"On the Empirics of International Smoothing"

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ON THE EMPIRICS OF INTERNATIONAL SMOOTHING$^1$

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Abstract

By fully exploiting the statistical properties of panel data, this paper improves upon existing methodologies to estimate consumption smoothing at least in three respects. First, we model explicitly incomplete risksharing as well as incomplete intertemporal smoothing, and couch the two mechanisms in a unified framework. Second, we fully exploit simple panel data analysis in order to measure degrees of both risksharing and intertemporal smoothing taking place in a given set of economic regions. In particular, we are able to measure not only the smoothing of idiosyncratic shocks, but also the dependence on aggregate (non-diversifiable) shocks. Third, we distinguish neatly between the effects of temporary vs. permanent shocks. This can be done by taking advantage of the complementarity between the “within” estimator and the “between” estimator in a panel regression.

We apply the above methodology to a panel of 23 OECD countries in the period from 1955 to 2005. The main finding is consistent with the puzzle of negligible international risksharing, in line with the results of Sørensen and Yosha (1998), and despite the use of a different data source. Our analysis shows that industrial countries have tended to absorb output shocks mostly through intertemporal smoothing. About 25% of all temporary shocks are smoothed this way, while a comparable fraction of permanent shocks determine consumption growth.
1 Introduction

Intertemporal macroeconomic theory underlines that, under certain assumptions, countries, like individuals, attempt to smooth their consumption, in the face of possibly volatile output paths. In autarky, the only way to absorb output shocks is for a country to engage in intertemporal smoothing: saving (and investing domestically) in good times (a positive shock) and dissaving in bad times. In an open economy, the possibilities for smoothing widen: besides engaging in intertemporal smoothing through domestic investment, countries can engage in intertemporal trade, through foreign lending and borrowing, in order to smooth temporary shocks; but they can also implement the intra-temporal smoothing solution by making (explicit or implicit) risksharing arrangements, in order to mutually smooth idiosyncratic shocks.

Until recently, the empirical literature which tried to test these tenets of open economy macro theory was not abundant. Tests for full risksharing in the aggregate appeared in Lewis (1996), Canova and Ravn (1996) and Ubide (1994),1 but these analyses focused on whether full risksharing was rejected by the data or not, and neglected to examine how much risksharing took place, and through which channels. As for tests of intertemporal smoothing, many studies have explored the life-cycle/permanent income hypothesis using aggregate time series data.2

Both risksharing and intertemporal smoothing tests have typically been carried out separately. The rationale underlying this partial equilibrium assumption stems in part from the result that full risksharing implies intertemporal smoothing. However, when risksharing is not complete, intertemporal smoothing does not necessarily ensue, and thus a separate test is warranted in order to assess the full range of smoothing capabilities of the economy. Indeed, recent research (e.g., Asdrubali and Kim 2004) has shown that there exists a degree of substitutability between risksharing and intertemporal smoothing channels, thereby lending support to the idea that the two smoothing mechanisms should not be explored independently. There are several possible ways to take care of this interdependence in a unified model. For example, Asdrubali, Sørensen and Yosha (1996) and Asdrubali and Kim (2004) decomposed smoothing into channels, whose very nature identifies risksharing and intertemporal smoothing mechanisms; Obstfeld (1994) regressed time series of country consumption growth on aggregate consumption growth and current income growth by implicitly assuming that there are no intertemporal consumption smoothing opportunities; Crucini (1999) replaced current income growth with permanent income growth by assuming that there exist full intertemporal consumption smoothing opportunities.3 In this paper we analyze risksharing and intertemporal smoothing by exploiting the statistical properties of panel data. Panel data allow to analyze cross-sectional and time-series variations in a consistent way, by studying the evolution over time of a group of countries; in

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1Earlier tests typically involved informal comparisons of cross-country consumption correlations with output correlations (Backus, Kehoe, and Kydland 1992, Pakko 1998). However, no standard errors were generally provided.


