

Interest Rate Changes and Economic Activity

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Look at Some Usually Ignored Implications of Interest Rate Movements

- Interest Rate Movements as Analyzed by Central Banks Operate through Intertemporal Substitution.
 - They are typically studied with Representative Agent Models.
 - Any effect of wealth or income changes has a small consumption increase: There is a lot of wealth (25 times quarterly consumption implying at best a Low Marginal Propensities to Consume $< 3\%$)
 - Consumption response is then humped via habits.
- Yet Evidence ([Fagereng et al. \(2021\)](#), [Crawley and Kuchler \(2021\)](#)) points to much larger Marginal Propensities to Consume.
- So Heterogeneous Agent Models with Incomplete Markets have arisen as an alternative ([Carroll \(1997\)](#), [Auclert et al. \(2020\)](#), [Alves, Bustamante, Guo, Kartashova, Lee, Pugh, See, Terajima, and Ueberfeldt \(2022\)](#)) because they have poor people that respond to transitory income changes while less concerned with direct changes in real interest rates ([Blundell et al. \(2008\)](#)).
- Heterogeneity is not enough by itself since there is a lot of wealth in the economy (about 4 times GDP) so
 - Models difficult access to wealth by imposing large transaction costs in two asset models ([Kaplan et al. \(2018\)](#))
 - Habits or sticky expectations to delay a bit the response ([Auclert et al. \(2020\)](#)) rather than the more grounded rational inattention ([Sims \(2003\)](#), [Mackowiak and Wiederholt \(2009\)](#)).

What Existing Heterogeneous Agents Models Capture

- Without restrictions on access to assets
 - Redistribution effects between borrowers and lenders
 - The implications of labor employment losses concentrated on those of the low end of the income distribution magnifying some income effects ([Castañeda et al. \(1998\)](#), [Fang and Nie \(2013\)](#))
 - The further reduction of consumption (more precautionary savings) in recessions associated to countercyclical earnings risk (more skewness) ([Gornemann et al. \(2021\)](#), [Ravn and Sterk \(2021\)](#)).
- With restrictions on access to assets
 - Much larger response to changes in interest rates.
- Overall, indirect effects of an unexpected changes in interest rates, operating through a general equilibrium increase in labor demand ([Kaplan et al. \(2018\)](#)) outweigh intertemporal substitution mechanisms.

What Existing Heterogeneous Agents Models Do NOT Capture

- Changes in Aggregate Wealth
 - Not because of asset destruction but because of changes in valuation of assets (partially noted by [Auclert \(2019\)](#))
 - Especially important because empirically Wealth Effects Matter. (which requires both household elastic responses and changes in wealth itself). ([Petev et al. \(2012\)](#), [Mian et al. \(2013\)](#), [Pistaferri \(2016\)](#), [Aladangady \(2017\)](#), [Guren, McKay, Nakamura, and Steinsson \(2020\)](#), [Graham and Makridis \(2021\)](#), [Padula \(2022\)](#), [Gilraine, Graham, and Zheng \(2022\)](#))
- It requires to have models that can change prices
 - Not Physical Capital but Land and Fixed factors that are sources of rents (especially in the presence of production adjustment costs)
- Abstract from any channel that allows for productivity changes being the result of expenditure changes (an Old-Keynesian Amplification Mechanism: if you build it they will come)
 - Having the shop full of customers increases business productivity without paying for it
 - The missing factor of production is household effort or inconvenienced ([Bai et al. \(2019\)](#), [Huo and Ríos-Rull \(2020\)](#))
 - Can be easily implemented via an expenditure externality ([Krueger, Mitman, and Perri \(2016\)](#))

Purpose Today: Lay out a Model Suitable to Study Business Cycles

- Pose an Aggregate Model Economy i.e. it replicates relevant macro aggregates (wealth and its distribution) where
 - Shocks Change Wealth (prices of houses and businesses)
 - Changes in Wealth Induce Large Changes in Behavior (associated to redistribution through leverage of many)
- It requires/has
 - Assets (Business and Houses) with Prices that Change Endogenously
 - Heterogeneous Households (with many very leveraged)
 - Real Frictions that difficult reallocation of resources
 - Sluggish wage adjustments
 - Expenditure externality
- The economy can be seen as a small open economy or as a study of regions (today the interest rate is exogenous and there is no monetary policy)
- Lot's of work ahead

- Adverse Events
 1. Raise of (Real) Interest Rates
 2. Fall in price of Exports
 3. Financial tightening
 - Loan to Value (LTV)
 - Debt Service to Income (DTI)
- Trigger Recessions where
 - Fall in Housing Prices and Local Business (insufficient diversification)
 - Reduce Expenditures (amplified via externalities in TFP)
 - Which in turn reduce output
 - The economy is too rigid to turn negative wealth effect into an expansion via harder working

- We want our model to be consistent with the Great Recession
- But also we want to interpret our model as a financial stability view of:
 - Monetary Policy (it moves real interest rates)
 - Typically looked at as a units of account issue that interacts with “slow” price adjusting firms to generate desired real effects.
 - Unlike in HANK models, in ours wealth disappears, not just inaccessible.
 - We are concerned with the asset price effects implied when assets are not just reproducible capital.
- More financial stability than standard new-Keynesian inflation-output tradeoffs.

