

## Quantifying the Losses from International Trade

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## Big Picture: The Backlash Against Trade

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Hard to deny that the benefits of globalization have been under attack.

A popular narrative. . .

- Large rise in import penetration from China in early/mid 2000's.
- A deteriorating trade deficit, i.e. imports did not arrive with corresponding export opportunities  $\Rightarrow$  negative affects on the US labor market.
- [Autor, Dorn, and Hanson \(2013\)](#) evidence seems supportive. . . Chinese import exposure lead to:
  - Drops in labor earnings,
  - Decreases in labor force participation (and take up of transfer payments),
  - Little out-migration (at least in the short/medium run).

## This Paper: How Much Do the Losers Lose From Trade?

This paper: Use theory + data to measure the aggregate and welfare effects of a trade shock.

Two important model elements:

1. Dynamic, Ricardo-Viner trade model. Similar to [Kambourov \(2009\)](#), [Artuç et al. \(2010\)](#), [Caliendo et al. \(2015\)](#).
  2. Households face incomplete markets, but can partially self insure as in the standard incomplete market model.
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1. allows our model to speak directly to the ADH evidence and then aggregate.
  2. makes the normative implications more nuanced...
    - large (or small) welfare losses by the inability to smooth out shocks,
    - appropriate policy interventions, e.g. [Lyon and Waugh \(2018\)](#).

## This Paper: How Much Do the Losers Lose From Trade?

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Our approach. . .

1. Show that our model lines up with the empirical approach of ADH.
2. Calibrate the model to match ADH evidence.
3. Hit the model with a “China Shock”.
  - A pure trade shock, i.e. lower the cost to import goods.

Ask and answer several questions:

- The aggregate effects of the China **Trade** Shock? labor supply  $\uparrow$ , output  $\uparrow$ , consumption  $\nearrow$ , trade deficit  $\downarrow$ .
- How much did the losers lose from trade? Large losses in labor market 2-3 $\times$  average; In welfare terms, very few actually lose.

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## Model

## Model: Overview

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**Time:** Discrete time, infinite horizon.

- We'll drop time subscripts unless necessary.

**Domestic Geography:** A continuum of "islands" indexed by  $\omega \in [0, 1]$ .

On an island  $\omega$ ...

- Competitive producers on an island produce intermediate good  $\omega$ .
- Households living on  $\omega$  can work for those producers on the island.

**International Trade:** Focus on a Small Open Economy, where world prices for an island's intermediate good follow an exogenous, stochastic process.

## Model: Production

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Island level intermediate good production:

$$q(\omega) = z(\omega)\ell.$$

Productivity  $z$  evolves according to:

$$\log z_{t+1} = \phi_z \log z_t + \epsilon_{t+1}$$

where  $\epsilon_{t+1} \sim \mathcal{N}(0, \sigma_\epsilon)$ .  $\epsilon_{t+1}$  is independent across time and goods/islands.

Intermediate goods are aggregated according to:

$$Q = \left[ \int_0^1 q(\omega)^\rho d\omega \right]^{\frac{1}{\rho}},$$

where  $\theta = \frac{1}{1-\rho}$  is the elasticity of substitution.



## Model: Trade

Focus on a Small Open Economy (SOE). World prices for intermediate good  $\omega$  evolve according to:

$$\log p_w(\omega)_{t+1} = \phi_w \log p_w(\omega)_t + \epsilon_{w,t+1}$$

where  $\epsilon_{w,t+1} \sim \mathcal{N}(0, \sigma_w)$ .  $\epsilon_{w,t+1}$  is independent across  $t$ , goods, and  $z$  shocks.

Trade is subject to iceberg trade cost:

- To ship internationally, produce  $\tau > 1$  to deliver one unit.

Intermediate goods can be non-traded, imported, or exported. International arbitrage  $\Rightarrow$  domestic prices must lie between

$$\left[ \frac{p_w(\omega)_t}{\tau_{ex}}, \tau_{im} p_w(\omega)_t \right],$$

and where the domestic price lies must be consistent with the pattern of trade.

## Model: Households

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Unit mass of households. Individual households **live and work** on islands.

Individual households have preferences:

$$E \sum_{t=0}^{\infty} \beta^t \left\{ \log(c_t) - B \frac{h_t^{1-\gamma}}{1-\gamma} + \nu_t^i \right\}$$

- $c_t$  is consumption of the final good,
- $h_t$  is hours worked.
- $\nu_t^i$  is i.i.d. preference shock, where  $i$  corresponds with the choice to move or not. Distributed Type 1 extreme value with scale parameter  $\sigma_\nu$ .

## Model: Households' Choices

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Island level state:  $\mathbf{s} = \{ z, p_w \}$ . Households can...

### 1. Work or not...

- Constrain the choice of labor units to be  $h \in \{0, \bar{h}\}$ .
- If a household works, receive island level wage:  $w(\mathbf{s})$ .
- If a household does not work, it receives home production:  $w_h$ .

### 2. Stay or move...

- By paying  $m > 0$  in units of the final good, households migrate and move to a new island.
- Moving households arrive at a random island.

### 3. Save or borrow...

- Accumulate a non-state contingent asset  $a$  that pays gross return  $R$ .
- Face a lower bound on asset holding  $-\bar{a}$ .

## Equilibrium: Overview

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**A Stationary Small Open Economy (SSOE) Equilibrium.** Given world prices  $\{p_w, R\}$ , a stationary Small Open Economy Equilibrium is domestic prices  $\{p(\mathbf{s})\}$ , policy functions  $\{g_a(\mathbf{s}, a, \nu), \iota_n(\mathbf{s}, a, \nu), \iota_m(\mathbf{s}, a, \nu)\}$ , and a probability distribution  $\lambda(\mathbf{s}, a, \nu)$  such that

- i Firms maximize profits; policy functions solve the household's problem;
- ii Demand for the final and intermediate goods equals production;
- iii The distribution  $\lambda(\mathbf{s}, a, \nu)$  is a stationary distribution.

The basic idea. . .

1. Households' consumption/savings, work, and moving decisions determine goods demand and labor supply.
2. Bounds on international arbitrage + firm optimization determine goods supply and labor demand.

Need **1.** and **2.** to be consistent.

