Spatial Consumption Risk Sharing

Prateek Arora, Dongwan Choo, Chenyue Hu

UC Santa Cruz

Motivation

Research Question

How does geography affect cross-region consumption comovement?

Answer

Through three potential channels: trade, migration, and finance.

Example: Wyoming

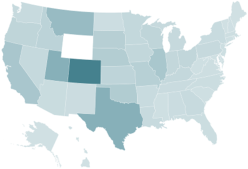


Figure: Trade

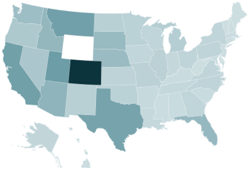


Figure: Migration

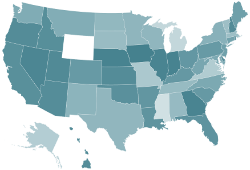
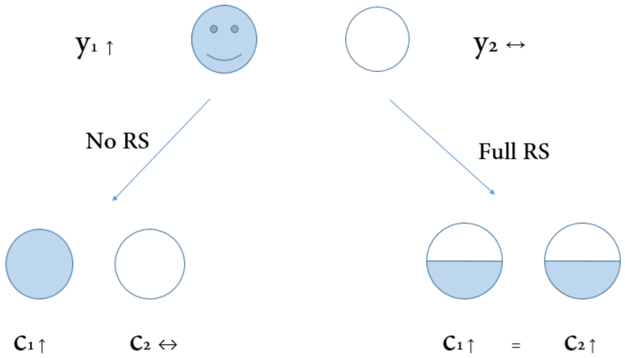


Figure: corr(consumption)

Note: bidirectional trade and migration flows, and correlation of consumption per capita between Wyoming (white) and other states over 1997-2019

Consumption Risk Sharing (RS)



Preview of Results (I)

Empirical Analysis

Analyze US state-level data over 1977-2019

- Establish a gravity model of consumption RS
- Use 2006 North Dakota's oil shock as an event study

Theoretical Framework

Develop a two-economy real business cycle model (BKK) with three channels of RS subject to frictions

- Identify the roles of trade, finance, and migration in facilitating RS
- Examine the interplay of channels in jointly influencing consumption

Preview of Results (II)

Quantitative Assessment

Calibrate a multi-region DSGE framework to the US data

- Quantify bilateral frictions and verify covariance with geography
- Conduct counterfactual analyses to disentangle impacts of frictions
- Explore implications for fiscal transfers to reduce consumption disparity caused by frictions

Related Literature

- International risk sharing:
  Obstfeld and Rogoff (2000), Corsetti, Dedola and Leduc (2008), Kalemli-Ozcan et al. (2003), Fitzgerald (2013)
  This paper proposes a comprehensive framework with multiple channels of RS.
- Intranational risk sharing:
  Asdrubali, Sorensen and Yosha (ASY) (1996), Del Negro (2002), Storesletten et al. (2004), Heathcote et al. (2014)
  This paper emphasizes influences of bilateral ties shaped by geography.
- Quantitative spatial models:
  Redding and Rossi-Hansberg (2017), Caliendo, Dvorkin, and Parro (2018), House et al. (2018)
  This paper adds a finance channel and embeds a portfolio choice problem.

Outline

Bilateral Consumption Risk Sharing

- Measure: ASY(1996) — response of relative consumption growth to output growth

$$\Delta \log c_{i,t} - \Delta \log c_{j,t} = \alpha_{ij} + \beta_{ij}(\Delta \log y_{i,t} - \Delta \log y_{j,t}) + \epsilon_{ij,t}.$$

  - c: consumption per capita, y: output per capita
  - Higher β_{ij} suggests weaker RS
  - No RS: β_{ij} = 1, perfect RS: β_{ij} = 0
- Covariance with geography:

$$\hat{\beta}_{ij} = \alpha + \gamma \log(dist_{ij}) + \Gamma X_{ij} + \nu_{ij}.$$

