# Quantifying the Losses from International Trade


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## 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.

1. allows our model to speak to the Autor, Dorn, and Hanson (2013) evidence and then aggregate.
2. makes the normative implications interesting. . .
   - large (or small) welfare losses by the inability to smooth out shocks,
   - b.c. the equilibrium is inefficient $\Rightarrow$ suggests a role for policy, e.g. Lyon and Waugh (2018).

## This Paper: How much do the losers lose from trade?

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

**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

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

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

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

# Model: Households

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

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

**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

# Walking through how the model works

The connection between trade exposure and ...

**1.** wages,

**2.** asset holdings and migration,

**3.** asset holdings and labor supply.

# Walking through how the model works

The connection between trade exposure and . . .

1. wages,
2. ~~asset holdings and migration~~,
3. ~~asset holdings and labor supply~~.

# Island-Level Trade

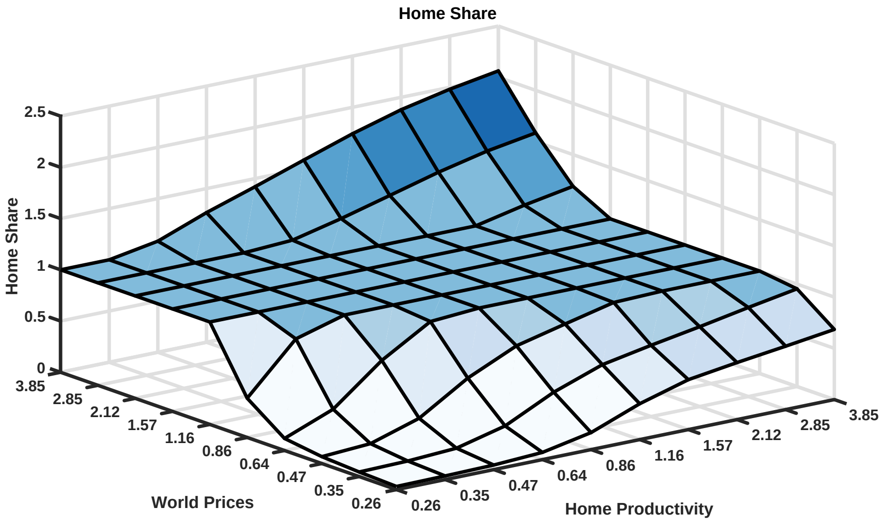
To understand the pattern of trade across islands define the following statistic:

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

- 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

**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

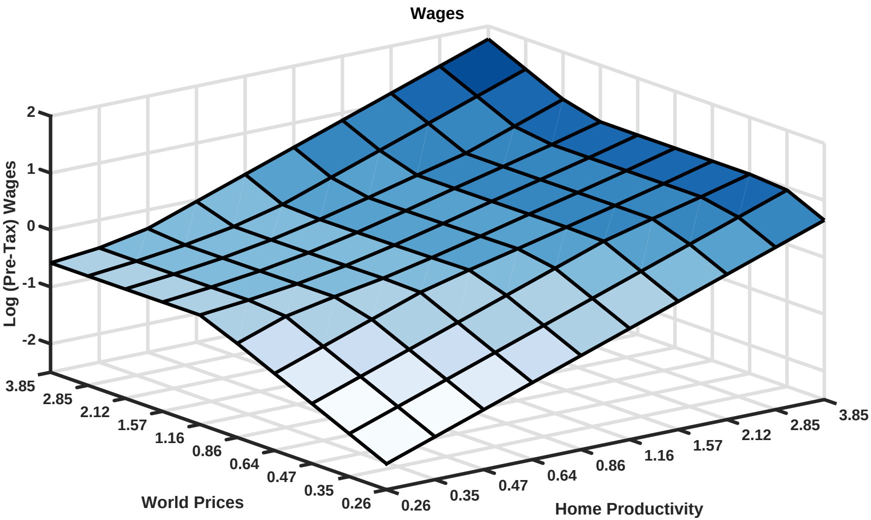
$$\omega(\mathbf{s}) := \frac{p(\mathbf{s}) z \mu(\mathbf{s}) \bar{h}}{p(\mathbf{s}) z \mu(\mathbf{s}) \bar{h} \ + \ p(\mathbf{s})\text{imports}(\mathbf{s}) - p(\mathbf{s})\text{exports}(\mathbf{s})},$$

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

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

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

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 $\gamma_t$.

