Globalization and Pandemics

Pol Antràs
Harvard University and NBER

Stephen J. Redding
Princeton University and NBER

Esteban Rossi-Hansberg
Princeton University and NBER

Motivation

- Globalization and pandemics have been closely intertwined in history
  - Black Death arrived in Europe in October 1347 when twelve ships from the Black Sea docked at the Sicilian port of Messina
  - First human-to-human COVID-19 infections in Europe occurred in Starnberg, Germany, when a local car parts supplier (Webasto) organized a training session with a Chinese colleague from Wuhan, China
- What is the relationship between globalization and pandemics?
  - Does globalization make societies more vulnerable to pandemics?
  - How do pandemics affect the volume and pattern of trade?
- We develop a model of human interaction that provides joint microfoundations for
  - Gravity equation for international trade
  - Susceptible-Infected-Recovered (SIR) model of disease dynamics

Main Findings

1. Globalization $\longrightarrow$ Pandemics : assume agents unaware of the threat of infection and no deaths
   - Whether a pandemic occurs in the open economy depends on disease environment in country with *highest* rates of domestic infection
   - Globalization can either *increase* or *decrease* the range of parameters for which a pandemic occurs and its severity
   - Globalization can generate *multiple waves* of infection

2. Globalization $\longleftrightarrow$ Pandemics: assume agents unaware of the threat of infection and deaths (GE effects of pandemic)
   - Unhealthy country sees its relative wage *rise* via lower labor supply (*GE social distancing*)
   - Which country is unhealthy can change over the course of the pandemic

3. Globalization $\longleftrightarrow$ Pandemics: (assume agents aware of the threat of infection and deaths (individual & GE effects of pandemic)
   - Unhealthy country typically sees its relative wage *fall*, through lower demand for its goods (*individual-level social distancing*)
   - Behavioral response generates large reductions in trade to output
   - Large aggregate welfare effects (deaths and reduced gains from trade)

Related Literature

- Large literature on the gravity equation in international trade
  - Anderson (1979), Anderson and van Wincoop (2003), Eaton and Kortum (2002), Chaney (2008), Helpman et al. (2008), Allen and Arkolakis (2014), Chaney (2014), Antràs et al. (2017), Allen et al. (2020)
- Role of business travel in greasing the wheels of trade
  - Cristea (2011), Blonigen and Cristea (2015), Startz (2018), Hovhannisyan and Keller (2015), Campante and Yanagizawa-Drott (2018)
- Epidemiological models of disease spread
  - Seminal SIR Model : Kermack and McKendrick (1927, 1932)
  - Multi-group SIR Model : Hethcote (1978), Hethcote and Thieme (1985), van den Driessche and Watmough (2002), and Magal et al. (2016)
  - Spatial SIR Model : Argente et al. (2020), Bisin and Moro (2020), Cuñat and Zymek (2020), Birge et al. (2020), and Fajgelbaum et al. (2020)
  - Behavioral Responses: Alfaro et al. (2020), Farboodi et al. (2020), Fenichel et al. (2011), and Toxvaerd (2020)
- Empirical literature on trade and the spread of disease
  - Saker et al. (2002), Christakos et al. (2005), Boerner and Severgnini (2014), Ricci et al. (2017), and Jedwab et al. (2019)

Outline

1. Globalization $\longrightarrow$ Pandemics
   - Assume agents unaware of the threat of infection and no deaths
2. Globalization $\longleftrightarrow$ Pandemics
   - Assume agents unaware of the threat of infection and deaths
   - General equilibrium social distancing
3. Globalization $\longleftrightarrow$ Pandemics
   - Assume agents aware of the threat of infection and deaths
   - Individual-level social distancing and general equilibrium effects

Model

- Armington model of trade through human interaction
- Consider a world with a set of locations $\mathcal{J} = \{East, West\}$
- Each location is inhabited by a continuous measure L_i of households, each of which has one unit of labor and a blueprint for a variety
- Each household is formed of two individuals
  - *Buyer:* procures varieties from other households
  - *Seller:* produces and sells the household's variety
- Trade in varieties is subject to iceberg variable costs
  - Trade frictions (t_{ij}) and distance (d_{ij})

$$\tau_{ij} = t_{ij} \times \left(d_{ij}\right)^{\delta}$$

- Sourcing varieties incurs utility costs from being away from home
  - Mobility frictions (μ_{ij})

$$c_{ij}(n_{ij}) = \frac{c}{\phi} \times \mu_{ij} \times (d_{ij})^{\rho} \times (n_{ij})^{\phi}$$