The US State-level Data

- Real GSP, consumption, and population (1977-2019)
  - Constructed consumption by rescaling state-level retail sales by country-level consumption to retail sales ratio
  - Source: Regional Economic Accounts from BEA
- Consumption Price index
  - Source: State-level inflation series from Nakamura and Steinsson (2014) for 1966-2008 and Regional Price Parities (RPP) from BEA for 2008-2019
- Inter-state geographic distance
  - Calculated with state capitals' longitude/latitude using the Haversine formula
  - Also considered shipment distance from CFS
- Inter-state bilateral flows
  - Migration: Tax information from IRS
  - Trade: Commodity Flows Survey (CFS)

Two-stage regression on RS

1. First stage

$$\Delta \log c_{i,t} - \Delta \log c_{j,t} = \alpha_{ij} + \beta_{ij}(\Delta \log y_{i,t} - \Delta \log y_{j,t}) + \epsilon_{ij,t}.$$

- β_{ij}: Risk-sharing coefficient between two states

	Mean	Std. Dev.	Median	Obs.
$\hat{\beta}_{ij}$	0.515	0.292	0.501	1,225

2. Second stage

$$\widehat{\beta}_{ij} = \alpha + \gamma \left(\log dist_{ij}\right) + \Gamma X_{ij} + \nu_{ij}.$$

- $dist_{ij}$: Geographic distance
- X_{ij}: Gravity control variables
- Hypothesis: $\gamma > 0$

Spatial Pattern of Risk Sharing

Dep. Var: $\hat{\beta}_{ij}$	(1)	(2)	(3)	(4)
$\log(d_{ij})$	0.151 ***	0.156 ***	0.220 ***	0.211 ***
	(0.010)	(0.010)	(0.012)	(0.012)
$\log(\bar{y}_i \cdot \bar{y}_j)$		-0.099 ***	-0.061 *	0.052
		(0.032)	(0.035)	(0.038)
Land Area			-0.038 ***	-0.022 ***
			(0.006)	(0.006)
Mainland			0.117 ***	0.079 ***
			(0.025)	(0.024)
Coastal			0.018	0.023 *
			(0.014)	(0.014)
Contiguity			0.128 ***	0.102 ***
			(0.033)	(0.033)
Number of Neighboring States			-0.002	-0.005
			(0.004)	(0.004)
Industrial Dissimilarity (Ind_{ij})				-5.480 ***
				(0.754)
Political Dissimilarity (Pol_{ij})				0.069 **
				(0.032)
Observations	1225	1225	1225	1225
R^2	0.161	0.169	0.255	0.288

An Event Study: ND Oil Shock

- North Dakota (ND)'s surprising discovery of oil in 2006
- We use the natural experiment to examine spatial characteristics of bilateral linkages:

$$X_{ijt} = \alpha_0 + \alpha_1 \mathrm{Oil}_t + \sum_{m=1}^{T} \alpha_{2m} \mathrm{Oil}_{t-m} + \alpha_3 \log(dist_{ij}) + \sum_{n=0}^{T} \alpha_{4n} \mathrm{Oil}_{t-n} \times \log(dist_{ij}) + \alpha_{5t} I_t + \epsilon_{ijt}.$$

- Dependent variable X_{ijt} (all demeaned over time) includes
  - ND's migration inflows ($\log(mig_{ijt})$), trade inflows ($\log(trd_{ij})$),
  - ND's relative consumption growth $\Delta c_{ijt} \equiv \Delta \log c_{it} - \Delta \log c_{jt}$,
  - and that adjusted for output growth $\Delta \tilde{c}_{ijt} \equiv (\Delta \log c_{it} - \Delta \log c_{jt}) - (\Delta \log y_{it} - \Delta \log y_{jt})$
- Oil_t: shock dummy, I_t time FE

