Dampening General Equilibrium: From Micro Elasticities to Macro Effects

George-Marios Angeletos  Chen Lian
MIT
February 15, 2016

Abstract

General equilibrium (GE) effects are key to macroeconomics: they turn partial-equilibrium intuitions on their head; they also limit the usefulness of identifying local responses to local shocks as a method of estimating the macroeconomic effects of aggregate shocks. In this paper, we argue that GE effects are weak in the short run. In particular, we establish an equivalence between (i) the Tâtonnement process of a standard macroeconomic model and (ii) the equilibrium dynamics of a variant model that removes common knowledge of aggregate economic conditions. This offers a formalization of the notion that GE adjustments take time; it provides a justification for extrapolating from the aforementioned kind of micro elasticities to macro effects; and it upsets conventional policy recommendations.

General equilibrium (GE) effects are key to macroeconomics: they turn partial-equilibrium intuitions on their head; they also limit the usefulness of identifying local responses to local shocks as a method for estimating the macroeconomic effects of aggregate shocks.

For example, consider Mian and Sufi (2014). That paper offers compelling evidence that a large part of the cross-sectional variation in US employment during the Great Recession is driven by variation in consumer deleveraging. This, however, does not mean that the same mechanism explains a large part of the employment drop at the aggregate level; equilibrium effects that operate at the national level, such as those associated with relative prices, wages, interest rates, and monetary policy, introduce a wedge between the aggregate effects of an aggregate deleveraging shock and the local effects of a local deleveraging shock. By the same token, even if that paper provides a valid estimate of the “micro” elasticity of local employment to a local deleveraging shock, this need not be useful in assessing the “macro” elasticity of aggregate employment to an aggregate deleveraging shock.

In this paper, we argue that GE effects, and the resulting disconnect between micro and macro elasticities, can be less important in the short run than what assumed in standard macroeconomic models.
We do so by inspecting the GE effects in a prototypical macroeconomic model and by devising two complementary mechanisms that can dampen these GE effects. These mechanisms are formalized with the help of two variants of the original model. In the first variant, we relax the standard equilibrium concept in favor of a Tâtonnement process; this helps accommodate the notion that “equilibrium adjustment” takes time. In the second variant, we maintain the standard equilibrium concept but introduce a certain type of incomplete information, which removes common knowledge of aggregate economic conditions while maintaining local knowledge of local conditions.

We then establish two key results. The first is an equivalence between the dynamics of the two variant economies. The second is that the “macro” elasticities of the variant models are closer to the “micro” elasticities of the original model in the short run, and closer to its “macro” elasticities in the long run. Combined, these results clarify how the GE effects of the original model hinged on (i) instantaneous equilibrium adjustment and (ii) perfect coordination. By the same token, if one expects coordination frictions and/or equilibrium adjustment to take time, then one must also expect the GE effects to be dampened in the short run—and therefore one must also feel more comfortable to extrapolate from the micro elasticities estimated in, e.g., Mian and Sufi (2014) and Nakamura and Steinsson (2014) to the macro effects of interest.

In extensions, we provide additional foundations for such GE dampening on the basis rational inattention, as well as of “Reflective Equilibrium” (Garcia-Schmidt & Woodford, 2015).

There is an extensive literature on inertia in response to shocks, including adjustment cost (Caballero and Engel, 1999), inattention (Sims, 2003; Reis, 2006; Alvarez et al., 2012), etc. These are based on decision-theoretic level mechanisms that tend to dampen both micro and GE effects. Our paper, instead, focuses on how GE effects can be dampened taking as given the (estimated) micro elasticities, and thus help merge micro and macro elasticities.

