

APPENDIX: SECULAR LABOR REALLOCATION AND BUSINESS CYCLES

Gabriel Chodorow-Reich

Harvard University and NBER

Johannes Wieland

UC San Diego and NBER

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A. Comparison to Other Measures

Our full cycle reallocation measures differ from existing metrics mainly in the choice of horizon.

In a seminal paper, [Lilien \(1982\)](#) measures sectoral dispersion as a weighted standard deviation of industry employment growth rates,

$$R_{a,t,t+1}^{\text{Lilien}} = \left[\sum_{i=1}^I s_{a,i,t} (\Delta \ln e_{a,i,t+1} - \Delta \ln e_{a,t+1})^2 \right]^{\frac{1}{2}}. \quad (\text{A.1})$$

To illustrate the differences, we rewrite Lilien's measure using an absolute value metric rather than a Euclidean metric,

$$R_{a,t,t+1}^{\text{Lilien-absolute}} = \sum_{i=1}^I s_{a,i,t} |\Delta \ln e_{a,i,t+1} - \Delta \ln e_{a,t+1}|, \quad (\text{A.2})$$

and take a first order approximation of equation (A.2) around the balanced growth path condition $s_{a,i,t+1} = s_{a,i,t} \forall i$, yielding

$$R_{a,t,t+1}^{\text{Lilien-absolute}} \approx \sum_{i=1}^I |s_{a,i,t+1} - s_{a,i,t}| = \frac{2}{12} R_{a,t,t+1}. \quad (\text{A.3})$$

Comparing equations (1), (A.1) and (A.3), up to a first order approximation our measure differs from Lilien's only in the choice of metric.

Our measure also has a close connection to the job reallocation rate defined by [Davis and Haltiwanger \(1992, p. 828\)](#),¹

$$R_{a,t,t+1}^{\text{D-H}} = \frac{1}{0.5(e_{at+1} + e_{at})} \sum_{i=1}^I |e_{a,i,t+1} - e_{a,i,t}| \quad (\text{A.4})$$

$$= \sum_{a=1}^I \bar{s}_{a,i,t,t+1} |g_{a,i,t+1}^{\text{sym}}|, \quad (\text{A.5})$$

where $\bar{s}_{a,i,t,t+1} \equiv \frac{(e_{a,i,t+1} + e_{a,i,t})}{(e_{a,t+1} + e_{a,t})}$ is the two period average employment share, and $g_{a,i,t+1}^{\text{sym}} \equiv \frac{(e_{a,i,t+1} - e_{a,i,t})}{0.5(e_{a,i,t+1} + e_{a,i,t})}$ is the symmetric growth rate of employment of industry i in area a . To illustrate the relationship between $R_{a,t,t+1}^{\text{D-H}}$ and our measures, we rewrite the full recession-recovery cycle

¹Davis and Haltiwanger call this term SUM_t . In their application a corresponds to a sector, i to an establishment and I to the total number of establishments in that sector.

reallocation measure in the case where employment at peak and at last-peak are exactly equal,

$$e_{a,t+T} = e_{a,t}, \text{ as,}$$

$$R_{a,t,t+T} = \frac{12}{T} \frac{1}{2} \sum_{i=1}^I \bar{s}_{a,i,t} |g_{a,i,t+T}|.$$

Thus, up to the scale normalization, our measure coincides exactly with the [Davis and Haltiwanger \(1992\)](#) measure evaluated over a full cycle rather than period-by-period.

B. Derivations in Simple Model

We provide here details of the derivations in section 2.3 in the main text.

Given frictionless reallocation of labor, the real wage across locations and industries must be equalized. Since the wedge $\Psi_{a,t}$ is area-specific the marginal revenue product is also area-specific,

$$w_t = p_{a,t} / \Psi_{a,t},$$

$$p_{a,t} = \eta_{i,t} P_{a,i,t}^Q,$$

where $P_{a,i,t}^Q$ is the real price of good i produced in area a . Using the CES demand function,

$$Q_{a,i,t} = \tau_{a,i,t} \left(\frac{P_{a,i,t}^Q}{P_{a,t}^Q} \right)^{-\zeta} Q_{a,t},$$

we solve for $P_{a,i,t}^Q$ in the expression for the wage,

$$w_t \Psi_{a,t} = \eta_{i,t} \tau_{a,i,t}^{\frac{1}{\zeta}} \left(\frac{Q_{a,i,t}}{Q_{a,t}} \right)^{-\frac{1}{\zeta}} P_{a,t}^Q.$$

Aggregating over all industries in a location, we write the price of output in location a as a function of the marginal revenue product,

$$P_{a,t}^Q = \frac{w_t \Psi_{a,t}}{\Phi_{a,t}^{\frac{1}{\zeta-1}}}$$

where $\Phi_{a,t} \equiv \sum_{i=1}^I \tau_{a,i,t} \eta_{i,t}^{\zeta-1}$.

Using the production function $Q_{a,i,t} = \eta_{i,t} e_{a,i,t}$, we derive industry-area and total area

employment as a function of local area demand $Q_{a,t}$,

$$\begin{aligned} e_{i,a,t} &= \tau_{a,i,t} \eta_{i,t}^{\zeta-1} \Phi_{a,t}^{-\frac{\zeta}{\zeta-1}} Q_{a,t} \\ e_{a,t} &= \Phi_{a,t}^{-\frac{1}{\zeta-1}} Q_{a,t}. \end{aligned}$$

The implied employment share of industry i in area a is:

$$s_{a,i,t} = \frac{\tau_{a,i,t} \eta_{i,t}^{\zeta-1}}{\Phi_{a,t}}.$$

We solve for local demand using the CES structure at the aggregate level,

$$Q_{a,t} = \tilde{\tau}_{a,t} \left(\mathcal{M}_{a,t} P_{a,t}^Q \right)^{-\xi} Q_t,$$

where $\mathcal{M}_{a,t}$ is the mark-up over real marginal costs $P_{a,t}^Q$. This mark-up can have both a local and an aggregate component. In the frictionless case described in the text the mark-up is $\mathcal{M}_{a,t} = 1$. Here we allow for time-variation in mark-ups, for example from sticky prices.

Substituting for local demand, we obtain local employment as a function of local and aggregate quantities:

$$\begin{aligned} e_{i,a,t} &= \tau_{a,i,t} \eta_{i,t}^{\zeta-1} \tilde{\tau}_{a,t} \Psi_{a,t}^{-\xi} \mathcal{M}_{a,t}^{-\xi} \Phi_{a,t}^{\frac{\xi-\zeta}{\zeta-1}} w_t^{-\xi} Q_t \\ e_{a,t} &= \tilde{\tau}_{a,t} \Psi_{a,t}^{-\xi} \mathcal{M}_{a,t}^{-\xi} \Phi_{a,t}^{\frac{\xi-1}{\zeta-1}} w_t^{-\xi} Q_t. \end{aligned}$$

Aggregating over all locations and using the definition of Q_t allows us to derive the real wage,

$$w_t = \left(\sum_a \tilde{\tau}_{a,t} \eta_{a,t}^{\xi-1} \Psi_{a,t}^{-(\xi-1)} \mathcal{M}_{a,t}^{-(\xi-1)} \Phi_{a,t}^{\frac{\xi-1}{\zeta-1}} \right)^{\frac{1}{\xi-1}}.$$

We derive industry employment by summing over all locations and using our expression for the marginal revenue product,

$$e_{i,t} = \tilde{\tau}_{i,t} \eta_{i,t}^{\zeta-1} \left(\sum_a \tilde{\tau}_{a,t} \Psi_{a,t}^{-\xi} \mathcal{M}_{a,t}^{-\xi} \Phi_{a,t}^{\frac{\xi-\zeta}{\zeta-1}} \right) w_t^{-\xi} Q_t,$$

where $\tilde{\tau}_{i,t} \equiv \sum_a \left(\frac{\tilde{\tau}_{a,t} \Psi_{a,t}^{-\xi} \mathcal{M}_{a,t}^{-\xi} \Phi_{a,t}^{\frac{\xi-\zeta}{\zeta-1}}}{\sum_b \tilde{\tau}_{b,t} \Psi_{b,t}^{-\xi} \mathcal{M}_{b,t}^{-\xi} \Phi_{b,t}^{\frac{\xi-\zeta}{\zeta-1}}} \right) \tau_{a,i,t}$ is an industry-specific weight.

