Incomplete Intertemporal Consumption Smoothing and Incomplete Risksharing

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- Abstract

This paper develops a theory-based method to estimate jointly the degree of intertemporal consumption smoothing and the degree of international/interregional risksharing. This approach improves upon studies that either examine only intertemporal consumption smoothing, or analyze risksharing by making an extreme assumption on intertemporal consumption smoothing, or by adopting a purely empirical framework. The method is applied to the US states and OECD and EU countries to analyze how the degrees of risksharing and intertemporal consumption smoothing differ within a country and across countries. The empirical results suggest that: 1) regardless of the assumption on the degree of intertemporal consumption smoothing, the degree of risksharing within a country is larger than across countries 2) the degree of intertemporal consumption smoothing within a country is also larger than across countries, contrary to the findings of past channel studies. Finally, this paper also provides some foundations and suggests limitations of the empirical literature on channels of risksharing and intertemporal consumption smoothing.

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1. Introduction

Empirical studies on risksharing have grown rapidly in recent years. The formal literature started by testing the null hypothesis of full risksharing at various aggregation levels, such as among individuals in a village (Townsend 1994), households (Mace 1991, Cochrane 1991, Altug and Miller 1990, Hayashi, Altonji and Kotlikoff 1996), countries (Canova and Ravn 1996, Lewis 1996).[1] These seminal papers, which were essentially based on regressions of consumption on income (and possibly other idiosyncratic variables), often controlling for aggregate consumption. originated two strands of macroeconomic literature. One line of research — firmly based on theoretical foundations — has allowed for the possibility of incomplete risksharing and has focused on its precise measurement (e.g. Obstfeld 1994, Crucini, 1999, Athanasoulis and van Wincoop, 2001, Hess and Crucini, 2000). These studies usually focus on the degree of risksharing across regions (mutual insurance across states of nature against idiosyncratic regional risks, ex ante), but many of them pay less attention to the degree of intertemporal consumption smoothing of the region (diversification of idiosyncratic consumption changes across time, ex post). For example, Athanasoulis and van Wincoop (2001) have performed estimations of the degree of risksharing, assuming away intertemporal consumption smoothing. Other studies have assumed an extreme degree of intertemporal consumption smoothing either by taking the permanent income hypothesis to hold fully (Crucini, 1999, and Crucini and Hess, 2000), or by postulating no intertemporal consumption smoothing altogether (Obstfeld, 1994, 1995).

A second line of work has concentrated on measuring the contribution to risksharing — possibly incomplete — of various risksharing channels (Asdrubali, Sørensen and Yosha 1996, Sørensen and Yosha, 1998, Mélitz and Zumer, 1999, Dedola, Usai and Vannini 1999, Del Negro 1998, Asdrubali and Kim, 2002. An important contribution of these papers has been the distinction between risksharing and intertemporal smoothing. However, by adopting a purely empirical framework, these analyses have not provided theoretical underpinnings to their empirical models.

This paper wields together these two major strands of the empirical risksharing literature, by developing a method that jointly estimates the degree of risksharing and the degree of intertemporal consumption smoothing, and that is rigorously derived from risksharing and intertemporal consumption smoothing theory. The paper also identifies the major econometric differences between the two approaches, and provides rationales for either choice. Like many other papers of both lines of research, we apply our method to three regions — the US states, the OECD countries, and the EU countries — in order to provide a possible rationalization for the failure of the full risksharing hypothesis by comparing intra vs. international risksharing and intertemporal consumption smoothing, and to shed a light on the cost of the European monetary unification process.

Our methodology improves upon each line of research. As for the former strand of the literature, a method of estimating the degree of risksharing without paying much

[1] Informal tests of full risksharing using cross-country income and consumption correlations were pioneered by Backus, Kehoe and Kydland (1992), and spurred a vast "cross-correlations" literature.

attention to the degree of intertemporal consumption smoothing is likely to provide a biased estimate since the two mechanisms are inter-related and the estimate of the degree of risksharing may depend on the assumption on the degree of intertemporal smoothing. Second, by paying attention to intertemporal consumption smoothing as well as to risksharing we contribute to clarify such practical issues as the costs of a monetary union. In fact, the role of regional macro policy, in particular, monetary policy, which is at the center of the debate on the costs of a monetary union, can be thought of as an intertemporal consumption smoothing mechanism that provides stabilization over time. Therefore, not only the role of automatic stabilization mechanisms — such as risksharing ex ante through portfolio diversification or via fiscal stabilizers — but also an intertemporanl consumption smoothing mechanism – intertemporal international lending and borrowing – becomes crucial, and its precise measurement bears paramount implications for the design of EU nstitutions. Assuming an extreme degree of intertemporal smoothing thus obscures the true costs and benefits of monetary unification. As for the latter strand of the literature, we provide a theoretical foundation of studies on channels of risksharing and consumption smoothing (e.g., Asdrubali, Sørensen, and Yosha, 1996, Sørensen and Yosha, 1998, and Mélitz and Zumer, 2000), which — albeit widely recognized as a useful first cut to smoothing measurement — have not been based on explicit links to theory. In addition, we suggest some limitations encountered by those studies.

