The Role of Risk Sharing in Attenuating Business Cycles Within Currency Unions

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Abstract

Lacking monetary policy, member states of a currency union rely on risk sharing mechanisms to attenuate state-specific business cycles. We show that risk sharing not only directly smooths consumption but also indirectly reduces the volatility of income by stabilizing demand. We causally estimate both direct and indirect effects by exploiting regional variation in military buildups across U.S. states. A $1 increase in external demand raises state-level income by $1.32, with 50% of this increase passing through to consumption. This pass-through is significantly higher than traditional unconditional estimates (15%). A multi-state model that incorporates multiple risk-sharing channels rationalizes these findings and shows that risk sharing between U.S. states reduces state-level consumption volatility by a factor of 3.5, with indirect effects accounting for 45% of this reduction. Risk-sharing channels act as substitutes and have heterogeneous benefits across states, with credit markets rather than capital markets providing the greatest smoothing.

JEL Codes: F44, F45, E32, F15, F41, F36.

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1 Introduction

When countries enter a currency union, they relinquish independent monetary policy, leaving them vulnerable to country-specific economic shocks. While a common monetary policy can stabilize union-wide business cycles, idiosyncratic output fluctuations pose a significant threat to the union's stability. The success of such unions therefore hinges on alternative stabilization mechanisms, as emphasized in the Optimum Currency Area (OCA) literature (Mundell, 1961), which highlights the importance of labor mobility, income diversification, fiscal transfers, and integrated credit markets.

A vast empirical literature, pioneered by Asdrubali, Sørensen and Yosha (1996) (hereafter ASY), has sought to quantify the role of these risk-sharing channels by decomposing the pass-through of output fluctuations to consumption using variance decomposition methods (Sørensen and Yosha, 1998; Kalemli-Ozcan, Sørensen and Yosha, 2003; Balli, Sørensen et al., 2006). This accounting framework, however, treats output fluctuations as exogenous, focusing solely on how much of an income shock is smoothed. It therefore overlooks a crucial feedback mechanism: by stabilizing demand, risk sharing can dampen the magnitude of output fluctuations itself. Consequently, the existing empirical framework cannot answer a central question in the optimum currency area debate—and the key question of this paper: *To what extent does risk sharing attenuate output and consumption volatility, thereby reducing the cost of currency union membership?*

In this paper, we argue that risk sharing reduces consumption volatility through two distinct channels: (1) a **direct effect**, smoothing consumption for a given change in output, and (2) an **indirect general equilibrium effect**, dampening output fluctuations themselves by stabilizing demand. This indirect mechanism is vital: for example, fiscal transfers to a recession-hit region boost local demand, mitigating the downturn's severity. Our analysis explicitly quantifies the magnitude and implications of this indirect effect, providing a more comprehensive understanding of the benefits of risk sharing in currency unions.

To formalize this argument, we first develop an analytical small open economy model that establishes a tight link between risk sharing and the open economy multiplier. Risk-sharing, measured as the pass-through of income changes to consumption, represents the direct effect on consumption volatility and has been the primary focus of the empirical literature pioneered by ASY. The open economy multiplier, which measures the response of income to demand changes, captures the indirect effect of risk sharing, as studied by Nakamura and Steinsson (2014) and others. We show that these two are endogenously related: the degree of risk sharing shapes the size of the multiplier, and the size of the multiplier determines the benefits of risk sharing.

We then empirically estimate both the direct and indirect effects of risk-sharing by exploiting regional variation in military buildups across U.S. states, following Nakamura and Steinsson (2014). This causal identification strategy is a key methodological departure from the existing literature, which has largely relied on unconditional variance decompositions. We estimate that a $1 increase in external demand raises a state's output by \$1.32, with 50% of this increase passing through to consumption. This pass-through is significantly larger than the 15% typically found in the ASY literature, and challenges the conventional view that most income fluctuations are shared across U.S. states. We show that this discrepancy arises because demand-driven shocks, unlike the average shock in the data, have a more balanced incidence on labor and capital income. Since labor income is less geographically diversified, these shocks are harder to smooth through capital markets. Our decomposition reveals that capital markets, federal fiscal transfers, and credit markets play a similar role on impact, while migration becomes increasingly important over the medium run.

We use these identified responses to discipline a quantitative multi-state model that explicitly incorporates these risk-sharing channels and their interdependencies. By modeling all 50 states and D.C. explicitly, we precisely quantify the effects of risk sharing on consumption volatility and its heterogeneous impacts across states. Our main counterfactual exercise, which shuts down all risk-sharing across U.S. states, shows that consumption volatility would be 3.5 times higher without risk sharing. This effect is substantially larger than would be implied by simply raising the share of unsmoothed income fluctuations from 50% to 100%, since the absence of risk sharing would cause the output multiplier to rise from 1.32 to 2.33—a 75% increase in output volatility. The indirect effect of risk sharing therefore accounts for a substantial 45% of the total reduction in consumption volatility.

In a second set of counterfactuals, we shut down one risk sharing mechanism at a time, revealing that each channel's empirically estimated contribution to smoothing provides an incomplete picture of its true stabilizing role. Although capital markets, fiscal transfers, and credit markets absorb similar amounts of income fluctuations in our empirical exercise, our model indicates that eliminating credit markets would increase consumption multipliers five times more than eliminating capital market diversification. These difference arise because when one risk-sharing mechanism is compromised, the remaining channels partially compensate. These compensating effects are stronger when eliminating capital markets rather than credit markets.

Finally, we document substantial heterogeneity in how U.S. states benefit from risk sharing. States that are more open to trade benefit less from risk sharing because a larger fraction of any demand shock already leaks out through imports, naturally dampening the local multiplier. This reveals an interesting interaction between risk sharing and trade openness, another classic OCA criterion (McKinnon, 1963).

The remainder of the paper is structured as follows. After reviewing the literature, we present a simple analytical model to formalize the direct and indirect effects of risk sharing. Section 3 details our empirical strategy and results. Section 4 introduces the quantitative multi-state model used to perform the counterfactual analysis. Section 5 outlines the calibration and solution method, and Section 6 describes our quantitative results. The final section concludes.

Related Literature This paper links two distinct literatures: an older literature that examines empirical measures and tests of risk sharing, and a more recent literature that exploits regional variation to estimate open-economy multipliers. Combining the two literatures has important implications for the literature on optimum currency areas.

Since the seminal work of Cochrane (1991), Mace (1991) and Townsend (1994), a vast literature testing risk sharing at the state and country level has developed, as exemplified by ASY, Sørensen and Yosha (1998); Becker and Hoffmann (2006); Hoffmann (2008); Flood, Marion and Matsumoto (2012) and Kohler, Müller and Wellmann (2023). Some of these papers highlight the lack of improved risk sharing over time despite increased financial globalization, while others contrast the relatively high level of risk sharing across U.S. states with the much lower level observed across euro area countries, thereby connecting to an older literature on optimal currency areas from the 1950s and 1960s (Friedman, 1953; Mundell, 1961). A defining feature of this literature is its structural agnosticism, as it builds on a pure accounting framework.[1] In contrast, our focus is to provide a structural interpretation of risk-sharing estimates, which allows us to quantify the contribution of risk-sharing in reducing consumption volatility through counterfactual analyses.

While several authors propose structural models for specific risk-sharing channels, they do so without connecting their work to the reduced-form risk-sharing regressions (see e.g. House, Proebsting and Tesar (2023) for labor mobility and Evers (2015); Pennings (2016); Beraja (2022) for fiscal transfers). These studies provide a detailed picture of a single risk-sharing mechanism. We instead incorporate all commonly discussed risk-sharing channels and highlight their interdependencies, emphasizing that the relevance of a specific channel depends on the size of the others.

Our approach also connects to a second, more recent literature on cross-regional spending multipliers (Nakamura and Steinsson, 2014; Chodorow-Reich, 2019). Cross-regional multipliers have gained popularity as an informative statistic because—in contrast to aggregate spending multipliers—they are robust to changes in monetary policy and federal tax responses as these effects are effectively "differenced out" by time fixed effects. Nakamura and Steinsson (2014) argue that large cross-regional multipliers call for models where output responds strongly to demand shocks. We show that cross-regional multipliers are instead very sensitive to the degree of risk sharing across states, which does not matter for purely aggregate shocks—casting doubt on how informative cross-regional multipliers are for aggregate multipliers.

Our paper is complementary to a set of more recent papers that have noted that cross-regional multiplier estimates are informative about local general equilibrium effects and can be used to estimate either micro parameters (Guren et al., 2021) or, in conjunction with aggregate fiscal multiplier estimates, to assess the aggregate effects of generic consumption demand shifters (Wolf, 2023). In the spirit of Guren et al. (2021), we show that, under certain conditions, the indirect effects of risk sharing are related to the size of the

[1] A notable exception is Asdrubali and Kim (2004) who set up a dynamic VAR framework that allows the various risk-sharing channels to feedback on output with a one-year lag.

cross-regional spending multiplier.

More broadly, our research relates to the literature on optimum currency areas, dating back to Friedman (1953). This literature established a set of "criteria" for monetary integration, such as factor market mobility (Mundell, 1961), the degree of economic openness (McKinnon, 1963), fiscal integration (Kenen, 1969), and financial integration through credit markets (Ingram, 1962) and equity markets (Mundell, 1973). We show that the quantitative benefits of these risk-sharing mechanisms include not only direct effects but also indirect benefits through lower per-capita output volatility, akin to the effects of a flexible exchange rate. Additionally, we highlight the interactions among these criteria, as the indirect benefits depend on countries' trade openness. For example, risk-sharing through fiscal transfers is particularly potent in economies that are less open to trade.

2 Risk sharing and open-economy multipliers

Consider a small open economy that faces a temporary and unexpected increase in external demand for its products. For concreteness, we think of an increase in federal government spending: $\Delta G_t^{nom} \equiv G_t^{nom} - G_{t-1}^{nom}$. Conceptually, we can decompose the response of nominal consumption into two components: the elasticity of nominal consumption to nominal output, $\frac{\hat{C}_t^{nom}}{\hat{Y}_t^{nom}}$ (where a hat denotes the percent change of a variable relative to the previous period), and the increase in output, ΔY_t^{nom}. The percent change in nominal consumption for an increase in external demand corresponding to 1% of $t-1$ output is given by

$$\frac{\hat{C}_t^{nom}}{\frac{\Delta G_t^{nom}}{Y_{t-1}^{nom}}} = \frac{\hat{C}_t^{nom}}{\hat{Y}_t^{nom}} \cdot \frac{\Delta Y_t^{nom}}{\Delta G_t^{nom}}.$$

Both of these terms have received substantial attention in the literature. The first term, $\frac{\hat{C}_t^{nom}}{\hat{Y}_t^{nom}}$, is a central object to the empirical international risk-sharing literature. ASY estimate this elasticity by regressing log changes in nominal consumption on log changes in nominal output across U.S. states. Following this literature, we denote this elasticity by β_t^C because it captures the share of risk that passes-through to consumption after accounting for all risk-sharing channels. Under log utility, perfect risk sharing requires that per-capita nominal consumption grows at equal rates in the small open economy and the rest of the world (Backus and Smith, 1993). This implies that the growth rate of the country's nominal consumption is independent of its nominal output growth: $\beta_t^C = 0$. With imperfect risk sharing, $\beta_t^C > 0$, and in the extreme case of $\beta_t^C = 1$, income fluctuations translate one-for-one into consumption fluctuations.

The second term, $\frac{\Delta Y_t^{nom}}{\Delta G_t^{nom}}$, is the open-economy relative multiplier. This follows Nakamura and Steinsson (2014), who estimate this multiplier by exploiting variation in external demand (federal government spending) across U.S. states. As in their study, we focus on nominal rather than real output because subnational price deflators for output are unavailable for the United States. We denote this term by m_t^Y.

Combining these definitions, we write the consumption multiplier, m_t^C, as

$$m_t^C \equiv \frac{\hat{C}_t^{nom}}{\frac{\Delta G_t^{nom}}{Y_{t-1}^{nom}}} = \beta_t^C \cdot m_t^Y. \tag{2.1}$$

The multiplier m_t indicates the percent change in income for a shock to external demand corresponding to 1 percent of output. The elasticity β_t^C governs how this change in income translates into a percent change in consumption.

While the literature typically studies risk sharing and fiscal multipliers in isolation, we show that they are endogenously related. Specifically, the multiplier is an increasing function of the share of unsmoothed income β_t^C. This interrelationship implies that greater risk sharing (a lower β_t^C) confers a dual benefit: It directly dampens the response of consumption to a *given* change increase in income, but it also simultaneously reduces the sensitivity of output to the initial increase in external demand. We now formalize this argument within a standard open-economy model.

2.1 A simple open-economy model

We consider a continuum of small open economies that belong to a currency union (Gali and Monacelli, 2005). Each economy experiences idiosyncratic fluctuations in federal government demand for its goods, while aggregate federal government spending at currency union level remains constant. Within this framework, we establish a formal link between the open-economy relative multiplier, m_t^c, and the share of unsmoothed income fluctuations, β_t^C.