Summing over all industries,

$$e_t = \left[\sum_{i=1}^I \tilde{\tau}_{i,t} \eta_{i,t}^{\zeta-1} \right] \left(\sum_a \tilde{\tau}_{a,t} \Psi_{a,t}^{-\xi} \mathcal{M}_{a,t}^{-\xi} \Phi_{a,t}^{\frac{\xi-\zeta}{\zeta-1}} \right) w_t^{-\xi} Q_t.$$

A mean-preserving shock at the aggregate level is one that keeps $\left[\sum_{i=1}^I \tilde{\tau}_{i,t} \eta_{i,t}^{\zeta-1} \right] \left(\sum_a \tilde{\tau}_{a,t} \Psi_{a,t}^{-\xi} \mathcal{M}_{a,t}^{-\xi} \Phi_{a,t}^{\frac{\xi-\zeta}{\zeta-1}} \right)$ unchanged.

The equations in the text are found by setting $\mathcal{M}_{a,t} = 1$.

C. Relationship Between Predicted Reallocation and Co-variates

In this Appendix we provide further detail of the area-specific time-varying control variables. We also report partial correlations with predicted reallocation and provide versions of the tables in section 4 of the main text showing the coefficients on the control variables.

The MSA/CSA level variables include employment growth over the 4 years before the cycle start; trend growth of the working-age population, measured as the log change between 5 and 1 years before the cycle start in the population of persons age 15-69;² house price growth over the 4 years before the cycle start;³ area size, measured by the log of sample mean employment; and the Herfindahl of industry employment concentration at the cycle start.

Table C.1 reports correlations of Bartik predicted employment with these variables after separately pooling over national recession-recovery cycles and national expansion cycles, and partialling out national month fixed effects and the predicted growth rate. The pairwise partial correlation coefficients are all less than 0.3 in absolute value.

We next provide versions of tables 4 and 6 reporting the coefficients and standard errors on

²We interpolate annual county-level population data from the Census Bureau to obtain a monthly series of population. We measure the trend up to 1 year before the cycle change to ensure the population trend does not incorporate data realizations after the cycle change.

³We construct area house price indexes using the Freddie Mac MSA house price indexes, available beginning in 1975. For CSAs combining multiple MSAs, we construct a CSA index as a geometric weighted average of the MSA indexes, using 1990 employment as weights. Noting that our data start in 1975 and the first national recession begins in 1980, we use a 4 year change to minimize loss of observations while still allowing for business cycle frequency lag length.

Table C.1 – Correlation of Predicted Reallocation With Other Variables

	Dependent variable: Bartik reallocation per year					
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: recession-recovery cycles:						
$\Delta \ln e_{t-48,t}$	-0.039 ⁺ (0.021)					-0.0038 (0.0064)
$\Delta \ln l_{t-60,t-12}$		-0.053** (0.018)				-0.012* (0.0056)
$\Delta \ln HPI_{t-48,t}$			0.023 (0.018)			0.012* (0.0049)
Log of mean employment				0.020 (0.016)		0.0017 (0.0033)
Herfindahl at peak					-0.051 (0.032)	-0.0094 (0.0080)
Observations	748	748	748	748	748	748
Panel B: expansion cycles:						
$\Delta \ln e_{t-48,t}$	-0.033 (0.041)					0.010 (0.0065)
$\Delta \ln l_{t-60,t-12}$		0.021 (0.058)				0.0092 (0.0078)
$\Delta \ln HPI_{t-48,t}$			-0.13** (0.037)			-0.025** (0.0043)
Log of mean employment				0.21** (0.043)		0.026** (0.0055)
Herfindahl at peak					-0.13** (0.042)	-0.012* (0.0051)
Observations	557	557	557	557	557	557

Notes: Each dependent and independent variable shown is first regressed on month fixed effects and predicted employment growth and then replaced with the residual from this regression and standardized to have unit variance. Standard errors in parentheses and clustered by CSA-MSA.

the control variables.

Table C.2 – Effects of Reallocation on Employment During Recession-Recovery Cycles

	Dependent variable: annualized peak to trough change in							
	ln e				u			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Right hand side variables:								
Predicted reallocation over cycle	−3.49** (0.79)	−2.89** (0.71)	−3.44** (0.94)	−3.73** (1.03)	0.88** (0.27)	0.93** (0.28)	0.95** (0.31)	1.16** (0.31)
Predicted growth to trough	1.49** (4.08)	1.55** (3.89)	1.39** (3.85)	2.08** (6.17)	−0.50** (1.79)	−0.38* (1.79)	−0.42* (2.13)	−0.44+ (2.86)
Predicted growth over cycle	0.019 (0.49)	−0.39 (0.50)	0.26 (0.90)	−0.58 (0.67)	0.16 (0.20)	0.017 (0.20)	0.023 (0.33)	0.078 (0.29)
$\Delta \ln l_{p-60,p-12}$		−0.049 (0.031)				0.023** (0.0071)		
$\Delta \ln e_{p-48,p}$		0.14** (0.023)				−0.016* (0.0066)		
$\Delta \ln HPI_{p-48,p}$		−6.32** (0.67)				0.98** (0.26)		
Log of mean employment		−0.18** (0.054)				0.055* (0.023)		
Herfindahl at peak		−2.78** (0.70)				0.54+ (0.29)		
National cycle FE	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Other controls	No	Yes	No	No	No	Yes	No	No
Bartik growth quantiles	No	No	Yes	No	No	No	Yes	No
Geographic area FE	No	No	No	Yes	No	No	No	Yes
Pred. reallocation mean	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Pred. reallocation s.d.	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Dep. var. mean	−1.32	−1.32	−1.32	−1.32	1.38	1.38	1.38	1.38
Dep. var. s.d.	2.70	2.70	2.70	2.70	0.96	0.96	0.96	0.96
R^2	0.52	0.63	0.58	0.70	0.57	0.60	0.63	0.77
CSA-MSA clusters	219	219	219	219	219	219	219	219
Observations	748	748	748	748	748	748	748	748

Notes: The dependent variable is the annualized change from the national peak to trough of log QCEW private sector payroll employment (left panel) or the LAUS unemployment rate (right panel). Predicted reallocation is from the national peak to the end of the national recovery. Predicted growth to trough is the Bartik predicted growth from the national peak to the national trough. Predicted growth over cycle is the Bartik predicted growth from the national peak to the end of the national recovery. Other time-varying controls: lagged employment growth; lagged population growth; lagged house price growth; area size, measured by the log of sample mean employment; and the Herfindahl of industry concentration at the cycle start. Standard errors in parentheses and clustered by CSA-MSA. ** indicates significance at the 1% level.

Table C.3 – Effects of Reallocation on Employment During Expansion Cycles

	Dependent variable: annualized 30 month change in							
	ln e				u			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Right hand side variables:								
Predicted reallocation over cycle	0.12 (0.81)	-0.75 (0.97)	-1.44 (1.05)	-0.44 (1.26)	-0.27 (0.22)	-0.13 (0.20)	0.15 (0.28)	-0.31 (0.40)
Predicted growth over cycle	0.019 (0.49)	-0.39 (0.50)	0.26 (0.90)	-0.58 (0.67)	0.16 (0.20)	0.017 (0.20)	0.023 (0.33)	0.078 (0.29)
Predicted growth first 30 months	0.88** (0.20)	0.47** (0.18)	0.94** (0.28)	0.80** (0.26)	0.14+ (0.075)	0.017 (0.070)	0.14 (0.090)	0.18* (0.088)
$\Delta \ln l_{p-60,p-12}$		0.022 (0.040)				0.0019 (0.0070)		
$\Delta \ln e_{p-48,p}$		0.10** (0.020)				0.017** (0.0050)		
$\Delta \ln HPI_{lp-48,lp}$		-3.09** (0.56)				0.55** (0.18)		
Log of mean employment		0.12 (0.081)				-0.0078 (0.018)		
Herfindahl at peak		-0.42 (1.05)				0.19 (0.29)		
National cycle FE	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Other controls	No	Yes	No	No	No	Yes	No	No
Bartik growth quantiles	No	No	Yes	No	No	No	Yes	No
Geographic area FE	No	No	No	Yes	No	No	No	Yes
Pred. reallocation mean	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76
Pred. reallocation s.d.	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Dep. var. mean	2.61	2.61	2.61	2.61	-0.37	-0.37	-0.37	-0.37
Dep. var. s.d.	2.07	2.07	2.07	2.07	0.52	0.52	0.52	0.52
R^2	0.29	0.38	0.38	0.64	0.19	0.30	0.32	0.51
CSA-MSA clusters	218	218	218	218	218	218	218	218
Observations	557	557	557	557	557	557	557	557
$\beta^{\text{recession}}$	-3.37	-2.75	-3.33	-3.64	1.07	1.13	1.08	1.38
P-value:								
$\beta^{\text{expansion}} = \beta^{\text{recession}}$	0.001	0.062	0.164	0.038	0.000	0.001	0.034	0.002