- Assume $\phi > 1/(\sigma - 1)$ and $\sigma > 2$ and focus on an interior equilibrium where not all varieties are consumed

Preferences and Demand

- Welfare of households in country i

$$W_i = \left(\sum_{j \in \mathcal{J}} \int_0^{n_{ij}} q_{ij}(k)^{\frac{\sigma-1}{\sigma}} dk \right)^{\frac{\sigma}{\sigma-1}} - \frac{c}{\phi} \sum_{j \in \mathcal{J}} \mu_{ij} (d_{ij})^{\rho} \times (n_{ij})^{\phi}$$

- CES demand

$$q_{ij} = \frac{w_i}{(P_i)^{1-\sigma}} \left(\frac{\tau_{ij} w_j}{Z_j} \right)^{-\sigma}$$

- Gravity

$$\pi_{ij} = \frac{(w_j / Z_j)^{-\frac{\phi(\sigma-1)}{\phi-1}} \times (\mu_{ij})^{-\frac{1}{\phi-1}} (d_{ij})^{-\frac{\rho+\phi(\sigma-1)\delta}{\phi-1}} (t_{ij})^{-\frac{\phi(\sigma-1)}{\phi-1}}}{\sum_{\ell \in \mathcal{J}} (\mu_{i\ell})^{-\frac{1}{\phi-1}} (d_{i\ell})^{-\frac{\rho+\phi(\sigma-1)\delta}{\phi-1}} (t_{i\ell} w_{\ell} / Z_{\ell})^{-\frac{\phi(\sigma-1)}{\phi-1}}}$$

- Human interactions

$$n_{ij} = (c(\sigma - 1)\mu_{ij})^{-1/(\phi-1)} (d_{ij})^{-\frac{\rho+(\sigma-1)\delta}{\phi-1}} \left(\frac{t_{ij} w_j}{Z_j P_i} \right)^{-\frac{\sigma-1}{(\phi-1)}} \left(\frac{w_i}{P_i} \right)^{1/(\phi-1)}$$

Trade and Welfare

- Recall gravity

$$\pi_{ij} = \frac{\left(w_j/Z_j\right)^{-\frac{\phi(\sigma-1)}{\phi-1}} \times \left(\mu_{ij}\right)^{-\frac{1}{\phi-1}} \left(d_{ij}\right)^{-\frac{\rho+\phi(\sigma-1)\delta}{\phi-1}} \left(t_{ij}\right)^{-\frac{\phi(\sigma-1)}{\phi-1}}}{\sum_{\ell\in\mathcal{J}} \left(\mu_{i\ell}\right)^{-\frac{1}{\phi-1}} \left(d_{i\ell}\right)^{-\frac{\rho+\phi(\sigma-1)\delta}{\phi-1}} \left(t_{i\ell} w_\ell/Z_\ell\right)^{-\frac{\phi(\sigma-1)}{\phi-1}}}$$

- Aggregate welfare gains from trade

$$W_i L_i = \frac{\phi\left(\sigma-1\right)-1}{\phi\left(\sigma-1\right)} \times \left(\pi_{ii}\right)^{-\frac{(\phi-1)}{\phi(\sigma-1)-1}} \times \left(\frac{\left(Z_i\right)^{\phi(\sigma-1)}}{c\left(\sigma-1\right)} \left(\Gamma_{ii}\right)^{-\varepsilon(\phi-1)}\right)^{\frac{1}{\phi(\sigma-1)-1}} L_i$$

$$\left(\Gamma_{ij}\right)^{-\varepsilon} \equiv \left(\mu_{ij}\right)^{-\frac{1}{\phi-1}} \left(d_{ij}\right)^{-\frac{\rho+\phi(\sigma-1)\delta}{\phi-1}} \left(t_{ij}\right)^{-\frac{\phi(\sigma-1)}{\phi-1}},$$

