Does US Fiscal Integration Stabilize Regional Business Cycles?*

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Abstract

Yes. Using the semi-structural methodology for policy counterfactuals in Beraja (2023), I find that in a counterfactual US economy without fiscal integration the standard deviation of employment across states increases by about 1 percent in the Great Recession and 1.5 percent in the long-run. The key feature of fiscal union models that generate large stabilization gains is the presence of shocks to household demand. These shocks were important drivers of regional business cycles during the Great Recession. Taken together, these results help rationalize why previous work has found small gains instead, and inform policy discussions about future fiscal arrangements for the European Monetary Union.

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1 Introduction

During the Great Recession, many US states were hit by large negative shocks that depressed their economies. Had they not been members of a fiscal union, how would they have fared? Previous research has pointed to the regional stabilization benefits of fiscal integration (Sala-i Martin and Sachs, 1991; Asdrubali, Sorensen, and Yosha, 1996; Feyrer and Sacerdote, 2013; Farhi and Werning, 2014). However, work quantifying such benefits using state-of-the-art models of business cycles is scarce. An important exception is Evers (2015) which finds small stabilization gains.

In this paper, I use the semi-structural methodology for policy counterfactuals in Beraja (2023) to show that US fiscal integration substantially contributes to stabilizing regional business cycles. The distinguishing feature of the class of fiscal union models I study is that a federal tax-and-transfer policy rule summarizes how resources are redistributed between members in a state-contingent manner. The class encompasses many models with realistic features such as nominal rigidities, adjustment costs, asset market incompleteness, and shocks to household demand.[1] As such, the class is rich enough to inform discussions on US fiscal integration as well as on future fiscal arrangements for the European Monetary Union.

There are two main findings. First, in a counterfactual US economy without a transfer policy rule, the standard deviation of employment across states increases by about 1 percent in the Great Recession and 1.5 percent in the long-run.[2] The transfer rule stabilizes regional economies because it redistributes resources from well to poorly performing states. For a sense of magnitudes, aggregate output volatility declined by about 0.7 percent during the "Great Moderation" (Clarida, Gali, and Gertler, 2000). The stabilization gains from fiscal integration are of same order of magnitude.

The second finding is that household demand shocks are a key feature of fiscal union models that generate large stabilization gains. These shocks were important drivers of regional business cycles during the Great Recession (Mian and Sufi, 2014; Beraja, Hurst, and Ospina, 2019). Other features like the particular form of wage stickiness and adjustment costs, whether there is extra discounting from behavioral agents, or how hand-to-

[1] Examples of fiscal union models that share some of these features are those in Farhi and Werning (2014) and Evers (2015), as well as Chari and Kehoe (2007) and Kollmann (2001). The focus on transfer rules as automatic stabilizers and the consequences of tax progressivity also relates to Oh and Reis (2012), McKay and Reis (2013), and Heathcote, Storesletten, and Violante (2017).

[2] As a comparison with another semi-structural methodology, I also use the "zeroing-out" methodology in Sims and Zha (2006) to construct the long-run counterfactual. I find an increase in the standard deviation of employment of only 0.5 percent. The stabilizations gains are therefore underestimated when the analysis ignores changes in agents' behavior and expectation-formation as they internalize the policy change (i.e., the Lucas Critique).

mouth agents are introduced are less crucial. This result can rationalize findings from seemingly disparate international business cycle models which showed small stabilization gains from fiscal integration (Evers, 2015) and risk-sharing more generally (Backus, Kehoe, and Kydland (1992) and the literature that followed).

2 A class of models of fiscal unions

In this section, I begin by describing models of fiscal unions in some generality. I then state the structural restrictions needed to implement the semi-structural methodology in Beraja (2023).

Consider an economy comprised of many states that are part of a fiscal and monetary union. The states are inhabited by households and firms. The only other agent in the economy is a federal government. Households consume, work, and save/borrow in a non-state-contingent asset — a nominal bond in zero net supply. We denote by n_{jt} employment in a state j, w_{jt} the nominal wage, and b_{jt} the assets holdings. The federal government gives lump-sum transfers τ_{jt} to the states and sets the nominal interest rate (common across states). The states are hit by shocks driving household demand γ_{jt}, firm productivity a_{jt}, and wealth η_{jt}.

I will focus on fiscal union models that satisfy four properties. Examples of models that satisfy them are in Online Appendix A.1, Beraja, Hurst, and Ospina (2019), and Beraja (2023). The models in Farhi and Werning (2014), Nakamura and Steinsson (2014), and Evers (2015) satisfy some of these properties too. While it is not needed for our purposes, these examples fully describe preferences and production technologies as well as any frictions that agents face (e.g., on wage setting). With some abuse of notation, all variables below denote log-deviations of a member state from the aggregate union.

Assumption 1. *Models of fiscal unions satisfy the following properties:*

1. **Transfer policy rule***: The tax-and-transfer system can be summarized by federal lump-sum transfers τ_t that are a function of state-level economic variables.*

2. **Linear aggregation:** *State-level economies in log-deviations from the aggregate union behave to a first-order approximation as if they were small open economies — independent of other states.*

3. **4 by 3:** *Employment n_t, nominal wages w_t, assets b_t, transfers τ_t; and exogenous processes $\{\gamma_t, a_t, \eta_t\}$ are sufficient variables for characterizing the state-level equilibrium in*

log-deviation from aggregates. The processes driving changes in household demand (γ_t), productivity (a_t) and wealth (η_t) are vector autorregressive of order 1.

4. **SVAR:** *The log-linearized equilibrium has a unique, finite, and stable structural vector autoregressive representation.*

Properties 1-3 imply that we can characterize the equilibrium in any state in log-deviations from the aggregate union with the linear system of matrix equations (SME)

$$\begin{aligned} 0 &= F\mathbb{E}_t[x_{t+1}] + Gx_t + Hx_{t-1} + L\mathbb{E}_t[z_{t+1}] + Mz_t \\ 0 &= \Theta_f\mathbb{E}_t[x_{t+1}] + \Theta_c x_t + \Theta_p x_{t-1} + \Theta_z z_t \\ 0 &= -z_{t+1} + Nz_t + \epsilon_{t+1}, \end{aligned} \tag{SME}$$

where $x_t \equiv \begin{bmatrix} n_t & w_t & b_t & \tau_t \end{bmatrix}'$ is a vector of endogenous variables, $z_t \equiv \begin{bmatrix} \gamma_t & a_t & \eta_t \end{bmatrix}'$ is a vector of exogenous variables, the *structure* $\xi \equiv \begin{bmatrix} F & G & H & (LN+M) \end{bmatrix}$ collects matrices of policy-invariant parameters, and the *policy* $\Theta \equiv \begin{bmatrix} \Theta_f & \Theta_c & \Theta_p & \Theta_z \end{bmatrix}$ collects the parameters of the transfer policy rule.[3] In the language of Beraja (2023), $\{\xi, \Theta\}$ is a *structural model* of a small open economy that is part of a fiscal union. Moreover, without loss of generality, I will say that the first equation in (SME) is the (Euler) equation in fiscal union models, the second is the (Labor Market) equation, and the third is the sequential budget constraint (Budget Constraint).[4]

Property 2 excludes from the analysis models where, for example, member states are inherently different because of industrial composition or household preferences, or models where states' idiosyncratic shocks do not average out. In Property 3, assets might encompass both non-state-contingent nominal bonds and tradable physical capital. What is important for the property to hold is that no other variables that are necessary to describe the equilibrium are left out (e.g., other endogenous or exogenous state variables).

Property 4 requires not only that a stable recursive law of motion for the equilibrium exists, but that it can be written as a finite SVAR. In particular, using results in Ravenna (2007) together with (SME), Online Appendix A.2.3 shows that there is a SVAR(2) repre-

[3]Property 1 excludes models where the tax-and-transfers system affects decisions at the margin, as it would be the case with distortionary taxation. In Online Appendix A.2.5, I relax this assumption and analyze the sensitivity of the results.