Ingredients of the Environment

- Standard Heterogeneous Incomplete Markets Model (Bewley (1984), Imrohoroglu (1989), Huggett (1993), Aiyagari (1994))
- Large Amount of Wealth, some in fixed supply (fixed factors, land), some reproducible (physical capital with adjustment costs and buildings), and risk free liquid assets.
- Large Wealth Concentration: Due to
 - Shocks to Earnings
 - Shocks to Shares of Local Businesses (the fixed factor in production)
- Incomplete markets: there are are financial frictions
 - Loan to Value Restrictions
 - Interest to Income Restrictions
 - Non tradable assets (not very important)
- Sluggish wages
- We also explore slow adjustment of nontradable prices (insufficient devaluation)

- Details of the environment
- Discussion of how to Map the model to data
- A bunch of Impulse Responses
 1. Pure real interest rate hike
 7. Perfect Storm: real interest rate hike, worsening of access to financial markets (more difficult to borrow) & fall in foreign demand for exports.
 - Exclude Amplification channel of Expenditures Effects on Productivity after the rate hike
 - Incomplete adjustment on the relative price of inputs (insufficient devaluation) after the rate hike

The Environment: First the Steady State:

- Three types of Agents
 - Heterogeneous Households
 - Nontradable producers
 - Export producers
- Three intermediate goods
 - nontradables: e
 - exports: x (not used domestically at all).
 - imports: m
- Consumption C (composite of e and m).
- Investment in Business Capital I^k (composite of e and m).
- Investment in Residential Structures I^s (composite of e and m).
 - Final Goods may have different ratios of e and m .
- Housing H , a combo of structures S & land L in fixed supply.

- Continuum of households that live forever (β), are subject to uninsurable idiosyncratic.
 - Care about composite of nontradables that are subject to search frictions and import that are not and houses.
 - Hold wealth as houses, liquid assets, and shares of local firms that are illiquid.
 - Standard uninsurable idiosyncratic labor productivity shocks
 - Quasi standard unemployment shocks (may not be stationary)
 - Non Standard shocks to the nontradable shares of local firms (accounts for the cross section of property of non traded firms)

Households: Preferences (over nontradables)

- H'holds care about quantities and number of varieties of nontradables.

$$c_N = \left(\int_0^{I_N} c_{Ni}^{\frac{1}{\rho}} di \right)^{\rho} = c_{Ni} I_N^{\rho}$$

- Households have to search for varieties, its number is a *choice*.

$$I_N = d \Psi^d(Q^g)$$

- $\Psi^d(Q^g)$: Probability (per search unit) of finding a variety (goods market frictions).
- Households also like tradables and housing and dislike goods searching

$$u [c_A(c_N I_N^{\rho}, c_T), h, d]$$

- Household skill type is ϵ , follows a Markov chain $\Gamma_{\epsilon, \epsilon'}$. Moves slowly and accommodates opportunities to get rich.
- Households either have a job $e = 1$ or not $e = 0$.
 - Type-dependent exogenous job destruction rate δ_n^ϵ .
 - Job finding rate is type independent and depends on job creation by firms (workers are rationed, it is like no matching function in labor market but hiring costs) (Fang and Nie (2013)).
- Households have assets a . These assets can be allocated to (frictionless) houses and/or to financial assets with a collateral constraint. The poor will have some housing wealth and a mortgage, the rich houses and shares of the economy's mutual fund.

- Search frictions in the markets for nontradables:
- Households look for varieties.
- Random search.
- Richer people consume and search more.
- Cuts in consumption cut search which cuts productivity.
- Perfect competition and frictionless markets for tradables.

- Workers are rationed.
- Firms hire as many workers as they wish paying hiring costs. (like a vacancy filling probability of 1, with hiring costs).
- Employment: $N = N_N + N_T$.
- Same job finding probability across types: $\Phi^e = \frac{V}{1-N}$.
- Wages are exogenous (set to some aggregate target).

- Total housing \bar{H} is in fixed supply.
- Negative financial assets ($b' < 0$) are (undefaultable) mortgages.
 - Its interest rate is predetermined: $\frac{1}{1+r^*} - \varsigma$, if $b < 0$.
 - Mortgages have to be collateralized by housing: if $b < 0$ then

$$|b| \leq [1 - \lambda] p_h h \left[\frac{1}{1+r^*} - \varsigma \right]$$

- Positive financial assets ($b > 0$) are shares of a mutual fund.
 - Its return, r , is determined ex-post (it matters when we hit the economy with shocks). Possible capital gains and losses.

$$R(b) = \begin{cases} 1 + r, & \text{if } b \geq 0 \\ 1, & \text{if } b < 0. \end{cases}$$