Finally, there is much recent work that focuses on intertemporal consumption smoothing, for example, Hall (1978), Campbell and Deaton (1989), Campbell and Mankiw (1990), Deaton (1992), and Østergaard, Sørensen, and Yosha (2002). Among them, just few very recent studies such as Sørensen and Yosha (2000) and Bayoumi and Klein (1997) have investigated the degree of intertemporal consumption smoothing within a country vs. across countries. From the viewpoint of these analyses, we develop a method to estimate the degree of risksharing, in addition to the degree of intertemporal consumption smoothing.

The test of intertemporal consumption smoothing and the test of risksharing often involve a similar set of variables, for example, consumption as a dependent variable and income as an independent variable. As a result, it is likely that estimating one side often turns out to be actually estimating the other side also. For example, sometimes a study intends to estimate the degree of intertemporal consumption smoothing, but the estimate may reflect in part the degree of risksharing.[2] This study offers one way to disentangle intertemporal consumption smoothing from risksharing in a unified framework.

The rest of the paper is organized as follows. Section 2 develops a method to estimate the degree of risksharing and the degree of intertemporal consumption smoothing. Section 3 extends the framework to provide a connection with the channel literature. Section 4 reports the estimation results. Finally, Section 5 concludes with a summary of findings.

[2] For example, *as argued by* Sørensen and Yosha (2000) that Bayoumi and Klein (1997) intended to estimate the degree of intertemporal consumption smoothing only, but they ended up with a measure of the degree of intertemporal consumption smoothing and risksharing combined.

2. Incomplete Risk Sharing and Incomplete Intertemporal consumption Smoothing

Consider possibly incomplete risksharing among J regions in a country (or among J countries in the world). Each region j sells a fraction λ of its income stream Y_j in exchange for a claim to the pooled income streams of all J regions.[3] The total date t amount in the pool of the country (or the average of the regional income in the country) is $Y_t \equiv \frac{1}{J}\sum_{j=1}^{J} Y_{jt}$. The flow of regional income after risk pooling is

$$\overline{Y}_{jt} \equiv \lambda Y_t + (1-\lambda) Y_{jt}. \tag{2.1}$$

Regional income after risksharing is equal to its own income stream when λ is 0 (no risksharing), and to the income stream of the pool when λ is 1 (full risksharing). When λ is between 0 and 1 (partial risksharing), regional income after risksharing is a weighted average of its own income stream and of the income stream of the pool.

Further consider possibly incomplete intertemporal consumption smoothing of each region j. In each region, there are two groups of agents. Agents in the first group consume their current income while agents in the second group consume their permanent income.[4] The total income (after risksharing) of all agents in the second group is assumed to be a fraction, γ, of the total income (after risksharing) of the region j, $\overline{Y}_{jt}$. Then, the change in consumption of region j is

$$\triangle C_{jt} = \mu + (1-\gamma)\triangle \overline{Y}_{jt} + \gamma \overline{\varepsilon}_{jt} \tag{2.2}$$

where $\overline{\varepsilon}_{jt} \equiv (1-\beta)\sum_{k=0}^{\infty} \beta^k \left[E_t \overline{Y}_{jt+k} - E_{t-1}\overline{Y}_{jt+k}\right]$ is the change in consumers' estimate of their permanent income from $t-1$ to t, which we will call the innovation in permanent income.[5] The regional consumption change is equal to its current income change when γ is 0 (no intertemporal consumption smoothing), and to the innovation in permanent income when γ is 1 (full intertemporal consumption smoothing). When γ is between 0 and 1 (partial intertemporal consumption smoothing), the regional consumption change is a weighted average of its current income change and the innovation in permanent income. Averaging the changes in consumption of all regions leads to the expression for the changes in consumption of the country (or the average of the regional consumption changes in the country).

$$\triangle C_t \equiv \frac{1}{J}\sum_{j=1}^{J} \triangle C_{jt} = \mu + (1-\gamma)\triangle Y_t + \gamma \varepsilon_t \tag{2.3}$$

where $\varepsilon_t \equiv \frac{1}{J}\sum_{j=1}^{J} \overline{\varepsilon}_{jt}$.

Using equations (2.1), (2.2), and (2.3), the change in regional consumption is

[3] The same λ is assumed for each region in a country (though in reality λ may be different across countries) since it is not so easy to identify a different λ for each region. Refer to Crucini (1999).

[4] Agents in the second group are assumed to smooth consumption by borrowing or lending at a fixed exogenous real interest rate.