[4]See the proof of Lemma A.1 in Online Appendix A.1 for an example of these three equations.

sentation of the equilibrium

$$x_t = \rho_1 x_{t-1} + \rho_2 x_{t-2} + Q\epsilon_t. \tag{SVAR}$$

Next, given Property 1 in Assumption 1, I assume that the benchmark transfer policy rule depends on state-level employment, current wages and asset holdings at the beginning of the period.

Assumption 2. *The benchmark policy* Θ^0 *is:* $\Theta^0_c = \begin{bmatrix} \vartheta_n & \vartheta_w & 0 & -1 \end{bmatrix}$, $\Theta^0_p = \begin{bmatrix} 0 & 0 & \vartheta_b & 0 \end{bmatrix}$, *and* $\Theta^0_f = \Theta^0_z = 0$.

Finally, I impose enough linear restrictions on the structural model described by structure ξ and the policy Θ so that Theorem 1 in Beraja (2023) can be applied. I assume that they take the form of exclusion restrictions (and a normalization of one of the coefficients).

Assumption 3. *The structure* ξ *satisfies the following restrictions:*

$$F = \begin{bmatrix} f_{11} & f_{12} & 0 & 0 \\ f_{21} & f_{22} & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}; G = \begin{bmatrix} g_{11} & g_{12} & 0 & 0 \\ g_{21} & g_{22} & 0 & 0 \\ g_{31} & g_{32} & g_{33} & 1 \end{bmatrix}; H = \begin{bmatrix} h_{11} & 0 & 0 & 0 \\ h_{21} & h_{22} & 0 & 0 \\ 0 & 0 & h_{33} & 0 \end{bmatrix};$$
$$L = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}; M = \begin{bmatrix} 0 & m_{12} & 0 \\ 0 & 1 & 0 \\ 0 & 0 & m_{33} \end{bmatrix}; N = \begin{bmatrix} n_{11} & n_{12} & n_{13} \\ 0 & n_{22} & n_{23} \\ 0 & n_{32} & n_{33} \end{bmatrix}$$

The key feature of models described by this structure is that the dependence of the (Labor Market) and (Euler) equations — the first and second lines in ξ — on future and lagged variables is relatively unconstrained, as well as the exogenous processes and their correlation structure. This is important for the question of regional stabilization in fiscal unions. It means that the semi-structural policy counterfactual will be robust to variations across many models with rich features. For instance, models with varying microfoundations for wage rigidities that are both forward- and backward-looking, employment adjustment costs, different utility functions, or behavioral features.

The restrictions in the (Euler) and (Labor Market) equations imply that (i) assets and transfers (future, contemporaneous, or lagged) do not appear in either of them, (ii) lagged wages do not appear in the first equation, and (iii) the household demand shifter γ_t does not appear in the second equation.[5] Regarding the (Budget constraint)

[5]Some of these restrictions have a natural economic interpretation within the context of specific mod-

equation — the third line in ξ — the absence of expected and lagged terms beside assets makes this structure consistent with most log-linearized, incomplete market models that include a (Budget constraint). Also, I assume that the only exogenous shifter in the sequential budget constraint is the wealth process η_t. The other two exogenous processes do not appear in the sequential budget constraint. Finally, I assume that past demand shocks do not cause movements in current productivity a_t or wealth η_t, as is evidenced by the autoregressive matrix N.[6]

3 A Counterfactual US without Fiscal Integration

In this section, I use US state-level data on employment, wages, assets, taxes and transfers to construct a counterfactual US economy without a transfer policy rule in place. Specifically, I first estimate the US transfer policy rule Θ^0 and the regional SVAR $\Gamma^0 \equiv \{\rho_1^0, \rho_2^0, Q^0\}$. Then, using the results in Theorem 1 of Beraja (2023), I identify the structure ξ of models that can match Γ^0 under policy Θ^0. Finally, I construct a counterfactual SVAR $\Gamma^1 \equiv \{\rho_1^1, \rho_2^1, Q^1\}$ corresponding to an economy with policy $\Theta^1 = 0$.

The counterfactual is robust to variation in primitives across models that have the same structure ξ, but also more generally across all models that are *counterfactually equivalent*. In short, these are models that can match the SVAR Γ^0 under the benchmark policy Θ^0 and the SVAR Γ^1 under the counterfactual policy Θ^1. That is, models that are observationally equivalent under both policies.[7]

To streamline the exposition, I leave to Online Appendix A.2 a detailed description of the data used as well as all the steps in constructing the semi-structural (transfer) policy counterfactual.

As a primer, the left panel of Figure 1 shows a scatter plot of net federal transfers growth (direct federal transfers minus federal taxes growth) between 2006 and 2010 against nominal wage income growth (wage plus employment growth) between 2006 and 2010 in the United States. There is a very strong, negative relationship between the two.[8] If the tax-and-transfer system helps stabilize regional economies, it is because a state whose economy worsens receives relief via federal transfers or lower taxes.

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els. For instance, the restrictions in (i) do not allow for wealth effects in labor supply or intertemporal consumption decisions.

[6] As Online Appendix A.2.3 shows, the restrictions on N and the third equation allow for identifying the shocks and the impulse response matrix in the SVAR.

[7] See Beraja (2023) for a formal characterization of the counterfactually equivalent set of models.

[8] This is due to both the progressivity of the tax system and automatic stabilizers like unemployment insurance.

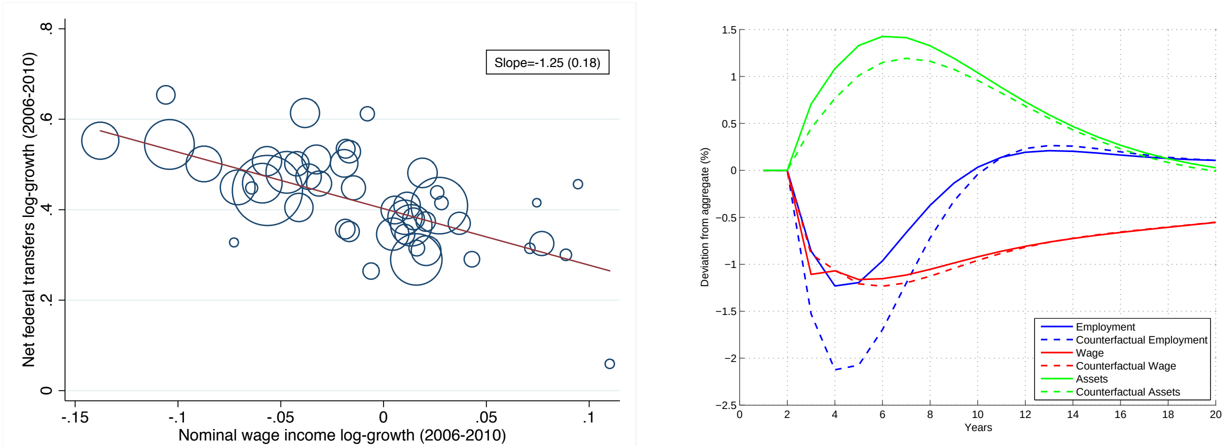

Figure 1: Transfers policy rule and responses to a demand shock γ_t . Left panel: Log-growth of net transfers in a state between 2006 and 2010 against nominal wage income log-growth during the same period. Circle sizes are state population size in 2006. The line is from an OLS population-weighted regression. Right panel: SVAR implied responses to a 1SD γ_t shock in the economy with transfers (Θ^0) and the counterfactual one without ($\Theta^1 = 0$).

The right panel of Figure 1 shows the responses to a one-standard-deviation demand shock γ, both using the actual estimated regional SVAR for the US and the counterfactual SVAR corresponding to a US economy without a transfer policy rule ($\Theta^1 = 0$). I find that employment and wages both decrease on impact, whereas assets increase in response to a demand shock. While these responses result from the restrictions imposed in the SVAR to identify the shocks (described in Online Appendix A.2.3), it is reassuring that they agree with the theoretical responses in typical small open economy models. As for the effects of fiscal integration, I find that amplification and persistence of demand shocks are mitigated by the transfer policy rule — e.g., the employment response (after two years) is -1.2 percent in the actual economy, whereas it is -2.1 percent in the counterfactual economy without transfers.