- Market clearing (income equals expenditure)

$$\pi_{ii}\left(w_i, w_j\right) w_i L_i + \pi_{ji}\left(w_i, w_j\right) w_j L_j = w_i L_i$$

- By standard arguments, there exists a unique equilibrium wage vector ($\boldsymbol{w}$) that solves this market clearing condition

Trade and Human Interactions

- Using gravity, we can rewrite human interactions as:

$$n_{ij}(\mathbf{w}) = \left(\frac{t_{ij} \left(d_{ij}\right)^{\delta} w_j}{P_i(\mathbf{w}) Z_j} \right)^{\sigma-1} \pi_{ij}(\mathbf{w}),$$

Proposition 2

(Domestic Versus Foreign Interactions) *A decline in any international trade or mobility friction (d_{ij}, t_{ij}, t_{ji}, μ_{ij}, μ_{ji}) leads to: (a) a decline in the rates (n_{ii} and n_{jj}) at which individuals will meet individuals in their own country; and (b) an increase in the rates at which individuals will meet individuals from the other country (n_{ij} and n_{ji}).*

Proposition 3

(Overall Interactions) *Suppose that countries are symmetric, in the sense that $L_i = L$, $Z_i = Z$, and $\Gamma_{ij} = \Gamma$ for all i. Then, a decline in any (symmetric) international trade frictions leads to an overall increase in human interactions ($n_{dom} + n_{for}$) experienced by both household buyers and household sellers.*

extensions

Extensions

- The key results of our economic model hold in the following alternative environments:

1. Whenever travel costs are specified in terms of labor rather than being modelled as a utility cost
2. Whenever differentiated varieties produced by households are intermediate inputs, so business travel is related to sourcing inputs rather than consumption goods
3. Whenever it is the household's seller rather than the buyer who travels to other locations (we model this via a framework featuring scale economies, monopolistic competition and fixed cost of exporting, as in Melitz, 2003)

- All equilibrium equations above apply to a multi-country world
    - Framework easily adaptable to the case in which there is a continuum of locations $i \in \Omega$

Disease Dynamics

- Standard "day" in a household
  - Buyer in i leaves the house and visits n_{ii} sellers in i and n_{ij} sellers in j
  - Seller in i sells own goods to n_{ii} domestic visitors and n_{ji} foreign visitors
  - Buyers travel separately and do not meet one another along the way
  - Perfect disease transmission within the household
- Susceptible (S_i)

$$\dot{S}_i = -\underbrace{2n_{ii}\alpha_i S_i I_i}_{\text{Domestic Infections}} - \underbrace{n_{ij}\alpha_j S_i I_j}_{\text{Buyer Foreign Infections}} - \underbrace{n_{ji}\alpha_i S_i I_j}_{\text{Seller Foreign Infections}}$$

- Infected (I_i)

$$\dot{I}_i = \underbrace{2n_{ii}\alpha_i S_i I_i}_{\text{Domestic Infections}} + \underbrace{n_{ij}\alpha_j S_i I_j}_{\text{Buyer Foreign Infections}} + \underbrace{n_{ji}\alpha_i S_i I_j}_{\text{Seller Foreign Infections}} - \underbrace{\gamma_i I_i}_{\text{Recovered}}$$

- Recovered (R_i)

$$\dot{R}_i = \underbrace{\gamma_i I_i}_{\text{Recovered}}$$

Closed Economy Special Case

- Model reduces to a standard SIR model when there is no trade

$$\begin{aligned}\dot{S}_i &= -\beta_i S_i I_i \\ \dot{I}_i &= \beta_i S_i I_i - \gamma_i I_i \\ \dot{R}_i &= \gamma_i I_i\end{aligned}$$

