SLIDE 01 – Quantitative methods for economic policy: limits and new directions

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Macroeconomic measurement, theory, prediction, and policy

A colloquium honoring the legacy of Lawrence R. Klein

SLIDE 02 – Outline

SLIDE 03 – Before the outbreak…

- While a number of instruments, including statistical models, have been and are currently being used in central banks (think of bridge models and coincident indicators, just to name a couple, as well as VARs, SVARs, GVARs…), **two classes of models can be considered as the core of the workhorse toolbox: Medium-scale New Keynesian DSGE models; Large-scale macro models.**
- The **Great Moderation** had favoured a convergence towards the use of **simple, stylized models** for policy analysis.
- New Keynesian DSGE models are "microfounded" models, based on two main assumptions:
    - **rational expectations**, and
    - **representative agent**.
- New Keynesian DSGE models:
    - have been enriched with **nominal and real rigidities to help replicate the observed cyclical dynamics** of the main macroeconomic variables;
    - provide a **structural interpretation** to the historical evolution of macroeconomic time series and offer a complement to VAR analysis;
    - offer a **modeling of cyclical developments à la Slutsky**;
    - importantly, they have provided **support to both positive and normative analysis** (optimal monetary policy literature);
    - Thus some convergence toward previous relatively large models such as the MPS model, including fricitons, rigidities and lagged adjustments, but linear, with representative agents and rational expectations [Visco (2005)].
- **Traditional, large-scale models are still widely used in policy institutions to formulate conditional forecasts**. They are flexible instruments; their large size has pros and cons (**pros**: detailed description of sectors and agents behaviour; ideal "hub" to take on board large amount of info; **cons**: opacity – perhaps exaggerated; missing explicit microfoundations).

SLIDE 04 – Before the outbreak …

- Starting in the mid-1980s most advanced economies experienced a period of **Great Moderation** (see Chart). The observed volatility of the business cycle declined significantly. As shown by the dotted line for the Euro area and by the solid line for the US, the **standard deviation of GDP growth** (calculated using a non-centered 10-year moving window) **sizably decreased** and seemed to even out in the 1990s and up to 2008, at a relatively low level. Similar patterns can also be observed for the rates of inflation and unemployment.
- The academic debate on the causes of such "low volatility" and flattening of the Phillips curve has been very lively; different explanations have been put forward (1. changes in the structure of production; 2. good luck; 3. improved macroeconomic policy; 4. globalization).
- Whatever the case, the Great Moderation led to an over-confidence among the economic profession in the ability to tame the business cycle.
- Episodes of **financial stress** during the Great Moderation, which affected a large share of economies – as shown in the figure by the red area) [e.g., the 1987 stock market crash, the 1992 ERM crisis, the 1998 LTCM collapse, the 2000 dot-com crash, etc.] were to some extent **downplayed**, as policy interventions succeeded in containing spillover effects and shore up economic recoveries ("Jackson Hole consensus", with some disagreement on asset price bubbles, see Bean 2003, with comments by Visco and Wadhwani).

Background

- *The Financial stress indicator (FSI) is based on IMF World Economic Outlook (2008). It is constructed as an average of: three banking-related variables, three securities-market-related variables and one foreign exchange variable. Episodes of financial stress are identified as those periods when the index for a country is more than one standard deviation above its trend (identified using the Hodrick-Prescott filter). The analysis includes 13 countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, Norway, Spain, Sweden, Switzerland, United Kingdom, and United States.*

SLIDE 05 – Before the outbreak …

As a result of the prolonged period of smooth macroeconomic developments, the profession may have indulged in **self-complacency.**

- **Robert Lucas** in his 2003 presidential address to the American Economic Association declared that the “macroeconomics in this original sense has succeeded: Its central problem of depression prevention has been solved, for all practical purposes, and has in fact been solved for many decades“.
- **Olivier Blanchard** in his 2008 NBER working paper stated “the state of macro is good“.

SLIDE 06 – Before the outbreak …

Meanwhile, a number of momentous developments in other areas were being ignored (see Chart)

- In the decade before the global financial crisis (when business cycle volatility hovered at very low levels) little attention was devoted to the fact that both **the size of the financial system and its role and pervasiveness in the economy had increased dramatically.**
- In the Eurozone, the overall amount of financial resources collected by the private sector (bank credit, bonds issued domestically and stock market capitalization) rose from 140% of GDP in 1996 to 210% in 2007, to further increase to 240% in 2012. Broadly similar patterns are found for the US, where the ratio rose from 230% in 1996 to 360% in 2007 and then declined to 310% in 2012.
- The total outstanding notional amount of over-the-counter (OTC) and exchange-traded derivatives rose from less than 100 trillion US dollars at the end of 1998 to around 500 trillion at the end of 2006, 700 at the end of 2007 and still 700 trillion in December 2012.
- **Financial deepening**, by allowing greater diversification of risk and making finance accessible to larger numbers of countries and firms, can be instrumental to broadening economic development. But **if not transparent and properly regulated it can favor excessive risk-taking and opportunism**, with consequences that can be more damaging as the system becomes more interconnected and the potential for externalities (contagion) and non-linearities increases. In these conditions, the risk of systemic crises increases.
- This excessive risk taking has certainly played a significant role in triggering the financial crisis in combination with too light regulation and supervision (subprimes, conduits, monolines… leading to the Lehman Brothers disaster), especially interacting with the monetary policy stance, global imbalances and the international monetary (“non-”) system in the new global economy [Visco (2009, 2013)].

SLIDE 07 – Before the outbreak …

- Klein's warning:

> "Philosophically, I do not believe that the market system, in even its purest form, provides adequate self-regulatory responses. The economy definitely needs guidance – even leadership – and it is up to professional economists to provide public policy makers with the right information to deliver such leadership. As for the methods of doing this, I see no alternative to the quantitative approach of econometrics, but I do realize that all policy issues are not quantitative and measurable. At times, subjective decisions must also be made."
>
> Lawrence Klein (1992)

SLIDE 08 – The outbreak …

- **Models used for policy analysis did not help foresee the Global Financial Crisis** (see Chart). To be fair, perhaps no model could have done so, at the very least because not enough information in historical data was available that could be used to extrapolate from. However, **not only was the crisis not foreseen**, indeed a crisis of that size was **virtually considered impossible**; once underway, its effects were **largely underestimated**; and even in the aftermath, it proved **hard to interpret with the tools at hand** [i.e. DSGE models, less so with large-scale models, e.g. Catte et al. 2011].