Notes: The dependent variable is the annualized change during the first 30 months of the national expansion of log QCEW private sector payroll employment (left panel) or the LAUS unemployment rate (right panel). Predicted reallocation is over the full expansion. Predicted growth over 30 months is the Bartik predicted growth for the first 30 months of the expansion. Predicted growth over cycle is the Bartik predicted growth over the full expansion. Other time-varying controls: lagged employment growth; lagged population growth; lagged house price growth; area size, measured by the log of sample mean employment; and the Herfindahl of industry concentration at the cycle start. Standard errors in parentheses and clustered by CSA-MSA. The line $\beta^{\text{recession}}$ reports the coefficient from the same specification as the main body of the table but for the first 30 months of a national recession. The line $\beta^{\text{expansion}} = \beta^{\text{recession}}$ reports the p-value from a t-test on predicted reallocation interacted with recession-recovery in a pooled regression including both recession-recovery and expansion episodes and interacting each covariate as well as predicted reallocation with an indicator for recession-recovery or expansion. **, *, + denote significance at the 1%, 5%, or 10% level, respectively.

D. Model appendix

D.1. Retailers

A continuum of retailers buy output from the local wholesaler at competitive price $(1-\nu)P_{a,t}^Q$ and rent capital at real price $(1-\nu)P_{a,t}^K$, where ν is an input-subsidy to offset steady-state distortions.⁴ The j th retailer combines $Q_{a,t}^j$ of wholesale output and capital $K_{a,t}^j$ and produces differentiated output,

$$Y_{a,j,t} = (Q_{a,t}^j)^{1-\alpha^K} (K_{a,t}^j)^{\alpha^K}$$

where α^K is the capital share. This production function implies that the average (and marginal) real cost of production for a firm is

$$\mathcal{M}_{a,t} = (1-\nu)[(\alpha^K)^{-\alpha^K} (1-\alpha^K)^{-(1-\alpha^K)} (P_{a,t}^Q)^{1-\alpha^K} (P_{a,t}^K)^{\alpha^K}].$$

Finally, consumers across all islands combine individual retail goods sold at price $P_{a,j,t}$ such that total output of island a is given by

$$Y_{a,t} = \left[\int_{j=0}^1 Y_{a,j,t}^{\frac{\xi-1}{\xi}} dj \right]^{\frac{\xi}{\xi-1}},$$

implying the demand function

$$Y_{a,j,t} = \left(\frac{P_{a,j,t}}{P_{a,t}} \right)^{-\xi} Y_{a,t},$$

and where $P_{a,t} = \left[\int_{j=0}^1 (P_{a,j,t})^{1-\xi} \right]^{\frac{1}{1-\xi}}$ is the local producer price index.

An individual retailer solves the problem:

$$\max_{\{\bar{P}_{a,j,t}\}_{t=0}^{\infty}} \sum_{a,t=0}^{\infty} m_{a,t} \left[\left(\frac{P_{a,t}}{P_{a,t}^C} \right) \left(\frac{\bar{P}_{a,j,t}}{P_{a,t}} \right)^{1-\xi} - \mathcal{M}_{a,t} \left(\frac{\bar{P}_{a,j,t}}{P_{a,t}} \right)^{-\xi} - \frac{c}{2} \left(\frac{\bar{P}_{a,j,t}}{\bar{P}_{a,j,t-1}} - 1 \right)^2 \right] Y_{a,t}, \quad (\text{D.1})$$

where $\bar{P}_{a,j,t}$ is the nominal reset price. We use price indexation to capture the persistence in

⁴The wholesaler sells to retailers at cost. As in [Woodford \(2003\)](#), we justify this assumption by appealing to a slightly more complicated model in which a continuum of identical wholesalers aggregate industry output and engage in perfect competition in the market to sell to retailers.

inflation in the data and compensate for the absence of (nominal) wage indexation. The first order condition is

$$m_{a,t}Y_{a,t} \left[(1 - \xi) \left(\frac{P_{a,t}}{P_{a,t}^C} \right) \left(\frac{\bar{P}_{a,j,t}}{P_{a,t}} \right)^{1-\xi} + \xi \mathcal{M}_{a,t} \left(\frac{\bar{P}_{a,j,t}}{P_{a,t}} \right)^{-\xi} - c \frac{\bar{P}_{a,j,t}}{\bar{P}_{a,j,t-1}} \left(\frac{\bar{P}_{a,j,t}}{\bar{P}_{a,j,t-1}} - 1 \right) \right] + m_{a,t+1}Y_{a,t+1} \left[c \frac{\bar{P}_{a,j,t+1}}{\bar{P}_{a,j,t}} \left(\frac{\bar{P}_{a,j,t+1}}{\bar{P}_{a,j,t}} - 1 \right) \right] = 0. \quad (\text{D.2})$$

Since this problem is identical for all firms, the reset-prices are the same $\bar{P}_{a,j,t} = \bar{P}_{a,t}$. Further, there is no price dispersion so $P_{a,t} = \bar{P}_{a,t}$ and the home-good price index solves

$$(1 - \xi) \left(\frac{P_{a,t}}{P_{a,t}^C} \right) + \xi \mathcal{M}_{a,t} - c \Pi_{a,t} (\Pi_{a,t} - 1) + c \frac{m_{a,t+1}Y_{a,t+1}}{m_{a,t}Y_{a,t}} \Pi_{a,t+1} (\Pi_{a,t+1} - 1) = 0. \quad (\text{D.3})$$

The absence of price dispersion implies that there is no inefficiency in transforming wholesale output into final output,

$$Y_{a,t} = Q_{a,t}^{1-\alpha^K} K_{a,t}^{\alpha^K}. \quad (\text{D.4})$$

D.2. Trade and market clearing

The local consumption and investment good is a CES aggregate of goods produced in all regions of the currency union:

$$C_{a,t} = \left[\sum_b \tilde{\tau}_{ab,t}^{\frac{1}{\varphi}} C_{ab,t}^{\frac{\varphi-1}{\varphi}} \right]^{\frac{\varphi}{\varphi-1}} \quad I_{a,t} = \left[\sum_b \tilde{\tau}_{ab,t}^{\frac{1}{\varphi}} I_{ab,t}^{\frac{\varphi-1}{\varphi}} \right]^{\frac{\varphi}{\varphi-1}},$$

where $C_{ab,t}$ and $I_{ab,t}$ denote consumption and investment in island a of the composite retail good produced on island b . The law of one price holds, implying the demand functions

$$C_{ab,t} = \tilde{\tau}_{ab,t} \left(\frac{P_{b,t}}{P_{a,t}^C} \right)^{-\varphi} C_{a,t} \quad I_{ab,t} = \tilde{\tau}_{ab,t} \left(\frac{P_{b,t}}{P_{a,t}^C} \right)^{-\varphi} I_{a,t},$$

where $P_{a,t}^C = [\sum_b \tilde{\tau}_{ab,t} (P_{b,t})^{1-\varphi}]^{\frac{1}{1-\varphi}}$ is the local consumer price index. Thus, consumer price indices across islands may differ if the consumption weights $\tilde{\tau}_{ab,t}$ differ as a result of, *inter alia*, home bias in consumption.

Market clearing in the final goods market requires

$$\sum_a (C_{ab,t} + I_{ab,t}) = Y_{b,t} \quad \forall b.$$

D.3. Financial markets

Financial markets are incomplete across areas. The only financial instrument that can be traded is a one-period nominal bond. We let $B_{a,t}$ denote total local holdings of the bond. The nominal interest rate on the bond, $R_t + \tilde{\mu}_{a,t}$, includes a spread $\tilde{\mu}_{a,t}$ over the gross nominal interest rate set by the central bank R_t . We follow [Schmitt-Grohé and Uribe \(2003\)](#) and let the interest rate wedge $\tilde{\mu}_{a,t}$ respond to the local asset position:

$$\tilde{\mu}_{a,t} = \mu_t - \rho_\mu \frac{B_{a,t}}{P_{a,t}},$$

where $\rho_\mu > 0$ but small. This formulation ensures a stationary steady state for local areas under incomplete markets. The component μ_t is exogenous and common to all areas. We use a shock to μ_t to simulate a demand-induced recession.

