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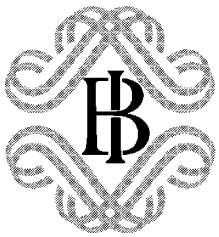

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INTERNATIONAL RISK SHARING AND EUROPEAN MONETARY UNIFICATION (*)

by Bent E. Srensen (**) and Oved Yosha (***)

Abstract

We explore income and consumption smoothing patterns among European Community countries and among OECD countries during the period 1966-90. We find that for OECD as well as for EC countries about 40 percent of shocks to GDP are smoothed at the one year frequency, with about half the smoothing achieved through national government budget deficits and half by corporate saving. At the three year differencing frequency only 25 percent of shocks to GDP are smoothed, mainly via government lending and borrowing. In the absence of alternative income and consumption smoothing mechanisms, the restrictions on budget deficits imposed by the Maastricht Treaty should be relaxed to allow governments to run large temporary deficits in response to output shocks.

Contents

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1 Introduction

Mechanisms for achieving income insurance and consumption smoothing are essential for the stability of a monetary union. Without such mechanisms, countries in recession will have an incentive to leave the union. Central fiscal institutions can provide cross-country income insurance via a tax-transfer system and by allocating grants to the governments of specific countries; Eichengreen (1993) and Obstfeld and Rogoff (1996) provide useful surveys.[1] Market institutions can also provide risk sharing. The members of a union can share risk via cross-ownership of productive assets, facilitated by a developed capital market, and may smooth their consumption by adjusting the composition and size of their asset portfolio in response to shocks, for example through lending and borrowing on international credit markets. This is a central theme in recent work on international risk sharing, e.g., Backus, Kehoe, and Kydland (1992), Obstfeld (1994b), Baxter and Crucini (1995), Stockman and Tesar (1995), and Lewis (1996).

Asdrubali, Srensen, and Yosha (1996) found that in the United States, a successful monetary union, 62 percent of shocks to the per capita gross product of individual states are smoothed on average through transactions on markets, 13 percent are smoothed by the federal tax-transfer and grant system, and 25 percent of shocks are not smoothed. Therefore, although perfect insurance is not achieved, there is considerable risk sharing among U.S. states.[2] In this paper, we explore risk sharing patterns among European Community (EC) countries and among OECD countries during the period 1966–90. Our results indicate that factor income flows do not smooth income across countries. This is true for the entire OECD group as well as for EC members, for the entire period as well as for two subperiods. Since factor income flows are an important component of income smoothing via capital markets, this suggests that European capital markets are less integrated than US capital markets.

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[1] Among the first to stress this point were Sala-i-Martin and Sachs (1992), von Hagen (1992), Atkeson and Bayoumi (1993), Goodhart and Smith (1993), and Bayoumi and Masson (1995).

[2] Asdrubali, Srensen, and Yosha (1996) measure, e.g., consumption as smoother than income if the elasticity of consumption with respect to output is lower than the elasticity of income with respect to output, when worldwide shocks are controlled for. The method for estimating these elasticities is based on a variance decomposition of shocks to output which is described in detail in Section 2.

The finding of much interstate income insurance among U.S. states is consistent with the fact, reported in this paper, that U.S. state income correlations are higher than U.S. state output correlations. The finding of no international income insurance among OECD countries is consistent with the fact, also reported here, that OECD country income correlations are roughly equal to OECD country output correlations.[3]

Robert A. Mundell (1961, pp. 661-2) defines an optimum currency area as one where internal factor mobility is high. Interestingly, he points out that whether or not Western Europe can be considered a single region is essentially an empirical issue. The findings in Asdrubali, Srensen, and Yosha (1996) of considerable income insurance among U.S. states suggest that the United States is close to being an optimum currency area, whereas our findings regarding negligible capital income flows among EC and OECD countries suggest that, at least for the time being, these are not optimal currency areas. Our work does not provide an overall evaluation of the costs and benefits of European Monetary Unification (EMU); rather, we point out that further integration of European capital markets should be of high priority, in particular in light of monetary unification.

We further find, for the period 1981–90, that the fraction of shocks to GDP smoothed via international transfers, including EC structural funds, is on the order of 3 to 7 percent, considerably less than the 13 percent fraction of shocks to the per capita gross state product smoothed by the federal government in the United States.

The bulk of the income and consumption smoothing among OECD and EC countries is achieved via savings: countries save less in bad years. For the period 1966–90, we find that about 40 percent of shocks to the GDP of OECD countries are smoothed at the one year frequency via this channel, while 60 percent of shocks are not smoothed. About half of the smoothing is achieved through corporate saving patterns and half through national government budget deficits. There is no cross-country consumption smoothing

[3]Consumption correlations, however, are low both for U.S. states and OECD countries, in line with the well known international consumption correlation puzzle. We endorse the explanation suggested by Stockman and Tesar (1995) who argue that low consumption correlations are due to country specific taste shocks, and are consistent with considerable, even full, risk sharing. We claim, though, that our method for decomposing the cross-sectional variance in shocks to output can measure the amount of consumption smoothing achieved despite the presence of taste shocks.

through personal saving. At the three year differencing frequency only about 25 percent of shocks to GDP are smoothed, with all the smoothing achieved via government lending and borrowing.[4]

An important implication is that, in the absence of alternative income and consumption smoothing mechanisms, the restrictions on budget deficits imposed by the Maastricht Treaty should be relaxed to allow governments to run large temporary deficits in response to output shocks.[5] The large amount of consumption smoothing achieved in the EC via government borrowing may not be sustainable in an EMU where fiscal coordination must be maintained. Until intercountry credit markets develop to allow substantial consumption smoothing through personal saving, the potential reduction in consumption smoothing via the budget deficits of national governments may call for a yet greater insurance role of EC institutions, imposing a further burden on the EC budget.

Of course, the creation of a common currency may in itself enhance capital market integration among EC members. The question is how fast this will happen. To the extent that informational barriers to cross-country ownership of productive assets are the main cause of little international capital flows (Gordon and Bovenberg 1996, Coval 1996), capital market integration may take time since informational barriers may be slow to disappear. If capital controls and cost of transacting in many currencies have been the main cause of little cross-country ownership, their removal may induce a swift process of capital market integration. To the extent that monetary unification progresses according to schedule while capital market integration occurs slowly, the EC may have to provide greater inter-regional insurance through its budget, until capital markets are sufficiently integrated to carry out this role, as they do in the United States. For an early study of these issues, see the

[4]If Ricardian considerations are important then such a decomposition is less meaningful. We address this issue in the empirical analysis, finding no evidence for or against the hypothesis that different forms of savings are substitutes. Although it is not possible to reject the claim that less consumption smoothing via government saving will be fully offset by increased smoothing through private sector consumption smoothing, we regard full and immediate Ricardian equivalence as unlikely.

[5]Most countries in the EC are close to or above the maximum public debt to GDP ratio allowed under the Maastricht Treaty. Eichengreen and von Hagen (1995) discuss the desirability of fiscal restraints in a future EMU, but do not raise the issue of consumption smoothing via national government borrowing and lending.

MacDougall Report, European Commission (1977).[6]

Since saving is related to net exports through the identity $S = I + (X - M)$, the physical cross-country flows of goods generated by saving is worth examining.[7] We, therefore, decompose smoothing through saving into smoothing via I and X-M, finding that all the smoothing is achieved through domestic net physical investment with virtually no smoothing via net exports, in line with the well known Feldstein and Horioka (1980) puzzle. This complements the fact that there is no smoothing through factor income flows, giving further indication of the limited cross-country risk sharing achieved via capital and credit markets among EC and OECD countries.[8] Of related interest is Bayoumi and Rose (1993) who find that saving and investment are not correlated across regions within the United Kingdom indicating that, unlike international capital markets, national markets are relatively well integrated.

In our empirical analysis we deflate all the magnitudes (GDP, GNP, S, etc.) by the country consumption deflator. That is, we measure the National Accounts figures of each country in terms of real consumption in that country. Of course, exchange rate fluctuations may affect consumption decisions and risk sharing patterns. If, for example, the currency of a country appreciates in real (inflation adjusted) terms, the citizens and the government of that country can, in principle, purchase more goods at international prices with a given amount of the country's currency. We find, using our data, that this effect is relatively small, namely, changes in the real exchange rate have a small effect on the cross-sectional consumption patterns that we consider.