3Therefore, the latter two studies are not fully successful in empirically measuring the two channels separately. Refer to Asdrubali and Kim (2004) for more details.
addition, they allow to easily distinguish between idiosyncratic and common shocks on one hand, and permanent vs. temporary shocks on the other.\footnote{Other advantages of panel data estimation include a reduction of multicollinearity and of measurement error, omitted variable, selectivity and heterogeneity bias (see Hsiao 2003). This contributes to an improvement of consistency and efficiency of estimations.} Typically, studies have found a degree of total intranational risksharing around 70\%, and of international risksharing around 0\%,\footnote{In fact, a general result of the risksharing literature is that the coarser the aggregation, the lower the risksharing.} suggesting that either market incompleteness or impatience or informational asymmetries, or some other frictions may be responsible for the observed less-than-full risksharing. As for intertemporal smoothing estimates, typical time-series figures revolve around 50\% (e.g., Campbell and Mankiw 1990).

However, there are several directions in which these studies can be improved, and new information can be extracted. This is the task the present paper takes up. First, we model explicitly incomplete risksharing as well as incomplete intertemporal smoothing, and couch the two mechanisms in a unified framework. Second, we fully exploit simple panel data analysis in order to measure degrees of both risksharing and intertemporal smoothing taking place in a given set of economic regions (provinces, states, countries...). In particular, we are able to measure the smoothing of not only idiosyncratic, but also aggregate (non-diversifiable) shocks. Third, we distinguish neatly between smoothing of current vs. permanent shocks. This can be done by taking advantage of the complementarity between the “within” estimator and the “between” estimator in a panel regression. Fourth, we use the panel structure of the data also to obtain more consistent and efficient estimates.

We apply the above methodology to a panel of 23 OECD countries in the period from 1955 to 2005. The main finding is consistent with the puzzle of negligible international risksharing, in line with the results of Sørensen and Yosha (1998), and despite the use of a different data source. Our analysis shows that industrial countries have tended to absorb output shocks mostly through intertemporal smoothing. About 25\% of all current shocks are buffered this way, while a comparable fraction of permanent shocks determine consumption growth.

In the next section we will outline a model of risksharing and intertemporal smoothing. In Section 3 we will lay out the econometric methodology, whereas we will discuss in Section 4 the estimation results for a panel of 23 OECD countries for the period 1955–2005. Section 5 will then conclude.

## 2 Consumption Smoothing in Open Economies

Consider a world composed of $N$ open economies, lasting for $T \to \infty$ periods, indexed by $t = 1, \ldots, T$. Each country $i$ is inhabited by a representative agent who maximizes a von Neumann-Morgenstern utility function, with a strictly concave period utility separable in leisure and nontradables. The product of country $i$ in period $t$, $Y^i_t$, is an exogenously given random variable, with a commonly known probability distribution. Typically, in this context of income uncertainty the constraints to utility maximization
depend on the financial structure, and in particular on the possibility of insuring against income shocks.

In a complete asset markets environment, agents can smooth country consumption across states of nature, for example by trading contingent claims internationally. When specializing to Constant Relative Risk Aversion (CRRA) preferences, and using the market-clearing restriction \( \sum_i C_i^t = \sum_i Y_i^t \), country consumption \( C_i^t \) is a constant share of aggregate income, and is independent of idiosyncratic variables, notably domestic output.\(^9\) In log-difference form:

\[
\Delta C_i^t = \Delta Y_t, \tag{1}
\]

where lowercase sans-serif letters indicate logs of per-capita variables.

It is important to note that alternative decentralization schemes can attain the same equilibrium in different contexts; for example, an appropriate tax-transfer regime, or free trade in goods and services can reproduce the complete-market allocation even though asset markets are not complete or even non-existent. Therefore, at this stage we will follow Canova and Ravn (1996) in taking no stand as to which mechanism precisely can attain complete risksharing.

As first pointed out by Cochrane (1991), an efficient empirical implementation of the full risksharing equation (1) consists in regressing consumption on idiosyncratic variables and test the zero-coefficient hypothesis. A typical specification in log-differences is:

\[
\Delta c_i^t = \nu_t + \beta \Delta y_i^t + \epsilon_i^t, \tag{2}
\]

where \( \epsilon_i^t \) represents a measurement error, the log-difference of aggregate income is captured by the time fixed effect \( \nu_t \), and a test is performed for \( \beta = 0 \). In this panel equation, the \( \beta \) coefficient is a weighted average of the year by year cross-sectional regressions.

When risksharing is complete, it is not necessary to worry about intertemporal allocation, because full risksharing implies intertemporal consumption smoothing, in the sense that the relevant Euler equation is satisfied.\(^7\) But when risksharing is incomplete, intertemporal consumption smoothing does not necessarily ensue, and it is therefore necessary to characterize the conditions for intertemporal allocation.