We study several applications in the paper. On the one hand, we turn supply-side economics on its head by showing that payroll tax cuts may be ineffective instruments for stimulating economic activity and, instead, fiscal multipliers can be quite large, even if prices are flexible and wealth effects on labor supply are negligible. On the other hand, we discuss how our mechanism can dampen the effectiveness of monetary policy in a New-Keynesian model. We also draw relations to the empirical literature.
Dampening General Equilibrium: From Micro Elasticities to Macro Effects

George-Marios Angeletos  Chen Lian

February 14, 2016
Outline

1 Introduction

2 Main Mechanism in an Abstract Dixit-Stiglitz Economy

3 Applications

4 Conclusion
Introduction

- General equilibrium effect key to macroeconomics
  - Difficult to apply PE intuition directly to macro question
    - Household deleveraging causing recessions? Interest rate may decrease!
  - Difficult to apply empirically estimated micro elasticity to study aggregate effect of macro shocks
    - Mian-Sufi

- Strength of GE hinges upon strong assumptions
  - Instataneous adjustment of aggregates to equilibrium level
  - Agents’ perfect knowledge of those movement

- This paper: How GE effect is dampened in short run if we relax these assumptions
  - “Wrong” PE intuition is justified in short run
  - Bridging empirically estimated micro elasticity and macro elasticity
Micro vs Macro Elasticity

- $i$ denotes a micro unit:
  - A differentiated good in Dixit-Stiglitz
  - A zipcode in Mian-Sufi
  - $\theta_i$: micro shocks

- Micro supply curve, $s_i = S(p_i, \theta_i, P)$
- Micro demand curve, $d_i = D(p_i, \theta_i, P)$
- Imposing market clearing at a micro level
  - Micro price and quantity in terms of micro shocks and aggregates
    - $q_i = f^q(\theta_i, P)$
    - $p_i = f^p(\theta_i, P)$

- For simplicity, log-linearization

  $P = \int p_i di; \quad Q = \int q_i di$
Micro vs Macro Elasticity

- **Micro elasticity:**
  - How micro outcomes respond to $\theta_i$, holding aggregates $P$ fixed
  - $\varepsilon_{i}^{micro} = \frac{\partial f^q}{\partial \theta_i}$

- **Macro elasticity:**
  - How aggregates respond to aggregate (macro) shock
  - $\varepsilon^{macro} = \frac{\partial Q}{\partial \theta} = \int \left( \varepsilon_{i}^{micro} + \frac{\partial f^q}{\partial P} \frac{\partial P}{\partial \theta} \right) di$

- Macro elasticity = Average Micro elasticity (PE) + Impact through aggregates $P$ (GE)

- Mainstream macro:
  - GE is both qualitatively and quantitatively important
  - Macro elasticity deviates from micro elasticity
Our Paper

- Formalize how GE effect is dampened in short run
- Equivalence in terms dampening GE
  - A tâtonnement process
  - Remove common knowledge of aggregate shocks
  - Reflective equilibrium, adaptive expectations, etc

- A new theory about how macroeconomy responds to aggregate shocks in the short run

- A justification of using empirically estimated micro elasticity as macro elasticity in the short run
  - Mian-Sufi, Nakamura-Steinsson
Micro Inertia vs Macro Inertia

- Literature about inertia in response to shocks
  - Adjustment cost, inattention, etc.
    - Decision-theoretic mechanisms dampening micro elasticity
  - This paper: Dampening GE for given micro elasticity
Applications and Policy Implications

- Ineffectiveness of payroll tax cut during a recession
- Inertia in response to monetary policy
- Deleveraging driven recession
  - Mian-Sufi
- Demand-driven fiscal stimulus
  - Nakamura-Steinsson
Outline

1. Introduction

2. Main Mechanism in an Abstract Dixit-Stiglitz Economy

3. Applications

4. Conclusion
Set Up

- A continuum of differentiated goods
  - A representative firm competitively produce each good
- A representative household consumes them and a numeraire
  - \( U = \xi^\gamma u(c) + z \)
  - \( u(c) = \frac{c^{1-\gamma}}{1-\gamma} \)
  - \( c = \left\{ \int_0^1 \left( \delta_i \frac{1}{\xi - 1} c_i \right)^{\frac{\epsilon-1}{\epsilon}} \right\}^{\frac{\epsilon}{\epsilon-1}} \)
- Aggregate demand for composite (log-linearization)
  - \( C = \xi - \frac{1}{\gamma} P \triangleq AD(P, \xi) \)
- Demand for good \( i \)
  - \( c_i = \xi_i - \epsilon \left( p_i - P \right) - \frac{1}{\gamma} P \triangleq D(p_i, P, \xi_i) \)
- \( \xi \) aggregate demand shock, \( \xi_i = \xi + \delta_i \) good specific demand shock
Supply