- This figure (taken from a paper by Chung, Laforte, Reifschneider, Williams, recently published in the JMCB) shows results from stochastic simulations of the FRB/US model for the output gap and the federal funds rate over the period 2008–10.
- Prior to the crisis, that model would have viewed the subsequent evolution of real activity and short-term interest rates as **extremely unlikely**: actual conditions observed in 2010 fall way outside the 95% bands built around the late-2007 projection. Notice in particular that the probability of hitting the ZLB was also deemed practically nil.
- Similar results are obtained using different types of models: Smets-Wouters, EDO (Estimated Dynamic Optimization-Based Model, a DSGE model of the U.S. economy developed and used at the Board of Governors for forecasting and policy analysis), a Time-varying parameters VAR; only a GARCH model was relatively less “surprised” by the events (Univariate GARCH model, estimated over the sample 1968Q1-2007Q4).

- All in all, we can conclude that the models used in the pre-crisis, Great Moderation period were not sufficiently equipped to deal with such a dramatic event

SLIDE 09 – The outbreak …

> “One thing we are not going to have, now or ever, is a set of models that forecasts sudden falls in the value of financial assets, like the declines that followed the failure of Lehman Brothers”
>
> Robert E. Lucas (2009)

> “The crisis has made it clear that this view was wrong and that there is a need for a deep reassessment.”
>
> Olivier Blanchard (2014)

- The historical data and the workhorse models available before the crisis were of little use in forecasting (*ex-ante*) as well as interpreting (*ex-post*) the highly nonlinear feedback loops between financial and real variables observed in the long stormy period that followed the collapse of Lehman Brothers. New mechanisms, new shocks, new channels of transmission that had been by and large neglected moved to centre-stage.
- While it is true that no model could have predicted such a dramatic sequence of events, in order to appropriately support policy decisions, macroeconomic models have to be adapted to the new economic environment.

SLIDE 10 – Limits unveiled

- Let me focus on three main limits of the quantitative analysis toolbox used in policymaking that the crisis has unveiled, i.e.:

    1. Real-financial linkages

    2. Non-linearities

    3. Increased interconnectedness

SLIDE 11 – Limit #1: Real-financial linkages

> “If the real sector of the economy does not function so well, for instance, if it is dynamically unstable under some circumstances […] then the need for stabilization policies is hard to deny, and with it the need to model financial and monetary sectors of the economy”
>
> Albert Ando (1979)

- The need to model the financial sector and its relationship with the real economy had been recognized by some economists, among whom was Albert Ando.
- Importantly, much macromodeling of the flow of funds was done in the 1970s and then abandoned.

SLIDE 12 – Limit #1: Real-financial linkages

- **The workhorse medium-scale NK models used for policy analysis in the pre-crisis period did not feature a financial sector** (think of the Smets-Wouters 2003 model as a prominent example). Typically, just one interest rate (the policy rate) was included and was deemed sufficient to characterize cyclical dynamics and provide normative prescriptions.
- Perhaps the main theoretical support to such a setup lies in the **Efficient Market Hypothesis: market clearing and the RE assumption guarantee that all the relevant information is efficiently used by the agents in the economy and is reflected in the (unique) interest rate**. As such, no explicit modeling of the financial sector was required. Also, no quantities were needed, everything was summarized in the term structure.
- However, important advances in this field had been overlooked or neglected in the medium-scale models used in central banks.
- A few examples are the collateral amplification mechanism developed in Kiyotaki and Moore (1997) and included in a NK model of the US economy by Iacoviello (2005), or the financial accelerator developed by Bernanke, Gertler and Gilchrist (1999).
- Other relevant contributions, largely overlooked in policy analysis include models of debt deflation à la Irving Fisher and financial crises, such as the work by Mendoza (2006).

SLIDE 13 – Limit #1: Real-financial linkages

- Since the outbreak of the financial crisis, a lot of effort has been devoted to the **inclusion of financial frictions in macroeconomic models** used for policy analysis.
- Existing medium-scale DSGE models are being enriched along several dimensions. A short, non-exhaustive list includes:
  - The **role of financial intermediation and the banking sector**:
    - Christiano, Motto and Rostagno (2014), now routinely used at the ECB to produce scenario analyses for the euro area;
    - Goodfriend and McCallum (2007) is an early contribution; Gerali, Neri, Sessa and Signoretti (2010) include a banking sector in a medium-scale DSGE model à la Smets-Wouters.
    - Gertler and Kiyotaki (2011), published in the new edition of the Handbook of Monetary Economics, is a sort of 'new' workhorse model. It provides theoretical foundations for the existence of (il)liquid assets and allows for the analysis of unconventional monetary policy.
  - **Liquidity**:
    - Kiyotaki and Moore (2012) provide foundations for the existence of money and liquid assets.
  - **Unconventional monetary policy**:
    - For the US: Curdia and Woodford (2011), Gertler and Karadi (2011), Chen, Curdia and Ferrero (2012);
    - For the euro area (forward guidance): Coenen and Warne (2014); Casiraghi, Gaiotti, Rodano and Secchi (2013), using the Bank of Italy's quarterly model.
- All these examples necessarily require a **relaxation of the representative-agent framework**, in that at the very least a borrower-saver setup must be introduced.
- One thing that we should keep in mind when modeling the financial sector is the **role of institutions**. Two examples: the shadow banking sector plays an important role in the US system, less so in Europe; on the contrary, the sovereign-banking linkages that we are observing in Europe may be less relevant in the US.
- More generally, the crisis has led to the rediscovery of Knightian uncertainty (see for example Caballero and Krishnamurty 2008, Bloom 2009), i.e. the distinction between known unknowns (risk) and unknown unknowns (uncertainty).

SLIDE 14 – Limit #1: Real-financial linkages

- The absence of a financial sector, or more generally of significant interactions between real and financial variables, was a main limitation of both medium-scale DSGE models and large-scale macroeconometric models, typically used for forecasting purposes in central banks and other policy institutions.
- However, throughout the years **large-scale models have often proved to be flexible instruments, open to non-mechanical use and, most importantly, to the use of information external to the model**.
- **Klein (first oil shock, 1973):** the use of external information allowed for a sizeable reduction of the Wharton and LINK model forecast errors. In particular, the models were not able to capture the increase in production costs generated by higher oil prices, as no distinction was made between the use of imported goods for consumption and production. In aggregate output price and value added deflators equations with markup estimates, the role of oil prices was confined to the constant, as they had historically remained unchanged.
- Extra-model estimates of the impact of cuts in oil supply on US foreign demand were used, to help the models cope with unprecedentedly large shocks.
- Klein's lesson is still valid today. Indeed, a similar approach has been used with the Bank of Italy Quarterly Model, in the case of credit supply shocks and the risks of credit crunch after Lehman Brothers, 2008-2009, and with the sovereign risk crisis, 2011-2012.