[5] Refer to Flavin (1981) and Campbell and Mankiw (1990) for the derivation.

$$\triangle C_{jt} = \mu(1-\lambda) + \lambda \triangle C_t + (1-\gamma)(1-\lambda) \triangle Y_{jt} + \eta_{jt} \tag{2.4}$$

where $\eta_{jt} \equiv \gamma(\overline{\varepsilon}_{jt} - \lambda \varepsilon_t) = \gamma(1-\lambda)\varepsilon_{jt}$ and $\varepsilon_{jt} \equiv (1-\beta)\sum_{k=0}^{\infty}\beta^k [E_t Y_{jt+k} - E_{t-1} Y_{jt+k}]$. The change in regional consumption is a weighted average of the changes in aggregate consumption, the changes in regional income (before risksharing), and the innovation in permanent income (before risksharing). λ shows the degree of interregional risksharing while γ indicates the degree of intertemporal consumption smoothing. As λ goes to 1, the change in regional consumption is closer to the change in aggregate consumption and risksharing is larger. As γ goes to 1 when λ is less than 1, the change in regional consumption depends more on the innovations in regional permanent income and intertemporal consumption smoothing is larger. When λ and γ both go to 0, the change in regional consumption is closer to the change in current regional income, which implies that risk sharing and consumption smoothing are closer to null. Observe that full risksharing ($\lambda = 1$) implies that intertemporal consumption smoothing is automatically achieved in the sense that an Euler condition is satisfied regardless of the value of γ;[6] this is why γ does not show up in (2.4) when $\lambda = 1$ (because the third term disappears).. On the contrary, full intertemporal consumption smoothing ($\gamma = 1$) does not imply that risksharing is automatically achieved, in the sense that regional consumption is not necessarily proportional to aggregate consumption; this is why λ still shows up in (2.4) when $\gamma = 1$ (the second term). Taking account of this asymmetry between risksharing and intertemporal smoothing is another value added of our formulation.

The equation (2.4) can be viewed as an advanced form of risksharing test that allows partial intertemporal consumption smoothing. Past studies such as Obstfeld (1994, 1995) consider a variant of the $\gamma = 0$ case (no intertemporal consumption smoothing), by including the change in current income as a regressor without considering the innovations in permanent income. Obstfeld (1994) estimated the following type of equation:

$$\triangle C_{jt} = \alpha + \alpha_1 \triangle C_t + \alpha_2 \triangle Y_{jt} + e_{jt} \tag{2.5}$$

Note that by assuming $\gamma = 0$ (no intertemporal consumption smoothing), equation (2.4) reduces to the following equation.

$$\triangle C_{jt} = \mu(1-\lambda) + \lambda \triangle C_t + (1-\lambda) \triangle Y_{jt} \tag{2.6}$$

which is the same as (2.5) with the additional condition $\alpha_1 + \alpha_2 = 1$.[7] Therefore, Obstfeld (1994) essentially assumed no intertemporal consumption smoothing. The equations (2.5) and (2.6) can be estimated without using instruments.

On the other hand, other papers such as Crucini (1999) and Crucini and Hess (2000) examined the case of $\gamma = 1$ (perfect intertemporal consumption smoothing)

[6] See, for example, Sorensen and Yosha (1998) for a formal proof.
[7] e_{jt} can be interpreted as region specific preference shocks.

by including the innovation in permanent income without considering the change in current income. Crucini (1999) estimated the following type of equation.

$$\triangle C_{jt} = \alpha_1 \triangle C_t + (1 - \alpha_1) \triangle YP_{jt} + e_{jt} \tag{2.7}$$

where $\triangle YP_{jt}$ $(= \varepsilon_{jt})$ is the innovation in permanent income. Note that equation (2.4) reduces to this equation by assuming $\gamma = 1$ (and $\mu = 0$). By assuming and estimating various stochastic processes for Y_{jt}, Crucini (1999) constructs YP_{jt}, and then estimates the equation (2.7) by OLS.

If Y_{jt} follows a random walk such as $\triangle Y_{jt} = \nu_{jt}$ where ν_{jt} is i.i.d., then all methods are similar (when estimating the degree of risksharing) since permanent income changes and current income changes are equal and it does not matter whether we use the former, the latter or a weighted average of the two as regressors. Specifically, all equations reduce to[8]

$$\triangle C_{jt} = \alpha + \lambda \triangle C_t + (1 - \lambda) \triangle Y_{jt} + e_{jt}. \tag{2.8}$$

However, realistically, Y_{jt} may follow a more general process. First, changes in regional income may depend on past changes in regional income. In fact, several studies, such as Campbell and Mankiw (1990), Campbell and Deaton (1989), and Deaton (1992), suggest that income changes do depend on past income changes. In this regard, we estimate the auto-correlation of Y_{jt} for each region. The average of the estimated auto-correlation of regional income is 0.32 for the US states, 0.29 for OECD countries, and 0.30 for EU countries; the dependence is non-trivial. Second, changes in regional income may be affected by other variables, for example, changes in aggregate income.