Table 1 presents moments of the employment distribution in the actual and counterfactual economies. The cross-state employment standard deviation in the US data in 2010 (σ_n^{2010}) was 2.6 percent (this corresponds to the last column in the left panel). I then consider the following thought experiment. At the end of 2007, it is announced that from 2008 onwards the United States federal government would cease to give transfers according to Θ^0 and instead would have the policy rule $\Theta^1 = 0$. How would regional economies have evolved if they had been hit by the same sequence of shocks? I find that the counterfactual standard deviation of employment in 2010 would have been 3.5 percent. To give some context to these numbers, aggregate output volatility during the pre-Volcker period (1960:1 to 1979:2) was 2.7, whereas during the post-Volcker-disinflation

		γ	(γ, a)	(γ, a, η)
σ_n^{2010}	Θ^0	2.3	2.5	2.6
	$\Theta^1 = 0$	3	3.4	3.5
$\overline{\sigma}_n$	Θ^0	2.3	2.7	3.5
	$\Theta^1 = 0$	3.9	4.5	4.9

Table 1: Employment statistics: Fiscal integration v. Fiscal autonomy. σ_n^{2010} is the SD of employment n_t across states in 2010 in percentages. $\overline{\sigma}_n$ is the SD in the stationary distribution. Line Θ^0 corresponds to the economy under the benchmark transfer policy rule, and line $\Theta^1 = 0$ corresponds to the counterfactual. The columns feed the shock γ alone, both γ and z, and all shocks together (γ, z, η).

period (1982:4 to 1996:4) volatility was 2.06.[9] Much literature examines the causes of this "Great Moderation." The consequences of the US federal tax-and-transfer system are in the same order of magnitude.

In the lower half of the table, I also present Monte Carlo estimates of the standard deviation ($\overline{\sigma}_n$) of employment in the stationary distribution. I construct them by sampling with replacement 1,000,000 observations from the empirical distribution of shocks, feeding them to the SVAR and calculating the corresponding statistic. Results are qualitatively similar to the ones during the Great Recession. Furthermore, in the first and second columns of the left panel, I calculate the same statistics if regional economies had been hit by only γ shocks or both γ and a shocks. Comparing the first and last columns, I find that most of the employment variation across states (in 2010 or in the stationary distribution) is accounted for by household demand shocks.[10] Moreover, fiscal integration reduced employment dispersion primarily by stabilizing such regional γ shocks. For instance, the total reduction in σ_n^{2010} is 0.9 (3.5 minus 2.6) of which 0.7 (3 minus 2.3) is achieved because of stabilization of such γ shocks.

To summarize, these results imply that the federal tax-and-transfer system stabilizes regional economies by redistributing resources from regions that are doing relatively well to regions that are doing relatively poorly. The figure below elaborates on this point for the Great Recession. It shows the employment gain (or loss) from fiscal integration for each state in 2010, where states are sorted according to their employment in 2010 from lowest to highest. We observe that fiscal integration increased employment in states with the worst employment outcomes, whereas the opposite is true for states with the best employment outcomes.

[9] These numbers come from Clarida, Gali, and Gertler (2000).
[10] This is in line with findings in Mian and Sufi (2014) and Beraja, Hurst, and Ospina (2019).

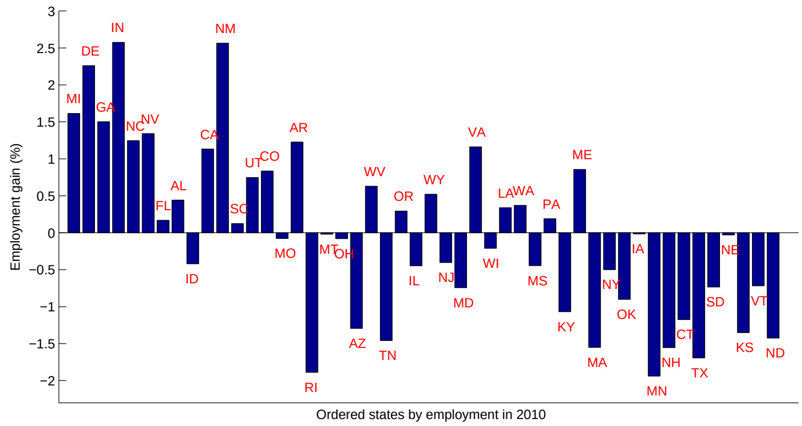

Figure 2: Employment Gains from Fiscal Integration by State in 2010. Note: For each state, the figure shows the employment difference between the counterfactual economy without a federal transfer policy rule and the actual economy in 2010. The states were sorted according to their actual employment in 2010 in ascending order. To the left, the states with the worst employment realizations; and, to the right, the states with best.

Comparison with Sims and Zha (2006) methodology. Table 2 shows the results when constructing the counterfactual using the methodology proposed by Sims and Zha (2006) instead. Specifically, to "zero-out" the transfer policy response, I construct transfer policy shocks (which are equivalent to η shocks in our class of fiscal union models) that exactly offset the endogenous response of the transfer policy rule. I then feed the SVAR with both the non-transfer policy shocks and these offsetting transfer policy shocks. This is the leading alternative semi-structural methodology in the literature to gauge the consequences of the endogenous components of policy in the context of SVARs.[11]

The top half shows results for the stationary standard deviation of employment, whereas the bottom half shows the (square-rooted) long-run variance, constructed from the spectrum at frequency zero of the multivariate SVAR. I find that fiscal integration also helps stabilizing regional economies when I follow the Sims-Zha methodology. However, the counterfactual increase in employment volatility across states is much smaller. For example, the stationary standard deviation increases by 1.4 (i.e., 4.9 minus 3.5) using the methodology in Beraja (2023) whereas it only increases by 0.5 (i.e., 4 minus 3.5) under the Sims-Zha methodology. These results imply that we would have erroneously concluded that fiscal integration is much less relevant in stabilizing regional business cycles if we had used a methodology that is not immune to Lucas critique —- i.e., if we did not take

[11] Admittedly, the methodology is typically used to study such consequences in the short-run when it is more plausible that agents do not understand that the policy rule has changed and, thus, Lucas critique is less of a problem. However, here we are interested in the long-run consequences of fiscal integration.

		Benchmark	Sims-Zha
$\overline{\sigma}_n$	Θ^0	3.5	3.5
	$\Theta^1 = 0$	4.9	4
$\sqrt{s_n(0)}$	Θ^0	7.8	7.8
	$\Theta^1 = 0$	10.7	8.4

Table 2: Comparison across methodologies. $\overline{\sigma}_n$ is the SD of employment n_t across states in the stationary distribution. $s_n(0)$ is the spectrum at zero frequency (the long-run variance of n_t). Column "Benchmark" corresponds to results when constructing a counterfactual using the semi-structural methodology in Beraja (2023). Column "Sims-Zha" follows the methodology in Sims and Zha (2006).

into account the change in agents' behavior as they internalize the change in the transfer policy rule when making decisions and forming expectations.

3.1 What did we learn from the counterfactual exercise?

By quantifying the regional stabilization consequences of fiscal integration, the first contribution of the exercise above is to inform policy-makers discussing these issues — for instance, in the context of talks about fiscal and risk-sharing arrangements for the European Monetary Union.

The second contribution is to inform models of international business cycles and risk-sharing arrangements more generally. While it may not be computationally hard to solve many fully-specified models and compute counterfactuals, the semi-structural methodology in Beraja (2023) seeks to boil them down to their core essence, thus allowing one to understand which assumptions are relevant for the question at hand and which ones less so. For the question of fiscal integration, we learn, for example, that different assumptions on the particular form of wage stickiness, extra discounting due to behavioral agents, or how hand-to-mouth households are introduced do not seem to be crucial. Many variants of fiscal union models are counterfactually equivalent. At the same time, we learn that whether models include exogenous demand shifters of the Euler equation like γ_t is indeed crucial. This is because, as shown in Table 1, I find that most of the reduction in employment volatility from fiscal integration comes from stabilizing these type of shocks.