# Quantitative Results

## Calibration Overview

Pre-determined parameters: discount factor, interest rate.

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

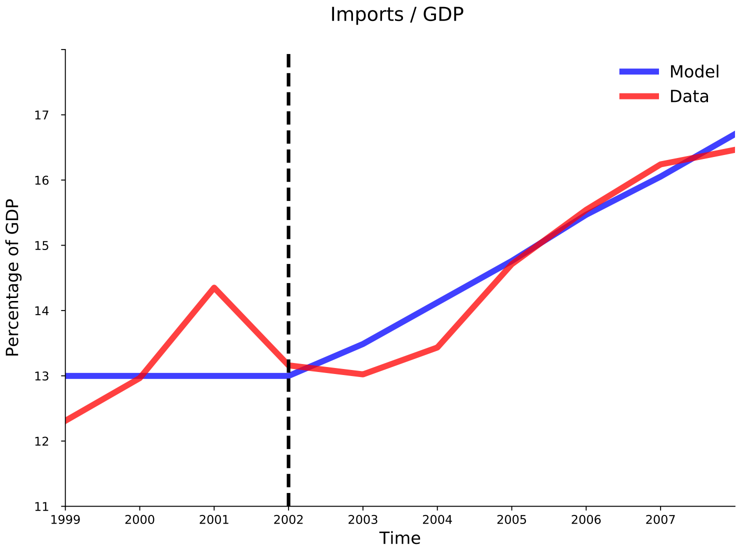
The moments. . .

- 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.

# Calibration: The Trade Shock...



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

| | $\Delta$ Labor Earnings | $\Delta$ NILF | GLM $\Delta$ Population |
|---|---|---|---|
| Data | $-4.30$<br>$[-6.62, \ -2.00]$ | $1.11$<br>$[0.52, \ 1.72]$ | $-1.43$<br>$[-3.33, \ 0.48]$ |
| Model | $-5.66$ | $1.15$ | $-1.57$ |
| | Demand elasticity $\theta$ | Home production $w_h$ | Moving shock variance $\sigma_\nu$ |
| Parameter Values | 10.06 | 0.18 | 0.95 |

**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...

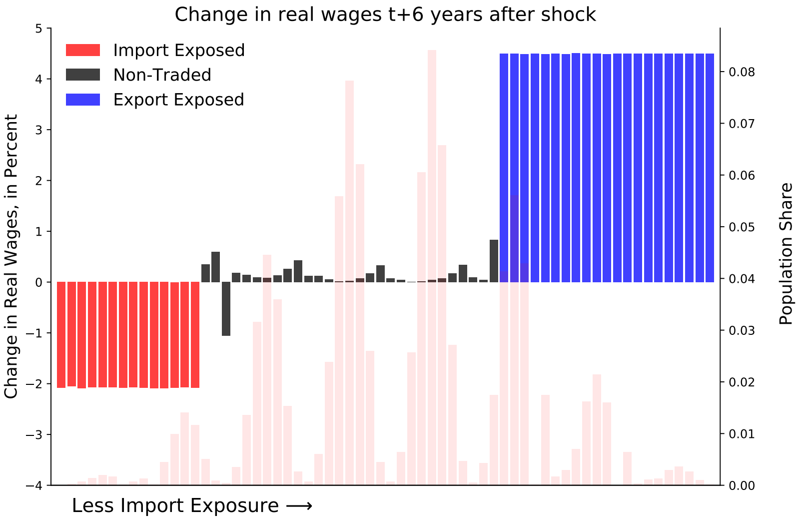
We will proceed in three steps...