SLIDE 15 – Limit #1: Real-financial linkages

- Right after Lehman, the **Bank of Italy Quarterly Model was augmented with a satellite model of the credit market**, to include the effects of the credit crunch on investment. This intervention was made necessary by the developments in the credit sector observed since 2008 (see also Visco 2009).

- The satellite model is a disequilibrium model of the credit sector, based on Fair and Jaffee (1972). It exploits (quarterly) data from the Euro area Bank Lending Survey to extract information about credit crunch episodes. The effects of the credit crunch were then embedded in the investment equation and hence in GDP projections.

- Result: a **sizeable reduction in forecast errors** (from the red to the green lines and histograms, see Chart): mean absolute errors **for GDP** (for both current year and one-year ahead projections) were reduced by 0.3 p.p. both in the 2008-2009 and in the 2011-2012 recessions.

Mean absolute errors of current Italian GDP growth			
1999-2007		2008-2010	
Bank of Italy	Other forecasters	Bank of Italy	Other forecasters
0.26	0.33	0.54	0.64

Mean absolute errors of 1-year ahead Italian GDP growth			
1999-2007		2008-2010	
Bank of Italy	Other forecasters	Bank of Italy	Other forecasters
1.12	1.25	2.22	2.25

- **Another important source of forecast error** are the assumptions on international variables, in particular **foreign demand**.

- As shown in the Figure, with correct information on the evolution of foreign demand, on top of the use of external information on credit supply, the model performance would have been improved by another 0.1-0.2 p.p. (from the green to the blue lines and histograms).

- The remaining portion of the forecast errors, by no means trivial, is largely due, at least for the current year, to **initial conditions**. I will get back to this source of error later.

Background: Main sources of forecast errors:

- *current year: imprecise evaluation of the current state of the economy (accounts for about 2/3 of the error);*

- *one-year ahead: during the crisis, about 40% of the error accounted for by technical assumptions on exogenous variables, especially foreign demand.*

SLIDE 16 – Limit #2: Nonlinearities

- Pre-crisis empirical tools for policy analysis were best suited to deal with an **environment in which economic fluctuations were regular enough** that, by looking at the past, agents (and econometricians) could understand their nature and form expectations of the future. Generally speaking, the basic tenet of all forecasting is that future outcomes are drawn from the same population that generated past outcomes.
- But: the **global financial crisis** has marked a **huge discontinuity** with the past…
- **In non-stationary environments**, when such discontinuities arise, changes may be far-reaching and the past fails to provide enough guidance for the future. Predictions based on past probability distribution functions can differ persistently from the actual outcomes.
- **Problems with existing models**:
- **Not enough information was contained in historical data about shocks of such size and nature**. To make things worse, a typical procedure in the face of unusual events is the exclusion from the estimation sample of those observations that do not fit the main mechanisms at work ("dummying-out"); their information content is thus neutralized. Yet, those very deviations from the norm may contain precious information on how the economy works in conditions other than those usually prevailing. Instead of excluding "outliers", we should perhaps investigate their behavior further.
    - Despite the development of techniques to deal with non-linearities, the dominant view was that the economy could be described as being roughly linear, constantly subject to different shocks, but statistically mean reverting [see Visco 2005 on Ando, Modigliani and Klein's view on this issue]. Such an approach has shown severe limitations since the outbreak of the crisis.

SLIDE 17 – Limit #2: Nonlinearities

- **Models with time-varying parameters and stochastic volatility** are broadly-used tools that capture in a flexible and robust manner the evolving nature of the underlying structure of the economy. A possible drawback is related to the structural interpretation of the results, which may become tricky if all parameters and volatilities are allowed to change at the same time [Primiceri (2005)].
- **Large shocks and non-Gaussian (tail) dependence:** Financial econometrics has by now standard methods to deal with thick tails [see Kim, Shephard and Chib 1998 and Glosten, Jagannathan and Runkle 1993] and non-Gaussian dependence [see Patton 2009 and Genest, Gendron and Bourdeau-Brien 2009]. One difficulty in applying these ideas to macroeconometrics is related to the small sample sizes, particularly in the case of nonparametric estimation. A few works on nonlinear dependence in macroeconometrics have used quantile regressions [e.g. for inflation, see Oka and Qu 2011 and Tillmann and Wolters 2014], which allows for departures from Gaussianity. Of course a lot of data are required for estimating outer quantiles.
- **Regime-switching models:** applications to GDP, inflation, interest rates, equity returns and volatility. They have a good in-sample fit, but a systematic advantage over simpler model in out-of-sample forecasting is still not clear [Hamilton (1989) , Sims and Zha (2006)].
- **Nonlinear methods in New Keynesian models.** To account for large shocks and nonlinear dynamics, modelers are starting to apply global solution methods to NK DSGE model, typically solved, until recently, up to first or second-order. Guerrieri and Iacoviello (2014) adapt a first-order perturbation approach and apply it in a piecewise fashion to handle occasionally binding constraints. Major advantage: can be applied to large scale DSGE model (the "course of dimensionality" is not a problem) and is computationally fast; **major limitation**: not able to capture precautionary behavior linked to the possibility that a constraint may become binding in the future, as a result of shocks yet unrealized. Fernandez-Villaverde, Gordon, Guerron-Quintana, and Rubio-Ramırez (2012) use a global method to solve a New Keynesian DSGE and thus find the solution (or policy functions) over the entire support of the state variables. Recent work by Braun, Körber, and Waki (2012) documents the existence of **multiple equilibria** in a fully nonlinear NK DSGE model at the zero lower bound. **However**, Christiano and Eichenbaum (2012) show that **only one equilibrium is stable under learning**, i.e. when agents act as econometricians in forming their beliefs, updating their estimates recursively, the economy will converge only to one equilibrium [see also McCallum 2007 and Evans and Honkapohja 2009 on this issue].
- Note: there is **not much information** in these models about the **speed of convergence** towards the **constraints**. Subjective judgement becomes necessary.