This relationship is independent of several model features that are known to influence the closed-economy multiplier, such as the degree of nominal price or wage rigidity, monetary policy, decreasing returns to scale in the production function, input market segmentation, and the elasticity of labor supply. Instead, the multiplier depends critically on the economy's openness in both financial and goods markets. We therefore focus our exposition on these two features and present the remaining model components alongside the quantitative model in section 4.[2]

2.1.1 Trade in financial assets

In this simple model, we focus on a single, generic risk sharing mechanism—an assumption we later relax in the quantitative model by incorporating multiple risk-sharing channels that can be mapped directly to the data. We assume that households can trade state-contingent bonds, but these transactions are subject to a tax. This friction, first introduced by Devereux and Yetman (2014), creates a wedge between bond returns for

[2]While these other features do influence the multiplier, they do so only through their effect on β_t^C.

households in the small open economy and those in the rest of the union.

More formally, let $B(s^t, s_{t+1})$ denote the quantity of state-contingent bonds purchased after history s^t that pay one unit of the country's currency in state s^{t+1}.[3] The price of these bonds to households in the small open economy is $(1 + t(s^t, s_{t+1}))Q(s^t, s_{t+1})$, where $Q(s^t, s_{t+1})$ is the net price and $t(s^t, s_{t+1})$ is a tax levied by the government in the rest of the union. This tax rate depends on both the state of the economy and the specific bond to which it applies. For consistency with its interpretation as a tax, we require $t(s^t, s_{t+1}) \geq 0$ for bond purchases (thereby raising the purchase price), whereas for bond sales, we require that $t(s^t, s_{t+1}) \leq 0$ (thereby lowering the income from the sale).

Beyond bond income, households receive nominal income from output production, $P^Y(s^t)Y(s^t)$, where $P^Y(s^t)$ is the nominal price of the economy's output, and purchase consumption goods, $C(s^t)$, at price $P(s^t)$. We remain agnostic about the production process, assuming a fixed capital stock that does not require investment. The household's budget constraint is then

$$P(s^t)C(s^t) + \sum_{s^{t+1}}(1 + t(s^t, s_{t+1}))Q(s^t, s_{t+1})B(s^t, s_{t+1}) = P^Y(s^t)Y(s^t) + B(s^{t-1}, s_t).$$

With log utility, optimal bond allocation yields the following international risk-sharing condition:

$$\frac{P(s^t)C(s^t)}{P(s^{t-1})C(s^{t-1})}(1 + t(s^{t-1}, s_t)) = \frac{P^*(s^t)C^*(s^t)}{P^*(s^{t-1})C^*(s^{t-1})} \tag{2.2}$$

Following Devereux and Yetman (2014), we specify the tax rate for bond $B(s^{t-1}, s_t)$ as an increasing function of the ratio of consumption growth to output growth:

$$1 + t(s^{t-1}, s_t) = \left(\frac{P(s^t)C(s^t)}{P(s^{t-1})C(s^{t-1})}\frac{P^Y(s^{t-1})Y(s^{t-1})}{P^Y(s^t)Y(s^t)}\right)^{\frac{1-\lambda}{\lambda}},$$

where $\lambda \in [0, 1]$ governs the degree of curvature of the tax function. This specification implies $t(s^{t-1}, s_t) \geq 0$ when nominal consumption growth exceeds nominal output growth (and households purchase bonds to insure against adverse states), and $t(s^{t-1}, s_t) \leq 0$ when nominal output growth exceeds nominal consumption growth (and households sell bonds that pay off in favorable states).

[3]We employ the standard notation for models that explicitly account for state-contingent bonds: In each period t, the economy experiences one of finitely many events $s \in S$. The transition probability from state s to s' follows a Markov chain denoted by $\pi(s'|s)$. We use $s^t = (s_0, s_1, ..., s_t)$ to represent the history of events through period t, with probability $\pi(s^t)$ as of period 0. For any variable X, $X(s^t)$ denotes its realization in state s^t, and unless confusion arises, we write X_t for $X(s^t)$.

Substituting this tax function into the international risk-sharing condition (2.2) yields:

$$\frac{P_t C_t}{P_{t-1} C_{t-1}} = \left(\frac{P_t^Y Y_t}{P_{t-1}^Y Y_{t-1}} \right)^{1-\lambda} \left(\frac{P_t^* C_t^*}{P_{t-1}^* C_{t-1}^*} \right)^{\lambda}. \tag{2.3}$$

Equation (2.3) demonstrates how λ determines the degree of risk sharing: If $\lambda = 0$, trade is balanced period-by-period, with nominal consumption equaling nominal output ($P_t C_t = P_t^Y Y_t$), representing financial autarky. If $\lambda = 1$, the tax is zero and markets are complete, resulting in equal rates of nominal consumption across countries ($P_t C_t = P_t^* C_t^*$). The parameter λ thus serves as an index of financial market integration, with higher values indicating greater integration.

More generally, a 1 percent increase in nominal output raises nominal consumption by $1 - \lambda$ percent. The share of income fluctuations that remain unsmoothed is therefore given by

$$\beta_t^C \equiv \frac{\hat{C}_t^{nom}}{\hat{Y}_t^{nom}} = 1 - \lambda$$

which remains constant over time.

2.1.2 Trade in goods

We model international trade in goods following Armington (1969), as is standard in the open-economy literature.[4] Consumption in this economy consists of a CES aggregate of domestically produced goods, H_t, and imports, M_t, with elasticity of substitution $\psi \geq 0$:

$$C_t = \left((\omega)^{\frac{1}{\psi}} (H_t)^{\frac{\psi-1}{\psi}} + (1-\omega)^{\frac{1}{\psi}} (M_t)^{\frac{\psi-1}{\psi}} \right)^{\frac{\psi}{\psi-1}}.$$

where ω represents the home bias parameter. The nominal price of domestic goods is P_t^Y, while the nominal price of imported goods is normalized to unity. Optimal demand for domestic and imported goods is:

$$H_t = \omega C_t \left(\frac{P_t^Y}{P_t} \right)^{-\psi} \qquad \text{and} \qquad M_t = (1-\omega) C_t \left(\frac{1}{P_t} \right)^{-\psi}.$$

The rest of the world demands the SOE's goods according to a similar demand schedule:

$$X_t = \bar{X}^{nom} \left(P_t^Y \right)^{-\psi},$$

[4] As shown by Arkolakis, Costinot and Rodríguez-Clare (2012), more complex trade models (e.g Eaton and Kortum, 2002; Melitz and Ottaviano, 2008) can be mapped into the Armington framework and yield, when appropriately calibrated, identical equilibrium conditions to first order.

where $\bar{X}^{nom}$ is the value of exported goods in the non-stochastic steady state. Finally, the good produced by the SOE can also be purchased by the government. The market clearing condition therefore reads

$$Y_t = H_t + X_t + G_t.$$

By substituting the optimal demand for domestic goods into this market-clearing condition, we derive a relationship between the multiplier and the share of unsmoothed income fluctuations, as formalized in Proposition 1.

Proposition 1 (Risk Sharing and Output Multipliers) *Consider the model discussed in this section. The share of income fluctuations that remain unsmoothed is given by*

$$\beta_t^C \equiv \frac{\hat{C}_t^{nom}}{\hat{Y}_t^{nom}} = 1 - \lambda,$$

where $\lambda \in [0, 1]$ is the index of financial market integration. Assuming a unit Armington elasticity, $\psi = 1$, the open-economy relative output multiplier is increasing in β_t^U:

$$m_t^Y = \frac{1}{1 - \omega c_{t-1}^{nom} \beta_t^U} = \frac{1}{1 - \omega c_{t-1}^{nom}(1 - \lambda)},$$

where ω is the share of final expenditure that falls on domestic goods, and $c_{t-1}^{nom} \equiv \frac{C_{t-1}^{nom}}{Y_{t-1}^{nom}}$ is the previous period's share of nominal consumption in nominal output.

Proof: Substituting the demand for H_t into the market-clearing condition with $\psi = 1$ and multiplying by P_t^Y yields:

$$Y_t^{nom} = \omega C_t^{nom} + G_t^{nom} + \bar{X}^{nom}.$$

Taking differences and dividing by ΔG_t^{nom} gives:

$$m_t^Y = \omega \frac{\Delta C_t^{nom}}{\Delta Y_t^{nom}} m_t^Y + 1,$$

where $m_t^Y \equiv \frac{\Delta Y_t^{nom}}{\Delta G_t^{nom}}$ is the open-economy multiplier. Rearranging yields:

$$m_t^Y = \left(1 - \omega \frac{C_{t-1}^{nom}}{Y_{t-1}^{nom}} \beta_t^C\right)^{-1},$$

where $\beta_t^C \equiv \frac{\hat{C}_t^{nom}}{\hat{Y}_t^{nom}}$ is the elasticity of consumption to output. ■

Proposition 1 establishes that risk sharing reduces the open-economy relative multiplier.[5] The intuition

[5] Up to a first-order approximation, the multiplier is constant and given by $m_t^Y = (1 - \omega \bar{c}(1 - \lambda))^{-1}$.

is straightforward: consider a \$1 increase in external demand. Under complete financial markets ($\beta_t^U = 0$), consumption remains unchanged and output rises by exactly \$1, yielding $m^Y|_{\beta^C=0} = 1$. Under financial autarky ($\beta_t^C = 1$), the output increase translates one-for-one into higher consumption (assuming that the share of federal military spending in the SOE's GDP is negligible). A share ω of this consumption increase falls on domestic goods, further stimulating output and consumption through a multiplier effect. The total impact exceeds that under complete markets:[6]

$$m^Y\Big|_{\beta^C=1} = 1 + \omega + \omega^2 + ... = \frac{1}{1-\omega} \geq 1 = m^Y\Big|_{\beta^C=0}.$$

The continuous, blue line in Panel (a) of Figure 1 illustrates this nonlinear relationship between risk sharing ($\lambda = 1-\beta^C$) and the multiplier (m^Y). Greater risk sharing (higher λ) lowers the multiplier substantially. Quantitatively, starting from a multiplier equal to $m = 3.2$ under zero risk sharing ($\beta^C = 1$), the multiplier falls to $m^Y = 2.05$ for $\beta^C = 0.75$ and to $m^Y = 1.5$ for $\beta^C = 0.5$. Under perfect risk sharing ($\beta^C = 0$), the multiplier equals 1.

Home bias plays a crucial role in this relationship, with stronger effects at higher values of ω that amplify the feedback loop. For our analysis, we set $\omega = 0.69$, following Nakamura and Steinsson (2014), who argue this value is representative of the average U.S. state.[7] The Armington elasticity is equally important. A unit elasticity simplifies the analysis by ensuring constant expenditure shares on domestic goods. A higher Armington elasticity would amplify expenditure switching and cause the expenditure share on domestic goods to decline, thereby weakening the feedback loop and the relationship between risk sharing and the multiplier. Empirical estimates of the Armington elasticity in the literature range from 5–8 in the long run (Broda, Greenfield and Weinstein, 2006) to values potentially below unity at business cycle frequencies (Boehm, Levchenko and Pandalai-Nayar, 2020). Nakamura and Steinsson (2014) employ a DSGE model with complete financial markets (which corresponds to the case $\lambda = 1$) and an Armington elasticity of 2, yielding multipliers below unity: 0.83 with sticky prices and 0.43 with flexible prices.

Having established the link between risk sharing and the open-economy output multiplier, we can now derive the consumption multiplier and decompose the effects of risk sharing on the consumption multiplier into a direct and an indirect effect:

[6]The elasticity β^C is approximately equal to the aggregate marginal propensity to consume $\frac{\Delta C_t^{nom}}{\Delta Y_t^{nom}}$. Proposition 1 thus generalizes the Keynesian multiplier to an open-economy context.

[7]We implicitly assume that government spending falls entirely on the good produced by the SOE, as in Nakamura and Steinsson (2014). Alternatively, we could have assumed that a fraction $1 - \omega$ of government spending in the SOE falls on imported goods (as we assume for private consumption). In that case, the expression for the multiplier needs to multiplied by ω because only a fraction ω of government spending actually falls on SOE's goods.

