DYNAMIC RISK SHARING IN THE UNITED STATES AND EUROPE

By

Pierfederico Asdrubali*
European University Institute, Florence

and

Soyoung Kim**
University of Illinois at Urbana-Champaign

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Abstract

This paper uses a panel VAR model to improve upon the existing literature on interregional risk sharing channels (e.g. Asdrubali, Sorensen and Yosha, 1996) in several respects. First, it endogenizes the output process within a multi-equation framework, capturing the dynamic feedback between output and various risk sharing channels. Second, in contrast to previous research's analysis of static risk sharing in the presence of exogenous output shocks, it uses impulse response functions to trace the role of each risk sharing channel over time, in the presence of different structural shocks (temporary vs. persistent and output vs. risk sharing channels). Third, the paper extends the risk sharing channels typically analyzed, by considering the consumption smoothing role of changes in the nominal exchange rate and relative commodity prices across regions. As a result, it is able to better address such policy issues as whether public risk sharing has been a substitute or a complement for financial market diversification activities, or whether the risk sharing role of exchange rate movements in Europe has been relatively unimportant.

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* Finance and Consumption Chair, European University Institute, via dei Roccettini 9, 50016 San Domenico di Fiesole (FI), Italy; phone: +(055) 4685-721, fax: +(055) 4685-731, email: asdrubal@iue.it

** Department of Economics, 225b DKH, 1407 W. Gregory Dr., Urbana, IL 61801, phone: (217) 356-9291, fax: (217) 333-1398, e-mail:kim11@uiuc.edu

1. Introduction

The European Union – like any other monetary union – entails virtually no role for regional monetary policy, and a much limited scope also for regional fiscal stabilization. Hence the monetary unification process has revived the attention to stabilization mechanisms able to insure against the risk of idiosyncratic output shocks among the regions of a currency area.. Sala-i-Martin and Sachs (1992) identified one such mechanism in the fiscal federalist structure of countries like the United States; they calculated that the tax/transfer system in the US smoothes up to 40% of an income shock to a state, and much less in Europe.[1] Another channel of risk sharing had long been identified by the finance literature: portfolio diversification. Since Arrow and Debreu's work on equilibrium contingent claims it was clear that income accruing from cross-regional asset ownership provides an important hedging against idiosyncratic contingencies. French and Poterba (1991) were among the first to document the (scarce) extent of such risk sharing in a few industrial countries, and van Wincoop (1994) confirmed the international risksharing puzzle for the OECD.

These analyses were relatively unconnected until Asdrubali, Sørensen and Yosha (1996) (henceforth ASY) – using a variance decomposition method – integrated all the risksharing channels in a unique framework, and were able to calculate that an output change in a US state is smoothed on average for 39% by interstate asset income, for 13% by fiscal risksharing, and for 23% by credit markets through interregional lending and borrowing.[2] Sørensen and Yosha (1998) (henceforth SY) repeated the analysis for the OECD and confirmed French and Poterba (1991)'s home bias result, while revealing that all international smoothing – about 30% of a shock to a country's output -- takes place through domestic credit markets (and mostly through budget deficits, as Arreaza, Sørensen and Yosha (1997) have documented). Several papers have refined ASY's methodology,[3] and a map is being created of the scope and capability of shock absorption of several countries, and regions therein. The pattern that seems to emerge is one of scarce international risksharing, where home bias prevails and smoothing takes place essentially through

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[1] von Hagen (1992) for the US and Bayoumi and Masson (1994) for the US and Canada found somewhat smaller numbers, due to different econometric techniques employed.

[2] It is not clear in the literature whether credit market smoothing is actually a form of risksharing, since it takes place after the realization of the shock. See a brief discussion in Athanasoulis and van Wincoop (1998).

[3] For example, Alberola and Asdrubali (1997) added risksharing through migration; Asdrubali (1998) distinguishes risksharing from intertemporal smoothing; Del Negro (1998) analyzes shocks to permanent rather than current output; Athanasoulis and van Wincoop (1998) separate out the unpredictable output shocks; Mélitz and Zumer (1999) add additional regressors. Other papers, such as Pellegrini (1998), and Dedola, Usai and Vannini (1999) apply the setup to different countries.

domestic saving; and richer interregional risksharing, where the role of capital markets can sometimes be preponderant.[4]

The literature mentioned above shares most of the same assumptions (e.g., exogeneity of output) and revolves around a basic setup (essentially static), which allows a simple quantification of risksharing channels, but also leaves some important questions unanswered. What kinds of shocks have the largest impact on consumption? How long does it take to absorb a given shock to output? Does it depend on the risksharing channels? What is the dynamic role of each risk sharing channel? What are the relations among different risk sharing channels? Are they substitutes or complements? It is somewhat surprising – given the econometric structure of the issue at hand – that the literature has so far neglected the use of dynamic and simultaneous econometric models. To address these questions, this paper uses a dynamic and simultaneous econometric model, namely a panel Vector Autoregression (VAR) framework, to generalize the stochastic processes of the relevant set of variables.

As a consequence, some limitations of the static literature are overcome, and new issues can be addressed. First, the model endogenizes the output process within a multi-equation framework, capturing the dynamic feedback between output and various risk sharing channels. Second, in contrast to previous research's analysis of static risk sharing in the presence of exogenous output shocks, it uses impulse response functions to trace the role of each risk sharing channel over time, in the presence of different structural shocks (temporary vs. persistent, shocks to output vs. shocks to risk sharing channels). Third, the paper extends the risk sharing channels typically analyzed, by considering the consumption smoothing role of changes in the nominal exchange rate and relative commodity prices across regions. As a result, it is able to better address such policy issues as whether public risk sharing has been a substitute or a complement for financial market diversification activities, or whether the risk sharing role of exchange rate movements in Europe has been relatively unimportant. We test our methodology on three groups of countries/regions: the states of the USA, the 23 OECD countries, and the 15 European Union members for which National Accounts data are available. Both for the US and for the OECD (and EU15), we find that the dynamics of risksharing are much richer than the simple static model could foreshadow. Some smoothing channels, like capital markets, exert their effect mostly on impact, and then decline rapidly; some others, like the tax/transfer system, continue to absorb output shocks years after they hit; still other channels, like the credit markets, start having a dis-

[4] Alberola and Asdrubali (1997) found that capital markets and credit markets in Spain smooth 23% of an output shock each. These figures rise respectively to 63% and 20% for Italy and 48% and 56% for the UK (Dedola, Usai and Vannini 1999).

smoothing effect after two years, thereby offsetting any initial buffering action. Another example of the complexity of risksharing dynamics comes from the analysis of real exchange rate changes in response to output shocks: while on impact the real exchange rate exhibits a dis-smoothing effect, over time it moves towards a neutral effect. Moreover, if we decompose its movements into changes in the nominal exchange rate and changes in relative prices, we find that the former are responsible for the initial dis-smoothing, since prices adjust slowly. As prices catch up, the effect of the nominal exchange rate on the real exchange rate is neutralized.

As for the issue of exogeneity of output, we find that most of the changes in output at annual horizon are caused by shocks to GDP, not by other structural shocks, including consumption. In addition, using a VAR system with long-run (LR) restrictions, we are able to distinguish the responses to permanent and temporary GDP shocks; we find that most of the changes in output at annual horizon are caused by permanent GDP shocks. However, these results also stem from the important fact that shocks to smoothing channels (including consumption) are mostly offset by the other smoothing channels (also including consumption) at annual horizon; for example, a change in the structure of financial markets affecting cross-regional income flows tends to be offset by changes in the smoothing role of saving. We will derive policy implications from this substitutability of smoothing channels, as well as from the dis-smoothing role of real exchange rates.

The paper is organized as follows. Section 2 summarizes the framework used so far to estimate risk sharing channels, and then explains the VAR modeling and the empirical methodology. Section 3 discusses the data and the basic results. Section 4 discusses the extended models, which quantify the role of additional smoothing channels. Section 5 summarizes the results and concludes.

2. Methodology

2.1. The foundations of risksharing tests

Most of the literature on risk sharing considers a world of endowment economies --- indexed by *i* --- lasting infinite periods – indexed by t. Each economy is populated by a representative risk-averse consumer who maximizes his expected VNM utility in the face of an exogenous stochastic output process, GDP_t^i. Under CRRA preferences, it can be shown that, if markets for contingent claims are complete,[5] every representative agent will insure his future

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[5] Market completeness is a sufficient, but not necessary condition for full risksharing. Several authors have shown that even if only a limited number of stocks are traded internationally, under certain spanning conditions full risksharing can still be achieved; for example, Duffie and Huang (1985).

income stream in any contingency. Thus, full risksharing ensues, implying that each economy's consumption will comove with aggregate, rather than domestic, output. Namely,

$$C^i{}_t = \mu^i Y_t \qquad (0.1)$$

where C_t^i represents consumption of individual i in period t, Y_t stands for aggregate output at time t, and μ^i is a factor which represents country i’s “power” in the risksharing arrangement.

This result has a few strong empirical implications warranting econometric testing. First, individual consumption growth must be equal across countries, and thus it must also be equal to aggregate output (or consumption) growth when risksharing is full. This has been tested by Backus, Kehoe, and Kydland (1992) and Obstfeld (1994), who rejected the international risksharing proposition, giving rise to the so called “quantity” anomaly, or international risksharing puzzle. A second implication is that consumption shouldn’t comove with idiosyncratic variables, such as domestic output or employment. For this reason, another group of empirical implementations of the full risksharing hypothesis focused on the analysis of the covariance of consumption with idiosyncratic variables (for example domestic output) in various specifications, interpreting the result as a measure of risksharing: the higher the correlation between GDP (gross domestic product) and C (total consumption), the lower the amount of risksharing attained in the economy.[6] Further tests on this line should measure whether idiosyncratic output shocks affect individual consumption *regardless of the stochastic process governing domestic output.* Not many studies have dealt with this issue. ASY estimate separately states with "high-persistence" and states with "low-persistence" shocks, and separate predictable from unpredictable shocks using lagged state and regional output as predictors. Del Negro (1998) considers different stochastic processes governing output, while Athanasoulis and van Wincoop (1998) disentangle the effects of unpredictable shocks using a prediction regression.

