix. Ord (1975) shows that estimators of spatial error models obtained by least squares are inconsistent and outlines a maximum likelihood estimator for spatial error models. The spatial error models (8) and (9) are therefore estimated by maximum-likelihood using the Stata package *spmlreg* (Jeanty, 2010a).

Despite significant progress in dynamic and spatial models, these streams of literature have so far developed largely independently. From an applied econometric point of view, this is an important drawback because there are numerous examples where the presence of a dynamic process and spatial dependence might occur (Kukenova and Monteiroz, 2009). Yu et al. (2008) and Belotti et al. (2016) propose a dynamic spatial lag model which applies the bias corrected quasi maximum likelihood approach,

$$\tilde{C}_{it} = \rho\tilde{C}_{it} + rW\tilde{C}_{it} + \eta\tilde{Y}_{it} + \varepsilon_{it}. \tag{7}$$

6.2 Risk Sharing Estimated with Spatial Models

Kolomak (2011) shows that growth rates of Russian regions are spatially correlated. Due to large distances between regions and poor-quality infrastructure, economic development of regions is found to be highly dependent on opportunities for economic cooperation among neighbors, besides initial economic conditions and resources. However, he also finds positive external effects of economic growth that spill over to other regions. While this is true for the western territories, eastern territories appear to experience mostly negative externalities. Fafchamps and Gubert (2007) apply spatial methods for estimating risk sharing, however in a very different context. They analyze interpersonal risk sharing networks in the rural Philippines controlling for spatial proximity of families. They find that geographic distance is relevant if the cost of sharing risk rises with increasing distance between households. Other than that, there is no study known to us that applies spatial methods in the context of risk sharing. Due to these findings, investigating the effect of spatial distances on interregional risk sharing in Russia is particularly interesting.

In all specifications for the level definition of risk sharing, using either spatial error (Table 4) or spatial lag models (Table 5), the spatial autoregressive parameters λ and ρ are significantly different from zero. This shows that spatial correlation between the regions is important. The income coefficients are again high in all spatial lag models, which also reflects regional correlations of consumption levels. According to this specification, the degree of income smoothing in this case remains relatively high at nearly 80 to 90 percent.

As in the previous analysis, the interaction terms remain largely insignificant. In the spatial lag model, only government size is negative and significant, while foreign investment and corporate loans are even positive and significant. In the spatial error model (Table 4), the time trend and oil price are significant and negative, while corporate loans are again positive and significant. However, the unexpectedly positive coefficients for these control variables have only a negligible impact on the level of estimated risk sharing.

Our analysis in this and in the previous section shows that both autoregressive dynamics and spatial correlation are important. The role of intertemporal and spatial correlation has been discussed only recently in applied economic research (Kancs et al., 2016). Therefore, we include both extensions in further sensitivity analysis. The results for a dynamic spatial lag model following Yu et al. (2008) and Belotti et al. (2016) show that spatial correlation dominates intertemporal dynamics, which become insignificant. The degree of risk sharing remains very high at 90 percent also for this method.[5]

[5] These results are available upon request from authors (see also Table A.5 in appendix).

7. Conclusions

We present a novel analysis of interregional consumption risk sharing in Russia using estimation methods which have not been applied in the risk sharing literature so far. The results are obtained using an extensive panel dataset on 75 Russian regions for the period between 1999 and 2009. In addition to the conventional fixed effects panel regressions, we apply difference and system GMM in order to reflect time dynamic properties and a spatial error model that controls for spatial dependence. We show that time and spatial interdependence are statistically important and that they should also potentially be reflected in the estimations of risk sharing for other countries and country groups.

Similarly to the previous literature (Skoufias, 2003, and Notten and de Crombrugghe, 2012), our results reveal that risk sharing in Russia is remarkably high. More than 70 to 90 percent of idiosyncratic income risk is smoothed across the regions. Taking dynamic properties in the data into account, we can show that regional consumption deviations are highly persistent, which, in a broader sense, is in line with permanent income hypothesis. The persistence is likely to reflect structural disparity across regions in terms of economic development. Moreover, the availability of personal and corporate loans is shown to be improving risk sharing as ex-post credit market smoothing is facilitated. While our key findings are robust to the exclusion of the main economic centers Moscow and Saint Petersburg, bank credit becomes insignificant if these two cities are excluded. A weaker credit market channel in income smoothing may indicate that shocks in the remaining regions are more persistent.

Moreover, we find spatial correlation to be important between the regions, confirming that Russian regions are strongly connected through numerous economic and structural links. However, controlling for spatial dependence does not have a substantial effect on risk sharing estimates either. A surprisingly high level of risk sharing is confirmed especially by the spatial lag model, which is reflecting a high degree of spatial interdependence in regional consumption patterns. Moreover, we can see that more control variables are significant if we account for spatial correlation.

