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Forecasting in a Central Bank

Stefano Siviero
Banca d'Italia, Directorate General for Markets and Payment Systems

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To start: why forecasts, why models, what model(s)

Why a central bank (CB) needs forecasts, 1/2

The answer is straightforward:

- monetary policy is well known to affect output and inflation with a lag (longer for the latter);
- hence, in setting today's monetary policy stance, one must have an idea of the scenario that will likely prevail in the future, when today's decision will exert their effects on the economy;
    - corollary: the forecast horizon should be at least as long as needed to include the full impact of monetary policy on inflation.

Why a CB needs forecasts, 2/2

Q: “Are forecasts, and particularly model-based forecasts, an absolute necessity for a CB?”

A: “No, they are not” (!!!) “The choice between modelling or not, and even more so the choice of which models, is largely dictated by the monetary policy strategy framework”

- In the old times, when monetary policy aimed at hitting intermediate targets (which are typically readily observable and respond immediately to policy impulses; e.g.: exchange rate; money supply), in principle forecasting the future was not necessarily required.

- But: developments in monetary theory in the past decades emphasize the role of final objectives rather than intermediate ones (e.g.: inflation targeting; Svensson: inflation forecast targeting). Targeting final objectives (inflation, output gap, employment, etc.) requires a model capable of: (i) extracting information from huge number of variables, and (ii) capturing the transmission mechanism from those variables to the objectives.

There are other reasons why a CB may be interested in (the very costly activity of building, maintaining and using) models.

Pros of using models

Since a model must be explicit as to the underlying mechanisms, it is a powerful story-telling device, which proves useful for both internal and external purposes (independently of monetary policy strategy framework):

inside: it provides order, discipline and a natural "structure for discussion," particularly if "shared" within the institution (we will get back to this); and, it may be is useful even if it does not work (!), as it may help identifying the reasons behind its failures (a special kind of story-telling; examples later)

outside: it facilitates external communication, hence contributing to enhance transparency of the monetary policy framework; it also promotes accountability (by making the relationships between instruments and targets clear, it makes it possible for society to appraise the options available to the policymaker and judge her/his actions)

What model(s)

Just one model or several models?

- No need to develop an all-encompassing model of the universe; better to have interconnected models (Jorge Luis Borges, 'On Exactitude in Science;' Lewis Carroll, 'Sylvie and Bruno Concluded').

CBs have a clear preference for structural models (as opposed to reduced form models). Why?

- In a CB, modellers are not simply expected to produce good forecasts. Rather, the policy-maker must (and must want to) be convinced about reliability of forecast figures.
- This being the case, a model in use in a CB must be able to "tell stories": it should be of help in building convincing "stories" to support a given forecast.

Advantages of a “story behind the figures”

- It can be “dissected”
- Therefore, it can be accepted, or contested, “locally”
- Specifically: for each individual component of the story, one may compare forecasts with:
  - similar historical episodes → plausibility
  - conjunctural info. → consistency with all is known
- Hence, the forecast is not “take-it-or-leave-it”: one may “trust the forecast selectively” (and, as a result, narrow the focus on the main sources of uncertainty)

If you can’t tell a story, then it ain’t good

“Math is a friend of mine. There have been a number of occasions in my life when doing the math on an economic model has led me to conclusions very different from my preconceptions. But I have always been able, after the fact, to find a way to express in plain English what the math is telling me. If you resort to math to justify what looks like a very foolish claim, and you can’t find a plausible way to express that justification in plain English, something is wrong.” (Paul Krugman)

The father of the great French mathematician Augustin-Louis Cauchy was a friend of Joseph-Louis Lagrange (born Giuseppe Lodovico Lagrangia); he asked his illustrious friend how to choose the best school for his child, a school that would strenghten the latter’s precocious mathematical skills: “On Lagrange's advice, Augustin-Louis Cauchy was enrolled in the École Centrale du Panthéon [now Lycée Henry-IV], the best secondary school of Paris at that time […] Most of the curriculum consisted of classical languages”

More on the pros of having a model

- The model provides a common ground for discussion: to the extent that the model framework is shared, having a model can facilitate the discussion about the forecasts (at the Bank of Italy, discussion about the forecasts orderly "follows the model structure", rather than rolling out in all directions without any discipline)

- Building a structural model of non-negligible size cannot be (nor should be) an individual effort: therefore, building it fosters co-operation and exchange of ideas among different units (or at least it should)

- Building a structural model imposes to collect statistical data in a systematic and consistent way

- Since models encompass the whole economy, in building them one may more easily spot inconsistencies among different sources regarding definitions, accounting criteria, etc.

- Routinely updating econometric models helps detecting structural changes in the working of the economy and in the transmission mechanisms

How can one best reap those pros

⇒ A model-building strategy most likely to maximise the benefits from the institution is one which tries to involve final users and researchers from different units, so that the resulting model is “shared”

⇒ By contrast, a model that is not “shared” risks becoming a toy (a very expensive one; but not as useful as it could be)

Why several models

In addition to being able to “tell a story”, a forecast, to be reliable, should satisfy other requirements:

- It should be demonstrably inclusive of all available information ($\rightarrow$ model as “information sieve”). Of course, forecasters must do both of the following: (i) making sure that all information is properly taken into account; (ii) resisting the temptation of “running after” each individual piece of news (assess and select)

- Being able to reassure that the forecast is robust, i.e., that it is supported by different models with different theoretical foundations and empirical properties

“Bridge” models

Information may differ as to timeliness, quality, ease of inclusion in the forecasts; it may belong to the following categories:

- quantitative and concerning model variables directly
- quantitative, but concerning variables not included in model
- quantitative, on discrete variables
- qualitative
- anecdotal

Difficulty of incorporating info. from different categories above differ considerably.

Solution: use “bridge” models

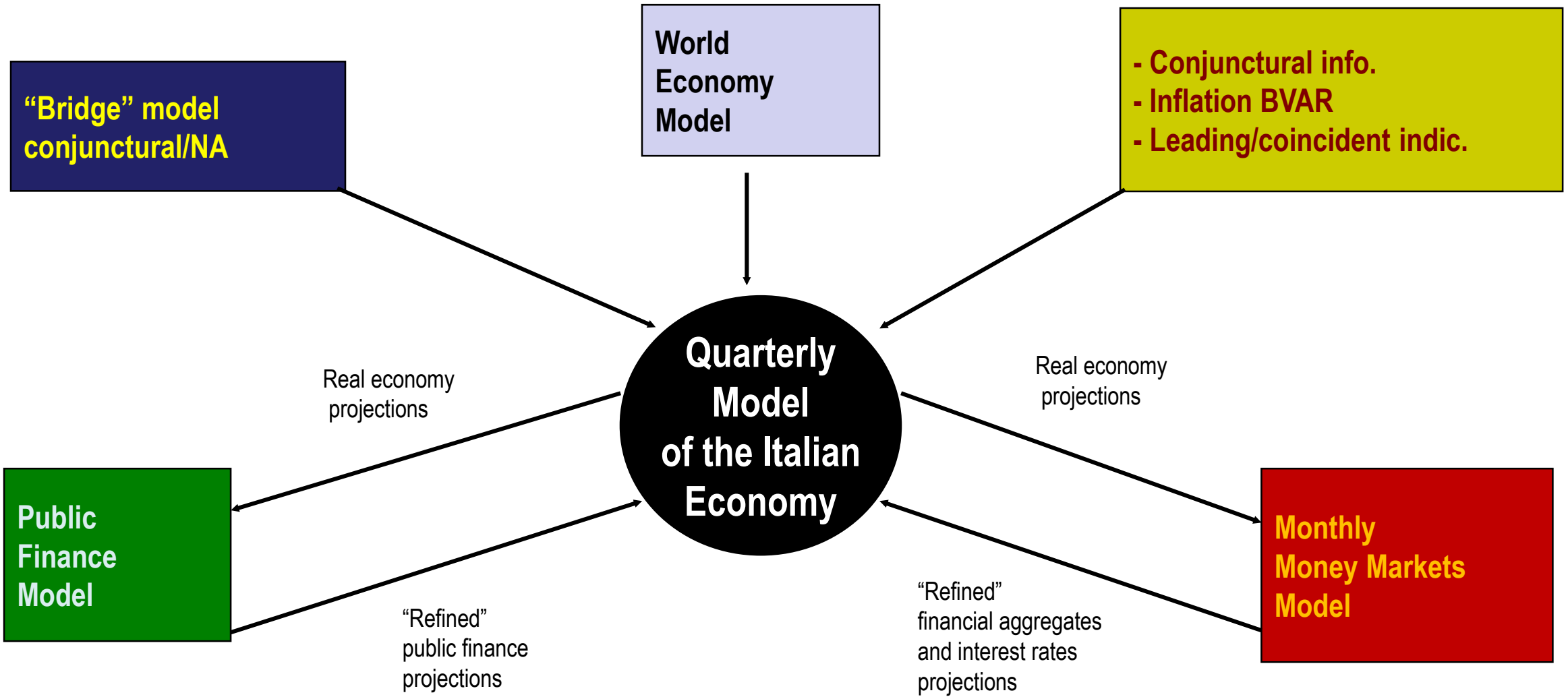
Other “satellite” models

Also, any model, no matter how large, cannot be all-inclusive (recall Jorge Luis Borges and Lewis Carroll).

A wiser approach:

- build sufficiently detailed large-scope model
- build supplementary models to go into deeper detail as to some specific aspects
- when using them, have the models interact (use large- scope model to feed variables as needed into supplementary ones, use latter’s results to fine-tune large-scope model)

Taking all available information on board



Robustness and information inclusiveness
→ At the Bank of Italy, lots of models in use