We do not examine the effects of labor mobility on smoothing of GDP shocks. Asdrubali, Srensen, and Yosha (1996) found that labor mobility among U.S. states smoothes around 2.7 percent of an income shock at the annual frequency (see also Barro and Sala-i-Martin 1991).

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[6] See also Inman and Rubinfeld (1994) who emphasize the desirability of EC-wide fiscal policies that provide aid to countries in need.

[7] Backus, Kehoe, and Kydland (1992) have analyzed, in the framework of a simulated stochastic two country general equilibrium model, the behavior of consumption, investment, and net exports. See also Mendoza (1991), Baxter and Crucini (1993), von Hagen and Hammond (1994), Ghosh (1995), Stockman and Tesar (1995), Phillips (1996), and Bayoumi and Klein (1996).

[8] The introduction to Leiderman and Razin (1994) and the papers therein provide an overview of related issues.

Eichengreen (1994) documents that labor mobility is lower among European countries and regions than among U.S. states. It is, therefore, unlikely that labor mobility among EC and OECD countries substantially affects risk sharing patterns at the annual frequency.

In the next section we address conceptual issues related to risk sharing among countries. We characterize the full risk sharing allocation and derive empirical implications of the theory, relating them to the approach taken by, e.g., Backus, Kehoe, and Kydland (1992), to that of Cochrane (1991), Mace (1991), and Townsend (1994), to that of Obstfeld (1994b), and to the method developed in Asdrubali, Srensen, and Yosha (1996) for decomposing shocks to GDP into various channels of smoothing and measuring the fraction of shocks that is not smoothed. In Section 3 we describe the estimated equations. Section 4 is devoted to a presentation of the data and the empirical findings, and Section 5 concludes.

2 International Risk Sharing and Consumption Smoothing

We start by characterizing the full risk sharing allocation, and its relation to perfect consumption smoothing. We draw empirical implications of the theory, comparing various approaches in the risk sharing literature, including International Real Business Cycle methodology, as well as our method for decomposing the variance in shocks to GDP.

2.1 Full risk sharing and perfect consumption smoothing: Theory

We think of GDP as a homogeneous tradable good. The period t per capita output of country i is an exogenous random variable with a commonly known probability distribution. Let the representative consumer of each country be a risk averse expected utility maximizer who derives utility from consumption.[9] Consumers within each country are assumed to be identical ex-ante (all have the same utility function and the same stochastic endowment), as well as ex-post (all are subject to the same realization of uncertainty). Thus, the derivation focuses on risk sharing between countries, ignoring risk sharing within countries.

[9] As in Cochrane (1991), Mace (1991), Townsend (1994), Obstfeld (1994b), and Asdrubali, Srensen, and Yosha (1996), we do not consider non-separabilities in the utility function between consumption and leisure, or non-tradability of output. See Canova and Ravn (1996) and Lewis (1996) for a treatment of these issues in the context of international risk sharing.

Suppose that asset markets are complete. Then country i faces a single budget constraint in period 0, and chooses a consumption plan by solving the problem:

$$\max_{\{c^i_{\omega_t}\}} \Sigma_{t=0}^{\infty} \delta^t \Sigma_{\omega_t} \pi_{\omega_t} u(c^i_{\omega_t}) \tag{1}$$
$$\text{s.t.} \quad \Sigma_{t=0}^{\infty} \Sigma_{\omega_t} p_{\omega_t} c^i_{\omega_t} \leq \Sigma_{t=0}^{\infty} \Sigma_{\omega_t} p_{\omega_t} \text{GDP}^i_{\omega_t},$$

where $\text{GDP}^i_{\omega_t}$ and $c^i_{\omega_t}$ are the per capita output and consumption in state of nature ω_t that occurs with probability π_{ω_t}, and p_{ω_t} is the price in period 0 of a (period t) state ω_t contingent unit of consumption. $\delta < 1$ is the intertemporal subjective discount factor, common to all consumers. The first order condition with respect to $c^i_{\omega_t}$ is

$$\delta^t \pi_{\omega_t} u'(c^i_{\omega_t}) - \lambda^i p_{\omega_t} = 0, \tag{2}$$

where λ^i is a Lagrange multiplier. Market clearing implies that for all ω_t

$$\Sigma_i n^i c^i_{\omega_t} = \Sigma_i n^i \text{GDP}^i_{\omega_t}, \tag{3}$$

where n^i is the population of country i. We normalize prices as follows:

$$\Sigma_{t=0}^{\infty} \Sigma_{\omega_t} p_{\omega_t} = 1. \tag{4}$$

Assuming that endowments are bounded, (4) implies that the sums in the budget constraint in (1) are well defined.

Letting $u(c) = \log c$, we derive an expression for the price of a state contingent security as follows.[10] Solve for $c^i_{\omega_t}$ in (2), multiply both sides by n^i, sum over i, solve for p_{ω_t}, sum over ω_t, sum both sides over t, solve for $\Sigma_i (n^i/\lambda^i)$ using (4) and substitute the result into the expression for p_{ω_t}, obtaining

$$p_{\omega_t} = \text{constant} \times \delta^t \frac{\pi_{\omega_t}}{\Sigma_i n^i c^i_{\omega_t}}, \tag{5}$$

[10] A similar, but slightly longer derivation can be performed for general CRRA utility.

where the constant is $\{\Sigma_{t=0}^{\infty}\,\delta^t\,\Sigma_{\omega_t}\,\pi_{\omega_t}\,[1/\Sigma_i\,n^i c^i_{\omega_t}]\}^{-1}$. Eliminating p_{ω_t} using (2) and (5), using the market clearing condition (3), and denoting world consumption by $\mathrm{C}^{\mathrm{W}}_t = (\Sigma_i n^i \mathrm{GDP}^i_t)\,/\,(\Sigma_i\,n^i)$, where for simplicity the index ω_t is replaced by t, we get

$$c^i_t = k^i\;\mathrm{C}^{\mathrm{W}}_t. \tag{6}$$

That is, risk is fully shared among countries if the consumption of a country comoves with world consumption, but does not comove with country specific shocks.

The constant k^i is country specific, and is independent of time and of the state of nature, reflecting country i's "power" in the risk sharing arrangement. With logarithmic utility, we can derive a closed form solution for k^i which is quite instructive. Multiply and divide by π_{ω_t} inside the summation operator on both sides of the budget constraint in (1) (which binds at an optimum), use (2) to substitute for $p_{\omega_t}/\pi_{\omega_t}$, substitute $k^i\mathrm{C}^{\mathrm{W}}_t$ for $c^i_{\omega_t}$, and solve for $k^i = (1-\delta)\Sigma_{t=0}^{\infty}\delta^t E\,(\mathrm{GDP}^i_t/\mathrm{C}^{\mathrm{W}}_t)$ where E denotes the expectation in period 0. Thus, the share of country i's consumption in world consumption is the discounted expected share of its future output in world consumption.

We now demonstrate that full risk sharing implies perfect consumption smoothing in the sense that intertemporal Euler equations are satisfied. Sum over ω_t in (2), to obtain $\delta^t\;\Sigma_{\omega_t}\,\pi_{\omega_t}\,u'(c^i_{\omega_t}) = \lambda^i\Sigma_{\omega_t}\,p_{\omega_t}$ where $\Sigma_{\omega_t}p_{\omega_t}$ is the period 0 price of a sure unit of consumption in period t. Doing the same for period $t+1$, and using the fact that λ^i is independent of time, we obtain

$$E_t u'(c^i_{\omega_t}) = \delta\,(1+r^{t+1}_t)\,E_{t+1}u'(c^i_{\omega_{t+1}}), \tag{7}$$

where $1+r^{t+1}_t = (\Sigma_{\omega_t}p_{\omega_t})\,/\,(\Sigma_{\omega_{t+1}}p_{\omega_{t+1}})$ is the (gross) riskless interest rate from period t to period $t+1$, reflecting the relative price of a sure unit of consumption in period t and a sure unit of consumption in period $t+1$. At $t=0$, suppressing the index ω_t, (7) becomes $u'(c^i_0) = \delta(1+r^1_0)\;Eu'(c^i_1)$.