Household Problem: State is $\{\eta, \epsilon, \theta^e, \theta^x, a\} = \{z, a\}$

$$V(z, a) = \max_{b, h, c} u[\Psi^c(e, m), h] + \beta \mathbb{E}\{V(z', a')\} \quad \text{s.t.}$$

$$p^e e + p^h h + m + b = a + \mathbb{1}_{\eta=1}\{w\epsilon\} + \mathbb{1}_{\eta=0}\{\bar{w}\} + \theta^e \pi^e + \theta^x \pi^x \quad \text{BC}$$

$$a' = \underbrace{p^{s'}(1 - \delta_h) s(h, H)}_{\text{value of undeprec Struct}} + \underbrace{p^{e'} \frac{h}{H}}_{\text{value of land}} + (1 + r') b \quad \text{EW}$$

$$b \geq -\lambda p^h h(1 + r) \quad \text{LTVC}$$

$$r b \geq -\mu \mathbb{1}_{\eta=1}\{w\epsilon\} \quad \text{FC}$$

- Production sectors face
 - Decreasing Returns to Scale production technologies due to a fixed factor owned locally (crucial for changes in asset (stocks) prices).
 - Adjustment costs of capital and workers
 - Search frictions when hiring
 - same job finding rate across ϵ from HHs
 - different job separation rates across ϵ

$$\Omega^e(k, \{n^\epsilon\}) = \max_{v, k', m, e} \left\{ p^e F^e(k, n) - m - p^e e - \kappa v - \phi^n(n', n) - w n + \frac{\Omega^e(k', \{n^{\epsilon'}\})}{1 + r'} \right\}$$

s.t.

$$n = \sum_{\epsilon} n^{\epsilon}$$

$$k' = (1 - \delta^k)k + \Psi^e(m, e) - \phi^{e,k}[k, \Psi^e(m, e)],$$

$$n^{\epsilon'} = \underbrace{\sum_{\tilde{\epsilon}} (1 - \delta_{\tilde{\epsilon}}) n_{\tilde{\epsilon}} \Gamma_{\tilde{\epsilon}\epsilon}}_{\text{unseparated worker}} + \underbrace{\sum_{\tilde{\epsilon}} \Gamma_{\tilde{\epsilon}\epsilon} \frac{u_{\tilde{\epsilon}}}{u}}_{\text{measure of hiring } \epsilon \text{ next period}} v$$

- Dividends $\pi^e = p^e F^e(k', l) - m - p^e e - \kappa v - \phi^n(n', n) - w \sum_{\epsilon} n^{\epsilon} \epsilon$

Some other Relevant Features

- Export Sector Similar to Non-tradable
- Rich households have no real use for a lot of housing
- Poor/middle households are very leveraged and constrained. They have less housing than they would like.
- Financial constraints limit and change the value of land.

- Employed Households supply labor inelastically and are paid $w\epsilon$.
- Unemployed Households earn \bar{w} from home production.
- Job Flows come from exogenous destruction and endogenous vacancy creation
- High Skilled households are employed more because lose jobs less often
- Note that u and V are equilibrium objects.
- Wages adjust slowly

- Nontradable goods are in a frictionless, perfect competitive environment but are subject to an externality in TFP akin to our previous work.
- Both nontradables and exports use capital, labor and a fixed factor to produce goods.
- Adjustment costs to adjust capital and employment.
- Search friction: hiring cost of κ per vacancy.
- Wage is exogenous in steady state (set to get labor share).
 - but is determined by a function of output deviation from steady state along the transition path
- All firms are owned locally

Steady State

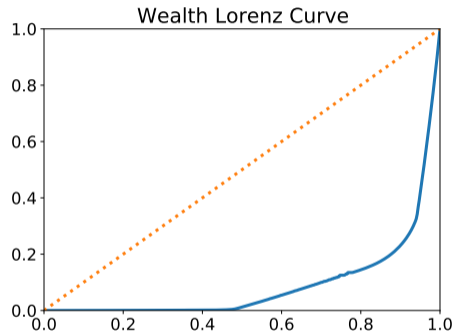
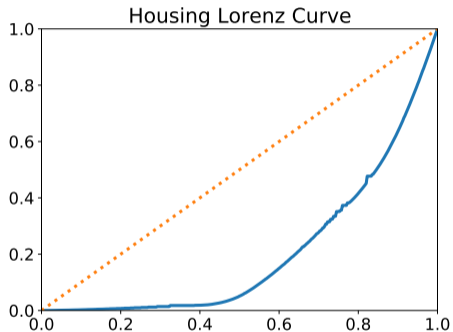
Some Additional Assumptions

- Model period is a quarter
- Perfect correlation between labor productivity and share holdings
- Households face mortality risk of 0.005 (Average life expectancy of 200 quarters or 40 years). To ensure enough poor people (perf annuity markets).
- Zero Int'l indebtedness
- Non homotetic Utility to prevent housing purchases by the rich

| Parameterization for St St | |
|--|------|
| Risk aversion for consumption | 2.0 |
| Satiation level for housing | 4.5 |
| Loan to value ratio | 0.8 |
| Annual world interest rate | 4.0% |
| Relevant Out of St St Elasticities | |
| Wage elasticity | 0.5 |
| TFP elasticity (with externality) (small) | 0.3 |
| Elasticity of Substitution bw nontradable and import | 0.8 |
| Adjustment cost coefficient (to be fine tuned) | 1.57 |