## Model Properties

## Island-Level Trade

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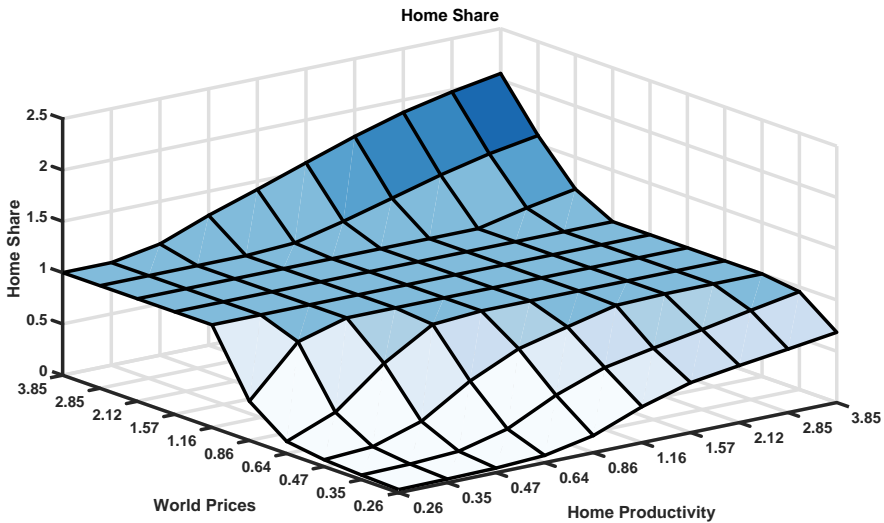
To understand the pattern of trade across islands define the following statistic:

$$\omega(\mathbf{s}) := \frac{p(\mathbf{s})z\mu(\mathbf{s})\bar{h}}{p(\mathbf{s})z\mu(\mathbf{s})\bar{h} + p(\mathbf{s})\text{imports}(\mathbf{s}) - p(\mathbf{s})\text{exports}(\mathbf{s})},$$

- Numerator is national production of an islands variety.
- Denominator is national consumption of that variety.

Essentially, this is the micro-level analog of the “home share” summary statistic emphasized in [Arkolakis et al. \(2012\)](#).

## Home Share $\omega(\mathbf{s})^{\frac{1}{\theta}}$ Across Islands



## Island-Level Trade and Wages

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**Trade exposure and wages:** Real wages on an island with state  $\mathbf{s}$  equal

$$w(\mathbf{s}) = \omega(\mathbf{s})^{\frac{1}{\theta}} \hat{\mu}(\mathbf{s})^{\frac{-1}{\theta}} z^{\frac{\theta-1}{\theta}} C^{\frac{1}{\theta}}.$$

where

$$\omega(\mathbf{s}) := \frac{p(\mathbf{s})z\mu(\mathbf{s})\bar{h}}{p(\mathbf{s})z\mu(\mathbf{s})\bar{h} + p(\mathbf{s})\text{imports}(\mathbf{s}) - p(\mathbf{s})\text{exports}(\mathbf{s})},$$

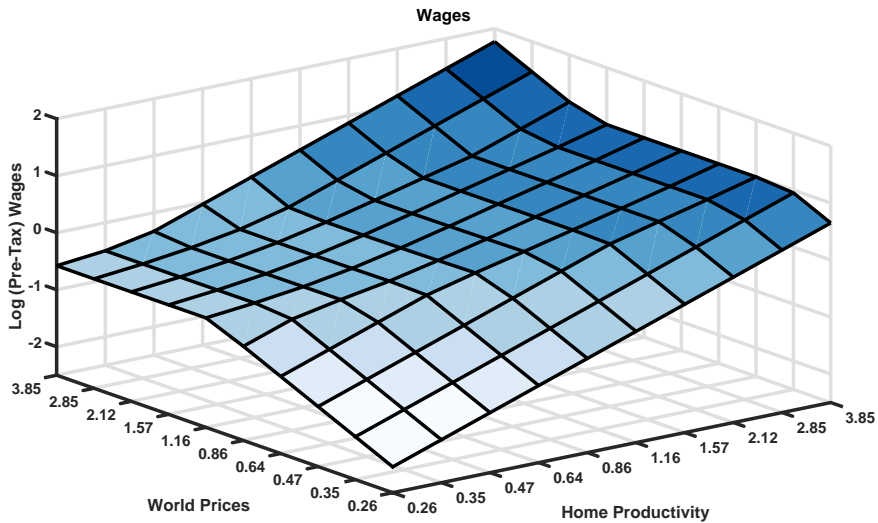
which is the “home share” and  $\hat{\mu}(\mathbf{s}) = \frac{\mu(\mathbf{s})\bar{h}}{\pi(\mathbf{s})}$  is workers per market.

A smaller home share (**larger import exposure**) implies that wages are **lower** with elasticity  $\frac{1}{\theta}$ . The economics are easy to understand. . .

- More imports  $\Leftrightarrow$  lower prices;  $\Rightarrow$  lower wages
- CES tightly connects the price with the home share and  $\theta$ .



## Real Wages Across Islands



## Connecting Our Model with ADH's Empirical Approach

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**ADH Empirical Approach:** Relate changes in labor earnings in a market to changes in import exposure

$$\Delta \log w(\mathbf{s}) = \frac{1}{\theta} \underbrace{\Delta \log (\omega(\mathbf{s})/\hat{\mu}(\mathbf{s}))}_{\text{trade exposure}} + \underbrace{\frac{1}{\theta} \Delta \log C}_{\gamma_t} + \underbrace{\Delta \log \left( z^{\frac{\theta-1}{\theta}} \right)}_{\epsilon_{s,t}}.$$

Highlights the empirical challenges of ADH:

- Issue #1: Shocks  $z$  are unobserved, but correlated with trade.
  - ADH's solution—use another country's imports as an instrument—is a valid IV strategy within our model. . .
- Issue #2: Aggregate effects,  $\Delta \log C$  not observed, absorbed into  $\gamma_t$ .

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Motivates our calibration strategy...

- ADH are “identifying” the  $\theta$  which controls the pass through of trade shocks into wages.
- So we will ask our model to match this moment.

## Quantitative Results

## Calibration Overview

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Pre-determined parameters: discount factor, interest rate.

Remaining parameters picked to match moments in beginning and ending stationary equilibrium and on transition path.

The moments. . .

- LFP, migration rate, hh net worth, std. of wage growth, persistence of comparative advg.
- long run trade elasticity,
- **ADH wage and nlfp elasticities, GLM migration elasticity.**

The nature of the shock behind the transition path:

- Unanticipated, new future path of  $\tau_{im}$ ; linear decrease from  $\tau_{im}$  to  $\tau'_{im}$  over five years to match rise in import penetration between 2002 and 2007.

