DSGE MODELS IN FISCAL POLICY ANALYSIS

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[1] The views expressed herein are those of the authors and should not be attributed to the IMF, its Executive Board, or its management.

PRESENTATION OUTLINE

- Why DSGE (dynamic stochastic general equilibrium) models for macro policy analysis?
- A quick review on the evolution of DSGE models
- Examples of DSGE models on fiscal policy analysis
- Promises and pitfalls of using DSGE models

DSGE MODELS IN MACRO POLICY ANALYSIS

- DSGE models have become the workhorse in modern macro research and policy analysis since mid 2000s.
- They are widely used in policy institutions around the world. Examples:
  - FRB: the Estimated Dynamic Optimization (EDO) Model, a medium-scale NK DSGE model since 2006.[2]
  - IMF: the Global Integrated Monetary and Fiscal Policy Model (GIMF), a multicountry model.[3] IMF also has various DSGEs for individual countries for different purposes.[4]

[2] https://www.federalreserve.gov/econres/edo-models-about.htm

[3] https://www.imf.org/en/Publications/WP/Issues/2016/12/31/The-Global-Integrated-Monetary-and-Fiscal-Model-GIMF-Theoretical-Structure-23615

[4] E.g., the DIGNAR model, https://www.imf.org/en/Publications/WP/Issues/2016/12/31/Debt-Sustainability-Public-Investment-and-Natural-Resources-in-Developing-Countries-the-41455

PROBLEMS OF CONVENTIONAL APPROACHES

- Conventional theoretical frameworks, likes IS-LM, almost disappear in macro research (See "Whither ISLM," Sims, 1998).
  - "ISLM inhibits attention to expectations in macroeconomics...This can lead to mistaken policy conclusions..." (p. 1).
  - ISLM is disconnected from fundamental principles in microeconomics.
- Traditional reduced-from (RF) empirical analysis cannot survive under Lucas Critique.
  - The Phillips Curve estimated by a RF regression leads to the Great Inflation in the 1970s in the U.S.

PHILLIPS CURVE

Erroneous inference from a RF regression of inflation on unemployment (Phillips, 1958 Economica).