Russia is strongly prone to macroeconomic risks as its economy is highly dependent on a small number of commodities. The exceptionally high degree of risk sharing between Russian regions may give some incentives for central and regional authorities to enhance economic diversification. From this perspective, the redistribution of oil revenues may constitute an accommodative tool seen as necessary by the state to smooth the massive gaps in economic development across regions. Hence, while risk sharing is exceptionally strong, it may support serious structural problems and deficiencies in terms of economic diversification.

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Appendix A

Table A.1: Variable Definitions and Descriptive Statistics

Label	Definition	Obs.	Mean	St. Dev.
C_{it}	Final household consumption per capita in logs	825	8.261	0.856
Y_{it}	Gross regional product per capita in logarithm	825	11.123	0.852
G_{it}	Government expenditure as a share of GRP	825	0.213	0.106
oil_{it}	Price of crude oil in dollars, Urals CIF Baltic	750	47.077	22.701
TFI_{it}	Total foreign investment as a share of GRP	866	1.784	4.008
FDI_{it}	Foreign direct investment as a share of GRP	752	0.716	2.898
LP_{it}	Personal loans as a share of GRP	860	0.067	0.057
LC_{it}	Corporate loans as a share of GRP	860	0.163	0.189
$\tilde{C}_{it}$	Consumption deviations from country average in logs	825	–0.305	0.473
$\Delta\tilde{C}_{it}$	Consumption deviations from average in first differences	750	–0.001	0.088
$\tilde{Y}_{it}$	Output deviations from country average in logs	825	–0.289	0.588
$\Delta\tilde{Y}_{it}$	Output deviations from average in first differences	750	–0.007	0.087
$\tilde{Y}_{it} \times G_{it}$	Interaction term of output deviation and government size	825	–0.079	0.170
$\tilde{Y}_{it} \times Oil_{it}$	Interaction term of output deviations and the oil price	750	–14.595	32.536
$\tilde{Y}_{it} \times TFI_{it}$	Interaction term of output deviations and TFI	770	0.209	2.648
$\tilde{Y}_{it} \times FDI_{it}$	Interaction term of output deviations and FDI	752	0.086	1.522
$\tilde{Y}_{it} \times LP_{it}$	Interaction term of output deviations and personal loans	750	–0.030	0.055
$\tilde{Y}_{it} \times LC_{it}$	Interaction term of output deviations and corporate loans	750	–0.062	0.211
$\tilde{Y}_{it} \times Trend_t$	Interaction term of output deviations and time trend	825	–0.105	2.048

All variables are calculated at the regional level.
Source: own estimation.

Table A.2: Correlation matrix for model variables

	$\tilde{C}_{it}$	$\tilde{Y}_{it}$	G_{it}	CPI_{it}	Oil_{it}	TFI_{it}	FDI_{it}	LP_{it}
$\tilde{Y}_{it}$	0.838							
G_{it}	0.016	–0.166						
PV_{it}	–0.241	–0.215	–0.030					
oil_{it}	0.689	0.506	0.177	–0.307				
TFI_{it}	0.197	0.261	–0.111	–0.100	0.059			
FDI_{it}	0.067	0.131	–0.072	–0.063	0.012	0.832		
LP_{it}	0.523	0.249	0.309	–0.276	0.058	–0.078	–0.079	
LC_{it}	0.506	0.230	0.228	–0.147	0.163	–0.029	–0.107	0.598

Source: own estimation.

Table A.3: Consumption Risk Sharing, Difference GMM

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\tilde{C}_{it-1}$	0.771***	0.718***	0.705***	0.689***	0.840***	0.818y	0.567***	0.499***
	(0.126)	(0.122)	(0.117)	(0.111)	(0.094)	(0.099)	(0.158)	(0.072)
$\tilde{Y}_{it}$	0.131*	0.078	0.165**	0.112	0.186**	0.149	–0.080	0.128
	(0.079)	(0.084)	(0.069)	(0.076)	(0.076)	(0.095)	(0.151)	(0.234)
$\tilde{Y}_{it} \times G_{it}$		0.018						
		(0.108)						
$\tilde{Y}_{it} \times Oil_{it}$			–0.001**					
			(0.000)					
$\tilde{Y}_{it} \times Trend_t$				–0.007**				
				(0.003)				
$\tilde{Y}_{it} \times TFI_{it}$					–0.008**			
					(0.004)			
$\tilde{Y}_{it} \times FDI_{it}$						–0.015**		
						(0.006)		
$\tilde{Y}_{it} \times LP_{it}$							–1.369**	
							(0.644)	
$\tilde{Y}_{it} \times LC_{it}$								–0.499***
								(0.182)
No. of obs.	675	675	675	675	620	599	675	675
No. of regions	75	75	75	75	73	72	75	75
Hansen *p*-value	0.636	0.900	0.796	0.647	0.972	0.614	0.145	0.242
AR(1) *p*-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AR(2) *p*-value	0.186	0.199	0.165	0.187	0.561	0.491	0.272	0.734
Implied risk sharing	86.9%	92.6%	78.8%	88.9%	80.0%	84.0%	98.9%	79.1%