- where $\beta_i = 2\alpha_i n_{ii}$ is the so-called contact rate
- If $\mathcal{R}_{0i} = \beta_i/\gamma_i < 1$, the *epidemic-free* equilibrium is globally stable
- If $\mathcal{R}_{0i} = \beta_i/\gamma_i > 1$, an *epidemic* occurs, and new infections necessarily rise until the system reaches a period t^* at which $S_i(t^*) = \gamma_i/\beta_i$, after which infections decline and eventually go to 0
- Steady-state susceptibles $S_i(\infty)$ solves

$$\ln S_i(\infty) = -\frac{\beta_i}{\gamma_i}\left(1 - S_i(\infty)\right).$$

Open Economy

- Dynamics of infection

$$\begin{bmatrix} \dot{I}_i \\ \dot{I}_j \end{bmatrix} = \underbrace{\begin{bmatrix} 2\alpha_i n_{ii} S_i & (\alpha_j n_{ij} + \alpha_i n_{ji}) S_i \\ (\alpha_j n_{ij} + \alpha_i n_{ji}) S_j & 2\alpha_j n_{jj} S_j \end{bmatrix}}_{F} \begin{bmatrix} I_i \\ I_j \end{bmatrix} - \underbrace{\begin{bmatrix} \gamma_i & 0 \\ 0 & \gamma_j \end{bmatrix}}_{V} \begin{bmatrix} I_i \\ I_j \end{bmatrix}$$

- R_0 determined by spectral radius of *next generation* matrix (FV^{-1})

$$\mathcal{R}_0 = \frac{1}{2}\left(\frac{2\alpha_i n_{ii}}{\gamma_i} + \frac{2\alpha_j n_{jj}}{\gamma_j}\right) + \frac{1}{2}\sqrt{\left(\frac{2\alpha_i n_{ii}}{\gamma_i} - \frac{2\alpha_j n_{jj}}{\gamma_j}\right)^2 + 4\frac{(\alpha_j n_{ij} + \alpha_i n_{ji})^2}{\gamma_i \gamma_j}}.$$

- Disease can only be contained (stable pandemic-free equilibrium) if *both* countries domestic reproduction rate is less than one

$$\mathcal{R}_0 \geq \mathcal{R}_0\big|_{n_{ij}=n_{ji}=0} = \max\left\{\frac{2\alpha_i n_{ii}}{\gamma_i}, \frac{2\alpha_j n_{jj}}{\gamma_j}\right\}.$$

- Cross-country epidemiological externalities, such that whether a pandemic occurs depends on the country with the worst disease environment

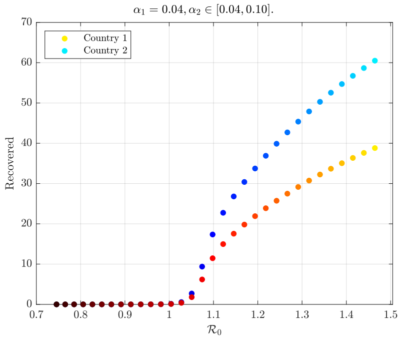
Open Economy Pandemic

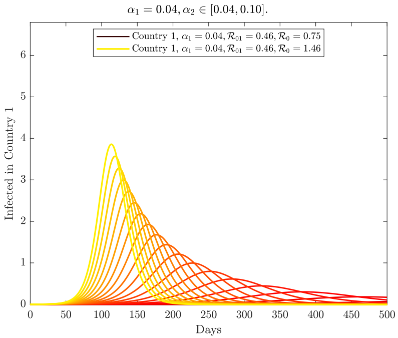
- If $\mathcal{R}_0 \leq 1$, no-pandemic equilibrium is unique stable equilibrium
- If $\mathcal{R}_0 > 1$, no-pandemic unstable, and unique stable endemic equilibrium

$$\ln S_i(\infty) = -\frac{2\alpha_i n_{ii}}{\gamma_i}(1 - S_i(\infty)) - \frac{\alpha_j n_{ij} + \alpha_i n_{ji}}{\gamma_j}(1 - S_j(\infty))$$

$$\ln S_j(\infty) = -\frac{2\alpha_j n_{jj}}{\gamma_j}(1 - S_j(\infty)) - \frac{\alpha_j n_{ij} + \alpha_i n_{ji}}{\gamma_i}(1 - S_i(\infty))$$

- Hold constant α_1 and vary α_2 (contact rates)