2.2. The static model of risksharing channels

The study of risk sharing *channels* builds on the test of the second implication above, by adding to the analysis the correlation between GDP and additional national accounts measures: GNP (gross national product), defined as GDP plus net factor income payments from abroad; GDI (gross disposable income) defined as GNP plus taxes paid to and minus transfers received

[6] As Hayashi, Altonji and Kotlikoff (1996) pointed out, any equation that regresses consumption on income is implicitly testing for risksharing.

from international organizations (or, in the case of regions, from the Government); C (total consumption) defined as GDI minus total savings. Note that we modified some definitions of components of National Accounts to be consistent with theoretical concepts of risk sharing. Detailed explanations of actual data are provided in Section 3.1. If one considers -- in every period t -- the following identity:

$$GDP^{i} = \frac{GDP^{i}}{GNP^{i}} \frac{GNP^{i}}{GDI^{i}} \frac{GDI^{i}}{C^{i}} C^{i} \tag{0.2}$$

and then manipulates it by taking logs and differences, multiplying through by $\Delta \log GDP$ minus its mean and taking expectations, one arrives at the relation:

$$\beta_{k} + \beta_{g} + \beta_{c} + \beta_{u} = 1 \tag{0.3}$$

where β_{k}, the coefficient in the regression of $\Delta \log GDP - \Delta \log GNP$ on $\Delta \log GDP$, is interpreted as the percentage of smoothing of a GDP shock carried out by capital markets (i.e., through net factor income payments); β_{g}, the coefficient in the regression of $\Delta \log GNP - \Delta \log GDI$ on $\Delta \log GDP$, is interpreted as the percentage of smoothing of a GDP shock carried out by international transfers; β_{c}, the coefficient in the regression of $\Delta \log GDI - \Delta \log C$ on $\Delta \log GDP$, is interpreted as the percentage of smoothing of a GDP shock carried out by credit markets (i.e., net lending abroad and domestic investment); finally β_{u}, the coefficient in the regression of $\Delta \log C$ on $\Delta \log GDP$, is interpreted as the percentage of smoothing of a GDP shock that remains unsmoothed. In practice, the following SUR panel system is estimated:

$$\begin{aligned}
\Delta \log GDP_{t}^{i} - \Delta \log GNP_{t}^{i} &= \nu_{t,k} + \beta_{k} \Delta \log GDP_{t}^{i} + \varepsilon_{kt}^{i} \\
\Delta \log GNP_{t}^{i} - \Delta \log GDI_{t}^{i} &= \nu_{t,g} + \beta_{g} \Delta \log GDP_{t}^{i} + \varepsilon_{gt}^{i} \\
\Delta \log GDI_{t}^{i} - \Delta \log C_{t}^{i} &= \nu_{t,c} + \beta_{c} \Delta \log GDP_{t}^{i} + \varepsilon_{ct}^{i} \\
\Delta \log C_{t}^{i} &= \nu_{t,u} + \beta_{u} \Delta \log GDP_{t}^{i} + \varepsilon_{ut}^{i}
\end{aligned} \tag{0.4}$$

where $n_{t,}$ are time fixed effects. A panel estimation for this system corresponds to a weighted average over time of cross-sectional regressions. Further details and results can be found in the research papers mentioned in the Introduction, and in particular in ASY and SY.

Even though the above framework encompasses several nice features of a relatively general endowment economy, it does not address several important issues of a dynamic production economy, buffeted with various structural shocks (in addition to exogenous output shocks). First, the model is silent on the exact nature of the output changes that exogenously cascade on the rest of the economy. One important implication of equation (0.1) suggests that individual consumption will be proportional to output *regardless of the stochastic process governing domestic output.* Therefore, an econometric test is warranted to estimate whether individual consumption varies, depending on the nature of the shock that caused the output change; for instance, while a temporary unpredictable shock should elicit complete simultaneous smoothing, a persistent predictable shock would entail some consumption change as optimal response. Second, the above framework ignores the possibility of endogenous output changes due to various structural disturbances. For example, in the presence of preference shocks, the proportionality of consumption to output may fail even under complete markets.[7] To examine risk sharing due to exogenous output changes, we should control for endogenous output components due to other structural shocks. In addition, the risk sharing properties in the presence of shocks other than exogenous output changes may be an another interesting issue.

A VAR framework seems the natural way to address these issues. A VAR model treats all variables in the system, including output, as endogenous, and allows dynamic feedback among those variables. In addition, a VAR framework is able to explicitly subtract the exogenous structural shocks and to trace the dynamic effects of structural shocks. As a consequence, we can distinguish the effects of different kinds of shocks (persistent vs. temporary, anticipated vs. unanticipated, shocks to each risk sharing channel), and at the same time address the endogeneity problem arising in a specification like (0.4), by fully accounting for the feedback from each components of output or each risksharing channel onto output.

An important aspect of (0.4) is that the model is essentially static, in the sense that the risksharing measure is computed as weighted average of cross-sectional regressions. The VAR, using impulse responses to shocks, traces the risksharing reaction to a well-defined shock over time, estimating how long it takes each risksharing channel to absorb a well-defined shock.

[7] SY argue that, although taste shocks may be important to explain the lack of full risksharing (as suggested by Stockman and Tesar (1995)), the variance decomposition measure in equation (0.4) is robust to such

2.3. Dynamic Simultaneous Analysis of Risk Sharing

In this section we will generalize the econometric specification of models like (0.4) in order to address the 3 novel issues we have in mind: dynamic responses to shocks, differing responses depending on the nature of the shock, and endogeneity of the output process.

Models like (0.4) can be generalized by allowing dynamic (contemporaneous and lagged) feedback among all variables, namely $\Delta \log GDP$, $\Delta \log GDP - \Delta \log GNP$, $\Delta \log GNP - \Delta \log GDI$, $\Delta \log GDI - \Delta \log C$, and $\Delta \log C$. In the following, we achieve that by employing a VAR framework.

2.3.1. Structural Panel VAR

First we pool the data and estimate the following reduced form panel VAR.

$$y_t^i = c + B(L)y_{t-1}^i + u_t^i, \qquad (0.5)$$

where c is an n×1 constant matrix, y_t^i is an n×1 data vector, B(L) is a matrix polynomial in the lag operator L and var(u_t)= Σ. Instead of explicitly introducing the time fixed effect in the model, we construct data series as deviations from aggregate values.[8] Based on the estimates of the reduced form VAR, we recover the following structural form equation.

We assume the economy is described by the structural form equation

$$G_0 y_t^i = d + G(L)\, y_{t-1}^i + e_t^i \qquad (0.6)$$

where G_0 is the n×n contemporaneous structural parameter matrix with 1's in the diagonal, G(L) is a matrix polynomial in the lag operator L, d is an n×1 constant matrix, and e_t is an n×1 structural disturbance vector. e_t is serially uncorrelated and var(e_t)=Λ. Λ is a diagonal matrix whose diagonal elements are the variances of structural disturbances, so structural disturbances are assumed to be mutually uncorrelated. If (G_0–LG(L)) is invertible, the structural form equation can also be written in the following moving average representation.

shocks. However, they do not consider the case in which taste shocks feed back on output, which would bias their estimates.

[8] One reason that we do not introduce the time fixed effect explicitly is to avoid the well-known bias in the case of both fixed effect and lagged independent variable. Refer to Hsiao (1986)

$y_t^i = d^* + G(L)^* e_t$ (0.7)

where $d^* = (G_0 - LG(L))^{-1} d$, $G(L)^* = (G_0 - LG(L))^{-1} G(L)$, and $G(0)^* = G_0^{-1}$.

There are several ways of recovering the parameters in the structural form equation from the estimated parameters in the reduced form equation. This paper employs two different methods. The first imposes restrictions on the contemporaneous structural parameters G_0 while the second imposes restrictions on the long run structural parameters $G(1)^*$.

In the first method, following Sims (1980), we postulate a recursive structure on the contemporaneous parameters G_0 in order to recover the parameters in the structural form equation. In the second method, following Blanchard and Quah (1989), we assume a recursive structure in the long run structural parameter $G(1)^*$.

2.3.2. The System with SR restrictions

First, we estimate the model with contemporaneous restrictions. The data vector is {Δ log GDP, Δ log GDP - Δ log GNP, Δ log GNP - Δ log GDI, Δ log GDI - Δ log C}. Again, note that all variables are deviations from the growth rate of own regional aggregates. In all estimations in this paper, we obtain Δ log C as the difference between Δ log GDP and the sum of all other variables using the national income identity. Like previous researchers, we interpret the size changes in $\Delta \log GDP - \Delta \log GNP$, $\Delta \log GNP - \Delta \log GDI$, and $\Delta \log GDI - \Delta \log C$ in reaction to exogenous shocks changing Δ log GDP as measures of risk sharing achieved by capital markets, international transfers, and credit markets, respectively, and the size of changes in $\Delta \log C$ as the unsmoothed part.

Our identifying restrictions based on equation (0.6) are:

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ g_{21} & 1 & 0 & 0 \\ g_{31} & g_{32} & 1 & 0 \\ g_{41} & g_{42} & g_{43} & 1 \end{bmatrix} \begin{bmatrix} \Delta \log GDP_t^i \\ \Delta \log GDP_t^i - \Delta \log GNP_t^i \\ \Delta \log GNP_t^i - \Delta \log GDI_t^i \\ \Delta \log GDI_t^i - \Delta \log C_t^i \end{bmatrix}$$
$$= d + G(L) \begin{bmatrix} \Delta \log GDP_{t-1}^i \\ \Delta \log GDP_{t-1}^i - \Delta \log GNP_{t-1}^i \\ \Delta \log GNP_{t-1}^i - \Delta \log GDI_{t-1}^i \\ \Delta \log GDI_{t-1}^i - \Delta \log C_{t-1}^i \end{bmatrix} + \begin{bmatrix} e_{GDP,t} \\ e_{k,t} \\ e_{g,t} \\ e_{c,t} \end{bmatrix} \quad (0.8)$$

That is, we assume a recursive structure on the contemporaneous structural parameters. Though this system does not consider some contemporaneous feedback among variables, it does not impose any restrictions on dynamic (lagged) feedback among them. In that sense, this system is more general than the static model described above, which does not consider any (dynamic) lagged interactions of this sort.