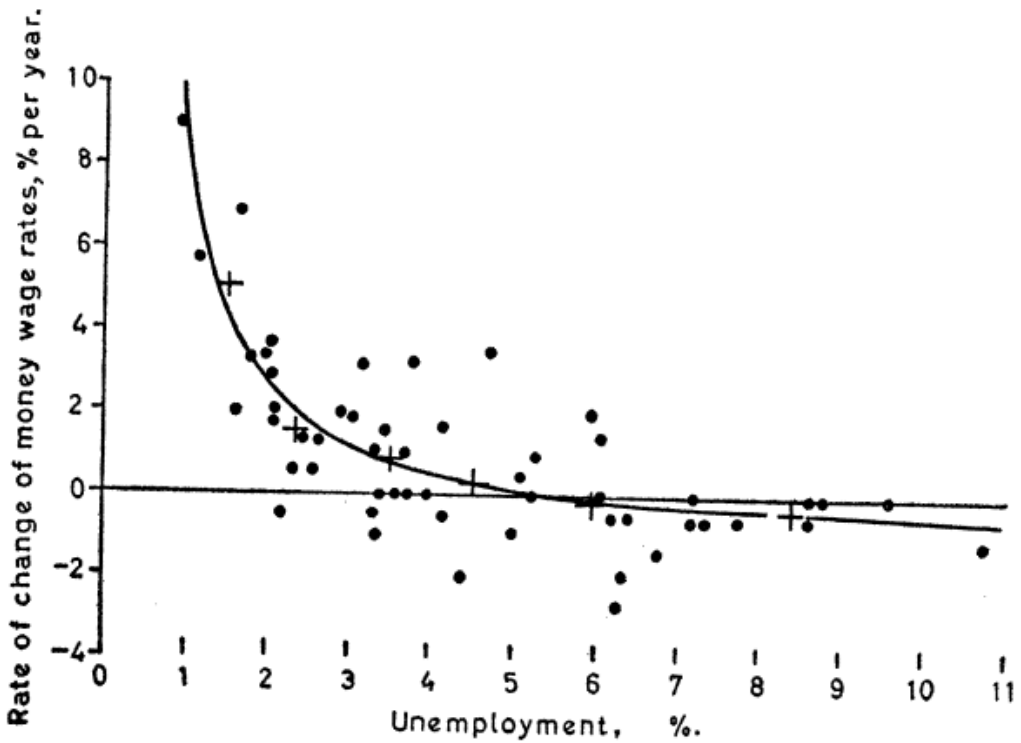
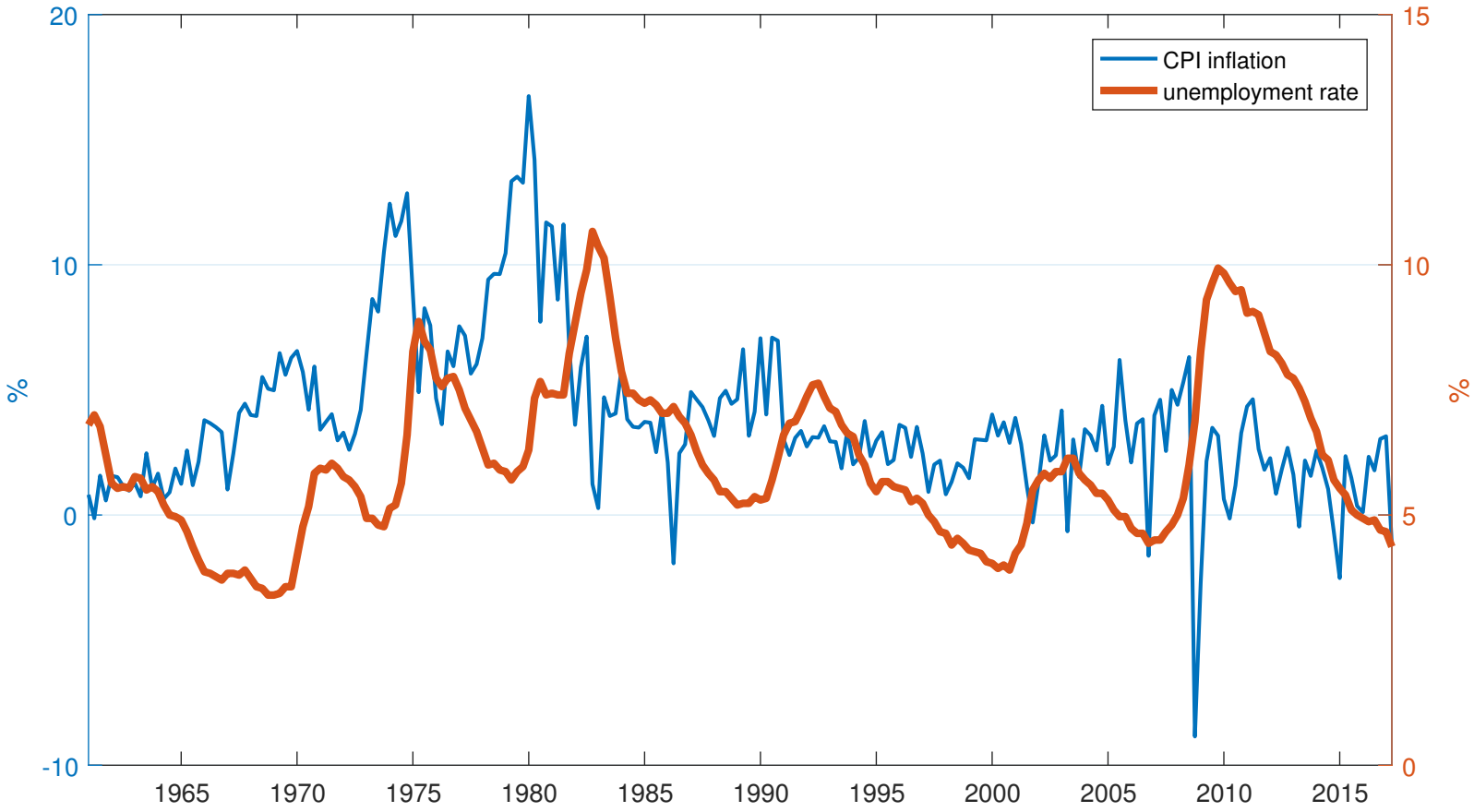