As an illustration, let us assume an AR-1 process for regional income changes, that is, $\triangle Y_{jt} = \rho \triangle Y_{jt-1} + \nu_{jt}$, where $0 < \rho < 1$, and examine how equations (2.4) and (2.7) diverge. Under the assumed income process, $\triangle YP_{jt} = \varepsilon_{jt} = \frac{1}{1-\rho} \triangle Y_{jt}$; therefore, equation (2.4) becomes

$$\triangle C_{jt} = \mu(1 - \lambda) + \lambda \triangle C_t + (1 - \lambda) \left((1 - \gamma) + \frac{\gamma}{1 - \rho} \right) \triangle Y_{jt} \tag{2.9}$$

Thus assuming full intertemporal consumption smoothing ($\gamma = 1$) as in Crucini (1999) and Crucini and Hess (2001) is likely to provide a different estimate of λ than our model allowing for partial intertemporal consumption smoothing (that is, without restricting the value of λ γ as 1). Notice that our specification remains the same, regardless of the stochastic process followed by regional income.

The equation (2.4) can be estimated by an instrumental variables (IV) approach. The error term η_{jt}, a function of the innovations in permanent income, is orthogonal to lagged variables but not necessarily to current independent variables such as $\triangle Y_{jt}$

[8]The following additional conditions are needed: $e_{jt} = 0$ for equation (2.4), $\alpha = 0$ for equation (2.7), and $\alpha_1 + \alpha_2 = 1$ for equation (2.5).

and $\triangle C_t$. The change in regional income, $\triangle Y_{jt}$, is likely to be correlated to ε_{jt} when the changes in regional income are persistent. The change in aggregate consumption, $\triangle C_t$ may be correlated with ε_{jt}; both aggregate consumption and regional permanent income are likely to be correlated with aggregate permanent income.

We use lagged values of $\triangle Y_{it}$, $\triangle Y_t$, $\triangle C_{it}$, $\triangle C_t$, S_{it} and S_t — where $S = Y - C$ — as instruments. Own lagged variables are good predictors. In addition, as Campbell (1987) and Campbell and Mankiw (1990) suggested, the history of consumption may be a good predictor for income, and income and consumption may be cointegrated. Therefore, we use lagged values of $\triangle C_{it}$ and S_{it}. On the other hand, since lagged income and saving may be good predictors for consumption, lagged values of $\triangle Y_t$ and S_t are also used. We include at least the second and the third lags of the instruments. Following Crucini (1999), the model is estimated for each region, and the averages of the point estimates and their standard errors are reported; a pooled regression would give a near zero estimate of the coefficient on the aggregate consumption since the aggregate consumption (or the average consumption) is regressed on individual consumption. In each estimation, the values of λ and γ are restricted to be no larger than 1 and no smaller than 0.[9] We estimate the model using log-level difference (instead of level difference) following recent studies such as Crucini (1999), Crucini and Hess (2000), Asdrubali, Sørensen, and Yosha (1996), and Sørensen and Yosha (1998). Refer to Crucini (1999) and Campbell and Mankiw (1990), which showed that a similar log-level representation can be obtained by approximation.

3. Alternative Method and Connections to the Channels Literature

The previous section shows a useful way to estimate the degree of risksharing and intertemporal consumption smoothing jointly when data on only (before-risksharing) income and consumption are available. In this section, we discuss an alternative procedure to estimate the degree of risksharing and intertemporal smoothing when data on intermediate measures of income, for example, income after risksharing, is available. We also connect the current method to studies on channels of risksharing and consumption smoothing, for example Asdrubali, Sørensen, and Yosha (1996) and Sørensen and Yosha (1998), that exploited such types of data.

From equation (2.1),

$$(\triangle Y_{jt} - \triangle Y_t) - \left(\triangle \overline{Y}_{jt} - \triangle Y_t\right) = \lambda \left(\triangle Y_{jt} - \triangle Y_t\right) \tag{3.1}$$

By using equations (2.2) and (2.3),

$$\left(\triangle \overline{Y}_{jt} - \triangle Y_t\right) - \left(\triangle C_{jt} - \triangle C_t\right) = \gamma \left(\triangle \overline{Y}_{jt} - \triangle Y_t\right) - \eta_{jt}. \tag{3.2}$$

[9] In a few cases, we found implausibly large and small values that change the average dramatically, so we restrict the values of λ and γ. We also experimented by restricting the values between -1 and 2, but the results are not much different.

where $\eta_{jt} = \gamma\left(\bar{\varepsilon}_{jt} - \varepsilon_t\right) = \gamma\left(1-\lambda\right)\left(\varepsilon_{jt} - \varepsilon_t\right)$. Therefore, if data on regional income after risksharing $(\overline{Y}_{jt})$ is available, λ and γ can be gauged by estimating equations (3.1) and (3.2). Equations (3.1) and (3.2) can be estimated by an OLS and an IV approach, respectively.