Targeted Moments

| | Target | Model | Tool | Value |
|-------------------------------|--------|-------|-------------------------|-------|
| Output | 1.00 | 1.00 | TFP in Export | 0.73 |
| Capital-to-Output | 2.00 | 2.00 | Capital dep. rate | 0.025 |
| Housing-Value-to-Output | 1.80 | 1.76 | Util shifter in housing | 0.50 |
| Debt-to-GDP | 0.00 | 0.02 | Discount rate | 0.92 |
| Wealth-to-Output | 4.50 | 4.57 | Dep. rate in housing | 0.008 |
| Wealth Gini | 0.82 | 0.82 | Top Share holdings | 13.20 |
| Frac. of H held by bottom 70% | 0.25 | 0.27 | \hat{h}_1 | 0.98 |
| Frac. of H held by bottom 80% | 0.39 | 0.41 | \hat{h}_2 | 1.80 |
| Frac. of H held by bottom 90% | 0.58 | 0.64 | σ_h | 2.98 |
| Relative Price of Nontradable | 1.00 | 1.00 | TFP in e | 0.73 |
| Share of Export | 0.30 | 0.30 | CES weight on e | 0.75 |
| Employment Rate | 0.92 | 0.92 | wage | 0.96 |



- Gini coeff: housing 0.63, Wealth 0.82 (data 0.82 in 2007 SFC)

Business Cycles

- 1 Increase in Interest Rate (world event or Policy) 1% (Baseline)
- 2 Perfect Storm: Base + Financial Constraint: Max LTV 80% \rightarrow 60% + $(p^x - 3\%)$
- 3 Base without any negative effect on TFP
- 4 Base with price stickiness (insufficient devaluation)

- A Temporary but persistent increase in the (World) Interest Rate
- With TFP Externality only on Nontradables

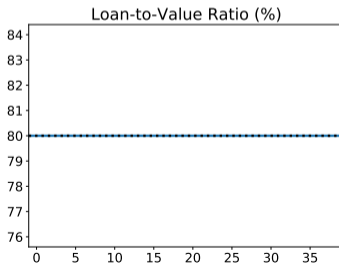
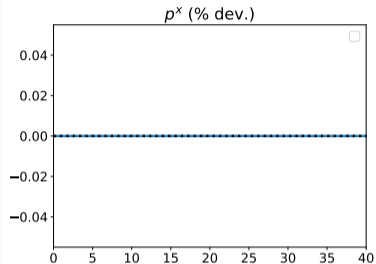
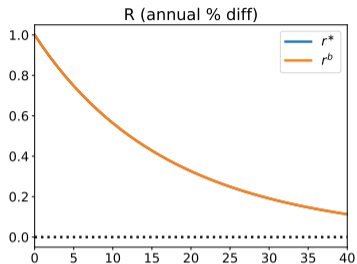
- TFP Elasticity wrt expenditures .5

- Wage Adjustments ($\psi^w = .5$)

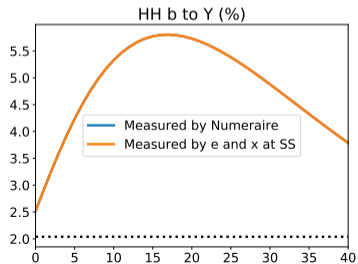
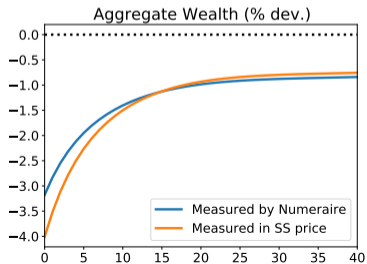
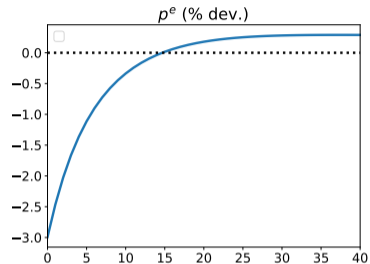
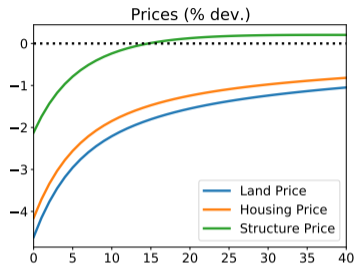
$$\log w_t - \log w^{ss} = -\psi^w (\log U_t - \log U^{ss})$$