Proposition 2 (Risk Sharing and Consumption Multipliers) *The nominal consumption multiplier m_t^c is*

$$m_t^c = \beta_t^C \cdot m_t^Y = (1-\lambda) \cdot \frac{1}{1-\omega c_{t-1}^{nom}(1-\lambda)}.$$

A marginal increase in risk sharing (i.e., an increase in λ) reduces the consumption multiplier through a direct effect ($\frac{\partial \beta_t^C}{\partial \lambda} \cdot m_t^Y$) and an indirect effect ($\frac{\partial m_t^Y}{\partial \lambda} \cdot \beta_t^C$). The indirect effect's share in the total marginal effect is:

$$\mathcal{S}_t^{indirect} \equiv \frac{\frac{\partial m_t^Y}{\partial \lambda} \cdot \beta_t^C}{\frac{dm_t^c}{d\lambda}} = \omega c_{t-1}^{nom}(1-\lambda).$$

Proof: The nominal consumption multiplier follows directly from $m_t^c = \beta_t^C \cdot m_t^Y$ and the expressions for β_t^C and m_t^Y in Proposition 1. Using the product rule to decompose the marginal effect of a change in λ on the consumption multiplier yields

$$\frac{dm_t^c}{d\lambda} = \frac{\partial \beta_t^C}{\partial \lambda} \cdot m_t^Y + \frac{\partial m_t^Y}{\partial \lambda} \cdot \beta_t^C = -m_t^Y - \omega c_{t-1}^{nom} \left(m_t^Y\right)^2 \beta_t^C.$$

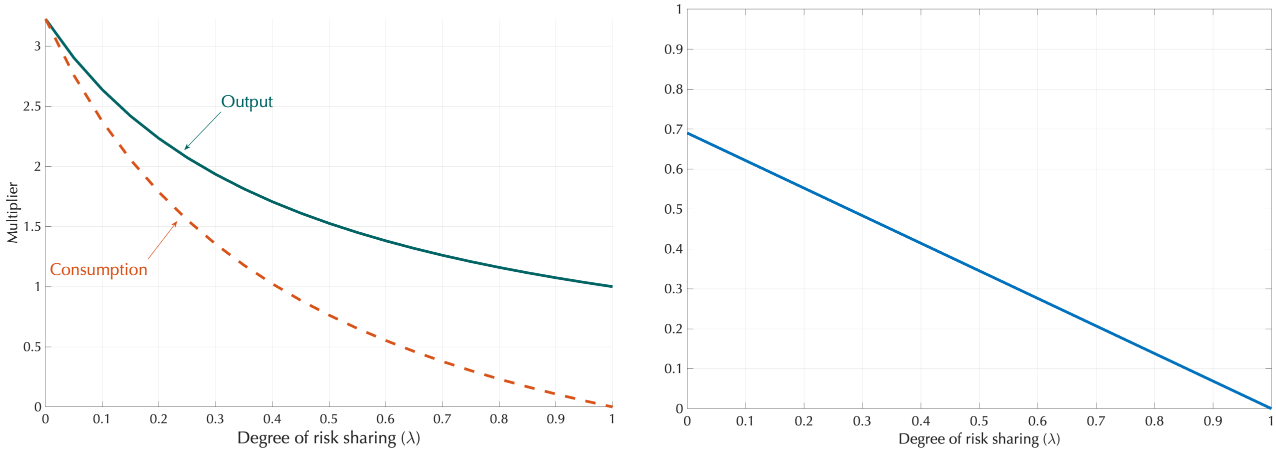
Then, the share of the indirect effect in the total marginal effect is

$$\mathcal{S}_t^{indirect} \equiv \frac{\frac{\partial m_t^Y}{\partial \lambda} \cdot \beta_t^C}{\frac{dm_t^c}{d\lambda}} = \frac{\omega c_{t-1}^{nom} \beta_t^C}{\left(m_t^Y\right)^{-1} + \omega c_{t-1}^{nom} \beta_t^C}.$$

Inserting the expressions for β_t^C and m_t^Y yields the result. ■

The dashed red line in Panel (a) of Figure 1 depicts the consumption multiplier $m^C = (1-\lambda) \cdot \frac{1}{1-\omega(1-\lambda)}$. Under financial autarky, consumption and output multipliers coincide since $C_t^{nom} = Y_t^{nom}$ at all times by definition. As financial integration increases, the consumption multiplier declines through two channels: risk sharing directly reduces consumption volatility for a given level of output volatility, and it indirectly reduces output volatility itself (as shown by the declining blue line).

Panel (b) of Figure 1 illustrates the indirect effect's contribution to the total effect. For low levels of financial market integration, the indirect effect of reducing output volatility dominates. Modest changes in financial market integration can substantially reduce consumption volatility—the consumption multiplier falls by a factor of four when risk sharing increases from $\lambda = 0$ to $\lambda = 0.5$. The relevance of the indirect effect is directly related to the degree of home bias: greater home bias amplifies the feedback loop as output becomes more dependent on domestic consumption. Consequently, the welfare gains from financial integration are larger for economies that are relatively closed to international trade in goods.



(a) Open-economy relative multipliers

(b) Share of the indirect effect

Figure 1: Risk sharing and multipliers

Notes: Panel (a) displays the relationship between the index of risk sharing on the x-axis and the open-economy relative multiplier for output, $m^Y = \frac{1}{1-\omega(1-\lambda)}$ and for consumption, $m^C = (1-\lambda)m^Y$, on the y-axis. The home bias parameter is set to $\omega = 0.69$. Panel (b) displays the share of the indirect effect in the total marginal effect of an increase in risk sharing, λ, on the consumption multiplier, m^C, $\mathcal{S}^{indirect} = \omega(1-\lambda)$.

3 Empirical Analysis

The previous section established that risk sharing reduces consumption volatility through two channels: (1) an *indirect effect*, whereby it dampens the response of output to a given shock, and (2) a *direct effect*, by which it smooths consumption for a given change in output. This section empirically quantifies these two effects using regional variation in U.S. military spending.

We proceed in three steps. First, we specify our strategy for estimating the open-economy relative output multiplier m^Y and the pass-through to consumption β^C, which correspond to the indirect and direct effects of risk sharing. Second, we detail how we decompose this pass-through using the framework of Asdrubali, Sørensen and Yosha (1996) to identify the contributions of specific risk-sharing channels. Finally, we present our instrumental variable strategy, a key departure from the existing literature that allows for a causal interpretation of our findings. These estimates will discipline our quantitative model in Section 4.

3.1 Direct and Indirect Effects of Risk Sharing

To quantify the *indirect effect* or risk sharing we first estimate the open-economy relative output multiplier m^Y, by regressing the change in a state's nominal GDP on federal military spending shocks:[8]

$$\Delta \ln GDP_{i,t} = \alpha_i + \alpha_t + m^Y \frac{G_{i,t} - G_{i,t-1}}{GDP_{i,t-1}} + \mathbb{Z}_{i,t} + \varepsilon_{i,t} \tag{3.1}$$

where $GDP_{i,t}$ is aggregate nominal GDP in state i at time t, $G_{i,t}$ denotes nominal federal military spending and $\mathbb{Z}_{i,t}$ is a vector of control variables described below.

To quantify the *direct effect*, we estimate the consumption multiplier m^c, by replacing the outcome variable with the change in per-capita consumption $\Delta \ln pce_{i,t}$. The unsmoothed share of the income shock, β^C, is then the ratio of these two coefficients:

$$\beta^C_t = \frac{m^c_t}{m^Y_t} \tag{3.2}$$

This ratio captures the pass-through from income to consumption in response to a change in external demand. We estimate standard errors for this parameter using the variance-covariance matrix of the estimates, which we estimate by stacking all regressions and saturating the model with sample indicators (Angrist, Hull and Walters, 2023; Angrist and Hull, 2023).[9]

To trace these causal effects over time, we also estimate Jordà (2005)-style local projections for each outcome. This yields cumulative multipliers m^Y_h over a horizon of h years (Ramey, 2019):

$$\sum_{s=0}^{h} \Delta \ln GDP_{i,t+s} = \alpha_{h,i} + \alpha_{h,t} + m^Y_h \sum_{s=0}^{h} \frac{G_{i,t+s} - G_{i,t-1}}{GDP_{i,t-1}} + \mathbb{Z}_{h,i,t} + \varepsilon_{h,i,t} \tag{3.3}$$

3.2 Decomposition Into Risk-Sharing Channels

To understand the mechanisms underlying the observed degree of smoothing (β^C), we decompose the wedge between aggregate GDP and per-capita consumption. Following the seminal work by Asdrubali, Sørensen and Yosha (1996), later extended by Parsley and Popper (2021) and Kohler, Müller and Wellmann (2023), we

[8]Unlike Nakamura and Steinsson (2014) and Dupor and Guerrero (2017), who use two-year differences, we focus on one-year differences. We can do this, since we adjust the fiscal-year military spending data to match the calendar year that the other macroeconomic variables follow. While this approach may not fully capture timing mismatches between military contract awards and actual expenditures (see Briganti, Brunet and Sellemi 2025), our results are robust to using a two-year difference specification, which we report in the Appendix.

[9]We compute standard errors for these nonlinear combinations using the Delta method. For related econometric approaches, see Erickson and Whited (2002) and Andrews, Gentzkow and Shapiro (2020).

use the accounting identity:

$$GDP_{i,t} = \frac{GDP_{i,t}}{gdp_{i,t}} \cdot \frac{gdp_{i,t}}{pi_{i,t}} \cdot \frac{pi_{i,t}}{di_{i,t}} \cdot \frac{di_{i,t}}{pce_{i,t}} \cdot pce_{i,t},$$

where i indexes U.S. states and t denotes years. The variables represent aggregate GDP ($GDP_{i,t}$), per capita GDP ($gdp_{i,t}$), per capita personal income ($pi_{i,t}$), per capita disposable income ($di_{i,t}$), and per capita personal consumption expenditure ($pce_{i,t}$).[10]

Taking logs and first differences yields:

$$\begin{aligned} \Delta \ln GDP_{i,t} = & \underbrace{\Delta \ln GDP_{i,t} - \Delta \ln gdp_{i,t}}_{\text{Migration}} + \underbrace{\Delta \ln gdp_{i,t} - \Delta \ln pi_{i,t}}_{\text{Capital markets}} \\ & + \underbrace{\Delta \ln pi_{i,t} - \Delta \ln di_{i,t}}_{\text{Fiscal transfers}} + \underbrace{\Delta \ln di_{i,t} - \Delta \ln pce_{i,t}}_{\text{Credit markets}} + \underbrace{\Delta \ln pce_{i,t}}_{\text{Unsmoothed}} . \end{aligned} \tag{3.4}$$

This decomposition identifies four distinct risk-sharing channels that can absorb fluctuations in aggregate GDP before they translate into per-capita consumption changes, introducing a wedge between m^Y and m^c. First, *migration (M)*—measured as the difference between changes in aggregate and per-capita GDP—captures how worker mobility dampens local economic shocks. For example, outward migration during recessions raises per-capita GDP for remaining residents.[11] Second, *capital market smoothing (K)* represents the difference between changes in per-capita GDP and personal income, capturing factor income flows across regions through dividends, interest payments, commuting income, capital depreciation, and retained earnings. Following ASY, we denote this channel as capital market smoothing. Third, *fiscal transfers (F)* create a wedge between changes in personal income and disposable income, reflecting cross-regional redistribution through taxes and transfers. Fourth, credit markets allow households to smooth consumption through borrowing and lending in *credit markets (B)*, represented by differences between changes in disposable income and consumption. Any fluctuations not absorbed by these four channels remain unsmoothed, resulting in a direct comovement between aggregate GDP and per-capita consumption.

We use the different outcome variables in equation (3.4) for each risk-sharing channel. We estimate the response of each outcome variable to the military spending shock as in equation (3.1). We then calculate the normalized contribution of each channel, β, as its estimated response relative to the total output response, m^Y, as in (3.2). These shares, by construction, sum to one:

$$\beta^M + \beta^K + \beta^F + \beta^B + \beta^C = 1.$$

[10] We convert all variables to per-capita terms using working-age population, as this demographic is more likely to respond to changing economic conditions through migration.

[11] By measuring migration through changes in working-age population, we implicitly assume that cyclical variations in population growth rates primarily reflect net migration rather than demographic factors.

3.3 Identification: Military Spending Shocks

A central contribution of our paper is the causal identification of the different risk-sharing measures. While Asdrubali, Sørensen and Yosha (1996) and subsequent literature has relied on unconditional variance decompositions, we estimate the response to an identified external demand shock using an instrumental variable (IV) approach. This strategy allows us to move from correlation to causation, providing a more robust foundation for our counterfactual analysis.

Following Nakamura and Steinsson (2014) and Dupor and Guerrero (2017), we address the endogeneity of state-level military spending with a shift-share instrument. The instrument combines national changes in military spending with cross-sectional variation in states' exposure to military contracts:

$$\text{instr}_{i,t} = \left(\frac{1}{2} \sum_{n=t-3}^{t-2} \frac{s^{G}_{i,n}}{s^{GDP}_{i,n}} \right) \cdot \frac{G_t - G_{t-1}}{GDP_{t-1}}, \tag{3.5}$$

where $\frac{G_t - G_{t-1}}{GDP_{t-1}}$ is the national shift component (changes in aggregate military spending relative to GDP), and $\frac{s^{G}_{i,n}}{s^{GDP}_{i,n}} = \frac{G_{i,n}/G_n}{GDP_{i,n}/GDP_n}$ captures each state's relative exposure to military spending. States with historically higher military spending per dollar of GDP experience larger shocks when national military spending changes. This identification strategy is valid if national military spending decisions reflect geopolitical considerations rather than state-specific economic conditions.

To ensure instrument validity, we implement several precautions based on recent methodological advances in shift-share designs (Adao, Kolesár and Morales, 2019; Goldsmith-Pinkham, Sorkin and Swift, 2020; Borusyak, Hull and Jaravel, 2022). First, we lag exposure shares by two years to ensure that the instrument does not capture variation in national military spending across states. Second, we include exposure shares as control variables to account for potential correlations between these shares and economic outcomes. Third, we incorporate time fixed effects to absorb aggregate temporal variation, including lagged values of national shifts, ensuring the instrument reflects only contemporaneous innovations in military spending. Fourth, we include lags of national military spending changes to isolate unexpected spending shocks.[12] Finally, we obtain unbiased standard errors by clustering our regressions at the treatment level—the state level in this case. To ensure our regressions account for the relative importance of different states for output fluctuations, we weight our regressions by the states' shares of national GDP.