Fig.1. 1861 – 1913

PHILLIPS CURVE IN THE US

Unstable relationships in the US



WHY DSGE MODELS?

- From the theoretical perspective, modern macro (or DSGE) uses structural, micro founded models that account for expectations, so that the analysis is less susceptible to Lucas Critique.
- From the empirical perspective, when estimated by Bayesian inference methods, DSGE models can be used for forecasting, analyzing historical policy effects, and assessing alternative policy.

I. SIMPLE RBC MODELS

- The backbone of DSGE models is the RBC or neoclassical growth models, consisting of all the ingredients of DSGE models:
  - optimization behaviors of economic agents;
  - forward looking decision making accounting for expectations;
  - dynamic/intertemporal;
  - general equilibrium;
  - stochastic driving forces, with a focus on technology shocks.
- RBC's contact with data is limited: Although some parameter calibration relies on data, moment matching of simulated data with real data is only rough way to assess whether a model is empirically relevant.

II. RBC W/ FP SHOCKS

- By adding fiscal (tax and spending), RBC models can better account for business cycle phenomena, e.g.,
  - McGrattan (1994, JME) finds tax shocks are important in the fluctuations of key macro variables.
  - Braun (1994, JME) finds that adding distorting tax shocks improves RBC's prediction on the correlation between real wage (average productivity) and hours worked.
  - Jones (2002, JME) assesses the effectiveness of estimated government spending and tax rules embedded in an RBC model to stabilize BC fluctuations.

III. RBC W/ REAL SLUGGISH ADJUSTMENTS

- Simple RBC models are added with habit formation, investment adjustment costs, etc.
  - The common solution method for solving DSGE yield has an AR representation. Its MA form can be compared to impulse responses to empirically isolated shocks.
  - Burnside, et al. (2004, JET) find that once allowing for habit formation and investment adjustment costs, a standard RBC model can better account for the quantitative effects of government spending.
  - Since then, these real sluggish adjustments are standard features in DSGE for studying policy effects, e.g., Leeper et al. (2010, JOE).