In addition to the degree of intertemporal consumption smoothing, past studies such as Asdrubali, Sørensen and Yosha (1996), Sørensen and Yosha (1998), and Athanasoulis and van Wincoop (2001) analyze the role of two risksharing channels — financial diversification and fiscal stabilizers — by constructing a measure of income after only capital market risksharing (by using net factor income data) and a measure of income after both types of risksharing (by using government net transfers data). The current framework can be extended to multiple channels of risksharing if data on various measures of income are available.

Assume that $\lambda = \lambda_1 + \lambda_2$, where λ_1 is the degree of risksharing achieved by the financial market and λ_2 is the degree of risksharing achieved by fiscal policy. Then, the flow of regional income after risksharing through both channels is

$$\overline{Y}_{jt} \equiv \left(\lambda_1 + \lambda_2\right) Y_t + \left(1 - \lambda_1 - \lambda_2\right) Y_{jt}. \tag{3.3}$$

We can also define the flow of regional income after risksharing only through financial market as

$$\widetilde{Y}_{jt} \equiv \lambda_1 Y_t + \left(1 - \lambda_1\right) Y_{jt}. \tag{3.4}$$

From the above two equations,

$$\overline{Y}_{jt} \equiv \widetilde{Y}_{jt} + \lambda_2 \left(Y_t - Y_{jt}\right). \tag{3.5}$$

Then, from equations (3.4) and (3.5),

$$\begin{aligned} \left(\triangle Y_{jt} - \triangle Y_t\right) - \left(\triangle \widetilde{Y}_{jt} - \triangle Y_t\right) &= \lambda_1 \left(\triangle Y_{jt} - \triangle Y_t\right) & (3.6) \\ \left(\triangle \widetilde{Y}_{jt} - \triangle Y_t\right) - \left(\triangle \overline{Y}_{jt} - \triangle Y_t\right) &= \lambda_2 \left(\triangle Y_{jt} - \triangle Y_t\right) & (3.7) \end{aligned}$$

Therefore, channels of risksharing can be estimated sequentially, as in Asdrubali, Sørensen, and Yosha (1996) or Sørensen and Yosha (1998).

Now we compare the current method to that in Asdrubali, Sørensen, and Yosha (1996) and Soresen and Yosha (1998). They estimated the following equation system.

$$\begin{aligned} \triangle Y_{jt} - \triangle \widetilde{Y}_{jt} &= \alpha_{1t} + \beta_1 \triangle Y_{jt} + e_{1t} & (3.8) \\ \triangle \widetilde{Y}_{jt} - \triangle \overline{Y}_{jt} &= \alpha_{2t} + \beta_2 \triangle Y_{jt} + e_{2t} & (3.9) \\ \triangle \overline{Y}_{jt} - \triangle C_{jt} &= \alpha_{3t} + \beta_3 \triangle Y_{jt} + e_{3t} & (3.10) \\ \triangle C_{jt} &= \alpha_{4t} + \beta_4 \triangle Y_{jt} + e_{4t}. & (3.11) \end{aligned}$$

where $\alpha_{.t}$ is a time fixed effect. Then, they interpreted β_1, β_2, and β_3 as the degree of risksharing provided by financial markets, by fiscal policy, and the degree of intertemporal consumption smoothing.

Our corresponding system of equations is:

$$\begin{aligned} (\triangle Y_{jt} - \triangle Y_t) - \left(\triangle \widetilde{Y}_{jt} - \triangle Y_t\right) &= \lambda_1 (\triangle Y_{jt} - \triangle Y_t) && (3.12) \\ \left(\triangle \widetilde{Y}_{jt} - \triangle Y_t\right) - \left(\triangle \overline{Y}_{jt} - \triangle Y_t\right) &= \lambda_2 (\triangle Y_{jt} - \triangle Y_t) && (3.13) \\ \left(\triangle \overline{Y}_{jt} - \triangle Y_t\right) - (\triangle C_{jt} - \triangle C_t) &= \gamma \left(\triangle \overline{Y}_{jt} - \triangle Y_t\right) + \eta_{jt} && (3.14) \end{aligned}$$

By reorganizing the equations,

$$\begin{aligned} \triangle Y_{jt} - \triangle \widetilde{Y}_{jt} &= -\lambda_1 \triangle Y_t + \lambda_1 \triangle Y_{jt} && (3.15) \\ \triangle \widetilde{Y}_{jt} - \triangle \overline{Y}_{jt} &= -\lambda_2 \triangle Y_t + \lambda_2 \triangle Y_{jt} && (3.16) \\ \triangle \overline{Y}_{jt} - \triangle C_{jt} &= (1-\gamma) \triangle Y_t - \triangle C_t + \gamma \triangle \overline{Y}_{jt} - \eta_{jt} && (3.17) \\ &= -\gamma \triangle Y_t + \gamma \triangle \overline{Y}_{jt} - \eta_{jt}, \text{ if } \triangle Y_t = \triangle C_t \end{aligned}$$

where $\eta_{jt} = \gamma (\overline{\varepsilon}_{jt} - \varepsilon_t) = \gamma (1-\lambda) (\varepsilon_{jt} - \varepsilon_t)$.