Notes: *, ** and *** indicate statistical significance at the 10 per cent level, 5 per cent level, and 1 per cent level. Robust standard errors are given in parentheses. Time and region effects as well as the control variables without interaction are included in the estimations but not reported. The endogenous variables include risk sharing, income deviations and income interacted with the control variables. The instruments include between 1 and 6 lags depending on specification.

Table A.4: Consumption Risk Sharing, Han-Phillips-Estimator

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\tilde{C}_{it-1}$	0.859***	0.852***	0.890***	0.855***	0.932***	0.934***	0.957***	0.977***
	(0.116)	(0.121)	(0.120)	(0.116)	(0.118)	(0.117)	(0.131)	(0.122)
$\tilde{Y}_{it}$	0.101**	0.096**	0.118**	0.101**	0.124***	0.118***	0.103**	0.097**
	(0.039)	(0.048)	(0.049)	(0.039)	(0.043)	(0.044)	(0.049)	(0.044)
$\tilde{Y}_{it} \times G_{it}$		0.126						
		(0.096)						
$\tilde{Y}_{it} \times Oil_{it}$			0.000					
			(0.000)					
$\tilde{Y}_{it} \times Trend_t$				–0.001				
				(0.008)				
$\tilde{Y}_{it} \times TFI_{it}$					0.002			
					(0.003)			
$\tilde{Y}_{it} \times FDI_{it}$						0.002		
						(0.005)		
$\tilde{Y}_{it} \times LP_{it}$							0.385	
							(0.438)	
$\tilde{Y}_{it} \times LC_{it}$								0.131*
								(0.079)
No. of obs.	750	750	750	750	699	683	750	750
No. of regions	75	75	75	75	74	74	75	75
Log-Likelihood	849.293	847.663	835.766	852.736	814.441	797.676	744.627	801.863
Implied risk sharing	89.9%	93.1%	86.2%	89.9%	87.9%	88.4%	92.3%	92.4%

Notes: *, ** and *** indicate statistical significance at the 10 per cent level, 5 per cent level, and 1 per cent level. Standard errors are given in parentheses. Time and region effects as well as the control variables without interaction are included in the estimations but not reported.

Table A.5: Consumption Risk Sharing in Levels, Dynamic Spatial Lag Model

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\tilde{C}_{it-1}$	–0.075*	–0.079*	–0.076*	–0.078*	–0.041	–0.046	–0.076*	–0.102*
	(0.045)	(0.045)	(0.045)	(0.045)	(0.053)	(0.053)	(0.044)	(0.054)
$\tilde{Y}_{it}$	0.071	0.049	0.012	0.063	0.067	0.070	0.050	0.110**
	(0.044)	(0.071)	(0.108)	(0.048)	(0.050)	(0.048)	(0.088)	(0.051)
$\tilde{Y}_{it} \times G_{it}$		0.119						
		(0.263)						
$\tilde{Y}_{it} \times Oil_{it}$			0.001					
			(0.002)					
$\tilde{Y}_{it} \times Trend_{t}$				0.017				
				(0.017)				
$\tilde{Y}_{it} \times TFI_{it}$					0.004			
					(0.007)			
$\tilde{Y}_{it} \times FDI_{it}$						–0.000		
						(0.005)		
$\tilde{Y}_{it} \times LP_{it}$							0.298	
							(0.899)	
$\tilde{Y}_{it} \times LC_{it}$								–0.023
								(0.147)
rho	0.122***	0.123***	0.119***	0.116***	0.082*	0.075*	0.117***	0.108**
	(0.040)	(0.040)	(0.040)	(0.040)	(0.045)	(0.044)	(0.043)	(0.043)
sigma	0.007***	0.007***	0.007***	0.007***	0.006***	0.006***	0.007***	0.007***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
No of obs.	648	648	648	648	549	549	648	648
No of cross sections	72	72	72	72	61	61	72	72
Log-Likelihood	710.4	710.9	710.6	711.2	650.2	651.9	710.9	721.2
Implied risk sharing	92.9%	97.6%	103.5%	93.5%	94.0%	93.0%	97.0%	88.6%

Notes: *, ** and *** indicate statistical significance at the 10 per cent level, 5 per cent level, and 1 per cent level. Robust standard errors are given in parentheses. Weight matrix is defined for three closest neighbors. Time effects, regional fixed effects, and control variables without interaction are included in the estimations but not reported.