The per capita nominal domestic net financial asset position then evolves according to:

$$\frac{B_{a,t}}{l_{a,t}} = (1 + R_t + \tilde{\mu}_{a,t} - \lambda_{a,t}^A) dl_{a,t}^{-1} \frac{B_{a,t-1}}{l_{a,t-1}} + \frac{P_{a,t} Y_{a,t}}{l_{a,t}} - \frac{P_{a,t}^C (C_{a,t} + I_{a,t})}{l_{a,t}} + \pi_{a,t-1}^A \sum_{b=1}^A \lambda_{b,t}^A \frac{l_{b,t}}{l_{a,t}} dl_{b,t}^{-1} \frac{B_{b,t-1}}{l_{b,t-1}},$$

where $dl_{a,t} = l_{a,t}/l_{a,t-1}$ denotes gross population growth in area a ($dl_{a,t} = 0$ in our baseline model). Zero net supply of bonds at all times implies the market clearing condition, $\sum_a B_{a,t} = 0$. We set initial bond allocations to zero for all areas, $B_{a,0} = 0 \quad \forall a$.

D.4. Government policy

The central bank follows a standard interest rate rule that obeys the Taylor principle:

$$R_t = \beta^{-1} (\Pi_t^C)^{\phi_\pi}, \quad \phi_\pi > 1,$$

where $\Pi_t^C = \prod_{a=1}^A (\Pi_{a,t}^C)^{\frac{l_{a,t}}{l}}$ is a population-weighted geometric average of local consumer price inflation rates. In the $A = 2$ small-large calibration, the nominal interest rate R_t evolves exogenously with respect to local economic conditions in the small area, $R_t = \beta^{-1} (\Pi_{b,t}^C)^{\phi_\pi}$.

D.5. Household optimization problem

Finally, each island resident has instantaneous utility $u(C_{a,t}/l_{a,t})$, where $C_{a,t}/l_{a,t}$ is consumption per capita. The representative household on an island maximizes the expected discounted sum of total per-period utility accruing to the residents of the island each period and subject to a flow budget constraint:

$$\begin{aligned} & \max \sum_{s=0}^{\infty} D^s l_{a,t+s} u(C_{a,t+s}/l_{a,t+s}) \\ \text{s.t. } & P_{a,t}^C(C_{a,t} + I_{a,t}) + B_{a,t+1} = \sum_i w_{a,i,t} e_{a,i,t} + (l_{a,t} - e_{a,t}) P_{a,t} z + (R_{t-1} + \tilde{\mu}_{a,t-1}) B_{a,t} - T_{a,t} \\ & K_{a,t} = (1 - \delta^K) K_{a,t-1} + I_{a,t} [1 - \Phi(I_{a,t}/I_{a,t-1} - 1)], \end{aligned}$$

where the period utility function takes the form $u(C_{a,t+s}/l_{a,t+s}) = (C_{a,t+s}/l_{a,t+s})^{1-\sigma}/(1-\sigma)$. The first order condition for households defines the island discount factor used in equations (25)–(28) and (D.3):

$$m_{a,t,t+1} = D \frac{u'(C_{a,t+1}/l_{a,t+1})}{u'(C_{a,t}/l_{a,t})} = \frac{R_t + \tilde{\mu}_{a,t}}{\Pi_{a,t}^C}.$$

The optimal investment choices given CEE-type adjustment costs are characterized by:

$$\begin{aligned} 1 &= q_{a,t}^K \left[1 - \Phi' \left(\frac{I_{a,t}}{I_{a,t-1}} - 1 \right) - \Phi \left(\frac{I_{a,t}}{I_{a,t-1}} \right) \right] + m_{a,t,t+1} q_{a,t+1}^K \left[\Phi' \left(\frac{I_{a,t+1}}{I_{a,t}} \right) \left(\frac{I_{a,t+1}}{I_{a,t}} \right)^2 \right], \\ q_{a,t}^K &= P_{a,t}^K + m_{a,t,t+1} q_{a,t+1}^K (1 - \delta), \end{aligned}$$

where $q_{a,t}^K$ is Tobin's q.

We use [Christiano, Eichenbaum, and Evans \(2005\)](#) capital adjustment costs,

$$\Phi \left(\frac{I_{a,t}}{I_{a,t-1}} \right) = \frac{\psi}{2} \left(\frac{I_{a,t}}{I_{a,t-1}} - 1 \right)^2.$$

D.6. Wage Rigidity

We implement the downward nominal wage constraint as follows. We first calculate the Nash-bargain job surplus J^* as

$$J_{a,t}^* = (1 - \beta)(J_{a,t} + W_{a,t} - U_{a,t}).$$

The implied Nash-bargain real wage in each industry is then,⁵

$$w_{a,i,t}^* = p_{a,i,t} - J_{a,t}^* + (1 - \delta)m_{a,t,t+1}J_{a,t+1}.$$

We then check whether this Nash-bargain real wage violates the downward nominal wage constraint,

$$w_{a,i,t} = \max\{w_{a,i,t}^*, (1 - \chi^w) w_{a,i,t-1}/\Pi_{a,t}\}. \quad (\text{D.5})$$

D.7. Calibration

Table D.1 provides a summary of the calibrated parameters and moments matched. The remainder of the section provides details of our calibration.

For convenience we reproduce the key labor market equations (25)–(28) from the text:

$$J_{a,i,t} = (p_{a,i,t} - w_{a,i,t}) + (1 - \delta_t)m_{a,t,t+1}J_{a,i,t+1}, \quad [\text{text eq. (25)}]$$

$$W_{a,i,t} = w_{a,i,t} + m_{a,t,t+1} \left\{ [(1 - \delta_t) + (\delta_t - \lambda_t) f_{a,i,t+1}] W_{a,i,t+1} + (\delta_t - \lambda_t) (1 - f_{a,i,t+1}) U_{a,i,t+1} \right. \\ \left. + \lambda_{a,t}^I \left(\mathbf{E} \max_j \{ (1 - f_{a,j,t+1}) U_{a,j,t+1} + f_{a,j,t+1} W_{a,j,t+1} + \varepsilon_j \} \right) \right\}, \quad [\text{text eq. (26)}]$$

$$U_{a,i,t} = z + m_{a,t,t+1} \left\{ (1 - \lambda_t) [f_{a,i,t+1} W_{a,i,t+1} + (1 - f_{a,i,t+1}) U_{a,i,t+1}] \right. \\ \left. + \lambda_{a,t}^I \left(\mathbf{E} \max_j \{ (1 - f_{a,j,t+1}) U_{a,j,t+1} + f_{a,j,t+1} W_{a,j,t+1} + \varepsilon_j \} \right) \right\}, \quad [\text{text eq. (27)}]$$

$$\kappa = q_{a,i,t} J_{a,i,t}. \quad [\text{text eq. (28)}]$$

Combining equations (26) and (27) provides a useful expression of the surplus to a worker from having a job:

⁵Alternatively, we could implement the Nash solution also at $t+1$, so $w_{a,i,t}^* = p_{a,i,t} - J_{a,t}^* + (1 - \delta)m_{a,t,t+1}J_{a,t+1}^*$. Doing so has negligible impact on our quantitative results.