**1.** What happens at the household/island-level in reaction to the shock?

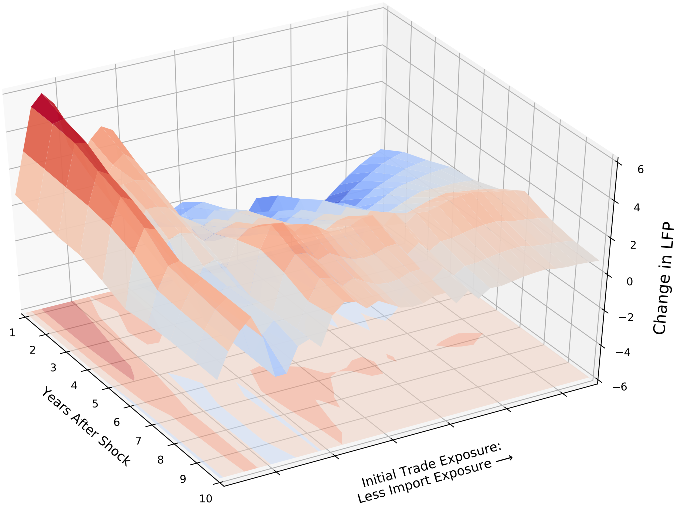
**2.** What happens at the aggregate level?

**3.** What are the welfare consequences?

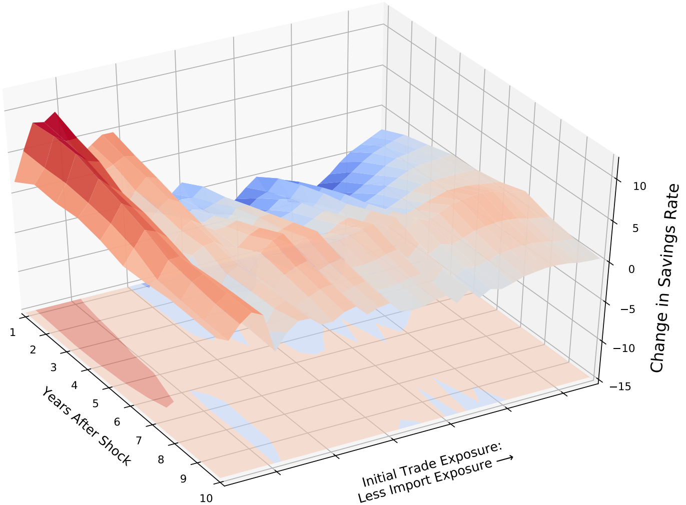
# Micro I: Real Wages Across Islands After the Shock



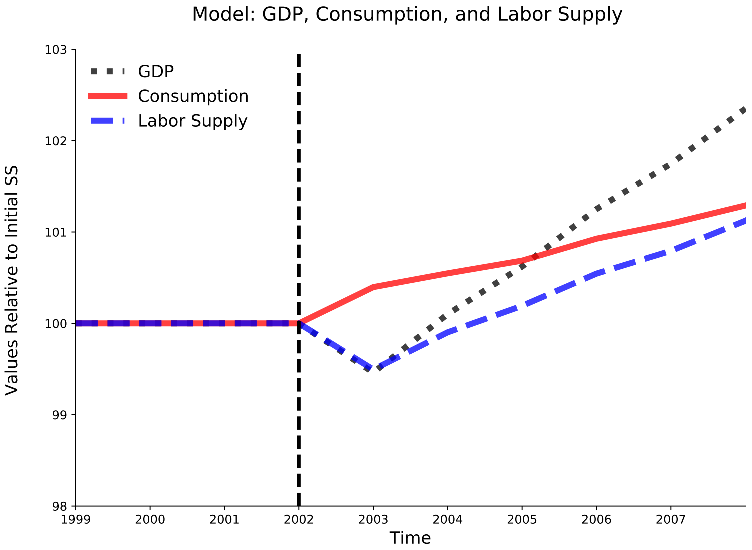
# Micro II: Labor Supply, Across Islands, Overtime



# Micro III: Savings Rates, Across Islands, Overtime



# Macro I: Aggregate Consumption, Labor Supply, Output



# Macro II: The Trade Deficit

# Welfare and Real Wages

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

## Final Thoughts

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. . .