Thus, if asset markets are complete, there is full risk sharing (equation (6)) *and* perfect consumption smoothing (equation (7)). If asset markets are not complete full risk sharing will typically not be satisfied, but perfect consumption smoothing may still hold. Baxter

and Crucini (1995) observe that in an incomplete markets economy where the only financial instrument is a riskless bond, equation (7) is satisfied while equation (6) is not. They show, however, that if shocks to output are highly persistent, the deviation from the full risk sharing consumption allocation will be substantial, whereas if shocks are transitory the deviation from the full risk sharing allocation will be small despite the incompleteness of markets.

2.2 Taste shocks

Let the period t utility function of country i be $\theta_t^i\, u(\cdot)$ where θ_t^i is an idiosyncratic taste shock, and normalize so that $\Sigma_i(1/\theta_t^i) = 1$ in all periods. An analogous derivation yields that under full risk sharing

$$c_t^i = \theta_t^i\; k^i\; C_t^{\mathrm{W}}, \tag{8}$$

in any state of nature, where the state of nature fully describes the distribution of taste shocks across countries. Thus, although consumption in country i is not a fixed fraction of world consumption, as is the case when there are no idiosyncratic taste shocks, the central property of equation (6) is preserved—the consumption of country i is affected by aggregate shocks and by idiosyncratic taste shocks, but not by other idiosyncratic shocks (including income shocks).

2.3 Empirical implications of full risk sharing

The empirical literature has tackled consumption smoothing and risk sharing as two distinct propositions. Euler equation tests of perfect consumption smoothing abound and are outside the scope of this paper. A central empirical implication of full risk sharing, equation (6), is that the correlation of consumption across economic agents should be equal to unity. The International Real Business Cycle literature, most notably Backus, Kehoe, and Kydland (1992), and more recently Baxter and Crucini (1995) and Stockman and Tesar (1995), among others, have taken this prediction to international macroeconomic data, finding that inter-country consumption correlations are nowhere close to unity. In fact, these consumption correlations are not higher than country output correlations as we

would expect if there were only partial international risk sharing. It is now a stylized fact that country consumption correlations are no higher than country output correlations, a phenomenon that has become known as the international consumption correlation puzzle.[11]

A second, related, empirical implication of equation (6) is that under full risk sharing, the consumption of an economic agent does not respond to idiosyncratic shocks, in particular income shocks. This proposition has been tested on micro-data by, e.g., Cochrane (1991), Mace (1991), and Townsend (1994).[12] These studies perform cross-sectional or panel regressions of individual consumption on sources of idiosyncratic risk (mainly on income but also on variables such as sickness or layoffs). In many of these studies full risk sharing is rejected (Cochrane 1991, Townsend 1994, Hayashi, Altonji, and Kotlikoff 1996).[13]

Obstfeld (1994b) tests for full risk among nine large OECD countries by running, for each country, the time series regression $\Delta \log c_t^i$ on $\Delta \log C_t^W$. In the absence of worldwide taste shocks, the coefficients in these regressions are estimated consistently, and if there is full risk sharing, they should be unity.[14] The coefficients in many of Obstfeld's regressions are positive but smaller than unity, which suggests that there is partial risk sharing but not full risk sharing.

Even if full risk sharing is rejected it is important to quantify the extent to which risk is shared within a group of economic agents, countries in our case. It is also interesting to identify the exact channels through which risk is shared, and to quantify the amount of risk sharing obtained via each channel. Asdrubali, Srensen, and Yosha (1996) developed a method for answering these questions. The method takes equation (6) as a benchmark, and quantifies the deviation from this benchmark, interpreting the deviation as the amount of risk that is not shared. We turn to a presentation of the conceptual framework and the

[11] Stockman and Tesar (1995) suggest country specific taste shocks as an explanation of the puzzle. We return to this issue shortly.

[12] See also Altug and Miller (1990) and Hayashi, Altonji, and Kotlikoff (1996).

[13] For extensions of the basic framework, see, e.g., Canova and Ravn (1996) and Lewis (1996). A comprehensive survey of research on international diversification is provided in Lewis (1995). For an estimation of welfare gains from risk sharing, see van Wincoop (1994) for OECD countries, and Srensen and Yosha (1996) for U.S. states; see also Obstfeld (1994a) and Tesar (1995).

[14] Obstfeld presents the results of regressions where world consumption includes and does not include country i's consumption, and of regressions with and without regressors controlling for country specific shocks.

method of measuring deviations from the full risk sharing allocation.

2.4 Channels of income insurance and consumption smoothing

There are several mechanisms for sharing risk among countries. The citizens or the government of a country can own claims to output produced in other countries. For example, if mutual funds or pension funds in one country invest internationally, the income of the citizens in that country will comove with the output in other countries. If financial intermediaries in one country lend to firms in other countries, the flow of interest payments smoothes the income of citizens in the lending country. This form of international risk sharing, namely, income insurance through cross-border ownership of productive assets, is reflected in the National Accounts data as the difference between GDP and GNP. The difference between the GNP and GDP of a country is precisely the net flow of factor income to that country.[15]

If risk is fully shared at this level then GNP will satisfy equation (6):

$$\text{GNP}_t^i = k^i \ \text{C}_t^{\text{W}}, \tag{9}$$

and, therefore, also equation (7), namely, the consumers in each country will want to consume their GNP.

If risk is not fully shared through factor income flows, GNP does not satisfy equation (6) and there may be scope for further consumption smoothing through saving behavior. Such consumption smoothing through saving is governed entirely by intertemporal considerations. If the shocks to GDP that are not smoothed through international factor income flows are highly persistent, individuals will optimally choose to engage in very little consumption smoothing through saving. In other words, although GNP does not satisfy equation (6), it may closely satisfy equation (7). If the shocks to GDP that are not smoothed through international factor income flows are transitory, individuals will optimally choose to engage in much consumption smoothing through saving.

[15]See, e.g., Atkeson and Bayoumi (1993).

Baxter and Crucini's (1995) insight is relevant here. If, for some reason, there is no income insurance through factor income flows, and if there is a riskless asset that can be traded then, if shocks to GDP are transitory, equation (6) will be closely approximated. That is, when shocks to GDP are transitory, a riskless bond (the credit market) is a close substitute for income insurance (i.e. for capital markets). In contrast, if shocks to GDP are highly persistent, consumption smoothing through trade in a riskless bond will not approximate the allocation in equation (6), namely, the credit market will not closely mimic the role of capital markets—shocks that were not insured ex-ante on capital markets will not be smoothed ex-post on credit markets.

The variance decomposition described below allows us to measure the fraction of shocks to GDP that are smoothed through international factor income flows, through saving, and the fraction of shocks that are not smoothed, namely, the residual deviation of the international consumption allocation from equation (6), the full risk sharing benchmark.

2.5 Decomposing the cross-sectional variance of shocks to GDP

In the empirical implementation, we measure the fraction of shocks to GDP absorbed at two additional levels which, for conciseness, were not described above. If risk is not fully shared through factor income flows, reflected in the National Accounts data as the difference between GDP and GNP, then further income insurance (or income smoothing—we use these terms interchangeably) can be achieved through international transfers if the net transfers to a country are larger during (country specific) recessions. The EC structural funds are an example of an international tax-transfer system that may contribute to risk sharing, although it is worth emphasizing that the motivation for having a tax-transfer system may have nothing to do with risk sharing. In the National Accounts, the difference between National Income (NI) and Disposable National Income (DNI) measures international net transfers.[16]

[16]We adopt the National Accounting concepts used in the OECD National Accounts publications that differ slightly from those used in the United States Statistical Abstract. For example, the Abstract defines Net National Income as Net National Product minus indirect taxes plus subsidies, whereas according to OECD conventions, Disposable National Income is obtained from National Income by adding and subtracting only *international* taxes and transfers.

Patterns of capital depreciation may also contribute to cross-country income smoothing. In the National Accounts data, depreciation is responsible for the discrepancy between GNP and NI. Depreciation is calculated according to fixed accounting rules. Therefore, since the capital-output ratio is typically countercyclical, the officially calculated depreciation will constitute a larger fraction of output in recessions and a smaller fraction in booms, resulting in cross-sectional dis-smoothing.[17] Finally, consumption smoothing through saving is manifested in the National Accounts data as the difference between DNI and total (private plus government) consumption, C+G.