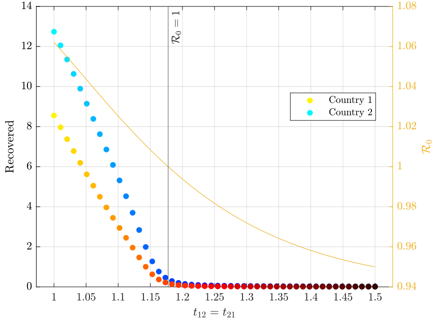


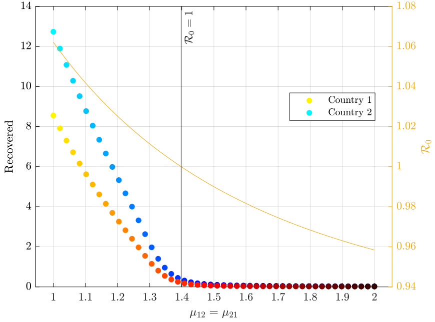
Globalization Can Create Pandemics

Proposition 6

Suppose that countries are symmetric, in the sense that $L_i = L$, $Z_i = Z$, $\Gamma_{ij} = \Gamma$, and $\gamma_i = \gamma$ for all i. Then, a decline in any (symmetric) international trade friction: (i) increases $\mathcal{R}_0$, and (ii) increases the share of each country's population that becomes infected during the pandemic when $\mathcal{R}_0 > 1$.

- Reduce trade ($t_{12} = t_{21}$) or mobility ($\mu_{12} = \mu_{21}$) frictions more



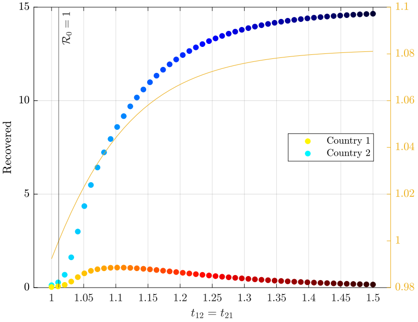


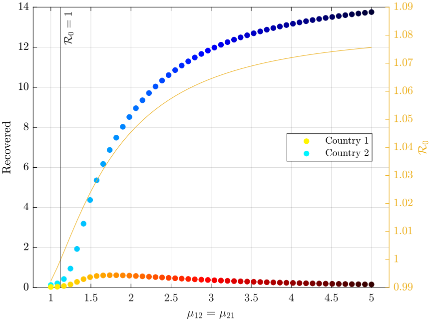
Globalization Can Prevent Pandemics

Proposition 7

When the contagion rate α_i and the recovery rate γ_i vary sufficiently across countries, a decline in any international trade friction (i) decreases $\mathcal{R}_0$, and (ii) when $\mathcal{R}_0 > 1$, it reduces the share of the population in the high-risk (high α_i, low γ_i) country that becomes infected during the pandemic, and it may also reduce this share in the low-risk (low α_i, high γ_i) country.

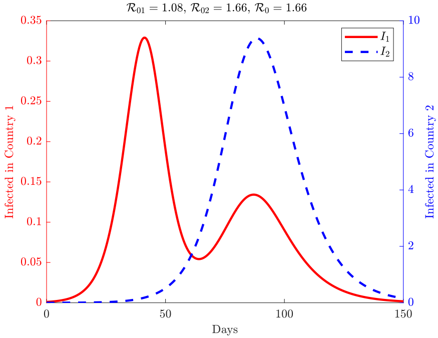
- Reduce trade ($t_{12} = t_{21}$) or mobility($\mu_{12} = \mu_{21}$) frictions ▸ more





Open Economy Second Waves

- Closed economy: single wave in the absence of a lockdown
- Open economy: multiple waves without lockdowns ▸ more
  - Different timings of epidemics and different country sizes
  - Small country has a rapid epidemic in the closed economy
  - Large country has a slower epidemic in the closed economy
  - In the open economy, small country has a first wave driven by its own epidemic, and a second wave driven by the large country's epidemic



Outline

1. Globalization $\longrightarrow$ Pandemics
   - Assume agents unaware of the threat of infection and no deaths
2. Globalization $\longleftrightarrow$ Pandemics
   - Assume agents unaware of the threat of infection and deaths
   - General equilibrium social distancing
3. Globalization $\longleftrightarrow$ Pandemics
   - Assume agents aware of the threat of infection and deaths
   - Individual-level social distancing and general equilibrium effects