$\Rightarrow$ **Welfare losses from the China shock are small; most gain.**

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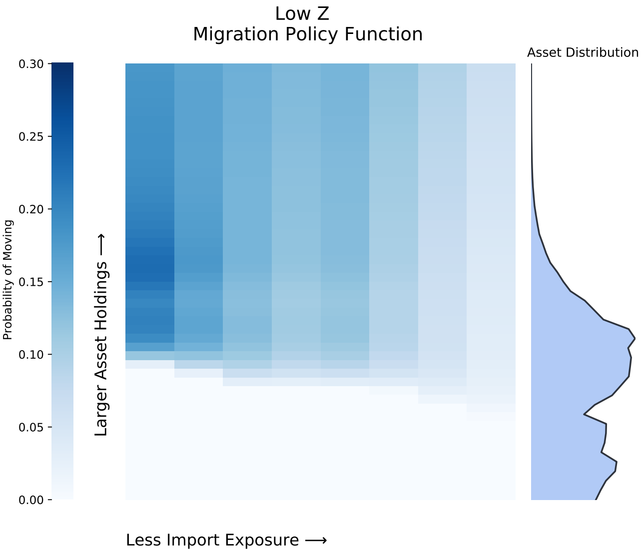
## Calibrated Parameters: SE Moments and Parameters

| 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 $(\tau_{ex}, \tau_{im})$ | 1.37 | 1990s Imports/GDP | 13 | 13 |
| Post-China Trade Cost $(\tau'_{im})$ | 1.31 | 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.

# Migration, Assets, and Trade Exposure



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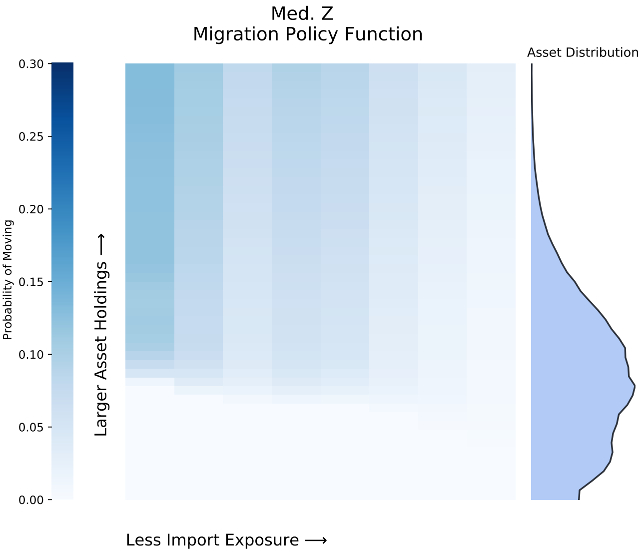
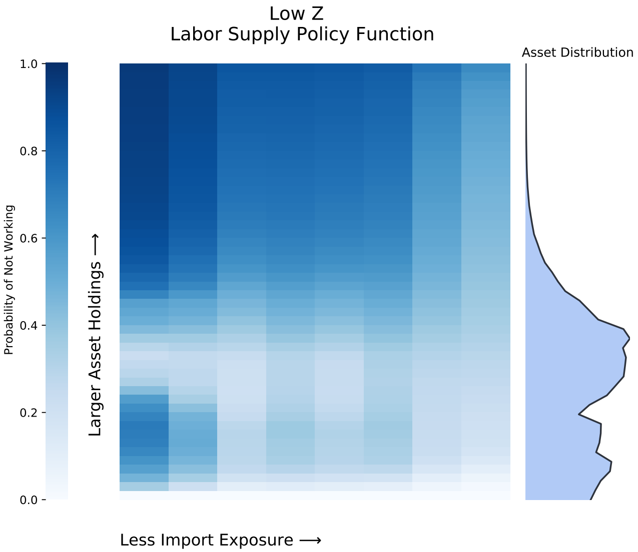
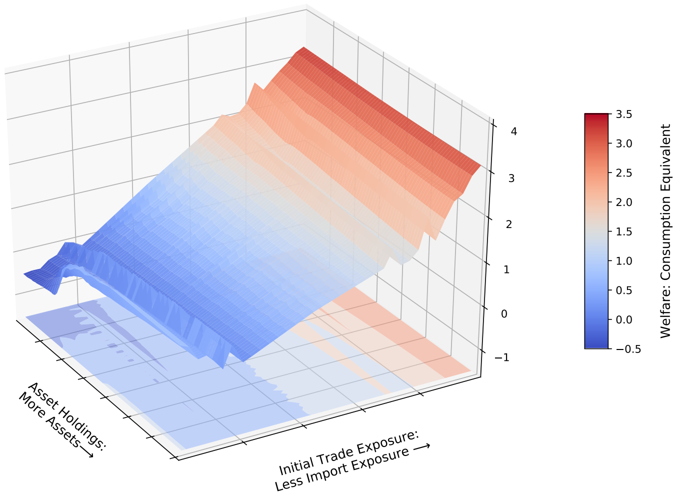