Background

1. *Gaussianity excludes comovements in the tails of the distribution and thus is not adequate to capture contagion effects.*
2. *'Tail dependence' is a measure of comovements in the tails of a bivariate distribution, i.e. the probability that X1 is in the tail given that X2 is in the tail. A multivariate Gaussian distribution is independent in the extreme tails (limiting result), whereas for instance t-distributions display tail dependence.*
3. *The 'copula' completely describes the dependence structure of a bivariate random variable: a fundamental theorem (Sklar's Theorem) states that any multivariate joint distribution can be written in terms of univariate marginal distribution functions and a copula* (Related to the estimation of the joint probability of default of banks).
4. *Tail dependence can be modeled using appropriate copulas, for given marginal distributions.*

SLIDE 18 – Limit #3: Increased interconnectedness

- **Trade linkages**: with few exceptions (e.g. Larry Klein's LINK) model forecasts typically rely on external assumptions about world demand, commodity prices, exchange rates (all exogenous variables). Open-economy dimension often contributes to a large part of the forecast error, especially during a crisis. We have already seen this with the example of the Bank of Italy quarterly model. Ignoring trade interconnections largely contributed to forecasting errors.
- **Cross-border financial integration** has markedly increased: our models need to go beyond trade linkages and account for foreign asset exposure, global banks.
- The literature has already developed methods to model global interconnections, possibly not limited to trade linkages.
- In particular, Global VARs and Panel VARs seem to be promising directions to account for complex linkages and exploit the cross-sectional dimension of data.
    - Recent work by **Diebold and Yilmaz (2013)** applies results from **network theory** to measure cross-country connectedness.
- A general issue with these models concerns the sources of observed cross-country comovement: common shocks or contagion? While the two hypotheses may be observationally equivalent – or at least very hard to disentangle – they require very different modeling structures and have potentially different implications.

Background

- *References on GVARs: Chudik and Pesaran (2014) and Di Mauro and Pesaran (2013) are both good surveys of the existing literature (methods and applications).*
- *References on Panel VARs: Canova and Ciccarelli (2013): a review.*
- *Diebold and Yilmaz (2013) on the application of network theory to cross-country connectedness.*

SLIDE 19 – Current challenges …

- Policymaking – especially in central banks – has faced and, most likely will continue to face a number of new challenges in the near future, as a long-lasting legacy of the global financial crisis and the sovereign debt crisis. In order to appropriately support policy decisions, macroeconomic models have to be adapted to the new economic environment. Indeed, several new directions for macroeconomic modeling in policy institutions are currently being explored.
- Let me briefly elaborate on some of these new directions. I will highlight the fields in which I, as a policymaker, see a most urgent need for advances, i.e:

    1. Taking advantage of large datasets
    2. Modeling inflation expectations
    3. Identifying structural vs. cyclical developments
    4. Macroprudential policy

SLIDE 20 – Challenge #1: Taking advantage …

- Lawrence Klein (in an interview with R. Mariano, published in Econometric Theory in 1987) on using large amounts of data:

> "My present approach is to construct simple time-series models of high frequency data based on latest information, by days or weeks or months - for use in somewhat lower frequency macromodels […] I am a proponent of combining different sources of information, and the information source in this case is cross-section data from survey investigations. They should be integrated within macromodels."

SLIDE 21 – Challenge #1: Taking advantage …

- **In times of crisis, the availability of accurate data is more crucial for policy analysis than it is in "normal" times**. The more timely, accurate and relevant the data, the better our assessment of the current state of economic activity, and thus the better our predictions.
    - Indeed, we have seen earlier that imprecise information on initial conditions were a major source of forecast error for the Bank of Italy model
- Various econometric instruments that exploit data of different types and sources to produce good "**nowcasts**" and are used in policy institutions include: single equations such as bridge equations or mixed-data sampling (MIDAS); large Bayesian VARs; factor models; coincident indicators (Banca d'Italia: €-Coin, I'll come back to this in a few seconds)

- A related field is the combination of several models (rather than several data sources). Since the pioneering work of Bates and Granger (1969), it is well known that **pooling several forecasts** can yield a mean square forecast error lower than that of each single forecast. Hence, rather than selecting a preferred forecasting model for a specific variable, it may be convenient to combine all the available forecasts. Several pooling procedures are available depending on how the various forecasts are weighted.

SLIDE 22 – Challenge #1: Taking advantage …

- Quoting Simon (1981): “Good predictions have two requisites that are often hard to come by. First they require **either a theoretical understanding** of the phenomena to be predicted, as a basis for the prediction model, **or phenomena that are sufficiently regular** that they can be simply extrapolated. Since the latter condition is seldom satisfied by data about human affairs (or even by the weather), our predictions will generally be only as good as our theories. **The second requisite for prediction is having reliable data about the initial conditions – the starting point from which the extrapolation is to be made**.”

SLIDE 23 – Challenge #1: Taking advantage …

- **€-coin is a real-time, monthly estimate of the underlying area-wide quarter-on-quarter GDP growth**, (i.e. an indicator of the euro area's growth momentum), computed each month by the staff of the Bank of Italy. More specifically, €-coin collates a large collection of 150 statistical data (industrial production, business surveys, stock market and financial data, demand indicators, and more) and extracts the information that is relevant to forecast GDP. It tracks GDP growth, preceding official GDP releases by several months and provides accurate and systematic predictions of euro-area cyclical turning points (see Chart).
- Its performance has been remarkably good even during the crisis, especially in terms of turning points predictions.

SLIDE 24 – Challenge #1: Taking advantage …

- Nowcasting of many indicators can also benefit from the use of "Big Data": for instance, various authors have documented that Google-based queries improve the nowcasting of variables such as unemployment benefits claims, car and housing sales, loan modification, etc.

- More generally, technological advances have made available a massive quantity of digital data coming from networked computers, business transactions, social media, etc. The combination of all these data is usually referred to as "big data."
- "Every two days now we create as much information as we did from the dawn of civilization up until 2003" [Eric Schmidt, Google Exec. Chairman, 2009].
- Analysis of this vast quantity of digital information can offer fresh insight for the monitoring of economic phenomena. Both statistical and economic analyses can take advantage of this large data availability (applications extend to backcasting, nowcasting and forecasting).
- To fully exploit the potential of big data there are **some methodological challenges regarding how to process (access/manage/aggregate) this information** so that it can provide meaningful signals about economic conditions. In this regard, the use of **machine-learning techniques** (i.e. new automated methods to find patterns and predictive relationships such as data mining and bioinformatics) can surely be a fruitful way…
- …but **we should not forget the importance of economic theory: as Klein (1977) said *"deep statistical theory with much stochastic structure in the analysis, […] is no substitute for economic theory. […] Without theory and other a priori information, we are lost*"**.
- Hence the challenge is to develop "new" analytical tools to integrate signals from Big Data with the information from more "conventional data".