Table D.1 – Calibrated Parameters

Name	Description	Value	Source
<i>Matching process</i>			
f	Job finding rate	0.5	Monthly job finding rate
q	Job filling rate	0.75	Davis et al. (2013)
δ	Separation rate	0.066	Matched monthly CPS
λ^I	Industry reallocation rate	0.039	Matched monthly CPS
ρ^I	Industry reallocation noise	1.1	Kline (2008), Artuç et al. (2010), symmetry
D	Discount factor	0.9967	4% annual rate
β	Bargaining power	0.6	
χ^w	Downward-wage rigidity	0.0035	Average monthly nominal wage growth
z	Opportunity cost	0.55 p	Chodorow-Reich and Karabarbounis (2016)
<i>Production</i>			
η	Steady-state productivity	$\frac{1}{12}/P^Q$	Annualized MRP $p = 1$
δ^K	Depreciation rate	0.8%	Annual depreciation rate of 10%
α^K	Capital share	0.33	
ψ	Investment adjustment costs	4.4	Christiano et al. (2016)
c	Cost of price adjustment	192.9	Altig et al. (2011)
<i>Preferences</i>			
σ	Inverse IES	0.5	
ζ	Elasticity of substitution over industries	4	Broda and Weinstein (2006)
τ_{ab}	Small area import share	0.3	Nakamura and Steinsson (2014)
φ	Elasticity of home vs foreign goods	2	Nakamura and Steinsson (2014)
<i>Policy</i>			
ϕ_π	Interest rate rule inflation response	2.5	
ν	NFA interest rate response to NFA	0.0001	

$$W_{a,i,t} - U_{a,i,t} = w_{a,i,t} - z + m_{a,i,t} (1 - \delta_t) (1 - f_{a,i,t+1}) (W_{a,i,t+1} - U_{a,i,t+1}). \quad (\text{D.6})$$

We calibrate parameters to a monthly frequency. We set the worker’s bargaining power β to 0.6 based on a matching efficiency of 0.4 and the Hosios condition. We set $D = 0.9967$ for an annual interest rate of 4%. We obtain a target for the steady state job finding rate f appropriate to a two state labor market model of 0.5 by updating the procedure described in Shimer (2012), and for the job filling rate q of 0.75 from Davis et al. (2013). Together these targets determine $\theta = f/q$, which in turn determines matching efficiency $M = f\theta^{\alpha-1}$. We use the longitudinally linked CPS described in appendix E to find a steady state separation rate inclusive of employed-to-employed transitions but exclusive of area movers of 0.062. In our

baseline calibration we abstract from migration, so we slightly adjust upwards total separations to $\delta = 0.066$ to include the incidence of migration in the data from [Kapan and Schulhofer-Wohl \(2017\)](#).⁶ We normalize aggregate $p = 1$ and set annualized z to 0.55, in the range suggested by [Chodorow-Reich and Karabarbounis \(2016\)](#).

We calibrate λ^I as follows. In steady state, there are δe new unemployed each period. The probability of switching industries conditional on a λ^I shock is approximately $(I - 1)/I$, and we take the limit of $\lim_{I \rightarrow \infty} \lambda^I \frac{I-1}{I} = \lambda^I$. Of the newly unemployed,

$$\frac{(\delta - \lambda^I) ef \left[1 + (1 - f) (1 - \lambda^I) + (1 - f)^2 (1 - \lambda^I)^2 + \dots \right]}{\delta ef \left[1 + (1 - f) + (1 - f)^2 + \dots \right]} = \frac{\frac{(\delta - \lambda^I)}{1 - (1 - f)(1 - \lambda^I)}}{\frac{\delta}{1 - (1 - f)}} \quad (\text{D.7})$$

will not switch industries at least once before regaining employment. Thus, the share c of workers who go through an unemployment spell and cross industries is:

$$c = 1 - \frac{\frac{(\delta - \lambda^I)}{1 - (1 - f)(1 - \lambda^I)}}{\frac{(\delta)}{1 - (1 - f)(1)}}$$

which given the values of δ and f described above, can be solved for λ^I . We use the CPS matched basic monthly files, described in appendix E, to find a c of 0.6 across NAICS 3 digit industries between 1994 and 2014, implying $\lambda^I = 0.039$.

We assume that the taste shocks $\varepsilon_{a,j,t}^I$ come from type 1 $\text{EV}(-\rho^I \tilde{\gamma}, \rho^I)$ distribution, where $\tilde{\gamma}$ is Euler's constant,

$$\varepsilon \sim \exp\left(-\frac{\varepsilon + \rho^I \tilde{\gamma}}{\rho^I}\right) \exp\left[-\exp\left(-\frac{\varepsilon + \rho^I \tilde{\gamma}}{\rho^I}\right)\right] \quad (\text{D.8})$$

The parameter ρ^I governs the variance of the taste shock and thus their importance in reallocation decisions. We normalize the mean of the distribution to zero. Standard derivations

⁶The CPS follows addresses rather than households. The longitudinal component therefore does not contain any movers. Thus, the separation rate calculated from the longitudinal component of the CPS is net of individuals who separate from their job and move. Likewise, in choosing the moment in equation (D.14) to compare to CPS data on industry switchers we consider only individuals who complete an employment-unemployment-employment spell within the same geographic area.

imply:

$$\pi_{a,j,t}^I = \frac{\exp\left(\frac{X_{a,j,t+1}}{\rho^I}\right)}{\sum_{i=1}^I \exp\left(\frac{X_{a,i,t+1}}{\rho^I}\right)}, \quad (\text{D.9})$$

where $\pi_{a,j,t}^I$ denotes the probability of moving to industry j conditional on receiving a λ^I reallocation shock, $X_{a,j,t+1} = (1 - f_{a,j,t+1})U_{a,j,t+1} + f_{a,j,t+1}W_{a,j,t+1}$ is the value of searching (net of the taste shock) in industry j . Moreover, using properties of the type 1 EV distribution,

$$\mathbf{E} \max_j \{X_{a,j,t} + \varepsilon_j\} = \rho^I \ln \sum_j \exp\left(\frac{X_{a,j,t}}{\rho^I}\right). \quad (\text{D.10})$$

The parameter ρ^I governs the directedness of search of re-optimizers across industries. When $\rho^I = 0$ then search is fully directed, whereas when $\rho^I \rightarrow \infty$ then search is fully undirected. The standard deviation of the taste shock is equal to $\rho^I \frac{\pi}{\sqrt{6}}$. Papers that have attempted to estimate this parameter come to a wide range of views. For example, [Kline \(2008\)](#) uses an indirect inference procedure to estimate a standard deviation equivalent to about 2.5 weeks of steady state earnings, while [Artuç et al. \(2010\)](#) directly estimate it from data on wages and industry mobility and find a value of 5 years of steady state earnings. We set $\rho^I = 1.1$, implying that a standard deviation of the taste shock corresponds to 1.41 years of steady state earnings. This magnitude is in the bottom half of the range estimated in previous work.

Adding together equations (25) and (D.6), setting the worker's share of match surplus to β , using the free entry condition (28), and the steady state condition $D = m_a$, and dropping t subscripts to denote steady state yields an expression for $\theta_{a,i}$ as an implicit function of parameters and the marginal revenue product $p_{a,i}$:

$$\frac{1}{1 - \beta} \kappa M^{-1} \theta_{a,i}^\alpha = \frac{D^{-1}}{D^{-1} - (1 - \delta)(1 - \beta M \theta_{a,i}^{1-\alpha})} (p_{a,i} - z). \quad (\text{D.11})$$

Given already calibrated $\beta, D, \delta, \lambda, M, \theta, z$, equation (D.11) then determines κ .

We calibrate downward wage rigidity based on the 0.0035% average monthly increase in hourly earnings of production and non-supervisory employees. Given that our model has neither productivity growth nor trend inflation, we set $\chi^w = 0.0035$. This allows nominal wages to fall

by 0.35% each month relative to trend, which corresponds to zero nominal wage growth.

We set Rotemberg price adjustment costs to match the slope of a linearized New Keynesian Phillips Curve in [Altig et al. \(2011\)](#). Their's is a quarterly estimate of 0.014, which we divide by 3 to arrive at a monthly estimate of the slope. We then set c to match the same slope in the linearized model under Rotemberg pricing frictions.

D.8. Solving for steady state

We solve for the steady-state in the currency union with a small member (a) and a much larger member (b).