General Equilibrium Effects

- A fraction $\eta_i/(\gamma_i + \eta_i)$ of the infected die and the remainder recover

$$\begin{aligned}
\dot{S}_i &= -2n_{ii}(\mathbf{w})\,\alpha_i S_i I_i - \left[n_{ij}(\mathbf{w})\,\alpha_j + n_{ji}(\mathbf{w})\,\alpha_i\right] S_i I_j \\
\dot{I}_i &= 2n_{ii}(\mathbf{w})\,\alpha_i S_i I_i + \left[n_{ij}(\mathbf{w})\,\alpha_j + n_{ji}(\mathbf{w})\,\alpha_i\right] S_i I_j - (\gamma_i + \eta_i)\, I_i \\
\dot{R}_i &= \gamma_i I_i \\
\dot{D}_i &= \eta_i I_i
\end{aligned}$$

- Deaths induce general equilibrium effects through relative wages ($\boldsymbol{w}$) that in turn affect human interactions ($n_{ij}(\boldsymbol{w})$)

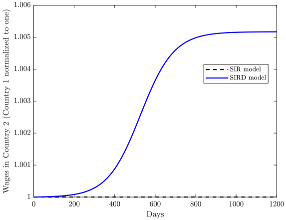
$$\sum_{j \in \mathcal{J}} \pi_{ji}(\mathbf{w})\, w_j (1 - D_j)\, L_j = w_i (1 - D_i)\, L_i,$$

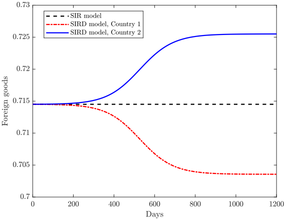
Proposition 8

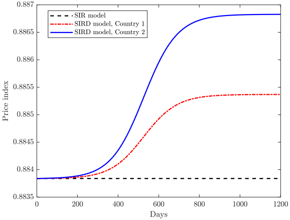
If country j experiences more deaths than country i, the resulting change in relative wages (w_j/w_i) leads country i to reduce its interactions with country j and increase its interactions with itself (general equilibrium social distancing).

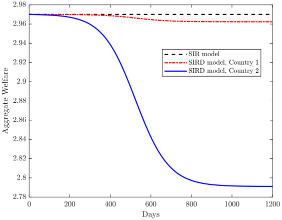
General Equilibrium Social Distancing

- Country 2 has a higher death rate than Country 1
- Rise in the relative wage and relative price index in Country 2
- Healthy Country 1 socially distances from unhealthy Country 2









Outline

1. Globalization $\longrightarrow$ Pandemics
   - Assume agents unaware of the threat of infection and no deaths
2. Globalization $\longleftrightarrow$ Pandemics
   - Assume agents unaware of the threat of infection and deaths
   - General equilibrium social distancing
3. Globalization $\longleftrightarrow$ Pandemics
   - Assume agents aware of the threat of infection and deaths
   - Individual-level social distancing and general equilibrium effects

Behavioral Responses

- Households realize that deaths are related to the pandemic
- Following Farboodi et al. (2020), infected individuals are asymptomatic
  - Household behavior is independent of their specific health status
  - Actual behavior is shaped by their expectation of the probability of being Susceptible (S), Infected (I) or Recovered (R)
  - Rational expectations using the model and observed deaths
- Households solve a dynamic forward-looking problem, with much richer dynamics that the conventional SIR model, because of time varying interactions between countries (n_{ij})
- To make this problem tractable, we assume that household commit to an optimal strategy at the beginning of a pandemic

Household's Problem

- Given known $i_i(0)$, $s_i(0)$ and $k_i(0) = 0$, the household maximizes:

$$W_i^s(0) = \max_{n_{ii}(\cdot), n_{ij}(\cdot)} \int_0^\infty e^{-\xi t} \left[\left[Q_i\left(n_{ii}(t), n_{ij}(t)\right) - C_i\left(n_{ii}(t), n_{ij}(t)\right) \right] \left(1 - k_i(t)\right) \right] dt$$