We turn to the cross-sectional variance decomposition of shocks to GDP. Consider the identity, holding for any period t,

$$\mathrm{GDP}^i = \frac{\mathrm{GDP}^i}{\mathrm{GNP}^i}\frac{\mathrm{GNP}^i}{\mathrm{NI}^i}\frac{\mathrm{NI}^i}{\mathrm{DNI}^i}\frac{\mathrm{DNI}^i}{\mathrm{C}^i+\mathrm{G}^i}(\mathrm{C}^i+\mathrm{G}^i), \tag{10}$$

where all the magnitudes are in per capita terms, and i is an index of countries. To stress the cross-sectional nature of our derivation, we suppress the time index. The national accounting identities that are relevant here are: GNP=GDP+net factor income, NI=GNP–capital depreciation, DNI=NI+international transfers, C+G=NI–net saving.

Now take logs and differences on both sides of (10), multiply both sides by $\Delta \log \mathrm{GDP}^i$ (minus its mean) and take the cross-sectional average, obtaining the variance decomposition

$$\begin{aligned}
\mathrm{var}\{\Delta \log \mathrm{GDP}^i\} \;=\; & \mathrm{cov}\{\Delta \log \mathrm{GDP}^i - \Delta \log \mathrm{GNP}^i, \Delta \log \mathrm{GDP}^i\} \\
& + \mathrm{cov}\{\Delta \log \mathrm{GNP}^i - \Delta \log \mathrm{NI}^i, \Delta \log \mathrm{GDP}^i\} \\
& + \mathrm{cov}\{\Delta \log \mathrm{NI}^i - \Delta \log \mathrm{DNI}^i, \Delta \log \mathrm{GDP}^i\} \\
& + \mathrm{cov}\{\Delta \log \mathrm{DNI}^i - \Delta \log(\mathrm{C}^i+\mathrm{G}^i), \Delta \log \mathrm{GDP}^i\} \\
& + \mathrm{cov}\{\Delta \log(\mathrm{C}^i+\mathrm{G}^i), \Delta \log \mathrm{GDP}^i\}\ .
\end{aligned}$$

[17] Real capital depreciation may be affected by economic conditions. For example, capital may depreciate faster during booms because it is utilized more intensely. Such effects are typically not reflected in the National Accounts data. Conceptually, the budget constraint in (1) is better formulated in terms of Net Domestic Product. We decompose shocks to Gross Domestic Product since the literature (e.g., Backus, Kehoe, and Kydland (1992) use GDP as the variable measuring "output."

In this equation "var { X }" and "cov { X,Y }" denote the statistics $\frac{1}{N}\sum_{i=1}^{N}(\mathrm{X}^i - \bar{\mathrm{X}})^2$ and $\frac{1}{N}\sum_{i=1}^{N}(\mathrm{X}^i - \bar{\mathrm{X}})(\mathrm{Y}^i - \bar{\mathrm{Y}})$, respectively, where N is the number of countries in the sample. Dividing by $\mathrm{var}\{\Delta \log \mathrm{GDP}^i\}$ we get

$$1 = \beta_f + \beta_d + \beta_\tau + \beta_s + \beta_u, \tag{11}$$

where, for example,

$$\beta_f = \frac{\mathrm{cov}\{\Delta \log \mathrm{GDP}^i - \Delta \log \mathrm{GNP}^i, \Delta \log \mathrm{GDP}^i\}}{\mathrm{var}\{\Delta \log \mathrm{GDP}^i\}} \tag{12}$$

is the ordinary least squares estimate of the slope in the cross-sectional regression of $\Delta \log \mathrm{GDP}^i - \Delta \log \mathrm{GNP}^i$ on $\Delta \log \mathrm{GDP}^i$, and similarly for β_d, β_τ, and β_s. The last coefficient in the decomposition is given by:

$$\beta_u = \frac{\mathrm{cov}\{\Delta \log(\mathrm{C}^i + \mathrm{G}^i), \Delta \log \mathrm{GDP}^i\}}{\mathrm{var}\{\Delta \log \mathrm{GDP}^i\}}, \tag{13}$$

which is the ordinary least squares estimate of the slope in the cross-sectional regression $\Delta \log(\mathrm{C}^i + \mathrm{G}^i)$ on $\Delta \log \mathrm{GDP}^i$.

We turn to the predictions of the theory regarding the signs and magnitudes of these coefficients. If there is full risk sharing, that is, if equation (6) holds, then $\mathrm{cov}\{\Delta \log(\mathrm{C}^i + \mathrm{G}^i), \Delta \log \mathrm{GDP}^i\} = 0$, and hence $\beta_u = 0$. If full risk sharing is not achieved, then consumption in country i varies positively with idiosyncratic shocks to country i's output, and $\beta_u > 0$. A cross-sectional regression of consumption on output, controlling for fluctuations in world consumption is, therefore, a test of full risk sharing.[18]

If full risk sharing is achieved through income insurance via factor income flows, GNP will satisfy equation (6). Then $\mathrm{cov}\{\Delta \log \mathrm{GNP}^i, \Delta \log \mathrm{GDP}^i\} = 0$ and hence, $\mathrm{cov}\{\Delta \log \mathrm{GDP}^i - \Delta \log \mathrm{GNP}^i, \Delta \log \mathrm{GDP}^i\} = \mathrm{var}\{\Delta \log \mathrm{GDP}^i\}$, implying $\beta_f = 1$. Moreover, in this case, since consumers in each country consume their GNP, namely, $\mathrm{C}^i = \mathrm{GNP}^i$, consumption satisfies

[18]This is precisely the test suggested by Mace (1991) and Townsend (1994). They test for full risk sharing by running cross-sectional (or panel) regressions of consumption on income, controlling for aggregate movements in income and consumption. Cochrane's (1991) test is very similar.

equation (6) implying $\beta_u = 0$.[19]

Suppose that full risk sharing is not achieved through income insurance via factor income flows and capital depreciation, but is achieved through the combination of factor income flows, depreciation, and international transfers. Then DNI will satisfy equation (6) and, by analogous reasoning, $\beta_f + \beta_d + \beta_\tau = 1$, and since consumers in each country will consume their DNI, $\beta_u = 0$. Similarly, if the full risk sharing allocation is achieved through factor income flows, depreciation, international transfers, and saving, C+G will satisfy equation (6). Then, by analogous reasoning, $\beta_f + \beta_d + \beta_\tau + \beta_s = 1$ and $\beta_u = 0$.

We interpret β_u as the fraction of shocks to GDP that is not smoothed. The coefficients β_f, β_d, β_τ, and β_s are interpreted as the fraction of shocks absorbed through factor income flows, depreciation, international transfers, and saving, respectively. If consumption satisfies equation (6), they sum to unity and $\beta_u = 0$. If not, they sum to less than unity. In either case, they reflect the incremental amount of smoothing achieved through the various channels discussed above.

We stress that β_s does not measure the extent to which countries smooth consumption optimally via saving. It measures the incremental fraction of shocks to GDP smoothed via savings. Nor does $\beta_u > 0$ indicate that, given the uninsured shocks to income, consumption is not intertemporally smoothed optimally. Rather, it measures the deviation of international consumption patterns from the full risk sharing allocation.

We conclude this subsection with two remarks. First, it should be stressed that the cross-sectional smoothing of shocks to GDP may involve cross-border flows of funds as in the case of factor income flows and international transfers, or it may not, as in the case of domestic investment or capital depreciation. Our method of measuring the amount of smoothing achieved at various levels allows us to do so in a consistent manner for income smoothing as well as consumption smoothing regardless of whether there is actual cross-border flow of funds. The effectiveness of both income smoothing and consumption smoothing are measured against the full risk sharing allocation in equation (6). This is the relevant

[19] If full risk sharing is not achieved through income insurance via factor income flows, then $\text{cov}\{\Delta \log \text{GNP}^i, \Delta \log \text{GDP}^i\} > 0$ and hence, $\text{cov}\{\Delta \log \text{GDP}^i - \Delta \log \text{GNP}^i, \Delta \log \text{GDP}^i\} < \text{var}\{\Delta \log \text{GDP}^i\}$, implying $\beta_f < 1$.

benchmark in terms of welfare, an issue we do not directly address in this paper but which constitutes the underlying motivation for studying patterns of international risk sharing in the first place.