- Import Elasticity .8

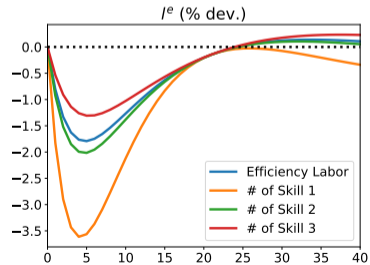
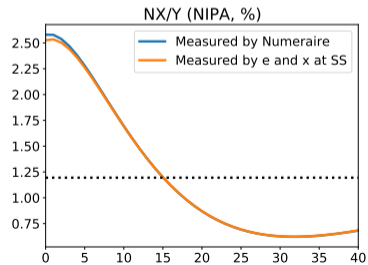
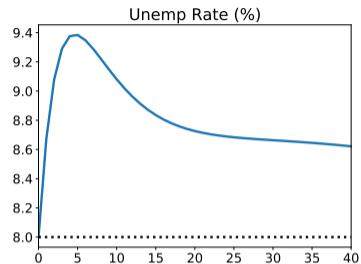
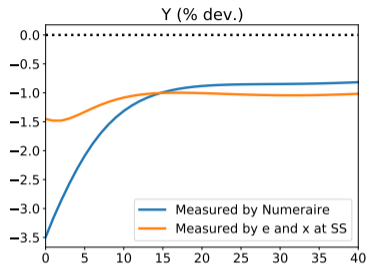
1- Exogenous Shifter: (Only r moves)



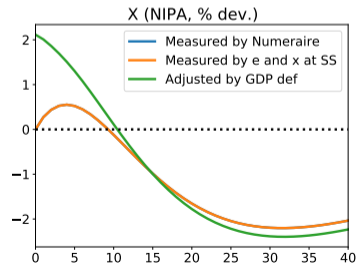
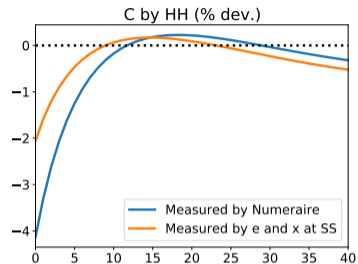
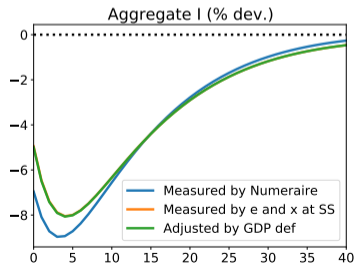
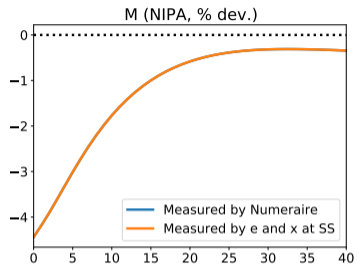
1- Asset Prices & Quantities (Financial and Total Wealth)



1- Main Business Cycle Objects

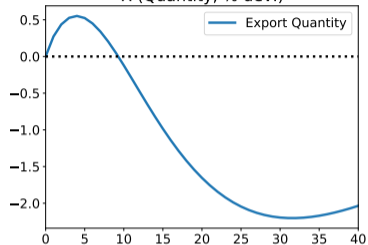


1- GDP Components

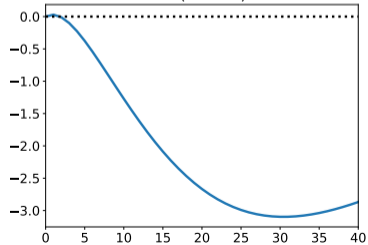


1- Sector

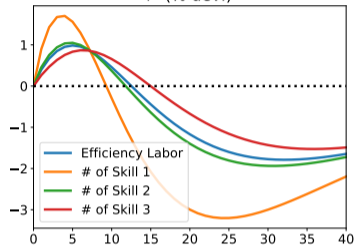
X (Quantity, % dev.)



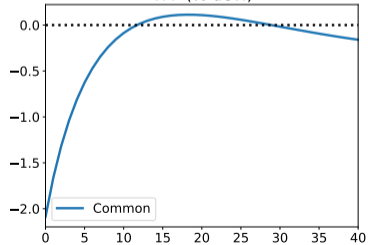
k^x (% dev.)



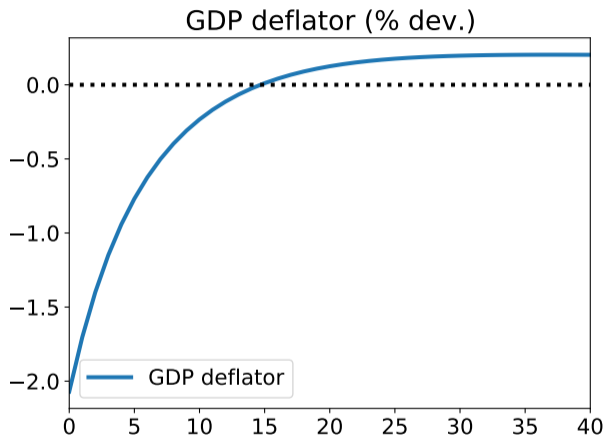
I^x (% dev.)