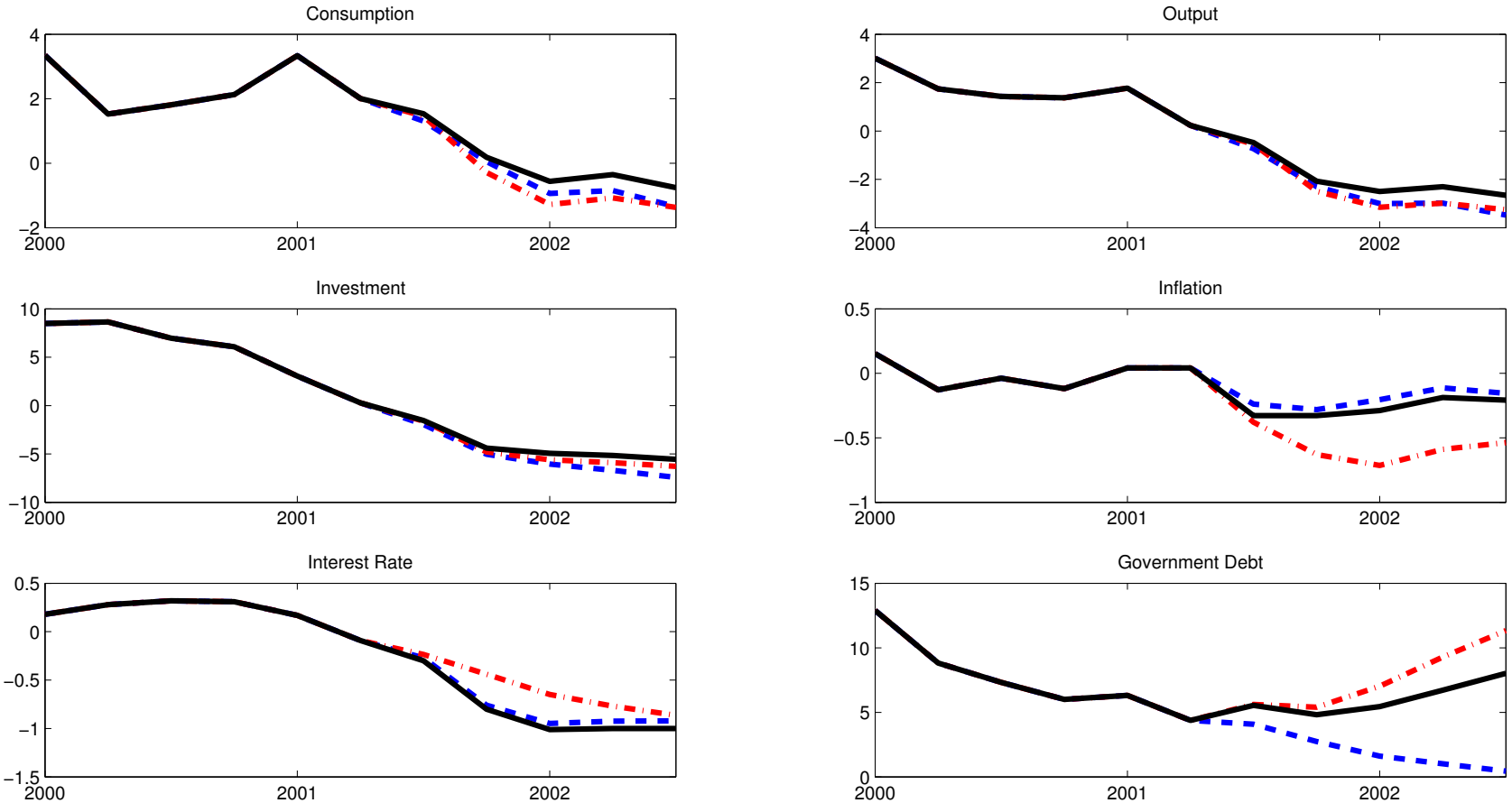
IV. NEW KEYNESIAN MODELS

- NK models are also DSGE.
  - Aside from FP shocks, another line of RBC research adds nominal side to RBC models to build monetary BC models, e.g, Goodfriend and King (1997, NBER Macro Annuals), Clarida et al. (1999, JEL), which have monopolistic competition and staggered Calvo pricing mechanisms for studying monetary policy effects.
  - Smets and Wouters (2003, JEEA) and Christiano and Eichenbaum (2005, JPE) combine real sluggish adjustments (habit formation and investment adjustment costs) with nominal price and wage rigidities to build the prototype of the NK models for analyzing MP effects.

V. BAYESIAN ESTIMATION OF DSGE MODELS

- Combining Bayesian estimation techniques developed in Geweke (1998, 1999), Schorfheide (2002, JAE), etc., a rich DSGE model can be estimated with data.
  - The seminal papers by Semts and Wouters (2003 JEEA; 2007 AER): A DSGE model with standard real and nominal rigidities can fit U.S. and euro area data reasonably well.
  - Instead of calibration, Bayesian estimation fits the model to data and get posterior estimates for most parameters, accounting for parameter uncertainty.
  - An estimated DSGE model can be used to examine historical effects to structural and policy shocks and to conduct counterfactual policy experiments.