Second, notice that our method does not impose any restrictions on the sign of the β-coefficients. If a country that is hit by a positive shock has a smaller share of GDP allocated to, e.g., capital consumption, then depreciation provides cross-sectional dis-smoothing. Similarly, if taxes increase or decrease less than proportionately with output, they provide dis-smoothing.

2.6 Consumption smoothing via saving: A closer look

Once National Income is decomposed into consumption and saving, total smoothing via saving can be further decomposed into smoothing via each of three components, personal, corporate, and government saving. This decomposition can shed light on institutional barriers to consumption smoothing. For example, the ability of national governments to smooth consumption by running budget deficits may be limited by law, as is the case for state governments in the United States (Poterba 1994, Bohn and Inman 1996). The 1992 Maastricht requirements regarding government debt suggest that similar restrictions are likely to be imposed in a future EMU. This will shift the burden of smoothing consumption from the national governments to the private sector (capital and credit markets) or to the EC budget.[20]

The corporate sector may contribute to income insurance if it adjusts patterns of earnings retention so that a larger share of profits is distributed to shareholders during recessions.[21] Of course, if shareholders can "see through the corporate veil," then changes in corporate saving may be offset by corresponding changes in the saving of shareholders (Poterba 1991).

Individuals can smooth consumption through personal saving by borrowing and lending

[20] See however footnote (4).

[21] This is consistent with the standard textbook view that corporations smooth dividend payout ratios, adjusting them only in response to shifts in long-run sustainable earnings; see, e.g., Brealey and Myers (1991, Chapter 16).

internationally or within their own country (provided, of course, that they want to smooth uninsured output shocks). The ability of individuals to smooth their consumption through cross-country borrowing and lending depends on whether the banking system, and credit markets in general, are sufficiently integrated internationally. For given international borrowing and lending, the aggregate amount of saving in a country must be reflected in the country's investment level.

The extent to which such consumption smoothing is possible in a closed economy is limited. If many individuals attempt to increase their saving, the interest rate will fall reducing the incentive to save (Christiano 1987). By contrast, if international credit markets are integrated, then, when individuals in one country increase savings, funds will be channeled to other countries.

The amount of consumption smoothing achieved through saving can also be decomposed according to the final uses of the amount saved, namely, domestic investment and net exports: $S = I + (X - M)$. If higher saving in a country in a particular year is mainly reflected in higher investment in that country in the same year, this would indicate that international trade patterns do not respond strongly to shocks and, therefore, do not contribute to cross-country consumption smoothing.

3 Estimation

At the practical level, the following (panel) equations are estimated:

$$\begin{aligned}
\Delta \log \mathrm{GDP}_t^i - \Delta \log \mathrm{GNP}_t^i &= \nu_{f,t} + \beta_f \ \Delta \log \mathrm{GDP}_t^i + \epsilon_{f,t}^i \ , \\
\Delta \log \mathrm{GNP}_t^i - \Delta \log \mathrm{NI}_t^i &= \nu_{d,t} + \beta_d \ \Delta \log \mathrm{GDP}_t^i + \epsilon_{d,t}^i \ , \\
\Delta \log \mathrm{NI}_t^i - \Delta \log \mathrm{DNI}_t^i &= \nu_{\tau,t} + \beta_\tau \ \Delta \log \mathrm{GDP}_t^i + \epsilon_{\tau,t}^i \ , \\
\Delta \log \mathrm{DNI}_t^i - \Delta \log(\mathrm{C}_t^i + \mathrm{G}_t^i) &= \nu_{s,t} + \beta_s \ \Delta \log \mathrm{GDP}_t^i + \epsilon_{s,t}^i \ , \\
\Delta \log(\mathrm{C}_t^i + \mathrm{G}_t^i) &= \nu_{u,t} + \beta_u \ \Delta \log \mathrm{GDP}_t^i + \epsilon_{u,t}^i \ ,
\end{aligned} \tag{14}$$

where $\nu_{\cdot,t}$ are time fixed effects. The inclusion of time fixed effects is crucial, since they capture year specific impacts on growth rates, most notably the impact of the growth in

aggregate EC (or OECD) output. Furthermore, with time fixed effects the β-coefficients are weighted averages of the year by year cross-sectional regressions.[22] To take into account autocorrelation in the residuals we assume that the error terms in each equation and in each country follow an AR(1) process. Since the samples are short, we assume that the autocorrelation parameter is identical across countries and equations. We further allow for state specific variances of the error terms. In practice, we estimate the system in (14) by a two step Generalized Least Squares (GLS) procedure. Unless we explicitly say otherwise, we use differenced data at the yearly frequency.[23] Notice that since our method is based on panel estimation with time fixed effects, it yields fully consistent estimates even if there are worldwide taste shocks.

4 Results

The data are from OECD National Accounts, Main Aggregates (Volume I) and Detailed Tables (Volume II), various issues, covering the period 1966–96. Although the data through at least 1992 are reliable (do not incorporate projections), we focus on the period 1966–90 to avoid complications arising from the unification of Germany.[24] The OECD countries in our sample consist of all 1996 members except Luxembourg and Mexico. Due to data availability, we use two subsets of the EC members and two subsets of the OECD members in the various regressions. EC8 denotes the EC members with the exception of Greece, Portugal, Spain, Sweden, Finland, and Austria that have only recently joined the EC, and Luxembourg which is very small and atypical.[25] EC6 denotes the countries in EC8 less the Netherlands and Ireland. OECD denotes all 1996 members of the OECD except

[22] See Asdrubali, Srensen, and Yosha (1996), footnote 5, for an explicit formula.

[23] To ensure that our results are robust, we estimate the main regressions using Hodrick-Prescott filtered data, obtaining very similar results.

[24] It would, of course, be interesting to study the patterns of income and consumption smoothing in the 90s with unified Germany replacing Germany in the sample, but for the moment the 90s sample is too short for such a study.

[25] EC8 includes Belgium, Denmark, France, Germany, Ireland, Italy, the Netherlands, and United Kingdom. Greece joined the EC in 1981, Portugal and Spain in 1985, whereas Sweden, Finland, and Austria joined in 1995.

Luxembourg and Mexico, while OECD* denotes a more restricted set of 13 countries.[26]

We begin by presenting our estimates of the fraction of shocks to GDP absorbed at the various levels of smoothing for EC and OECD countries. We then compare the results to those of Asdrubali, Srensen, and Yosha (1996) who estimated the amount of income and consumption smoothing achieved among U.S. states. Next, we contrast our results with those obtained through comparison of country correlations of output, income, and consumption along the lines of, e.g., Backus, Kehoe, and Kydland (1992). We briefly discuss methodological differences between these two approaches to measuring risk sharing, stressing the similarities and providing potential explanations for the discrepancies. We conclude Section 4 by presenting estimates of consumption smoothing via subcomponents of saving.

4.1 Income insurance and consumption smoothing among EC and OECD countries

In Table 1 we display the estimated percentages of shocks to GDP smoothed through each channel, among OECD and EC8 countries, for two subperiods.[27] From the first line in Table 1 it is immediately apparent that the contribution of cross-country factor income flows to cross-country risk sharing, among EC as well as OECD countries, is not significantly different from zero for both subperiods. This finding is consistent with Atkeson and Bayoumi (1993) who noticed that the difference between GNP and GDP as a ratio of GDP for the seven largest industrial countries, averaged over the period 1963–86, is very small—only two countries (United States and Canada) show a ratio above 1 percent of GDP in absolute value. It is also fully consistent with the "home bias" puzzle as documented by French and Poterba (1991) and Tesar and Werner (1995), but not with Obstfeld's (1994b) conclusion of increased international capital market integration during the 70s and 80s in comparison to previous decades.

The fourth line in Table 1 indicates that the bulk of the consumption smoothing of

[26]OECD* includes Austria, Belgium, Denmark, Finland, France, Germany, Italy, Sweden, United Kingdom, United States, Japan, Australia, and Canada.