Using the static system, previous studies examined how Δ log GDP is smoothed by different channels of risk sharing by regarding Δ log GDP as exogenous. Instead, we examine how e_{GDP} is smoothed by different channels of risk sharing by regarding e_{GDP} as exogenous. Our measure of exogenous output change is more general since in our system e_{GDP} is constructed as conditional on information about the history of all variables in the system. In practice, the system in (0.4) is a special case of our specification, with the coefficients g_{32}, g_{42}, g_{43}, g_{52}, g_{53}, g_{54} and G(L) all equal to zero.

On the other hand, we interpret $e_{k,1}$, $e_{g,2}$, and $e_{c,3}$, as shocks to each risk sharing channel, that is, shocks to capital market, shocks to international transfers, shocks to credit market. They are surprises in risk sharing channels, conditional on all lagged variables in the system and on contemporaneous output (and some other risk sharing channels). By tracing the impulse responses of all variables, we can examine whether each risk sharing channel is a substitute or a complement for the others. For example, we can investigate how much the role of other risk sharing channels such as credit channel decreases (or increases) given GDP when there is an unexpectedly large increase in risk sharing through the capital market. In this respect, the inclusion of the contemporaneous value of GDP in those equations is important since we can control for its changes.

Regarding the contemporaneous restrictions among those risk sharing channels, we rely on the natural properties and interpretations of each channel. First, we assume that the credit channel is contemporaneously affected by all others since consumers would decide how much to save after considering the risk sharing done by other channels such as international transfers and capital market smoothing. Second, the ordering between international transfers (or federal government transfers) and capital market might be more controversial, but we assume that capital market smoothing comes first because federal income taxes are based on capital income too, so that it must be known before the tax is levied. At any rate, we examine the robustness of our results under alternative identifying assumption in Section 4.

We estimate the model using not only yearly data but also quarterly data when they are available. By using quarterly data, the restrictions are on quarterly interactions. In such a case, our identifying assumptions become weaker because we allow interactions among variables within a year, and our measure of e_{GDP} becomes more exogenous.

2.3.3. System with LR restrictions

We use the same data vector as that in the system with SR restrictions. Our identifying restrictions based on equation (0.7) are:

$$\begin{bmatrix} \Delta \log GDP_t^i \\ \Delta \log GDP_t^i - \Delta \log GNP_t^i \\ \Delta \log GNP - \Delta \log GDI_t^i \\ \Delta \log GDI_t^i - \Delta \log C_t^i \end{bmatrix} = d^* + \begin{bmatrix} 1 & 0 & 0 & 0 \\ g_{21}^* & 1 & 0 & 0 \\ g_{31}^* & g_{32}^* & 1 & 0 \\ g_{41}^* & g_{42}^* & g_{43}^* & 1 \end{bmatrix} \begin{bmatrix} e_{GDP,t} \\ e_{k,t} \\ e_{g,t} \\ e_{c,t} \end{bmatrix} \tag{0.9}$$

Note that the 5×5 matrix on the RHS is the long run structural coefficients, G(1). Therefore, e_{GDP} represents the structural shocks that may affect all variables in the long run; e_{K1}, e_{K2}, e_{K3}, and e_{K4} are structural shocks that do not affect the *level* of regional output in the long run. Then, we can attach some interesting structural interpretations to the shocks. e_{GDP} is the permanent shock to GDP; other structural shocks can tentatively be interpreted as temporary shocks to GDP since it is difficult to justify any LR recursive structure among risk sharing channels. However, they turned out to be similar to shocks to each risk sharing channel (Refer to Section 3.).

Also note that our restrictions are only on the long run structural coefficients and we do not impose any other restrictions on $G(L)^*$. Therefore, all variables are endogenously determined by considering all contemporaneous and lagged interactions. Again, a model like (0.4) can be considered as a special case of our system since it does not allow contemporaneous and lagged interactions.

In the following sections, we examine impulse responses of Δ log GDP, $\Delta \log GDP - \Delta \log GNP$, $\Delta \log GNP - \Delta \log GDI$, $\Delta \log GDI - \Delta \log C$, and $\Delta \log C$ to each structural shock to analyze the dynamic risk sharing properties under each structural shock.

3. Basic Results

3.1. Data and Estimation

Our analysis of international risksharing within OECD (and EU) countries uses National Accounts data for 23 countries from 2 sources: the International Monetary Fund's *International Financial Statistics Yearbook*, various issues and CD, supplemented, where available, by the monthly issues (period 1956--1990); and the OECD's *Statistical Compendium* on CD, for both annual data (period 1960--1997) and quarterly data (period 1980-I--1998-IV). Our variables are derived from the National Accounts as follows:

- GDP (gross domestic product)

- GNP (gross national product) = GDP + net factor income from abroad
- GDI (gross disposable income) = GNP + net transfers from abroad[9]
- C (total consumption) = GDI - (depreciation + fixed investments + inventory change + trade balance)

As for the United States, our data are the same as those constructed by ASY, and we refer to their data appendix for a detailed description. However, we augmented the dataset with the state CPI series, constructed by Del Negro (1998). The list of variables is:

- GSP (gross state product)
- SI (state income) = GSP + net factor income from other states
- DI (state disposable income) = SI - federal taxes + federal transfers
- C (state consumption) = DI - (investment + interstate trade balance)

It is important to point out that the US data lack measures of investment at the state level, so that it is impossible to disentangle interstate smoothing from domestic smoothing.

In estimating VAR equations, we included 2 lags and a constant term in all equations.[10] All variables are in real per capita terms, and are constructed by deflating nominal values by domestic CPI, and dividing by population. Each variable is then subtracted from the aggregate measure. The aggregate measure of each variable's growth rate is constructed based on domestic growth rates, where the weight is driven by the relative size of GDP in 1990. In the extended model, we use nominal exchange rates, defined as the amount of national currency exchanged for one US dollar at mid-year or mid-quarter.

3.2. The United States

Figure 1 reports impulse responses with two standard error bands over 5 years in the system with the SR restrictions. Each column shows the impulse responses of all interested variables to each structural shock. The name of each structural shock is noted at the top of each column while the names of the responding variables are noted at the far left of each row. “GSP” “KAP,” “GOV,” “CRE,” and “C” represent $\Delta \log GSP$, $\Delta \log GSP - \Delta \log SI$, $\Delta \log SI - \Delta \log DI$, $\Delta \log DI - \Delta \log C$, and $\Delta \log C$, respectively. Therefore, they depict the changes in GSP, capital market smoothing, smoothing by Federal Government, credit market smoothing, and unsmoothed part. Note that our data do not allow to separate capital depreciation and retained earnings from state income, so that our KAP measures smoothing through these two

[9] Net transfers from National Accounts are unavailable in *IFS* sources.
[10] Using higher lags does not change results much in most cases.

channels besides capital market smoothing.[11] The scales of all the graphs in each column are the same.

First, we examine the effects of exogenous GSP shocks (in the first column in Figure 1). To examine the exact numbers, we also report the responses in Table 1 (1). For Table 1(1), we normalize the size of the shocks so that the sum of total changes in GSP over time is 100. In addition, we also report the exact numbers with standard error in the parenthesis in Table 1 (1). In Table 1 (2), we report cumulative impulse responses in order to examine the cumulative role of each risk sharing channel over time.

Table 1. Impulse Responses to e_{GDP} in the System with SR restrictions, U.S. States

1) Impulse Responses

	GSP	KAP	GOV	CRE	C
0 year	74.9 (1.6)	34.7 (1.3)	7.3 (0.8)	20.9 (2.5)	12.0 (2.3)
1 year	22.4 (2.3)	3.1 (1.4)	7.1 (0.8)	6.1 (2.5)	6.1 (2.3)
2 year	2.9 (2.1)	-1.6 (1.4)	1.3 (0.9)	-9.4 (2.5)	12.5 (2.3)
3 year	-0.1 (1.3)	-0.1 (0.6)	-0.2 (0.4)	-3.7 (1.1)	3.9 (1.0)
4 year	0.1 (0.7)	-0.2 (0.3)	-0.3 (0.2)	-0.4 (0.5)	1.0 (0.6)

2) Cumulative Impulse Responses

	GSP	KAP	GOV	CRE	C
0 year	74.9 (1.6)	34.7 (1.3)	7.3 (0.8)	20.9 (2.5)	12.0 (2.3)
1 year	97.3 (3.1)	37.9 (2.0)	14.4 (1.2)	27.0 (3.3)	18.1 (3.1)
2 year	100.1 (4.1)	36.3 (2.5)	15.7 (1.4)	17.6 (4.1)	30.6 (4.0)
3 year	100.0 (4.8)	36.2 (2.7)	15.4 (1.5)	13.9 (4.5)	34.4 (4.6)
4 year	100.0 (5.1)	36.0 (2.7)	15.1 (1.5)	13.5 (4.6)	35.4 (4.9)

From the impulse responses of GSP, we can infer the nature of the shocks. On impact, GSP increases sharply and also shows a positive response in the next year. From two years after the shocks, GSP is not much different from zero. As shown in the scale, the impact increase in GSP is 74.9% of total GSP increases, and the increase in the next period is about 22.4%.