Bilateral Linkages after the Oil Shock

	(1)	(2)	(3)	(4)
Dep. Var:	$\log(mig)$	$\log(trd)$	Δc	$\Delta\tilde{c}$
Oil_t	0.124		-0.009	0.014
	(0.465)		(0.049)	(0.054)
$\sum_{m=1}^{T} Oil_{t-m}$	-0.974	1.883 *	-0.045	0.098
	(0.599)	(0.967)	(0.077)	(0.063)
$\log(dist)$	0.013	0.012	-0.002	-0.001
	(0.014)	(0.075)	(0.002)	(0.002)
$\sum_{n=0}^{T} Oil_{t-n} \times \log(dist)$	-0.394 ***	-0.578 *	0.049 ***	0.040 **
	(0.146)	(0.325)	(0.017)	(0.017)
Observations	1,360	244	1,372	1,372
R^2	0.645	0.657	0.650	0.676

- The finding suggests imperfect consumption RS potentially through channels influenced by geography.

Outline

Introduction

Empirical Motivation

Theory

Quantitative Analysis

Conclusion

Model

Setup: A mass of households reside in I regions with bilateral goods, migration, and capital flows

- They supply labor and spend on consumption in their region of residence every period

$$U_{i,t} = \frac{c_{i,t}^{1-\sigma}}{1-\sigma} - \kappa \frac{l_{i,t}^{1+\eta}}{1-\eta}$$

- Region i's aggregate budget constraint

$$P_{i,t}C_{i,t} + P_{Ii,t}I_{i,t} + \sum_{j}^{I} B_{ji,t+1} = w_{i,t}L_{i,t} + \sum_{j}^{I} e^{-f_{ji}} R_{j,t}B_{ji,t},$$

Notations: Price of consumption (investment) P_i (PI_i), Bilateral asset holdings B_{ji} with returns R_j subject to asset transaction costs $e^{-f_{ji}}$, $L_{i,t} = N_{i,t}l_{i,t}$ labor hours

- Consumption evenly distributed among its current residents

$$C_{i,t} = c_{i,t} \times N_{i,t}$$

Commodity Market

- Each region produces a traded good and a non-traded good using Cobb-Douglas technology

$$Y_{i,t}^{s} = A_{i,t}(K_{i,t}^{s})^{\alpha}(L_{i,t}^{s})^{1-\alpha}, s \in (T, N)$$

- Consumption and investment composition

$$C_{i,t} = (C_{i,t}^{T})^{\nu}(C_{i,t}^{N})^{1-\nu}, \qquad I_{i,t} = (I_{i,t}^{T})^{\nu_I}(I_{i,t}^{N})^{1-\nu_I}$$

- Tradables are CES bundles of intermediate goods sourced from different regions subject to bilateral trade costs τ_{ij}

$$X_{i,t}^{T} = C_{i,t}^{T} + I_{i,t}^{T} = [\sum_{j}^{I}(X_{ji,t}^{T})^{\frac{\theta-1}{\theta}}]^{\frac{\theta}{\theta-1}}$$

- Bilateral trade flows:

$$X_{ij,t}^{T} = (\frac{\tau_{ij}p_{i,t}}{P_{j,t}^{T}})^{1-\theta}P_{j,t}^{T}X_{j,t}^{T}$$

Labor Market

- At the end of every period, a household derives an idiosyncratic benefit ϵ from being in *i* and decides where to live next.
- ϵ, iid over time and space, is drawn from an extreme-value distribution with 0 mean (Artuc et al (2010))
- households' value of being in region *i*

$$\begin{aligned} V_{i,t} &= U_{i,t} + \beta E(V_{i,t+1}) \\ &+ \underbrace{\sum_{j}^{I} \int (\bar{\epsilon}_{ij,t} + \epsilon_{jt}) f(\epsilon_j) \Pi_{k \neq j} F(\bar{\epsilon}_{ij,t} - \bar{\epsilon}_{ik,t} + \epsilon_{jt}) d\epsilon_j}_{\Omega(\epsilon_i)} \end{aligned}$$