US COUNTERCYCLICAL POLICY



Solid lines—data (observed or model-implied) conditional on all the estimated shocks; dashed lines—capital and labor tax shocks turned off; dotted-dashed lines—monetary policy shock turned off. The y-axis measures percentage deviation from the steady state.

CALIBRATION VS. ESTIMATION

- Estimating DSGE models in a coherent framework is an important breakthrough in modern macro.
  - Simulation based on a calibrated model only allows us to describe the theoretical impulse responses for shocks, but difficult to say their relative importance in data.
  - DSGE estimation allows us to separate quantitatively the relative contribution of shocks to the dynamics of all endogenous variables.
  - Once shocks are isolated, we can conduct counterfactual exercises to see the effects of historical policies.

FP ANALYSIS W/ DSGE MODELS

- DSGE models are initially used by central banks, mainly for monetary policy analysis. Most DSGE models have simplified fiscal specifications.
- Key modifications of prototype DSGE for FP analysis:
  - Adding liquidity constrained households
  - Different types of government spending: government consumption vs. investment; goods purchase vs. compensation, etc.
  - Various tax instruments: consumption tax, labor income tax, capital income tax, etc.
  - Endogenous debt accumulation and distorting fiscal adjustments

EXAMPLES OF DSGE ANALYSIS ON FP

- Dynamic scoring: the extent to which tax cuts can pay for themselves (Leeper and Yang, 2008)
- Analyzing government investment as a fiscal stimulus (Leeper, Walker, and Yang, 2010)
- Building a DSGE model for CBO—examining the crowding-out effect of government debt (Traum and Yang, 2015)
- Building a DSGE model for resource-rich developing countries for resource-rich developing countries (Berg, Portillo, Yang, and Zanna, 2013)

GOVERNMENT INVESTMENT AS A STIMULUS

- Common arguments:
  - In the S.R., it creates jobs and offsets falling private demand by increasing government purchases.
  - In the L.R., it adds to public capital, promoting economic growth.

  These conclusions are supported by neoclassical growth models without accounting for implementation delays and fiscal financing, (e.g. Baxter and King (1993, AER) and Kamps (2004)).

SUBSTANTIAL IMPLEMENTATION DELAY

B.A.: budget authority; E.O.: estimated outlay

ARRA, Highway Construction in Title XII, billions									
	2009	2010	2011	2012	2013	2014	2015	2016	total
B.A.	27.5	0	0	0	0	0	0	0	27.5
E.O.	2.8	6.9	5.5	4.1	3.0	2.8	1.9	0.6	27.5

By the end of fiscal 2009, outlays for infrastructure spending were less than 10 percent of the budget authority.

TIME-TO-BUILD FOR PUBLIC CAPITAL

- We use a neoclassical growth model with standard real frictions and time-to-build (Kydland and Prescott (1982)) for public capital formation.
- It includes a variety of fiscal instruments—income taxes, government consumption, and transfers—that can adjust to stabilize debt growth.
- Bayesian estimation is performed to calibrate historical fiscal instrument responses to debt.

GOVERNMENT INVESTMENT EFFECTS

- A substantial time-to-build lag has a muted macro effect in the short run at best.
- The productivity of public capital is crucial in determining the size of fiscal multipliers: If public capital cannot sufficiently productive, long-term fiscal multipliers can be negative because of fiscal adjustments.
- In contrast to the popular view that the stimulative effect of government spending is immediate, short-run output multipliers can be quite small—much below 1 (or even turn negative)—under substantial implementation delays.

A DSGE FOR TAIWAN'S FP ANALYSIS

We intend to build a DSGE model to analyze fiscal policy.

- The model should have
  - a basic model structure with fiscal details: distorting taxes, endogenous debt, various government spending types
  - identifying important shocks that affect business cycles of Taiwan: need to test whether model implications are consistent with our basic understanding
- Depending particular questions asked, the model needs to target on specifics to make fresh economic insight, e.g., effects of consumption coupons and effects of railway construction.