In response to such an exogenous shock to GSP, a large capital market smoothing (34.7%) is found on impact, but in the next period, a little smoothing (3.5%) is found, and later the capital market does not play much role. Overall capital market smoothing contributes about 36.0% of total GSP changes. In the first two periods, smoothing by the Federal government is significant, 7.3% and 7.1%, respectively. Overall, the contribution is more than 15.1%. Credit market contributes 20.9% on impact, about 6.1% in the next period. However, in the second and

[11] In any case, SY have illustrated how those two channels are unlikely to affect the capital smoothing measure.

third years after the shocks, a significant negative contribution is found, -9.4% and –3.7%, respectively. Overall, credit market smoothes 13.5 % of total GSP shocks. Consumption (UNS) increases up to three years after the shocks. Overall, 35.4% of the GDP changes are unsmoothed.

The impulse responses show different dynamic roles of the different risk sharing channels. Most smoothing by capital market occurs on impact while smoothing by credit market occurs over time and it is positive initially but negative later. The results are consistent with our interpretations of the capital market smoothing; however, the behavior of credit market smoothing is somewhat difficult to be explained clearly.

Capital market smoothing insures uncertain future contingencies. Parts of capital market smoothing such as capital gains and dividends may occur almost on impact when there are unexpected changes in *expected current and future income*, though some other components, such as interest payments, may accrue whether the income change is expected or not. Therefore, a substantial part of smoothing by capital market is achieved on impact when the nature of the shock is revealed.[12]

However, it is not so easy to explain the credit market smoothing based on traditional theories of consumption smoothing. We may regard the credit market smoothing (at least part of it) as intertemporal trade. Following traditional theory on consumption smoothing or intertemporal trade, in the presence of AR-1 output growth rate shocks with a positive AR-1 coefficient, consumption growth rate in the first period should be more volatile than output growth rate while consumption growth rate in the later period should be less volatile than output. However, we find the opposite regarding the relative volatility of consumption and output, even though the GSP dynamics in our model is similar to the AR-1 output growth rate shocks with a positive AR-1 coefficient. This problematic relative volatility between consumption and output is known as "Deaton's paradox." We suggest three possible explanations for this behavior of consumption. First, we rely on imperfect information of consumers. Suppose the GSP shocks are a mixture of permanent and temporary shocks in the level of GSP. When a shock hits, consumers don't know which shock is realized, so initially they smooth a little (or lend). However, in later periods, consumers realize that the shocks is very persistent, (as shown in the results for the long-run restrictions below), and borrow in the face of an increasing permanent income level. Alternatively, we may interpret that consumers smooth the *growth rate* of consumption, instead of the *level* of consumption. In such a case, the dynamics are consistent with consumption growth

[12] Note that the role of capital market is very small in the one year after the shock. Even though we find a substantial increase in GSP (22%), it is already expected in the one year after the shock. (It is already

rate smoothing. Since the GSP is higher for the first two periods, consumers save for the first two periods. In the next two periods, consumers use the saving. As a result, consumption is smoothed over the four periods.[13] Finally, all these problems may be properties of a production economy subject to productivity shocks or other structural shocks generating such GSP dynamics, regarding which we do not have a full-fledged theory.

Finally, most smoothing by the Federal Government occurs within two years. It suggests that smoothing by the Federal Government seems to be based on the current value (and possibly one period lagged value) of GSP.

In general, these results are consistent with previous studies by ASY, Del Negro (1998), and others, in that they reveal that a large fraction of a shock is smoothed across states in the US, and that the role of private markets as compared to the tax/transfer system is preponderant for risksharing. However, impulse responses convey a more informative picture on the evolution over time of smoothing responses. The first original result is that it takes some time to absorb a shock, even with automatic stabilizers like cross-state capital income payments or taxes. In the former case, the adjustment lag of about 3 years may be due to the structure of cross-state payments in the US (interest payments may not accrue annually, as in zero-coupon bonds), to capital depreciation or retained earnings (both included in the measure of state income). As for fiscal smoothing, certain taxes (and subsidies) may refer to events occurred years before (e.g., refunds). The credit market channel presents an additional feature deserving attention: 2 years after the shock on average, credit flows have a dis-smoothing role, that is they flow towards the state hit two years before by a positive shock. As a result, the cumulative response of credit markets is lower than the impact response, and lower than it had been previously estimated in other studies. Since this channel measures both interstate and intrastate smoothing, it is possible that – as mentioned above -- intertemporal smoothing considerations may affect the behavior of savings over time.

Next, we examine the impulse responses of shocks to each risk sharing channel (in the second, third, and fourth columns in Figure 1). First, the positive shocks to credit market and Federal government payment system does not affect other variables much except for own variable and consumption. That is, an increase in saving or federal government net transfers does not affect other risk sharing channels. Also note that GSP does not change much. As a result, the increase in saving or Federal government net transfers just decreases the unsmoothed part (C).

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reflected in the capital market smoothing in the first period.) We still find some positive role of capital market one year after the shocks, which may reflect interests and other prearranged payments.

However, the shocks to capital market do affect all variables significantly. First, an increase in net factor income decreases saving -- and smoothing through savings -- significantly. The size of the impact increase and the impact decrease are similar, which implies that an increase in the capital market channel crowds out the credit market channel almost perfectly. We also find a small decrease in Federal government net transfers. Overall, an increase in net factor income is almost perfectly offset by decreases in other channels on impact. As a result, consumption does not change at all on impact. In the next period, GSP increases and most part of the increase is smoothed by the credit channel. Probably this effect is due to the impact on productivity of financial income. This is an example of a feedback from risksharing channels to output that was neglected by previous studies, and that may help assess the relative importance of these channels for smoothing purposes; indeed, if a change in capital markets is destabilizing for output, this may prompt to reconsider their overall role in smoothing disturbances.

The above results on shocks to each risk sharing channel have another interesting policy implication. The Federal Government's attempt to increase risk sharing within U.S. states via taxes and transfers is crucial, in that other relatively private market mechanisms cannot substitute them automatically. For example, suppose the Federal Government reduces the overall level of taxes and transfers in a particular year. In such a case, market mechanisms do not help to make up for the lost income insurance. On the other hand, the capital market's failure in hedging income in a particular year is mostly rescued by the credit market channel, though there may be some differences in terms of permanent income.[14]

Figure 2 reports the impulse responses to permanent shocks to GSP in the system with LR restrictions. In general, we find similar quantitative results to those in the model with SR restrictions. This may imply that most of the shocks to GSP identified in the model with SR restrictions are permanent shocks. In response to GSP shocks, compared to the system with SR restrictions, smoothing by capital markets and the Federal Government plays a slightly larger role while smoothing by credit markets plays a slightly smaller role. The unsmoothed part becomes slightly smaller. Since e_{GSP} in the system with SR restrictions may be a mixture of temporary and permanent shocks to GSP, the larger role played by capital markets and smaller role of credit markets confirm what other authors, such as ASY, suggested, namely that, credit markets are less suitable than capital markets to deal with persistent (or permanent) shocks. Indeed, when negative

[13] Suppose that credit channel does not change at all. Then, the first two period consumption would be far higher than the next two period consumption.

[14] The sharp contrast between Federal Government and capital market is robust under different identifying assumptions. For example, when we change the ordering of KAP and GOV, still we find a similar result,

shocks are persistent, lenders may reduce loans, whereas when positive shocks persist, they may decide to transfer the boon on consumption.

Impulse responses to other structural shocks are also similar to those in the system with SR restrictions. Though we do not attempt to interpret those structural shocks in the previous section, they may be interpreted as shocks to each risk sharing channels. Given this similarity with the SR model, we may conclude that the results on shocks to risk sharing channels seem to be quite general.

3.3. OECD and Europe

We report the results for 23 OECD countries and 15 EU countries[15], using OECD data. Since results for the model with LR restrictions and the model with SR restrictions are qualitatively similar, we only report the results for the model with SR restrictions. Figure 3 and Table 3 report results for 23 OECD countries while Figure 4 and Table 4 report results for 15 EU countries.

Table 3. Impulse Responses to e_{GDP} in the System with SR restrictions, OECD 23

1) Impulse Responses

	GDP	KAP	GOV	CRE	C
0 year	71.5 (1.9)	0.7 (0.5)	-0.2 (0.3)	32.0 (1.9)	38.9 (1.7)
1 year	23.7 (2.8)	-0.7 (0.5)	-0.4 (0.3)	-1.0 (2.0)	25.8 (2.4)
2 year	3.5 (2.9)	-0.6 (0.5)	-0.4 (0.3)	-7.1 (1.8)	11.6 (2.3)
3 year	1.0 (2.0)	0.0 (0.4)	0.2 (0.2)	-1.5 (1.0)	2.3 (1.7)
4 year	0.5 (1.2)	0.2 (0.2)	0.2 (0.1)	0.0 (0.6)	0.1 (1.2)
5 year	-0.1 (0.5)	0.1 (0.1)	0.0 (0.0)	0.0 (0.2)	-0.2 (0.6)

2) Cumulative Impulse Responses

	GDP	KAP	GOV	CRE	C
0 year	71.5 (1.9)	0.7 (0.5)	-0.2 (0.3)	32.0 (1.9)	38.9 (1.7)
1 year	95.1 (3.9)	0.1 (0.8)	-0.6 (0.5)	31.0 (2.7)	64.7 (3.2)
2 year	98.6 (5.6)	-0.5 (1.1)	-1.0 (0.6)	23.9 (3.2)	76.3 (4.7)
3 year	99.6 (6.8)	-0.5 (1.4)	-0.8 (0.7)	22.4 (3.4)	78.6 (5.7)
4 year	100.1 (7.3)	-0.3 (1.5)	-0.6 (0.7)	22.5 (3.3)	78.6 (6.3)
5 year	100.0 (7.5)	-0.2 (1.6)	-0.6 (0.7)	22.4 (3.3)	78.4 (6.6)

Table 4. Impulse Responses to e_{GDP} in the System with SR restrictions, EU 15

1) Impulse Responses

though changes in net factor income tend to substitute for changes in Federal Government net transfers slightly.