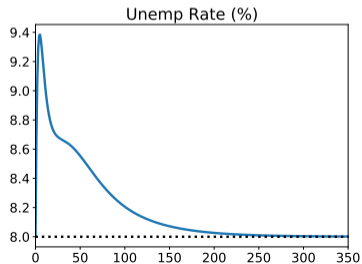
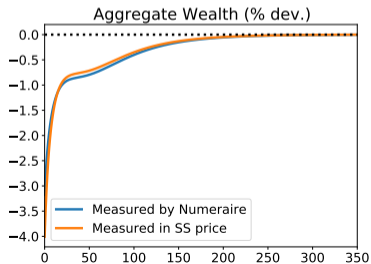
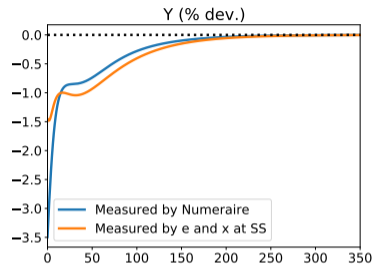
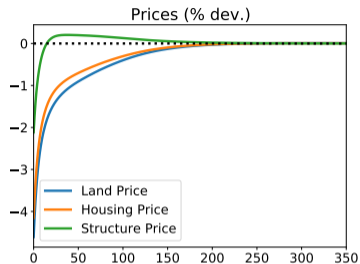
TFP (% dev.)



1- GDP Deflator



1- The Longer View: 87 years



1- Takeaways from a 1% persistent but temporary real interest rate hike

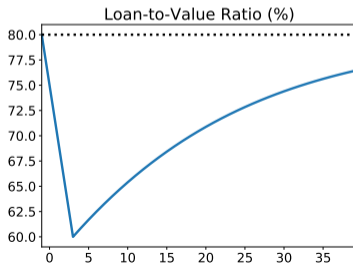
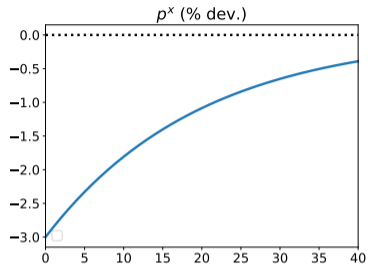
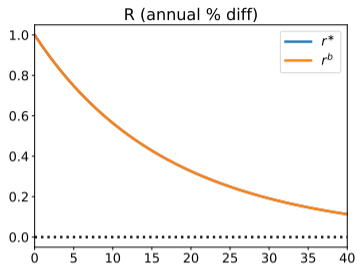
- Sizeable Recession With Large Drop of Wealth
- Large Drop of Consumption.
- Large Reduction in Employment
- Large Devaluation
- But Large Improvement in Balance of Payments (large reduction of imports)
- Exports move up then down. Slowly due to adjustment costs in investment and productivity propagation
- Recessions are Long ([Aguiar and Gopinath \(2007\)](#))

2th Experiment: Perfect Storm: The Great Recession?

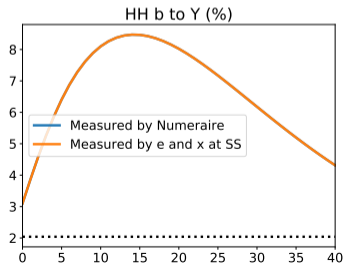
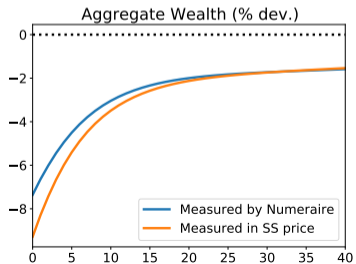
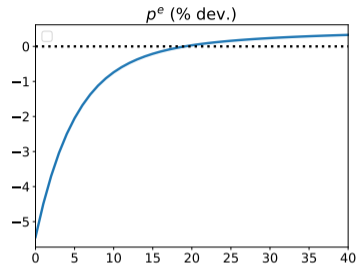
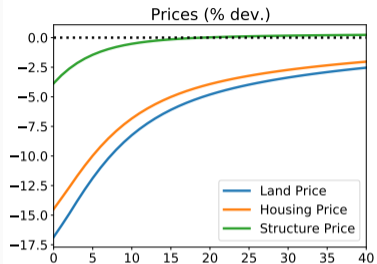
- A Temporary but persistent Increase in Interest Rates
- A 3% Temporary but persistent Decrease in the Terms of Trade
- Reduction in Max LTV from 80% to 60%
- With TFP Externality
 - TFP Elasticity wrt expenditures .5
 - Wage Adjustments ($\psi^w = .5$)
 - Import Elasticity .8