3.4 Data

Geographical Coverage and Sample Period. Our analysis covers the 50 U.S. states and the District of Columbia. The sample spans 1966–2019, with 1966 marking the first year for which state-level military

[12] Our results are robust to adding a greater set of control variables, including lags of dependent variables and further lags of spending changes.

spending data are available.

Data Sources. Data on state GDP, personal income, disposable income, and consumption are from the Bureau of Economic Analysis (BEA).[13] We focus on consumption of non-durable goods and services, as this measure aligns more closely with the standard international risk-sharing framework where purchases of goods coincide with their consumption.[14] Official state-level consumption data are available only from 1997 onward. For prior years, we construct a proxy for state-level consumption growth by allocating national consumption growth to states based on their employment growth in sectors producing non-tradable, non-durable consumption goods. This proxy shows a strong correlation with actual consumption data and performs better than other proxies commonly used in the literature.[15] Data on state-level working-age population are from the National Cancer Institute's Surveillance, Epidemiology, and End Results Program.

Military spending data are constructed from the universe of U.S. military prime contracts, aggregated to the state level. Data before 2004 are from the Department of Defense's Directorate for Information Operations and Control archives; data from 2004 onward are from USAspending.gov. We convert the data from fiscal to calendar years by allocating spending proportionally.[16] All variables are in nominal terms.

3.5 Results

Table 1 presents our main empirical results. We first establish the strength of our instrumental variable approach using the weak-instrument-robust test of Montiel Olea and Pflueger (2013). The effective first-stage F-statistic is 114.8 on impact, substantially exceeding the 5% worst-case bias critical value of 37.4 and indicating strong instrument relevance.

Panel A of Table 1 reports our main findings on the aggregate response. On impact (Column 1), we estimate an open-economy relative multiplier of 1.32 (0.58), implying that a $1 increase in federal military spending raises state-level GDP by $1.32 in the year of the shock. This point estimate is comparable to the two-year multiplier reported by Nakamura and Steinsson (2014). Critically, we find that 50% of this military-

[13]Appendix **??** provides additional details on data sources and includes a table decomposing the relationship between GDP and personal consumption.

[14]As shown in Appendix X, durable consumption responds more strongly to shocks to output, consistent with the view that durables act as an additional saving device.

[15]For the years where both series are available (1997 onward), the average correlation between our proxy and actual state-level consumption growth is 0.94. This correlation is higher than that of alternative proxies used in the literature, such as retail employment growth (0.91) or retail sales growth (0.22) (Asdrubali, Sørensen and Yosha, 1996; Hoffmann et al., 2019; Guren et al., 2021). See Appendix XXX for more details on how the proxy is constructed and comparison with commonly used measures.

[16]For a given fiscal year's total spending: if the fiscal year is from the 1966-1976 period (which ran from July 1st of the previous calendar year to June 30th of the current calendar year), half of that fiscal year's spending is allocated to the previous calendar year and half to the current calendar year. If the fiscal year is from 1977 onward (which ran from October 1st of the previous calendar year to September 30th of the current calendar year), one-quarter of that fiscal year's spending is allocated to the previous calendar year and three-quarters to the current calendar year.

Table 1: THE EFFECTS OF MILITARY SPENDING SHOCKS ON OUTPUT AND CONSUMPTION

	Impact (1)	Medium-Run (2)
Panel A: Multipliers		
Output Multiplier (m^Y)	1.32**	2.12***
	(0.58)	(0.43)
Consumption Multiplier (m^C)	0.66***	0.74***
	(0.23)	(0.21)
Panel B: Decomposition of Risk-Sharing Channels		
Migration (β^M)	0.05	0.18***
	(0.10)	(0.06)
Capital Markets (β^K)	0.15	0.17*
	(0.22)	(0.10)
Fiscal Transfers (β^F)	0.14***	0.13***
	(0.04)	(0.02)
Credit Markets (β^B)	0.15	0.18*
	(0.14)	(0.09)
Unsmoothed Component (β^C)	0.50**	0.35***
	(0.22)	(0.09)

Notes: The table reports responses to a $1 military spending shock. The impact response sets $h = 0$, the medium response sets $h = 3$. Panel A reports the open-economy relative output multiplier (m^Y) and the consumption multiplier (m^c). Panel B reports the risk-sharing coefficients (β), which decompose the fraction of the output shock absorbed by each of the four channels. β^C represents the pass-through of shocks in income to consumption. The β coefficients are the ratio of each channel's response to the output response (e.g., $\beta^C = m^C/m^Y$). All regressions include state fixed effects and controls as described in Section 3. The sample period is 1967–2019 ($N = 2,652$). Standard errors, clustered by state, are in parentheses. *First-stage F-statistics:* $h = 0$: 114.8; $h = 3$: 226.7. Full IV coefficient tables are reported in Appendix XXX. *p<0.10, **p<0.05, ***p<0.01.

driven increase in output passes through to consumption (the unsmoothed component), as per-capita consumption only rises by $0.66.

Panel B decomposes how the remaining 50% of the output shock is absorbed through different risk-sharing mechanisms. The migration channel provides modest initial smoothing, with net in-migration offsetting 5 cents of the aggregate shock at the per-capita level. Capital markets smooth an additional 15 cents, primarily through retained earnings or dividend payments to non-residents, though this estimate is imprecise. The federal fiscal transfer system provides significant and precisely estimated smoothing, reducing per capita disposable income by another 14 cents. Finally, credit markets absorb 15 cents of the income shock, although this coefficient is not statistically significant.

The dynamic response changes somewhat over the medium run (column 2). The output response strengthens over time, with the cumulative multiplier reaching 2.12 three years after the shock. The overall share of unsmoothed income (β^C) falls to 0.35. This increase in smoothing is driven almost entirely by labor mobility; the migration channel's contribution triples to 0.18, becoming a dominant smoothing mechanism in the medium term.[17] The contributions of the other channels remain roughly constant but gain statistical significance.

3.6 How important is risk sharing through capital markets?

Our findings challenge the conventional view that almost all idiosyncratic state-level income fluctuations are shared across U.S. states. We estimate that a $1 military-driven increase in GDP causes state-level consumption to increase by $0.50, whereas prior literature and our own OLS specification estimates that only $0.15 of a shock to output passes-through to consumption. Figure 2 illustrates this stark contrast by comparing our IV and OLS estimates.

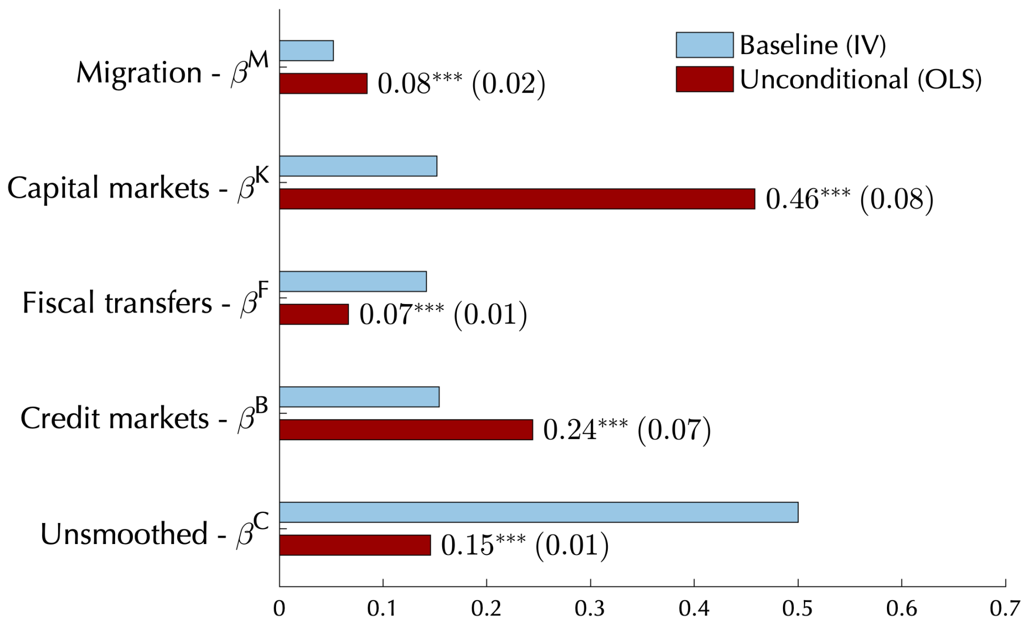


Figure 2: Comparison of IV vs OLS risk-sharing channels

This figure compares risk-sharing coefficients estimated using military spending shocks (IV) with those from unconditional regressions of each channel on GDP growth (OLS). For instance, the β^M coefficient in the OLS specification is estimated from regressing $\Delta \ln GDP_{i,t} - \Delta \ln gdp_{i,t}$ on $\Delta \ln GDP_{i,t}$ and a set of state and time fixed effects.

This striking discrepancy is driven almost entirely by the capital market channel. Unconditional variance decompositions, pioneered by ASY, consistently find that capital markets are the single largest channel for smoothing state-specific shocks. Our OLS regressions confirm this, indicating they absorb 46 cents of every

[17] This growing importance of migration as an adjustment mechanism aligns with findings in Foschi et al. (2022).

dollar increase in output. In our IV specification, however, the contribution of this channel is a statistically insignificant 15 cents.

This finding raises a puzzle: why does the capital market channel, which appears to be the linchpin of regional risk sharing in unconditional data, play such a diminished role in response to a well-identified government demand shock?

The answer is that risk-sharing channels are not deep structural parameters, but depend critically on the nature of the underlying shock hitting the economy. OLS-based variance decomposition estimates are unconditional, capturing responses to *all* shocks to GDP, whereas our IV estimates isolate a specific government demand shock. We next show that the unconditional dominance of the capital market channel reflects the fact that typical state-level GDP fluctuations are driven by shocks that disproportionately accrue to capital. Since capital income is far more geographically diversified than labor income, shocks that load heavily on capital are more easily smoothed. Government spending shocks, in contrast, have a more balanced incidence on labor and capital.

Table 2: Elasticities of income components to GDP

	Labor		Capital	
	Unconditional (OLS)	Military spending (IV)	Unconditional (OLS)	Military spending (IV)
Paid	0.46***	1.02***	1.49***	1.03***
	(0.04)	(0.27)	(0.04)	(0.32)
Received	0.46***	0.91***	0.64***	0.51
	(0.05)	(0.30)	(0.20)	(0.32)

Notes: Elasticities of state-level labor and capital income with respect to GDP based on unconditional OLS or IV estimates conditional on military spending shocks. "Paid" refers to income paid in a state, "Received" refers to income received by residents. Sample: 1967–2019. *Notes*: The table reports elasticities of state-level labor and capital income with respect to state GDP. OLS estimates are from regressions of log changes in the income component on log changes in GDP. IV estimates are the ratio of the instrumented response of the income component to the instrumented response of GDP, conditional on military spending shocks. "Paid" refers to income generated within a state; "Received" refers to income accruing to state residents. All specifications include state and time fixed effects. Sample: 1967–2019.

To substantiate this argument, we estimate the elasticities of state-level labor and capital income with respect to state GDP, comparing unconditional OLS estimates with our IV estimates. Table 2 displays the results. The unconditional OLS estimates reveal a strongly countercyclical labor share: a 1% increase in GDP is associated with only a 0.46% increase in labor income paid within the state, but a 1.49% increase in capital income. The IV estimates, however, show that the labor share is acyclical in response to a government spending shock, with the elasticities of both labor and capital income paid being approximately one.

This difference in factor incidence matters critically because capital income is far more geographically diversified. The second row of Table 2 repeats the exercise for income *received* by state residents.[18] The elasticity of received labor income to GDP is nearly identical to that of paid labor income, indicating limited diversification through e.g. cross-state commuting. For capital income, however, the elasticity of received income is less than half that of paid income. This efficient diversification means that when shocks primarily affect capital income—as they appear to do unconditionally—the capital market channel provides substantial risk sharing. When shocks affect labor and capital proportionally—as government spending shocks do—this channel is naturally less important.

This finding—that the state-level labor share is strongly countercyclical unconditionally but acyclical in response to a demand shock—raises a deeper question: What generates such a strongly countercyclical labor share in the unconditional state-level data? A canonical Cobb-Douglas production function with perfect competition predicts constant factor shares, inconsistent with our findings. Models with sticky wages or sticky prices also fail to generate countercyclical labor shares.[19] While models with overhead labor (e.g., Nekarda and Ramey (2020); Kaplan and Zoch (2024)) can generate such dynamics, this mechanism is quantitatively too weak to explain the large effect observed at the state level and does not explain why the effect is so much more pronounced at the state level than nationally.

One potential explanation involves oligopolistic competition and granular shocks. In models like Atkeson and Burstein (2008), large firms respond to positive idiosyncratic productivity or demand shocks by raising markups as they gain market power. This leads to a decline in the labor share of income. If such shocks are sufficiently geographically concentrated, they could drive local GDP while being averaged out at the national level. This class of models naturally generates volatile capital income and a countercyclical labor share, consistent with the unconditional data.

An alternative, complementary explanation is measurement error. State-level labor income is derived from detailed wage data reported by employers in the Quarterly Census of Employment and Wages, while capital income is estimated indirectly and proves difficult to allocate accurately across states, particularly for firms operating in multiple states. Systematic misattribution of profits could mechanically amplify capital income volatility and inflate the apparent role of capital markets in OLS regressions.[20] Our IV estimates are immune to this type of measurement error.