By comparing equations (3.8) and (3.9) with equations (3.12) and (3.13) or equations (3.15) and (3.16), we can see that the procedure to estimate the degree of risksharing is very similar.[10] The main difference comes from the procedure to estimate the degree of intertemporal consumption smoothing. First, in past studies $\triangle Y_{jt}$ is used as a regressor but $\triangle \overline{Y}_{jt}$ is used as a regressor in the current setup. Intuitively, consumers smooth consumption given income after risksharing, rather than given income before risksharing. Therefore, past studies' estimates of β_3 can be regarded as the correct estimate of the degree of intertemporal consumption smoothing only if risksharing is null ($\lambda = 0$). To infer how the results would be biased if we used income before risksharing, we further modify equation (3.13) by using equation (2.1).

$$\begin{aligned} \triangle \overline{Y}_{jt} - \triangle C_{jt} &= (1 - \gamma + \gamma\lambda) \triangle Y_t - \triangle C_t + \gamma (1-\lambda) \triangle Y_{jt} - \eta_{it} && (3.18) \\ &= (-\gamma + \gamma\lambda) \triangle Y_t + \gamma (1-\lambda) \triangle Y_{jt} - \eta_{it}, \text{ if } \triangle Y_t = \triangle C_t. && (3.19) \end{aligned}$$

The above equation suggests that the results would be biased downward if there was non-zero risksharing; the more risksharing there is, the larger the downward bias. Second, in the current set up, IV estimation may be more appropriate since the error terms may be correlated with the regressor. In other words, past studies do not allow the possibility that consumption may depend on permanent income or the possibility that current income may be different from permanent income.

[10] The aggregate income change in equations (3.15), (3.16), and (3.17) can be captured in the time-fixed effect in equations (3.8), (3.9), and (3.10). In fact, Asdrubali, Sorensen, and Yosha (1996) stated that the time fixed effect is introduced to control the aggregate effect.

We estimate equations (3.12), (3.13), and (3.14) by running a pooled regression. The first two equations are estimated by OLS while the last equation is estimated by IV methods. As instruments, we use own lagged variables, lagged values of $\triangle C_{jt} - \triangle C_t$, lagged values of $\triangle Y_{jt} - \triangle Y_t$, lagged values of $\triangle \widetilde{Y}_{jt} - \triangle Y_t$, and lagged values of various definitions of saving, $S_{jt} - S_t$, $S^1_{jt} - S^1_t$, and $S^2_{jt} - S^2_t$ ($S_{jt} = Y_{jt} - C_{jt}$, $S^1_{jt} = \widetilde{Y}_{jt} - C_{jt}$, and $S^2_{jt} = \overline{Y}_{jt} - C_{jt}$,). We include at least the second and the third lags of the instruments.

The two methods of estimating the degree of risksharing and the degree of intertemporal consumption smoothing are complementary. The first method, represented by equation (2.4), can be implemented without data on income after risksharing, but may be subject to the multi-collinearity problem (if $\triangle C_t$ and $\triangle Y_{jt}$ are correlated). On the other hand, the second method, represented by equations (3.12), (3.13), and (3.14), can avoid the multi-collinearity problem but is problematic in the absence or poor quality of data on income after risksharing.

4. Empirical Results

We estimate both models by using annual data for 50 US states (1963-1990, annual data) and 22 OECD and 15 EU countries (1960-1990, annual data). For data sources and details on data construction, refer to Asdrubali, Sørensen, and Yosha (1996) and Asdrubali and Kim (2002). Table 4.1 shows the results of estimating equation (2.4). We report the results of using 2-3 lags, 2-4 lags, and 2-5 lags of the instruments (for saving, only the second lag is used in all cases) in Table 4.1. Since the constant term, $\boldsymbol{\mu}$, often turns out to be statistically insignificant, we also estimate the model by assuming $\boldsymbol{\mu} = \mathbf{0}$.

First, the degree of risksharing is higher among the US states than across the OECD countries; the estimated λ is 0.53-0.65 for US states but 0.38-0.51 for the OECD countries and 0.41-0.58 for the EU countries. This result is consistent with the past studies that find a higher degree of risksharing within a country than across countries, for example, Sørensen and Yosha (1998), Asdrubali and Kim (2002), Crucini and Hess (2000), and Crucini (1999).

Second, the degree of intertemporal consumption smoothing is also higher in the US states than that in the OECD countries and in the EU countries; the estimated $\boldsymbol{\gamma}$ is 0.32-0.45 for the US but 0.10-0.22 for the OECD and 0.13-0.21 for the EU.

To compare our method to that used in past studies, we estimate equation (2.6) ("Obstfeld"), equation (2.6) with $\mu = 0$ or equation (2.8) with $\alpha = 0$ ("Crucini, RW"), equation (2.9) with $\gamma = 1$ ("Crucini, AR-1"), and equation (2.9) with $0 \leq \gamma \leq 1$ ("General, AR-1"). For the last two estimations, we first estimate ρ, then use the estimate in the main regression. Table 4.2. reports the estimate for λ in each case.