The third contribution is to help us organize previous results in the literature coming from disparate models. Because transfer rules are a form of risk-sharing arrangement, the quantitatively small reductions in volatility found by Evers (2015) are less surprising once we connect them to the literature studying the Backus-Kehoe-Kydland consumption correlation puzzle (see Backus, Kehoe, and Kydland (1992)). Even in leading quantitative models with incomplete asset markets (e.g., when only a one-period bond is traded) and where many other frictions are present (e.g., nominal rigidities, habits), consumption is more highly correlated across countries than output whereas the opposite holds in the data. This implies that the consumption and employment volatility reductions from better risk-sharing arrangements are small in such models because the equilibrium is rather close to the complete-markets allocation. While these models are not, strictly speaking, counterfactually equivalent with respect to changes in risk-sharing policy rules, they are rather close in practice. In contrast, for the fiscal union models in Section 2, there are rather large reductions in the volatility of employment from fiscal integration due to the presence of demand shocks. In turn, these imply a lower correlation of consumption and output since I assume that consumption is a non-tradable in these models. In fact, a recent paper by Itskhoki and Mukhin (2017), shows that including similar shifters of the Euler equation can resolve several puzzles in international macroeconomics.

4 Conclusions

I have used the semi-structural methodology in Beraja (2023) to quantify how US fiscal integration contributes to regional stabilization by redistributing resources across states through a transfer policy rule. This question has received surprisingly little attention in the literature beyond reduced-form calculations and calibration exercises in particular models, despite existing theoretical work on fiscal unions and its relevance for current discussions about European fiscal integration. My primary finding is that during the Great Recession fiscal integration substantially reduced cross-state employment differences by transferring resources from states that were doing relatively well to states that were doing relatively poorly. In particular, because these transfers helped smoothing household demand shocks that were important drivers of regional business cycles in that period.

Some caveats are in order regarding the stabilization gains from fiscal integration more generally. On the one hand, they may be overstated because demand shocks might no be as important in other contexts or because fiscal integration could partially displace existing private risk-sharing arrangements.[12] On the other hand, the gains may be larger if the reduction in state-level volatility reduces within-state individual risk exposure by more than it reduces risk exposure of a state's average household.

[12] Analogously, if the federal tax-and-transfer system was eliminated, private risk-sharing arrangements (e.g. better financial integration) would substitute for it.

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ONLINE APPENDIX (NOT FOR PUBLICATION)

A.1 A Model of a Fiscal and Monetary Union

Consider an economy comprised of many islands, inhabited by a representative household and firm. The only other agent in the economy is a federal government. Households consume, work, and save/borrow in a non-state-contingent asset—a nominal bond in zero net supply. Firms produce final consumption goods using labor and intermediate goods. By assumption, the final consumption good is non-tradable, intermediate goods are tradable, and labor is not mobile across islands. Finally, each island has an exogenous endowment of intermediate goods.

The federal government sets the nominal interest rate on the nominal bond, and gives lump-sum transfers to the islands. Assume that the nominal interest rate follows an endogenous rule that is a function of only aggregate variables (together with a fixed nominal exchange rate, this implies that the islands are part of a monetary union). Also, assume that federal transfers are a function of island-level variables alone. Throughout, I assume that parameters governing preferences and production are identical across islands and the islands only differ, potentially, in the shocks that hit them—these shocks include a demand shock that shifts the households discount rate, a productivity shifter in the production function of final goods, and the exogenous endowment of tradable intermediate goods. Finally, I assume that all labor, goods and asset markets are competitive.

Firms and Households. Final goods producers use labor N^y_{kt} and intermediates X_{kt} in island k at time t and face prices P_{kt}, wages W_{kt}, and intermediate prices Q_t (equalized across all islands because of assumed tradability). Their profits are

$$\max_{N^y_{kt}, X_{kt}} P_{kt} e^{a_{kt}} (N^y_{kt})^{\alpha} (X_{kt})^{1-\alpha} - W_{kt} N^y_{kt} - Q_t X_{kt}$$

where a_{kt} is a productivity shock and $\alpha : \alpha < 1$ is the labor share. Unlike the tradable goods prices, final good prices (P_{kt}) vary across islands.

Households preferences are given by

$$\mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t e^{-\rho_{kt} - \delta_{kt}} \left(\frac{(C_{kt})^{1-\sigma}}{1-\sigma} - \frac{\nu}{1+\nu} N_{kt}^{\frac{1+\nu}{\nu}} \right) \right]$$

where C_{kt} is consumption of the final good, N_{kt} is labor, δ_{kt} is an exogenous processes driving the household's discount rate. Moreover, I follow Schmitt-Grohé and Uribe (2003) and let ρ_{kt} be the endogenous component of the discount factor that satisfies

$\rho_{kt+1} = \rho_{kt} + \Phi(.)$ for some function $\Phi(.)$ of the average per capita variables in an island. As such, agents do not internalize this dependence when making their choices. This modification induces stationarity for an appropriately chosen function $\Phi(.)$ when assets markets are incomplete (as we assume below).

Households are able to spend their labor income $W_{kt}N_{kt}$ plus profits accruing from firms Π_{kt} and exogenous endowment of tradable goods $Q_t e^{\eta_{kt}}$, financial income $B_{kt-1}i_{t-1}$ and transfers from the government τ_{kt}, where B_{kt-1} are nominal bond holdings at the beginning of the period and i_t is the nominal interest (equalized across islands given our assumption of a monetary union where the bonds are freely traded) on consumption goods (C_{kt}) and savings ($B_{kt} - B_{kt-1}$). Thus, they face the period-by-period budget constraint

$$P_{kt}C_{kt} + B_{kt} \leq B_{kt-1}(1 + i_{t-1}) + W_{kt}N_{kt} + \Pi_{kt} + \tau_{kt} + Q_t\bar{\eta}e^{\eta_{kt}}$$

Federal government. The federal government budget constraint is

$$B_t^g + \sum_k \tau_{kt} + Q_t G = B_{t-1}^g(1 + i_{t-1})$$

where G is some exogenous level of government spending in intermediate goods. The key feature of a fiscally integrated economy is that the federal government has the ability to redistribute resources across islands via transfers τ_{kt}. If the islands where fiscally independent such transfers would not be possible.

I assume that the federal government announces a nominal interest rate rule $i_t = i(.)$ as a function of aggregate variables in the economy alone. Moreover, it announces a transfer policy rule as a function of per-capita employment, wages and assets in an island

$$\tau_{kt} = \bar{\tau}(\tilde{W}_{kt})^{\vartheta_w}(\tilde{N}_{kt})^{\vartheta_n}(\tilde{B}_{kt-1})^{\vartheta_b}$$

Again, agents do not internalize this dependence when making their choices.

Exogenous shocks and processes. I assume the exogenous processes are AR(1) processes, with an identical autoregressive coefficient across islands, and that the innovations are iid, mean zero, random variables with an aggregate and island specific component. First, define $\gamma_{kt} \equiv \delta_{kt} - \delta_{kt-1}$. Then,

$$
\begin{aligned}
a_{kt} &= \rho_a a_{kt-1} + \tilde{\sigma}_a v_t^a + \sigma_a \epsilon_{kt}^a \\
\gamma_{kt} &= \rho_\gamma \gamma_{kt-1} + \tilde{\sigma}_\gamma v_t^\gamma + \sigma_\gamma \epsilon_{kt}^\gamma \\
\eta_{kt} &= \rho_\eta \eta_{kt-1} + \tilde{\sigma}_\eta v_t^\eta + \sigma_\eta \epsilon_{kt}^\eta
\end{aligned}
$$

with $\sum_k \epsilon_{kt}^z = \sum_k \epsilon_{kt}^\gamma = \sum_k \epsilon_{kt}^\eta = 0$. By assumption, I assume the average of the regional shocks sum to zero in all periods.