- subject to

$$\begin{aligned} \dot{s}_i(t) &= -s_i(t) \left[\left(\alpha_i n_{ii}(t) + \alpha_i n_{ii}^*(t) \right) I_i(t) + \left(\alpha_j n_{ij}(t) + \alpha_i n_{ji}^*(t) \right) I_j(t) \right] \\ \dot{i}_i(t) &= s_i(t) \left[\left(\alpha_i n_{ii}(t) + \alpha_i n_{ii}^*(t) \right) I_i(t) + \left(\alpha_j n_{ij}(t) + \alpha_i n_{ji}^*(t) \right) I_j(t) \right] \\ &\quad - \left(\gamma_i + \eta_i \right) i_i(t) \\ \dot{k}_i(t) &= \eta_i i_i(t) \end{aligned}$$

- where $k_i(t)$ is the probability of death and we have

$$Q_i\left(n_{ii}(t), n_{ij}(t)\right) = w_i(t) \left(\sum_{j \in \mathcal{J}} n_{ij}(t) \left(\frac{\tau_{ij} w_j(t)}{Z_j} \right)^{1-\sigma} \right)^{\frac{1}{(\sigma-1)}}$$

$$C_i\left(n_{ii}(t), n_{ij}(t)\right) = \frac{c}{\phi} \sum_{j \in \mathcal{J}} \mu_{ij} \left(d_{ij}\right)^{\rho} \times \left(n_{ij}(t)\right)^{\phi}$$

Optimality Conditions

- Optimality condition with respect to the choice of n_{ij} is:

$$\left[\begin{array}{c} \frac{\partial Q_i(n_{ii}(t),n_{ij}(t))}{\partial n_{ij}} \\ -\frac{\partial C_i(n_{ii}(t),n_{ij}(t))}{\partial n_{ij}} \end{array} \right] (1 - k_i(t)) e^{-\xi t} = \left[\theta_i^s(t) - \theta_i^i(t)\right] s_i(t) \alpha_j I_j(t)$$

- Optimality conditions associated with the co-state variables:

$$\begin{aligned} -\dot{\theta}_i^s(t) &= -\left[\theta_i^s(t) - \theta_i^i(t)\right] \left[\left(\alpha_i n_{ii}(t) + \alpha_i n_{ii}^*(t)\right) I_i(t) + \left(\alpha_j n_{ij}(t) + \alpha_i n_{ji}^*(t)\right) I_j(t) \right] \\ -\dot{\theta}_i^i(t) &= \eta_i \theta_i^k(t) - (\gamma_i + \eta_i)\, \theta_i^i(t) \\ -\dot{\theta}_i^k(t) &= -\left[Q_i(n_{ii}(t), n_{ij}(t)) - C_i(n_{ii}(t), n_{ij}(t))\right] e^{-\xi t} \end{aligned}$$

- Transversality conditions:

$$\begin{aligned} \lim_{t\to\infty} \theta_i^i(t)\, i_i(t) &= 0 \\ \lim_{t\to\infty} \theta_i^s(t)\, s_i(t) &= 0 \\ \lim_{t\to\infty} \theta_i^k(t)\, k_i(t) &= 0 \end{aligned}$$

Individual Social Distancing

- Agents internalize that sourcing varieties exposes them to infection
  - Reduce interactions during pandemic, such that the current marginal utility from interactions exceeds current marginal cost

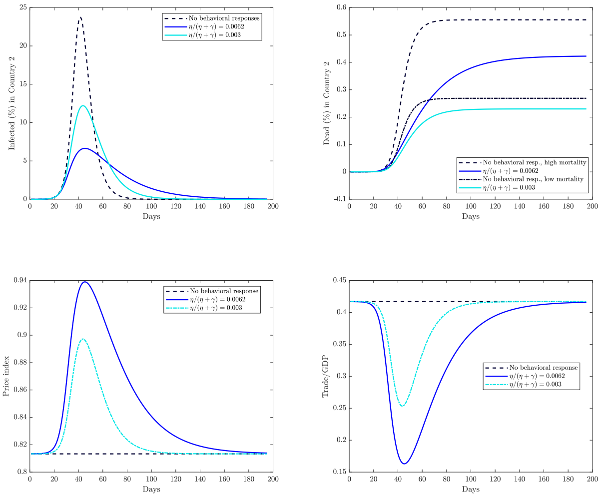
Lemma 1

Along the transition path, $\theta_i^s(t) - \theta_i^i(t) \geq 0$ for all t, which implies:

$$\frac{\partial Q_i\left(n_{ii}(t), n_{ij}(t)\right)}{\partial n_{ij}} > \frac{\partial C_i\left(n_{ii}(t), n_{ij}(t)\right)}{\partial n_{ij}}, \qquad \text{as long as } I_j(t) > 0$$