The method assuming no intertemporal consumption smoothing ("Obstfeld" or "Crucini, RW") tends to give a higher estimate of λ for both, and more for the US state case. The method assuming full intertemporal consumption smoothing ("Crucini, RW" and "Crucini, AR-1") also gives a higher estimate for both. The method allowing possibility of partial intertemporal consumption smoothing under the assumption that

Region	**instruments**	$\boldsymbol{\mu}$	$\boldsymbol{\gamma}$	$\boldsymbol{\lambda}$
US	2,3 lags	-0.02 (0.10)	0.41 (0.23)	0.53 (0.18)
US	2,3 lags		0.45 (0.27)	0.65 (0.17)
US	2-4 lags	-0.05 (0.42)	0.40 (0.25)	0.63 (0.19)
US	2-4 lags		0.34 (0.20)	0.64 (0.18)
US	2-5 lags	0.02 (0.21)	0.36 (0.21)	0.62 (0.22)
US	2-5 lags		0.32 (0.20)	0.64 (0.19)
OECD	2,3 lags	0.003 (0.010)	0.17 (0.08)	0.51 (0.15)
OECD	2,3 lags		0.16 (0.15)	0.50 (0.12)
OECD	2-4 lags	0.004 (0.008)	0.22 (0.10)	0.46 (0.15)
OECD	2-4 lags		0.11 (0.08)	0.46 (0.10)
OECD	2-5 lags	0.006 (0.005)	0.21 (0.13)	0.38 (0.15)
OECD	2-5 lags		0.10 (0.07)	0.45 (0.10)
EU	2,3 lags	-0.004 (0.024)	0.21 (0.12)	0.58 (0.12)
EU	2,3 lags		0.13 (0.09)	0.51 (0.13)
EU	2-4 lags	0.006 (0.007)	0.19 (0.13)	0.43 (0.16)
EU	2-4 lags		0.16 (0.07)	0.53 (0.10)
EU	2-5 lags	0.004 (0.006)	0.19 (0.09)	0.41 (0.12)
EU	2-5 lags		0.15 (0.10)	0.52 (0.09)

Table 4.1: Model 1

	Obstfeld	Crucini, RW	Crucini, AR-1	General, AR-1
US	0.74 (0.21)	0.73 (0.20)	0.86 (0.12)	0.77 (0.11)
OECD	0.52 (0.14)	0.49 (0.14)	0.69 (0.10)	0.54 (0.08)
EU	0.52 (0.15)	0.49 (0.15)	0.69 (0.10)	0.54 (0.10)

Table 4.2: Model 2

	$\boldsymbol{\lambda}_1$	$\boldsymbol{\lambda}_2$	$\boldsymbol{\gamma}$, 2,3 lags	$\boldsymbol{\gamma}$, 2-4 lags	$\boldsymbol{\gamma}$, 2-5 lags
US	0.41 (0.01)	0.12 (0.01)	0.78 (0.22)	0.73 (0.17)	0.64 (0.16)
OECD	0.02 (0.02)	0.00 (0.01)	0.61 (0.13)	0.57 (0.12)	0.61 (0.11)
EU	0.05 (0.02)	0.00(0.01)	0.30 (0.15)	0.39 (0.13)	0.46 (0.11)

Table 4.3: Model 2

regional income follows an AR-1 process ("General, AR-1") also provides a higher estimate of λ for both, and slightly more for the US state case. Overall, all these methods suggest that the degree of the risksharing in the US states is larger than in the OECD (EU) countries. That is, although a different assumption on the degree of intertemporal consumption smoothing gives a different estimate of λ, all predict the same for the relative ranking of the degree of intertemporal consumption smoothing within the US states and within the OECD (and EU) countries.

Table 4.3. reports the results of estimating equations (3.12), (3.13), and (3.14). As documented by past channel studies, we find that the extent of risksharing is far larger in the US states than in the OECD and in the EU countries, which is not surprising since our regressions are very similar to those. Interestingly, the estimated value of γ is 0.64-0.78 for the US states, but 0.57-0.61 for OECD countries and 0.30-0.46 for EU countries, which implies that the degree of intertemporal consumption smoothing is larger in the US states than in the OECD and in the EU countries, consistently with the results of our previous regression. However, this result is different from past channel studies that report a higher degree of intertemporal consumption smoothing in the OECD or EU countries than in the US states (Sørensen and Yosha (1998) and Asdrubali and Kim (2002)), while it agrees with other studies such as Mélitz and Zumer (1999) and Sørensen and Yosha (2000) that use consumption regressions developed by Hall (1978), Campbell and Deaton (1989), Deaton (1992), Østergaard, Sørensen, and Yosha (2002).