When asset markets are incomplete, in the sense that agents can only trade riskless bonds, with CRRA preferences the intertemporal allocation is characterized by a proportionality between country consumption and permanent income \( Y_t^{P,i} \), so that in log-differences:\(^8\)

\[
\Delta c_i^t = \Delta y_t^{P,i} \tag{3}
\]

In analogy with the risksharing test, a test of equation (3) can be implemented in a panel setup by introducing current income (that captures the deviation from optimality) and an individual fixed effect (that captures unobservable country specificities):

\(^7\)See the proof in Sorensen and Yosha (1998).
\(^8\)The derivation goes back at least to Hansen and Singleton (1983) and rests on the assumption that consumption growth has a weakly stationary conditional normal and homoskedastic distribution, and the gross real interest rate follows an independent white noise process (not necessarily normal) with mean \( \bar{R} \) (see Bean 1986).
where $\varepsilon_t^i$ represents a measurement error and a test can be performed for $\beta = 0$.\footnote{In a non-panel setup, as for the test of equation (3), Campbell and Mankiw (1989, 1990) in assuming a constant expected interest rate and estimating the deviations from optimality, suggested $\Delta c_t = \mu + \lambda \Delta y_t + \varepsilon_t$. Notice that $\Delta y_t$ can be divided into two terms, $\mu$ and $\varepsilon_t$, where $\varepsilon_t$ represents innovations in permanent income and is i.i.d. and uncorrelated with the regressor’s past history. As in our case and in the case of risksharing test, they used the estimated parameter for the current income, $\lambda$, for representing the deviation from optimality.}

In a world of incomplete markets, where available financial assets may not span all the possible states of nature, both equations (2) and (4) need to be estimated in order to assess the global consumption smoothing properties of the economies under examination. How to implement such a joint estimation in a set-up able to measure the degrees of risksharing and intertemporal smoothing is the subject of the next section.

3 Econometric Model with Panel Data

Consider the simple panel model representing the response of consumption growth to income growth:

\begin{equation}
\Delta c_t^i = \lambda \Delta y_t^i + \eta_t^i,
\end{equation}

This model can be decomposed either cross-sectionally or intertemporally, depending on the assumption on the error term structure.

3.1 Risksharing test

Let us start with the cross-sectional decomposition, where:

\begin{equation}
\eta_t^i = \nu_t + \varepsilon_t^i.
\end{equation}

where the error term $\varepsilon_t^i$ is i.i.d. Typically, the time effect term $\nu_t$ is not further modelled, and in the resulting risksharing test

\begin{equation}
\Delta c_t^i = \nu_t + \beta \Delta y_t^i + \varepsilon_t^i,
\end{equation}

where $\nu_t$ is treated as fixed, and the parameter $\beta$ is estimated through either the ”between” estimator or the ”within” estimator in order to gauge a measure of risksharing.

However, Mundlak (1978) proposed a way to take into account time heterogeneity more explicitly by appropriately modelling the time effect term as random. In our case, the term $\nu_t$ typically captures the effect of aggregate output growth, and as such it is likely to be correlated with domestic output growth $\Delta y_t^i$. It is therefore appropriate to take explicitly into account such relationship assuming that:

\begin{equation}
\nu_t = \alpha \Delta y_t + u_t,
\end{equation}

\begin{equation}
\Delta c_t^i = \nu_t + \beta \Delta y_t^i + \varepsilon_t^i,
\end{equation}
where $\Delta y_t = \sum_i \Delta y^i_t$ and $E[u_t|\Delta y] = 0$. As long as $\alpha > 0$, the random-effects estimator of $\beta$ is both biased and inconsistent. Substituting (8) into (7) and rearranging we obtain:

$$
\Delta c^i_t = u_t + \beta \Delta y^i_t + \alpha \Delta y_t + \epsilon^i_t,
$$

(9)

where $E[(u_t + \epsilon^i_t)|\Delta y] = 0$.