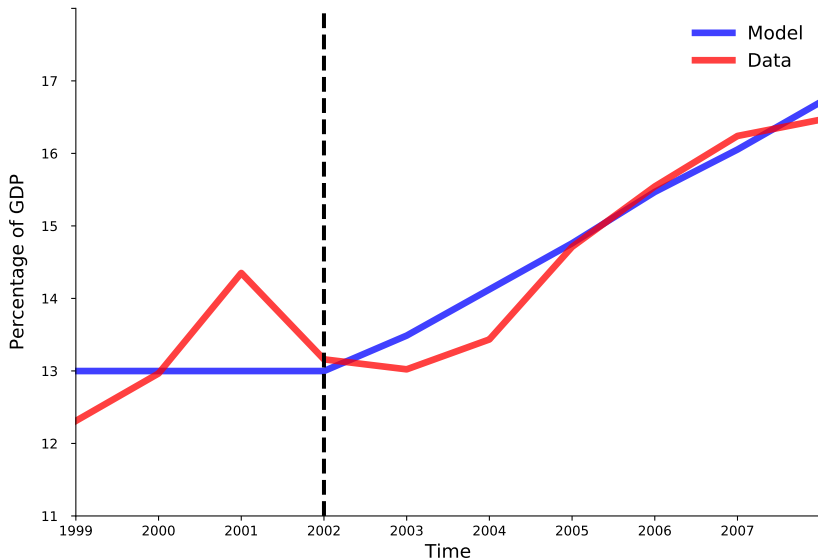
## Calibrated Parameters: SE Moments and Parameters

Parameter	Value	Target	Data	Model
Disutility of work, $B$	1.05	Aggregate participation rate	66	66
Migration Cost, $m$	2.46	CMZ. migration rate	3	3
Borrowing Limit, $-\bar{a}$	0.65	Net worth, bottom 40 percentile	0	0
Pre-China Trade Cost ( $\tau_{ex}, \tau_{im}$ )	1.31	1990s Imports/GDP	13	13
Post-China Trade Cost ( $\tau'_{im}$ )	1.37	2007 Imports/GDP	16.2	15.4
Autocorr. $z, p_w$ ( $\phi$ )	0.98	Exports in top 5% in $t + 20$	40	40
Std. Dv. of $z$ ( $\sigma_z$ )	0.032	Var. in Log CMZ earnings	0.037	0.037
Std. Dv. of $p_w$ ( $\sigma_w$ )	0.07	Trade Elasticity	4	4.6

**Note:** Migration cost and borrowing limit parameters are reported as a fraction of output per worker.

## Calibration: The Trade Shock...

Imports / GDP



## Calibration: ADH Diff-in-Diff Moments and Parameters

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	$\Delta$ Labor Earnings	$\Delta$ NILF	GLM $\Delta$ Population
Data	-4.30 [-6.62, -2.00]	1.11 [0.52, 1.72]	-1.43 [-3.33, 0.48]
Model	-5.66	1.15	-1.57
	Demand elasticity $\theta$	Home production $w_h$	Moving shock variance $\sigma_\nu$
Parameter Values	10.062	0.18	0.95

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**Note:** Values in brackets report 95-5 confidence intervals. [Greenland et al. \(2017\)](#) (GLM) replace ADH regional controls with lagged population growth at the commute zone level.

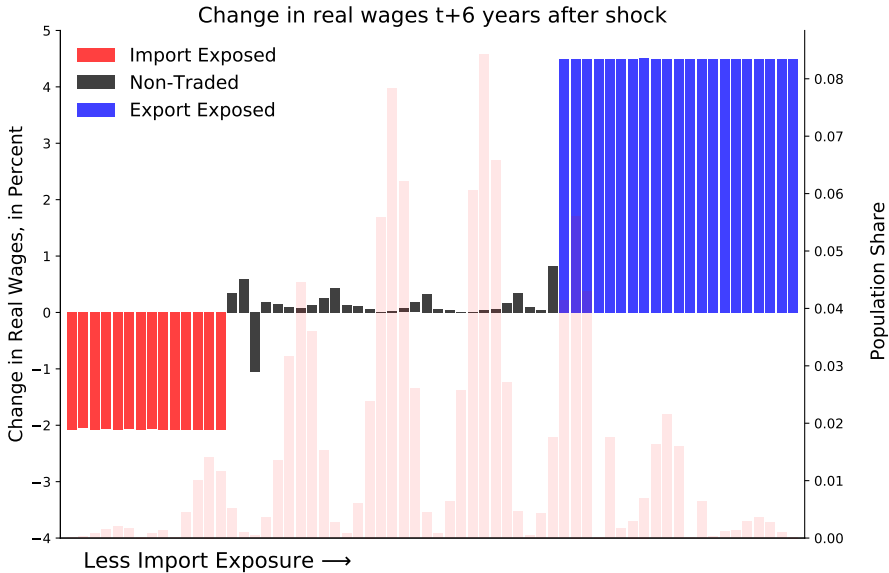


## Walking Through the Results...

We will proceed in three steps...

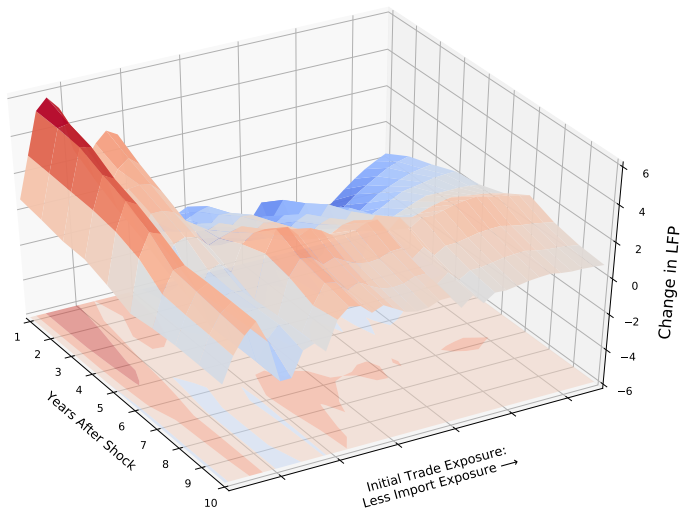
1. What happens at the household/island-level in reaction to the shock?
2. What happens at the aggregate level?
3. What are the welfare consequences?