# Labor Supply, Assets and Trade Exposure



# Welfare Across Islands and Asset States



# 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 | −.06 | −3.00 | 0.18 | −2.32 |
| | | [ 0.21 ] | [ 0.21 ] | [ 0.07 ] | [ 0.07 ] |
| | Non-Traded | 0.73 | 0.00 | 0.74 | 0.23 |
| | | [ 0.33 ] | [ 0.33 ] | [ 0.68 ] | [ 0.68 ] |
| | Export Exposed | 1.71 | 3.50 | 1.65 | 4.38 |
| | | [ 0.46 ] | [ 0.46 ] | [ 0.25 ] | [ 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

## Autor et al. (2013), background...

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

Mechanically, construct the following:

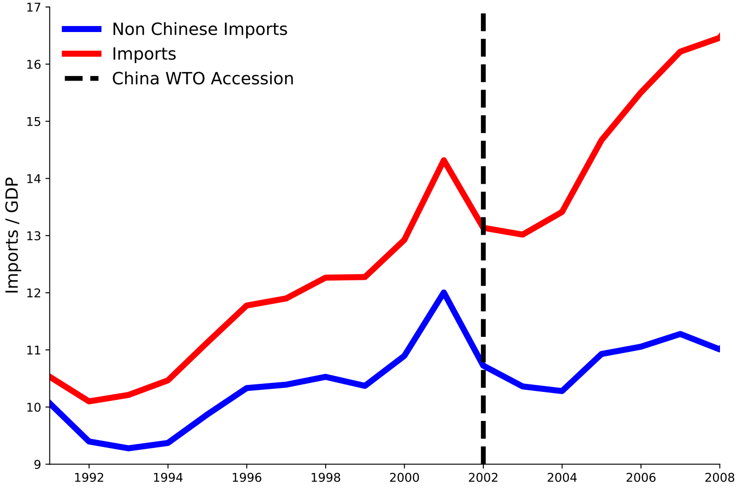
$$\Delta IPW_{uit} = \sum_j \left(\frac{L_{ijt}}{L_{it}}\right)\left(\frac{\Delta M_{ucjt}}{L_{ijt}}\right)$$

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

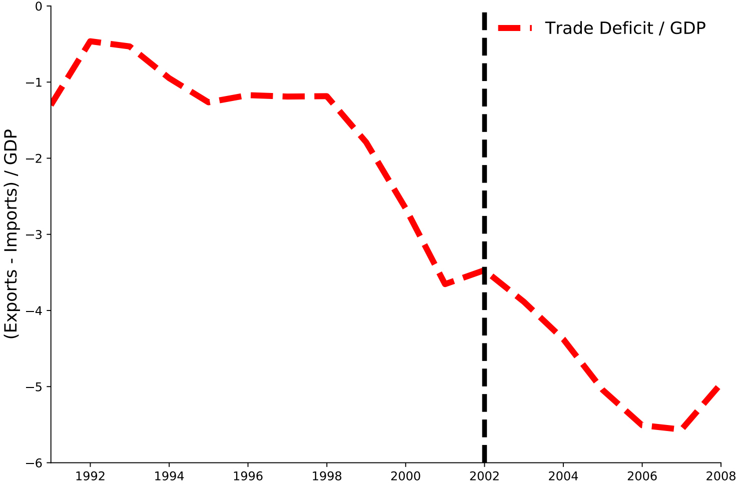
Lots of notation here:

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

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



# US Data: The Trade Deficit



**Labor Market Outcomes and Trade Exposure**

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

**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 neting out the mean and dividing by the standard deviation.

**Migration and Trade Exposure**

| | ADH $\Delta$ Population | GLM, $\Delta$ Population |
|---|---|---|
| Standardized $\Delta$ IPW | $-0.05$<br>$[-1.51, \quad 1.41]$ | $-1.43$<br>$[-3.33, \quad 0.48]$ |

**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

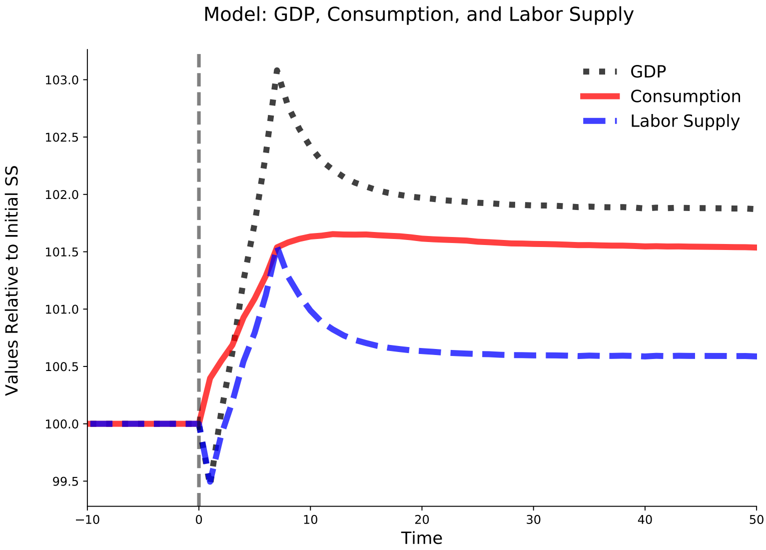
Pre-determined parameters. . .

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

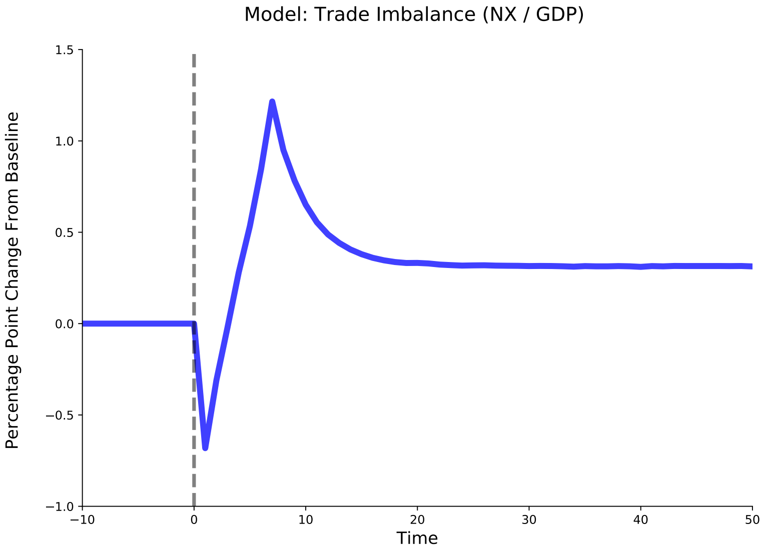
The nature of the shock(s):

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

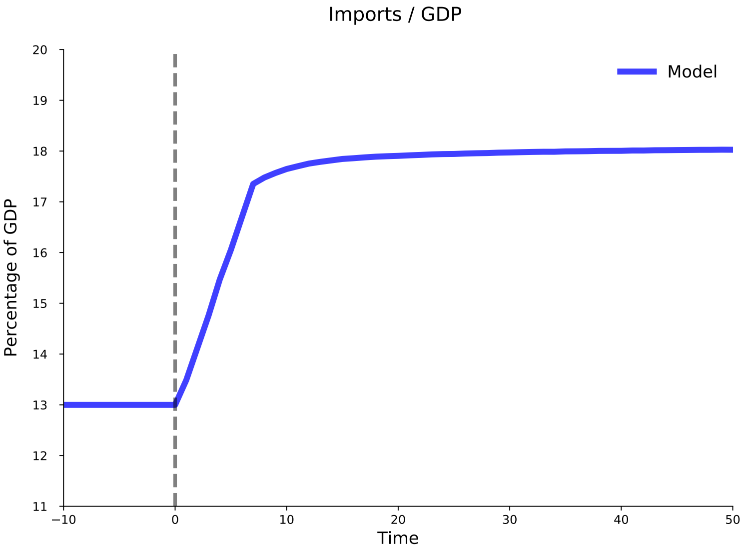
# Long Run: Aggregate Consumption, Labor Supply, Output