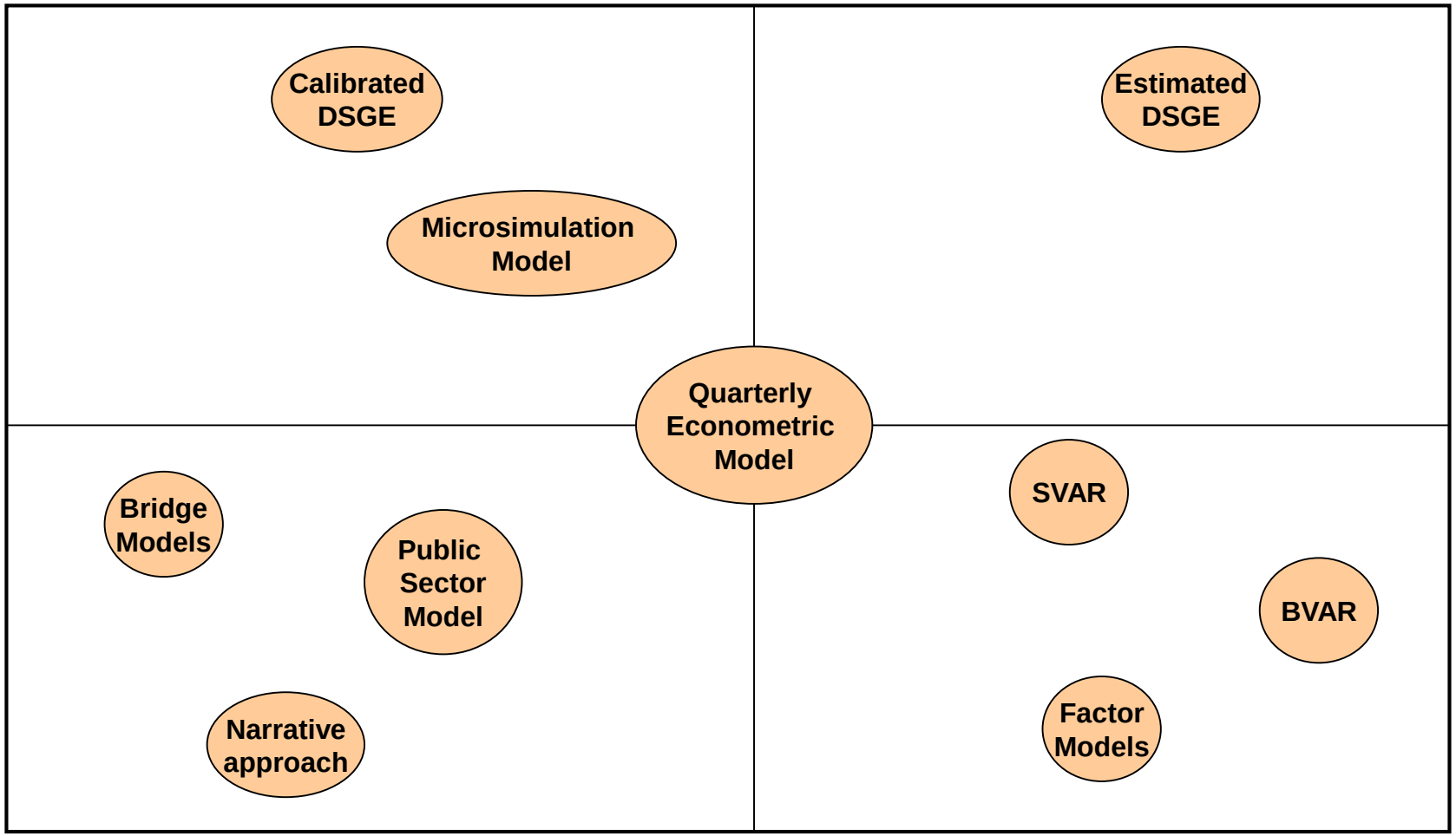
Several models are (or have been in recent past) in use at Banca d'Italia, other than BIQM (which is itself available in different versions):

- Monthly Money Market
- Monthly Balance of Payments
- Monthly Public Finance [*]
- GEM [*]
- Domestic conjunctural 'bridge' [*]
- Short-term inflation forecasts (BVAR) [*]
- Main world economies BVARs [*]
- Main euro economies small structural [*]
- Main euro economies 'bridge' [*]
- Microsimulation of saving behaviour [*]
- Other: industrial production, leading/coincident indicators, etc. [*]
- Main world economies DSGE [*]
- Euro area and Italy DSGE [*]
- Euro area DSGE with financial sector [*]
- …

[*] In use or being developed

A continuum of models

Economic content / Role of economic theory



Degree of statistical / mathematical sophistication

My own view on the best way to organize modeling activities

Two feasible organisational solutions:

Solution 1: dedicated unit (say, 6 people exclusively devoted to build the model and nothing else, with no "external" help)?

Solution 2: involve larger number of economists from the whole department, most working part-time?

- Solution 1 runs the risk of making the model a "toy": interesting, possibly useful, but likely to be used only by those who know it (i.e., those who built it)
- Solution 2, has in this respect, a great advantage: an essential condition for an effective use of an econometric model is that the model be shared within the institution that is going to use it, and that it be perceived as a common framework that facilitates comparison of different views.
- Incidentally, all this is likely to take time: the time needed to sediment confidence in the model and familiarity with its use. A model built in a very short time and by a small-sized, dedicated "special team" could not only be inaccurate, but, more importantly, will not produce sufficient confidence in and knowledege of the model within the institution, so that it might end up being under-utilized.

To publish or not to publish, that is the question

Most CBs produce forecasts: given the average lag with which monetary policy is estimated to affect economic activity and prices (most estimates suggest a delay of about 2 years before the maximum effect is reached), monetary policy-making needs projections about the future.

However, not all CBs publish forecasts.

For instance, until a few years ago the Banca d'Italia never published its forecasts (although hints to projected figures could be found in official publications).

Why? Because publishing has pros as well as cons.

Publishing: Pros

- Increase transparency of monetary policy. Specifically, to the extent that projections are used in policy-making process, by publishing them one makes it easier for the markets to understand the motivations behind monetary policy decisions, and makes it clear that the latter depend on a forward-looking perspective. Expectations may also be influenced in this way.

- The demand for more accountability is met (with beneficial effects on reputation).

- From the viewpoint of modellers: the management may feel more involved in the projection-making process

Publishing: Cons

- Given the emphasis that the publication would give to projections, the markets may be induced to think that they represent a synthesis of all information reviewed by the CB's top management.

- The projections are typically conditional upon the assumption of unchanged (or market-expectations-consistent) monetary policy: hence, they do not represent the "most likely scenario". The conditional nature must be clearly explained.

- Forecast errors may be negative for reputation (incidentally: conditional projections are even more prone to be affected by errors). On the whole: this risk is likely to be limited.

- Publication of forecasts may distract the public from the wealth of analyses that are presented the CB's publications.

Publishing: Operational aspects

Given that the publication of forecasts has both pros and cons (and the latter are in no small number), the operational aspects of the publication should be carefully designed.

- Presenting the forecasts as a “technical” product reduces the possibility that they are over-reacted to.
- Which variables should be included?
  - Few but good? Or many (with increasing risks of making errors)?
  - What about policy sensitive variables (e.g., public finance ones? Risks both in departing from and in reproducing faithfully the official programs).
- What’s the best publication format?
  - In a separate document?
  - Or in one of the publications that already exist?

Practical issues

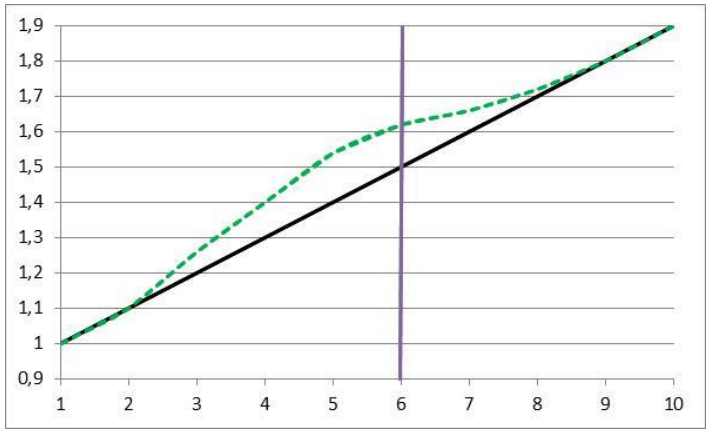
Using the model when it is known not to work

- When it comes to forecasting, models (and model users) always make mistakes. («It is difficult to make predictions, especially about the future.» Winston Churchill, Niels Bohr, Yogi Berra, Albert Einstein, …).

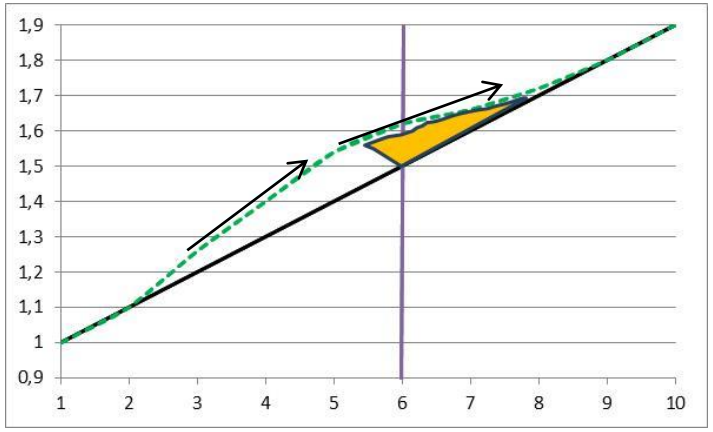
- One should not simply accept that mistakes are made. Mistakes should always be interpreted, and they may have a lot to tell:
  - Was anything forgotten in building the model?
  - Or else, were wrong assumptions made?
  - Or else, is it the case that something happened that the model is not equipped to predict, but may perhaps predict if properly «massaged»?
    - If this is the case, what kind of model inadequacy is it?
      - Is it something that no model can capture?
      - Is it something that models could capture, if properly amended?

An example of “curable” model inadequacy : Temporary tax relief for investment spending

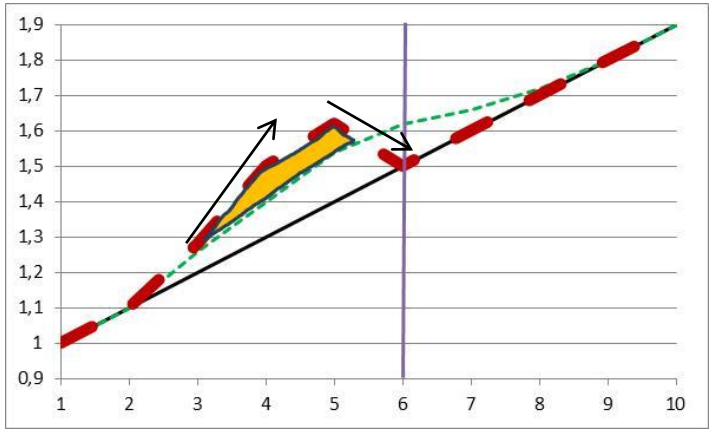
1. Baseline: investment without investment incentives (lower tax rate).



2. Tax incentive. Given the typical equations with distributed lags, the effects take a long time fully to materialize.



3. But the law only allowed tax relief for investment in, say, the first 3 semesters. However, this simulation may allow to estimate the overall impact.



4. Solution: Assume the model indeed correctly assesses the overall impact of the incentive. «Allocate» (somewhat arbitrarily) the overall impact to the «eligible» periods, by means of add factors.

Errors in preliminary data, 1/2

Because of the (typically) preliminary nature of economic data, initial conditions (i.e., recent past developments) are somewhat fuzzy. This contributes to the overall forecast error.