We first solve for the steady-state of the large (foreign) part of the currency union. With our calibration just described, equation (D.11) provides a one-to-one mapping between $p_{b,i}$ and $\theta_{b,i}$: $\theta_{b,i} = \theta(p_{b,i})$. The steady-state real wage is then

$$w_{b,i} = z + \beta(p_{b,i} - z) \frac{D^{-1} - (1 - \delta)(1 - M\theta_{b,i}^{1-\alpha})}{D^{-1} - (1 - \delta)(1 - \beta M\theta_{b,i}^{1-\alpha})},$$

and the steady-state set of unemployment values solves

$$U_{b,i} = z + \frac{1}{D^{-1}} \left\{ (U_{b,i} + \theta_{b,i}\kappa \frac{\beta}{1-\beta}) + \lambda^I \rho^I \ln \sum_{j=1}^I \exp \left(\frac{U_{b,j} + \theta_{b,j}\kappa \frac{\beta}{1-\beta} - U_{b,i} - \theta_{b,i}\kappa \frac{\beta}{1-\beta}}{\rho^I} \right) \right\},$$

which is I equations for I unknowns. In general, we need a non-linear solver to find $\{U_{b,i}\}_{b,i}$. In the simple symmetric equilibrium we have $U_{b,i} = [zD^{-1} + \theta\kappa\beta/(1-\beta) + \lambda^I \rho^I \ln I]/(D^{-1} - 1)$. Once we have the set of unemployed values for the large part of the currency union, we can also solve for unemployed values of the small member.

In turn we can solve for the remaining value functions and reallocation probabilities:

$$W_{b,i} = \beta(p_{b,i} - z) \frac{D^{-1}}{D^{-1} - (1 - \delta)(1 - \beta M\theta_{b,i}^{1-\alpha})} = \frac{\beta}{1 - \beta} \kappa M^{-1} \theta_{b,i}^\alpha + U_{b,i},$$

$$J_{b,i} = \kappa M^{-1} \theta_{b,i}^\alpha,$$

$$S_{b,i} = J_{b,i} + W_{b,i} - U_{b,i},$$

$$\pi_{bj}^I = \frac{\exp \left(\frac{(1-f_{bj})U_{bj} + f_{bj}W_{bj}}{\rho^I} \right)}{\sum_{k=1}^I \exp \left(\frac{(1-f_{bk})U_{bk} + f_{bk}W_{bk}}{\rho^I} \right)}.$$

It remains to solve for the employment distribution. In steady-state, inflows to each sector have to equal outflows,

$$\lambda_b^I \pi_{b,i}^I \sum_{j=1}^I l_{bj} = \lambda_b^I l_{a,i},$$

which is $I - 1$ linear independent variables that we solve for I unknowns using the adding up condition,

$$\sum_{i=1}^I l_{b,i} = l,$$

where l is the total population of the currency union.

Using the adding up condition $l_{b,i} = u_{b,i} + e_{b,i}$ and the steady state formula for the unemployment rate yields the employment distribution

$$\begin{aligned} x_{b,i} &= \frac{\delta}{M\theta_{b,i}^{1-\alpha} + \delta(1 - M\theta_{b,i}^{1-\alpha})} l_{b,i}, \\ e_{b,i} &= \frac{f_{b,i}}{\delta} x_{b,i}, \\ u_{b,i} &= (1 - f_{b,i})x_{b,i}, \\ v_{b,i} &= \theta_{b,i}x_{b,i}. \end{aligned}$$

The output and marginal product of each industry is then given by,

$$\begin{aligned} Q_{b,i} &= \eta_i e_{b,i}, \\ p_{b,i} &= \eta_i P_{b,i}^Q. \end{aligned}$$

This requires us to solve for the real price $P_{b,i}^Q$ of industry i 's output. It's relative demand is given by,

$$Q_{b,i} = \tau_{b,i} \left(\frac{P_{b,i}^Q}{P_b^Q} \right)^{-\zeta} Q_b$$

where the aggregate price of the DMP good P^Q is determined by the relative cost of capital,

$$q_b^K = 1,$$

$$P_b^K = 1 - \beta(1 - \delta).$$

From the firm's first order condition, the marginal production cost is,

$$\mathcal{M}_b = \frac{\xi - 1}{\xi}$$

which given the relative choices of capital and the DMP good implies,

$$P_b^Q = (1 - \alpha) \left[\frac{\alpha}{1 - \beta(1 - \delta)} \right]^{\frac{\alpha}{1-\alpha}}.$$

This price, combined with total DMP output,

$$Q_b = \left[\sum_i \tau_{b,i}^{\frac{1}{\xi}} (\eta_i e_{b,i})^{\frac{\xi-1}{\xi}} \right]^{\frac{\xi}{\xi-1}},$$

allows us to solve for the marginal product $p_{a,i}$ in each industry.

Finally, we solve for total capital and output,

$$K_b = \frac{\alpha}{1 - \alpha} \left(\frac{P_b^K}{P_b^Q} \right)^{-1} Q_b$$

$$Y_b = Q_b^{1-\alpha} K_b^\alpha.$$

This completes the steady-state solution for the large member of the currency union b . Using this solution we can next compute the steady-state of the small member of the currency union a by repeating the steps above. In doing so, we impose three additional normalization. First, net debt is zero in steady-state $B_a = 0$. Second, relative Pareto weights are proportional to population size,

$$\Omega_{a,b} = \bar{\Omega} \frac{l_a}{l_b}.$$

Third, we solve for $\bar{\Omega}$ such that the relative price of home and foreign goods is 1.

The set of unemployment value functions then solves,

$$U_{a,i} = z + \frac{1}{D-1} \left\{ (U_{a,i} + \theta_{a,i} \kappa \frac{\beta}{1-\beta}) + \lambda^I \rho^I \ln \sum_{j=1}^I \exp \left(\frac{U_{a,j} + \theta_{a,j} \kappa \frac{\beta}{1-\beta} - U_{a,i} - \theta_{a,i} \kappa \frac{\beta}{1-\beta}}{\rho^I} \right) \right\}$$

which is I equations for I unknowns since we have solutions for $U_{b,i}$ and $\theta_{b,i}$.

In turn we can solve for the remaining value functions and reallocation probabilities

$$\begin{aligned}
W_{a,i} &= E_{a,i} + U_{a,i} \\
J_{a,i} &= \kappa M^{-1} \theta_{a,i}^\alpha \\
S_{a,i} &= J_{a,i} + W_{a,i} - U_{a,i} \\
\pi_{a,j}^I &= \frac{\exp\left(\frac{(1-f_{a,j})U_{a,j} + f_{a,j}W_{a,j}}{\rho^I}\right)}{\sum_{k=1}^I \exp\left(\frac{(1-f_{a,k})U_{a,k} + f_{a,k}W_{a,k}}{\rho^I}\right)}
\end{aligned}$$

It remains to solve for the employment distribution. With constant sectoral shares, the distribution of the labor force satisfies,

$$\lambda_a^I \pi_{a,i}^I \sum_{j=1}^I = \lambda_a^I l_{a,i}$$

where we normalize $l_a = 1$. Solving for the remainder of the steady-state proceeds analogously as for the large area.

D.9. Model with geographic mobility

We next describe the labor market in the model with geographic mobility. At the end of period t , employed workers transition into unemployment in their same industry at rate $\delta_t - \lambda_t$. Both unemployed and employed workers receive an industry reallocation shock at exogenous rate $\lambda_{a,t}^I$ and an area reallocation shock at exogenous rate $\lambda_{a,t}^A$, where $\lambda_t = \lambda_{a,t}^I + \lambda_{a,t}^A$. An industry reallocation shock consists of an immediate job separation if previously employed, and a draw of I idiosyncratic taste shocks $\{\varepsilon_j\}_{j=1}^I$ from a distribution $F^I(\varepsilon)$. These taste shocks enter additively into the worker's value function for searching in each sector $j = 1, \dots, I$ in the worker's initial area a . An area reallocation shock has two parts. First, the worker draws A idiosyncratic shocks $\{\varepsilon_b\}_{b=1}^A$ from a distribution $F^A(\varepsilon)$, which enter additively into the worker's value function for searching in area $b = 1, \dots, A$. After choosing a location, she then draws idiosyncratic industry taste shocks $\{\varepsilon_j\}_{j=1}^I$ to determine her new industry. We parameterize $F^I(\varepsilon)$ and $F^A(\varepsilon)$ as Type I EV($-\rho^h \tilde{\gamma}, \rho^h$), where $h \in \{I, A\}$ and $\tilde{\gamma}$ is Euler's constant.

Reallocation shock frequencies $\lambda_{a,t}^A$ may be area-specific. We let $\bar{\lambda}_t^A$ denote the average area reallocation shock across islands. In our calibration, $\lambda_{a,t}^A$ will vary inversely with initial area

size to ensure balanced migration flows in steady state. As a corollary, workers in small areas disproportionately receive taste shocks ε_b , which raises their utility. Offsetting this, residents of area a enjoy an amenity $(\bar{\lambda}_t^A - \lambda_{a,t}^A) (\mathbf{E} \max_b \varepsilon_b)$, where \mathbf{E} denotes the expectation operator and the absence of a time subscript denotes the steady state value, so that the option value of moving does not vary with island size. The assumption that workers receive amenities from living in areas with greater population density has some empirical support (Diamond, 2015).