[27]The estimated coefficients do not sum to 100 percent because of rounding.

EC as well as of OECD countries is achieved via saving. Such smoothing need not involve actual cross-border flows of funds. Suppose that saving in each country simply responds to country specific shocks, with higher saving in booms and lower saving in recessions and no international lending and borrowing. The cross-sectional variance decomposition would then measure the contribution of within country saving patterns to the reduction of the cross-sectional variance of consumption with respect to the cross-sectional variance of Disposable National Income. Further, our methodology allows us to express this reduction in the cross-sectional variance in a way that is consistent with the measurement of income smoothing via actual factor income flows, namely, as a fraction of shocks to GDP smoothed. For example, the number in the first column, fourth line of Table 1 means that, on average, 46 percent of shocks to the GDP of the EC8 countries during the period 1966–80 were smoothed via saving.

Although consumption smoothing through this channel need not involve actual cross-border flows of funds, it very well may involve such flows, since aggregate consumption smoothing via saving is more difficult in a closed economy. If many individuals or corporations within a country attempt to increase saving in a particular year, bond prices will rise (i.e. the real interest rate will fall) reducing the incentive to save. By contrast, if international credit markets are integrated internationally, savings will be channeled to countries where the supply of funds has fallen. This, of course, is a reflection of the fact that aggregate saving is equal to net investment plus net exports. We investigate the relative importance of these channels later.

For OECD countries, consumption smoothing via saving amounted to about 40 percent of shocks to GDP in both subperiods. The point estimates are 40 percent for 1966-80 and 44 percent for 1981–90. For the EC8 group, the point estimates for these subperiods are 46 and 24 percent.[28] The decline in the amount smoothed via saving among the EC8 countries during the 80s may have to do with the world wide increase in real interest rates, although

[28]For each row in Table 1 we tested if the coefficients were similar across sub-periods using an F-test. For the OECD we found no significant differences across subperiods, while for the EC the difference in saving is significant at the 5 percent level, and depreciation and the overall amount not smoothed are significantly different at the 10 percent level.

this interpretation is not entirely convincing in light of the stability across subperiods of the fraction of shocks smoothed via saving among the OECD group. As can be seen in the last line of Table 1, the decline in consumption smoothing via saving among the EC8 countries is fully reflected in the increase in the fraction of shocks not smoothed in the later time period.

The third line of Table 1 indicates that international transfers, which include contributions to international institutions and foreign aid, provide very little income smoothing for OECD countries suggesting that, on average, such transfers constitute a fixed fraction of GDP. We return to this issue later when we discuss the results in Table 2.

The results for EC and OECD countries displayed in Table 1 are not directly comparable with those in Asdrubali, Srensen, and Yosha (1996) for U.S. states. Country level data are richer than U.S. state level data; for example, there are no GNP estimates for U.S. states, so Asdrubali, Srensen, and Yosha could not estimate interstate income smoothing via factor income flows. The level of smoothing denoted "capital market smoothing" in their work on U.S. states includes the fraction of shocks to GDP smoothed through factor income flows, depreciation of capital, and corporate saving (retained earnings); income smoothing through the US federal tax-transfer and grant system is directly comparable with income smoothing via international transfers; and consumption smoothing on asset and credit markets among U.S. states corresponds to smoothing via personal and government saving.

To compare the extent of capital and credit market integration of EC and OECD countries with that of U.S. states, we decompose the cross-sectional variance in GDP for a group of six EC countries, denoted EC6, as well as for a larger group of OECD countries, into the levels of smoothing analyzed in the U.S. study.[29] The results for the period 1981–90 are displayed in Table 2. The substantially higher fraction of shocks to GDP smoothed via capital markets in the US is immediately apparent. The amount of consumption smoothing through saving is similar for OECD countries and U.S. states. The total amount left not smoothed among the OECD, and especially the EC6 countries, is considerably larger than

[29]EC6 includes Belgium, Denmark, France, Germany, Italy, and United Kingdom. The OECD countries, denoted OECD*, are listed in footnote 26 and in the notes to Table 2. The OECD* and EC6 samples are smaller since corporate saving is not reported in the OECD National Accounts for some countries.

the amount not smoothed among U.S. states.

We performed the analysis for the 70s obtaining similar estimates, in particular for the total amount of smoothing via saving as well as through the various sub-components of saving.[30] We have no evidence for or against the hypothesis that various forms of saving are perfect substitutes. In particular, we cannot tell if a potential decrease in consumption smoothing through consumption smoothing through government saving as a result of the Maastricht deficit requirements will be offset by a corresponding increase in smoothing via private saving.

The fraction of shocks to GDP smoothed via international transfers for the EC6 countries during the period 1981–90 is 7 percent. Together with the 5 and 3 percent smoothing estimated in the regressions in Table 1 for this time period, we obtain an order of magnitude for the amount of smoothing achieved through this channel—3 to 7 percent of shocks. This income smoothing incorporates the insurance provided by transfers via the EC budget, e.g. the structural funds. Even if we attribute all the smoothing to the EC budget, we see that the fraction of shocks to per capita GDP smoothed through EC fiscal institutions is at most a half of the fraction of shocks to the per capita gross state product smoothed by the federal government in the United States. Further, actual EC budget data are available for 1976–86 from Eurostat Review, various issues (EC transfers to individual countries are no longer disclosed since 1987). We estimated the equations using these data finding zero smoothing via the EC budget. Since the coefficients are estimated quite imprecisely due to the shorter sample period, and since the point estimates are overall very similar, we do not report the results.

The 15 percent capital market income smoothing for OECD countries in Table 2 is not driven by factor income flows. We know this from the results displayed in the first line of Table 1. Since we also know that depreciation of capital dis-smoothes GDP, the 15 percent capital market smoothing must originate from smoothing via corporate saving.

[30] Since the detailed OECD data for the 70s, on which these calculations are based, are not consistent with those of the 80s and the sample of countries is different, we cannot directly compare the results, and do not report the estimates for the 70s.

4.2 OECD country versus U.S. state correlations of output, income, and consumption

In Table 3 we compare average country correlations of output, income, and consumption for OECD countries with the corresponding state correlations for U.S. states. The correlations are calculated for the logarithm of each series, differenced at the 1-year frequency (left panel) or Hodrick-Prescott filtered (right panel) with the corresponding aggregate U.S. series. Similar cross-country correlations for GDP and consumption are reported, *inter alia*, by Backus, Kehoe, and Kydland (1992), Baxter (1995), and Stockman and Tesar (1995). These studies find that consumption correlations are lower than output correlations, which is interpreted as evidence against full risk sharing. Lack of full risk sharing in and of itself can account for consumption correlations that are lower than unity but larger or equal to output correlations. Lack of risk sharing cannot account for consumption correlations that are smaller than output correlations. Our results regarding GDP and consumption correlations for OECD countries as well as for U.S. states, reported in Table 3, are in full agreement with this well documented international consumption correlation puzzle.

The income and disposable income (GNP, NI, DNI) correlations reported in Table 3 have not, to the best of our knowledge, been studied before. For OECD countries they are roughly the same as GNP correlations which is fully consistent with lack of international income insurance through factor income flows and international transfers (Table 1). By contrast, for U.S. states the correlations of state income are higher than those of output (gross state product) reflecting income insurance through cross-country factor income flows, which is fully consistent with the results reported in Table 2. Furthermore, the correlations of disposable state income are higher than those of disposable state income reflecting income insurance through cross-state net transfers, which is also fully consistent with the results reported in Table 2.

Thus, there is no contradiction between the conclusions drawn from country correlations and from the cross-sectional variance decomposition, regarding income insurance via factor income flows and via international transfers (although the cross-sectional method enables us to estimate the fraction of shocks to GDP absorbed through each channel).

What needs to be explained is the discrepancy between the methods regarding the amount of consumption smoothing. Although country consumption correlations are lower than output correlations, which is not consistent with risk sharing in the absence of taste shocks, the cross-sectional variance decomposition yields estimates of considerable consumption smoothing via saving (as well as considerable overall income insurance and consumption smoothing) both for OECD countries and U.S. states. We endorse the explanation suggested by Stockman and Tesar (1995) who show that low country consumption correlations can be rationalized by a model with substantial risk sharing, even with full risk sharing, when countries are subject to idiosyncratic taste shocks. If equation (8) holds and the θ_t^i shocks are sufficiently large and independent, country consumption correlations can be very small even though there is full risk sharing.