SLIDE 25 – Challenge #2: Modeling inflation …

- With policy rates at the ZLB (in US and euro area), policymakers are particularly concerned with the evolution of inflation expectations. In the **euro area** we have observed **repeated, downward revisions to inflation expectations (and projections)** since last year. This clearly poses a challenge to monetary policy, as a self-fulfilling deflationary spiral may be triggered.
- From a more analytical standpoint, the observation of persistent differences between actual and expected inflation rates questions the validity of the RE assumption.
- It is perhaps fair to recognize that, while the RE assumption may apply to financial markets (although, following the financial crisis, this assumption is far from granted in financial markets as well), it is quite unlikely that households and firms can fully discount the effects of current and future policies in their consumption, investment and pricing decisions.
- As a matter of fact, **workhorse models used for policy analysis have largely ignored decades of fruitful research on modeling expectations formation.**
- Recall **the work of Sargent, Marcet and many others on learning mechanisms** (I'll provide an example of an application in a minute), **Chris Sims on rational inattention** and **Bob Shiller on applications of behavioural economics to macroeconomics and finance.**

Background

References on:

- *Learning: two books, Evans and Honkapohja (2001) and Hansen and Sargent (2007).*
- *Rational inattention: Sims (2003); Sims (2010).*
- *Behavioural economics: Shiller (1997); Yellen (2007) on implications for monetary policy.*

SLIDE 26 – Challenge #2: Modeling inflation …

- Recent work by Busetti, Ferrero, Gerali and Locarno (2014).
- Simulations of the 3-equation New Keynesian model in **Clarida, Galí and Gertler (1999): AD equation, AS equation, monetary policy rule**. Each equation has a shock, which follows a stationary AR(1) process.
- Objective: assess the impact of the assumption of bounded rationality (learning), as opposed to RE, on equilibrium outcomes.
- Exercise: **calibrate model parameters to standard values; use ECB forecast (as of December 2013) for the 2013-2015 period as observations and apply the Kalman filter to recover the underlying structural shocks** over the same period (note: the Kalman filter assumes RE).
- Then, **drop the RE assumption and assume that expectations are formed through adaptive learning** (constant gain learning scheme).
- The model is simulated under the same set of shocks (recovered via Kalman filter), alternatively **under RE (blue line) and learning (red line)**, over the 2013-2015 horizon (see Chart).
- **Under learning, inflation expectations in 2014-15 would be systematically lower** compared to the case of RE, as agents are more strongly affected by the observed persistent sequence of deflationary shocks (not reported in the Figure). Agents would also be more pessimistic as regards output-gap developments and hence actual GDP.
- **If the RE assumption were inappropriate, actual and expected inflation developments would be much lower than predicted** (which is indeed what has been observed in the most recent period)

SLIDE 27 – Challenge #3: Structural vs. cyclical …

- **Financial crises are typically followed by a much slower recovery than "normal" recessions**. The current one – that started in 2007! - is no exception.
- From a policy perspective, it is imperative to **disentangle the structural and cyclical effects of the Great Recession**, while at the same time making sure that both are properly taken on board in our analyses.
- The **"natural" rates** (think of potential output or the natural rate of interest) are **likely to change in the near future**, reflecting persistent variations in the levels of economic activity in some countries and the resulting adjustment of production capacity.
- Yet, long and short term developments may be most closely related.
- The distinction between **short and long-term unemployment** is a relevant and important example. While it is crucial to distinguish between cyclical and structural unemployment, it is also most important to **detect possible hysteresis effects**. When it comes to the labour market, cyclical and structural problems must be tackled with distinctively different policy tools; yet, short-term difficulties may, in time, turn into structural problems (Draghi's speech at Jackson Hole this year).
- When global growth prospects are surrounded by large uncertainty - as is the case at the current juncture - these challenges are even more daunting.
    - Some, e.g. **Larry Summers (2013)**, have envisioned a **"Secular stagnation"**: chronically low global demand stemming from persistent headwinds and structural factors that predate the crisis (hysteresis in the labor market, population aging). **Gordon (2012)**, instead, has focused on the return to **low productivity growth**.
    - Others, such as **Brynjolfsson and McAfee (2013)**, have prefigured instead a **"Second Machine Age"**; they expect technological progress in areas such as nanotechnology, computing, robotics and artificial intelligence to generate strong productivity gains.
- Against this background, it is likely that **short and long-term considerations will be more and more intertwined in the policymaking process**. Redistribution policies and **fiscal consolidation measures** are an interesting example.

SLIDE 28 – Challenge #3: Structural vs. cyclical …

- **Public debt** levels have increased in many advanced economies since the onset of the crisis, reaching historically record levels in some cases.
- As advocated by **Klein (1992) "there is nothing in the Keynesian prescriptions to support highly unbalanced policies or excessive reliance on monetary policy to provide economic stabilization".**
  - **High levels of public debt** represent a source of **vulnerability** that must be **tackled to guarantee fiscal sustainability over the years**. **Sovereign risk itself, something we have learned to monitor but perhaps are not yet able to model in a convincing and empirically reliable way**, is a key element whose behavior reflects both long and short-term considerations [recent work at the Bank of Italy: Di Cesare, Grande, Manna and Taboga (2012)].
- **How to measure fiscal sustainability and model its effects on sovereign risk?** To guarantee fiscal sustainability debt must be reduced over the years. Short-term and long-term uncertainty must be factored in when assessing a country's ability to sustain a high public debt-to-GDP ratio.
- Many countries in Europe have implemented **fiscal consolidation programs** over the past few years. Their success or failure depend on a number of factors. **Credibility** is one of these; **structural reforms**, adopted to increase potential output, are another crucial ingredient. The on-going debate about the **opportunity of implementing reforms in times of crisis, with policy rates at the zero lower bound**, reflects the **vital importance of developing adequate tools to frame both short- and long-term considerations into one integrated, consistent economic analysis**, so as to support policy actions in the most effective way.

SLIDE 29 – Challenge #4: Macroprudential policy

- Macroprudential policy mandate (definition): **maintain the stability of the financial system.**
- We must ask ourselves – as researchers and policymakers – a number of questions: **which forces endogenously contribute to the build-up of imbalances and which shocks should we expect to be more prominent in the financial cycle?**
- **What are the sources of financial cycles?** Recent works on financial shocks include Jermann and Quadrini (2012), which show that financial shocks contributed significantly to the observed dynamics of real and financial variables; Liu, Wang and Zha (2012) also document a sizeable contribution of financial shocks (i.e. shocks to credit availability) to US business cycle dynamics. Other sources of shocks considered in recent literature: news about future developments [e.g. Lambertini, Mendicino and Punzi 2013] and risk shocks, as in Christiano, Motto and Rostagno (2014). The latter capture changes in the variance of idiosyncratic productivity shocks that hit firms' investment opportunities. Similarly, Fernandez-Villaverde, Guerron-Quintana, Rubio-Ramirez and Uribe (2011) show that changes in the volatility of the real interest rate at which small open economies borrow have important effects on real variables.
- **What generates systemic risk?** Which externalities should we consider when designing appropriate supervisory and regulatory frameworks? Recent contributions: Bianchi and Mendoza (2010) and Jeanne and Korinek (2010) study the role of collateral constraints and the pecuniary externality generated by the unintended valuation effect on the existing collateral of changes in individual consumption plans. Brunnermeier and Sannikov (2014) provide a **model of endogenous risk.**
- **What are the boundaries of the financial system or, alternatively, who are the relevant players?** Regulatory measures must address the regulatory arbitrage concerns posed by the shadow banking system: shadow banking activity can be used to circumvent and undermine banking regulations, leading to a build-up of leverage and risk.
- **Under what institutional arrangements are conflicts between macro-prudential and monetary policy minimized and complementarities best exploited?** References: Angelini, Neri and Panetta (2014), Catte, Cova, Pagano and Visco (2011). [see also Angelini, Nicoletti-Altimari and Visco (2013)]