- A representative firm competitively uses numeraire to produce good $i$
  
  \[ y_i = a_i \frac{(l_i)^{1+k}}{1+k} \]
  
  - $a_i$ good specific technology shock

- Supply curve for good $i$ (after log-linearization)
  
  \[ y_i = \frac{1}{k} p_i + \frac{k+1}{k} a_i \triangleq S(p_i, a_i) \]

- Aggregate supply of composite
  
  \[ Y = \frac{1}{k} P + \frac{k+1}{k} A \triangleq AS(P, A) \]
Micro and Macro Elasticity

- Imposing market clearing for each good:
  - $i$’s price and quantity as a function of micro shocks and aggregates
    - $q_i = f^q(a_i, \xi_i, P) = \frac{\varepsilon(k+1)}{\varepsilon k + 1} a_i + \frac{1}{\varepsilon k + 1} \xi_i + \frac{\varepsilon - \frac{1}{\gamma}}{\varepsilon k + 1} P$
    - $p_i = f^p(a_i, \xi_i, P) = -\frac{k+1}{\varepsilon k + 1} a_i + \frac{k}{\varepsilon k + 1} \xi_i + \frac{\varepsilon - \frac{1}{\gamma}}{\varepsilon k + 1} P$
  - Micro elasticity (e.g. output to technology shock)
    - $\varepsilon_{i}^{\text{micro}} = \frac{\partial q_i}{\partial a_i} = \frac{\varepsilon(k+1)}{\varepsilon k + 1}$
  - Macro elasticity
    - $\varepsilon^{\text{macro}} = \frac{k+1}{\gamma + k} = \int \varepsilon_{i}^{\text{micro}} \, di - \frac{(\gamma \varepsilon - 1)(k+1)}{(\varepsilon k + 1)(\gamma + k)}$
  - When $\varepsilon < \frac{1}{\gamma}$, that is, differentiated goods are complements
    - $\varepsilon^{\text{macro}} > \varepsilon^{\text{micro}}$
    - Postive aggregate technology shock $\to$ low aggregate price $\to$ more consumption of composite goods $\to$ more consumption of goods $i$
Tâtonnement

- Start from an ad-hoc economy with a tâtonnement process of aggregate price
  - Illustrate how GE is dampened especially in short run
  - How macro elasticity is micro elasticity
- Here: Adjustment of aggregate price off equilibrium
- Later: Adjustment on equilibrium
  - With lack of common knowledge of aggregate shocks
  - Replicate the dampening GE effect result
**Tâtonnement**

- Consider aggregate technology shock $A$
- Auctioneer starts conjectured aggregate price from steady state: 
  \[ \hat{P}_0 = 0 \]
  - Agents submit their supply/demand curves to auctioneer
- At round of iteration $t$, suppose auctioneer conjecture is $\hat{P}_t$
  - Adjustment according to excess aggregate supply
    \[ \frac{d\hat{P}_t}{dt} = -c_t \left( AS(\hat{P}_t, A) - AD(\hat{P}_t, 0) \right) \]
  - $c_t$ controls the speed of Tâtonnement
- Agents uses Walrasian auctioneer’s $\hat{P}_t$ as aggregate price
  - $q_{i,t} = f^q \left( a_i, \xi_i, \hat{P}_t \right)$; $p_{i,t} = f^p \left( a_i, \xi_i, \hat{P}_t \right)$
    - Micro market always clearing
  - $Q_t = \int q_{i,t} \, dj$; $P_t = \int p_{i,t} \, dj$
Tâtonnement

- Interpretation of $t$:
  - Round of iteration
  - Calendar time: Auctioneer adjusts aggregate price in real time
    - Benchmark economy happens repetitively