WIDESPREAD USE OF DSGE MODELS

- Software packages like `dynare` have made solving, estimating, and simulating DSGE models relatively easy.
- It is popular to specify a model or directly import existing equilibrium equations of other papers in `dynare` to generate a bunch of results: impulse responses, posterior estimates, historical decomposition, etc. The paper then reports `dynare`'s output is without questioning whether they make sense or not.
- This type of exercises may not have much policy or academic values.

DSGE MODELS AS AN ANALYTICAL TOOL

- What matters for research is the questions one asks and whether one can say something new relative to existing literature for an issue of some significance.
- DSGE models are not bulletproof to Lucas Critique. Like other econometric/economic models, DSGE models also encounter problems like misspecification and identification issues.[5] (the example of tax foresight)

[5] See Chang, Kim, and Schorfheide (2013, JEEA), "Labor-Market Heterogeneity, Aggregation, and Policy (In)variance of DSGE Model Parameters." They simulate data using a heterogeneous-agents model in which households insure themselves against idiosyncratic income risks. They find that "if the representative-agent model is estimated with data from the heterogeneous-agents economy under different policy regimes, several important parameters vary considerably," including preference and technology parameters. As a result, the representative-agent model can potentially mislead fiscal policy predictions.

THINGS TO CONSIDER

Public wage effects as an example:

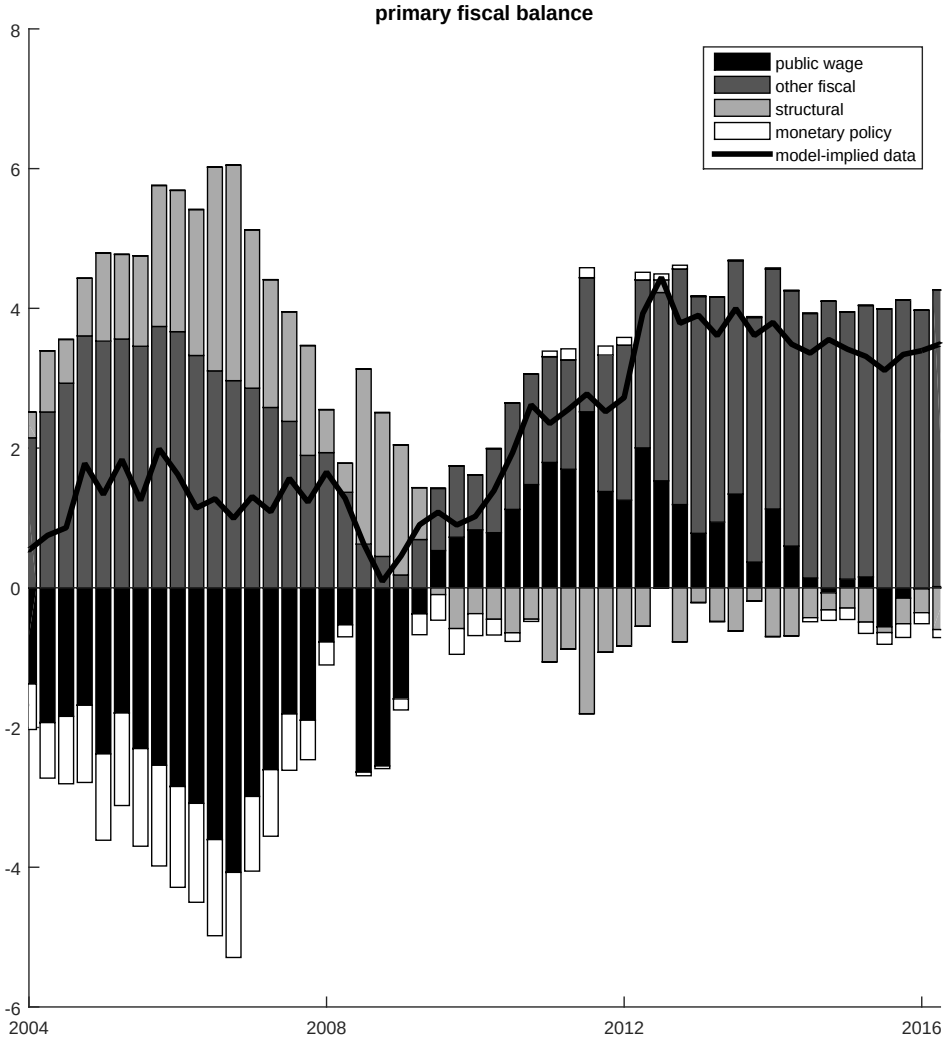
- Be specific on the questions to ask.
  - What are the macro and fiscal effects as a fiscal consolidation tool?
  - Can increasing public wages raise private wages?
- Think carefully about what shocks to incorporate and how a standard DSGE model should be revised.
  - Separating government goods purchase from compensation, adding government production to isolate the effects on private production, modeling sectoral labor mobility friction, etc.
  - Modeling separately goods purchase vs. public wage rule.