SLIDE 30 – Challenge #4: Macroprudential policy

- In terms of **quantitative analysis**, several relevant issues emerge.
- **Monitoring financial (in)stability immediately calls for the use of density, as opposed to point forecasts, as an instrument to study tail events.**
- **Early warning**: one way to proceed is the ex-ante definition of a tail event to be monitored and possibly predicted; alternatively, we can use model-based density forecasts and look at some percentiles.
- **Data**: lot of effort in the past few years. A prominent example is the G20 Data Gaps Initiative, a broad thrust towards collecting data that are needed for policy analysis (FSB-IMF, 2013).
  - **Differently from monetary policy, the effects of policy changes in macroprudential instruments are still uncertain at the aggregate level** (despite lots of evidence on microprudential policy, at individual banks' level). Most of the available evidence is related to EMEs. Moreover, there are important identification issues related to the fact that macroprudential policies are implemented in conjunction with monetary and fiscal policy [see Elliott, Feldberg and Lehnert (2013) on the history of cyclical macroprudential policy in the U.S.].
- **Which methods shall we use to measure the effects of macroprudential policy?** A plethora of different tools can be and are being applied, ranging from event studies and stress tests to panel regressions, to regime-switching models. The latter include both VAR and DSGE models and seem particularly useful to account for historical data [a recent example: Alessandri and Mumtaz 2014]. Perhaps it may be better to proceed with a **suite of models**, to better account for the **large uncertainty that still surrounds the effects of macroprudential policy interventions.**

SLIDE 31 – Conclusion (I)

- Let me conclude. Some things have already been done, but much still remains to be done.
- Quoting Popper:

  “The history of science, like the history of all human ideas, is a history of irresponsible dreams, of obstinacy, and of error. But science is one of the very few human activities — perhaps the only one — in which errors are systematically criticized and fairly often, in time, corrected. This is why we can say that, in science, we often learn from our mistakes, and why we can speak clearly and sensibly about making progress there”.

  Karl Popper (1963)

SLIDE 31 – Conclusion (II)

- Let me conclude. Some things have already been done, but much still remains to be done.
- Quoting Klein:

  “It is my firm belief that the only satisfactory test of economics is the ability to predict, and in crucial predictive situations such as reconversion after World War II, the settlement of the Korean War, the settlement of the Vietnam War, the abrupt economic policy switch of the Nixon Administration in August 1972, the oil shock of 1973 (forecast of a world-wide succession by LINK), the recession of 1990. In these crucial periods, econometric models outperformed other approaches, yet there is considerable room for improvement, and that is precisely what is being examined in development of high-frequency models that aim to forecast the economy, every week, every fortnight, or every month, depending on the degree of fineness of the information flow...”

  Lawrence Klein (2005)

REFERENCES

Alessandri, P. and H. Mumtaz 2014. "Financial Conditions and Density Forecasts for US Output and Inflation," Working Papers 715, Queen Mary, University of London, School of Economics and Finance.

Ando, A. 1979 "Financial sector model building and their inclusion in econometric models of national economies", in Modèles monétaires et financiers: VIe Colloque international d'économétrie appliquée, Vol. 1, [s.l.], Association d'Econométrie Appliquée, Roma, Banca d'Italia, [Nanterre], Groupe d'Analyse Macroéconomique Appliquée, 1979, pp. 1-32.

Angelini, P., S. Neri and F. Panetta 2014. "The Interaction between Capital Requirements and Monetary Policy," Journal of Money, Credit and Banking, Wiley, 46, pp. 1073–1112.

Angelini, P., S. Nicoletti-Altimari and I. Visco 2013. "Macroprudential, microprudential and monetary policies: conflicts, complementarities and trade-offs," in: A. Dombret and O. Lucius, Stability of the financial system, Cheltenham, Edward Elgar, 2013, pp. 474-501.

Bates, J. and C. Granger 1969. "The Combination of Forecasts," Operations Research Quarterly, 20, pp. 451-468.

Bean, C. 2003. "Asset prices, financial imbalances and monetary policy: are inflation targets enough?," BIS Working Papers 140, Bank for International Settlements.

Bernanke, B. S., M. Gertler and S. Gilchrist 1999. "The financial accelerator in a quantitative business cycle framework," in: J. B. Taylor & M. Woodford (ed.), Handbook of Macroeconomics, edition 1, volume 1, chapter 21, pp. 1341-1393.

Bianchi, J. and E. G. Mendoza 2010. "Overborrowing, Financial Crises and 'Macro-prudential' Taxes," NBER Working Papers 16091, National Bureau of Economic Research, Inc.

Blanchard, O. J. 2008. "The State of Macro," NBER Working Papers 14259, National Bureau of Economic Research, Inc.

Blanchard, O. J. 2014. "Where Danger Lurks," in Finance and Development, Vol. 51, No. 3, International Monetary Fund, September.

Bloom, N. 2009. "The Impact of Uncertainty Shocks," Econometrica, Econometric Society, vol. 77(3), pp. 623-685, 05.

Braun, R. A., L. M. Körber and Y. Waki 2012. "Some unpleasant properties of log-linearized solutions when the nominal rate is zero," Working Paper 2012-05, Federal Reserve Bank of Atlanta.

Brunnermeier, M. K. and Y. Sannikov 2014. "A Macroeconomic Model with a Financial Sector," American Economic Review, 104(2): 379-421.

Brynjolfsson, E. and A. McAfee 2014. The Second Machine Age: Work Progress, and Prosperity in a Time of Brilliant Technologies. New York: W. W. Norton & Company, 2014.

Busetti, F., G. Ferrero, A. Gerali and A. Locarno 2014. "Bounded rationality and de-anchoring of inflation expectations," mimeo, Banca d'Italia.

Caballero, R. J. and A. Krishnamurthy 2008. "Collective Risk Management in a Flight to Quality Episode," Journal of Finance, American Finance Association, vol. 63(5), pp. 2195-2230, October.