Here the coefficient $\beta$, attached to domestic output growth, naturally measures the deviation from the risksharing arrangement, and the orthogonal coefficient $\alpha$, attached to aggregate output growth, measures the extent of risksharing. Mundlak (1978) shows that $\beta$ can be unbiasedly estimated through the "within" estimator applied to (7), and $\alpha$ can be gauged via the corresponding (and orthogonal) "between" estimator, minus the "within" estimator. Thus, imposing an appropriate structure to the standard risksharing equation (7), allows us to obtain straightforward and unbiased estimates of both the extent of risksharing, and the extent of deviation from the risksharing benchmark. Our specification posits that the extent of risksharing can be inferred directly from the coefficient on aggregate income growth, instead of the coefficient on domestic income growth. The advantage of this formulation is that domestic consumption growth may fail to comove with domestic income growth even in the absence of risksharing — for example, if there is an intertemporal consumption smoothing opportunity. Thus, estimating how much domestic consumption growth depends on aggregate income growth constitutes a more direct and correct measure of the risksharing equation (7).

3.2 Intertemporal smoothing test

In order to derive an intertemporal smoothing test stemming from the same model, we use again the basic equation (5), this time focusing on the time dimension. Then the error term can be decomposed as:

$$
\eta^i_t = \mu^i + \upsilon^i_t,
$$

(10)

so that

$$
\Delta c^i_t = \mu^i + \gamma \Delta y^i_t + \upsilon^i_t.
$$

(11)

Again following Mundlak’s methodology, we could model individual heterogeneity by taking explicitly into account the correlation between $\mu^i$ and the time average of output:

$$
\mu^i = \delta \Delta y^i + \zeta^i,
$$

(12)

The equation to be estimated then becomes:

$$
\Delta c^i_t = \zeta^i + \gamma \Delta y^i_t + \delta \Delta y^i + \upsilon^i_t.
$$

(13)

Here the coefficient $\delta$, attached to the time average of output growth, can be interpreted as consumption smoothing out of permanent output growth,\(^{10}\) whereas the

\(^{10}\)Note that our econometric model replaces permanent output growth with average output growth. However, it is easy to show that — under our assumption of output following a linear stochastic process — the two measures are extremely close.
orthogonal coefficient $\gamma$, attached to current output growth, measures the extent of consumption smoothing out of temporary income growth. Note that for both the cross-sectional and the intertemporal decomposition, the adoption of Mundlak’s methodology automatically solves the problem of choosing between a fixed-effect and a random-effect estimator, since under the above assumptions the two estimators coincide. In analogy with the risksharing specification, our intertemporal smoothing equation allows us to estimate the smoothing coefficient directly, rather than indirectly through the coefficient on current income growth.

3.3 A joint test

The error $\eta^i_t$ in (5) can be alternatively decomposed in a two-way fashion as:

$$\eta^i_t = \nu_t + \mu^i + \nu^i_t.$$  

Making explicit the correlation between the time and country random effects and the regressor:

$$\eta^i_t = \alpha \Delta y^i_t + u_t + \delta \Delta y^i_t + \zeta^i_t + \nu^i_t,$$

so that the single panel equation to be estimated becomes:

$$\Delta c^i_t = u_t + \zeta^i_t + \delta \Delta y^i_t + \alpha \Delta y^i_t + \beta \Delta y^i_t + \nu^i_t.$$  

This is a well-specified two-way model, where by definition the time and country effects are i.i.d. and uncorrelated with the regressors. The coefficient attached to $\Delta y^i_t$ measures the degree of intertemporal smoothing, for it represents the extent to which country consumption growth follows permanent (average) income growth. The coefficient attached to $\Delta \overline{y}_t$ measures the degree of risksharing, for it quantifies the co-movement of country consumption growth with aggregate income growth. Finally, the coefficient on $\Delta y^i_t$ is a measure of the joint failure of the permanent income hypothesis and of the risksharing hypothesis, for it is an estimate of the degree to which country consumption growth follows idiosyncratic and temporary income growth. The interest of equation (16) lies in the fact that it orthogonalizes the effects of risksharing and intertemporal smoothing on consumption, while still maintaining the direct estimations of the aggregate income growth and of the average income growth coefficients.