The cross-sectional variance decomposition is immune to such idiosyncratic taste shocks since it involves regressing changes in log-consumption on changes in log-output. Since it is the *left* hand side variable that is subject to taste shocks, the regression coefficients, β_s or β_u according to the case, are not biased. Only their standard errors are larger due to the taste shocks, as can be seen in Tables 1 and 2. We therefore, believe that our findings regarding substantial consumption smoothing among EC and OECD countries, as well as among U.S. states, are sound, and that our method for obtaining them is particularly useful since consumption is indeed likely to be subject to taste shocks.

4.3 Consumption smoothing via subcomponents of national saving

Table 4 displays a more detailed decomposition of the levels of smoothing. A central finding is that personal saving contributes nothing to cross-country consumption smoothing. The fraction of shocks to GDP smoothed through saving for OECD countries during the 80s (44 percent; see the fourth column of Table 1) is due to corporate saving and national government saving, with roughly 20–25 percent of shocks absorbed through each of these channels.[31] Qualitatively similar point estimates are obtained for the EC6 group. Since

[31] Because of non-linearities, the components of consumption smoothing in Table 4 do not add up to consumption smoothing in Table 2. Further, the estimated coefficients in Table 4 have not been restricted to add up to 100 percent.

the standard errors are very high, due to the small sample, we do not present the results for the EC6 countries.

In the second column of Table 4 we display the results of the same regressions using data differenced at the three year frequency. We find that with longer differencing, smoothing via corporate saving among OECD countries decreases drastically (basically to zero given the standard error), but smoothing via government saving does not decrease (it even increases slightly). The longer differencing period captures the response of changes in income and consumption to longer lasting shocks to GDP. The first column suggests that when profits decrease temporarily, corporations decrease (on average) the fraction of earnings they retain (to avoid a sharp decrease in distributed profits.) The second column of the table suggests that over longer horizons, corporations do not change the fraction of earnings retained.[32] By contrast, national governments seem to respond to transitory as well as to longer lasting shocks by increasing or decreasing the budget deficit in response to fluctuations in GDP.

The amount of income and consumption smoothing may depend on country characteristics. Asdrubali, Srensen, and Yosha (1996) found that U.S. states with more persistent shocks to gross state product exhibit less consumption smoothing via saving, which is consistent with permanent income theory. We performed similar exercises for the sample of OECD countries (the EC sample is too small to split). We estimated the average persistence of GDP shocks using the methodology suggested by Campbell and Mankiw (1987), and split the sample into two groups: a high persistence group and a low persistence group of countries. We did not find significant differences in income and consumption smoothing patterns between these two groups.[33] We examined, in the same manner, if more open states (states with high exports plus imports to GDP ratios) exhibit different patterns of risk sharing, but again found no significant differences.

In Table 5 we display patterns of risk sharing among OECD countries and U.S. states at the 3-year frequency. The results in Table 4 and Table 5 can help assess whether the 39

[32]See Brealey and Myers (1991, Chapter 16).

[33]It is interesting that neither government nor private saving seem to respond differently to shocks that are more persistent. A more in-depth study of this issue will take us too far afield and is left to future research. See Dahlberg and Lindström (1996) and the references therein.

percent capital market income smoothing among U.S. states (Table 2) is driven by factor income flows or by corporate saving patterns. Since the fraction of shocks smoothed among U.S. states does not decline when the differencing interval lengthens, whereas for OECD countries it does (Table 2 versus Table 5), and recalling from Table 4 that corporations do not smooth distributed profits at the 3-year horizon then, assuming that U.S. and OECD corporations exhibit similar behavior, we conclude that the capital market income smoothing in the U.S. over longer horizons is not driven by corporate saving patterns. Since it is certainly not driven by depreciation (which dis-smoothes income), it must reflect income smoothing through interstate factor income flows.

Note also that consumption smoothing among U.S. states decreases sharply as the differencing interval lengthens whereas consumption smoothing among OECD countries does not. We know that consumption smoothing among OECD countries is not driven by personal saving, but rather by national government saving (Table 4). Interstate consumption smoothing in the United States may, however, result from personal or state government saving. The results for 3-year differencing displayed in Table 5 indicate that, unlike OECD national governments that, as we have seen, attempt to smooth national consumption in response to transitory as well as longer lasting shocks, individuals and state governments in the United States do not, or cannot do so.[34]

As we stressed in the introduction, the large amount of consumption smoothing achieved in the EC via government borrowing may not be sustainable in an EMU where fiscal coordination must be maintained. Until private capital and credit markets develop, there may be a need for a greater insurance role of EC institutions.

We turn to the decomposition of smoothing via saving to smoothing via domestic net physical investment and via net exports. We measure the fraction of shocks smoothed via domestic net investment by estimating the coefficient in the regression of $\Delta \log \text{GDP}^i - \Delta \log(\text{GDP}^i - \text{I}^i)$ on $\Delta \log \text{GDP}^i$. Similarly, the coefficient in the regression of $\Delta \log \text{GDP}^i - \Delta \log(\text{GDP}^i - (\text{X}^i - \text{M}^i))$ on $\Delta \log \text{GDP}^i$ measures the fraction of shocks smoothed via net exports ("investment abroad"). The results, displayed in Table 6, indicate that the bulk

[34]In fact, many state governments in the United States are prohibited by law from running deficits; see Poterba (1994) and Bohn and Inman (1996).

of smoothing is achieved via domestic investment, not international trade.[35] A potential explanation for the finding that trade flows do not contribute to cross-country consumption smoothing, is that central banks attempt to neutralize the impact of foreign capital inflows on domestic credit markets. Another possible explanation is limited flexibility in cross-border trade credit arrangements among exporters and importers. The finding that shocks to output are smoothed via domestic net physical investment is consistent with the procyclical behavior of investment in aggregate US data; see Blanchard and Fischer (1989), p.16.[36]

5 Concluding Remarks

We provided evidence that, for OECD as well as for EC countries, about 40 percent of shocks to GDP are smoothed at the one year frequency, with about half the smoothing achieved through national government budget deficits and half by corporate saving. At the three year differencing frequency only 25 percent of shocks to GDP are smoothed, with all the smoothing achieved via government lending and borrowing. We further found that factor income flows do not smooth income shocks among EC and OECD countries.

The general picture that emerges is that capital and credit markets in OECD countries,

[35] We find that the current account is actually counter-cyclical, which is consistent with results in the Real International Business Cycle literature, e.g., Mendoza (1991) and Backus, Kehoe, and Kydland (1992).

[36] One important difference between U.S. states and OECD countries is, of course, that countries are subject to real exchange rate fluctuations. In our empirical analysis we have deflated all the magnitudes by the country consumption deflator, measuring the output and consumption of each country in terms of real consumption in that country. Since Eichengreen (1994) reports that deviations from PPP among EC countries can be quite large, we wanted to evaluate the potential effect of exchange rate fluctuations on consumption. We regress, for the entire sample of OECD countries, $\Delta \log c_t^i$ on $\Delta \log \text{GDP}_t^i$ and $\Delta \log \text{PPP}_t^i$, where c_t^i and GDP_t^i are deflated using country i's period t consumption deflator, and PPP_t^i denotes the period t ratio of country i's consumption deflator (measured in U.S. dollars) and the U.S. consumption deflator. The regression coefficients are interpreted as the elasticities of consumption with respect to GDP and with respect to changes in the real exchange rate. The estimated elasticity of consumption with respect to changes in output is 0.62 and 0.73 at the one and three year differencing frequencies. The estimated elasticity of consumption with respect to changes in the real exchange rate is 0.015 and 0.061 (all the elasticities are estimated very precisely). The partial R^2 for the elasticities with respect to output are 0.80 and 0.89, and 0.01 and 0.04 for the elasticities with respect to the exchange rate. They represent the increment in the sum of squares explained by the variable, given the fraction of the sum of squares already explained by the other variable. We conclude that when the currency of a country appreciates in real (inflation adjusted) terms, although the citizens and the government of that country can, in principle, purchase more goods at international prices with a given amount of their country's currency, they do so to a relatively small extent. Our measures of risk sharing are, therefore, not likely to be affected by deviations from PPP.

unlike interstate markets in the United States, are not well integrated, since neither factor income flows nor cross-border flows of physical goods contribute much to international risk sharing. An important implication is that the restrictions on budget deficits imposed by the Maastricht Treaty should be relaxed, allowing governments to run large deficits in response to output shocks, at least until alternative risk sharing mechanisms develop.