One reason that past channel studies often find the opposite result might be that those studies used income before risksharing, instead of income after risksharing, as regressor, although consumers smooth consumption based on income after risksharing. A high degree of risksharing within a country would make the estimated degree of intertemporal smoothing biased downward significantly, which may lead to a conclusion that the degree of intertemporal consumption smoothing within a country is low. Another reason might be that past channel studies consider only current income changes, even though intertemporal consumption smoothing is related to permanent income changes that are often different from current income changes.

In this regard, we run some pooled OLS regressions and report the results in Table 4.4. The second and the third columns report the pooled OLS estimate of $\boldsymbol{\gamma}$ when the regressor is $\triangle Y_{jt}$ (income before risksharing) and $\triangle \overline{Y}_{jt}$ (income after risksharing), respectively. When the instrument is not used and income before risksharing is adopted as regressor, the γ estimate is far higher for OECD (EU) countries than for US states. When the regressor changes to income after risksharing, the difference becomes smaller. These results are consistent with the above conjecture that using income before risksharing may cause the significant downward bias in the U.S. estimate.

	$\triangle Y_{jt}$	$\triangle \overline{Y}_{jt}$
US	0.18 (0.03)	0.36 (0.04)
OECD	0.55 (0.02)	0.47 (0.02)
EU	0.53 (0.03)	0.45 (0.03)

Table 4.4: Model 2. OLS

On the other hand, using income after risksharing, without considering permanent income by estimating the equation by OLS, still shows a higher estimate for the US states. This result is consistent with the above explanation; considering permanent income changes are important since they are relevant for intertemporal consumption smoothing but may be different from current income changes.

The exact estimate of γ and λ tends to be different for two empirical methods (estimating equation (2.4) and estimating equations (3.12), (3.13), and (3.14)); the estimate of λ is higher but the estimate of γ is lower in the former than in the latter. Besides a possible imprecision of the estimated parameters due to the multi-colliniearity problem, business cycles may generate a positive comovement of regional and aggregate consumption even without risksharing, which implies that λ may be positively biased in the former. On the other hand, the problem of the data on income after risksharing, in particular, omissions of some risksharing income flows, may generate a negatively biased estimate of λ and a positively biased estimate of γ in the latter.[11] Despite these possible problems, both methods converge on the relative degree of risksharing and intertemporal consumption smoothing for the intra vs. the international dimension: the degree of risksharing and the degree of intertemporal consumption smoothing are higher within countries than across countries.

Finally, the results provide a few insights on monetary policy in the European monetary unification process. Monetary policy's stabilization role is included in the intertemporal consumption smoothing estimate for EU countries while it is not likely to be important for the US states which do not allow a regional monetary policy. As for the measure of risksharing mechanisms before monetary unification, our results suggest that EU members pool their income risks to a lower degree than a successful monetary union, such as the US.

5. Conclusion

Models of consumption smoothing in open economies have typically assumed two extreme international financial structures: the "bonds only" and the "complete markets" framework (see Baxter and Crucini (1993) and Baxter (1995) for the comparison of the two modeling strategy in business cycle studies). In the former, only ex post international borrowing and lending is available to smooth consumption, whereas, in the latter, complete markets in contingent claims allow for consumption buffer-

[11] Such a bias is likely to be more severe in the case of international data; international data on capital market smoothing (using the difference between GNP and GDP) does not include capital gains and losses on net foreign assets. To be consistent, the discrepancy is more severe for the OECD and EU estimates.

ing through full risksharing of income shocks. Since the evidence seemed to point away from full risksharing or optimal intertemporal smoothing, recent work in empirical open economy macroeconomics has tried estimation either of possibly incomplete risksharing, or of possibly incomplete intertemporal smoothing.

This paper develops a method to estimate a possibly incomplete degree of intertemporal consumption smoothing and a possibly incomplete degree of risksharing jointly, based on the theories of risksharing and intertemporal consumption smoothing. This method improves upon past risksharing work featuring extreme assumptions on the intertemporal consumption smoothing, as well as on past studies that focus only on intertemporal consumption smoothing. In addition, the paper provides some foundations and limitations of empirical analyses on channels of risksharing and consumption smoothing and suggests a more theoretically sound estimation method in the line of the channel literature. The two suggested empirical methods are complementary. By applying both frameworks to US states, OECD and EU countries, we try to draw a robust conclusion on the degree of risksharing and intertemporal consumption smoothing both across countries and within a country.

The main findings are as follows. First, even after allowing for the possibility of partial intertemporal consumption smoothing, the degree of risksharing within a country is larger than across countries, in line with the findings of past studies. Although methods with different assumptions on the degree of intertemporal consumption smoothing provide different estimates for the degree of risksharing in the US states and OECD (EU) countries, all methods predict a higher degree of risksharing in the US states than in the OECD (EU) countries. Second, the degree of intertemporal consumption smoothing within a country is also larger than across countries. Although past channel studies often find the opposite, such results may have been obtained as a result of improperly measuring the degree of risksharing, and of overlooking the importance for intertemporal consumption smoothing of the difference between permanent income and current income changes.

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