$$\log w_t - \log w^{ss} = \psi^w (\log Y_t - \log Y^{ss})$$

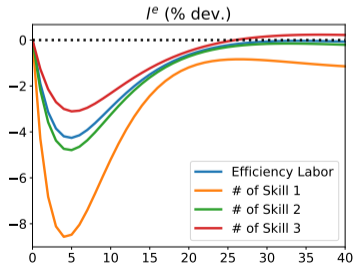
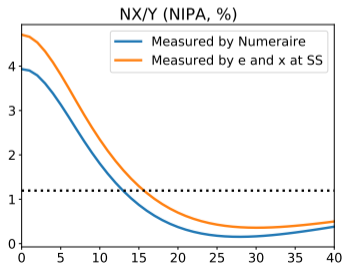
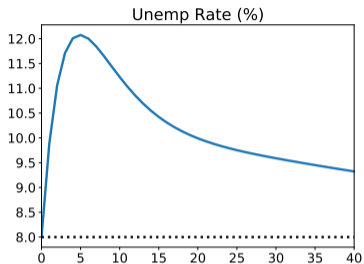
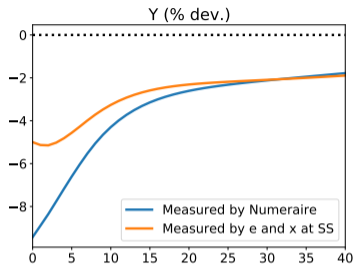
2. Exogenous Shifters: r moves 1% and p^x 5%



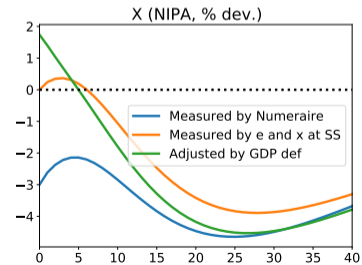
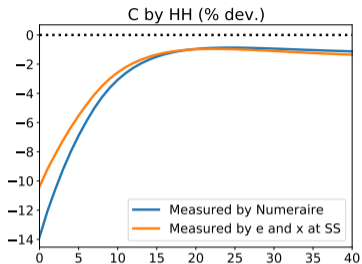
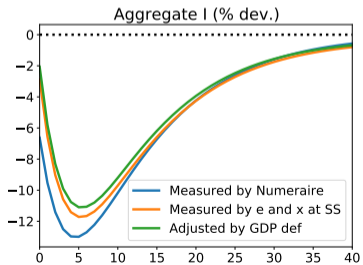
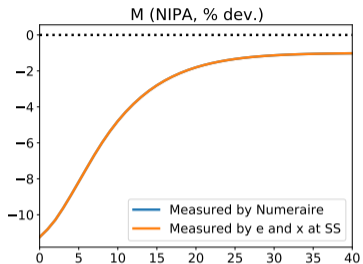
2. Asset Prices & Quantities (Financial and Total Wealth)



2. Main Business Cycle Objects



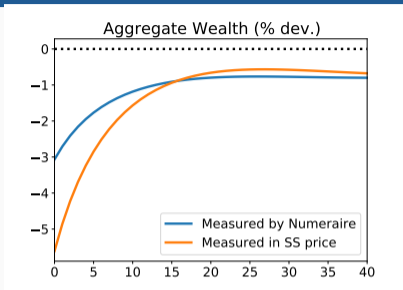
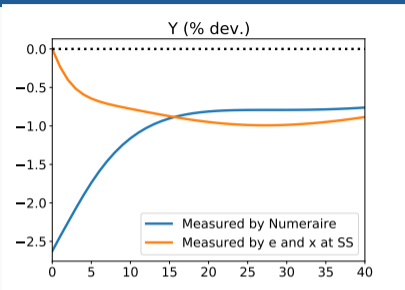
2. GDP Components



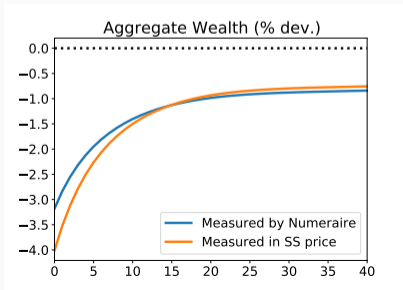
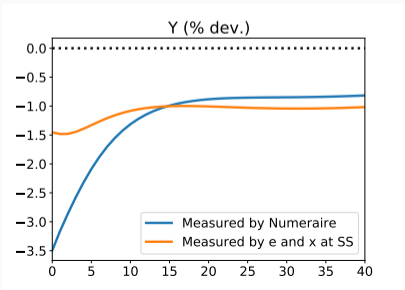
2. Main Takeaways

- Everything Larger
- Very Large Devaluation relative to price decrease
- Huge Drop of Consumption, Investment and Exports
- Huge Reduction in Employment
- Humongous reduction of imports: Sizeable Improvement in Balance of Payments.
- Not consistent world wide. Need much larger drop in foreign demand.

3- No Amplification via Expenditure Externality



Comparing with Baseline

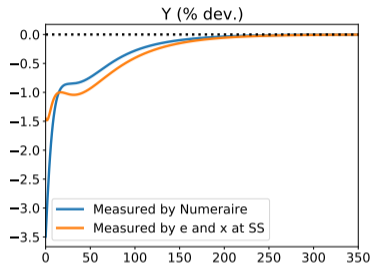


4th: Insufficient Devaluation

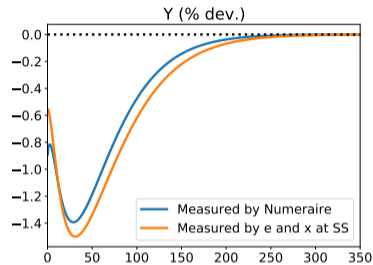
- A Temporary but persistent Increase in Interest Rates
- Elastic Non-tradable price no market clearing on non-tradables, demand determined quantities
- Reduction in Max LTV from 80% to 60%
- With TFP Externality
 - TFP Elasticity wrt expenditures .5
 - Wage Adjustments ($\psi^w = .5$)
$$\log w_t - \log w^{ss} = \psi^w (\log Y_t - \log Y^{ss})$$
 - Import Elasticity .8