  where cutoff benefit $\bar{\epsilon}_{ij,t} \equiv \beta[E(V_{j,t+1}) - E(V_{i,t+1})] - d_{ij}$ given a non-pecuniary migration cost d_{ij}
- Share of population moving from *i* to *j* at *t*

$$m_{ij,t} = \frac{exp(\bar{\epsilon}_{ij,t}/\nu)}{\sum_k^I exp(\bar{\epsilon}_{ik,t}/\nu)}$$

Financial Market

Assets

- Dividend as capital income net of investment expenditure:

$$D_{i,t} = \alpha p_{i,t} Y_{i,t} - P_{Ii,t} I_{i,t}$$

- Return: $R_{i,t} = \frac{q_{i,t}+D_{i,t}}{q_{i,t-1}}$

  Notations: α capital share in production, $p_{i,t}$ and $Y_{i,t} = Y_{i,t}^T + Y_{i,t}^N$ are price and quantity of output, $P_{Ii,t} I_{i,t}$ investment expenditure, $q_{i,t}$ asset prices

Holders

- A mutual fund in each region i that represents local households
- A household has the right to an equal share of the fund as long as it resides there
- A household is myopic and lets the mutual fund construct portfolios

$$E_t\left[\frac{U'(c_{i,t+1})}{P_{i,t+1}} R_{i,t+1}\right] = E_t\left[\frac{U'(c_{i,t+1})}{P_{i,t+1}} e^{-f_{ji}} R_{j,t+1}\right], \forall j \in [1, \mathcal{I}]. \qquad (1)$$

Financial Market

Frictions

- Form: a transaction cost f_{ij} on foreign returns
  Alternatively, information frictions; Okawa and van Wincoop (2012) show their comparability
- Literature: Heathcote and Perri (2004), Tille and van Wincoop (2010)
- Magnitude: second-order (i.e. proportional to variance of shocks)

Solution Method

- Solving portfolio choice embedded in a DSGE framework
- Literature: Devereux and Sutherland (2008)
- Main idea: 2nd-order approximation of Euler equations + 1st-order approximation of other equations $\Rightarrow$ a zero-order (steady-state) portfolio

Calibration

Parameter	Description	Value	Source
	(I)		
β	Annual discount factor	0.95	
σ	Coefficient of relative risk aversion	1	Macroeconomic
δ	Capital depreciation	0.06	Literature
η	Inverse of elasticity of labor supply	0.5	
	(II)		
ν	Weight of tradables in consumption	0.31	Johnson (2017)
ν_I	Weight of tradables in investment	0.40	Bems (2008)
α	Capital intensity in production	0.41	BEA
θ	Elasticity of trade	4	Simonovska and Waugh (2014)
ϕ	Elasticity of migration	4.5	Artu et al. (2010)
	(III)		
ρ	Persistence matrix of productivity	$\begin{bmatrix} 0.65 & 0.06 \\ 0.04 & 0.53 \end{bmatrix}$	Estimated from GA and OH's TFP
Σ	Covariance matrix of shocks	$\begin{bmatrix} 1.21 & 1.25 \\ 1.25 & 2.56 \end{bmatrix}$ e−4	
	(IV)		
τ	Trade cost	1.031	Calibrated to match GA and OH's mean
d	Migration cost	19.58	export-to-output, emigrant-to-population,
f	Financial cost	3e-5	and consumption comovement

Model Fit

Table: Contemporaneous Correlations of Variables

	Model	Data
	(I) Cross-state Correlation	
Output $\rho(Y_1, Y_2)$	0.85	0.84
Consumption $\rho(C_1, C_2)$	0.79	0.78
Output per capita $\rho(y_1, y_2)$	0.84	0.88
Consumption per capita $\rho(c_1, c_2)$	0.82	0.82
	(II) Correlation with Self Output	
Consumption per capita $\rho(c, y)$	0.95	0.91
Net exports $\rho(NX/Y, Y)$	-0.04	-0.03
Population $\rho(N, Y)$	-0.01	-0.02