We denote the transition probability from area a to area b conditional on an area reallocation shock by $\pi_{ab,i,t}^A$ for a worker starting in industry i . Upon entering a new area b , the worker chooses industry j with probability $\pi_{b,j,t}^I$. Area reallocation shocks are then also independent of the worker's employment status, initial area and initial industry, $\pi_{ab,i,t}^A = \pi_{cb,j,t}^A = \pi_{b,t}^A$. We have three laws of motion for the evolution of job seekers, employment, and unemployment:

$$\begin{aligned} x_{a,i,t} &= \delta_{t-1} e_{a,i,t-1} + u_{a,i,t-1} - \lambda_{t-1} l_{a,i,t-1} + \pi_{a,i,t-1}^I \left[\lambda_{a,t-1}^I l_{a,t-1} + \pi_{a,t-1}^A \sum_{b=1}^A \lambda_{b,t-1}^A l_{b,t-1} \right], \\ e_{a,i,t} &= (1 - \delta_{t-1}) e_{a,i,t-1} + f_{a,i,t} x_{a,i,t}, \\ u_{a,i,t} &= (1 - f_{a,i,t}) x_{a,i,t}. \end{aligned}$$

The Bellman equations and free entry condition summarizing the labor market block of the model are now:

$$\begin{aligned} J_{a,i,t} &= (p_{a,i,t} - w_{a,i,t}) + (1 - \delta_t) m_{a,t,t+1} J_{a,i,t+1}, \\ W_{a,i,t} &= w_{a,i,t} + m_{a,t,t+1} \left(\bar{\lambda}_t^A - \lambda_{a,t}^A \right) \left(\mathbf{E} \max_b \varepsilon_b \right) \\ &\quad + m_{a,t,t+1} \left\{ [(1 - \delta_t) + (\delta_t - \lambda_t) f_{a,i,t+1}] W_{a,i,t+1} + (\delta_t - \lambda_t) (1 - f_{a,i,t+1}) U_{a,i,t+1} \right. \\ &\quad \left. + \lambda_{a,t}^I \left(\mathbf{E} \max_j \{ (1 - f_{a,j,t+1}) U_{a,j,t+1} + f_{a,j,t+1} W_{a,j,t+1} + \varepsilon_j \} \right) \right. \\ &\quad \left. + \lambda_{a,t}^A \left(\mathbf{E} \max_b \left\{ \max_j [(1 - f_{b,j,t+1}) U_{b,j,t+1} + f_{b,j,t+1} W_{b,j,t+1} + \varepsilon_j] + \varepsilon_b \right\} \right) \right\}, \\ U_{a,i,t} &= z + m_{a,t,t+1} \left(\bar{\lambda}_t^A - \lambda_{a,t}^A \right) \left(\mathbf{E} \max_b \varepsilon_b \right) \\ &\quad + m_{a,t,t+1} \left\{ (1 - \lambda_t) [f_{a,i,t+1} W_{a,i,t+1} + (1 - f_{a,i,t+1}) U_{a,i,t+1}] \right\} \end{aligned}$$

$$\begin{aligned}
& + \lambda_{a,t}^I \left(\mathbf{E} \max_j \{ (1 - f_{a,j,t+1}) U_{a,j,t+1} + f_{a,j,t+1} W_{a,j,t+1} + \varepsilon_j \} \right) \\
& + \lambda_{a,t}^A \left(\mathbf{E} \max_b \left\{ \max_j [(1 - f_{b,j,t+1}) U_{b,j,t+1} + f_{b,j,t+1} W_{b,j,t+1} + \varepsilon_j] + \varepsilon_b \right\} \right) \Bigg\},
\end{aligned}$$

$$\kappa = q_{a,i,t} J_{a,i,t}.$$

We also assume that the taste shocks $\varepsilon_{a,j,t}^A$ come from type 1 $\text{EV}(-\rho^I \tilde{\gamma}, \rho^A)$ distribution,

$$\varepsilon \sim \exp\left(-\frac{\varepsilon + \rho^A \tilde{\gamma}}{\rho^A}\right) \exp\left[-\exp\left(-\frac{\varepsilon + \rho^A \tilde{\gamma}}{\rho^A}\right)\right]. \quad (\text{D.12})$$

Following the same steps as for the industry taste shocks, we get

$$\pi_{b,t}^A = \frac{\exp\left(\frac{X_{b,t+1}}{\rho^I}\right)}{\sum_{a=1}^A \exp\left(\frac{X_{a,t+1}}{\rho^A}\right)}, \quad (\text{D.13})$$

where $\pi_{b,t}^A$ denotes the probability of moving to area b conditional on receiving a λ^A shock, and $X_{b,t} = \mathbf{E} \max_j [X_{b,j,t+1} + \varepsilon_j]$ is the value of searching (net of the taste shock) in area b .

We calibrate the geographical mobility parameters as follows. We set $\lambda_a^A = 0.004$ in the small area to match the 2.5% average annual migration rate in [Kapan and Schulhofer-Wohl \(2017\)](#). In a steady-state the migration rate must scale inversely with population. Since the large area is infinitely larger than the small area, we set $\lambda_b^A = 0$. However, note that there is still migration from large to small, only that it is finite from the perspective of the small area and infinitesimal from the perspective of the large area. We adjust the incidence of (non-migration) separations, $\delta - \lambda_a^A = 0.062$, so that total separations are unchanged relative to our baseline model, $\delta = 0.066$.

We adjust our calibration procedure for λ^I to account for migration. In steady state, there are $(\delta - \lambda_a^A)e$ new unemployed each period from the current location. The probability of switching industries conditional on a λ_a^I shock is approximately $(I-1)/I$, and we take the limit of $\lim_{I \rightarrow \infty} \lambda^I \frac{I-1}{I} = \lambda^I$. Of the newly unemployed who remain in their same geographic area

throughout their unemployment spell,

$$\frac{(\delta - \lambda_a^A - \lambda_a^I) ef \left[1 + (1-f) \left(1 - \lambda_a^A - \lambda_a^I \right) + (1-f)^2 \left(1 - \lambda_a^A - \lambda_a^I \right)^2 + \dots \right]}{(\delta - \lambda_a^A) ef \left[1 + (1-f) \left(1 - \lambda_a^A \right) + (1-f)^2 \left(1 - \lambda_a^A \right)^2 + \dots \right]} = \frac{\frac{(\delta - \lambda_a^A - \lambda_a^I)}{1 - (1-f)(1 - \lambda_a^A - \lambda_a^I)}}{\frac{(\delta - \lambda_a^A)}{1 - (1-f)(1 - \lambda_a^A)}} \quad (\text{D.14})$$

will not switch industries at least once before regaining employment. Thus, the share c of workers who go through an unemployment spell and cross industries is:

$$c = 1 - \frac{\frac{(\delta - \lambda_a^A - \lambda_a^I)}{1 - (1-f)(1 - \lambda_a^A - \lambda_a^I)}}{\frac{(\delta - \lambda_a^A)}{1 - (1-f)(1 - \lambda_a^A)}},$$

which given the values of δ , λ_a^A , and f described above, can be solved for λ_a^I . We use the CPS matched basic monthly files, described in appendix E, to find a c of 0.6 across NAICS 3 digit industries between 1994 and 2014, implying $\lambda_a^I = 0.037$. Symmetric industry reallocation in steady-state implies $\lambda = \lambda_a^I + \lambda_a^A = \lambda_b^I = 0.041$.