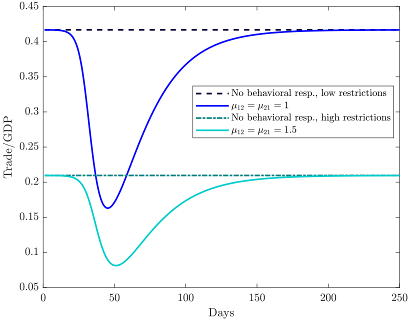
Behavioral Responses (Country Symmetry)

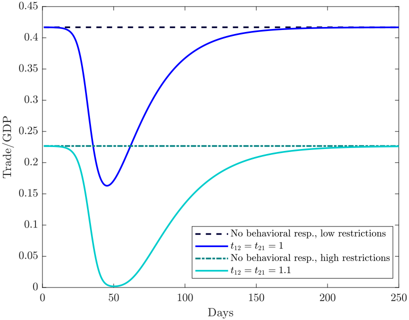
- Reduction in interactions flattens the curve of infections
- Less death, higher price index, and lower trade / GDP ▸ more
- Foreign interactions fall more because have higher marginal cost



Behavioral Responses (Country Symmetry)

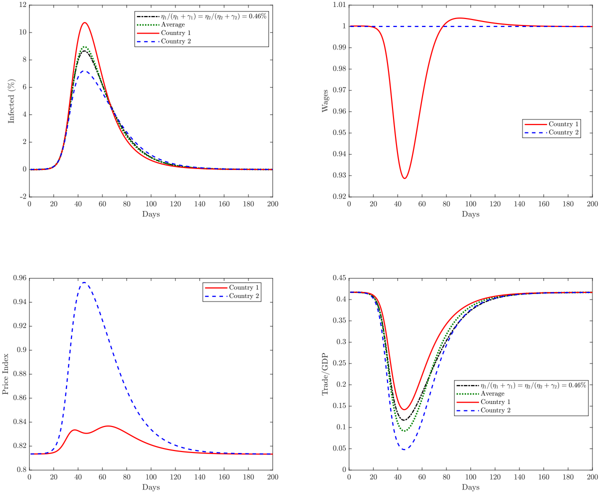
- Compare high versus low values of mobility frictions ($\mu_{12} = \mu_{21}$) and trade frictions ($t_{12} = t_{21}$)
- Larger reductions in trade / GDP for lower values of mobility and trade frictions





Behavioral Responses (Asymmetric Countries)

- Country 1 low mortality (0.3%), Country 2 high mortality (0.62%)
- Country 1 has more infections initially, then later Country 2 has more
- Country with more infections has a fall in its relative relative wage



Adjustment Costs

- We develop an extension with adjustment costs to creating new links with sellers
- This allows us to study how economic activity (and trade, in particular) reacts
  - During the pandemic (behavioral responses are attenuated)
  - Before and after a pandemic (find anticipatory depressed activity, but quantitatively extremely small)

– We conclude that a persistent negative effect on international trade is unlikely unless the perceived probability of a future pandemic is significantly higher after a pandemic than before one

Conclusions

- We develop a model of human interaction to analyze the relationship between globalization and pandemics
  - Gravity equation for international trade
  - Susceptible-Infected-Recovered (SIR) model of disease dynamics
- Cross-country epidemiological externalities
  - Whether a pandemic occurs in the open economy depends on disease environment in country with highest rates of domestic infection
- Globalization can either increase or decrease the range of parameters for which a pandemic occurs
  - Under symmetry, increases levels of human interaction
  - Under asymmetry, can reduce interaction in worst disease environment
- Globalization can generate multiple waves of infection when a single wave would occur in the closed economy
- General equilibrium social distancing
  - More deaths in an unhealthy country raises its relative wage
- Individual-level social distancing
  - Social distancing from an unhealthy country reduces its relative wage
  - Central to generating large reductions in trade to output
  - Implies substantial effects on aggregate welfare