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[18] Received labor income and received capital income sum to personal income.

[19] Sticky wage models predict constant labor shares, while sticky price models generate procyclical labor shares.

[20] Specifically, if the capital market channel, $\Delta \ln gdp_{i,t} - \Delta \ln pi_{i,t}$, contains measurement error, this error also enters the regressor, $\Delta \ln GDP_{i,t}$, (see equation (3.4)). Regressing $\Delta \ln gdp_{i,t} - \Delta \ln pi_{i,t}$ on $\Delta \ln GDP_{i,t}$ yields a coefficient that is upward-biased due to spurious correlation from measurement error appearing on both sides. The coefficients for the other risk-sharing channels would be biased downward due to measurement error of the independent variable.

4 Multi-State Quantitative Model

We find that 50% of state-specific income fluctuations induced by government spending shocks are smoothed through various risk-sharing mechanisms. The corresponding open-economy relative multiplier of government spending shocks is 1.32, implying that a $1 increase in government spending raises GDP by $1.32. In Section 2, we proposed a simple model that links these two measures, arguing that risk sharing reduces the size of the multiplier. The model was purposefully simple and only had a generic risk-sharing mechanism to focus on the qualitative result. Still, as we can see from Figure 1, which displays the multiplier as a function of the amount of risk sharing, the simple model's *quantitative* predictions are quite accurate as well, as it only slightly overpredicts the multiplier for the observed amount of risk sharing (around 1.53 rather than 1.32).

But the simple model has its limitations. For instance, it does not allow us to run counterfactuals that shut down one risk-sharing channel at a time. It also does not speak to possibly heterogenous effects of risk sharing across U.S. states. In this section, we correct these shortcomings and present a quantitative, multi-region model that replaces the generic risk-sharing mechanism by several risk-sharing channels that we can map more easily to the data.

The world economy consists of N U.S. states that form a currency union. Several model ingredients are standard in this class of models, such as sticky wages, Armington trade and a production process that requires labor. As in the simple model, we focus on external demand shocks, modeled as state-specific unpredicted changes in federal government spending, as a driving force.

We complement our baseline model with four features to capture the distinct risk-sharing channels emphasized in the empirical section: First, we allow for labor mobility across states as in House, Proebsting and Tesar (2023) to model the migration channel. Second, households' stock holdings are potentially biased towards domestic firms to capture imperfect risk sharing through capital markets. Third, the fiscal transfer channel is modeled through a progressive (federal) income tax as in Heathcote, Storesletten and Violante (2017). Finally, households can trade in non-contingent bonds subject to adjustment costs to capture the credit market channel.

4.1 Households, Population and Migration

Each U.S. state is populated by capital owners and workers. Capital owners are immobile. Their number is given by $\mathbb{N}_i^k$. Workers are mobile and can move between states if they find it optimal to do so. The number of workers in state i at time t is given by $\mathbb{N}_{i,t}^w$ and the total population is

$$\mathbb{N}_{i,t} = \mathbb{N}_i^k + \mathbb{N}_{i,t}^w. \tag{4.1}$$

The U.S. population is constant and normalized to 1: $\sum_{i=1}^{N} \mathbb{N}_{i,t} = 1$. Variables are indicated in per capita terms. For example, $C^w_{i,t}$ is the consumption of a single worker while the total consumption for workers is $\mathbb{N}^w_{i,t} C^w_{i,t}$.

4.1.1 Capital Owners

Capital owners receive income from dividends and interest. Capital owners in state i own a (fixed) share κ of state i firms that pay out dividends $P_{i,t} D_{i,t}$, where $P_{i,t}$ is the price index of state i's final good and $D_{i,t}$ are state i's real dividends per capital owner. They also own a share κ^*_i of a nationally representative portfolio of firms that pays out $D^*_t \equiv \frac{\sum_i \mathbb{N}^k_i P_{i,t} D_{i,t}}{\sum_i \mathbb{N}^k_i}$ (the national price index is normalized to 1). The parameter κ indicates the home bias in capital owners' firm ownership. As κ goes to zero, capital owners are more and more diversified. *We later calibrate κ to match the empirically observed strength of the capital market channel.* The parameter κ^*_i is state specific and set such that, in the non-stochastic steady state, net dividend flows are zero for each state.[21]

Capital owners can also trade in bonds. Bonds purchased in $t-1$ mature in t and pay a nominal interest rate i_{t-1}. The face value of bonds purchased in $t-1$ is given by $B_{i,t-1}$. Adjusting one's bond position entails some cost, given by $\frac{\iota \overline{gdp}_i}{2} \left(\frac{B_{i,t-1}}{\overline{gdp}_i} \right)^2$, where $\overline{gdp}_i$ is steady-state per-capita GDP and $\iota \geq 0$ disciplines the strength of the adjustment costs.[22] The higher ι, the more costly it is for capital owners to use bonds to smooth income shocks. We scale ι to express it in percent of per-capita GDP, which simplifies the interpretation of ι and makes adjustment costs equally bite across states with different levels of per-capita GDP. Up to a first order, changing the bond position by 1 percent of GDP entails a cost of ι percent of GDP. *We later calibrate ι to match the empirically observed strength of the credit market channel.* Taken together, nominal capital income is

$$P_{i,t} Y^k_{i,t} = \kappa P_{i,t} D_{i,t} + \kappa^*_i D^*_t + B_{i,t-1} i_{t-1} - \frac{\iota \overline{gdp}_i}{2} \left(\frac{B_{i,t}}{\overline{gdp}_i} \right)^2 .$$

Income is taxed according to a log-linear tax and transfer function (Heathcote, Storesletten and Violante, 2017): For any pre-government income $P_{i,t} Y^k_{i,t}$, the disposable income is given by $\mu_{i,t} \left(P_{i,t} Y^k_{i,t} \right)^{1-\tau}$. The parameter $\mu_{i,t}$ captures the level of taxation (and might vary over time to balance the government budget), while the parameter $\tau < 1$ measures tax progressivity. Positive values of τ indicate a progressive tax system,

[21]In particular, we impose $\kappa \bar{D}_i + \kappa^*_i \bar{D}^* = \bar{D}_i$ in the non-stochastic steady state, implying $\kappa^*_i = (1-\kappa)\frac{\bar{D}_i}{\bar{D}^*}$. That is, capital owners in high-productivity states that pay out more dividends than the national average, $\bar{D}_i > \bar{D}^*$, can afford more of the national portfolio, $\kappa^*_i > 1-\kappa$.

[22]These adjustment costs are common in the literature on open-economy models because they induce stationarity (Schmitt-Grohé and Uribe, 2003). A very small value of ι is enough to induce stationarity. More recently, calibrations with larger values of ι have been proposed to model segmentation in international financial markets, see e.g. Maggiori (2022).

while negative values indicate a regressive tax system. If $\tau = 0$, the taxes paid are proportional to income and the tax rate is given by $1 - \mu_{i,t}$. In that case, a 1 percent increase in pre-tax income raises post-tax income by 1 percent and the fiscal system does not contribute to consumption smoothing. More generally, a 1 percent increase in pre-tax income leads to a $1 - \tau$ percent rise in post-tax income. The larger τ, the stronger the fiscal transfer channel. *We later calibrate τ to match the empirically observed strength of the fiscal transfer channel.*

Capital owners use their income to purchase consumption goods at price $P_{i,t}$ and to save or borrow by adjusting their bond position, $B_{i,t} - B_{i,t-1}$. Taken together, at any point in time t, capital owners choose consumption, $C^k_{i,t}$, and bond holdings, $B_{i,t}$, to maximize the expected discounted sum of utility

$$\mathbb{E}_t \sum_{j=0}^{\infty} \beta^j \ln\left(C^k_{i,t+j}\right)$$

subject to the nominal budget constraint

$$P_{i,t}C^k_{i,t} + B_{i,t} - B_{i,t-1} = \mu_{i,t}\left(P_{i,t}Y^k_{i,t}\right)^{1-\tau}. \tag{4.2}$$

The optimal demand for bonds satisfies the following Euler equation

$$1 = \beta\mathbb{E}_t\left\{\frac{C^k_{i,t}}{\pi_{i,t+1}C^k_{i,t+1}}\left[1 + (1-\tau)\mu_{i,t+1}\left(P_{i,t+1}Y^k_{i,t+1}\right)^{-\tau}\left(i_t - \iota B_{i,t}\right)\right]\right\} \tag{4.3}$$

where $\pi_{i,t+1} = \frac{P_{i,t+1}}{P_{i,t}}$ is inflation in state i. Notice that absent income taxation ($\tau = 0$, $\mu_{i,t} = 0$) and adjustment costs ($\iota = 0$), this collapses to the standard Euler equation, $1 = \beta(1 + i_t)\mathbb{E}_t\left\{\frac{C^k_{i,t}}{\pi_{i,t+1}C^k_{i,t+1}}\right\}$.

4.1.2 Workers

Workers are mobile and earn only labor income. Each worker in state i earns nominal labor income $P_{i,t}Y^w_{i,t} = W_{i,t}L_{i,t}$. Similar to capital owners, their income is taxed according to a log-linear tax and transfer function. Workers are assumed to be "hand-to-mouth", so their consumption satisfies

$$P_{i,t}C^w_{i,t} = \mu_{i,t}\left(P_{i,t}Y^w_{i,t}\right)^{1-\tau}. \tag{4.4}$$

At the level of the individual, labor supply is inelastic and thus the only meaningful choice workers make is which state to work in. Before describing the migration decision, we first discuss how effective labor $L_{i,t}$ is determined.

Labor Supply per Worker Workers supply fixed amounts of labor, normalized to 1, in their state of residence. As in Erceg, Henderson and Levin (2000), workers are randomly assigned a job $\iota \in [0,1]$ that pays a nominal wage $W_{i,t}(\iota)$. For each job, there is a labor union with market power that acts in the interest of its members in setting a wage rate.

Job-specific labor $L_{i,t}(\iota)$ is employed by competitive labor-aggregating firms who sell aggregate effective labor to goods-producing firms at wage W_t. Labor-aggregating firms choose a combination of jobs $L_{i,t}(\iota)$ to maximize their profits

$$W_{i,t}L_{i,t} - \int_0^1 W_{i,t}(\iota)L_{i,t}(\iota)d\iota.$$

subject to the definition of effective labor $L_{i,t}$:

$$L_{i,t} = \zeta + \left(\int_0^1 \left(L_t(\iota) - \zeta\right)^{\frac{\psi_w - 1}{\psi_w}} d\iota\right)^{\frac{\psi_w}{\psi_w - 1}},$$

where $\psi_w > 1$ is the elasticity of substitution across jobs. The parameter $\zeta > 0$ in this aggregator ensures a positive equilibrium wage in the presence of inelastic labor supply (House, Proebsting and Tesar, 2023). The demand for each labor type then satisfies

$$L_{i,t}(\iota) = \zeta + \left(\frac{W_{i,t}(\iota)}{W_{i,t}}\right)^{-\psi_w} \left(L_{i,t} - \zeta\right) \tag{4.5}$$

Each period, labor unions can reset wages for individual jobs, $W_{i,t}(\iota)$, with probability $1 - \theta_w$. If they can adjust the wage, labor unions set it to maximize the expected net present value of total labor income for their workers taking the demand curve for each job (4.5) as given. This optimization problem then gives rise to the following labor supply curve:[23]

$$\tilde{\pi}^w_{i,t} = \frac{(1-\theta_w\beta)(1-\theta_w)}{\theta_w}\tilde{L}_{i,t} + \beta\mathbb{E}_t\left[\tilde{\pi}^w_{i,t+1}\right], \tag{4.6}$$

where a tilde denotes log deviations from the non-stochastic steady state and $\pi^w_{i,t}$ is wage inflation at time t. Notice that if wages were fully flexible ($\theta_w \to 0$), then hours per worker would be constant.

Migration At the start of each period, workers choose to migrate or remain in their current state. Migration takes place at the beginning of each period and migrants immediately work and consume in their new location.

A worker moving from state i to state j incurs a migration cost υ^i_j (with $\upsilon^i_i = 0$). In addition to migration costs, workers receive idiosyncratic (i.e. worker-specific) shocks for each destination j, denoted by $\epsilon_{j,t}$.[24]

[23] See the Appendix for more details.

[24] Since every worker draws his or her own shock $\epsilon_{j,t}$, we could add a subscript to denote the individual worker. We

Define $v_{i,t}(\epsilon_t)$ as the value of a worker living in state i at time t conditional on the aggregate state and the worker's vector of idiosyncratic shocks, $\epsilon_t = \left[\epsilon_{1,t}, \epsilon_{2,t}, ..., \epsilon_{N,t}\right]$ drawn at that date. The value for a worker living in state i at time t is

$$v_{i,t}(\epsilon_t) = \max_j \left\{ U\left(C^w_{j,t}\right) + \frac{1}{\gamma}\epsilon_{j,t} - \upsilon^i_j + \beta \mathbb{E}_t\left(V_{j,t+1}\right) \right\}. \tag{4.7}$$

The flow utility function $U(c)$ is $\ln c$. The value $V_{i,t}$ is the expected value of $v_{i,t}(\epsilon_t)$ prior to the realization of the vector ϵ_t and thus, $V_{i,t}$ is the average expected utility of workers in state i at the start of time t. The parameter γ governs how strongly idiosyncratic location shocks affect migration decisions.