# Micro I: Real Wages Across Islands After the Shock



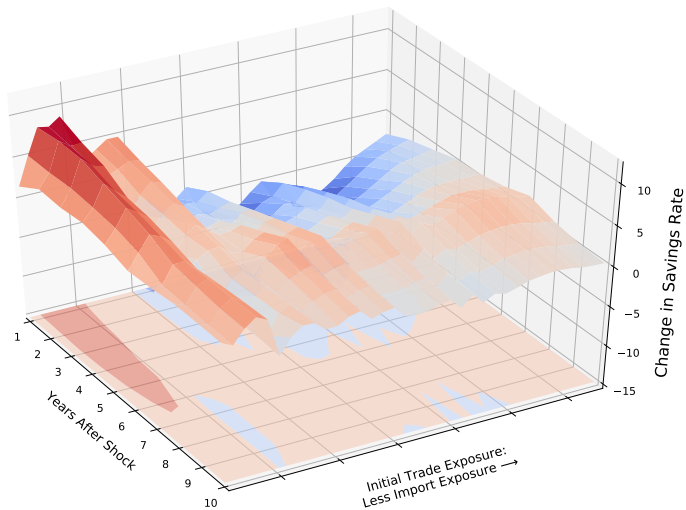
## Micro II: Labor Supply, Across Islands, Overtime

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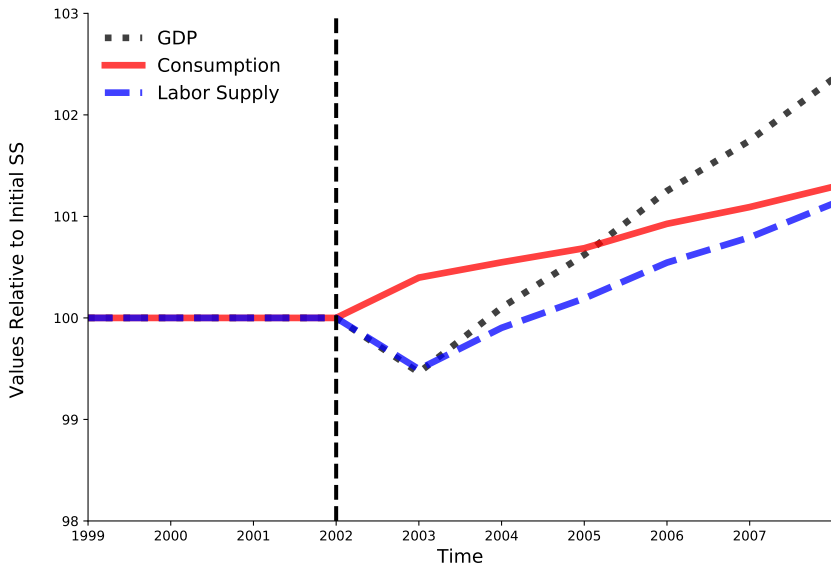
## Micro III: Savings Rates, Across Islands, Overtime

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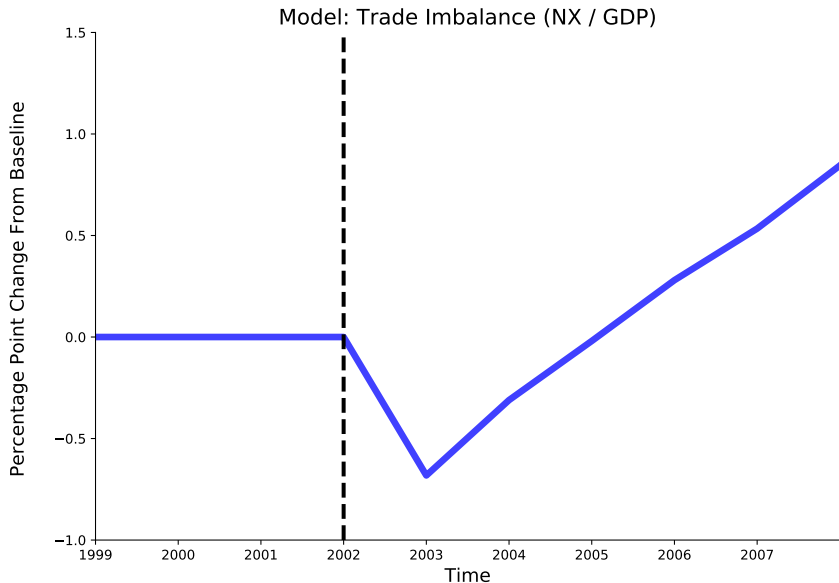
## Macro I: Aggregate Consumption, Labor Supply, Output

Model: GDP, Consumption, and Labor Supply



## Macro II: The Trade Deficit

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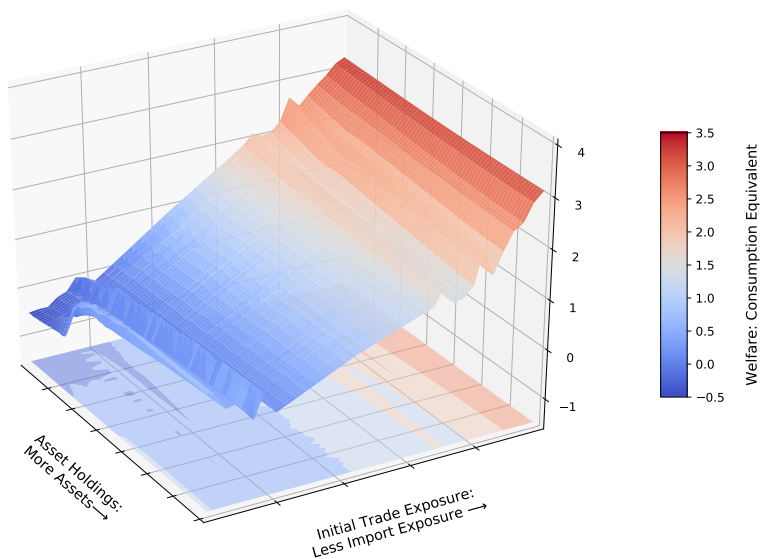
## Welfare and Real Wages

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		Welfare (Baseline)	$\Delta$ Real Wages
Initial Exposure	Import Exposed	0.09 [ 0.05 ]	-2.55 [ 0.05 ]
	Non-Traded	0.71 [ 0.70 ]	0.18 [ 0.70 ]
	Export Exposed	2.12 [ 0.25 ]	5.45 [ 0.25 ]
Average		1.02	1.26

**Note:** Welfare values are lifetime consumption equivalents; values in brackets report the initial share of the population in that category.

## Welfare Across Islands and Asset States





## Final Thoughts

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Ok, so what have we learned?

Standard neoclassical model of trade/labor markets/consumption-savings behavior matching ADH diff-in-diff evidence. . .

Consistent with ADH narrative—trade had large impacts on the labor market.

Yet, naive extrapolations about the aggregate effects are **completely wrong**.

- Aggregate labor supply and output (wages) move in the **opposite direction** as diff-in-diff estimates.

Why? Because forward-looking households adjust to the shock. . .

⇒ welfare losses from the China shock are small; most gain.