The demand process γ_{kt} is a shifter of a household's discount rate, but it can be viewed as a proxy for the tightening of household borrowing limits. The productivity process a_{kt} can be interpreted as actual productivity, or a shifter of firm's demand for labor or firm's mark-ups. Finally, wealth process η_{kt} is modeled as an endowment of intermediate goods but can be interpreted as shifters of the budget constraint that agents face such as exogenous changes in household wealth.

Equilibrium. An equilibrium is a collection of prices $\{P_{kt}, W_{kt}, Q_t\}$ and quantities $\{C_{kt}, N_{kt}, B_{kt}, \tau_{kt}, N_{kt}^y, X_{kt}\}$ for each island k and time t such that, for an interest rate rule $i_t = i(.)$ and given exogenous processes $\{a_{kt}, \eta_{kt}, \gamma_{kt}\}$, they are consistent with household utility maximization and firm profit maximization and such that the following market clearing conditions hold:

$$
\begin{aligned}
C_{kt} &= e^{a_{kt}} (N_{kt}^y)^\alpha (X_{kt})^\beta \\
N_{kt} &= N_{kt}^y \\
G + \sum_k X_{kt} &= \sum_k \bar{\eta} e^{\eta_{kt}} \\
0 &= \sum_k B_{kt} + B_t^g
\end{aligned}
$$

Aggregation. The first important assumption for aggregation is that all islands are identical with respect to their underlying production and utility parameters.[1] The second assumption is that the joint distribution of island-specific shocks is such that its cross-sectional summation is zero. If K, the number of islands, is large this holds in the limit because of the law of large numbers. I log-linearize the model around this steady state and show that it aggregates up to a representative economy where all aggregate

[1]Given that the broad industrial composition at the state level does not differ much across states, the assumption that productivity parameters are roughly similar across states is not dramatically at odds with the data.

variables are independent of any cross-sectional considerations to a first order approximation.[2] I denote with lowercase letters an island variable's log-deviation from the aggregate union equilibrium. Lowercase letters with a tilde denote deviations from the steady state. For example, $n_{kt} \equiv \tilde{n}_{kt} - \tilde{n}_t$ and $\tilde{n}_t \equiv \sum_k \frac{1}{K}\tilde{n}_{kt} = \sum_k \frac{1}{K} log\left(N_{kt}/\bar{N}\right)$. I assume that the monetary authority announces the nominal interest rate rule in log-linearized form: $\tilde{i}_{t+1} = \varphi_\pi \mathbb{E}_t[\tilde{\pi}_{t+1}]$ where $\tilde{\pi}_t$ is the aggregate inflation rate. Finally, I assume that the endogenous component of the discount factor is such that $\Phi(.) = \phi n_{kt}$.

The following lemma present the aggregation result and shows that we can write the island level equilibrium in deviations from these aggregates.

Lemma A.1. *For given $\{a_{kt}, \gamma_{kt}, \eta_{kt}\}$, the behavior of $\{w_{kt}, n_{kt}, b_{kt}, \tau_{kt}, p_{kt}, c_{kt}, x_{kt}\}$ in the log-linearized economy for each island in log-deviations from aggregates is identical to that of a small open economy where the price of intermediates and the nominal interest rate are at their steady state levels, i.e. $\tilde{q}_t = \tilde{i}_t = 0\ \forall t$.*

Proof. The following equations characterize the log-linearized equilibrium

$$
\begin{aligned}
\tilde{w}_{kt} - \tilde{p}_{kt} &= \frac{1}{\nu}\tilde{n}_{kt} + \sigma c_{kt} \\
\tilde{w}_{kt} - \tilde{p}_{kt} &= (\alpha - 1)(\tilde{n}_{kt} - \tilde{x}_{kt}) + \tilde{a}_{kt} \\
\tilde{q}_t - \tilde{p}_{kt} &= \alpha(\tilde{n}_{kt} - \tilde{x}_{kt}) + \tilde{a}_{kt} \\
0 &= \mathbb{E}_t\left(-(\tilde{m}u_{kt+1} - \tilde{m}u_{kt+1}) + (\tilde{p}_{kt+1} - \tilde{p}_{kt}) + \phi(\tilde{n}_{kt} - \tilde{n}_t) + \gamma_{kt+1} - \tilde{i}_t\right) \\
\tilde{m}u_{kt} &= -\sigma\tilde{c}_{kt} \\
\tilde{c}_{kt} &= \tilde{w}_{kt} - \tilde{p}_{kt} + \tilde{n}_{kt} \\
\bar{B}\tilde{b}_{kt} &= \bar{B}(1+r)(\tilde{b}_{kt-1} + \tilde{i}_t) + \bar{\eta}\eta_{kt} - \bar{\eta}(\tilde{q}_t + \tilde{x}_{kt}) + \bar{\tau}\tilde{\tau}_{kt} \\
\sum_k \tilde{x}_{kt} &= \sum_k \tilde{\eta}_{kt} \\
\bar{B}^g\tilde{b}^g_t + \bar{\tau}\sum_k \tilde{\tau}_{kt} + \bar{G}\tilde{q}_t &= \bar{B}^g(1+r)(\tilde{b}^g_{t-1} + \tilde{i}_t) \\
\tilde{\tau}_{kt} &= \vartheta_w\tilde{w}_{kt} + \vartheta_n\tilde{n}_{kt} + \vartheta_b\tilde{b}_{kt-1} \\
\tilde{i}_{t+1} &= \phi_p\mathbb{E}_t[\tilde{p}_{t+1} - \tilde{p}_t]
\end{aligned}
$$

[2]The model we presented has many islands subject to idiosyncratic shocks that cannot be fully hedged because asset markets are incomplete. By log-linearizing the equilibrium we gain in tractability, but ignore these considerations and the aggregate consequences of heterogeneity. As usual, the approximation will be a good one as long as the underlying volatility of the idiosyncratic shocks is not too large. If our unit of study was an individual, as for example in the precautionary savings literature with incomplete markets, the use of linear approximations would likely not be appropriate. However, since our unit of study is an island the size of a state I believe this is not too egregious of an assumption. The volatilities of key economic variables of interest at the state level are orders of magnitude smaller than the corresponding variables at the individual level.

After adding up, the aggregate log-linearized equilibrium evolution of $\{\tilde{w}_t - \tilde{p}_t, \tilde{n}_t\}$ is characterized by

$$
\begin{aligned}
0 &= \mathbb{E}_t(-(\tilde{m}u_{t+1} - \tilde{m}u_t) + (1-\phi_p)(\tilde{p}_{t+1} - \tilde{p}_t) + \tilde{\gamma}_{t+1}) \\
0 &= \sigma(\tilde{w}_t - \tilde{p}_t + \tilde{n}_t) + \frac{1}{\nu}\tilde{n}_t - (\tilde{w}_t - \tilde{p}_t) \\
\tilde{w}_t - \tilde{p}_t &= (\alpha - 1)\tilde{n}_t + \tilde{a}_t + (1-\alpha)\tilde{\eta}_t \\
\tilde{m}u_t &\equiv -\sigma(\tilde{w}_t - \tilde{p}_t + \tilde{n}_t)
\end{aligned}
$$

which is equivalent to the system of equations characterizing the log-linearized equilibrium in a representative agent economy with a production technology that utilizes labor alone with an elasticity of α, no endogenous discounting and only 2 exogenous processes $\{\tilde{a}_t + (1-\alpha)\tilde{\eta}_t, \tilde{\gamma}_t\}$.