	GDP	KAP	GOV	CRE	UNS
0 year	72.4 (2.5)	2.3 (0.7)	-0.3 (0.5)	36.3 (2.3)	34.1 (2.1)
1 year	18.9 (3.7)	-0.8 (0.8)	-0.9 (0.5)	-0.5 (2.6)	21.0 (2.7)
2 year	2.8 (3.4)	-1.3 (0.9)	-0.8 (0.5)	-7.8 (2.5)	12.7 (2.5)
3 year	3.0 (2.0)	-0.5 (0.6)	0.2 (0.3)	-2.1 (1.3)	5.5 (1.8)
4 year	2.2 (1.5)	-0.1 (0.4)	0.4 (0.2)	-0.7 (0.9)	2.7 (1.4)
5 year	0.7 (0.9)	0.0 (0.3)	0.1 (0.1)	-0.5 (0.4)	1.1 (1.0)

2) Cumulative Impulse Responses

	GDP	KAP	GOV	CRE	UNS
0 year	72.4 (2.5)	2.3 (0.7)	-0.3 (0.5)	36.3 (2.3)	34.3 (2.1)
1 year	91.2 (4.8)	1.5 (1.3)	-1.2 (0.8)	35.8 (3.6)	55.1 (3.8)
2 year	94.0 (6.6)	0.3 (1.8)	-2.0 (1.0)	28.0 (4.3)	67.8 (5.3)
3 year	97.1 (7.6)	-0.3 (2.1)	-1.8 (1.1)	25.8 (4.6)	73.3 (6.4)
4 year	99.3 (8.3)	-0.4 (2.3)	-1.4 (1.1)	25.1 (4.6)	76.0 (7.2)
5 year	100.0 (8.3)	-0.4 (2.5)	-1.3 (1.2)	24.7 (4.7)	77.0 (7.8)

Results for 23 OECD and 15 EU countries are qualitatively similar, and both are somewhat different from the results for the U.S. states. Again, in response to the e_{GDP} shocks, GDP responds mostly for the first two years, though the response is a little more delayed and we find larger increases two and more years after the shocks. In contrast to the U.S., capital market and international transfers do not play a very significant role. Among 23 OECD countries, the estimates of either channel are not statistically significant. Among the 15 EU countries, smoothing through international transfers is not statistically significant while capital market smoothing plays a small positive role on impact (2.3%) and no significant role overall. Among these countries, most smoothing is achieved through the credit channel (overall about 22-25%). We find a similar dynamic behavior of credit smoothing to that among the U.S. states. On impact, a significant positive smoothing is found while a significant negative smoothing is found for two and three years after the shock. Overall 77-79% of GDP changes are not smoothed, which is far larger than the size of the unsmoothed part among the U.S. states.

These results confirm the international risksharing puzzle, but reveal that the dynamic response of international credit markets to GDP shocks is extremely similar to that of domestic credit markets in the US: an initial smoothing via lending and borrowing is followed, after about 3 years, by plain dis-smoothing. The alternance between smoothing and dis-smoothing helps explain why different authors have failed to agree on the "static" measure of credit markets risksharing. Unfortunately, other conclusions on the similarity between the US and the international pattern of credit market smoothing would be unwarranted, because we cannot

[15] They are Australia, Belgium,

separate domestic investment from interstate lending and borrowing in the U.S states and we cannot compare international provision of credit separately. More importantly, however, systematic differences between domestic and international smoothing seem to disappear in the case of credit markets: to find the reason for the existence of the international risksharing puzzle, as opposed to domestic risksharing, we should perhaps look elsewhere.

The responses to shocks to each risk sharing channel are similar to the U.S. in some cases, but slightly different in others. First, an increase in saving does not change international transfers or net factor income, as in the U.S. Second, an increase in net factor income decreases saving as in the U.S. However, the size of the decrease in saving is about half the size of the increase in net factor income. That is, a rise in net factor income crowds out saving only by half. Finally, now an increase in international government transfers also decreases saving, which is not observed in the U.S. state case. The size of decrease in saving is even larger than the increase in the international transfers on impact. Therefore, policy implications are quite different from the U.S. state case. The credit market channel now substitutes for international government transfers even more than it does for the capital market channel. In order to better understand which components of saving are mainly responsible for these results, we now turn to analyze how saving is decomposed into domestic gross investment and the trade balance.

4. Extended System

4.1. Components of Saving in OECD and EU Countries

Since the credit market (or saving) is the only risk sharing channel that works significantly among OECD and EU countries, we further examine its role in detail. We divide saving into four components – capital depreciation (DEP), net fixed investment (NFINV), inventories (INVT), and trade balance (TB).[16]

We use the following ordering in our recursive system: DEP, NFINV, TB, INVT. First, we include inventories last since they are computed as residuals by definition. Second, we include capital depreciation, because it applies to last year's capital formulation. Third, we assume net fixed investment affects the trade balance contemporaneously (not vice versa) since people may decide the domestic use of saving first, and then decide its foreign use.

Figure 5 and 6 report the impulse responses to each structural shock in the system with SR restrictions in 23 OECD and 15 EU countries, respectively. In response to e_{GDP} shocks, DEP

[16] From National Accounts identities, S = I +X-M, where S is national saving, I is gross total investment (further decomposable into net fixed investment, inventory investment and capital depreciation), X represents exports and M

decreases slightly in the first two years, NFINV increases a lot in the first three years, TB increases significantly in the first period, but decreases later, and INVT increases in the first two periods but decreases in the next two years. Among these, NFINV plays the most significant role in the first period, absorbing about 15 % of total GSP changes, and overall about 25% of total GDP changes. TB smoothes about 5-10% in the first period, but dis-smoothes about 5-10% in each of the second and the third period, so that overall it dis-smoothes about 5-10%. INVT smoothes about 10-13% on impact, but in the third and fourth year it dis-smoothes about 5%, averaging at 5-7% overall.

These results shed light on the domestic (as opposed to international) extent of credit smoothing among OECD countries. Of the total 36% smoothing on impact occurring through this channel, the bulk (about 30%) takes place domestically, that is, without any international risksharing. If we consider overall smoothing, of the total 25% smoothing, a whopping 35% is achieved domestically (mainly through gross fixed investments) on impact, with the trade balance even playing an overall dis-smoothing role. The above breakdown also helps explain the timing pattern of credit smoothing. It is apparent that both inventories and the trade balance are responsible for the dis-smoothing behavior of the credit channel after the third year. While the volatility of inventories is hardly a surprise, the trade balance appears to behave according to intertemporal patterns predicted by the theory in case of an output shock that turns out to be persistent. The behavior of the trade balance, therefore, comes to the forefront as one of the main culprits of the timing of the credit market response; this is a novel result that had been overlooked by previous analyses.

Next, we examine the impulse responses to other structural shocks. First, about two-thirds of an initial increase in net factor income is offset by a decrease in the trade balance. We also observe a little increase in depreciation. In the next period, a substantial part of the increase in net factor income is offset by the decrease in inventories. Second, the most part of the increase in international government transfers is offset by a decrease in trade balance. Third, the most part of the increase in capital depreciation is offset by the decrease in the other three channels of saving. The size of the decrease in each channel is similar. Fourth, the most part of the increase in net fixed investment is offset by the decrease in trade balance. Fifth, some of the increase in trade balance is offset by the decrease in inventories. Finally, an increase in inventories does not affect other risk sharing channels (due to our identifying assumption), but the following year a little decrease in inventories is observed, which is offset by an increase in the trade balance. In

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imports of goods and services. We exclude net factor income and international transfers from saving since they are already separated as the difference between GDP and GNP, and GNP and GDI.

summary, shocks to each risk sharing channel are offset by change in trade balance in most cases.[17] The logic behind this result is that, as alternative means to smooth income increase, the discrepancy between saving and investment shrinks, and the size of the trade balance automatically declines.

4.2. The Role of Relative Price across Countries

The variables used in our risksharing regressions are deflated using own state (country)'s CPI.[18] But since state (national) prices may respond as well to output shocks, it is important to examine whether the results we obtained above were driven by the relative dynamics of prices. There are sound theoretical reasons to expect both a smoothing and a dis-smoothing effect of relative prices. Centering the discussion on relative supply shocks, as we have done up to now, open-economies real exchange rate models, as in Obstfeld (1985), suggest that positive productivity shocks create an excess supply which reduces relative prices; on the contrary, when differences between tradable and non-tradable sectors are considered, as in the Balassa-Samuelson hypothesis, positive productivity shocks, which mainly benefit tradable sectors, result in relative price increases.

To examine the role of relative prices in risk sharing, we need to extend the basic model. In the case of the U.S. states, the smoothing role of prices can be derived by considering *nominal* consumption deflated by the *national* CPI index (P), which we denote C_t^{i*}, instead of *nominal* consumption deflated by the *state* CPI index, as in C_t^i above. By appending this new term into the original identity in (0.2), as it applies to the US, we obtain

$$GSP^i = \frac{GSP^i}{SI^i}\frac{SI^i}{DSI^i}\frac{DSI^i}{C^i}\frac{C^i}{C^{i*}}C^{i*}, \qquad (0.10)$$

and the system of equations (0.4) becomes:

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[17] This result is robust under alternative identifying assumptions.