Comparing with output across horizons between base and partial devaluation

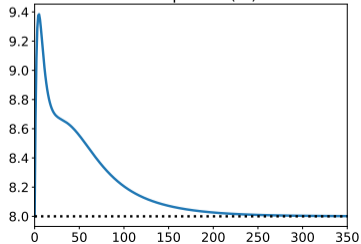
Baseline



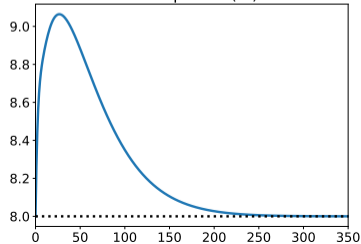
Partial Devaluation



Unemp Rate (%)

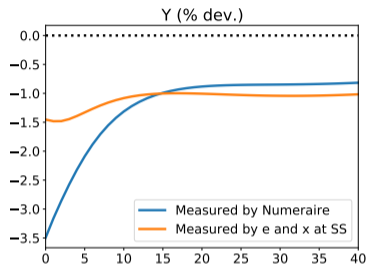


Unemp Rate (%)

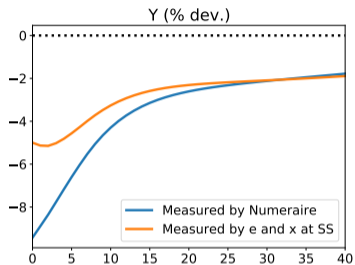


Comparison between all Economies: Output

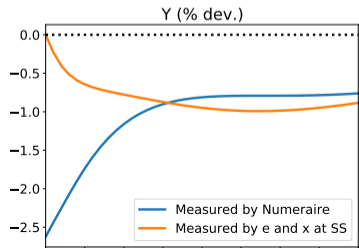
Baseline



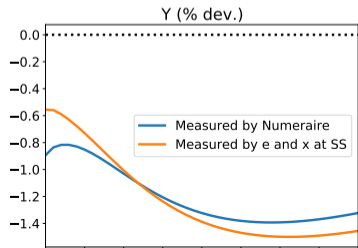
Perfect Storm



No TFP Externality

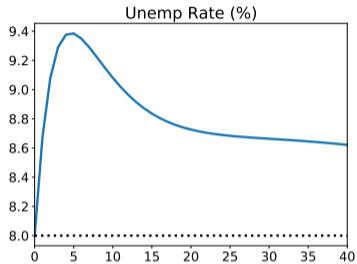


Insufficient Devaluation

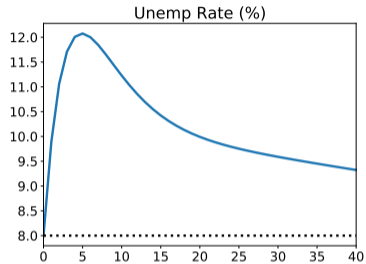


Comparison between all Economies: Unemployment

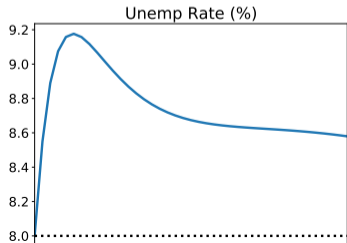
Baseline



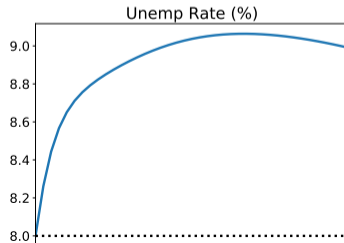
Perfect Storm



No TFP Externality



Insufficient Devaluation



What we want to have but do not have YET

- Some Technical Things
 - Incorporate Financial Restrictions ONLY on newly born
 - Loan to Value Restrictions ONLY to New Loans
- Build this into a World Economy
 - So Interest Rates are Endogenous
 - So Crisis are Simultaneous and Devaluations are Not Helpful
- Have a modern New Keynesian structure to model the link between nominal and real interest rates

- Heterogeneous Agent Models have come a long way (empirically, computationally, theroretically) to become useful tools to understand aggregate economies and to evaluate policy.
- Wider mechanisms than just through intertemporal substitution as in Rep Agent models.
- They incorporate some wealth and redistribution effects.
- Build more Asset prices and productivity propagation into those models.

- We need to develop models of Monetary policy that are beyond those in New Keynesian Models.
- Financial Stability is a Concern
- Not only because financial firms are affected
- But also because Households are affected, especially in Europe where mortgages are NOT indexed.
- In other work we show how expansionary policy (with house price increases) put households more at risk for later interest rate hikes.

Thank you very much

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