Next, take log-deviations from the aggregate in the original system and replace c_{kt}, p_{kt}, mu_{kt} for their corresponding expressions. When we set $\rho_\gamma = \rho_a = \rho_\eta = 0$ and $\theta_w = \theta_b = 0$, this results in the system displayed in Section 2 characterizing the equilibrium of $\{n_{kt}, w_{kt}, b_{kt}, \tau_{kt}\}$ (where we drop the 'k' index for convenience).

$$
\begin{aligned}
0 &= \mathbb{E}_t(n_{t+1} - n_t) + \left(\alpha + \frac{1}{\sigma}(1-\alpha)\right)\mathbb{E}_t(w_{t+1} - w_t) + (\frac{1}{\sigma} - 1)a_t + \frac{\rho}{\sigma}n_t && \text{(Euler)} \\
0 &= -\alpha w_t + \left(\frac{(1+\nu)}{(1-\sigma)} - 1\right)n_t - a_t && \text{(Labor market)} \\
0 &= -\frac{\bar{B}}{\bar{\tau}}b_t + (1+r)\frac{\bar{B}}{\bar{\tau}}b_{t-1} + \frac{\bar{\eta}}{\bar{\tau}}(\eta_t - (w_t + n_t)) + \tau_t && \text{(Budget Constraint)} \\
0 &= -\tau_t + \theta_n n_t && \text{(Policy)} \\
0 &= -a_{t+1} + \epsilon^a_{t+1}; \quad 0 = -\eta_{t+1} + \epsilon^\eta_{t+1} && \text{(Shocks)}
\end{aligned}
$$

This system is independent of all aggregate variables and is analogous to the system characterizing the equilibrium in a small open economy without movements in the terms of trade and nominal interest rate. □

A.2 A Counterfactual US without Fiscal Integration

A.2.1 Data description

I exclude Alaska, District of Columbia, and Hawaii from the analysis, leaving 48 observations (one for each remaining state) per year, and 6 years (2006-2011) of data.

To make state-level nominal wages indices, I use data from the 2000 US Census and the 2001-2012 American Community Surveys (ACS).[3]

The 2000 Census includes 5 percent of the US population. The 2001-2012 ACS's include approximately 600,000 respondents between 2001-2004, and about 2 million after 2004. The large sample sizes allow detailed labor market information at the state level. I begin by using the data to make individual hourly nominal wages. I restrict the sample to only individuals who are employed, who report usually working at least 30 hours per week, and who worked at least 48 weeks during the prior 12 months. For each individual, I divide total labor income earned during the prior 12 months by a measure of annual hours worked during the prior 12 months.[4] The composition of workers differs across states and within a state over time, which might explain some variation in nominal wages across states over time. To account for this, I run the following regression:

$$\ln(w_{itk}) = K_t + \Gamma_t X_{itk} + u_{itk},$$

where $\ln(w_{kt})$ is log-nominal wages for household i in period t residing in state k, and X_{kt} is a vector of household specific controls. The vector of controls include a series of dummy variables for usual hours worked (30-39, 50-59, and 60+), a series of five-year age dummies (with 40-44 being the omitted group), 4 educational attainment dummies (with some college being the omitted group), three citizenship dummies (with native born being the omitted group), and a series of race dummies (with white being the omitted group). I run these regressions separately for each year such that both constant K_t and the vector of coefficients on the controls, Γ_t, can differ for each year. I then take the residuals from these regressions for each individual, u_{itk}, and add back constant K_t. Adding back the constant from the regression preserves differences over time in average log wages. To compute average log wages within a state, holding composition fixed, I average $u_{itk} + K_t$ across all individuals in state k. I refer to this measure as the demographically adjusted, log-nominal wage in time t in state k.

The measure of employment at the state level is the employment rate for each state, calculated using data from the US Bureau of Labor Statistics. The BLS reports annual employment counts and population numbers for each state and year. I divide employ-

[3] I access the data through the IPUMS-USA website https://usa.ipums.org/usa/. See Ruggles, Sobek, Fitch, Hall, and Ronnander (1997).

[4] Total labor income during the prior 12 months is the sum of both wage and salary earnings and business earnings. Total hours worked during the previous 12 months is a multiple of total weeks worked during the prior 12 months and the respondents' reports of their usual hours worked per week. For some years, bracketed reports are provided for weeks worked during the prior 12 months, and the usual hours per week worked. In those cases, I take the midpoint of the brackets.

ment counts by population to make an annual employment rate measure for each state.

Data on federal transfers net of taxes paid come from the Bureau of Economic Analysis.[5] Transfers include retirement and disability insurance benefits, medical benefits, income maintenance benefits, unemployment insurance compensation, veterans benefits, federal education and training assistance, and other transfer receipts of individuals from governments. Federal taxes are the sum of personal income taxes that are withheld, usually by employers, from wages and salaries, quarterly payments of estimated taxes on income that is usually not subject to withholding, and final settlements, which are additional tax payments made when tax returns for a year are filed, or as a result of audits by the Federal Government.[6]

Given the unavailability of official state-level data on asset positions, I construct a measure of state-level assets as the sum of physical and financial assets. From national account identities, we can derive the law of motion for assets B_t in a given state as:

$$B_t = B_{t-1}(1 + r_t) + Y_t - C_t + \tau_t - G_t^{local} + v_t,$$

where Y_t is nominal gross domestic product, C_t is private consumption expenditures, τ_t are net transfers (i.e., expenditures minus taxes) from the federal government, G_t^{local} are expenditures from the local government, and r_{t-1} captures the change in asset valuation between $t-1$ and t. Finally, error term v_t includes income receipts from abroad minus income payments to foreigners, federal government expenditures not counted as federal transfers (e.g., salaries and wages), and differences in returns between physical and financial assets for which no data are available.[7] I obtain Y_t and C_t directly from the Bureau of Economic Analysis website. $\tau_t - G_t^{local}$ also comes from several variables in the BEA. I calculate it as (personal current transfers receipts) - (personal current taxes paid + taxes on production and imports net of subsidies).[8] The revaluation of assets term r_t is obtained residually to ensure that the growth rate of the sum of local assets across states is consistent with the growth rate of aggregate net worth in the US economy. Having all components in the law of motion for B_t, I calculate assets at each point in time for each state by iterating forward with 2006 as the initial observation. I obtain initial

[5] I access the data through the BEA website on regional GDP and personal income: http://www.bea.gov/iTable/index_regional.cfm

[6] Excise, Medicare and Social security federal taxes are not included in this measure.

[7] Error term v_t accounts for most of the wealth exogenous process. The remainder is the error term e_t in the difference between observed net transfers and estimated policy rule in equation Section A.2.2.

[8] As long as local government expenditures plus transfers are close enough to local tax revenues (i.e., local governments have a nearly balanced budget), the calculation is accurate. If not, the difference is absorbed by error term e_t.

state level assets in 2006 from Mian, Rao, Sufi et al. (2013). In particular, I aggregate (at the state level) their zip code level total net worth data.

A.2.2 Estimating the transfer policy rule Θ

The transfer policy rule is:

$$\tau_t = \vartheta_n n_t + \vartheta_w w_t + \vartheta_b b_{t-1} + e_t$$

For regional data to be used to estimate Θ, one of the following must hold: (1) the innovations to the policy rule have no regional component ($e_t = 0$)—in which case, a simple OLS regression produces consistent estimates—or (2) valid instruments can be found that isolate movements in n_t, w_t, b_{t-1} that are orthogonal to e_t. The issue of endogeneity arises because of reverse causality. When the innovation in the policy rule is part of the wealth shock ϵ_t^{η}, employment and wages both cause and are caused by net transfers in the equation above. To deal with the endogeneity of n_t, w_t, b_{t-1}, I proceed in various ways. First, I estimate a regression of net transfers onto nominal wage income alone (assuming $\theta_w = \theta_n$) using house price growth between 2006 and 2010 as an instrument. This accords with many recent papers, including Mian and Sufi (2014). Contemporaneous housing price growth strongly predicts contemporaneous nominal wage income growth. The instrument is valid as long as local housing prices are orthogonal to the transfer policy rule shock, which appears plausible. In the second approach, I use demand and productivity shocks in 2008, estimated from our SVAR, as instruments for wages and employment. They are linear combinations of wages, employment, and assets in 2008 that are orthogonal to the wealth shock, and hence e_t, by construction.