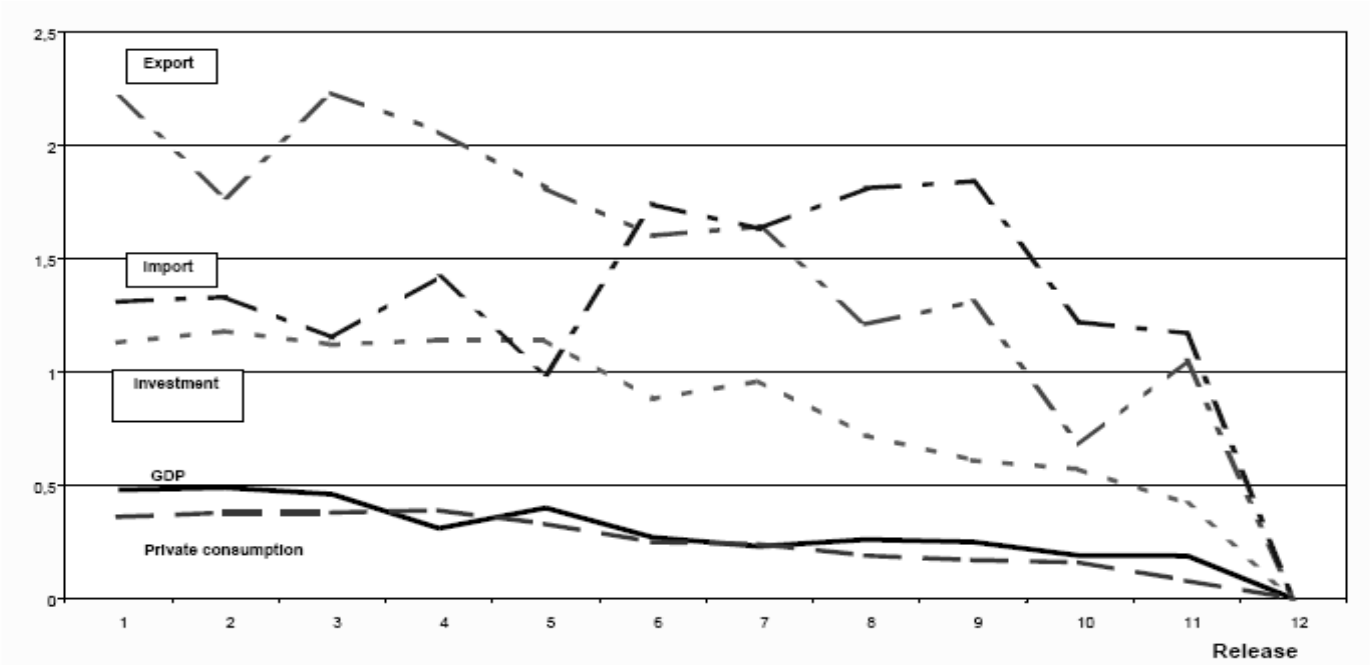
$$
\begin{aligned}
y_t - \hat{y}_t &= (\alpha x_t + \beta y_{t-1} + e_t) - (\hat{\alpha} x_t^f + \hat{\beta} y_{t-1}^p + a_t) \\
&= (\alpha - \hat{\alpha}) x_t + (\beta - \hat{\beta}) y_{t-1} \\
&\quad + \hat{\alpha}(x_t - x_t^f) \\
&\quad + \hat{\beta}(y_{t-1} - y_{t-1}^p) \\
&\quad + e_t \\
&\quad - a_t
\end{aligned}
$$

Components of forecast error

- Due to estimated (as opposed to "true") parameters
- Due to error in exogenous assumptions
- Due to noise in preliminary data
- Due to stochastic error component
- Due to erroneous judgement

Errors in preliminary data, 2/2

RMSE of successive releases for GDP and components (≈ 30 obs./release)



- Ignoring the fact that preliminary data may differ from final ones results in sub-optimal forecasts.
- In theory, if the error component in the preliminary data is particularly large, it may be better to ignore those data altogether, and rely on the projections produced by the model (suppose, in the simple model above, that the standard deviation of the equation is much smaller that the RMSE of preliminary data: in this case it may be wiser to produce yt-1 with the model itself, rather than adopting the preliminary figure).
- More generally, the quality of one's forecast may be improved if one combines both sources of information.
- Busetti (2002) shows that the forecast performance gains may indeed be sizeable.

Forecast combination, 1/3

- Many competing forecasts are available which may rely on different techniques, theoretical foundations, statistical approaches, and information sources.
- It may be a good idea to take the best out of them all, rather than discarding most of them to keep only the “best” one.
- Several techniques are available that may be used to combine competing forecasts.
- This is a very simple idea that works well in practice. Why? Not clear. But it works.

- Suppose two alternative forecasts are available, f_{1t} and f_{2t}, for the same variable y_t
- Let us consider a combined forecast, given by a weighted average (ex ante, not ex post!) of individual forecasts:

$$f_{ct} = (1-\lambda) f_{1t} + \lambda f_{2t}$$

- The forecast errors for the individual forecasts are:

$$e_{2t} = y_t - f_{2t} \qquad e_{1t} = y_t - f_{1t}$$

- so that the forecast error for the combined forecast is:

$$e_{ct} = (1-\lambda) e_{1t} + \lambda e_{2t}$$

- Let us make the assumption that both individual forecasts be unbiased, and that they may be correlated with one another.

Forecast combination, 2/3

- Because of the assumption on the second moments, the variance of the forecast error of the combined forecast may be alternatively written as follows:

$$E(e_{ct}^2) = (1-\lambda)^2\sigma_1^2 + \lambda^2\sigma_2^2 + 2\lambda(1-\lambda)\sigma_{12}$$

$$E(e_{ct}^2) = (1-\lambda)^2\sigma_1^2 + \lambda^2\sigma_2^2 + 2\lambda(1-\lambda)\rho\sigma_1\sigma_2$$

- We want to combine the two forecast in an optimal way, i.e., we want to choose the parameter l in such a way that the mean square error (= the variance) of the combined forecast error is minimal.
- As usual, we compute the minimum of the expression above with respect to λ, which results in the following expression:

$$\lambda = \frac{\sigma_1^2 - \sigma_{12}}{\sigma_1^2 + \sigma_2^2 - 2\sigma_{12}} = \frac{\sigma_1^2 - \rho\sigma_1\sigma_2}{\sigma_1^2 + \sigma_2^2 - 2\rho\sigma_1\sigma_2}$$

which may be easily estimated.

Forecast combination, 3/3

Let us consider the expression for λ again:

$$\lambda = \frac{\sigma_1^2 - \sigma_{12}}{\sigma_1^2 + \sigma_2^2 - 2\sigma_{12}} = \frac{\sigma_1^2 - \rho\sigma_1\sigma_2}{\sigma_1^2 + \sigma_2^2 - 2\rho\sigma_1\sigma_2}$$

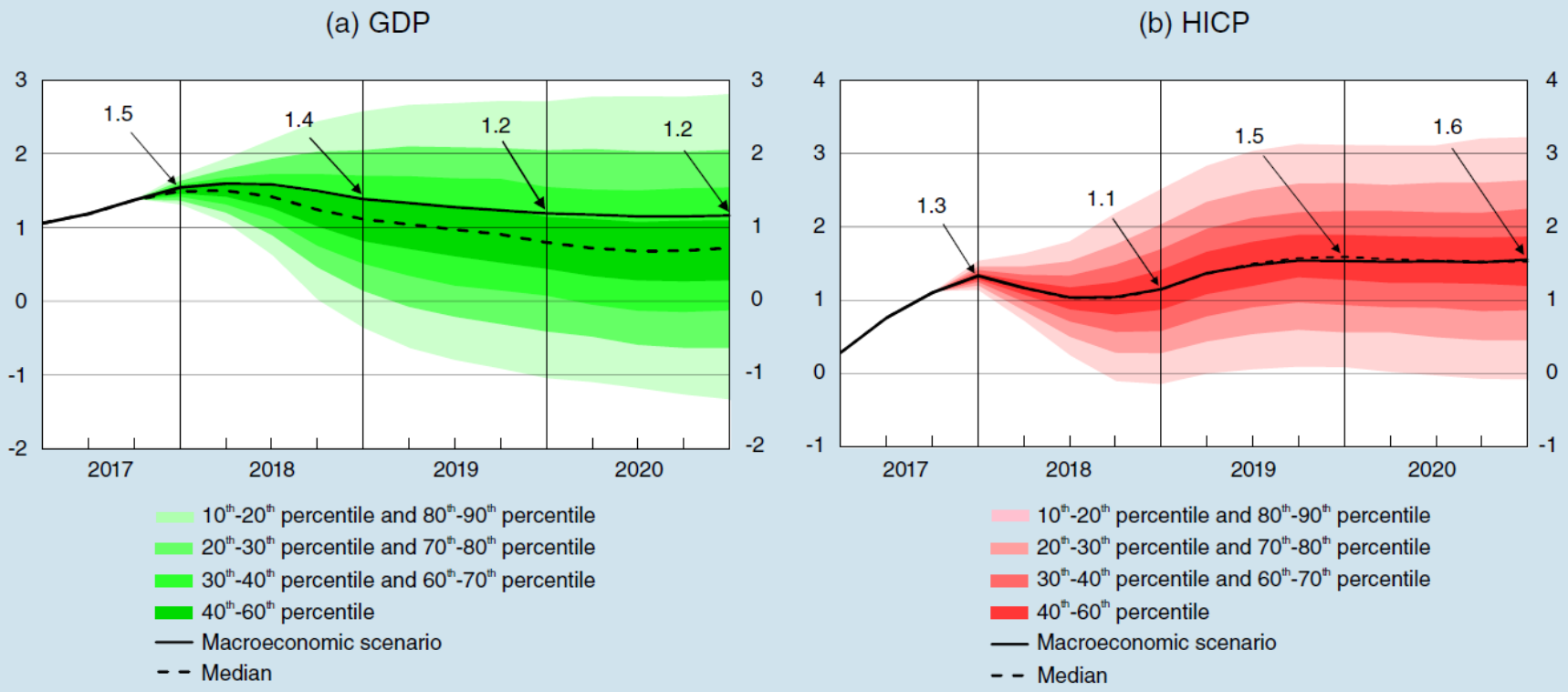
If ρ = 0, then the expression above delivers a perfectly logical result: the higher the variance of the first forecast, the higher is the weight that we assign to the second forecast in the combination of the two (recall that l is the weight of the second forecast).

Note, however, that if ρ is not nil, then one may easily run into cases in which λ is not included in the [0, 1] interval.

Several refinements to this basic set-up have been proposed over time, but it is usually the case that the out-of-sample properties are best with the simplest forecast combination set-up.

Coping with uncertainty

Distribution of probabilities of GDP and HICP projections (1)
(percentage changes on year-earlier period; 4-term moving averages)



(1) The probability distribution is graphed, for percentile groups, by *fan charts*, based on stochastic simulations made via random extractions from the shock distribution of the Bank of Italy's quarterly econometric model. The distribution takes account of asymmetric shocks to the equations that reflect the main risk factors according to the procedure described in C. Miani and S. Siviero, 'A non-parametric model-based approach to uncertainty and risk analysis of macroeconomic forecasts', Banca d'Italia, Temi di Discussione (Working Papers), 758, 2010. The figure shows year-on-year percentage changes of 4-term moving averages. The value corresponding to the fourth quarter of each year coincides with the average annual percentage change.