4 Results

All equations have been implemented econometrically using the IMF’s International Financial Statistics Series of National Accounts, from 1955 to 2005. Figures 1 and 2 plot the data from two viewpoints of interest for our analysis: figure 1 displays the time series of output and consumption growth for selected countries, revealing visually the extent of intertemporal smoothing (see, for instance, the UK plot); figure 2 shows

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11 The 23 countries considered are: Austria, Belgium, Denmark, France, Germany, Finland, Greece, Iceland, Ireland, United Kingdom, Italy, Luxembourg, Netherlands, Norway, Sweden, Switzerland, Portugal, Spain, United States, Canada, Japan, Australia, New Zealand.
the cross sections of output and consumption growth for selected years, illustrating
the extent of risksharing (see the 1970 plot). The data have been log-differenced to
purge away the stochastic trend of I(1) variables, as identified in Augmented Dickey-
Fuller unit root tests. In general, the results of various panel cointegration tests,
considered in Pedroni (1999), are not against the difference specification in our empiri-
cal equations (Table I). In addition, log-differences allow us to interpret regression
coefficients in percentage terms, a natural avenue to measure the fractions of shocks
smoothed through the various mechanisms. Deflating variables by population and con-
sumer price indexes, as well as using logs and first differences contributes to minimize
ex-ante heteroskedasticity and autocorrelation issues. Finally, the adoption of panel
data improves the efficiency of estimations in general and curbs the multicollinearity
problem, whereas the use of time and country effects addresses possible biases caused
by omitted variables.

Tests of any remaining problems of heteroskedasticity and autocorrelation have
been carried out through appropriate diagnostics, whereas ancillary instrumental
variable estimations have been adopted to assess the degree of endogeneity. When
necessary — as in the case of heteroskedasticity — the corrected estimators have been
used.

4.1 Two-equation approach

In the two-equation approach, equations (9) and (13) have been estimated by applying
the random effects estimators, with time effects and with country effects respectively,
after correcting for the presence of time and country heteroskedasticity.

4.1.1 Risksharing estimates

Table III reports the estimation results for equation (9). The estimate for the coeffi-
cient on country income growth is 0.62, suggesting that 38% of idiosyncratic income
growth shocks are insured. This figure is larger than the usual estimates, for our
specification controls for the typical omission of aggregate income in regressions of
this type. Interestingly, the estimate for the coefficient on aggregate income is 0.18;
this may suggest positive regional risksharing and positive intertemporal smoothing.
Indeed the inference on the coefficient of aggregate income growth provides a direct

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12Seven panel cointegration tests have been carried out, following Pedroni (1999). For the specification
of equation (9), the null of no cointegration cannot be rejected at any conventional significance
level in all seven tests. For the specification of equation (13), it is not rejected at 5% significant level in
three out of seven cases. Although Pedroni’s tests only allow for fixed effects, vector panel cointegra-
tion with random effects is near the frontier, and not yet a consolidated field. Thus, we will share with
most of the consumption smoothing literature the inconsistency of estimating an essentially long-run
theory (the permanent income hypothesis) with first-differenced data.

13Breusch and Pagan (1979) tests for heteroskedasticity and Durbin and Watson (1950, 1951) for
autocorrelation, both adapted to random-effects panel data, have been used (Table II).

14As shown in the paper, (weighted) random-effect estimates of $\beta$ and $\alpha$ in equation (9) correspond
to the (weighted) "within" and the "between-minus-within" estimates of $\beta$ in equation (7). Similarly,
(weighted) random-effect estimates of $\gamma$ and $\delta$ in equation (13) correspond to the (weighted) "within"
and the "between-minus-within" estimates of $\gamma$ in equation (11).
estimate for the degree of international risksharing, while regional income pooling effects, as documented, for example, by Sorensen and Yosha (2000) may put a wedge between a country’s consumption growth and income growth rates. In addition, as documented in the next section, positive intertemporal smoothing may also make a country’s consumption growth rate deviate from its income growth rate.

4.1.2 Intertemporal Smoothing Estimates

Table IV illustrates how output shocks — be they current or permanent — are dealt with intertemporally within the average OECD country (equation (13)). While about 40% of current disturbances are absorbed over time, only a fourth of a permanent shock is smoothed, in the sense that country consumption growth follows only 26% of movements in a measure of permanent income growth. As in the case of risksharing, the coefficient on permanent income growth represents a more direct measure of the degree of intertemporal smoothing since a country’s consumption growth may deviate from its output growth even in the absence of intertemporal consumption smoothing, for example, if there is an opportunity for regional risksharing. The breakdown into subperiods shows an increase in overall smoothing from the 50s and 60s to the 70s and 80s and a subsequent reduction in the last 15 years. While the $\gamma$ and $\delta$ coefficients represent two sides of the same coin — namely, the difficulty of using domestic and international credit markets to smooth domestic consumption over time — the difference between the two can be interpreted as the relative imperfection of long-term vs. short-term borrowing.