- Macro elasticity in Tâtonnement economy

  \[
  \epsilon_t^{macro} = \frac{\partial Q_t}{\partial A} = \frac{\epsilon(\kappa + 1)}{\epsilon \kappa + 1} - \left( \frac{(\kappa + 1) \left( \epsilon - \frac{1}{\gamma} \right)}{(\epsilon \kappa + 1)(1 + \frac{\kappa}{\gamma})} \right) \left( 1 - e^{-\frac{\kappa + 1}{\kappa} \int_0^t c_s ds} \right)
  \]

  \[
  \lim_{t \to 0} \epsilon_t^{macro} = \epsilon^{micro} \\
  \lim_{t \to +\infty} \epsilon_t^{macro} = \epsilon^{macro}
  \]

- Macro elasticity close to micro elasticity in short run
  - But gradually converges to what traditional paradigm predicts in the long run
Tâtonnement: Graph

Figure: Tâtonnement
Figure: Tâtonnement
Tâtonnement: Graph

Figure: Tâtonnement
Figure: Tâtonnement
Incomplete Information: Set Up

- Start from a static economy, dynamics later
- Same payoff-relevant set up
  - Adding “islands” for a natural info structure
- Each differentiated good is produced competitively on an island $i$
- The representative household sends one sibling to each island
  - Make consumption decision of that island-specific goods
- Sibling: A “self” of a person purchasing a particular product
  - The yesterday myself purchasing milk in Whole Foods
- Agents informed about local conditions, but not aggregates
  - When I buy milk, know price and my taste of the milk
  - Not know/consider the price of clothes
  - Not know/consider CPI and interest rate
Incomplete Information

- Similarly, consider an aggregate technology shock $A$
- All agents on island $i$ share the same information set
  - Perfect knowledge of local shock $a_i$
    - If $\sigma_a \gg \sigma_A$, one cannot infer $A$ from $a_i$
  - Prior about aggregate shock: $A \sim N(0, \kappa_A^{-1})$
  - Private signals about $A$: $s_i = A + \frac{\varepsilon_i}{\sqrt{\omega_\varepsilon}}$
    - Where $\varepsilon_i \sim N(0,1)$ and $\omega_\varepsilon$ is the precision of private signal
- Average expectation of aggregate technology shock:
  - $\bar{E}A = \frac{\omega_\varepsilon}{\omega_\varepsilon + \kappa_A} A \triangleq \lambda A$
Incomplete Information

- Heterogenous information creates coordination friction within household
  - $\chi$: error in optimal composite consumption
    - $\tilde{C} = \tilde{\xi} - \frac{1}{\gamma} \tilde{P} - \frac{1}{\gamma} \frac{\chi}{\varepsilon - \frac{1}{\gamma}} \tilde{P}$

- Island demand under incomplete information
  - $D^{inc} \left( \tilde{\xi}_i, \tilde{p}_i, E_i \tilde{P} \right) \triangleq \tilde{\xi}_i - \varepsilon \tilde{p}_i + \left( \varepsilon + \chi - \frac{1}{\gamma} \right) E_i \tilde{P}$

- Island supply under incomplete information
  - $S^{inc} \left( \tilde{a}_i, \tilde{p}_i \right) \triangleq \tilde{y}_i = \frac{1}{\kappa} \tilde{p}_i + \frac{\kappa + 1}{\kappa} \tilde{a}_i$
Incomplete Information