[18] In the case of U.S. states, the results in Section 3 used variables deflated by aggregate U.S. CPI since the results are similar to those using variables deflated by each state's CPI and each state's CPI is available only from 1969.

$$
\begin{aligned}
&\Delta \log GSP_t^{\,i} - \Delta \log SI_t^{\,i} = \nu_k + \beta_k \Delta \log GSP_t^{\,i} + \varepsilon_{kt}^{\ \ i} \\
&\Delta \log SI_t^{\,i} - \Delta \log DSI_t^{\,i} = \nu_g + \beta_f \Delta \log GSP_t^{\,i} + \varepsilon_{gt}^{\ \ i} \\
&\Delta \log DSI_t^{\,i} - \Delta \log C_t^{\,i} = \nu_c + \beta_c \Delta \log GSP_t^{\,i} + \varepsilon_{ct}^{\ \ i} \\
&\Delta \log C_t^{\,i} - \Delta \log C_t^{\,i*} = \nu_p + \beta_p \Delta \log GSP_t^{\,i} + \varepsilon_{pt}^{\ \ i} \\
&\Delta \log C_t^{\,i*} = \nu_{u*} + \beta_{u*} \Delta \log GSP_t^{\,i} + \varepsilon_{u*t}^{\ \ \ i}
\end{aligned}
\tag{0.11}
$$

The difference between this system and the previous one lies in the last two equations. In particular, the part corresponding to the unsmoothed component in (0.4) corresponds now to the last two equations, so that $\beta_p + \beta_{u*} = \beta_u$. Note that the original unsmoothed component β_u is now decomposed into two parts, the first of which measures the smoothing effect of prices. To see this more clearly, from the definitions of $C_t^{\,i}$ and $C_t^{\,i*}$ it follows that, in logs:

$$
\Delta \log C_t^{\,i} - \Delta \log C_t^{\,i*} = -(\Delta \log P_t^{\,i} - \Delta \log P_t) \tag{0.12}
$$

Substituting this expression above, it follows that, when relative prices (the right term in (0.12)) increase (fall) in response to a positive shock in state output, β_p will be negative (positive), implying a smoothing (dismoothing) effect of prices. More specifically, $-\beta_p$ in (0.11) reflects the percentage of smoothing achieved by the adjustment of relative prices. Therefore, the effect of price adjustments on global smoothing can be recovered by performing this modification to the system.[19]

In the VAR specification, therefore, we include another recursive equation, whose left-hand side variable is Δ log CPI (the state consumer price index). Since the CPI data for each U.S. state is available only from 1969, we estimate over 1969-1990.

In the case of OECD and European countries, the existence of different currencies implies that nominal exchange rates, besides prices, can vary in response to an output shock, and exhibit either a smoothing or a dis--smoothing behavior. In fact, this is a way of describing the entire debate on optimality of the EMU as a currency area that has been taking place both in the literature and in policy circles.[20] Operationally, we have to include two additional variables, Δ log E (the nominal exchange rate) and Δ log CPI. Following the same steps as above, we obtain a

[19] For details on this procedure, see Alberola and Asdrubali (1997).

recursive system with two additional equations, one measuring the response of relative prices, the other reflecting the reaction of the nominal exchange rate to output and other shocks. Again, all variables are deviations from own regional aggregates.

Regarding the identifying restrictions, we include the new variables as the last ones in equations (0.8) and (0.9). That is, the new variables are assumed to be affected by all variables in the system with SR restrictions while the shocks to the new variables do not affect any basic variables in the long run.

Table 5 reports the results. We report only results from the system with SR restrictions since results from the one with LR restrictions are similar. We do not report the responses of real variables, since response of real variables are similar to the basic systems. For the OECD and EU countries, we also report the implied real exchange rate changes due to exchange rate and CPI changes.

Table 5. Impulse Responses of Δ log CPI, Δ log E, and Δ log RER to e_{GSP}.

	US States CPI	OECD 23 CPI	EU 15 CPI	OECD 23 EXC	EU 15 EXC	OECD 23 RER	EU 15 RER
0 year	1.1 (0.6)	-23.1 (2.6)	-19.7 (3.2)	-35.3 (8.4)	-23.1 (11.4)	-12.0	-3.4
1 year	1.7 (0.5)	4.0 (3.6)	4.9 (4.4)	-28.4 (8.9)	-33.1 (13.9)	-32.4	-38.0
2 year	0.0 (0.6)	18.3 (4.0)	15.4 (5.2)	-15.3 (9.1)	-31.8 (13.4)	-33.8	-47.2
3 year	0.3 (0.3)	23.1 (4.0)	19.0 (5.2)	12.0 (7.4)	-0.1 (10.3)	-11.1	-19.1
4 year	0.2 (0.2)	23.5 (3.9)	20.6 (5.0)	26.7 (5.7)	21.3 (9.1)	-2.2	-0.7
5 year	0.0 (0.1)	21.7 (3.7)	19.7 (4.8)	26.9 (4.6)	24.9 (7.2)	2.2	5.2

First of all, in the U.S. states, in response to shocks to GSP, the CPI growth rate increases over two years, thereby slightly smoothing output shocks. However, the increases are relatively small; a 1% increase in the growth rate of GSP (over a few years) increases less than 0.04% overall. Such a small relative price change does not seem to have much risksharing effects across U.S. states. In contrast, in OECD and EU countries, the CPI growth rate decreases for the first year, but increases for the second year and after, while the exchange rate growth rate decreases for the first three years but increases later. As a result, the real exchange rate growth rate decreases for most years up to four years after the shocks.

The result on CPI is clearly to be interpreted as a sluggish response of prices, which decline (increase) initially after a positive (negative) output shock, to then gradually rise (fall) to smooth a remarkable fraction of the output shock overall (a whopping 77% for OECD). This novel result appears to lend weight to the Balassa-Samuelson hypothesis of a price system

[20] See for example Eichengreen.(1997).

reacting positively to productivity shocks. An equally interesting behavior is displayed by the nominal exchange rate, which also has a dis-smoothing effect at first, but provides some smoothing later. This means that the exchange rate appreciates initially in the face of a positive shock to output (both the simple monetary theory and more complex microfundation general equilibrium theories of the nominal exchange rate[21] can rationalize such a result), but then depreciates in the longer run (and this is harder to justify without invoking the driving role of CPI inflation). Finally, the real exchange rate appears to play a more important role than had previously been estimated[22] : it is only in the longer run that it becomes negligible, since nominal exchange rate changes and inflation changes offset each other. The implications of these results for the smoothing pattern of monetary unions are crucial for the debate on the effectiveness of exchange rate policy and the optimality of currency areas. In the short run, the real exchange rate (as well as the nominal rate) appears to work against stabilization of output shocks, due to sluggishness in price adjustment. From this point of view, removing the exchange rate instrument through the creation of a monetary union may not subtract an important stabilization channel from the toolbox of monetary authorities. At most, in a few years' time, real exchange rates have no smoothing role, as prices adjust to the initial output disturbance.

5. Conclusion

We have used a structural panel VAR model to analyze channels of interstate risksharing among the states of the US from 1963 to 1990, as well as channels of international risksharing among 23 OECD countries from 1960 to 1990 and the 15 EU members from 1960 to 1990. We have obtained several results worth discussing.

In the US, the bulk of risksharing is provided through private channels (capital markets and credit markets), while fiscal risksharing is very limited. The response of each channel to output shocks is not exhausted on impact, but lingers over time, and credit markets exhibit a dis-smoothing effect after the first two years. Potential explanations of this behavior may have to do with intertemporal smoothing patterns embedded in the credit market channel.

We also investigated the response of each channel and consumption to other channels' shocks, finding that consumption obviously reacts also in response to shocks not involving output (for example, changes in the availability or cost of credit); therefore our controlling for alternative smoothing channels in the estimation of risksharing seems to be vindicated. While shocks to fiscal and credit channels elicit no response from capital markets, shocks to capital markets

[21] For instance, Obstfeld and Rogoff (1995).
[22] See for example SY.

affecting cross-state income flows crowd out the credit channel almost completely. This result testifies to a strong substitution between the two smoothing mechanisms, that was impossible to detect in regressions only involving output as a regressor.[23] The response to the fiscal channel has the interesting policy implication that Federal Government's attempts to increase risk sharing within U.S. states via taxes and transfers is crucial, for other relatively private market mechanisms cannot substitute them automatically.

All these results are essentially confirmed in the impulse response analysis with long run restrictions (which identify the response to permanent output shocks). This suggests that most of the output shocks in our sample are permanent. Finally, an analysis of interstate price risksharing suggests that in the US such a smoothing mechanism is not at work.

Turning to the 23 OECD countries, we confirmed that most risksharing on impact takes place through the credit market channel, and the impulse response presents the same pattern as the US credit market smoothing: an initial smoothing is followed after two years by a dis-smoothing behavior. Since international data allow to break down the credit channel into the components of saving (capital depreciation, net fixed investment, inventory change and trade balance), we could separate the credit channel smoothing into domestic smoothing (through gross total capital formation) and international smoothing (through the trade balance). This detailed analysis revealed that the bulk of smoothing is actually carried out through domestic investment (and in particular net fixed investment), rather than via lending and borrowing internationally.[24]

From the analysis of shocks to risksharing channels, we learned that most of these shocks are offset, at least partially, by changes in other smoothing channels -- in particular, the trade balance is especially reactive to changes in financial and credit markets. This points to a large substitutability of smoothing channels and therefore to a possible unifying decisional mechanism that presides to them all.

Further investigation disclosed the smoothing role that the real exchange rate exhibits across countries: an initial dis-smoothing effect -- mainly induced by changes in the nominal exchange rate -- that peters out over time -- as relative prices adjust. One interpretation of the counter-cyclical behavior of nominal exchange rates relies on the role of nominal interest rates in response to the output shock. The policy implication of this result is fairly strong: at best, nominal (and real) exchange rate changes provide no smoothing against idiosyncratic shocks to real

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[23] To be sure, SUR estimations do involve the computation of cross-equation correlations, reflecting mutual influence among the left-hand variables of the system in (0.4). However, these correlations have only been used to make point estimates and standard errors more precise, not to assess dynamic responses among smoothing channels.

output; at worst, they initially exacerbate them. Hence, the establishment of a monetary union in Europe does not appear to have withdrawn from the monetary authorities' toolbox a crucial stabilization instrument. Exploring the exact reasons and mechanism why this occurs is certainly going to be a future research topic of great interest.