4.2 Single-equation regression

Table V illustrates the results of the estimation of equation (16) as a two-way random effects model. For this specification, we adopted an heteroskedasticity-corrected GLS estimation. The degree of risksharing — measured by the coefficient $\alpha$ — is essentially nil, a confirmation of the international risksharing puzzle examined at length elsewhere (e.g., Asdrubali and Kim 2004). The orthogonal coefficient $\delta$, a measure of intertemporal consumption smoothing, amounts to 0.26, meaning that consumption growth follows 26% of the changes in permanent income growth. The coefficient $\beta$ reveals the extent of the failure of the consumption models analyzed jointly in this paper: 61% of idiosyncratic temporary income growth dictates annual consumption growth behavior, contrary to standard predictions. The subperiod estimation exhibits a pattern of falling intertemporal smoothing and probable rising of regional risksharing in the 70s and 80s, and a subsequent reversal in the last fifteen years. The opposite trends of changes in intertemporal smoothing and international risksharing are consistent with the substitutability between the two channels, as found in Asdrubali and Kim (2004).

It is worth stressing the general consistency of the two approaches adopted in this paper, and the usefulness of both, although the single-equation specification should be preferred. The coefficient on aggregate income growth is 18% in the two-equation approach but it is 0% in the single-equation approach. This difference is due to the partialling out of intertemporal smoothing and country effects in the single-equation
approach: once we control for changes in permanent income and unobservable country differences, the dependence of consumption growth on aggregate income growth disappears. This result suggests that the estimate of the degree of risksharing (or dependence on aggregate income growth) is biased upward substantially if intertemporal consumption smoothing (or dependence on country permanent income growth) is not properly considered. On the other hand, the coefficient on country permanent income growth does not differ much between the two approaches, which suggests that the estimate of the degree of intertemporal consumption smoothing (or dependence on country permanent income growth) is not biased much even if risksharing (or dependence on aggregate income growth) is not properly considered. The implication is that country consumption movements following permanent income changes may be falsely regarded as risksharing in the model without an explicit measure of permanent income. Given the consistency of the intertemporal smoothing estimates, it is also of interest to analyze the similarity of the coefficient on country income across the two specifications: a consistent estimate around 0.60 suggests that in our sample idiosyncratic shocks tend to be temporary. This result may rationalize the lack of international risksharing as the incapability of setting up insurance mechanisms (or agreements) in the presence of temporary disturbances, that are typically better dealt with intertemporally (see Asdrubali and Kim 2004).

For robustness testing, ancillary equations have been estimated. To control for error autocorrelation, a first-order autoregressive error structure has been imposed on the GLS covariance matrix, with results very similar to the ones reported in the baseline regression. A similar result for $\beta$ has been obtained from an IV estimation with lagged regressors as instruments. The estimate for the intertemporal smoothing coefficient $\delta$, instead, fell a little, from 0.26 to 0.18, thus leaving our qualitative conclusions unaffected.

5 Conclusions

What can we learn from the previous exercise? From a methodological viewpoint, it is possible to study both risksharing and intertemporal smoothing in a simple, unified and internally consistent framework, distinguishing and quantifying the effects of different types of shocks. As for the application to OECD countries, several interesting conclusions emerge. First, the paper lays support to analyses that have found scarce (or non-existent) international risksharing as domestic consumption growth — once properly analyzed — does not depend on aggregate income growth; however, domestic consumption growth follows "only" 60% of movements in idiosyncratic (and temporary) income growth, a signal of the presence of regional risksharing and other smoothing opportunities. Second, despite the virtual absence of international risksharing, the average OECD country is indeed able to smooth intertemporally 26% of its temporary output growth shocks, for current domestic consumption growth optimally follows an equal fraction of shocks to a measure of permanent output growth. Thus, we have detected a strong tendency for countries to rely on intertemporal smoothing as an alternative optimum allocation mechanism, presumably in the face of frequent
shocks to their permanent income. This may explain the strong dependence of consumption growth on income growth in the years 1956–1972 and 1990-2005, but a much weaker relation in the shock-ridden years from 1973 to 1989. The overall trend towards greater intertemporal smoothing — albeit no greater risksharing — may instead be rationalized by the international capital liberalization and the developments in the European Union of the last 15 years. Interestingly, such developments appear to have substituted risksharing also at the regional level.