THINGS TO CONSIDER

- Try mode search from different starting points drawn from priors to check whether you have a well converged mode.
  - If you don't, it indicates some parameters may not be well identified. Then, try alternative specifications, prior assumptions, observables, data series, etc.
- Upon simulating posterior distributions, one must perform diagnostic analysis: prior-posterior plots, whether you have stationary distributions, etc.
- Ask if your analysis makes sense.
  - Figure out the economics of your impulse response functions. You often need to start with some simple models.
  - Do the historical decompositions roughly correspond to historical events?

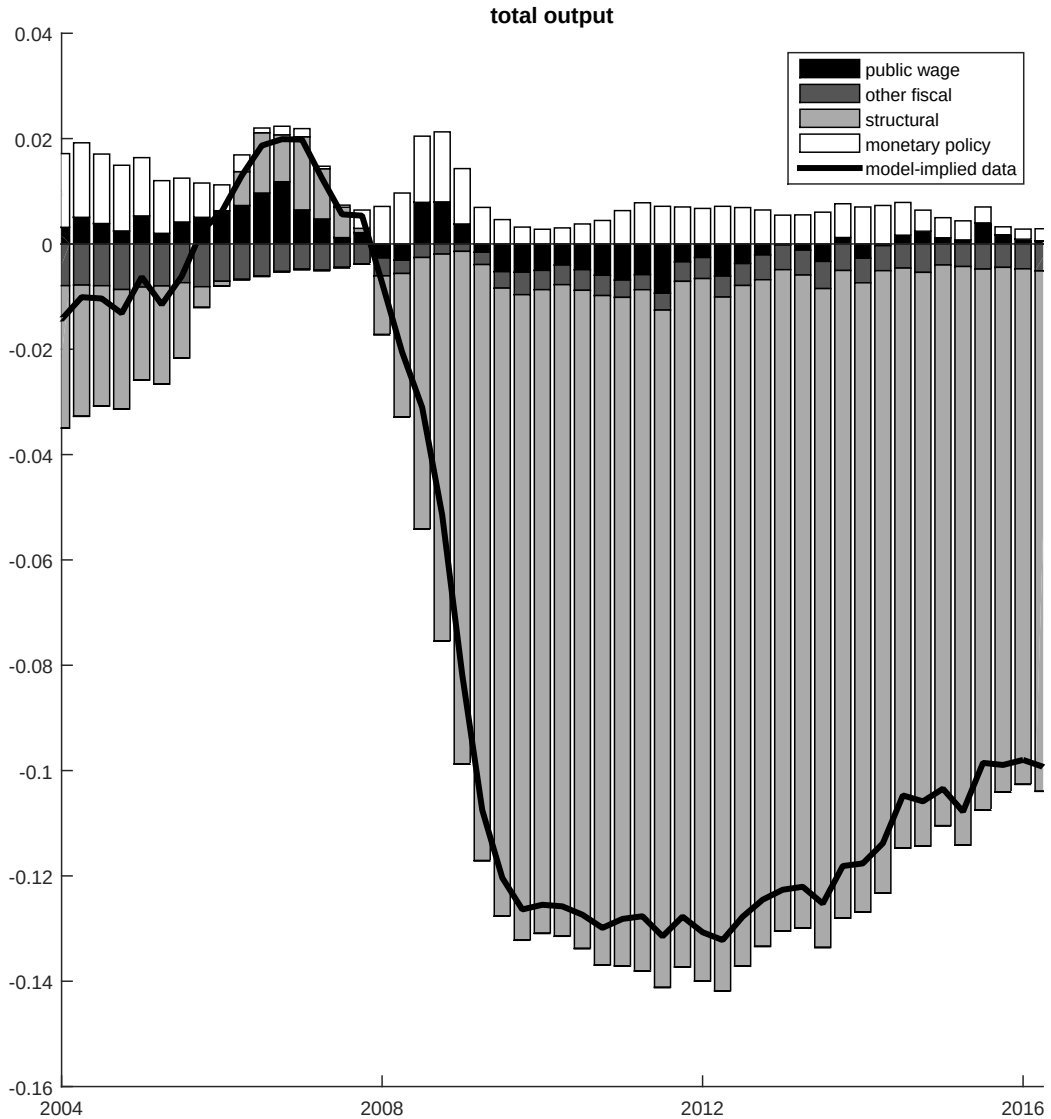
EXAMPLES OF HISTORICAL DECOMPOSITION

Primary Fiscal Balance of U.S. S&L governments



EXAMPLES OF HISTORICAL DECOMPOSITION

U.S. Output



THINGS TO CONSIDER: MISSPECIFICATION

No models are a complete description of reality. Many of restrictions imposed by DSGE models are at odds with data.

- Examine correlogram between key variables of interest
- Perform model comparison: computing log-marginal data densities and Bayes factors among competing models.
  - The literature has no consensus on how to model public wage rules; we estimate alternative public wage rules.