[24] This is all the more true as we follow the dynamic response to the output shock, so that, cumulatively, gross total capital formation smoothes even more than the overall credit smoothing, because the trade balance has a dis-smoothing effect.

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Figure 1. US States, 1963-1990, SR Recursive, Basic Model

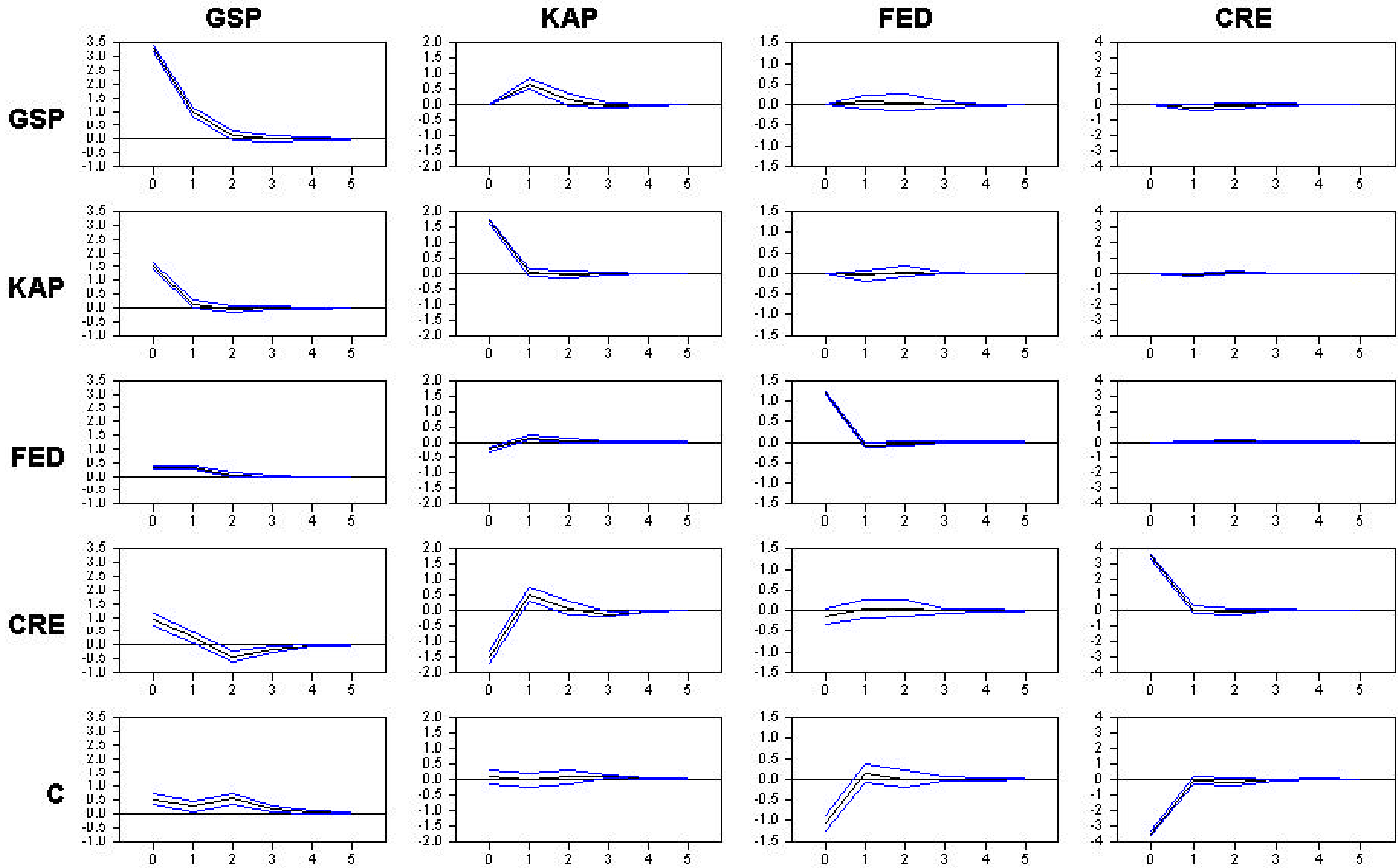

Figure 2. US States, 1963-1990, LR Recursive, Basic Model