International transfers, including EC structural funds, have in recent years smoothed about 5 percent of shocks to per capita GDP in the EC, compared to 13 percent of shocks to the per capita gross state product smoothed by the federal government in the United States. If the EC wishes to achieve, via its budget, a degree of intercountry insurance comparable to that of the United States, namely 25 percent of shocks to GDP not smoothed, then the size of the budget has to increase dramatically. The desirability and feasibility of greater insurance to EC members through an EC-wide tax-transfer system depends on the speed at which private capital markets integrate, and on the ability of EC institutions to overcome potential moral hazard problems such as misreporting on the part of member countries. The design of risk sharing institutions is, however, beyond the scope of the present paper; see Persson and Tabellini (1996) for an analysis.

We have decomposed the smoothing via saving into smoothing via I and X-M, finding that all the smoothing is achieved through domestic net physical investment with virtually no smoothing via net exports. Since international trade patterns do not respond to shocks they do not contribute to cross-country risk sharing. Frankel and Rose (1997) argue that over longer horizons, trade among countries increases the correlation between their output. If EMU will indeed induce more trade among EC countries, then shocks may gradually become less country specific. In light of the large amount of diversifiable regional risk in the United States (see Srensen and Yosha (1996) for an empirical study) we should not expect to see country specific risk in Europe totally disappear.

Table 1

Income and Consumption Smoothing (percent) by National Accounts Categories

	EC8 1966-80	EC8 1981-90	OECD 1966-80	OECD 1981-90
Factor Income (β_f)	0	2	0	−2
	(1)	(3)	(1)	(1)
Capital Depreciation (β_d)	−4	−8	−6	−9
	(2)	(2)	(1)	(2)
International Transfers (β_τ)	0	5	0	3
	(2)	(3)	(1)	(1)
Saving (β_s)	46	24	40	44
	(6)	(8)	(3)	(4)
Not Smoothed (β_u)	57	78	66	65
	(6)	(7)	(3)	(4)

Notes. EC8: Belgium, Denmark, France, Germany, Ireland, Italy, the Netherlands, United Kingdom. OECD: All 1996 members of the OECD except Luxembourg and Mexico. Percentages of shocks absorbed at each level of smoothing. Standard errors in brackets. β_f is the GLS estimate of the slope in the regression of $\Delta \log \text{GDP}^i - \Delta \log \text{GNP}^i$ on $\Delta \log \text{GDP}^i$, β_d is the slope in the regression of $\Delta \log \text{GNP}^i - \Delta \log \text{NI}^i$ on $\Delta \log \text{GDP}^i$, and similarly for β_τ and β_s. β_u is the coefficient in the regression of $\Delta \log(\text{C}^i + \text{G}^i)$ on $\Delta \log \text{GDP}^i$. We interpret the β-coefficients as the incremental percentage amounts of smoothing achieved at each level, and β_u as the percentage of shocks not smoothed.

Table 2

Income and Consumption Smoothing among EC and OECD Countries and among U.S. States

	OECD* 1981-90	EC6 1981-90	U.S. States 1981-90
Capital Markets	15	8	39
	(4)	(10)	(3)
Transfers	2	7	13
	(1)	(3)	(1)
Consumption Smoothing	26	3	23
	(5)	(11)	(6)
Not Smoothed	57	82	25
	(5)	(9)	(6)

Notes. OECD*: Austria, Belgium, Denmark, Finland, France, Germany, Italy, Sweden, United Kingdom, United States, Japan, Australia, Canada. EC6: Belgium, Denmark, France, Germany, Italy, United Kingdom. Percentages of shocks absorbed at each level of smoothing. Standard errors in brackets. The decomposition is constructed in an analogous manner to that in Table 1. The U.S. states column is from Asdrubali, Srensen, and Yosha (1996).

Table 3

Average Correlations of Output, Income, Disposable Income, and Consumption with the Corresponding U.S. Aggregate Series for OECD Countries and U.S. States

	1-year differenced series	HP-filtered series
	OECD Countries 1960-1993	
Gross Domestic Product	.40	.52
Gross National Product	.42	.52
National Income	.43	.54
National Disposable Income	.44	.54
Consumption	.41	.53
	U.S. States 1963-1990	
Gross State Product	.75	.68
State Income	.83	.79
Disposable State Income	.84	.83
Consumption	.54	.59

Notes. OECD: All 1996 members of the OECD except Luxembourg and Mexico. The correlations with the corresponding aggregate series for the U.S. are calculated country by country, and the simple averages across countries are presented in the table. U.S. states: All 50 U.S. states. The correlations are calculated state by state with the corresponding aggregate series for the U.S., and the simple averages across the 50 states are presented in the table.

Table 4

Smoothing via Corporate, Personal, and Government Saving among OECD Countries at Various Differencing Frequencies

	OECD* (1yr) 1981-90	OECD* (3 yr) 1981-90
Factor Income + Depreciation	−8	−2
	(2)	(2)
Corporate Saving	23	4
	(5)	(3)
International Transfers	2	3
	(1)	(1)
Personal Saving	5	−2
	(6)	(5)
Government Saving	25	30
	(5)	(5)
Not Smoothed	56	73
	(4)	(10)

Notes. OECD*: Austria, Belgium, Denmark, Finland, France, Germany, Italy, Sweden, United Kingdom, United States, Japan, Australia, Canada. Percentages of shocks absorbed at each level of smoothing. Standard errors in brackets. The decomposition is constructed in an analogous manner to that in Table 1. The levels of smoothing correspond to those in Table 1, but are more detailed. Comparing to the levels of smoothing in Table 2, the first two levels constitute "capital market smoothing," while "consumption smoothing" is decomposed into smoothing via personal and national government saving. The fractions smoothed have not been constrained to add up to 100 percent.

Table 5

Income and Consumption Smoothing among EC and OECD* Countries

and among U.S. States—3 Year Differencing Intervals

	OECD* (3yr) 1981-90	U.S. States (3yr) 1981-90
Capital Markets	3	44
	(6)	(2)
Transfers	2	16
	(2)	(1)
Consumption Smoothing	20	7
	(8)	(6)
Not Smoothed	75	34
	(10)	(7)

Notes. OECD*: Austria, Belgium, Denmark, Finland, France, Germany, Italy, Sweden, United Kingdom, United States, Japan, Australia, Canada. EC6: Belgium, Denmark, France, Germany, Italy, United Kingdom. Percentages of shocks absorbed at each level of smoothing. Standard errors in brackets. The decomposition is constructed in an analogous manner to that in Table 1. The U.S. States column is from Asdrubali, Srensen, and Yosha (1996).

Table 6

Smoothing through Domestic Net Physical Investment and via Net Exports among EC and OECD Countries

	EC8 1966-90	OECD 1966–90
Net Investment	42	47
	(5)	(3)
Net Exports	−4	−10
	(5)	(2)

Notes. EC8: Belgium, Denmark, France, Germany, Ireland, Italy, the Netherlands, United Kingdom. OECD: All 1996 members of the OECD except Luxembourg and Mexico. Percentages of shocks absorbed at each level of smoothing. Standard errors in brackets. We measure the fraction of shocks smoothed via domestic net physical investment by estimating the coefficient in the regression of $\Delta \log \text{GDP}^i - \Delta \log(\text{GDP}^i - \text{I}^i)$ on $\Delta \log \text{GDP}^i$. Similarly, the coefficient in the regression of $\Delta \log \text{GDP}^i - \Delta \log(\text{GDP}^i - (\text{X}^i - \text{M}^i))$ on $\Delta \log \text{GDP}^i$ measures the fraction of shocks smoothed via net exports ("investment abroad").

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