  - Some existing papers model public services being utility enhancing and productive in private production; we estimate an alternative utility and production function.
- When the estimation is not informative on a parameter, consider calibrating the parameter and perform sensitivity analysis if the parameter is important.

PRIOR PREDICTIVE ANALYSIS

- DSGE models impose strong restrictions on data. Estimation results are conditional on priors, model structures, observables, and data. Prior predictive analysis studies model implications *before* confronting with data.
- An example on government spending multipliers (see Leeper, et al. (2017, AER))

TABLE 3—GOVERNMENT SPENDING OUTPUT MULTIPLIER PROBABILITIES IMPLIED BY PRIOR PREDICTIVE ANALYSIS BASED ON 20,000 DRAWS FROM THE PRIOR DISTRIBUTION

	$\Pr\left(PV\frac{\Delta Y}{\Delta G} > 1\right)$				
	Impact	4 qtrs	10 qtrs	25 qtrs	10 years
Model 1: RBC real frictions	0.00	0.00	0.00	0.00	0.00
Model 2: New Keynesian sticky prices and wages					
Regime M	0.11	0.01	0.00	0.00	0.01
Regime F, short debt	1.00	0.98	0.94	0.92	0.92
Regime F, long debt	0.96	0.79	0.67	0.68	0.68
Model 3: New Keynesian non-savers					
Regime M	0.58	0.22	0.06	0.04	0.03
Regime F, short debt	1.00	1.00	0.97	0.95	0.94
Regime F, long debt	1.00	0.94	0.81	0.77	0.76
Model 4: New Keynesian G in utility					
Regime M, substitutes	0.00	0.00	0.00	0.00	0.00
Regime M, complements	0.84	0.69	0.49	0.33	0.29