Table A.1 presents results for several specifications. The dependent variable is the log-growth rate of transfers minus the growth rate of taxes between 2006 and 2010 for each state. The independent variables are the log-growth rate of nominal wages between 2006 and 2010 and the log-growth rate of employment between 2006 and 2010 in the first two columns, and the log-growth rate of assets between 2006 and 2009 in the third column. In the fourth column, the independent variable is the sum of wage and employment growth. The first line is a simple OLS regression. The second presents two-stage, least-squares results using the demand and productivity shocks in 2008 $\epsilon_{2008}^{\gamma}, \epsilon_{2008}^{a}$. The third uses house price log-growth between 2006 and 2008 as an instrument instead. The fourth uses all three instruments. For all specifications, and when possible, I consider case (1) when b_{t-1} is not endogenous, and case (2) when b_{t-1} might be endogenous.

I find that the policy rule estimates have the expected sign and are significant in all

Table A.1: Policy rule baseline estimates

	ϑ_n	ϑ_w	ϑ_b	ϑ_{w+n}	R^2
OLS	-1.6^{**} (0.5)	-0.9^{*} (0.7)	-0.03 (0.02)	.	0.41
IV w/ shocks (1)	-1.3^{*} (0.7)	-1.4^{*} (0.8)	-0.02 (0.02)	.	0.41
IV w/ house prices (1)	.	.	-0.03 (0.02)	-1.1^{**} (0.4)	0.42
IV w/ house prices and shocks (1)	-1.4^{*} (0.6)	-1.2^{*} (0.6)	-0.02 (0.02)	.	0.43
(2)	-1.3^{*} (0.7)	-1.4^{*} (0.7)	0.01 (0.08)	.	0.38

Note: Numbers in parenthesis are OLS (or second stage) standard errors. Variables with '*' are significant at a 5% level. Variables with '**' are significant at 1%. All variables are state log-growth rates between 2006 and 2010. b_{t-1} is exogenous in (1) and endogenous in (2)

specifications. They are also similar in magnitude, ranging from -1.3 to -1.6 for ϑ_n and -0.9 to -1.4 for ϑ_w. Lagged assets have nearly no independent explanatory power for net transfers across all specifications. To give a sense of the magnitudes involved, when net transfers increase by 30 percent for every 1 percent decrease in nominal wage income, and the average income tax rate is 0.17, for every 1 dollar decrease in nominal wage income, a state receives 0.22 dollars in federal transfers. This result is similar to findings by Feyrer and Sacerdote (2013), who find a 0.25 decrease, and Bayoumi and Masson (1995), who find a 0.31 decrease.

A.2.3 SVAR identification

A necessary input for implementing the semi-structural methodology described in Theorem 1 of Beraja (2023) is the impulse response matrix Q. The literature proposes myriad ways to identify it, ranging from simple ordering assumptions to more sophisticated sign and long-run restrictions. In this section, I show how to use the equilibrium equations of structural models that we feel more confident about in order to derive linear restrictions on the structure ξ that are sufficient to identify Q. Specifically, I use the sequential budget constraint to generate these theoretical restrictions because many fiscal union models are consistent with it. These theoretical restrictions imply a series of particular linear restrictions linking the reduced form errors to the structural shocks. Hence, this identification scheme fits nicely with the philosophy in this paper and makes it easy to verify that the restrictions in Assumption 3 are not violated. Baumeister and Hamilton (2015) present a scheme that is very similar in spirit.

Following Ravenna (2007), if Assumptions 1 and 2 hold, and there is a matrix B such that BQ is a non-singular square matrix, then there is a SVAR representation of the solution (RR) of the form:

$$x_t = \rho_1 x_{t-1} + \rho_2 x_{t-2} + Q\epsilon_t \tag{SVAR}$$

where $\rho_1 \equiv P + QN(BQ)^{-1}B$, $\rho_2 \equiv (P - \rho_1)P$ and $V \equiv Var(Q\epsilon_t) = Q\Sigma\Sigma' Q'$.

To see this, note that we can write $z_{t-1} = (BQ)^{-1}(Bx_{t-1} - BPx_{t-2})$ and replace it and the law of motion for the exogenous states into the law of motion for the endogenous variables to obtain the SVAR(2) representation.

Without loss of generality, I normalize the covariance matrix of structural shocks Σ to the identity matrix in what follows. The first step in the procedure consists of estimating the reduced form VAR to obtain the autoregressive matrices $\{\rho_1, \rho_2\}$, and the reduced form errors covariance matrix V. The second step is deriving identification restrictions that will allow us to infer Q and the shocks.

In what follows, I will assume that $B = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$. That is, a matrix that selects the impulse responses in Q associated with n_t, w_t, b_t. Replacing out the policy rule τ_t, and applying the conditional expectation operator $\mathbb{E}_{t-1}(.)$ on both sides of the third line in the structure (i.e., the (Budget constraint)) and constructing the reduced form expectational errors, we obtain:

$$0 = \begin{bmatrix} g_{31} + \vartheta_n & g_{32} + \vartheta_w & g_{33} \end{bmatrix} BQ \begin{bmatrix} \epsilon_t^{\gamma} \\ \epsilon_t^{a} \\ \epsilon_t^{\eta} \end{bmatrix} + m_{33}\epsilon_t^{\eta} \tag{Id1}$$

This equation must hold for all realizations of the shocks. Whenever there is an innovation to ϵ_t^{γ} or ϵ_t^{a} and $\epsilon_t^{\eta} = 0$, employment, wages, and debt must co-move on impact in a way that satisfies this linear relationship. Hence, it gives us two linear restrictions in the second and third columns' elements of BQ when there are either contemporaneous ϵ_t^{γ} or ϵ_t^{a} shocks.

Similarly, constructing $\mathbb{E}_{t-1}(.) - \mathbb{E}_{t-2}(.)$, we obtain:

$$0 = \left(\begin{bmatrix} g_{31} + \vartheta_n & g_{32} + \vartheta_w & g_{33} \end{bmatrix} B\rho_1 B' + \begin{bmatrix} 0 & 0 & h_{33} + \vartheta_b \end{bmatrix} \right) BQ \begin{bmatrix} \epsilon^{\gamma}_{t-1} \\ \epsilon^{a}_{t-1} \\ \epsilon^{\eta}_{t-1} \end{bmatrix}$$
$$+ m_{33} n_{33} \epsilon^{\eta}_{t-1} + m_{33} n_{32} \epsilon^{a}_{t-1} \qquad \text{(Id2)}$$

This gives us one extra linear restriction in the second column's elements of BQ when there are ϵ^{γ}_{t-1} shocks. These three linear restrictions, combined with six non-linear restrictions coming from the orthogonalization of the shocks, are sufficient to identify all nine elements in BQ associated to the impulse responses of n_t, w_t, b_t to each of the three shocks. Intuitively, equation (Id1) separates the wealth shock from the other two shocks. If the unexpected component of employment, wages, and assets does not co-move in the linear way implied by equation (Id1), when $\epsilon^{\eta}_{t} = 0$, a wealth shock must have occurred. Analogously, equation (Id2) separates demand and productivity shocks. If the unexpected component of employment, wages, and assets does not co-move in the linear way implied by equation (Id2), when $\epsilon^{z}_{t-1} = \epsilon^{\eta}_{t-1} = 0$, a demand shock occurred. For completeness, matrix BQ solves the system:

$$\begin{bmatrix} g_{31} + \vartheta_n & g_{32} + \vartheta_w & g_{33} \end{bmatrix} BQ \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ 0 & 0 \end{bmatrix} = \begin{bmatrix} 0 & 0 \end{bmatrix}$$

$$\left(\begin{bmatrix} g_{31} + \vartheta_n & g_{32} + \vartheta_w & g_{33} \end{bmatrix} B\rho_1 + \begin{bmatrix} 0 & 0 & h_{33} + \vartheta_b \end{bmatrix} \right) BQ \begin{bmatrix} 1 \\ 0 \\ 0 \\ 0 \end{bmatrix} = 0$$

$$V = BQ(BQ)'$$

Finally, to construct the full matrix Q from BQ, we just need to append the last line corresponding to the impulse responses of τ_t. That is : $Q = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ \theta_n & \theta_w & 0 \end{bmatrix} BQ.$

A.2.4 Estimating the structure ξ and the reduced form model

I estimate a vector autoregression on employment, wages, and assets via weighted OLS where the weights are the 2006 population in the state, using data described in subsection A.2.1. For each variable and year, I take the cumulative log-growth between 2006 and 2011 and express it in log-deviations from the average across states. I pool all data between 2006 and 2011, leaving 240 observations (5 years*48 states), and estimate common autoregressive coefficients ρ_1^0, ρ_2^0 and reduced form errors U covariance matrix for all states $V^0 = \frac{UU'}{240-3*2}$.[9]

Given ρ_1^0, ρ_2^0, we find solutions X with all eigenvalues inside the unit circle to the quadratic equation $\rho_2^0 = (X - \rho_1^0)X$. Under Assumptions 1-2 and Property 4, there are only two such solutions. The first corresponds to BP^0B' in the unique stable recursive representation of the equilibrium under fiscal integration.[10] The second corresponds to $(BQ^0)N^0(BQ^0)^{-1}$. I identify BP^0B' as the solution that results in an implied $N^0 = \left(BQ^0\right)^{-1}(BP^0B' - \rho_1^0)BQ^0$ that satisfies the exclusion restrictions described in Assumption 5.