Dynamics after $A_1 \uparrow$

Figure: Cross-state Comparison of Impulse Response Functions

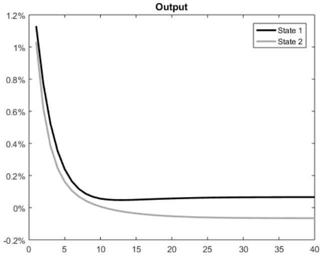


Figure: Output

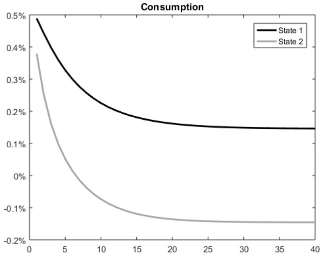


Figure: Consumption

Figure: Impulse Response of State 1’s Macroeconomic Variables

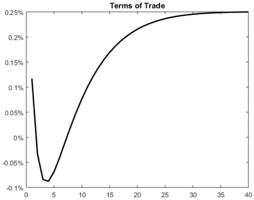


Figure: Terms of Trade

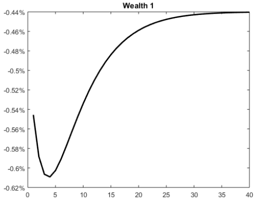


Figure: External Wealth

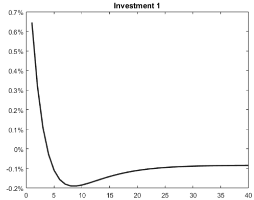


Figure: Investment

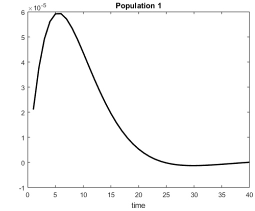


Figure: Population

Figure: Consumption under Different Trade Costs

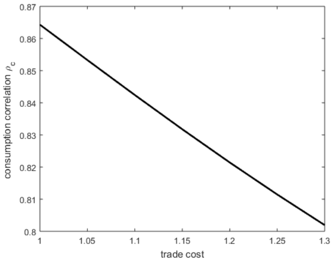


Figure: $\rho(c_1, c_2)$

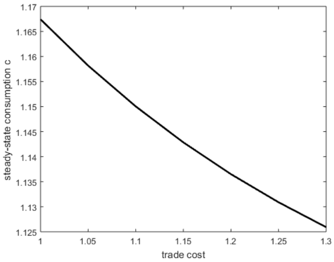
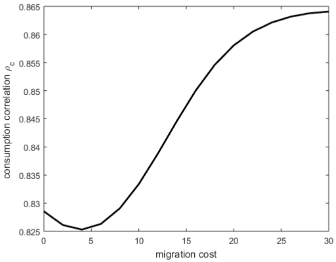


Figure: $\bar{c}_i$

Figure: Consumption under Different Migration Costs



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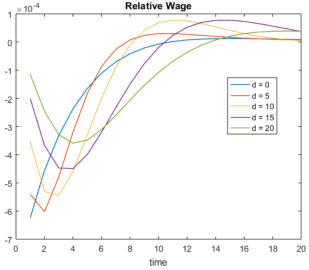
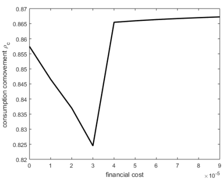


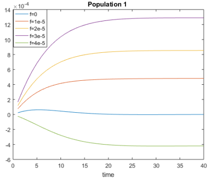
Figure: IRF of relative $w = \frac{w_1}{w_2}$

$$A_1 \uparrow \Rightarrow \begin{cases} \text{Trade} & p_1 \downarrow & \Rightarrow w_1 \downarrow & \\ \text{Migration} & L_1 \uparrow & \Rightarrow w_1 \downarrow & \text{Limited by high } d \\ \text{Investment} & R_1 \downarrow & \Rightarrow I_1 \downarrow & \Rightarrow c_1 \uparrow \end{cases}$$

Higher migration costs may raise consumption synchronization.