Has anything changed following the long crisis?
1. The starting point (at the Bank of Italy)

The Bank of Italy model suite in "good old times"

- Two main tasks:
  - ✓ **forecasting**
  - ✓ **policy analysis**

- Forecasting and policy analysis (Italy): traditional **large-scale** macroeconometric models:
  - ✓ Flexibility; room for (educated) judgment
  - ✓ Detailed description of the economy (pros and cons)

- Policy analysis (Italy, euro area): medium-size New Keynesian dynamic stochastic general equilibrium (**DSGE**) models:
  - ✓ Rational expectations, representative agent, real/nominal rigidities
  - ✓ Structural approach. Estimation: quantify structural shocks ("storytelling"), produce forecasts, make inference on unobserved variables (output gap, natural interest rate)

The Bank of Italy Quarterly Model (BIQM)

General characteristics

- Semi-structural quarterly macro-econometric model of the Italian economy
- In the current version of the model: more than 700 endogenous variables, around 100 stochastic equations
- Four sectors (“core”: private sector net of agriculture and energy)

Model variables

Endogenous variables

- Production and demand of goods and services
- Prices of goods and services
- Labor demand and supply, unemployment, wages
- Public sector balance sheet: revenues, outlays, borrowing requirements
- Financial assets
- Current account and Balance of payments
- Interest rates at all maturities

Exogenous variables

- Behavior of foreigners
- Monetary and fiscal policy instruments
- Structural features of the economy

The BIQM: Main properties (1)

The long run

Supply determined (growth = function of exogenous population and productivity growth), consistent with neoclassical exogenous growth model (Solow), with endogenous saving. In equilibrium:

- full employment (constant inflation)
- capital and labor consistent with level of output and relative prices
- output price = mark-up over unit labor cost

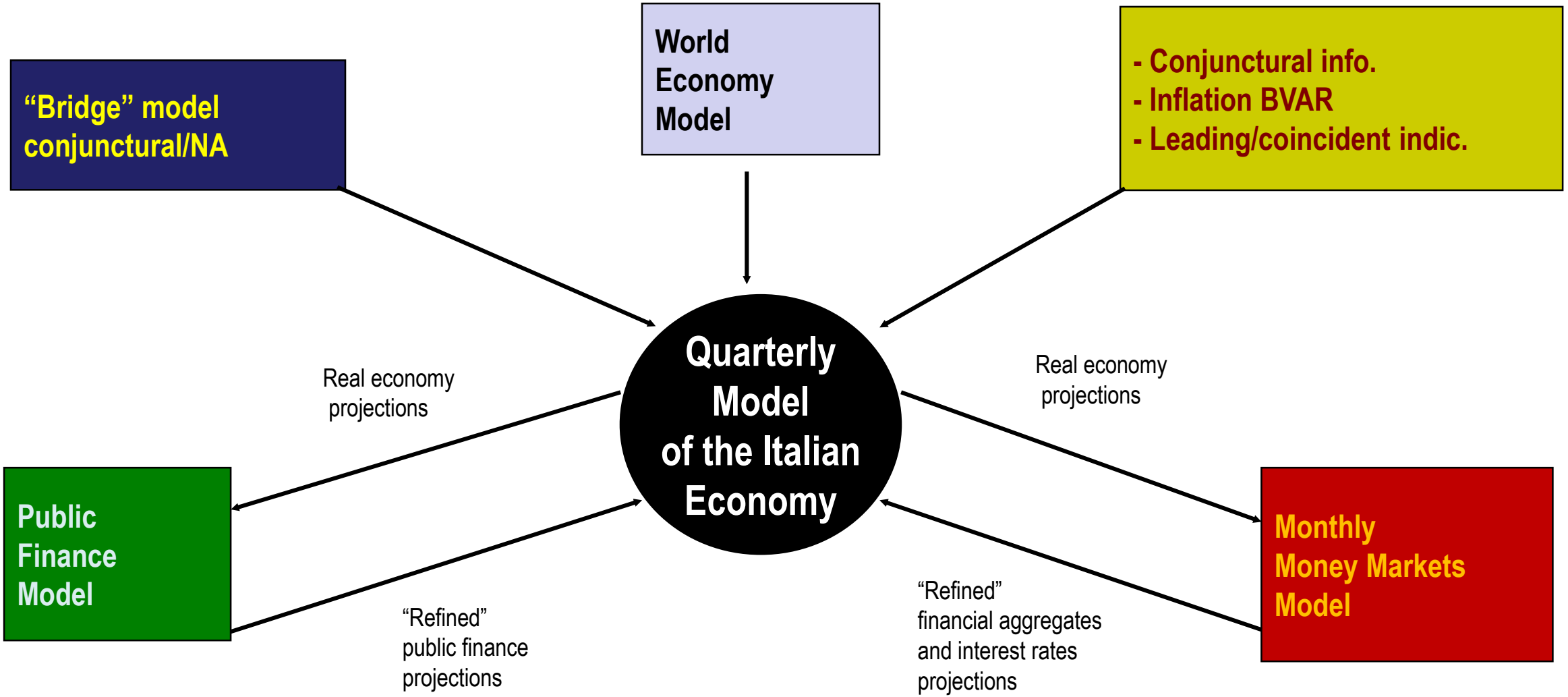
The short run

- demand determined (“Keynesian”)
- price and wage stickiness
- non malleability of installed physical capital
- expectations errors are not innovations

The BIQM: Main properties (2)

- Demand of **production inputs**: directly derived from a cost minimization problem with putty-clay Cobb-Douglas technology; labor and capital inputs depend on the desired addition to capacity output and on relative prices of inputs
- Private **consumption** depends on disposable income and wealth (in line with life-cycle hypothesis); inter-temporal choices are captured by a real interest rate
- Foreign **trade** modelled in terms of an absorption variable and competitiveness
- **Supply prices** modelled as a markup over unit labor cost. The latter depend on labor costs, while the markup is a function of foreign competitive pressures, domestic cyclical conditions and commodity prices
- **Demand prices** are homogeneous of degree 1 in value-added and imported prices

Taking all available information on board, redux



Short-term forecasting models: Bridge models

- Motivation: need to **bridge the gap** between **monthly** indicators (which provide a timely tracking of economic activity) and **quarterly** national account data, which are available with delay (flash estimates 45 days after the end of the quarter)

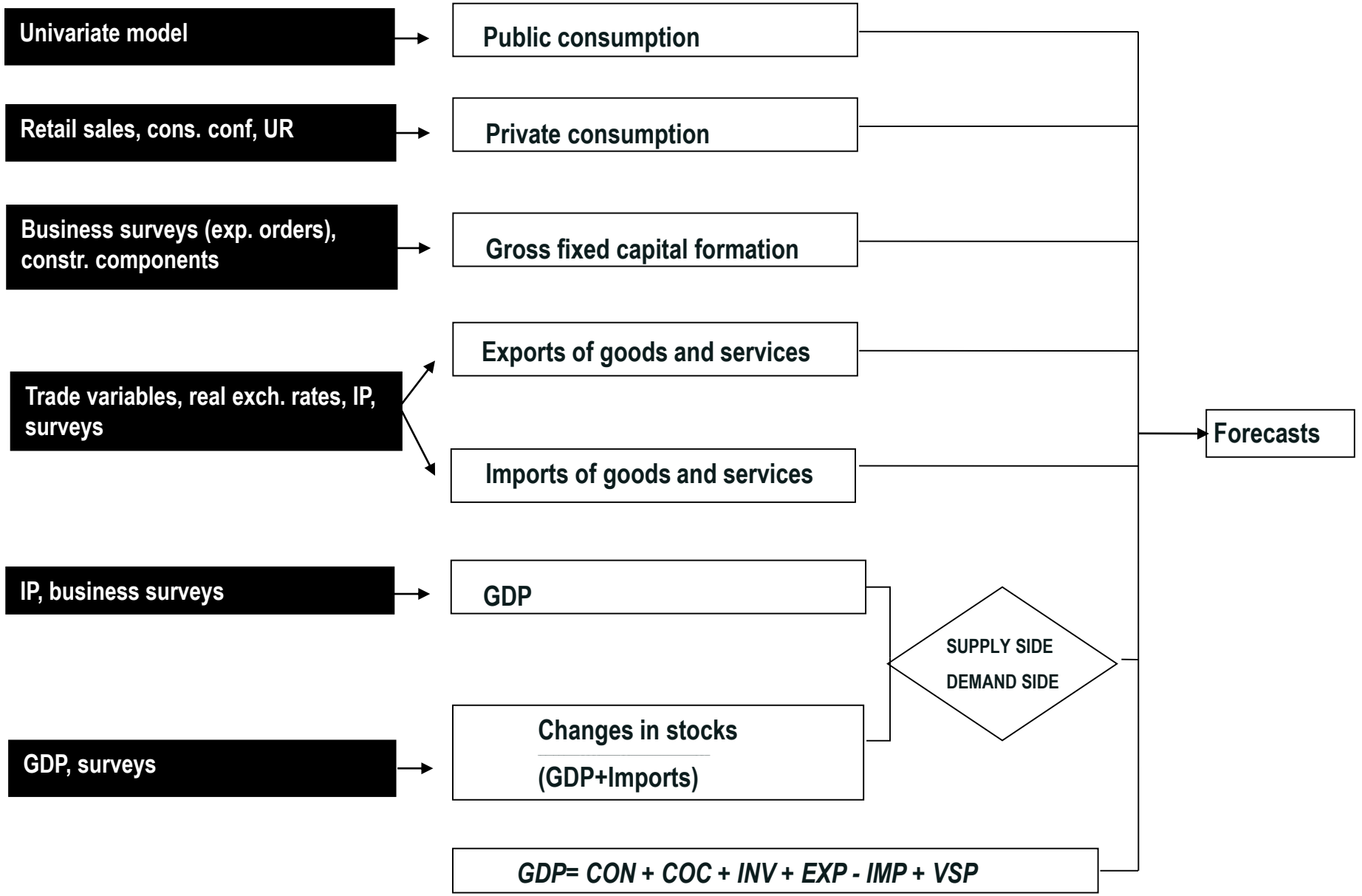
- Bridge models (BM): system of simultaneous equations, estimated by OLS. Main GDP components: demand-side BM; aggregate GDP level: supply-side BM

- Estimation captures co-movement between GDP and selected explanatory variables, but no causal link

- Main issues:

  ✓ Selection of explanatory variables (general-to-specific, LASSO, Bayesian model averaging)
  ✓ Temporal aggregation of high-frequency indicators (MiDaS?)

Bridge models: matching variables and indicators



DSGE models for policy analysis

- Main reference: **Smets and Wouters (2003)**: medium-size, New Keynesian dynamic stochastic general equilibrium (DSGE) model of the euro area as a closed economy, estimated using Bayesian methods

- General characteristics: general equilibrium, internally consistent microfounded structure; imperfect competition; nominal and real rigidities; role for monetary policy

- Most central banks (and other policy institutions) have developed their own DSGE model after Smets and Wouters (2003). A few examples: ECB/Eurosystem (NAWM, EAGLE), Federal Reserve System (SIGMA), IMF (GIMF), European Commission (QUEST), Sveriges Riksbank (RAMSES), Bank of Italy (IDEA + several others).