- Economic outcome is determined by island market clearing:
  - \( \tilde{q}_i = \frac{\varepsilon(\kappa+1)}{\varepsilon\kappa+1} \tilde{a}_i + \frac{1}{\varepsilon\kappa+1} \tilde{\xi}_i + \frac{\varepsilon+\chi-\frac{1}{\gamma}}{\varepsilon\kappa+1} E_i \tilde{P} = f_{q,inc}\left(\tilde{a}_i, \tilde{\xi}_i, E_i \tilde{P}\right) \);
  - \( \tilde{p}_i = -\frac{\kappa+1}{\varepsilon\kappa+1} \tilde{a}_i + \frac{\kappa}{\varepsilon\kappa+1} \tilde{\xi}_i + \frac{(\varepsilon+\chi-\frac{1}{\gamma})\kappa}{\varepsilon\kappa+1} E_i \tilde{P} = f_{p,inc}\left(\tilde{a}_i, \tilde{\xi}_i, E_i \tilde{P}\right) \);
  - \( \tilde{Q} = \int \tilde{q}_i di = f_{q,inc}\left(\tilde{A}, 0, E\tilde{P}\right) ; \tilde{P} = \int \tilde{p}_i di = f_{p,inc}\left(\tilde{A}, 0, E\tilde{P}\right) \)

- Aggregate expectation of endogenous aggregate price level:
  - Derived by iterating \( \tilde{P} = f_{p,inc}\left(\tilde{A}, 0, E\tilde{P}\right) \)
  - \( \tilde{E}\tilde{P} = -\frac{\kappa+1}{\varepsilon\kappa+1} \sum_{h=1}^{+\infty} \left(\frac{\varepsilon+\chi-\frac{1}{\gamma}}{\varepsilon\kappa+1}\right)^{h-1} \tilde{E}_h \tilde{A} = -\frac{\kappa+1}{\varepsilon\kappa(1-\lambda)+1-\kappa(\chi-\frac{1}{\gamma})\lambda} \lambda \tilde{A} \)

- Strategic uncertainty generates additional inertia in beliefs about \( P \) through higher-order beliefs
  - Information friction dampens macro elasticity more than micro elasticity
Incomplete Information: Outcome

- Given $\bar{E}\bar{P}$, one can write $\tilde{Q}$ and $\tilde{P}$ in terms of $\bar{A}$ and $\chi$
  - $\tilde{Q} = f^{q, inc}(\bar{A}, 0, \bar{E}\bar{P})$; $\tilde{P} = f^{p, inc}(\bar{A}, 0, \bar{E}\bar{P})$

- By definition of $\chi$, error in optimal composite consumption,
  - $\tilde{Q} = \bar{\zeta} - \frac{1}{\gamma} \tilde{P} - \frac{1}{\gamma} \frac{\chi}{\varepsilon - \frac{1}{\gamma}} \tilde{P}$

- We derive a fixed point condition about $\chi$, solve it:
  - $\chi = \frac{(\varepsilon - \frac{1}{\gamma})(1 - \lambda)}{\frac{1}{(1 - \gamma)^2} + \lambda}$

- Under complete information, $\lambda = 1, \chi = 0$
  - Perfect coordination within family maximizing composite consumption
Incomplete Information: Outcome

- **Macro elasticity in incomplete information economy**
  \[
  \varepsilon^{macro}(\omega_\varepsilon) = \frac{\varepsilon(\kappa+1)}{\varepsilon\kappa+1} - \frac{\varepsilon+\left(\chi-\frac{1}{\gamma}\right)}{\varepsilon\kappa+1} \frac{\kappa+1}{\varepsilon\kappa(1-\lambda)+1-\kappa(\chi-\frac{1}{\gamma})\lambda}
  \]

- \[\lim_{\omega_\varepsilon \to 0} \varepsilon^{macro}(\omega_\varepsilon) = \varepsilon^{micro}\]
- \[\lim_{\omega_\varepsilon \to +\infty} \varepsilon^{macro}(\omega_\varepsilon) = \varepsilon^{macro}\]

- **Imprecise information of A: macro elasticity close to micro elasticity**
  - Precise information: traditional macro elasticity
Equivalence Result, Static

**Proposition 1.** For any $t$ and $\{c_s\}_{s \leq t}$ governing the speed of Tâtonnement, there exists a precision of private signal $\omega_\varepsilon$ such that

1. Tâtonnement economy’s $Q_t$ and $P_t$
   - same as incomplete information economy’s $Q$ and $P$
2. Walrasian auctioneer’s conjectured $\hat{P}(t)$
   - same as $\bar{E}P$ in incomplete information economy