Figure: Consumption under Different Financial Frictions





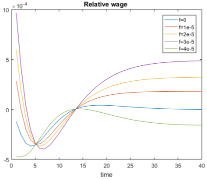


Figure: $\rho(c_1, c_2)$ **Figure:** population 1 **Figure:** relative w

$$A_1 \uparrow \Rightarrow \begin{cases} \text{Trade} & p_1 \downarrow & \Rightarrow w_1 \downarrow & \\ \text{Finance} & wealth_1 \uparrow & \Rightarrow l_1 \uparrow & \Rightarrow c_1 \downarrow \\ \text{Migration} & L_1 \downarrow & \Rightarrow c_2 \uparrow & \end{cases}$$

Higher financial frictions raise consumption synchronization and redirect migration.

Outline

Introduction

Empirical Motivation

Theory

Quantitative Analysis

Conclusion

Extended Model

Develop a trilateral framework consisting of a state pair and the rest of economy (ROE) from the pair's perspective

Calibration for each of the 1225 trilateral economy

- Obtain population, degree of consumption RS, covariance of productivity shocks, net asset positions from data
- Calculate empirical moments as targets: bilateral trade shares (π), migration shares (m), and risk sharing (β)
- Estimate trade costs (τ), migration costs (d), financial frictions (f) to match moments

Model Fit

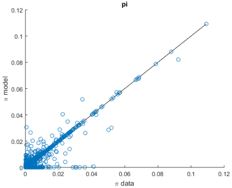


Figure: Trade

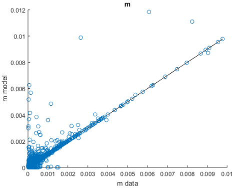


Figure: Migration

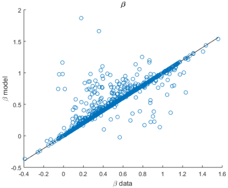


Figure: RS

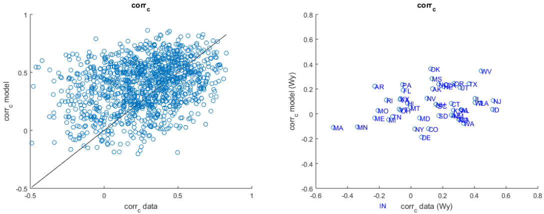


Figure: Consumption Correlation

Example: Wyoming

Figure: Wyoming's Estimated Frictions with Other States

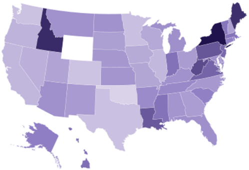


Figure: Trade

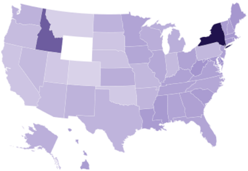


Figure: Migration

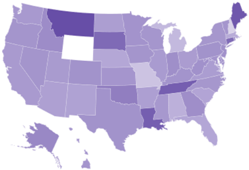


Figure: Finance

Bilateral frictions and Geographic Distance

Dep. Var: Est. Frictions	$\log(\hat{\tau}_{ij})$	$\log(\hat{d}_{ij})$	$\log(\hat{f}_{ij})$
$\log(dist_{ij})$	0.525 ***	0.100 ***	0.232 **
	(0.047)	(0.01)	0.097
Observations	2442	2442	2226
R^2	0.041	0.023	0.003

Robust standard errors in parentheses. *** significant at 1%, ** significant at 5%.