The Bank of Italy's DSGE model: IDEA

- **IDEA**: focus on **Italy** and the rest of the **E**uro **A**rea (in a monetary union; plus rest of the world)

- General features: New Keynesian (nominal and real rigidities; role for monetary policy), open economy (trade linkages)

- Core structure:

  - ✓ *Households*: consume, work, invest in physical capital (real rigidities)
  - ✓ *Final goods firms*: aggregate intermediate goods into consumption and investment
  - ✓ *Intermediate goods*: internationally tradable/nontradable; produced using capital and labor, under monopolistic competition and sticky prices
  - ✓ *Monetary policy*: Taylor-type interest rate rule
  - ✓ *Fiscal policy*: debt-stabilizing rule, distortionary taxation
  - ✓ Explicit role for *exchange rate* and international *trade* linkages

IDEA at work - Policy analysis: consolidation & reforms (1)

- Macroeconomic effects of **simultaneously** implementing growth-friendly **fiscal consolidation** and **competition-friendly reforms** in one European country (Gerali, Notarpietro and Pisani 2016)

- **Fiscal consolidation**: exogenous reduction in target debt-to-GDP ratio (10 pp in a decade). Distortionary taxes initially increase, then decrease once fiscal room is created by fall in debt/GDP
  - ✓ Tax on capital income affects long-run investment
  - ✓ Tax on wage income affects long-run labor supply

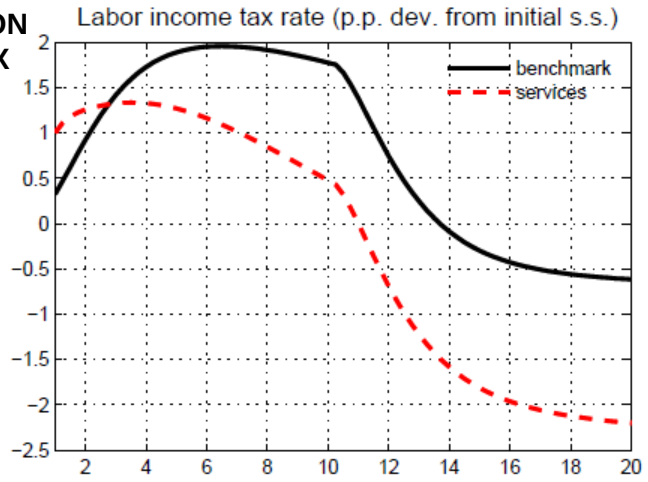
- **Structural reforms**: permanent reduction in service sector markup (5 pp in 10 years)
  - ✓ elasticity of substitution (θ), a decreasing index of imperfect competition, pins down steady-state markup:

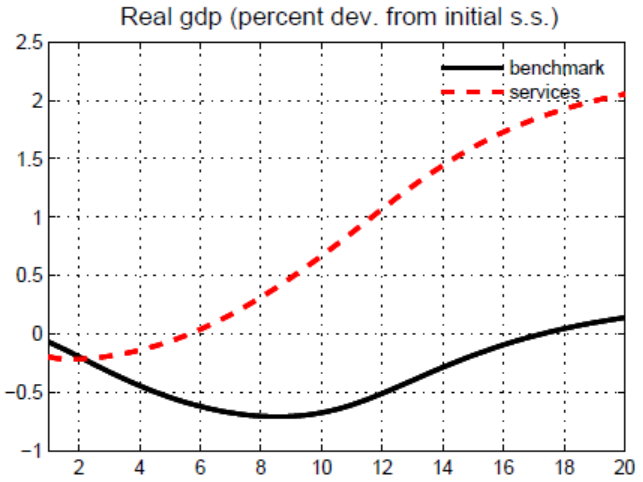
$$p = \frac{\theta}{(\theta - 1)} * mc$$

IDEA at work - Policy analysis: consolidation & reforms (2)

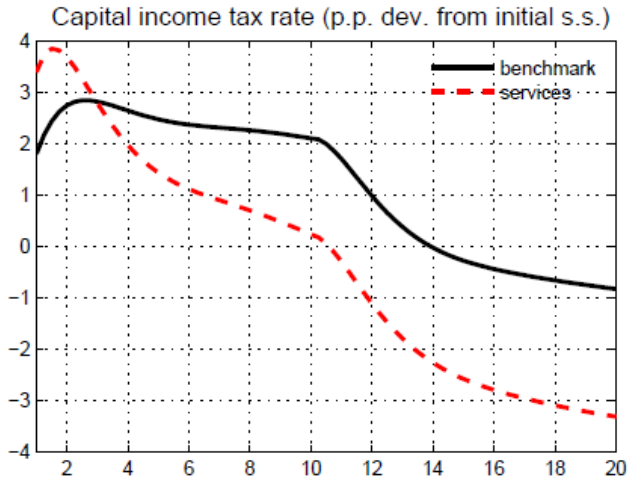
Bottom line: with competition-friendly reforms (red dotted line), consolidation requires much less aggressive tax policy and implies much smaller cost in terms of output, compared with the case of consolidation without reforms (black solid line).

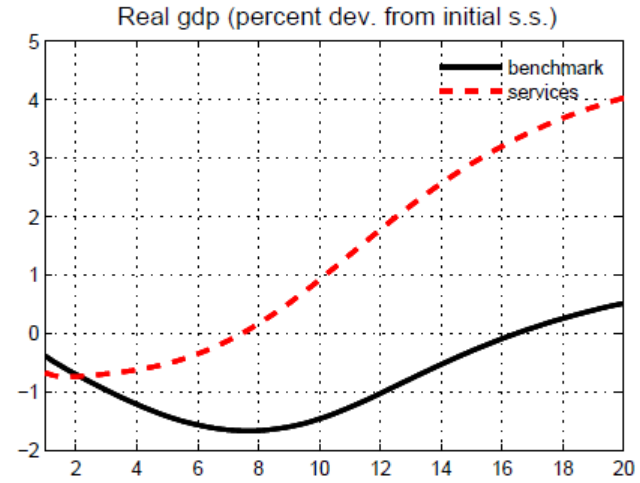
CONSOLIDATION VIA LABOR TAX





CONSOLIDATION VIA CAPITAL TAX





Short-term forecasting models: Eurocoin

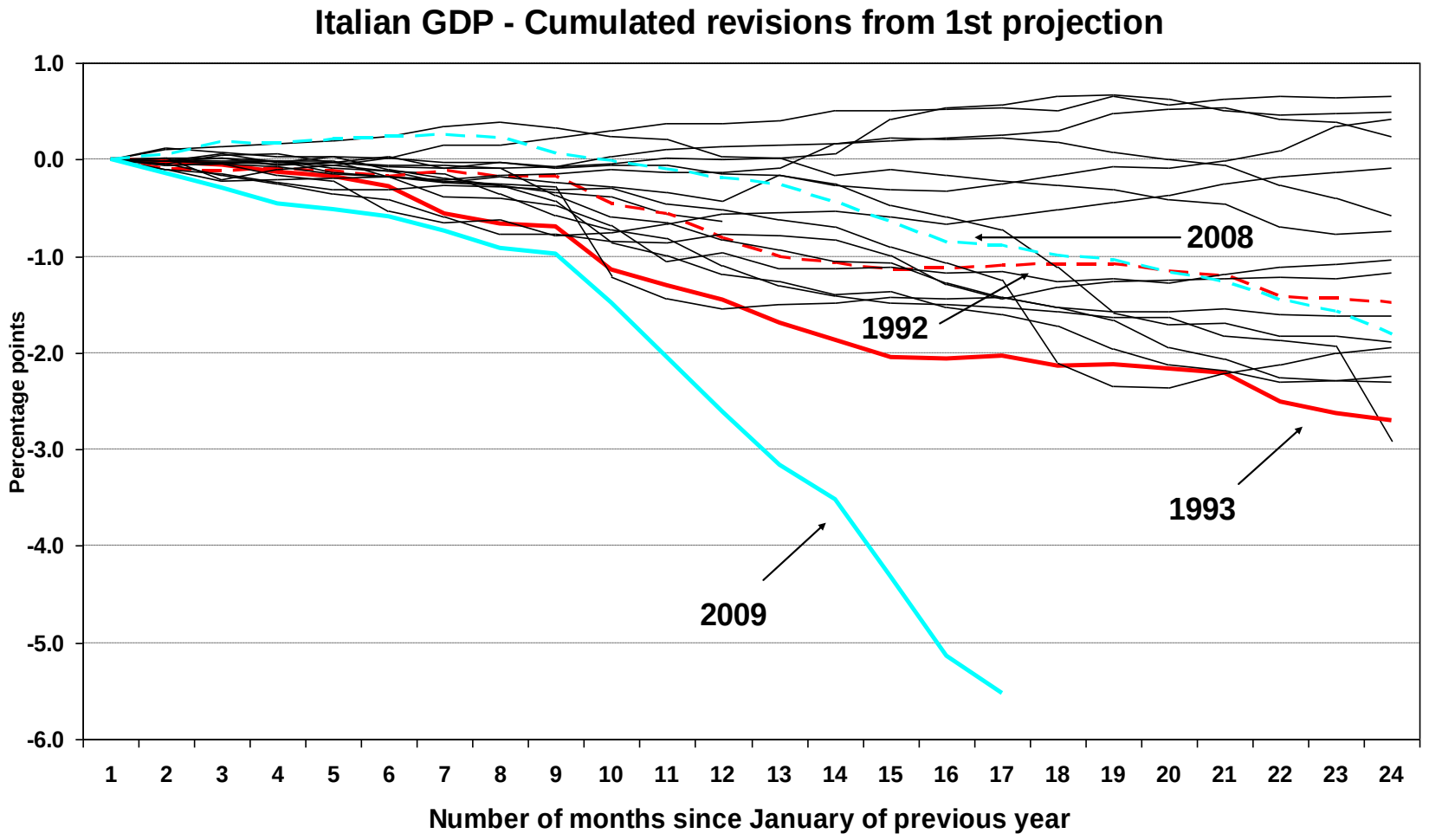
- Eurocoin: a real-time monthly estimate of euro-area q-o-q GDP growth (coincident indicator)
- Collates large number of statistical series (about 150, relating to industrial production, business surveys, financial data, demand indicators, etc.) and extracts information relevant to forecast GDP
- Tracks current state of the economy in real time:
  - ✓ timely monthly signal
  - ✓ reliable: end-of-sample efficient estimate of signal
  - ✓ smoothing filter (free from short- run fluctuations)

- Two-step procedure:
  - ✓ estimation of the regressors space: generalized dynamic factor model
  - ✓ projection of the target on the factor space: OLS in frequency band