From the restrictions implied by the third line of the structure in Assumption 5, together with results in Theorem 1, we have,

$$\begin{bmatrix} g_{31} + \vartheta_n^0 & g_{32} + \vartheta_w^0 & g_{33} \end{bmatrix} BP^0B' + \begin{bmatrix} 0 & 0 & h_{33} + \vartheta_b^0 \end{bmatrix} = \mathbf{0_{1,3}}$$

Then, g_{31}, g_{32}, h_{33} are identified from the above system of equations, given BP^0B' and setting $g_{33} \equiv \frac{\bar{B}}{\bar{\tau}}$, to match the ratio of median net worth across states to total income tax revenues in the United States in 2006, and $\vartheta_n^0 = -1.6, \vartheta_w^0 = -0.9, \vartheta_b^0 = -0.03$, which correspond to the OLS policy rule estimates in Table A.1. To construct the full matrix P^0 from BP^0B', we just need to append the last line and column corresponding to τ_t. That is : $P^0 = \left[\begin{bmatrix} BP^0B' \\ \begin{bmatrix} \vartheta_n^0 & \vartheta_w^0 & 0 \end{bmatrix} BP^0B' + \begin{bmatrix} 0 & 0 & \vartheta_b^0 \end{bmatrix} \end{bmatrix}, \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} \right]$.

Then, with the above inputs, I follow Section A.2.3 to identify Q^0. Furthermore, the rest of the structure ξ is identified by following the results in Theorem 1 using the

[9]Note that ρ_1^0, ρ_2^0, V^0 do not exactly correspond to the theoretical matrices in (SVAR). The reason is that the theoretical matrices also include the lines and columns associated with transfers τ_t, whereas I have estimated the VAR without them. Then, for example, V^0 is missing the fourth line compared to $V(\xi, N, \Theta)$, which corresponds to the variance of reduced form expectational errors of τ_t.

[10]Since τ_t is not a state variable in the set of models we study, then the fourth column of P^0 is a column of zeros. Then, P^0B' is the autoregressive matrix without this fourth column.

restrictions in Assumption 3 and the estimated P^0, Q^0, N^0, Θ^0.

A.2.5 Sensitivity to alternative policy specifications

Results from the previous section are based on a particular transfer policy specification where $\vartheta_n = -1.6, \vartheta_w = -0.9, \vartheta_b = 0.03$, which corresponds to the OLS estimates of the transfer policy rule in Table A.1 in Appendix A.2.2.

First, we would like to evaluate the sensitivity of results to estimates of the transfer policy rule other than the benchmark OLS estimates. Thus, I consider alternative initial policy parameterizations corresponding to the instrumental variable estimates in Table A.1. Results are similar to those reported in the previous section for the benchmark policy rule. Although quantitatively reduced somewhat for some of the parameterizations, the reduction of dispersion in employment across states due to fiscal integration remains large. The largest difference is for the case in which I restrict coefficients on employment and wages in the policy rule to be identical ($\vartheta_n = \vartheta_w = -1.1$). In this case, the counterfactual employment standard deviation in 2010 would have been 3.1 percent (instead of 2.6 percent in the data), and the counterfactual standard deviation in the stationary distribution is 4.5 percent (instead of 3.5). The counterfactual using the benchmark policy estimates instead resulted in counterfactual standard deviations of 3.5 and 4.9 percent respectively.

Second, we would like to evaluate an alternative policy that accounts for the distortionary effects of taxation. The benchmark policy specification is consistent with households in each state receiving lump-sum transfers from the federal government because the only affected equation that characterizes the equilibrium is the sequential budget constraint (the third equation in this case). In practice, lump-sum transfers are rare and, instead, the federal government uses distortionary taxes.

For simplicity, consider the transfer policy without lagged assets in log-deviations from the aggregate.[11]

$$\tau_t = \vartheta_n n_t + \vartheta_w w_t$$

This implies that tax rate $\tilde{\tau}_t$ per unit of nominal labor income $w_t + n_t$ in log-deviations from the aggregate can be written as:

$$\tilde{\tau}_t = -(1 + \vartheta_n) n_t - (1 + \vartheta_w) w_t$$

[11] Since the estimated coefficient on lagged assets is so small, results are identical whether we include it or not.

The potential labor supply (or wage-setting) tax distortion relates to $\tilde{\tau}_t$, not total transfers τ_t for which we estimated elasticities ϑ_w, ϑ_n. If the federal tax-and-transfer system affects equilibrium equations beyond the sequential budget constraint, $(1+\theta_w), (1+\theta_n)$ would appear in these equations, not θ_w, θ_n.

I consider the case in which the second equation in the structure is a (Labor Market) equation. If the federal tax-and-transfer system is distortionary, we can write this equation as:

$$\begin{aligned}
0 =& f_{21}\mathbb{E}_t[n_{t+1}] + f_{22}\mathbb{E}_t[w_{t+1}] + \left(g_{21} + \frac{\bar{\tau}\vartheta_n}{1-\bar{\tau}\vartheta_n}(1+\vartheta_n)\right) n_t + \left(g_{22} + \frac{\bar{\tau}\vartheta_n}{1-\bar{\tau}\vartheta_n}(1+\vartheta_w)\right) w_t \\
&+ h_{21}n_{t-1} + h_{22}w_{t-1} + \mathbb{E}_t[z_{t+1}] + l_{23}\mathbb{E}_t[\eta_{t+1}] + m_{22}z_t + m_{23}\eta_t
\end{aligned}$$

The equation above accords with the tax rate that affects the target wage in the wage-setting equation by distorting the marginal rate of substitution. The distortion is given by terms $1+\theta_n$ and $1+\theta_w$. For example, the case $\theta_w = \theta_n = -1$ is such that the tax schedule is flat (i.e., a proportional labor income tax). Due to the lack of curvature, it would not affect the island's log-deviations of the marginal rate of substitution from the aggregate.

I next construct a counterfactual using this alternative policy specification, setting $\bar{\tau} = 0.17$ to match the average tax rate in the US economy. I find that the results from the previous section are essentially unchanged because estimates of transfer policy rule ϑ_n, ϑ_w are close to -1. Thus, policy-related terms that distort this equation are very small in absolute magnitude, in comparison with terms in the policy-invariant structure. To see this, consider the case in which the second equation is interpreted as a static labor supply equation, and the policy rule depends on employment alone: $w_t = \left(-g_{21} - \frac{\bar{\tau}\vartheta_n}{1-\bar{\tau}\vartheta_n}(1+\vartheta_n)\right) n_t$. Plausible calibrations of labor supply Frisch elasticity $-g_{21}$ are in the range 0.5 to 4 (Chetty, Guren, Manoli, and Weber, 2011). The policy-related term for the case when $\bar{\tau} = 0.17, \vartheta_n = -1.6$ is -0.08, which is an order of magnitude smaller than the Frisch elasticity.

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