Table: Estimated Financial Frictions and Banking Linkage

Dep. Var: Est. Frictions $\log(\hat{f}_{ij})$	(1)	(2)
Branches	-5.7e-04***	
	(1.1e-04)	
Deposits		-6.8e-09***
		(1.6e-09)
Observations	2442	2442
R^2	0.001	0.001

The number of bank branches, and the dollar amount of deposits collected by financial institutions, located in i and headquartered in j, are based on FDIC.

Counterfactual Bilateral Linkages

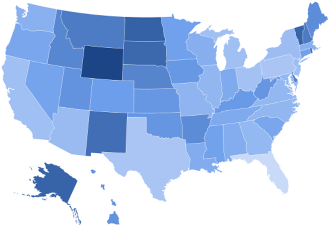
	(I). With Friction		(II). Without Friction	
	Mean	Median	Mean	Median
Trade	0.0061	0.0030	0.4411	0.4557
Migration	0.0008	0.0005	0.4910	0.4920
Finance	0.1633	0.1745	0.2326	0.2392

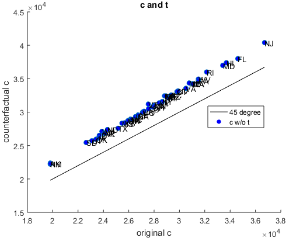
This table reports the counterfactual bilateral trade, migration, and asset shares across all the state pairs.

	Org	No τ	No d	No f
ρ_c	0.4010	0.7354	0.3953	0.4293

ρ_c: bilateral consumption correlation, β_c: degree of risk sharing $1-\beta$, both median values across state-pairs

Counterfactual Consumption without Trade Costs





Note: This figure plots the ratio of counterfactual to original level of consumption per capita in the steady state of the economy.

Counterfactual Consumption without Migration Costs

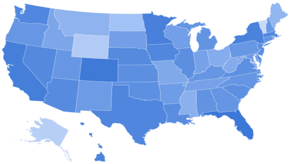
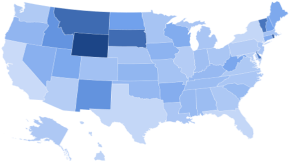


Figure: c



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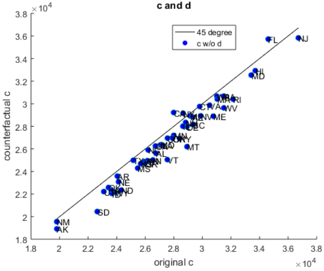


Note: This figure plots the ratio of counterfactual to original level of consumption per capita in the steady state of the economy.

Implications for Fiscal Transfers

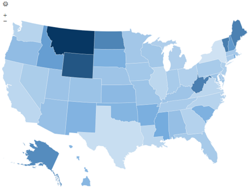
Compute fiscal transfers that undo impacts of frictions

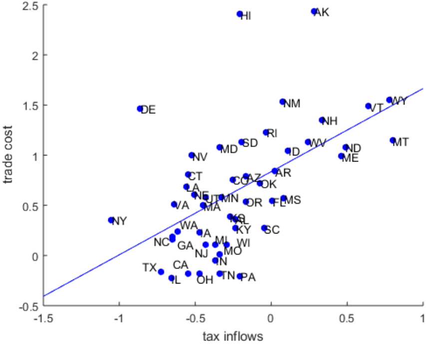
- Step 1. Calculate the policy's targeted moment under counterfactual scenarios
- Step 2. Loop over a grid of tax transfers T given each
- Step 3. Solve the real side of the economy under the counterfactual frictions and new budget constraint
- Step 4. Solve portfolio choice under the new wealth constraint

$$\mathcal{W}_{i,t+1} = R_{\mathcal{I},t}\mathcal{W}_{i,t} + \sum_{j}^{\mathcal{I}} \alpha_{j,i,t}(R_{j,t} - R_{\mathcal{I},t}) + p_{i,t}\sum_{s} Y_{is,t} + T_i - P_{i,t}C_{i,t} - P_{Ii,t}I_{i,t}$$