## References I

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- ARKOLAKIS, C., A. COSTINOT, AND A. RODRÍGUEZ-CLARE (2012): "New Trade Models, Same Old Gains?" *American Economic Review*, 102, 94–130.
- ARTUÇ, E., S. CHAUDHURI, AND J. McLAREN (2010): "Trade shocks and labor adjustment: A structural empirical approach," *The American Economic Review*, 100, 1008–1045.
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- LYON, S. AND M. WAUGH (2018): "Redistributing the Gains From Trade Through Progressive Taxation," .

## Role of the ADH Evidence. . .

		2×ADH Cal. (-8.60, 4.74)		Baseline (-4.30, 10.15)	
		Welfare	Δ Log Wages	Welfare	Δ Log Wages
Initial Exposure	Import Exposed	-0.06 [ 0.21 ]	-3.00 [ 0.21 ]	0.18 [ 0.07 ]	-2.32 [ 0.07 ]
	Non-Traded	0.73 [ 0.33 ]	0.00 [ 0.33 ]	0.74 [ 0.68 ]	0.23 [ 0.68 ]
	Export Exposed	1.71 [ 0.46 ]	3.50 [ 0.46 ]	1.65 [ 0.25 ]	4.38 [ 0.25 ]
Average		0.91	1.01	0.94	0.94

**Note:** Welfare values are lifetime consumption equivalents; values in brackets report the share of the population in that category. First two columns are from a calibration targeting a ADH wage elasticity of -8.60.

## Motivating Evidence

Basic idea: Relate changes in labor-market outcomes across US local labor markets to changes in exposure to Chinese imports.

Mechanically, construct the following:

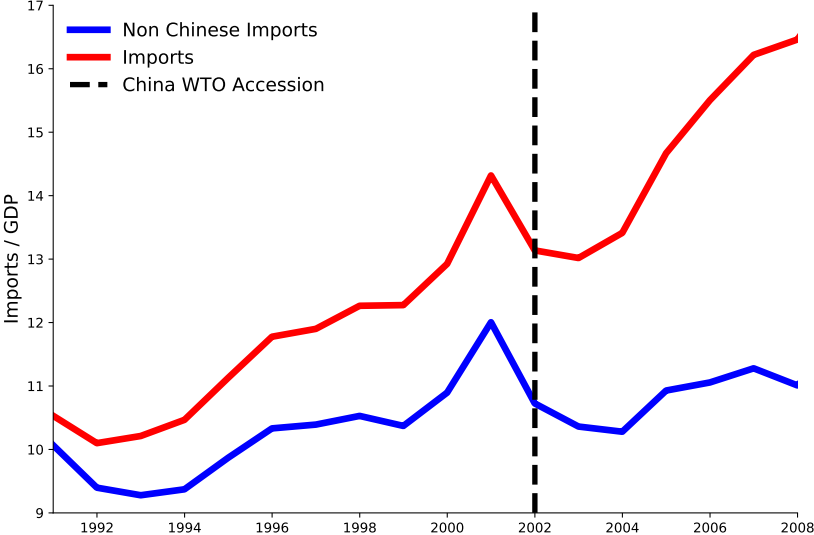
$$\Delta IPW_{uit} = \sum_j \left( \frac{L_{ijt}}{L_{it}} \right) \left( \frac{\Delta M_{ucjt}}{L_{ijt}} \right)$$

And project labor-market outcomes on  $\Delta IPW_{uit}$ .

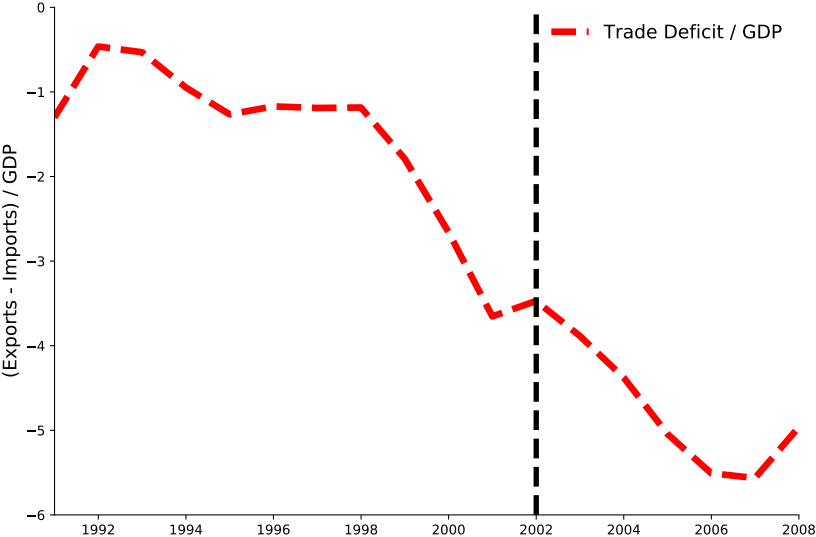
Lots of notation here:

- $uc = US$ ,  $j = \text{industry}$ ,  $i = \text{commute zone}$
- $M_{ucjt} = \text{US imports in industry } j \text{ at time } t$ .
- $L_{ijt} = \text{Labor in commute zone } i, \text{ industry } j, \text{ at time } t$ .

# US Data: Rising Import Penetration... Almost all from China



# US Data: The Trade Deficit



### Labor Market Outcomes and Trade Exposure

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	$\Delta$ Labor Earnings	$\Delta$ NILF
Standardized $\Delta$ IPW	-4.30 [-6.62, -2.00]	1.11 [0.52, 1.72]

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**Note:** Values in brackets report 95-5 confidence intervals.  $\Delta$  Labor Earnings is average household “wage and salary” income per adult; units are in decadal, percent changes.  $\Delta$  NILF corresponds to the change in the not in labor force share.  $\Delta$  IPW is standardized by netting out the mean and dividing by the standard deviation.



### Migration and Trade Exposure

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	ADH $\Delta$ Population	GLM, $\Delta$ Population
Standardized $\Delta$ IPW	-0.05 [-1.51, 1.41]	-1.43 [-3.33, 0.48]

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**Note:** Values in brackets report 95-5 confidence intervals. [Greenland et al. \(2017\)](#) (GLM) replace ADH regional controls with agged population growth at the commute zone level.

## Calibration: Pre-determined Parameters

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Pre-determined parameters. . .