We follow Artuç, Chaudhuri and McLaren (2010) and assume that the idiosyncratic shocks are i.i.d. over time and across individuals and are distributed according to a Type-I extreme value distribution with zero mean. Given these assumptions, $V_{i,t}$ is

$$V_{i,t} = \frac{1}{\gamma} \ln \left\{ \sum_j \exp\left\{\gamma\left(U\left(c^w_{j,t}\right) - \upsilon^i_j + \beta \mathbb{E}_t\left(V_{j,t+1}\right)\right)\right\} \right\}. \tag{4.8}$$

Migration decisions depend on this average utility. Let $n^i_{j,t}$ denote the fraction of workers that relocate from i to j, such that the number of workers living in state i evolves according to

$$\mathbb{N}^w_{i,t} = \sum_j n^j_{i,t} \mathbb{N}^w_{j,t-1}.$$

Then, this fraction is given by

$$n^i_{j,t} = \frac{\exp\left\{\gamma\left(U\left(C^w_{j,t}\right) - \upsilon^i_j + \beta \mathbb{E}_t\left(V_{j,t+1}\right)\right)\right\}}{\sum_k \exp\left\{\gamma\left(U\left(c^w_{k,t}\right) - \upsilon^i_k + \beta \mathbb{E}_t\left(V_{k,t+1}\right)\right)\right\}}. \tag{4.9}$$

Naturally, markets with higher expected utility attract more workers. The strength of the response of migration to consumption differentials is driven by two parameters: the migration cost matrix υ and the inverse of the standard deviation of the idiosyncratic shocks, γ. A higher value of γ implies a lower variance for the idiosyncratic shock and migration decisions are more driven by consumption differentials rather than idiosyncratic preferences. This makes the migration response larger. The migration cost parameter pins down the share of migrants, n, in steady state. *Given υ, we calibrate γ to match the empirically observed strength of the migration channel.*

suppress this index for ease of notation.

4.2 Firms, Production and Trade

Production takes place in a two-stage process. A first set of competitive firms produce intermediate goods and sell these either domestically to final-good firms or to firms abroad. Final-good firms, in turn, combine the domestically produced intermediates with imported intermediates to produce a final good that is used for consumption and investment.

4.2.1 Intermediate Goods

Intermediate good producers own the capital stock and pay dividends to households. Nominal dividends are nominal sales less labor costs:

$$\mathbb{N}_i^k P_{i,t} D_{i,t} = \mathbb{N}_{i,t} P_{i,t}^Y Y_{i,t} - \mathbb{N}_{i,t}^w W_{i,t} L_{i,t}. \tag{4.10}$$

Here, $P_{i,t}^Y$ is the price of the intermediate good in state i and $Y_{i,t}$ is the per-capita quantity of intermediate goods produced.

The production of intermediate goods requires labor L_t. Output of intermediates is

$$\mathbb{N}_{i,t} Y_{i,t} = A_i \left(\mathbb{N}_{i,t}^w L_{i,t}\right)^{1-\alpha}, \tag{4.11}$$

where A_i is a scaling factor. Each period t, intermediate good firms choose dividends, $D_{i,t}$, and labor, $L_{i,t}$, to maximize the expected discounted sum of their dividends, $\mathbb{E}_t \sum_{s=0}^{\infty} \beta^{t+s} D_{t+s}$ subject to (4.10) and (4.11).[25] Optimal labor demand implies

$$W_{i,t} \mathbb{N}_{i,t}^w L_{i,t} = (1-\alpha) P_{i,t}^Y \mathbb{N}_{i,t} Y_{i,t} \tag{4.12}$$

4.2.2 Consumption-good Producers

A second set of producers combine domestically produced intermediates and imported intermediates to produce a final consumption good, $C_{i,t}$. These producers choose inputs to maximize profits

$$\max \left\{ P_{i,t} C_t - \sum_{j=1}^{N} P_{j,t}^Y Y_{i,t}^j \right\}$$

[25] Technically, firms apply a stochastic discount factor to discount their expected future dividends. The log-linearized equilibrium conditions would not be affected by this and we therefore omit it for brevity.

subject to the CES production function

$$C_{i,t} = \left(\sum_j \left(\omega_i^j\right)^{\frac{1}{\psi}} \left(y_{i,t}^j\right)^{\frac{\psi-1}{\psi}} \right)^{\frac{\psi}{\psi-1}}. \tag{4.13}$$

Here, the parameter ψ describes the elasticity of substitution between intermediate goods, ω_i^j describes the preference weight by state i firms for goods imported from j (with $\sum_j \omega_i^j = 1$), and $y_{i,t}^j$ is the quantity of intermediate goods imported from state j by state i. The optimal expenditure share on goods imported from j is given by

$$s_{i,t}^j := \frac{P_{j,t}^Y y_{i,t}^j}{P_{i,t} C_{i,t}} = \omega_i^j \left(\frac{P_{j,t}^Y}{P_{i,t}} \right)^{1-\psi}. \tag{4.14}$$

4.3 Monetary and Fiscal Policy

4.3.1 Monetary Policy

Monetary policy in the US is set by the Federal Reserve. The Federal Reserve follows a "Taylor rule" that targets GDP-weighted averages of GDP fluctuations and inflation throughout the United States:

$$i_t = \phi i_{t-1} + (1-\phi) \left[\bar{r} + \phi_Y \sum_{i=1}^N \overline{GDP}_i \cdot \widetilde{GDP}_{i,t} + \phi_\pi \sum_{i=1}^N \overline{GDP}_i \cdot \pi_{i,t} \right]. \tag{4.15}$$

The parameters ϕ, ϕ_Y and ϕ_π govern interest rate persistence, the interest rate reaction to fluctuations in GDP and the reaction to inflation, respectively.

4.3.2 Fiscal Policy

The federal government spends $\mathbb{N}_{i,t} P_i^Y G_{i,t}$ on intermediate goods produced in state i. We assume that $G_{i,t}$ follows an AR(1) with persistence ρ:

$$\ln G_{i,t} = \rho \ln G_{i,t-1} + \epsilon_{i,t}. \tag{4.16}$$

The government's budget constraint is

$$\sum_i \mathbb{N}_{i,t} P_{i,t}^Y G_{i,t} = \sum_i \left(P_{i,t} \left(\mathbb{N}_i^k Y_{i,t}^k + \mathbb{N}_{i,t}^w Y_{i,t}^w \right) - \mu_{i,t} \left[\mathbb{N}_i^k \left(P_{i,t} Y_{i,t}^k \right)^{1-\tau} + \mathbb{N}_{i,t}^w \left(P_{i,t} Y_{i,t}^w \right)^{1-\tau} \right] \right).$$

To ensure a balanced budget at all times, the government adjusts $\mu_{i,t}$. We impose that any changes in nominal government spending outside the steady state are financed by adjusting $\mu_{i,t}$ proportionally across states.[26]

4.4 Market Clearing

Market clearing of the intermediate good requires that the total production of intermediates by state j, $\mathbb{N}_{j,t}Y_{j,t}$,equals total demand, which consists of demand by consumption-good producers, $\sum_i \mathbb{N}_{i,t}y^j_{i,t}$, and demand by the government, $\mathbb{N}_{j,t}G_{j,t}$.

$$\mathbb{N}_{j,t}Y_{j,t} = \mathbb{N}_{j,t}G_{j,t} + \sum_{i=1}^{N} \mathbb{N}_{i,t}y^j_{i,t} \tag{4.17}$$

Final consumption equals consumption by capital owners and by workers:

$$\mathbb{N}_{i,t}C_{i,t} = \mathbb{N}^k_i C^k_{i,t} + \mathbb{N}^w_{i,t}C^w_{i,t}. \tag{4.18}$$

Bond market clearing requires

$$\sum_{i=1}^{N} \mathbb{N}^k_i B_{i,t} = 0.$$

5 Model Solution and Estimation

We solve the model using a first-order approximation around a zero inflation steady state. We calibrate the model to U.S. states. The model is expressed at a quarterly frequency.

We partition the parameters into a set of calibrated parameters and a set of estimated parameters. Parameters that have commonly accepted values used in the international business cycle literature or parameters that have direct analogues in the data (e.g., trade shares, migration shares, etc.) are calibrated accordingly. Taking the calibrated parameters as given, we estimate the remaining four parameters pertaining to the risk-sharing channels: the migration sensitivity, γ, the home bias in capital markets, κ, the parameter of tax progressivity, τ, and the adjustment costs on bond holdings, ι, as well as the Armington elasticity ψ.

5.1 Calibration

Table 3 lists the calibrated parameter values for our baseline specification. While some parameters are assumed to be the same across states, our model captures states'variation in size, their exposure to trade and migration flows, and their exposure to military spending shocks.

[26] Note that the Euler equation by the capital owners pins down the ratio $\bar{\mu}_i$ to $\bar{\mu}_j$ for any pair i and j.

Households, Population and Migration From the Euler equation, we obtain an equation relating the discount factor β to the steady-state interest rate, as well as the tax progressivity parameter τ and aggregate military spending over GDP, $\bar{g}^*$: $\beta = \left(\bar{i}(1-\tau)(1-\bar{g}^*)+1\right)^{-1}$. We choose an annual interest of 4 percent and then solve for β given values for $\bar{g}^*$ and τ. The share of workers in the total population is $1-\alpha$ such that steady-state consumption of workers and capital owners are equalized. Data on population by U.S. state is taken from the BEA. The migration cost parameters υ_j^i enter the system of log-linearized equations only through their effect on bilateral migration shares $\bar{n}_j^i$. Instead of explicitly solving for the migration cost parameters, we directly condition on the observed bilateral matrix of migration shares that we derive from IRS data (House, Proebsting and Tesar, 2025). We set the wage rigidity parameter to $\theta_w = 0.87$, consistent with estimates by Grigsby, Hurst and Yildirmaz (2021).

Firms, Production and Trade We set $\alpha = 0.37$ to match a labor income share of 0.63 (Karabarbounis and Neiman, 2013). States' productivity, A_i, enters the system of log-linearized equations through its effect on states' steady-state GDP. We directly condition on the observed GDP levels that we take from the BEA. Similarly, we can directly condition on observed expenditure shares on goods imported from other states, $\bar{s}_j^i$, rather than explicitly solving for the preference weights, ω_j^i. Data on interstate trade is primarily taken from the freight analysis framework that sources most of its data from the commodity flow survey (CFS). The freight analysis framework also publishes numbers on trade within states, so that we can calculate each state's expenditure share on goods from all other states, including the own state. As pointed out by Nakamura and Steinsson (2014), the CFS misses trade in services, which tend to be less tradable. Using international trade data, they conclude that the import share for the average state is around 31%. We proportionately adjust the trade flows in our trade matrix, $\{\bar{s}_j^i\}$, to match that number.

Fiscal and Monetary Policy We set the steady-state ratio of federal government purchases to GDP to the observed value at the U.S. national level. The monetary policy rule (4.15) is parameterized as $\phi = 0.75$, $\phi_Y = 0.5$ and $\phi_\pi = 1.5$, in line with Clarida, Gali and Gertler (1997).

The share of federal military spending in state GDP is taken from Nakamura and Steinsson (2014). They also estimate a shock persistence parameter for national military spending of $\rho = 0.93$ for quarterly data.

5.2 Estimation

Given the set of calibrated parameters, we employ a simulated method of moments to estimate the risk-sharing parameters—the migration elasticity (γ), the equity home bias (κ), the tax progressivity (τ) and the adjustment cost on bond holdings (ι)—and the Armington elasticity (ψ). We proceed in three steps: First, given an initial guess for $[\gamma, \kappa, \tau, \iota, \psi]$, we feed in the observed changes in government spending for each state into the model. For this we quarterly interpolate the annual government spending data and log-linearly

Table 3: Calibration

Parameter		Value	Source / Target
Households, Population and Migration			
Steady-state interest rate	$\bar{i}$	0.01	Annual interest rate of 4 percent
Population	$\bar{\mathbb{N}}_i$	st.sp.	BEA
Migration costs	υ_j^i	st.sp.	Bilateral migration shares, $\bar{n}_j^i$, IRS
Wage stickiness	θ_w	0.84	Wage duration of 1.5 years (Grigsby, Hurst and Yildirmaz, 2021)
Firms, Production and Trade			
Curvature of production function	$1-\alpha$	0.63	Labor income share (Karabarbounis and Neiman, 2013)
State size	A_i	st.sp.	State GDP, BEA
Preference weights on intermediates	ω_j^i	st.sp.	Expenditure shares on intermediates, $\bar{s}_i^j$, CFS
Monetary and Fiscal Policy			
MP rule persistence	ϕ	0.75	Clarida, Gali and Gertler (2000)
MP rule GDP coefficient	ϕ_Y	0.5	Clarida, Gali and Gertler (2000)
MP rule inflation coefficient	ϕ_π	1.5	Clarida, Gali and Gertler (2000)
Military spending over GDP	$\bar{g}_i$	st.sp.	Data on military spending (see text)
Shock process			
Shock persistence	ρ	0.93	Nakamura and Steinsson (2014)

Notes: Values marked with st.sp. are state specific or state-pair specific.

detrend it.[27] The model then produces time series of all model variables and each state, expressed in log deviations from the non-stochastic steady state. Second, we re-run regressions along the lines of (3.1) on the simulated data. Since our model is only accurate up to a first order, we use a first-order approximation of the regressor and its instrument.[28] As in the empirical section, we replace the outcome variable in (3.1) by the various risk-sharing channels. Third, we compare our estimates of the risk-sharing betas of the four channels: β^M, β^K, β^F and β^B, as well as the output multiplier, m^Y, to those found in the empirical data (see Table 1), and adjust our initial guess until the two sets of parameter values match.