Has anything changed following the long crisis?
2. The crisis

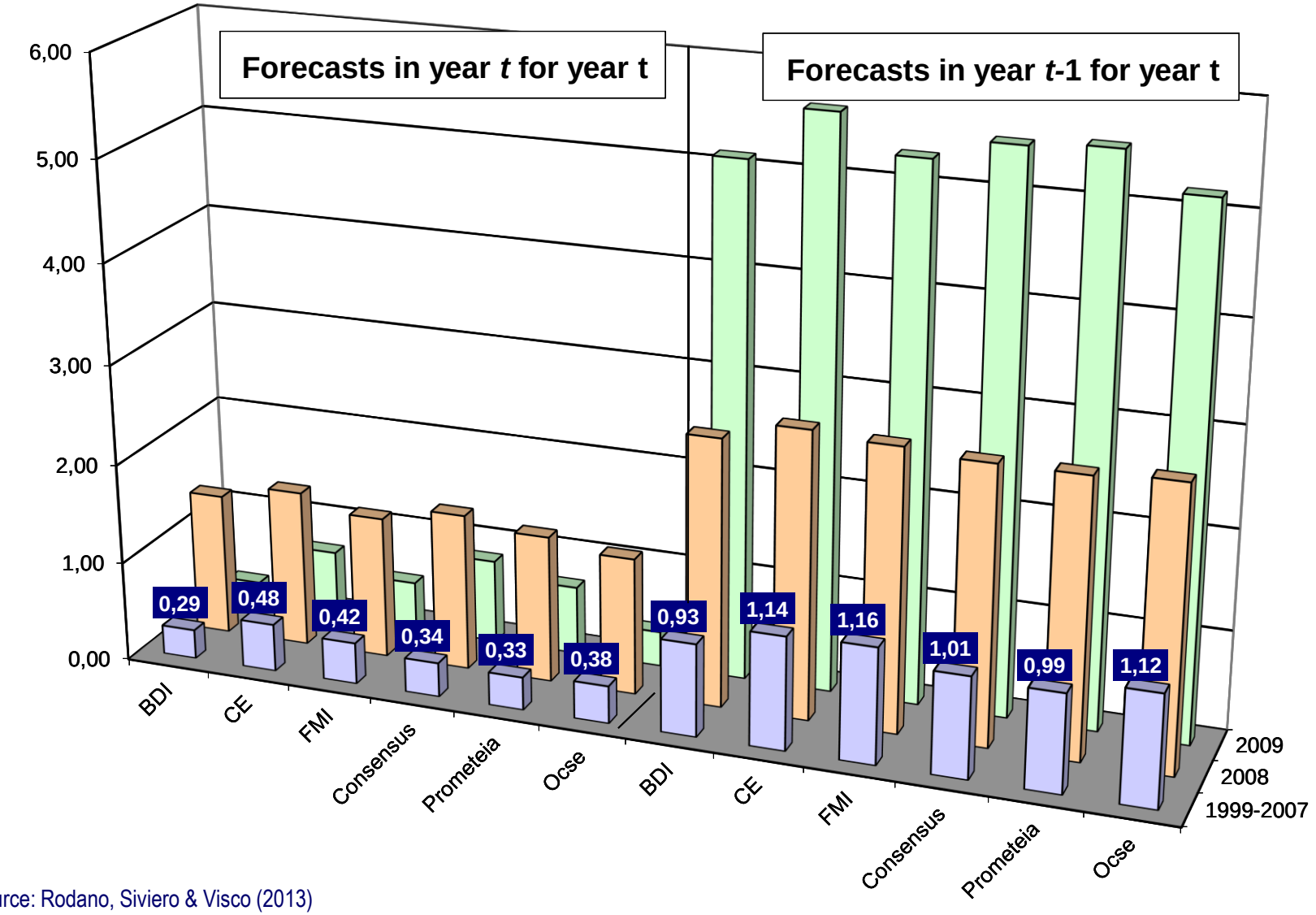
Huge forecast errors in the Great Recession

Revisions to Italy GDP projections for various years (projections from Q1 of year Y-1 to Q4 of year Y; Consensus Forecasts)



Multi-fold increase in forecast errors for all forecasters

Forecast error, Italy's GDP growth

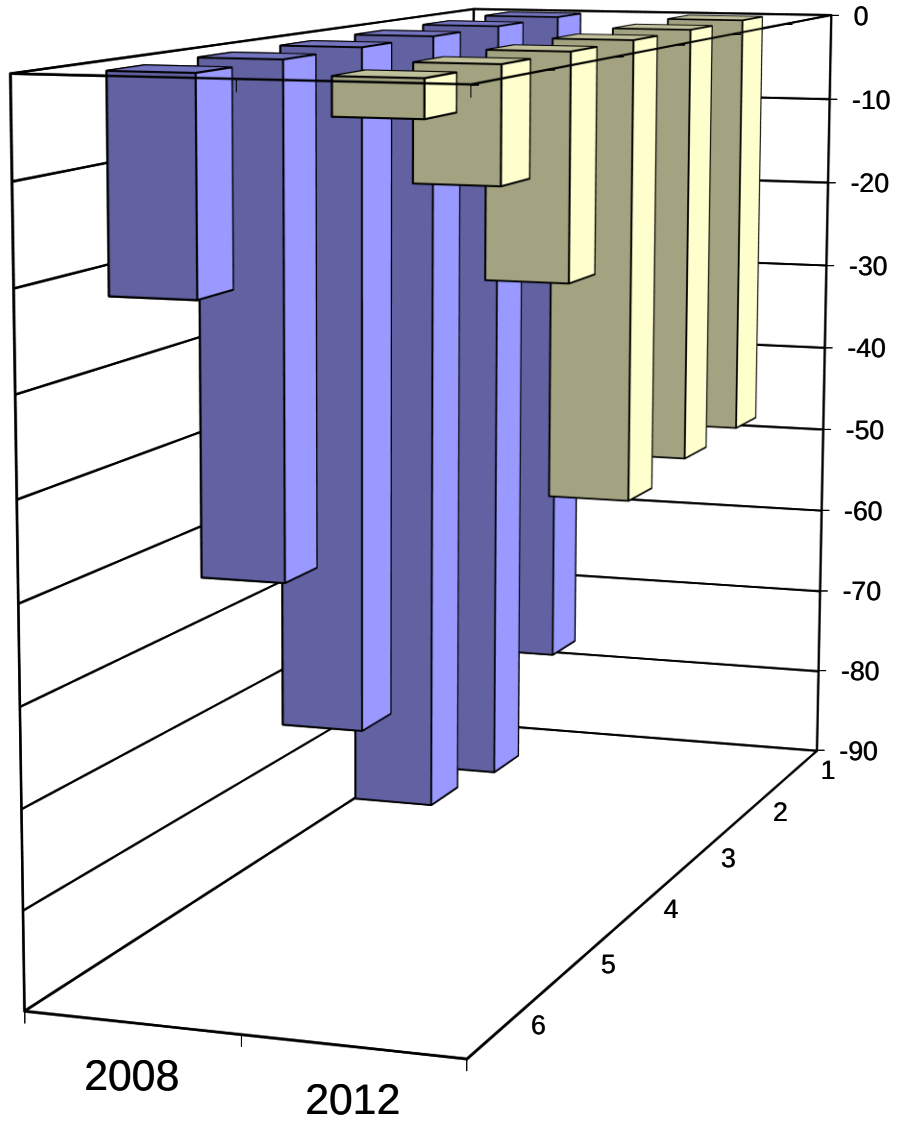


Source: Rodano, Siviero & Visco (2013)

Consolation prize: signs of (relatively quick) learning-by-doing

GDP

Bank of Italy forecast error, Italy's GDP growth



Source: Rodano, Siviero & Visco (2013)

Reasons for forecast underperformance, 1

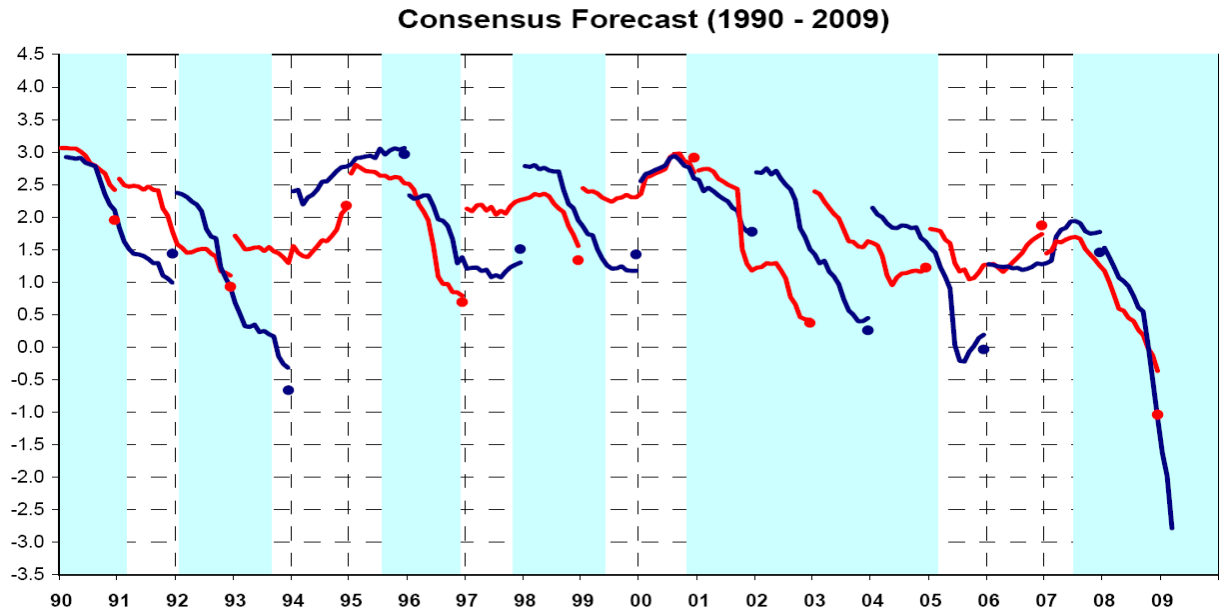
Structural breaks

- Changes in the framework in which economic agents (consumers and businesses) make their decisions in turn lead to changes in their behaviour. When there is marked discontinuity with the past, such changes may be far-reaching and the past (and hence the models which reflect that past) cease to provide a reliable guide.
- This problem is partly innate to the use statistical and econometric techniques, which require relations to be sufficiently stable over time. But anomalous observations could actually be the ones providing precious information about the economy's behaviour in conditions other than those usually prevailing.
- An obstacle to detecting the emergence of stability problems, and thus to taking corrective measures, is the nature of economic information (fragmentary, available with varying lags, characterized by approximation)
- These considerations do not imply, however, that structural forecasting models (i.e. models in which the relations are not just a statistical reflection of the interaction between variables but are a quantitative representation, albeit approximate, of behavioural mechanisms) become completely useless after breaks
- First, anomalies in the relations between variables can only be recognised (and counter-measures taken, adapting and updating available instruments or creating new ones) if an instrument is available which can reliably represent the norm (and hence signal anomalies)
- Second, structural models do not just signal the appearance of discontinuities, they also help to identify where discontinuities arose. One may thus circumscribe the area affected by discontinuity, identify the nature of that discontinuity more easily and rapidly, and focus efforts to overcome it more effectively.
- Forecasting models have experienced episodes of acute difficulty in the past, especially in the presence of large and unprecedented shocks (e.g., oil shock of 1970s). Indeed, the effort to overcome the shortcomings that those episodes had revealed has been one of the main factors driving the development of forecasting instruments; aspects and mechanisms that had previously been neglected and whose importance was unexpectedly revealed have been gradually incorporated into successive generations of macroeconomic models.

Reasons for forecast underperformance, 2

Innate optimism

- Recent work carried out at the Bank of Italy suggests that macroeconomic forecasters keep indulging in excessive optimism in recessionary phases of the cycle
- There are also indications of (much more limited) excessive pessimism (relatively speaking) during upswings
- Indeed, revisions tend to be all of the same sign (which, as we know from Lecture 6, is clearly suboptimal: this systematic pattern could be exploited to revise with more aggressiveness in the early stages)
- However, specific features of forecast production / consumption process may partly explain that systematic pattern (final users' suspiciousness very easily aroused by large revisions)



Each line gives two years of consecutive projections (24 projections in all) for all years between 1991 and 2009). Final outcome represented by dot. Projections in alternate colors to avoid confusion from overlapping. Shaded areas are negative cycles.