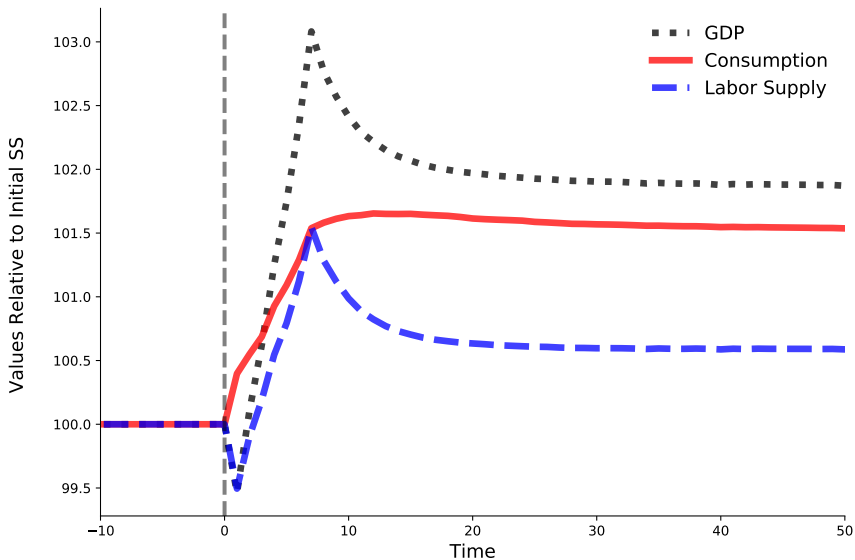
Parameter	Value
Discount Factor, $\beta$	0.95
World Interest Rate, $R$	1.02

The nature of the shock(s):

- Unanticipated, future path of trade costs is changed.
- Linearly decrease from  $\tau_{im}$  to  $\tau'_{im}$  over five years.

## Long Run: Aggregate Consumption, Labor Supply, Output

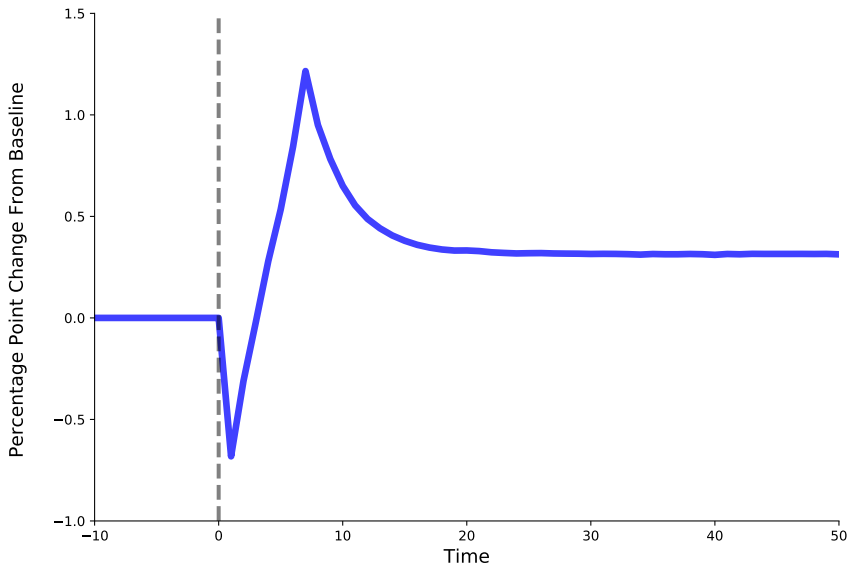
Model: GDP, Consumption, and Labor Supply



## Long Run: The Trade Deficit

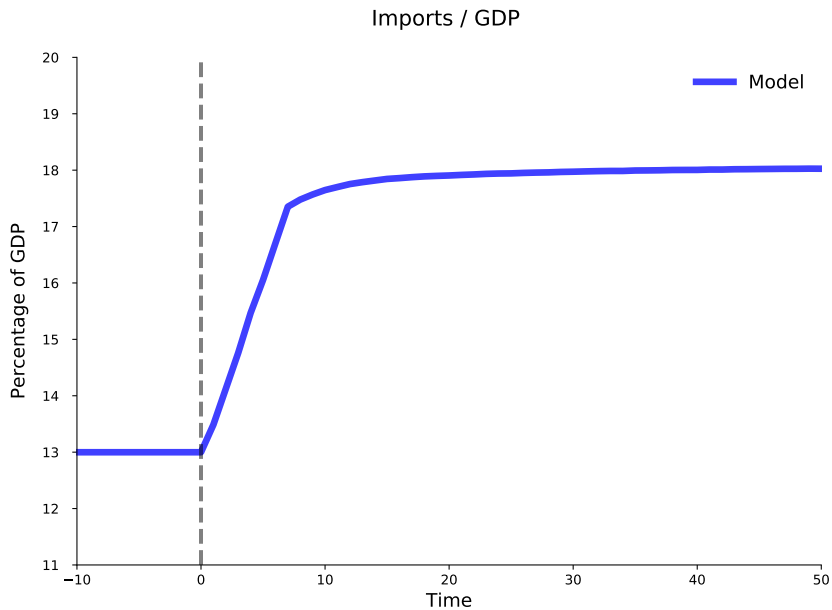
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Model: Trade Imbalance (NX / GDP)