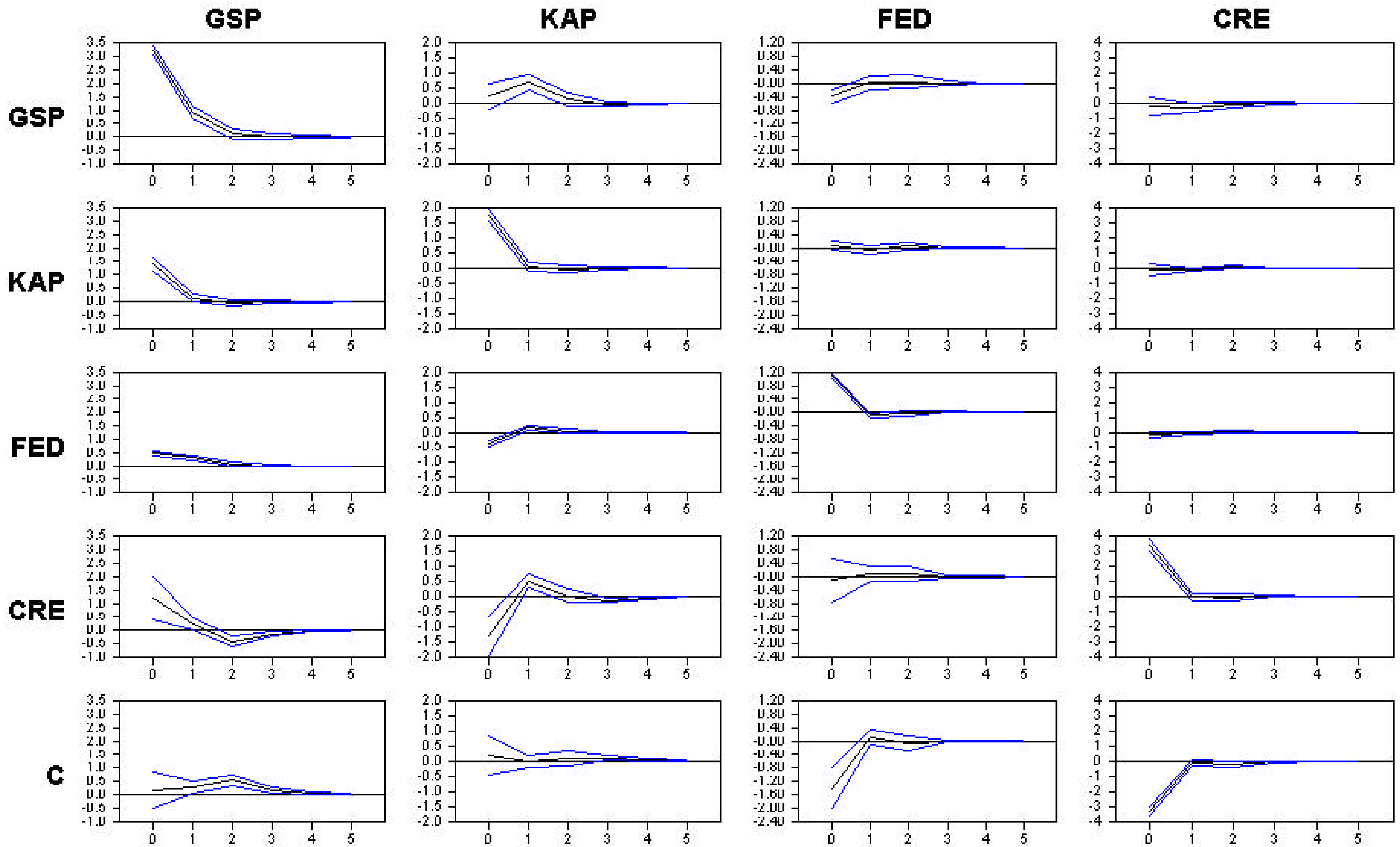

Figure 3. 23 OECD Countries, 1960-1990, SR Recursive, Basic Model

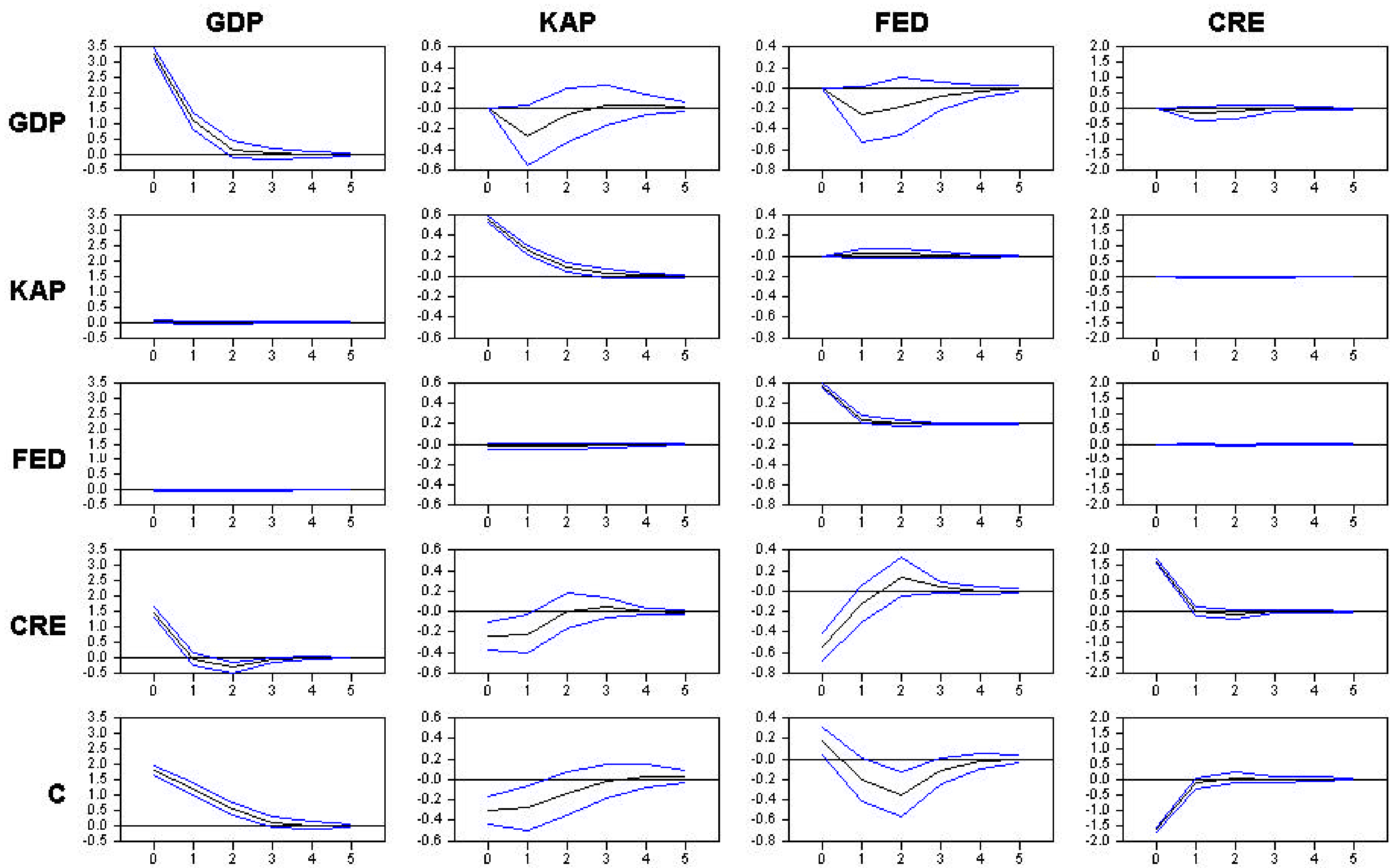

Figure 4. 15 EU Countries, 1960-1990, SR Recursive, Basic Model

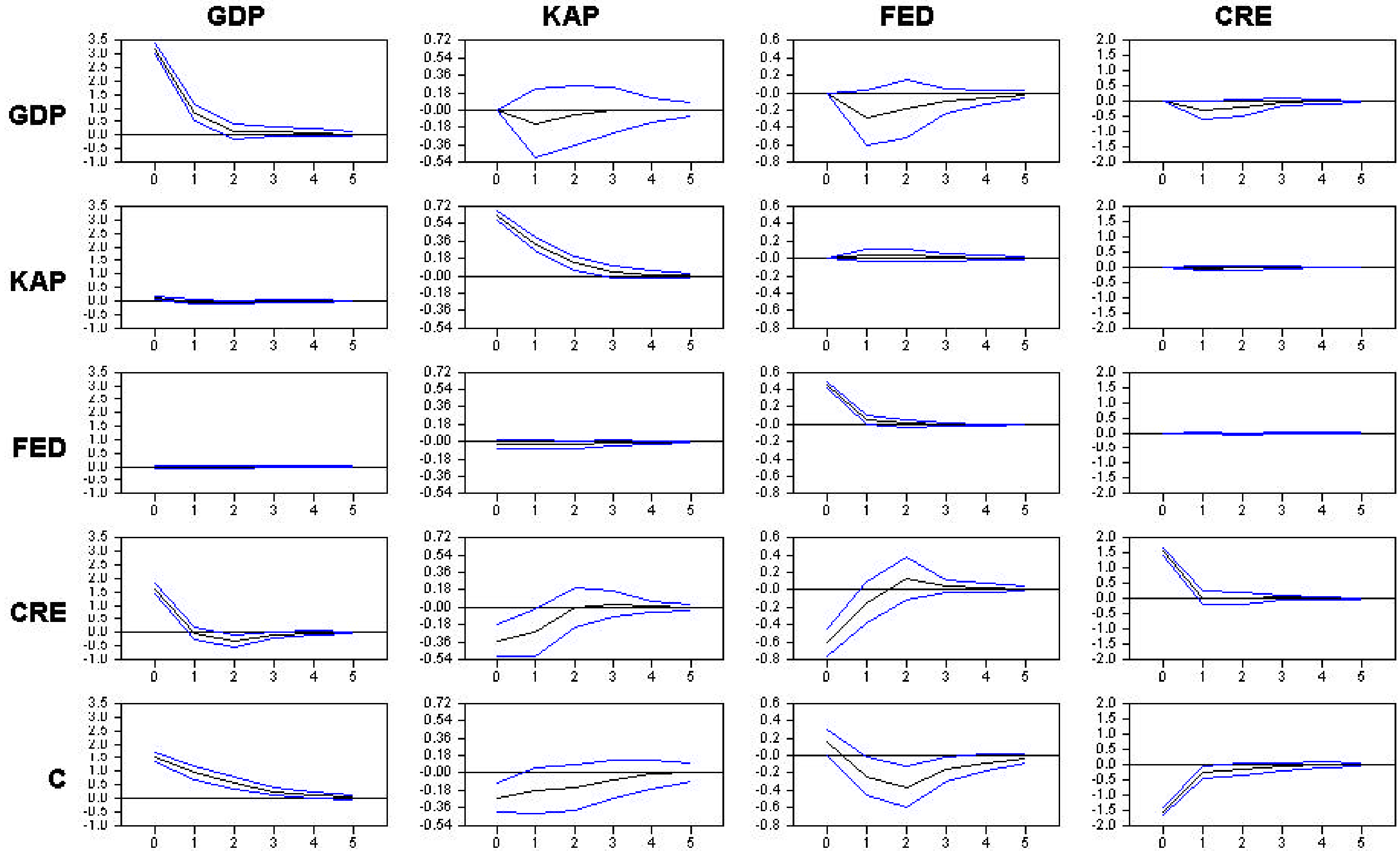

Figure 5. 23 OECD Countries, 1960-1990, SR Recursive, Extended

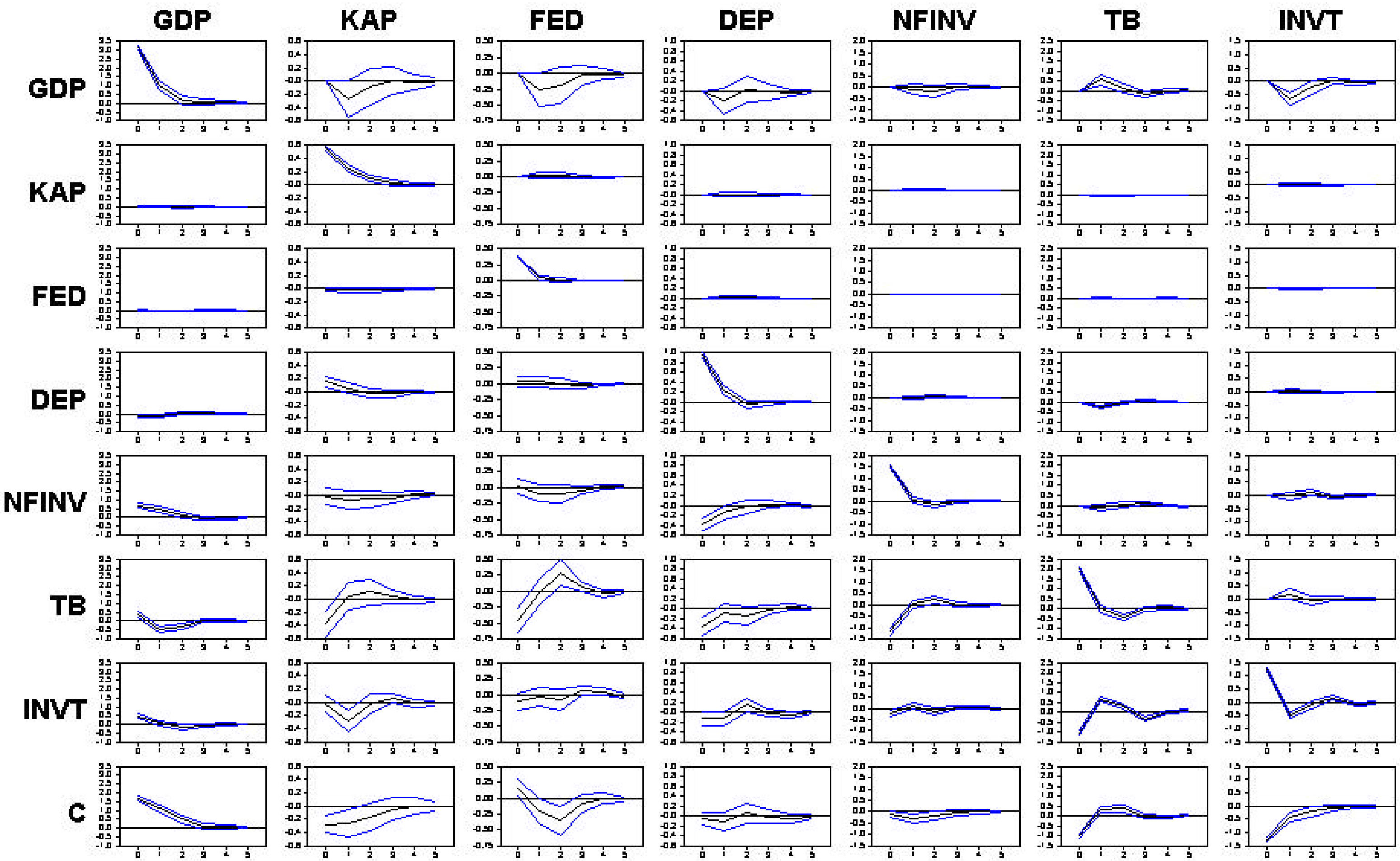

Figure 6. 15 EU Countries, 1960-1990, SR Recursive, Extended