Canova, F. and M. Ciccarelli 2013. "Panel Vector Autoregressive Models: A Survey," CEPR Discussion Papers 9380.

Casiraghi, M., E. Gaiotti, L. Rodano and A. Secchi 2013. "The impact of unconventional monetary policy on the Italian economy during the sovereign debt crisis," Questioni di Economia e Finanza (Occasional Papers) 203, Bank of Italy.

Catte, P., P. Cova, P. Pagano and I. Visco 2011. "The role of macroeconomic policies in the global crisis," Journal of Policy Modeling, Elsevier, vol. 33(6), pp. 787-803.

Chen, H., V. Cúrdia and A. Ferrero 2012. "The Macroeconomic Effects of Large-scale Asset Purchase Programmes," Economic Journal, Royal Economic Society, vol. 122(564), pp. 289-315, November.

Christiano, L. J and M. Eichenbaum 2012. "Notes on Linear Approximations, Equilibrium Multiplicity and E-learnability in the Analysis of the Zero Lower Bound", mimeo, Northwestern University.

Christiano, L. J., R. Motto and M. Rostagno 2014. "Risk Shocks," American Economic Review, American Economic Association, vol. 104(1), pp. 27-65, January.

Chudik, A. and M. H. Pesaran 2014. "Theory and practice of GVAR modeling," Globalization and Monetary Policy Institute Working Paper 180, Federal Reserve Bank of Dallas.

Chung, H., J.-P. Laforte, D. Reifschneider and J. C. Williams 2012. "Have We Underestimated the Likelihood and Severity of Zero Lower Bound Events?," Journal of Money, Credit and Banking, Wiley, vol. 44(s1), pp. 47-82.

Coenen, G. and A. Warne 2014. "Risks to Price Stability, the Zero Lower Bound, and Forward Guidance: A Real-Time Assessment," International Journal of Central Banking, vol. 10(2), pp. 7-54, June.

Cúrdia, V. and M. Woodford 2011. "The central-bank balance sheet as an instrument of monetary policy," Journal of Monetary Economics, Elsevier, vol. 58(1), pp. 54-79, January.

Di Cesare, A., G. Grande, M. Manna and M. Taboga 2012. "Recent estimates of sovereign risk premia for euro-area countries," Questioni di Economia e Finanza (Occasional Papers) 128, Bank of Italy.

Diebold, F. X. and K. Yilmaz 2013. "Measuring the Dynamics of Global Business Cycle Connectedness," PIER Working Paper Archive 13-070, Penn Institute for Economic Research, Department of Economics, University of Pennsylvania.

Di Mauro, F. and M. H. Pesaran (ed.) 2013. "The GVAR Handbook: Structure and Applications of a Macro Model of the Global Economy for Policy Analysis," OUP Catalogue, Oxford University Press, number 9780199670086, October.

Elliott, D. J., G. Feldberg and A. Lehnert 2013. "The history of cyclical macroprudential policy in the United States," Finance and Economics Discussion Series 2013-29, Board of Governors of the Federal Reserve System.

Evans, G. W. and S. Honkapohja 2001. Learning and Expectations in Macroeconomics. Princeton, NJ: Princeton University Press.

Evans, G. W. and S. Honkapohja 2009. "Learning and Macroeconomics," Annual Review of Economics, Annual Reviews, vol. 1(1), pp. 421-451, 05.

Fair, R. C. and D. M. Jaffee 1972. "Methods of Estimation for Markets in Disequilibrium," Econometrica , vol. 40(3), May.

Fernandez-Villaverde, J., P. A. Guerrón-Quintana and J. Rubio-Ramírez 2012. "Estimating Dynamic Equilibrium Models with Stochastic Volatility," NBER Working Papers 18399, National Bureau of Economic Research, Inc.

Fernandez-Villaverde, J., P. Guerron-Quintana, J. F. Rubio-Ramirez and M. Uribe 2011. "Risk Matters: The Real Effects of Volatility Shocks," American Economic Review, American Economic Association, vol. 101(6), pp. 2530-61, October.

Genest, C., M. Gendron and M. Bourdeau-Brien 2009. "The Advent of Copuls in Finance" The European Journal of Finance, Routledge Taylor & Francis Group, vol. 15, Nos.7-8, pp. 609-618.

Gerali, A., S. Neri, L. Sessa and F. M. Signoretti 2010."Credit and Banking in a DSGE Model of the Euro Area," Journal of Money, Credit and Banking, Wiley, vol. 42(s1), pp. 107-141.

Gertler, M. and P. Karadi 2011. "A model of unconventional monetary policy," Journal of Monetary Economics, Elsevier, vol. 58(1), pp. 17-34, January.

Gertler, M. and N. Kiyotaki 2010. "Financial Intermediation and Credit Policy in Business Cycle Analysis," in: Benjamin M. Friedman & Michael Woodford (ed.), Handbook of Monetary Economics, edition 1, volume 3, chapter 11, pp. 547-599.

Glosten, L. R., R. Jagannathan and D. E. Runkle 1993. "On the Relation between the Expected Value and the Volatility of the Nominal Excess Return on Stocks" Journal of Finance, American Finance Association, vol. 48(5), pp. 1779-1801, December.

Goodfriend, M. and B. T. McCallum 2007. "Banking and interest rates in monetary policy analysis: A quantitative exploration," Journal of Monetary Economics, Elsevier, vol. 54(5), pp. 1480-1507, July.

Gordon, R. J. 2012."Is U.S. Economic Growth Over? Faltering Innovation Confronts the Six Headwinds," NBER Working Papers 18315, National Bureau of Economic Research, Inc.

Gordon, R. J. 2014. "The Demise of U.S. Economic Growth: Restatement, Rebuttal, and Reflections," NBER Working Papers 19895, National Bureau of Economic Research, Inc.

Guerrieri, L. and M. Iacoviello 2014. "OccBin: A toolkit for solving dynamic models with occasionally binding constraints easily," Journal of Monetary Economics, Elsevier, vol. 70, March 2015, pp. 22-38.

Hamilton, J. D. 1989. "A New Approach to the Economic Analysis of Nonstationary Time Series and the Business Cycle," Econometrica, Econometric Society, vol. 57(2), pp. 357-84, March.

Hansen, L. P. and T. Sargent 2007. Robustness. Princeton, NJ: Princeton University Press.

Iacoviello, M. 2005. "House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle," American Economic Review, American Economic Association, vol. 95(3), pp. 739-764, June.

International Monetary Fund, 2008. World Economic Outlook, October.

Jeanne, O. and A. Korinek 2010. "Excessive Volatility in Capital Flows: A Pigouvian Taxation Approach," American Economic Review, 100(2), pp. 403-07, May.