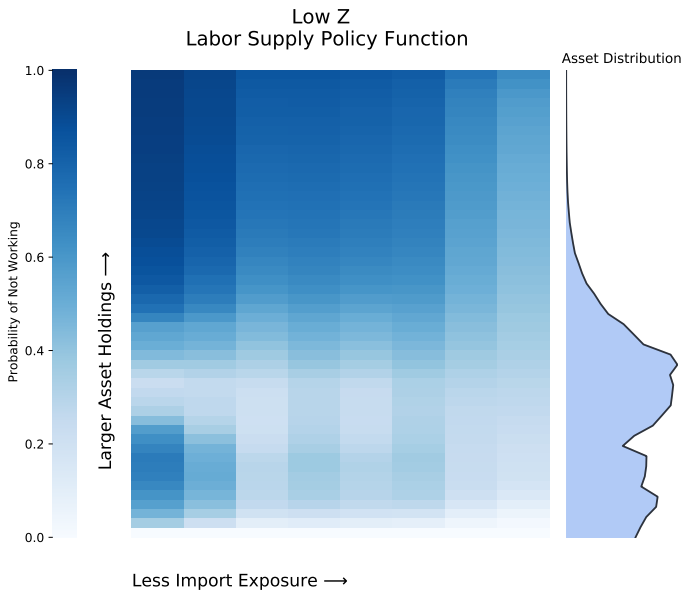


## Long Run: Trade

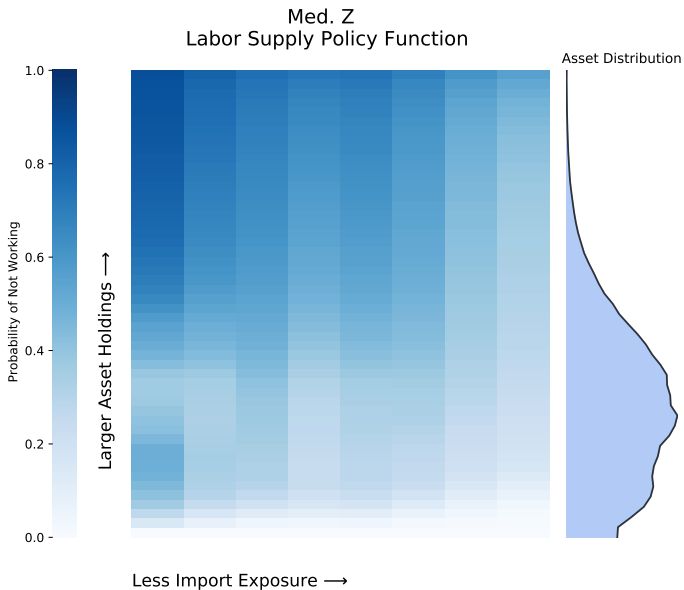
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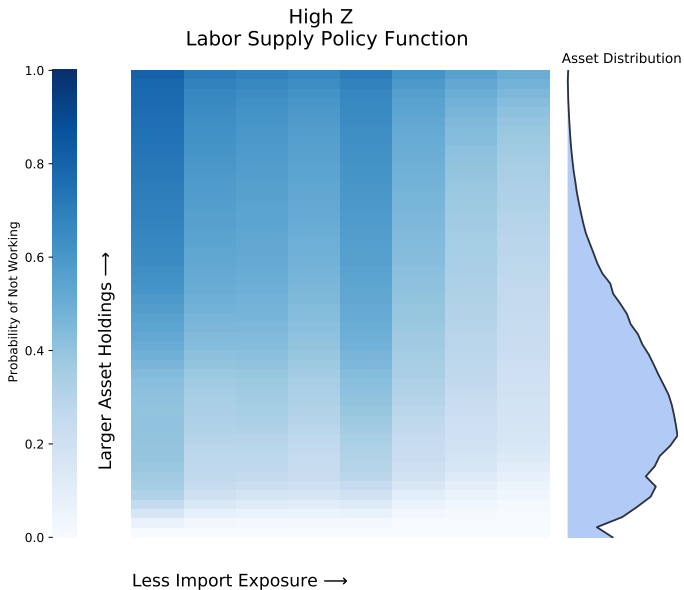
## Labor Supply by $z$ , Assets and Trade Exposure



## Labor Supply by $z$ , Assets and Trade Exposure

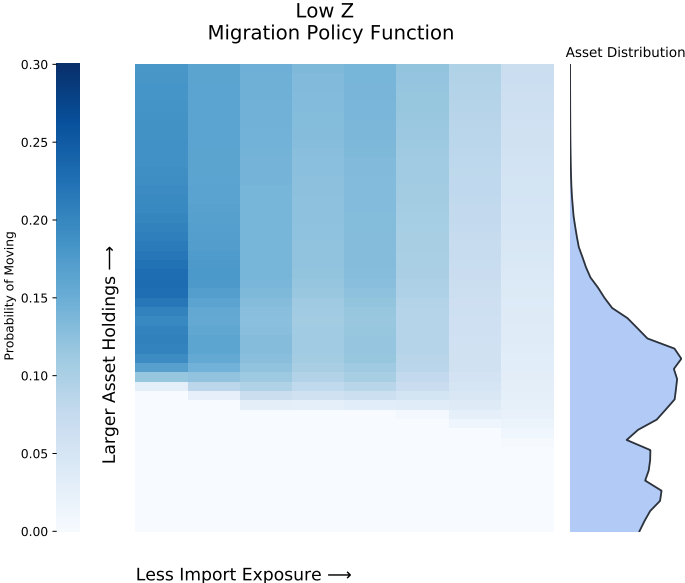


## Labor Supply by $z$ , Assets and Trade Exposure

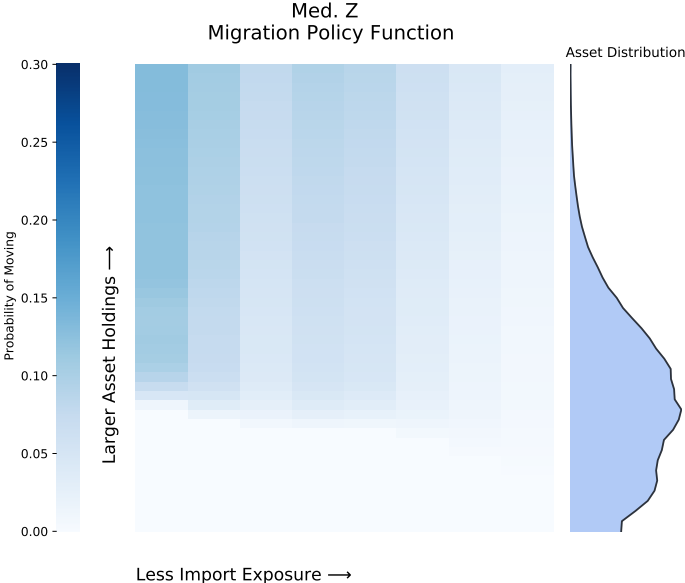




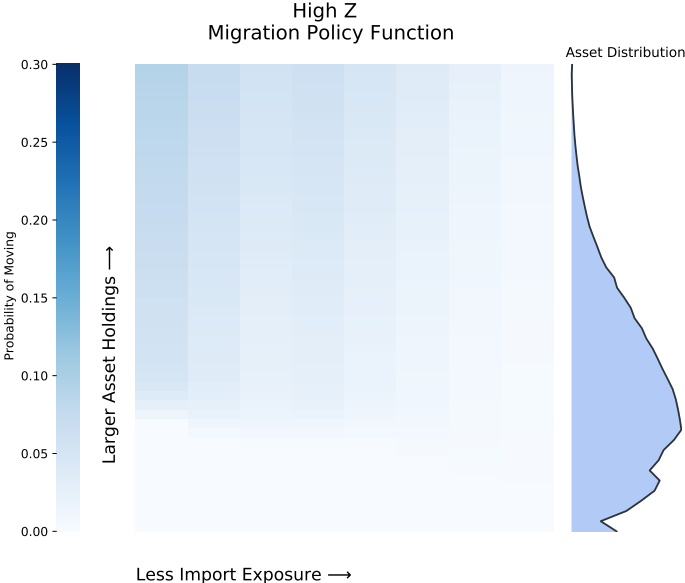
# Migration by z, Assets, and Trade Exposure