- Step 5. Calculate the model-implied moment of interest and compare it to the target from step 1
- Step 6. Repeat 2-5 until the two moments converge

Optimal Tax Transfers under Trade Costs





Outline

Conclusion

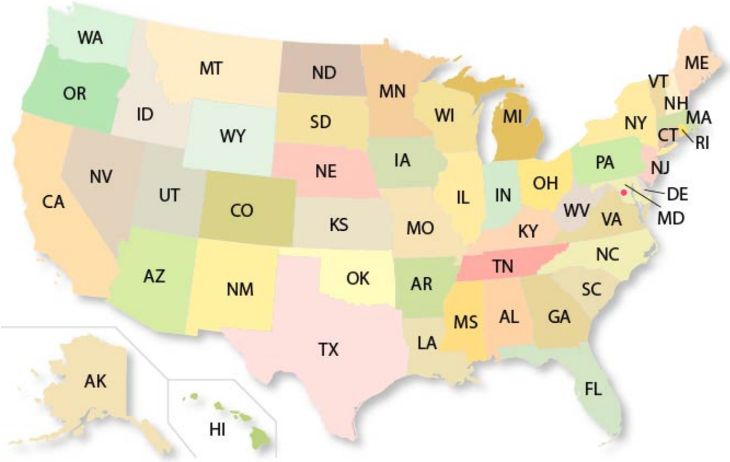
Summary

- Empirically establish a gravity model of consumption RS
- Build a theoretical framework incorporating three channels
- Quantify the magnitude and impact of frictions

Future Research

- Add New Keynesian ingredients
- Compare Intra- versus Inter-national RS

US State Map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Gravity Model of Risk Sharing – Alternative Data Sources

Dep. Var.: $\hat{\beta}_{ij}$	A. CPI by Hazell et. al.			B. Consumption from BEA		
	(1)	(2)	(3)	(4)	(5)	(6)
$\log(d_{ij})$	0.119 ***	0.123 ***	0.155 ***	0.041 ***	0.043 ***	0.049 ***
	(0.017)	(0.017)	(0.022)	(0.004)	(0.005)	(0.006)
$\log(\bar{y}_1 \cdot \bar{y}_2)$		-0.035	-0.160 **		-0.037 ***	-0.057 ***
		(0.064)	(0.074)		(0.013)	(0.015)
$\log(\sigma(y_1) \cdot \sigma(y_2))$			0.152 ***			0.032 ***
			(0.055)			(0.011)
$\log(\bar{N}_1 \cdot \bar{N}_2)$			0.024 ***			-0.013 ***
			(0.013)			(0.003)
Obs.	528	528	528	1225	1225	1225
R^2	0.077	0.077	0.102	0.056	0.061	0.090

Robust standard errors in parentheses. *** significant at 1%.

Gravity Model of Risk Sharing – Alternative β and distance

	A. Adjusted $\hat{\beta}_{ij}$			B. Alternative Distance		
	(1)	(2)	(3)	(4)	(5)	(6)
$\log(d_{ij})$	0.147 ***	0.151 ***	0.168 ***	0.154 ***	0.158 ***	0.168 ***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
$\log(\bar{y}_1 \cdot \bar{y}_2)$		-0.083 ***	-0.108 ***		-0.089 ***	-0.108 ***
		(0.034)	(0.037)		(0.032)	(0.037)
$\log(\sigma(y_1) \cdot \sigma(y_2))$			0.016			0.016
			(0.023)			(0.023)
$\log(\bar{N}_1 \cdot \bar{N}_2)$			0.028 ***			0.028 ***
			(0.005)			(0.005)
Obs.	1,225	1,225	1,225	1,225	1,225	1,225
R^2	0.148	0.153	0.178	0.163	0.169	0.186

Robust standard errors in parentheses. *** significant at 1%.