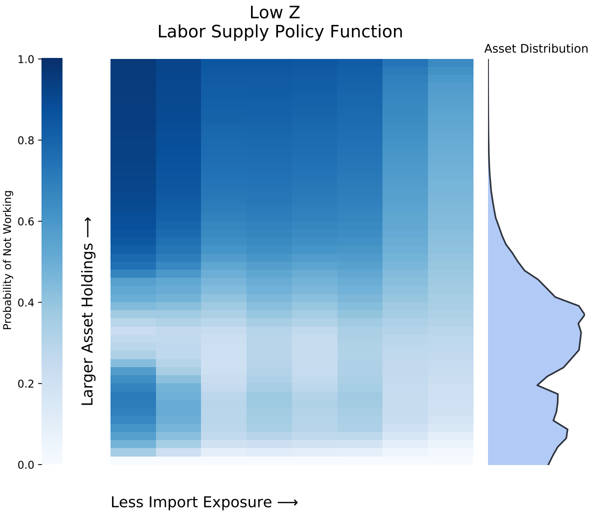
# Long Run: The Trade Deficit



# Long Run: Trade



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



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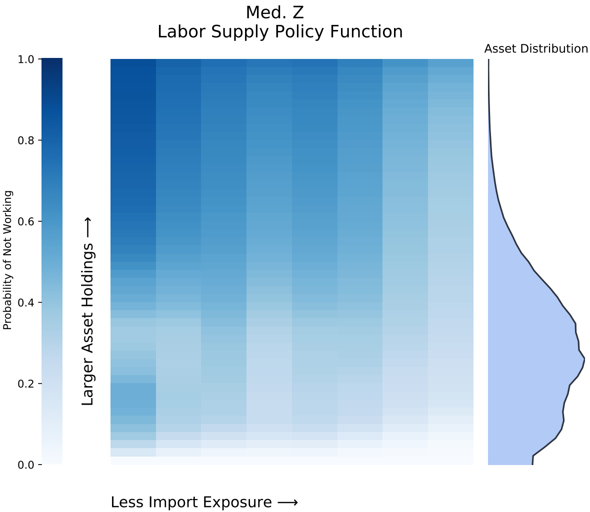

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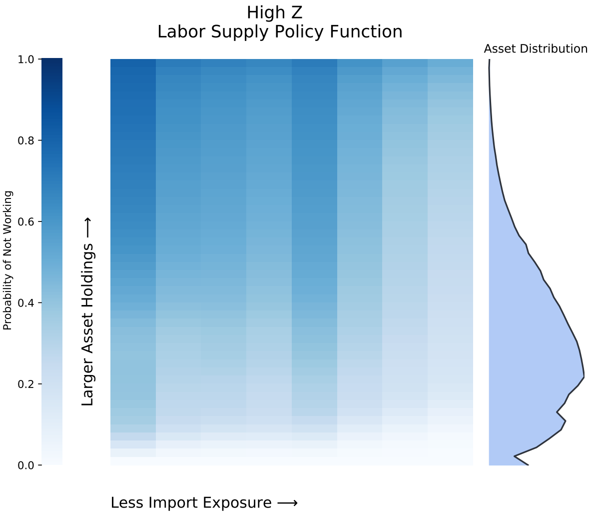
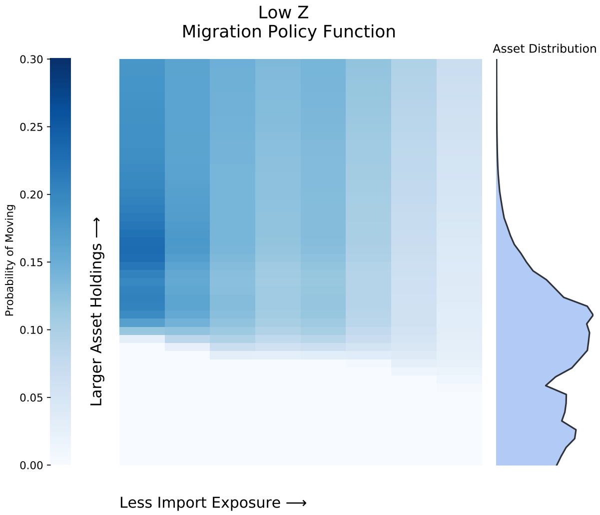