6 References


Table I: Pedroni (1999)’s Panel Cointegration Test

<table>
<thead>
<tr>
<th></th>
<th>Time effect</th>
<th>Country effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel $v$-Statistics</td>
<td>-0.13773</td>
<td>1.97217</td>
</tr>
<tr>
<td>Panel $\rho$-Statistics</td>
<td>0.74360</td>
<td>-0.77370</td>
</tr>
<tr>
<td>Panel PP-Statistics</td>
<td>0.34023</td>
<td>-1.75886*</td>
</tr>
<tr>
<td>Panel ADF-Statistics</td>
<td>0.01295</td>
<td>-2.05137*</td>
</tr>
<tr>
<td>Group $\rho$-Statistics</td>
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<td>-0.43568</td>
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<tr>
<td>Group PP-Statistics</td>
<td>0.22112</td>
<td>-1.89048*</td>
</tr>
<tr>
<td>Group ADF-Statistics</td>
<td>-0.65570</td>
<td>-2.55515**</td>
</tr>
</tbody>
</table>

All reported values are distributed $N(0,1)$ under the null of unit root or no cointegration. Panel statistics are weighted by long run variances (see Pedroni 1999 for details). For significance, ** implies 1% rejection, and * implies 5% rejection.
Table II: Diagnostics

<table>
<thead>
<tr>
<th></th>
<th>Time effect</th>
<th>Country effect</th>
<th>Two-way effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Durbin-Watson tests (1)</td>
<td>—</td>
<td>1.97</td>
<td>1.97</td>
</tr>
<tr>
<td>Breusch-Pagan tests (2) (3) (4)</td>
<td>$\chi^2(1) = 81.74$</td>
<td>$\chi^2(1) = 88.02$</td>
<td>$\chi^2(2) = 78.22$</td>
</tr>
</tbody>
</table>

(1) Durbin and Watson tests for AR(1) autocorrelation.
(2) Breusch and Pagan test for over time heteroskedasticity ($H_0: var(\varepsilon_i^t) = 0$).
(3) Breusch and Pagan test for cross-sectional heteroskedasticity ($H_0: var(u_i) = 0$).
(4) Breusch and Pagan test for both over time and cross-sectional heteroskedasticity ($H_0: var(v_i^t) = 0$).
Percentages of cross-sectional shocks to income growth reflected in domestic consumption growth. Weighted random-effects estimates of panel regression $\Delta c_i = u_t + \beta \Delta y_i + \alpha \bar{y}_t + \epsilon_i$, where $\hat{\beta}$ corresponds to a weighted "within" estimate of panel regression $\Delta c_i = \nu_t + \beta \Delta y_i + \epsilon_i$, and $\hat{\alpha}$ corresponds to a weighted "between-minus-within" estimate of the same equation.

Table III: Risksharing

<table>
<thead>
<tr>
<th>Subperiod</th>
<th>idiosyncratic ($\beta$)</th>
<th>Aggregate ($\alpha$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full sample</td>
<td>62</td>
<td>18</td>
</tr>
<tr>
<td>z value</td>
<td>(12)</td>
<td>(4)</td>
</tr>
<tr>
<td>Wald test</td>
<td>$\chi^2(2) = 810.13$</td>
<td></td>
</tr>
<tr>
<td>1956–1972 subperiod</td>
<td>67</td>
<td>12</td>
</tr>
<tr>
<td>z value</td>
<td>(10)</td>
<td>(3)</td>
</tr>
<tr>
<td>Wald test</td>
<td>$\chi^2(2) = 451.45$</td>
<td></td>
</tr>
<tr>
<td>1973–1989 subperiod</td>
<td>56</td>
<td>25</td>
</tr>
<tr>
<td>z value</td>
<td>(6)</td>
<td>(3)</td>
</tr>
<tr>
<td>Wald test</td>
<td>$\chi^2(2) = 361.38$</td>
<td></td>
</tr>
<tr>
<td>1990–2005 subperiod</td>
<td>64</td>
<td>21</td>
</tr>
<tr>
<td>z value</td>
<td>(7)</td>
<td>(3)</td>
</tr>
<tr>
<td>Wald test</td>
<td>$\chi^2(2) = 307.33$</td>
<td></td>
</tr>
</tbody>
</table>
### Table IV: Intertemporal Smoothing