The four risk-sharing parameters closely map to the risk-sharing β's. For instance, the migration elasticity γ determines the response of migration to changes in labor income. The Armington elasticity ψ is closely linked to the output multiplier. A higher Armington elasticity amplifies expenditure switching in response to an increase in military spending and leads to a stronger increase imports, thereby weakening local general equilibrium effects and reducing the multiplier.

To implement this procedure, we need to define the model counterparts of the various income concepts in the data: *Aggregate nominal GDP* is

$$GDP_{i,t} = \mathbb{N}_{i,t} P^Y_{i,t} Y_{i,t}.$$

[27] See the Appendix for more details.

[28] That is, the regressor is $\frac{\bar{G}_i}{GDP_i}\Delta \ln G_{i,t}$ and the instrument is $\frac{\bar{G}_i}{GDP_i}\Delta \ln G_t$.

Per-capita nominal GDP is simply

$$gdp_{i,t} = P^Y_{i,t} Y_{i,t}.$$

Per-capita personal income is labor income of workers plus dividends received by capital owners as well as net interest:

$$pi_{i,t} = \frac{\mathbb{N}^w_{i,t}}{\mathbb{N}_{i,t}} W_{i,t} L_{i,t} + \frac{\mathbb{N}^k_i}{\mathbb{N}_{i,t}} \left(\kappa P_{i,t} D_{i,t} + (1-\kappa) D_t\right) + P_{i,t-1} B_{i,t-1} i_t.$$

It differs from GDP by including dividends and interest income earned abroad. Hence, the capital market channel reflects movements in differences in capital market returns.[29] *Per-capita disposable income* is

$$di_{i,t} = \mu_t \left(pi_{i,t}\right)^{1-\tau}$$

And *per-capita nominal consumption* is given by

$$pce_{i,t} = P_{i,t} C_{i,t}.$$

Estimated parameters Table 4 displays the estimated parameters together with the targeted moments. Since we are exactly identified, our model perfectly matches the empirical moments. Our estimate of the Armington elasticity is $\psi = 1.73$, which is slightly higher than what is typically estimated from international data (Boehm, Levchenko and Pandalai-Nayar, 2020), but in line with the notion that trade across U.S. states encounters lower barriers and might therefore be more responsive to relative price changes. The estimated migration elasticity is $\gamma = 0.38$ and is therefore about twice as high than what is estimated by House, Proebsting and Tesar (2025) for a set of European countries. The equity home bias is estimated to be about $\kappa = 0.61$, implying that a \$1 increase in capital income generated in state *i* raises received capital income in that state by \$0.61. This number is in line with the shares of the different types of capital income. Over our sample period, about 40% of capital income is likely to be generated locally (proprietors' income including taxes, rental income), whereas the remaining 60% are easier to diversify (corporate profits including taxes and net interest).[30] Our estimate of tax progressivity is $\tau = 0.18$, which corresponds to the estimate found

[29] In particular, the difference is

$$gdp_{i,t} - pi_{i,t} = -\frac{\mathbb{N}^k_t}{\mathbb{N}_{i,t}} \left((1-\kappa)\left(D_t - P_{i,t} D_{i,t}\right)\right) - P_{i,t-1} B_{i,t-1} i_t.$$

[30] Over our sample period, about a quarter of capital income stems from proprietors' income, generally income generated by self-employed (e.g. restaurant owners) that, in practice, is linked to the household's home state. Another 5% stems from rental income, which might also be biased towards a household's home state. About 45% of capital income consists of corporate profits and interest rate income, where geographical diversification is easier. And another quarter relates to taxes on production and imports less subsidies. Distributing those taxes proportionately to proprietors' income and corporate profits suggests that about 40% of capital income is accounted for by proprietors' income including taxes and rental income.

Table 4: Estimation

Moment	Data	Model	Parameter	Value
Output multiplier (m^Y)	1.32	1.32	Trade elasticity (ψ)	1.73
Migration channel (β^M)	0.05	0.06	Migration elasticity (γ)	0.38
Capital market channel (β^K)	0.15	0.15	Equity home bias (κ)	0.61
Fiscal transfer channel (β^F)	0.14	0.14	Tax progressivity (τ)	0.18
Credit market channel (β^C)	0.15	0.15	Bond adj. cost (ι)	0.02

Notes: Table displays the targeted moments and estimated parameters. The targeted moments correspond to those reported in Table 1. Column 2 reports the values of those moments as estimated from the actual data. Column 3 reports the values as estimated from the simulated data. Bond adjustment costs are expressed in percent (i.e. they are multiplied by 100).

by Heathcote, Storesletten and Violante (2017). They use household-level data on income and disposable income from the Panel Study of Income Dynamics combined with the NBER's TAXSIM program to estimate $\tau = 0.184$. Bond adjustment costs are estimated to be about 0.02%, meaning that adjusting bond holdings by 1% of GDP generates costs of 0.02 basis points of GDP.

6 Quantitative Results

This section uses our estimated structural model to quantify the benefits of risk sharing. We conduct a series of counterfactual experiments to assess how interstate risk-sharing mechanisms attenuate regional business cycles in the United States. In each experiment, we feed the same sequence of federal military spending shocks into the model and examine how the output and consumption multipliers change.

6.1 Multipliers Without Any Risk Sharing

Our main counterfactual shuts down all risk-sharing channels by setting the migration elasticity to zero, $\gamma \to 0$, imposing complete equity home bias $\kappa = 1$, implementing a linear tax system, $\tau = 0$, and making the adjustment costs on bonds go towards infinity, $\iota \to \infty$. We then feed the observed sequence of military spending shocks into this counterfactual economy and re-estimate the output and consumption multipliers from the simulated data.

Figure 3 displays the main result of this exercise. In the baseline calibration, the output multiplier is 1.32, as observed in the data. In the counterfactual economy without any risk sharing, the output multiplier rises to 2.33, a 75% increase. This demonstrates that the risk-sharing mechanisms currently operating across U.S. states substantially attenuate regional business cycle fluctuations.

This amplification of output volatility translates into an even larger increase in consumption volatility.

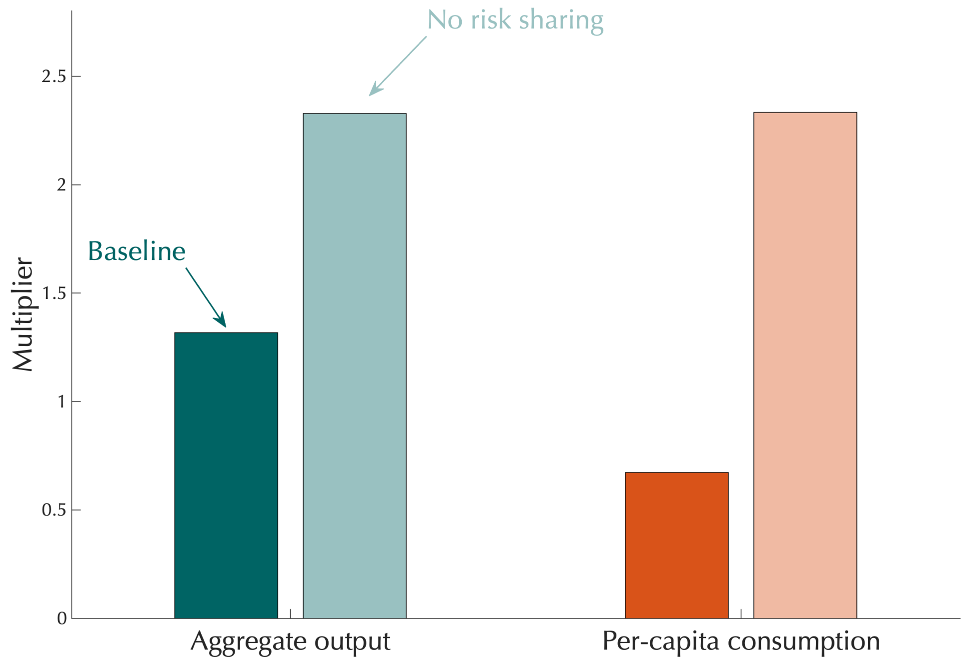


Figure 3: MULTIPLIERS WITH AND WITHOUT RISK SHARING

Notes: The figure displays multipliers for aggregate nominal GDP and per-capita nominal consumption. The estimates are based on model data, simulated from the benchmark calibration and a counterfactual calibration that shuts down all risk-sharing channels ($\gamma \to 0$, $\kappa = 1$, $\tau = 0$ and $\iota \to \infty$).

In the baseline, the consumption multiplier is 0.66, consistent with the empirical finding that 50% of the income shock passes through to consumption. If we were to only consider the direct effect of eliminating risk sharing—that is, raising the pass-through from 50% to 100% while holding the output multiplier fixed at its baseline value of 1.32—the consumption multiplier would rise to 1.32.

However, the full impact on consumption volatility is far greater because the absence of risk sharing also amplifies the output multiplier itself. When this indirect general equilibrium effect is taken into account, the consumption multiplier rises from 0.66 in the baseline to 2.33 in the counterfactual. Decomposing this total effect reveals that the indirect channel—the amplification of the output multiplier—accounts for 45% of the total reduction in consumption volatility provided by risk sharing.[31]

[31] Based on equation (2.1), the change in the log consumption multiplier can be decomposed as:

$$\Delta \ln(m^c) = \Delta \ln(\beta^C) + \Delta \ln(m^Y),$$

where the first term reflects the direct effect of risk sharing (the change in the pass-through) and the second term reflects the indirect effect (the change in the output multiplier).

6.2 The Role of Individual Risk-Sharing Channels

Having established the aggregate benefits of risk sharing, we now isolate the contribution of each channel. We do this by shutting down one channel at a time while keeping the others active at their baseline calibration. This exercise highlights the interdependencies between the channels and reveals which mechanisms are most critical for stabilization.

A simple inspection of the empirically estimated risk-sharing coefficients would provide a misleading picture of each channel's importance, as it would ignore that households optimally adjust their behavior in response to policy changes. For instance, reducing fiscal transfers across states might incentivize more migration. Our model allows us to account for these general equilibrium interactions.

Figure 4 presents the results. Each subplot corresponds to a counterfactual where one channel is eliminated. The top bars show the resulting changes in output and consumption multipliers, while the bottom bars illustrate how the remaining channels' coefficients adjust.

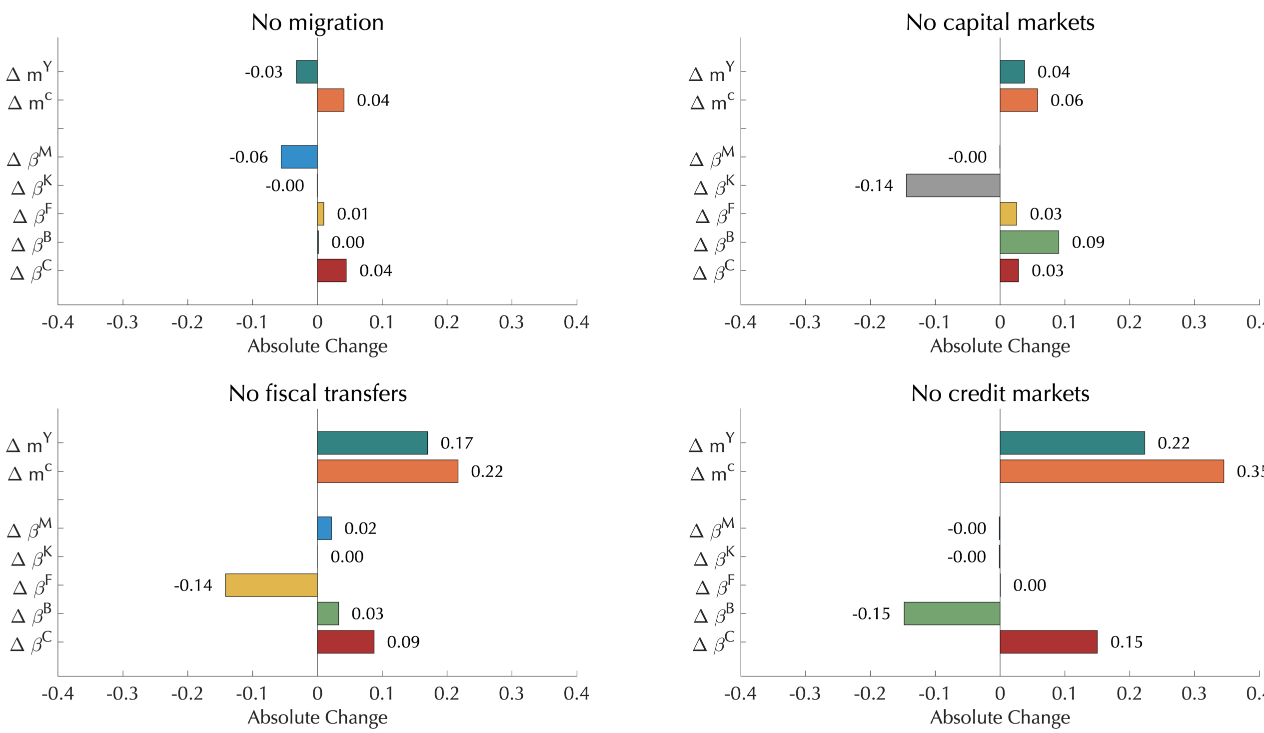


Figure 4: Risk-sharing β's for counterfactuals

Notes: Risk-sharing β's and per-capita nominal consumption multipliers are reported for alternative model calibrations. The notes to Figure 3 explain how the various β's and the consumption multiplier are estimated from the simulated data. In the counterfactuals, eliminating migration is achieved through $\gamma \to 0$, eliminating capital markets requires $\kappa = 1$, eliminating fiscal transfers implies $\tau = 0$, and eliminating credit markets implies $\iota \to \infty$.