THERE IS A CLEAR TENDENCY TO DRAMATICALLY UNDERESTIMATE THE SEVERITY OF RECESSIONS

Reasons for forecast underperformance, 3

Nature of that particular (originally financial) crisis

- For a long time this crisis incubated in an environment that was beyond the ken of macroeconomic models
- Also, the crisis was long characterized by widespread opacity as to the actual soundness of the markets and individual participants: it was known that banks' were holding toxic assets, but the total amount was unknown, let alone the distribution among intermediaries.
- Although macroeconomic repercussions appeared inevitable, it became possible to assess them more precisely only after the scale of the banking system's difficulties became clear in the autumn of 2008, generating widespread panic and sudden, generalized increases in risk aversion.
- Also, the global contours of the crisis also have only become clear relatively recently

Too optimistic conditioning assumptions

- Considering now projections for a specific country or group of countries (rather than for the world economy as a whole), it is clear that errors in projecting the external context may affect the forecast performance for one particular country or group of countries
- For a long time, it was thought (hoped?) that the crisis may be confined to the USA; also, it was thought that the global economy may remain relatively unaffected (the so-called "de-coupling," which was so long debated in 2007)
- The difference between the projections for world trade growth in 2009 prevailing in December 2008 and the actual outcome is some 15-20%; this factor alone explains a large portion of the revisions GDP growth projections for Italy

Reasons for forecast underperformance, 4

Crisis hit in particularly poorly underdeveloped areas of existing models

- This one crisis emerged in correspondence with a particularly weak and underdeveloped problem area in the macroeconomic models in use: the point of interaction between financial variables and the real sector.
- Influence of macroeconomic variables (prices, demand, output) on financial variables is captured sufficiently by the available forecasting tools
- However, our understanding of the reverse effect is much more limited, indeed inadequate. In fact, the impact of financial on macroeconomic variables (i.e. the situation prevailing up until recently in the present crisis) is only crudely represented in many models. Translating tensions in the interbank markets and banks' funding problems into an assessment of their presumed impact on corporate investment and household consumption decisions is no easy task given our current state of knowledge.
- Ad hoc adjustments have been used (see below)
- Need to improve our understanding of how the evolving macroeconomic framework may influence the stability of the financial system and the state of health of banks, especially in the presence of extreme events.

Has anything changed following the long crisis?
3. Post crisis: New tricks for old dogs?

As the proverb goes: “You can’t teach an old dog new tricks”

… Or can you?

New trick #1
Real-financial linkages: credit constraints in BIQM (1)

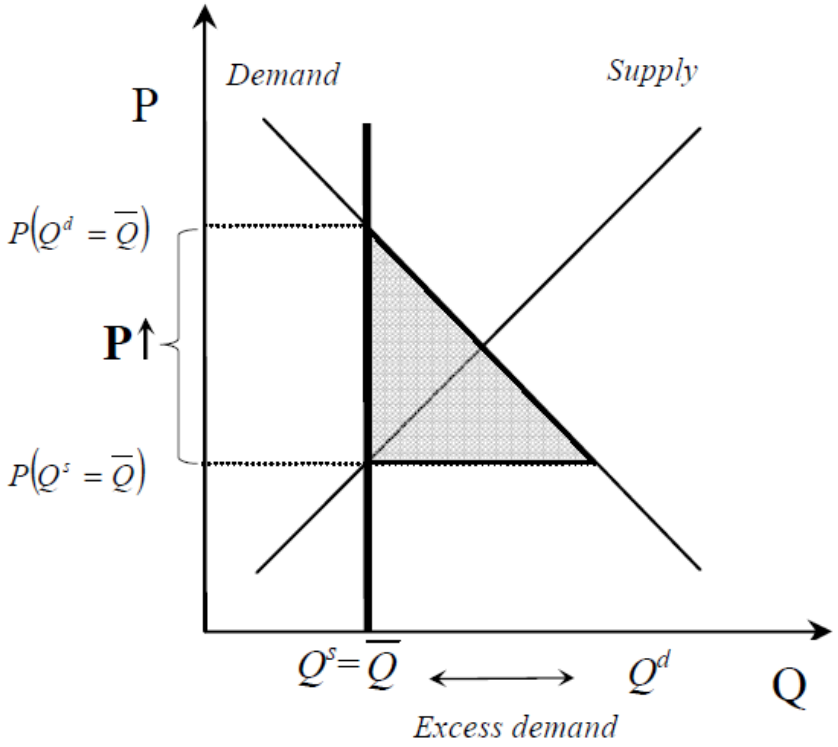
- Working assumption before the global financial crisis: credit issued by financial intermediaries is always adequate and fully satisfies actual credit demanded by economic agents.
- The financial crisis reminded everyone that this is not always the case: notional unobserved demand of credit by the non-financial sector might exceed credit supply and go unsatisfied.
- Let credit rationing (*CR*) be defined as the difference between the amount of bank loans demanded by firms (L^d) and the amount of credit that is actually supplied to them (L^s):

$$CR_t = L_t^d - L_t^s = L_t^d - \bar{L}_t$$

- L^d and hence *CR* are not directly observable in the data; data represent only the actual amount of loans, which may or may not reflect an equilibrium between demand and supply.

New trick #1
Real-financial linkages: credit constraints in BIQM (2)

- In a generic market, when there is excess demand, observed price and quantity lay between the demand and supply schedules (in the case of credit, observed loans only reflect credit supply, while credit demand cannot be observed)



- Intuition: whenever demand exceeds supply, (relative) prices tend to rise; therefore, the change in prices can be used as an indicator of excess demand

$$\Delta P_t = \gamma \left(\frac{Q_t^d - Q_t^s}{Q_t^s} \right)$$

with $\gamma > 0$

New trick #1
Real-financial linkages: credit constraints in BIQM (3)

- In the credit market, $Q = L$ (loans) and $DP = DS$ (spread between bank lending rates and the cost of funding); therefore:

$$\Delta S_t = \gamma\left(\frac{L_t^d - \bar{L}_t}{\bar{L}_{t-1}}\right) = \gamma\left(\frac{CR_t}{\bar{L}_{t-1}}\right) \text{ implying } CR_t = \frac{\bar{L}_{t-1}}{\gamma}\Delta S_t$$

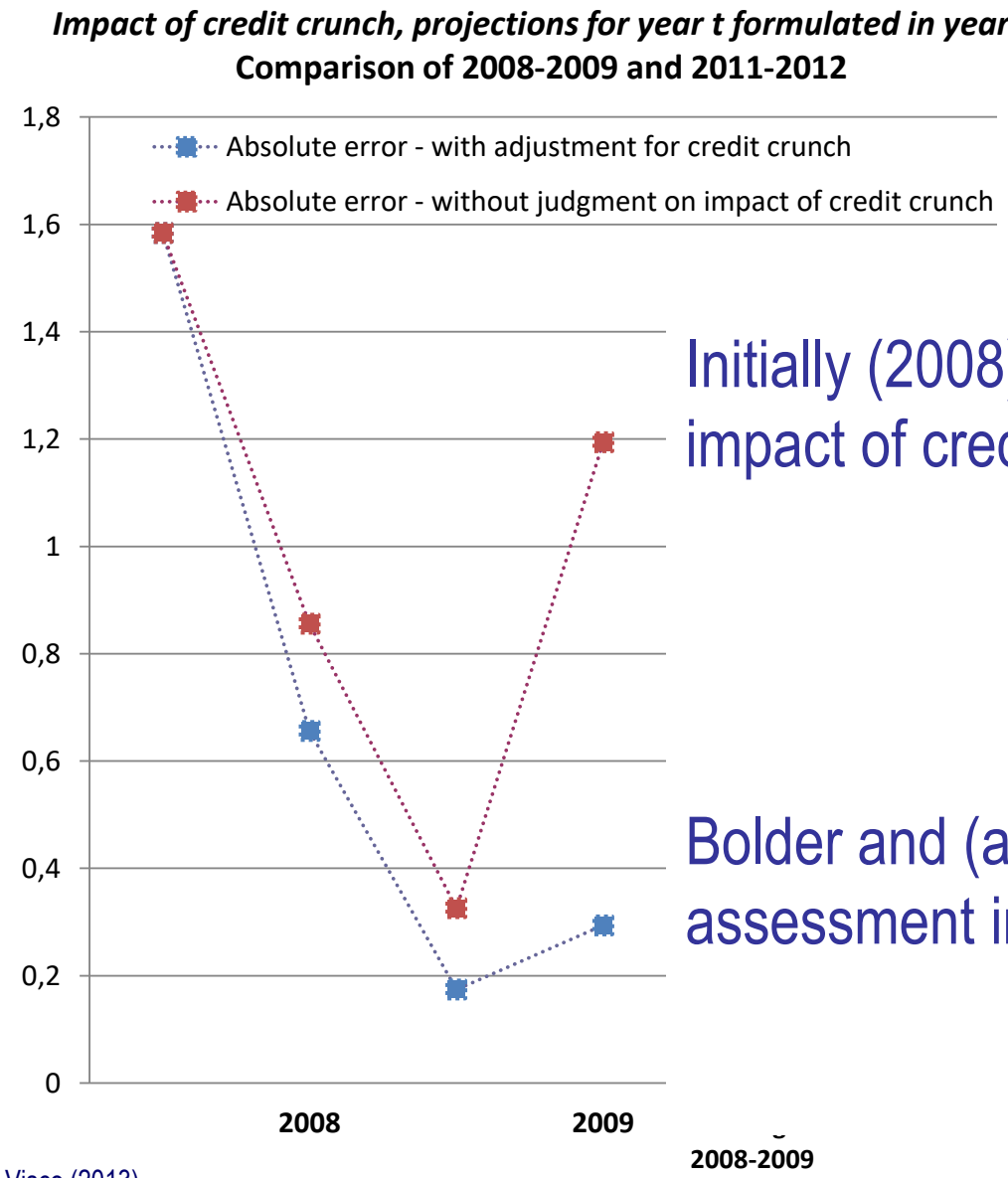
- An estimate of γ can be obtained by adding the expression for CR (credit rationing) into the credit equation in time periods when credit restrictions are known (or thought) to be binding

$$L_t = L_t^d(X) + D_t^{BLS}\frac{\bar{L}_{t-1}}{\gamma}\Delta S_t$$

where D^{BLS} is a dummy variable signaling episodes of credit restrictions; specifically, $D^{BLS} = 1$ whenever the Bank Lending Survey (BLS) indicator is higher than a threshold

- CR may then be measured (using the formula above) and used as a regressor elsewhere in the model (i.e., in the equation for firms' investment) to capture the impact of credit constraints on agents' behavior

New trick #1
Quick-and-dirty credit crunch fix substantially lowered forecast error



Initially (2008) too timid assessment of the impact of credit crunch

Bolder and (as it turned out) more accurate assessment in 2009

Source: Rodano, Siviero & Visco (2013)

New trick #2
Nonlinearities: Borrowers' riskiness in BIQM (1)

- Credit supply conditions in the BIQM traditionally modelled through bank lending rate (i_t) equations (i_t was solely a function of the risk-free rate, $i_{RF,t}$). Following the crisis, they include a time-varying risk premium linked to default probabilities on the relevant loans (bd_t):

$$\beta(L)i_t = \alpha + \theta(L)i_{RF,t} + \delta bd_t$$

$$bd_t = f(y_t, bc_t)$$

- Default probabilities bd_t (proxied by new bad loans over existing loans) in turn depend on cyclical conditions (y_t) and on a measure of the ability to service debt (bc_t), measured by the ratio between interest payments on bank loans and firms' profits.