<table>
<thead>
<tr>
<th></th>
<th>temporary ($\gamma$)</th>
<th>permanent ($\delta$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full sample</td>
<td>61</td>
<td>26</td>
</tr>
<tr>
<td>$z$ value</td>
<td>(10)</td>
<td>(5)</td>
</tr>
<tr>
<td>Wald test</td>
<td>$\chi^2(2) = 2178.93$</td>
<td></td>
</tr>
<tr>
<td>1956–1972 subperiod</td>
<td>64</td>
<td>27</td>
</tr>
<tr>
<td>$z$ value</td>
<td>(8)</td>
<td>(2)</td>
</tr>
<tr>
<td>Wald test</td>
<td>$\chi^2(2) = 1174.5$</td>
<td></td>
</tr>
<tr>
<td>1973–1989 subperiod</td>
<td>58</td>
<td>30</td>
</tr>
<tr>
<td>$z$ value</td>
<td>(8)</td>
<td>(5)</td>
</tr>
<tr>
<td>Wald test</td>
<td>$\chi^2(2) = 1132.02$</td>
<td></td>
</tr>
<tr>
<td>1990–2005 subperiod</td>
<td>63</td>
<td>19</td>
</tr>
<tr>
<td>$z$ value</td>
<td>(7)</td>
<td>(4)</td>
</tr>
<tr>
<td>Wald test</td>
<td>$\chi^2(2) = 1058.15$</td>
<td></td>
</tr>
</tbody>
</table>

Percentages of intertemporal shocks to income growth reflected in domestic consumption growth. Weighted random-effects estimates of panel regression $\Delta c_i^t = \zeta^i + \gamma \Delta y_i^t + \delta \bar{\Delta} y + v_i^t$, where $\hat{\gamma}$ corresponds to a weighted ”within” estimate of panel regression $\Delta c_i^t = \mu^i + \gamma \Delta y_i^t + v_i^t$, and $\hat{\delta}$ corresponds to a weighted ”between-minus-within” estimate of the same equation.
Table V: Risksharing and Intertemporal Smoothing

<table>
<thead>
<tr>
<th></th>
<th>aggregate (α)</th>
<th>permanent (δ)</th>
<th>current &amp; domestic (β)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full sample</td>
<td>0</td>
<td>26</td>
<td>61</td>
</tr>
<tr>
<td>z value</td>
<td>(0)</td>
<td>(3)</td>
<td>(12)</td>
</tr>
<tr>
<td>Wald test</td>
<td>χ²(3) = 400.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1955–1972 subperiod</td>
<td>-5</td>
<td>31</td>
<td>62</td>
</tr>
<tr>
<td>z value</td>
<td>(-1)</td>
<td>(2)</td>
<td>(9)</td>
</tr>
<tr>
<td>Wald test</td>
<td>χ²(3) = 3281.93</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1973–1989 subperiod</td>
<td>6</td>
<td>27</td>
<td>54</td>
</tr>
<tr>
<td>z value</td>
<td>(1)</td>
<td>(2)</td>
<td>(5)</td>
</tr>
<tr>
<td>Wald test</td>
<td>χ²(3) = 238.86</td>
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<td></td>
</tr>
<tr>
<td>1990–2005 subperiod</td>
<td>-2</td>
<td>35</td>
<td>65</td>
</tr>
<tr>
<td>z value</td>
<td>(0)</td>
<td>(2)</td>
<td>(7)</td>
</tr>
<tr>
<td>Wald test</td>
<td>χ²(3) = 535.48</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Percentages of shocks to aggregate, permanent, and current domestic income growth reflected in domestic consumption growth. Random-effects estimates of panel regression \( \Delta c_i^t = u_t + \zeta_i + \delta \Delta y + \alpha \Delta y_t + \beta \Delta y_i^t + \nu_i^t \).
Figure 1: Time Series of Output and Consumption in Selected Countries - growth rates

Figure 2: Cross Section of Output and Consumption in Selected Years - growth rates