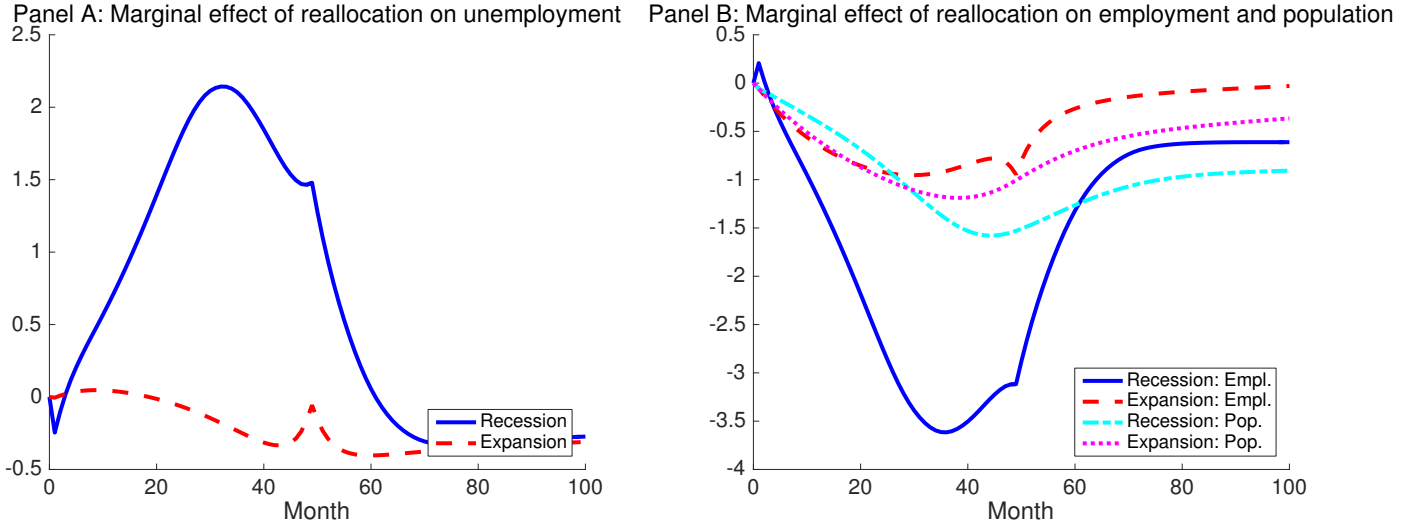
The only estimate of ρ^A of which we are aware comes from [Kennan and Walker \(2011\)](#). Translated into our setting, these authors find a value of ρ^A of about 1.1.

Solving for the steady-state is analogous, except for the following equations for the small area,

$$\begin{aligned} U_{a,i} &= z + \frac{1}{D-1} \left\{ (U_{a,i} + \theta_{a,i} \kappa_{1-\beta}^{\beta}) + \lambda \rho^I \ln \sum_{j=1}^I \exp \left(\frac{U_{a,j} + \theta_{a,j} \kappa_{1-\beta}^{\beta} - U_{a,i} - \theta_{a,i} \kappa_{1-\beta}^{\beta}}{\rho^I} \right) \right. \\ &\quad \left. + (\bar{\lambda}^A - \lambda_a^A) (\rho^A \ln A) + \lambda_a^A \rho^A \ln \sum_{x=a,b} \left[\frac{\sum_{j=1}^I \exp \left([U_{x,j} + \theta_{x,j} \kappa_{1-\beta}^{\beta}] / \rho^I \right)}{\sum_{j=1}^I \exp \left([U_{x,j} - \theta_{x,j} \kappa_{1-\beta}^{\beta}] / \rho^I \right)} \right]^{\frac{\rho^I}{\rho^A}} \right\} \\ \pi_{a,j}^A &= \frac{\exp \left[\frac{\rho^I \ln \sum_{i=1}^I \exp \left([(1-f_{a,j}) U_{a,j} + f_{a,j} W_{a,j}] / \rho^I \right)}{\rho^A} \right]}{\sum_{x=a,b} \exp \left[\frac{\rho^I \ln \sum_{i=1}^I \exp \left([(1-f_{x,j}) U_{x,j} + f_{x,j} W_{x,j}] / \rho^I \right)}{\rho^A} \right]} \\ \lambda l_{a,i} &= \lambda_a^I \pi_{a,i}^I \sum_{j=1}^I l_{a,j} + \pi_{a,i}^I \pi_a^A (\lambda_a^A l_{a,j} + \bar{\lambda}_b) \end{aligned}$$

where $\bar{\lambda}_b$ is the inflow of labor from the large member of the currency union b . Recall that $\bar{\lambda}_b$ is infinitesimal with respect to that area, but it is finite with respect to the size of the small member a . We set $\bar{\lambda}_b = \lambda_a$, so that area a has initial population of $l_a = 1$ in a symmetric

Figure 9 – Model Impulse Response Function and Marginal Effect



Notes: Panels A and B displays the marginal effect of reallocation in recessions and expansions based on equation (33). The marginal effect is the difference in unemployment/employment/population between the high-reallocation and low-reallocation area divided by the difference in predicted reallocation.

equilibrium.

We conduct the same experiment in the model with geographical mobility as before. Figure 9 shows the implies marginal effects of reallocation on unemployment, employment, and population. The marginal effect on unemployment is similar to our baseline model. With migration it peaks at 2.14 compared to 2.3 in the baseline. Migration does amplify the marginal effects on employment and population. At its peak, approximately 38% of the employment response is accounted for by migration. This is consistent with our empirical results in section 4. In footnote 19 we note a coefficient on the labor force of -1.53 and on working-age population of -1.88. This is respectively 44% and 54% of the employment coefficient in column (1) of table 4.

E. CPS Sample Construction

We describe the construction of the dependent variable in table 8. Raw earnings are usual hourly earnings from the Current Population Survey Outgoing Rotation Group (CPS ORG).⁷ For each month from 1979-2014, we construct crosswalk files between the CPS industry variable

⁷We extract the data using the CEPR uniform extracts: Center for Economic and Policy Research. 2015. CPS ORG Uniform Extracts, Version 2.0.1. Washington, DC. <http://ceprdata.org/cps-uniform-data-extracts/cps-outgoing-rotation-group/cps-org-data/>.

and NAICS 2 digit (1983-2014), SIC 2 digit (1979-February 1990) or NAICS 3 digit (March 1990-2014) industries.⁸ We restrict to individuals 16 years of age or older, employed and at work at least 15 hours in the CPS reference week, with an hourly wage of at least one-half the national minimum wage, and not a government employee. For each industry classification, we then regress the log of usual hourly earnings on an exhaustive set of industry categorical variables, state of residence categorical variables, 5 year age bins, educational attainment bins, race bins, an indicator for gender, an indicator for rural area, and categorical variables for occupation. To increase power, we estimate overlapping 5 month regressions allowing for the industry coefficients but not the other covariates to vary by month. We demean the coefficients on the industry categorical variables for the middle month and refer to the demeaned coefficients as the industry wage premia for that month. We then append the industry wage premia across months to create time series of the wage premia and take 13 month centered moving averages to remove seasonal effects and noise. The difference between the moving average of the premium in the first and last month of the episode is the dependent variable in table 8.

We next describe our construction of the longitudinal component of the basic monthly CPS used in section 5.3. The CPS employs a rotating sample, wherein a selected address will participate in the survey for four consecutive months, not participate for eight months, and then reenter the sample for four more months. We use the longitudinal linkage file constructed by IPUMS and described by [Drew, Flood, and Warren \(2014\)](#) to match individual records across months. The CPS implemented referenced-based interviewing as part of the 1994 survey redesign. Of particular relevance, rather than asking all respondents the full set of employment status questions each month, respondents not in an incoming rotation group (i.e. not in their first or fifth month in the sample) and employed in the previous month first get asked whether they have changed employer (question Q25-CK) or job duties (question Q25DEP-2,3). Those reporting no change in employer or job duties have a number of fields automatically carried forward from the previous month, including industry of employment. Likewise, unemployed respondents have their previous industry carried forward if applicable; other unemployed re-

⁸Crosswalk files available from the authors upon request.

spondents (except new entrants) report the industry of their previous place of employment. The adoption of reference-based interviewing sharply reduced the number of respondents reporting a change of industry each month. As a result, we restrict our sample to the post-1994 redesign period. We use the set of respondents not in an incoming rotation group in the reference or previous month in the longitudinally-linked CPS to obtain job finding rates, job separation rates, and the fraction of spells beginning and ending with employment which involve a change in NAICS 3 digit industry.⁹ We again use our constructed CPS-NAICS 3 crosswalk to map CPS industries into NAICS 3 digit industries.

⁹We follow [Fallick and Fleischman \(2004\)](#) in discarding respondents in rotation groups 2 and 6 to correct for rotation group bias known to affect incoming rotation groups.

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