# Migration by $z$, Assets, and Trade Exposure



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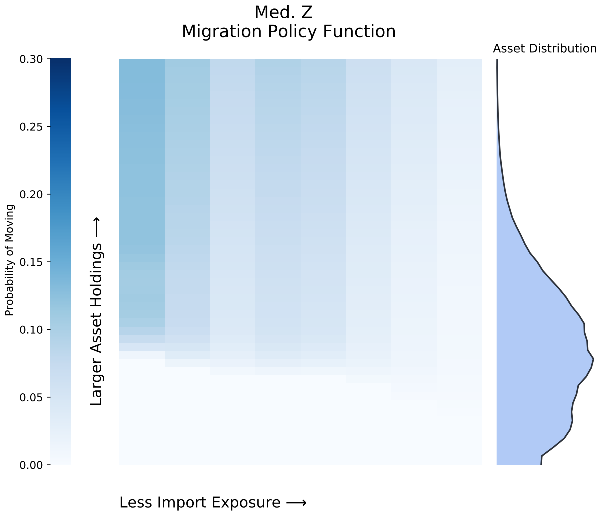
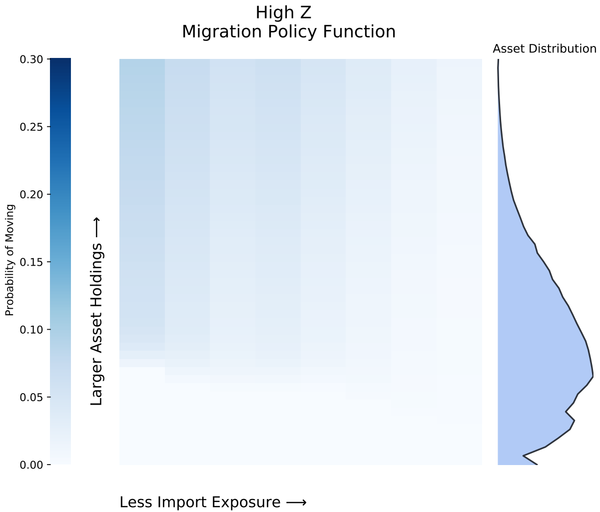


# Migration by $z$, Assets, and Trade Exposure



# Value Functions

The value functions for different options

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

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

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

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

Putting everything together...

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

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

**Non-Traded Case**: An islands 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:

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

**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

**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:

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

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

**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:

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

## Law of Motion for Distribution of Households

$$\lambda'(\mathbf{s'}, a', \nu') = \phi(\nu') \int_{\mathbf{s}} \int_{\nu} \int_{a:a'=g_a(\mathbf{s},a,\nu)} \lambda(\mathbf{s}, a, \nu)(1 - \iota_m(\mathbf{s}, a, \nu))\pi(\mathbf{s'}, \mathbf{s})$$

$$+ \lambda(\mathbf{s}, a, \nu)\iota_m(\mathbf{s}, a, \nu)\bar{\pi}(\mathbf{s'}) \; da \; d\nu \; d\mathbf{s}.$$

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 **s** to **s'**.
- The third term is the mass of households that do move, multiplied by the probability that they end up in state **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 **s**.

## Connection with National Accounts. . . Income Side

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

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

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

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

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

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

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

$$= -r\mathcal{A} + (\mathcal{A}' - \mathcal{A}) + \int_a \int_{\mathbf{s}} \int_{\nu} m\iota_m(\mathbf{s}, a, \nu)\lambda(\mathbf{s}, a, \nu) d\nu \; d\mathbf{s} \; da,$$

Special case with no moving:

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