# Migration by z, Assets, and Trade Exposure



# Migration by z, Assets, and Trade Exposure



## Value Functions

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The value functions for different options

$$V^{s,w}(a, \mathbf{s}, \nu) = \max_{a' \geq -\bar{a}} [u(Ra + w(\mathbf{s}) - a') - B + \nu^s + \beta EV(a', \mathbf{s}', \nu')],$$

$$V^{s,nw}(a, \mathbf{s}, \nu) = \max_{a' \geq -\bar{a}} [u(w_h + |Ra - a'|^+) + \nu^s + \beta EV(a', \mathbf{s}', \nu')]$$

$$V^{m,w}(a, \mathbf{s}, \nu) = \max_{a' \geq -\bar{a}} [u(Ra + w(\mathbf{s}) - a' - m) - B + \nu^m + \beta V^m(a')]$$

$$V^{m,nw}(a, \mathbf{s}, \nu) = \max_{a' \geq -\bar{a}} [u(w_h + |Ra - a' - m|^+) + \nu^m + \beta V^m(a')]$$

Putting everything together...

$$V(a, \mathbf{s}, \nu) = \max [V^{s,w}, V^{s,nw}, V^{m,w}, V^{m,nw}].$$

## Equilibrium: A Little Bit of Detail... Non-Traded Goods

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**Non-Traded Case:** An island with state  $\mathbf{s}$  where the good is non-traded...

- Because it's non-traded:  $\frac{p_w}{\tau_{ex}} < p(\mathbf{s}) < \tau_{im} p_w$ .
- Real wages on the island are:

$$w(\mathbf{s}) = \frac{p(\mathbf{s})z}{P}.$$

- Goods market clearing:

$$\left(\frac{p(\mathbf{s})}{P}\right)^{-\theta} Q = z(\mu(\mathbf{s})/\pi(\mathbf{s}))$$

**Note:** Household decisions matter in two places: (i) labor supply  $\mu(\mathbf{s})$  on the island and (ii) aggregate consumption,  $Q$ .

## Equilibrium: A Little Bit of Detail... Imported Goods

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**Imported Case:** An islands with state  $\mathbf{s}$  where the good is **imported**...

- Because it's imported:  $p(\mathbf{s}) = \tau_{im} p_w$ .
- Real wages on the island are:

$$w(\mathbf{s}) = \frac{\tau_{im} p_w Z}{P}.$$

- Goods market clearing:

$$\underbrace{\left( \left( \frac{\tau_{im} p_w}{P} \right)^{-\theta} Q \right) - z(\mu(\mathbf{s})/\pi(\mathbf{s}))}_{\text{imports}} > 0.$$

## Equilibrium: A Little Bit of Detail... Exported Goods

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**Exported Case:** An islands with state  $\mathbf{s}$  where the good is **exported**...

- Because it's exported:  $p(\mathbf{s})\tau_{ex} = p_w$ .
- Real wages on the island are:

$$w(\mathbf{s}) = \frac{p_w z}{\tau_{ex} P}.$$

- Goods market clearing:

$$\underbrace{\left(\frac{p_w/\tau_{ex}}{P}\right)^{-\theta} Q - z(\mu(\mathbf{s})/\pi(\mathbf{s}))}_{- \text{ exports}} < 0$$

## Law of Motion for Distribution of Households

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$$\lambda'(\mathbf{s}', a', \nu') = \phi(\nu') \int_{\mathbf{s}} \int_{\nu} \int_{a: a' = g_a(\mathbf{s}, a, \nu)} \lambda(\mathbf{s}, a, \nu) (1 - \iota_m(\mathbf{s}, a, \nu)) \pi(\mathbf{s}', \mathbf{s}) \\ + \lambda(\mathbf{s}, a, \nu) \iota_m(\mathbf{s}, a, \nu) \bar{\pi}(\mathbf{s}') da d\nu ds.$$

Several elements here:

- $\phi(\nu')$  is the probability that preference shocks  $\nu'$  are realized where  $\phi$  is the probability density function associated with the Type 1 extreme value distribution.
- Second term (after integrals) is the mass of household that do not move multiplied by transition probability of  $\mathbf{s}$  to  $\mathbf{s}'$ .
- The third term is the mass of households that do move, multiplied by the probability that they end up in state  $\mathbf{s}'$ .
- All is conditional on households choosing asset holdings equal to  $a'$ , this is denoted by the conditionality under the innermost integral sign. And integrated across preference shocks and current island state  $\mathbf{s}$ .



Labor supply is:

$$\mu(\mathbf{s}) = \int_{\nu} \int_a \iota_n(\mathbf{s}, a, \nu) \lambda(\mathbf{s}, a, \nu) da d\nu.$$

Aggregate income must equal all payments to labor. . .

$$Y = \int_{\mathbf{s}} w(\mathbf{s}) \mu(\mathbf{s})$$

Combining this with households budget constraints and then aggregating connects aggregate income with consumption

$$Y = C - RA + A' + \int_a \int_{\mathbf{s}} \int_{\nu} m \iota_m(\mathbf{s}, a, \nu) \lambda(\mathbf{s}, a, \nu) d\nu ds da$$

In words, income equals consumption minus (i) returns on assets (ii) new purchases of assets and (iii) plus moving costs.

## Connection with National Accounts. . . Production Side

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Aggregate production equals the value of all island level output. . .

$$Y = \int_{\mathbf{s}} p(\mathbf{s})z\mu(\mathbf{s})$$

which then working with the island level market clearing conditions gives

$$Y = C + \int_{\mathbf{s}} p(\mathbf{s})\text{exports}(\mathbf{s}) - \int_{\mathbf{s}} p(\mathbf{s})\text{imports}(\mathbf{s}).$$

## Savings, Trade Imbalances, and Capital Flows

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Then combining the previous results allows us to connect savings with trade imbalances. . .

$$\begin{aligned} Y - C &= \int_{\mathbf{s}} p(\mathbf{s}) \text{exports}(\mathbf{s}) - \int_{\mathbf{s}} p(\mathbf{s}) \text{imports}(\mathbf{s}), \\ &= -r\mathcal{A} + (\mathcal{A}' - \mathcal{A}) + \int_a \int_{\mathbf{s}} \int_{\nu} m \nu_m(\mathbf{s}, a, \nu) \lambda(\mathbf{s}, a, \nu) d\nu ds da, \end{aligned}$$

Special case with no moving:

$$Y - C = \int_{\mathbf{s}} p(\mathbf{s}) \text{exports}(\mathbf{s}) - \int_{\mathbf{s}} p(\mathbf{s}) \text{imports}(\mathbf{s}) = -r\mathcal{A} + (\mathcal{A}' - \mathcal{A}).$$