Jermann, U. and V. Quadrini 2012. "Macroeconomic Effects of Financial Shocks," American Economic Review, American Economic Association, vol. 102(1), pp. 238-71, February.

Kiyotaki, N. and J. Moore 1997. "Credit Cycles," Journal of Political Economy, University of Chicago Press, vol. 105(2), pp. 211-48, April.

Kiyotaki, N. and J. Moore 2012. "Liquidity, Business Cycles, and Monetary Policy, "NBER Working Papers 17934, National Bureau of Economic Research, Inc.

Kim, S.,, N. Shephard and S. Chib 1998. "Stochastic Volatility: Likelihood Inference and Comparison with ARCH Models," Review of Economic Studies, Wiley Blackwell, vol. 65(3), pp. 361-93, July.

Klein, L. R. 1977. "Comments on Sargent and Sims' "Business Cycle Modeling Without Pretending to Have Too Much *A Priori* Economic Theory" in: New Methods in Business Cycle Research: Proceedings from a Conference, Federal Reserve Bank of Minneapolis, Minneapolis, pp. 203-208.

Klein, L. R. 1992. "The Keynesian revolution: Fifty years later. A last world," in: Lawrence Klein's the Keynesian revolution: 50 years later. Proceedings of the 12th annual economics day Department of Economics, University of Pennsylvania, Philadelphia, pp. 41–53.

Klein, L. R. 2005. "Autobiography". Addendum, May 2005.
http://www.nobel.se/economics/laureates/1980/klein-autobio.htm

Lambertini, L., C. Mendicino and M. T. Punzi 2013. "Leaning against boom–bust cycles in credit and housing prices," Journal of Economic Dynamics and Control, Elsevier, vol. 37(8), pp. 1500-1522.

Liu, Z., P. Wang and T. Zha 2013. "Land-Price Dynamics and Macroeconomic Fluctuations," Econometrica, Econometric Society, vol. 81(3), pp. 1147-1184, 05.

Lucas, R. E. Jr. 2003. "Macroeconomic Priorities," American Economic Review, American Economic Association, vol. 93(1), pp. 1-14, March.

Lucas, R. E. Jr. 2009. "In Defence of the Dismal Science," in The Economist, August 6.

Mariano, R. S. 1987. "The ET Interview: Professor L. R. Klein", Econometric Theory, 3, pp. 409-460.

McCallum, B. T. 2007. "E-stability vis-a-vis determinacy results for a broad class of linear rational expectations models," Journal of Economic Dynamics and Control, Elsevier, vol. 31(4), pp. 1376-1391, April.

Mendoza, E. G. 2006. "Lessons from the Debt-Deflation Theory of Sudden Stops," American Economic Review, American Economic Association, vol. 96(2), pp. 411-416, May.

Oka, T. and Z. Qu 2011. "Estimating structural changes in regression quantiles," Journal of Econometrics, Elsevier, vol. 162(2), pp. 248-267, June.

Patton, A. J. 2008. "Copula-Based Models for Financial Time Series, "OFRC Working Papers Series 2008fe21, Oxford Financial Research Centre.

Popper, K 1963. Conjectures and Refutations: The Growth of Scientific Knowledge, Rouletdge & Kegan Paul.

Primiceri, G. 2005. "Time Varying Structural Vector Autoregressions and Monetary Policy," Review of Economic Studies, Oxford University Press, vol. 72(3), pp. 821-852.

Rodano, L., S. Siviero and I. Visco 2014. "Inversioni cicliche e previsioni macroeconomiche: racconto di due recessioni", in R. Bardazzi (ed.), Economic multisectoral modelling between past and future: a tribute to Maurizio Grassini and a selection of his writings, Firenze, Firenze University Press, 2014, pp. 229-247.

Shiller, R. J. 1997. "Why Do People Dislike Inflation?," NBER Chapters, in: Reducing Inflation: Motivation and Strategy, pp. 13-70 National Bureau of Economic Research, Inc.

Simon, H. A. 1981. The sciences of the artificial, MIT Press, Cambridge, Mass., pp. 170.

Sims, C. A. 2003. "Implications of rational inattention," Journal of Monetary Economics, Elsevier, vol. 50(3), pp. 665-690, April.

Sims, C. A. 2010. "Rational Inattention and Monetary Economics," in: B. M. Friedman and M. Woodford (ed.), Handbook of Monetary Economics, edition 1, Elsevier, volume 3, chapter 4, pp. 155-181.

Sims C. A. and T. Zha 2006. "Were There Regime Switches in U.S. Monetary Policy?," American Economic Review, American Economic Association, vol. 96(1), pp. 54-81, March.

Smets, F. and R. Wouters 2003. "An Estimated Dynamic Stochastic General Equilibrium Model of the Euro Area," Journal of the European Economic Association, MIT Press, vol. 1(5), pp. 1123-1175, 09.

Smets, F. and R. Wouters 2007. "Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach," American Economic Review, American Economic Association, vol. 97(3), pp. 586-606, June.

Summers, L. H. 2013. Speech at IMF 14th Annual Research Conference In Honor Of Stanley Fisher, International Monetary Fund, November 8, 2013.

Tillmann, P. and M. Wolters 2014. "The changing dynamics of US inflation persistence: a quantile regression approach," Kiel Working Papers 1951, Kiel Institute for the World Economy.

Visco, I. 2003. Discussion of "Asset prices, financial imbalances and monetary policy: are inflation targets enough?" by Charles Bean, in C. Bean (ed.), Asset prices, financial imbalances and monetary policy: are inflation targets enough?, BIS Working Papers, 140, 2003, pp. 20-25.

Visco, I. 2005. "From theory to practice in macroeconomic models: post-Keynesian eclecticism," BNL Quarterly Review, Banca Nazionale del Lavoro, vol. 58 (233-234), pp. 67-90.

Visco, I. 2009. "The financial crisis and economists' forecasts", BIS Review, 49, 2009, pp. 26-47.

Visco, I. 2013. "The aftermath of the crisis: regulation, supervision and the role of central banks ", CEPR Policy Insight, 68.

Wadhwani, S. 2003. Discussion of "Asset prices, financial imbalances and monetary policy: are inflation targets enough?" by Charles Bean, in C. Bean (ed.), Asset prices, financial imbalances and monetary policy: are inflation targets enough?, BIS Working Papers, 140, 2003, pp. 20-25.

Yellen, J. L. 2007. "Implications of Behavioral Economics for Monetary Policy," Panel on: "Behavioral Economics and Economic Policy in the Past and Future", Federal Reserve Bank of Boston Conference: "Implications of Behavioral Economics for Economic Policy" Boston, Massachusetts, September.

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