A key insight from Figure 4 is that the risk-sharing channels function as substitutes. If they operated independently, the sum of changes in individual consumption multipliers when shutting down each channel separately would equal the increase from shutting down all channels at once. Instead, we find that the sum of the four "single-channel-off" counterfactuals is 0.67, which is less than half of the total 1.67 increase in consumption volatility when all channels are eliminated (see Figure 3). This gap shows that when one risk-sharing mechanism is compromised, the remaining channels partially compensate.

The analysis also demonstrates that each channel's estimated coefficient provides an incomplete picture of its overall contribution in smoothing consumption. Capital markets, fiscal transfers, and credit markets have similar estimated impact coefficients (0.14–0.15), yet their roles in stabilizing the economy are vastly different. Eliminating credit markets raises the output multiplier by 0.22, while eliminating capital markets has a much smaller effect of 0.04.[32] Removing migration actually *reduces* the aggregate output multiplier, since in-migration to booming states raises production, but migration still stabilizes per-capita consumption and—an effect that strengthens over longer horizons as shown in the Appendix.

The bottom bars in each panel make the substitution mechanism transparent. Shutting one risk-sharing channel typically raises the contributions of the other channels. For example, in the absence of fiscal transfers (bottom-left panel), households rely more on migration and borrowing: the migration coefficient increases from 0.06 to 0.08, and credit-market smoothing rises. As a result, the unsmoothed share β^C increases by only 9 percentage points, not the 14 percentage points one would infer from $\Delta\beta^F = -0.14$ in isolation.

These compensatory responses are strongest when capital-market diversification is shut down, but they are almost absent when credit markets are eliminated. Part of the reason is mechanical. For instance, federal taxes are assessed on personal income, not consumption, so the fiscal system cannot readily substitute for missing borrowing and saving opportunities. In contrast, if households do not diversify their income directly through capital markets, the progressive tax system partly smoothes out the higher volatility in personal pre-tax income. An important caveat is that we treat the home-equity bias parameter κ as fixed rather than endogenous, ignoring the possibility that households might adjust their equity portfolios if other risk-sharing channels became unavailable.

The counterfactuals above quantify the marginal contribution of each channel around the observed equilibrium. However, because channels interact, these marginal effects are not constant. To obtain each channel's average marginal contribution across all possible combinations of active channels, we implement a Shapley decomposition that averages the effect of adding the channel over every subset of other channels.

Table 5 presents these results, expressed as shares of the total reduction in consumption volatility. The results from Figure 4 survive: Credit markets emerge as the most important mechanism, accounting for 45% of the total reduction in the consumption multiplier. Fiscal transfers contribute 30%, while capital markets and migration account for 21% and 4%, respectively.

[32]This dependence of multipliers on credit markets is in line with Corbi, Papaioannou and Surico (2019). Studying the effects of federal transfers to municipal governments in Brazil, they show that the employment effects of transfers are larger in less financially developed municipalities.

Table 5: Shapley decomposition: Marginal effects of each risk-sharing channel

Migration	Capital markets	Fiscal transfers	Credit markets	Sum
4%	21%	30%	45%	100%

Notes: This table reports the Shapley value for each risk-sharing channel's contribution to consumption smoothing. Each value is the average marginal contribution of a channel to reducing the consumption multiplier, computed across all possible coalitions of active channels. Values are expressed as shares of the total reduction in the consumption multiplier when moving from no risk sharing to the observed level of risk sharing.

6.3 Why Some States Benefit More from Risk Sharing Than Others

Our final analysis explores why the benefits of risk sharing vary across states. For each state, we compute the output multiplier as the one-year response of GDP to a targeted increase in federal government spending equivalent to 1% of state GDP. We do this in both our baseline model and in the counterfactual with no risk sharing.

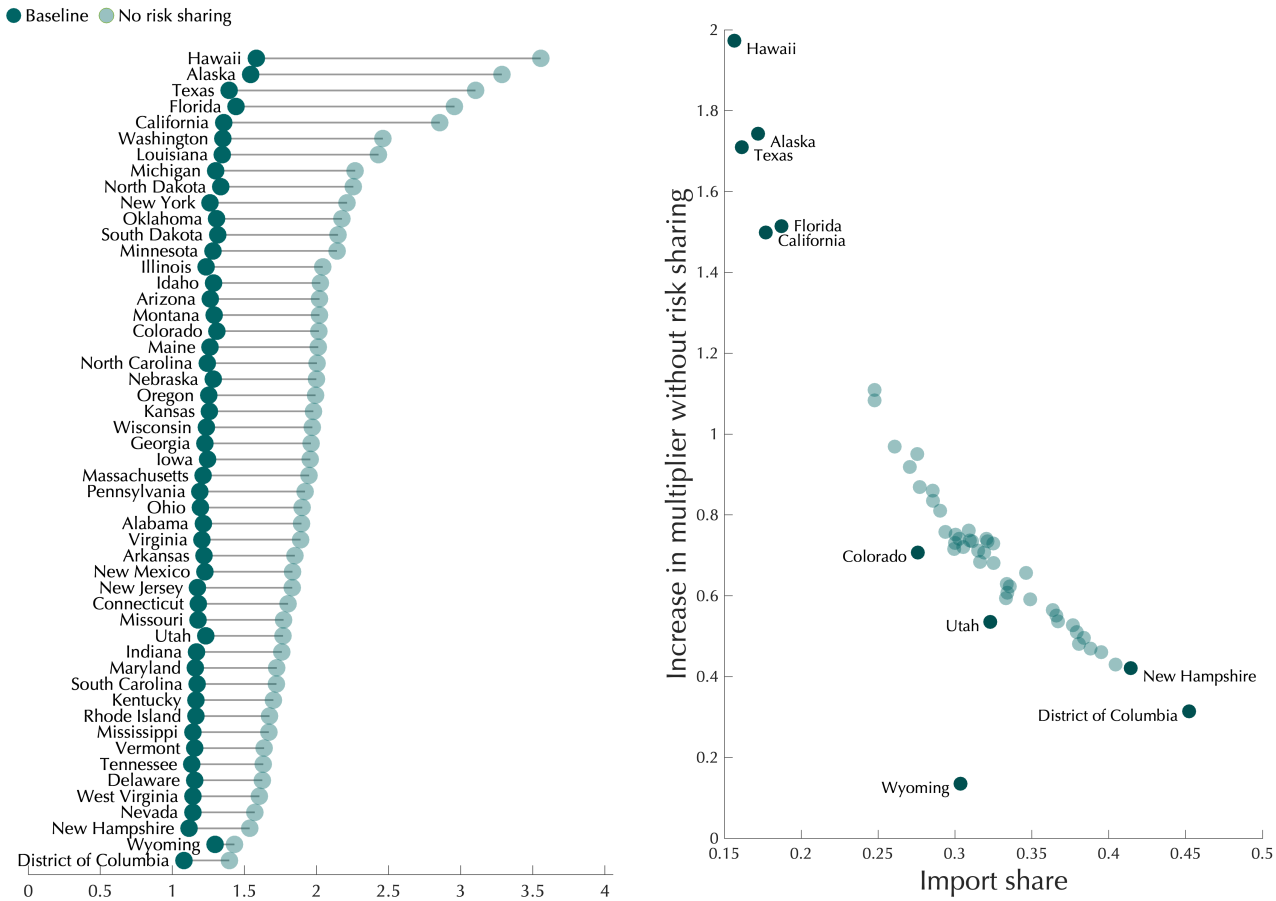
Figure 5a displays the results. In the baseline scenario, multipliers are relatively homogeneous across states (ranging from 1.1 to 1.6). Without risk sharing, however, they become larger and more dispersed (ranging from 1.4 to 3.5). While the ranking of states is mostly unaffected, the model suggests that some states benefit substantially more from risk sharing than others. Panel (b) reveals a strong negative relationship between a state's import share and the "benefit" of risk sharing, measured as the increase in the output multiplier when risk sharing is shut down.

States with low import shares (i.e., relatively closed economies) like the non-contiguous states Hawaii and Alaska, and some of the bigger states, Texas, Florida and California, experience stronger feedback loops between consumption and income. In these states, risk-sharing mechanisms that weaken this feedback loop are particularly effective at reducing the multiplier. Conversely, for very open states like New Hampshire, a larger fraction of any demand shock naturally leaks out through imports, dampening the output multiplier even without formal risk-sharing mechanisms.[33]

This finding highlights an interesting interaction between risk-sharing and trade openness. Trade openness was proposed by (McKinnon, 1963) as another precondition for an optimal currency area. Our findings reveal that these two notions that have been discussed separately in the literature are partial substitutes.[34]

[33]This reasoning also underpins Proposition 1 in Section 2 that shows that multipliers in the simple model are equal to 1 under perfect risk sharing, but are decreasing in the import share $1 - \omega$ with complete risk sharing.

[34]An exception is Farhi and Werning (2014) that point out that labor mobility has a more stabilizing role in economies that are more open to trade.



(a) Output multipliers by state (b) Openness and multipliers

Figure 5: Output multipliers and openness by state

Notes: The left panel displays output multipliers for each U.S. state in the baseline model and a model without any risk sharing. Multipliers are estimated from the model as the 1-year response of GDP to a one-time increase in government spending amounting to $1 over the first year in a particular state. The right panel displays the change in the output multiplier from the baseline scenario to the no-risk-sharing scenario as a function of a state's home bias in trade (one minus the import share).

7 Conclusion

This paper re-evaluates the benefits of risk sharing in currency unions, showing that traditional risk-sharing measures underestimate these benefits by ignoring crucial general equilibrium effects on output volatility. Our central insight is that risk sharing not only directly smooths consumption for a given income shock but also indirectly dampens the income shock itself by stabilizing aggregate demand. These indirect benefits are quantitatively large. A multi-state DSGE model, disciplined by our empirical estimates, shows that the observed level of risk sharing across U.S. states reduces state-level consumption volatility by a factor of 3.5, with 45% of this reduction attributable to these indirect, general equilibrium effects.

Although a full quantitative welfare analysis is outside the scope of this paper, our findings have important implications for understanding the welfare benefits of risk sharing. First, by documenting how indirect effects substantially amplify the consumption-smoothing benefits of risk sharing, our results imply that the welfare gains from these mechanisms are considerably larger than previously thought. Second, our finding that risk sharing reduces output volatility is critical, as the literature has established that output volatility itself can generate first-order welfare costs. For instance, work by Schmitt-Grohé and Uribe (2016); Dupraz, Nakamura and Steinsson (2023) highlights how output volatility directly lowers average output through mechanisms such as downward nominal wage rigidity. Accounting for these first-order effects would further magnify the welfare gains from risk sharing beyond what consumption smoothing alone would imply.

We see an important contribution of our paper to analyze the benefits of risk sharing through the lens of a structural model, which allows us to conduct proper counterfactuals. However, there are some limitations to our exercise: For instance, we do not account for potential endogenous responses in production specialization. As Kalemli-Ozcan, Sørensen and Yosha (2003) document, greater geographical diversification of income sources through capital markets can enable regions to specialize more intensively, since higher variance in locally generated income need not translate into higher variance in received income.[35] Our counterfactuals focus solely on the demand-side feedback effects of risk sharing on income volatility, abstracting from these potential supply-side adjustments.

While our analysis centers on U.S. states, our findings have important implications for other currency unions, particularly the euro area. The conventional wisdom, reflected in numerous policy discussions, is that the primary deficiency in euro area risk sharing is the lack of capital market integration compared to the United States (Nikolov, 2016; Cimadomo et al., 2023). Our results challenge this view. Both our causally identified empirical estimates and our structural model suggest that capital market integration may play a less important role in attenuating regional business cycles than previously thought. Instead, fiscal transfers and credit markets emerge as more potent stabilization mechanisms. A fruitful exercise for future research would be to apply our integrated empirical and structural framework to the euro area to better gauge its progress toward becoming an "optimal currency area" and to identify the most effective policy interventions for enhancing macroeconomic stability.

[35]This is consistent with our finding that capital income is 2-3 times more volatile than labor income at the state level.

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