Similar mapping from incomplete information economy to Tâtonnement economy
Equivalence Result, Dynamic

- Instead of receiving one private signal only
  - Receive private signals continually about $A$: $ds_{it} = Adt + \frac{dW_{it}}{\sqrt{\omega_{\varepsilon t}}}$
  - Where $W_{it}$ is a Brownian Motion and $\omega_{\varepsilon t}$ is the precision of private signal at time $t$

- **Proposition 2.** For any $\{c_t\}$ governing the speed of Tâtonnement, there exists a series of private signal with precision $\{\omega_{\varepsilon t}\}$ such that
  1. Tâtonnement economy’s $Q_t$ and $P_t$
     - same as incomplete information economy’s $Q_t$ and $P_t$
  2. Walrasian auctioneer’s conjectured $\hat{P}(t)$
     - same as $\bar{E}_tP_t$ in incomplete information economy

- Similar mapping from incomplete information economy to Tâtonnement economy
Connection to Literature

- Inertia of response to shocks
  - Adjustment cost (Caballero-Engel); Inattention (Reis, Sims, Alvarez-Lippi)
  - Decision-theoretic level mechanism dampens micro and macro elasticity in proportion

- This paper:
  - How information friction
    - dampens macro elasticities more than micro elasticities
An Alternative

- **Reflective Equilibrium** (Garcia-Schmidt & Woodford, 2015)
  - Walrasian auctioneer adjusts conjectured aggregate price $\hat{P}_t$ according to the difference between $\hat{P}_t$ and $P_t$
  - Agents act as aggregate price is $\hat{P}_t$
    - $q_{i,t} = f^q \left( a_i, \xi_i, \hat{P}_t \right)$; $p_{i,t} = f^p \left( a_i, \xi_i, \hat{P}_t \right)$
    - $Q_t = \int q_{i,t} dj; \quad P_t = \int p_{i,t} dj$
  - $\hat{P}_t$ Adjustment:
    - $\frac{d\hat{P}_t}{dt} = -c_t \left( \hat{P}_t - P_t \right); \quad \hat{P}_0 = 0$
  - Garcia-Schmidt & Woodford interprets $\hat{P}_t$ agents' perceived aggregate price
  - Similar equivalence result
Household Deleveraging Shock

Preview:

- Adding non-tradables
- Directly mapping Mian-Sufi’s estimated micro elasticity to aggregate effect of household deleveraging shock
- A theory of household deleveraging driven recession without nominal rigidity
Household Deleveraging Shock

- A continuum of regions $i$
  - For each region $i$, a representative firm competitively produce region-specific non-tradable goods

- A representative household in each region $i$
  - Consume a common traded good and a region-specific non-traded good (GHH)
    - $u_i = \beta_i \left[ u \left( c_i - \frac{n_i^{1+\kappa}}{1+\kappa} \right) \right] + c_{i,2}$
    - $c_i = \left( (1-\alpha) \frac{1}{\varepsilon} \left( c_{i}^t \right)^{\varepsilon-1} + \alpha \frac{1}{\varepsilon} \left( c_{i}^{nt} \right)^{\varepsilon-1} \right) \frac{\varepsilon}{\varepsilon-1}$

- $\beta_i < 0$: household deleveraging shock
  - Equivalent to a tightening in budget constraint

- GE effect comes from interest rate: $R$
  - One tradable -> $R$ second period goods

- $\equiv$ effect comes from interest rate: $R$
Supply and Demand

- **Unit of account**: tradable good
- **Supply of region-specific non-tradable** $i$
  \[ y_i^{nt} = a_i + \frac{1}{k} (a_i + (1 - \alpha) p_i^{nt}) = S(a_i, p_i^{nt}) \]
- **Demand of region-specific non-tradable** $i$: \[ D(\{a_i, \beta_i\}, p_i^{nt}, R) \]
  \[ c_i^{nt} = \frac{1}{\gamma(\mu+1)} \beta_i - \frac{1}{\gamma(\mu+1)} R - \left( \varepsilon (1 - \alpha) + \frac{\alpha}{\gamma(\mu+1)} \right) p_i^{nt} + \]
  \[ \frac{\mu(1+\kappa)}{(\mu+1)k} \left( a_i + (1 - \alpha) p_i^{nt} \right) \]
  - Second term: intertemporal substitution
  - Third term: substitution between tradables and non-tradables
  - Fourth term: labor-consumption complementarity as a result of GHH
- **Tradebiles are endowed**
Micro and Macro Elasticity

- Consider household deleveraging shock: \( \beta < 0 \)
- Micro elasticity: \( \varepsilon^{micro} = \frac{\varepsilon_S}{\varepsilon_S - \varepsilon_D} \frac{1}{\gamma(\mu+1)} > 0 \)
  - \( \varepsilon_S, \varepsilon_D \) slope of local supply/demand curves for non-tradables:
- Local household deleveraging shock generates local recessions
  - Because interest rate is fixed, demand of region-specific non-tradable moves downwards
- Macro elasticity
  - Interest rate drops to crowd in consumption: \( R = \beta_{agg} \)
  - Aggregate output of non-tradables are fixed (GHH): \( Y^{nt} = C^{nt} = 0 \)
  - Macro elasticity (of non-tradable output responding to deleveraging shock): \( \varepsilon^{macro} = 0 \)
This Paper

- Macro elasticity is close to micro elasticity in short run
  - Household deleveraging shock *does* drive recession
- Intuition:
  - When buying meals, people realize tightened budget, but not low interest
  - AD curve *does* move downward
- Mian-Sufi uses regions’ heterogenous exposure to household deleveraging shock
  - To estimate average micro elasticity: $\varepsilon^{\text{micro}}$
- In the short run, micro elasticity is close to macro elasticity
  - Aggregate impact of household deleveraging shock: $\varepsilon^{\text{micro}} \beta_{\text{agg}}$
Government Spending Shock

- Similar setting as household deleveraging shocks
- Government purchase both traded goods and non-traded goods
  - Lump sum taxation in terms of second-period goods
- Supply of region-specific non-tradable $i$: 
  - $y_{i}^{nt} = \frac{\kappa + 1}{\kappa} a_i + \frac{1}{\kappa} (1 - \alpha) p_i^{nt} = S(a_i, p_i^{nt})$
- Demand of region-specific non-tradable $i$: $D\left(\{a_i, g_i\}, p_i^{nt}, R\right)$
  - $c_{i}^{1, nt} = -\frac{\lambda}{\gamma(\mu+1)} R - \lambda \left( \varepsilon (1 - \alpha) + \frac{\alpha}{\gamma(\mu+1)} \right) p_i^{nt} + \frac{\lambda \mu (1+\kappa)}{(\mu+1)\kappa} (a_i + (1 - \alpha) p_i^{nt}) + (1 - \lambda) g_i$
Micro elasticity: $\varepsilon^{micro} = \frac{1-\lambda}{\varepsilon_S - \lambda \varepsilon_D} > 0$
- Local government spending shock stimulating local economy

Macro elasticity: $\varepsilon^{macro} = 0$
- Interest rate moves up to crowd out consumption

This paper
- Macro elasticity is close to micro elasticity in short run
- Government spending does stimulate economy

Nakamura-Steinsson uses regions’ heterogenous exposure to military spending
- To estimate average micro elasticity: $\varepsilon^{\bar{micro}}$
- Aggregate impact of government spending shock: $\varepsilon^{\bar{micro}} G$
Outline

1. Introduction

2. Main Mechanism in an Abstract Dixit-Stiglitz Economy

3. Applications

4. Conclusion
Conclusion

- Slow adjustment of beliefs of aggregate endogenous outcomes
- In short run
  - GE response to macro shock is dampened
  - Empirically estimated micro elasticity is macro elasticity
  - A new theory about how macroeconomy responds to aggregate shocks
- Robust predictions in multiple settings
  - Tâtonnement, incomplete information, reflective equilibrium