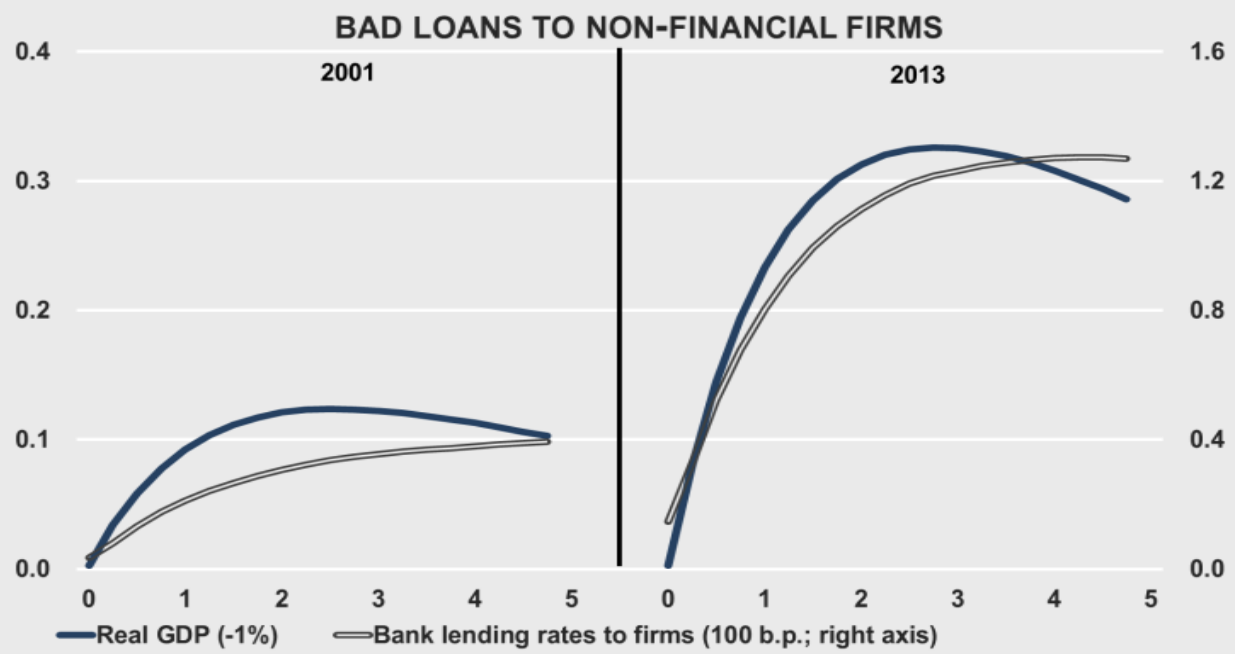
- This defines a real-financial amplification mechanism: after a negative shock to output, default probabilities increase, leading to higher bank lending rates, which in turn involve even worse cyclical conditions

New trick #2
Nonlinearities: Borrowers' riskiness in BIQM (2)

The link between cyclical conditions and default probability is non-linear:

$$Tbd_t \equiv log\left(\frac{bd_t}{1-bd_t}\right) = \alpha_0 + \alpha_1 Tbd_{t-1} + \alpha_2 y_{t-1} + \alpha_3 r_t + \alpha_4 bc_t + u_t$$

In 2013 the impact of cyclical conditions on *bd* was much stronger than in 2001:



New trick #3:
Real-financial linkages: Credit and banking in IDEA (1)

- Typical assumption before the global financial crisis: financial sector largely irrelevant; banking sector just a veil
- One of the main lessons from the crisis: financial sector as both a source of shocks and a propagation mechanism (amplification)
- Introduction of financial frictions in workhorse medium-scale DSGE models: private sector borrowing constraints (e.g.: due to value of collateral), imperfect asset substitutability, financial intermediation (banking)
- Allow for analysis of various policy issues: e.g. macroprudential policy, unconventional monetary policy, bank capital regulation

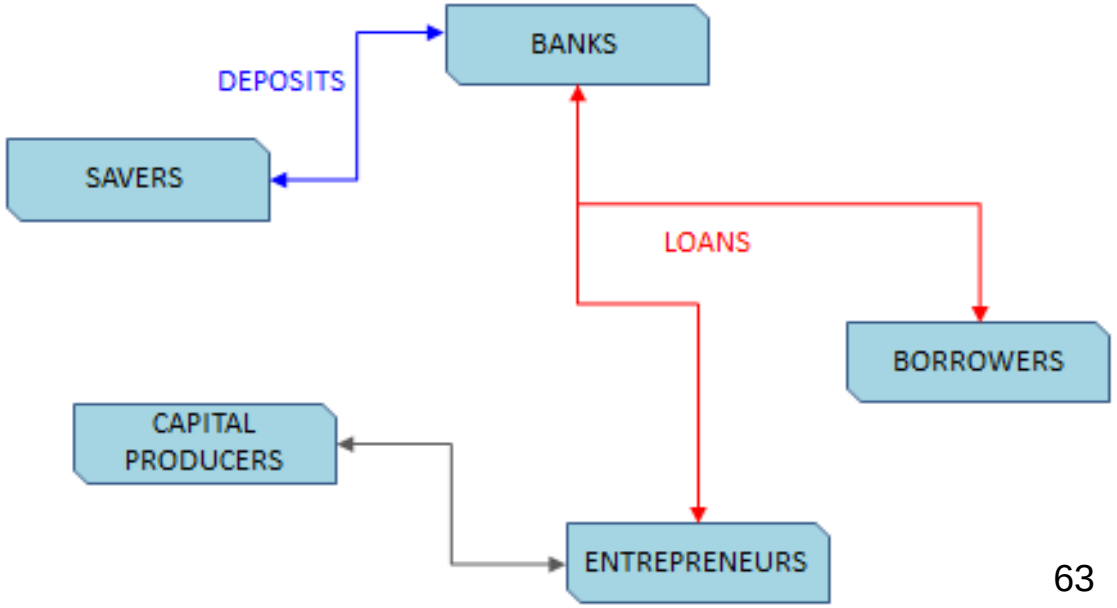
New trick #3:
Real-financial linkages: Credit and banking in IDEA(2)

Impatient households (**borrowers**) and **entrepreneurs** borrow from domestic banks, using housing as collateral:

$$HH\,debt \leq m\ * Real\ HH\ asset\ * Price\ of\ HH\ asset$$

where m is a regional loan-to-value (LTV) ratio, controlled by local macroprudential authority (similar for entrepreneurs)

Banks: receive deposits from savers, hold bank capital, provide loans to households and firms, set interest rates on loans under monopolistic competition (non-zero profits)



New trick #4:
Macroprudential policy analysis with IDEA (1)

- IDEA: financial market segmentation (APP), region-specific real estate markets and collateral constraints (see above), plus overly optimistic expectations on real estate prices (Dupor 2005)

$$HH\,debt = m\ * Real\ HH\ asset * E_t\vartheta_{t+1} * Price\ of\ HH\ asset$$

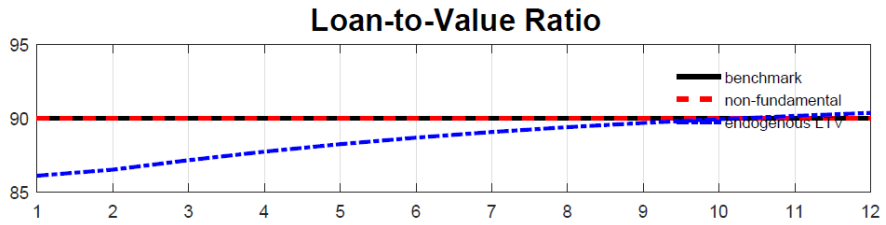
- Generate excess increase in households' borrowing, thus providing a role for macroprudential policy

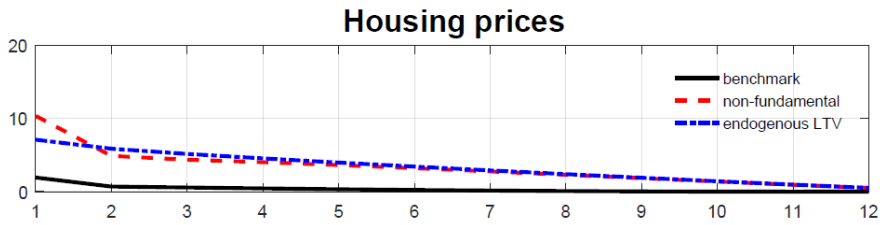
- Rule on LTV ratio:

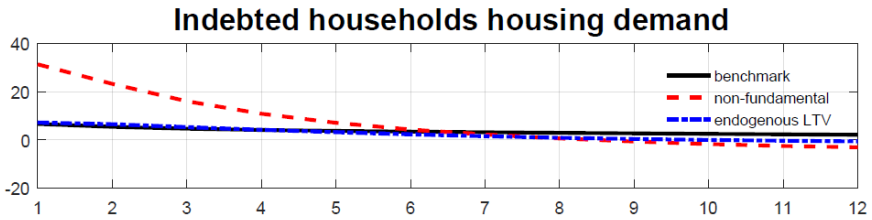
$$m_t = min\left\{\overline{m}, (1-\rho_m)\rho_\Pi \overline{m} + \rho_m m_{t-1}\right.$$

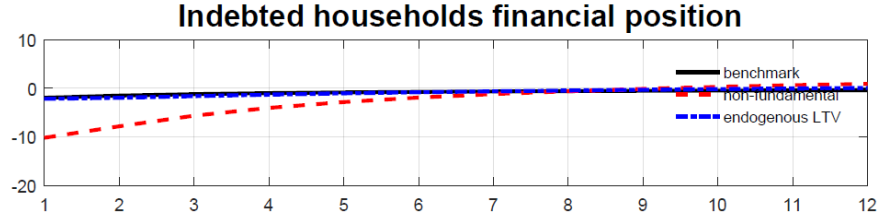
New trick #4:
Macroprudential policy analysis with IDEA (2)

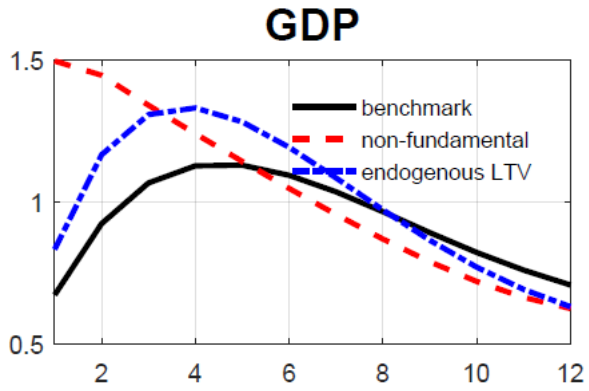
- The larger the increase in borrowing, the larger the reduction in the LTV ratio.
- Result: smaller increase in household borrowing for a given value of the collateral

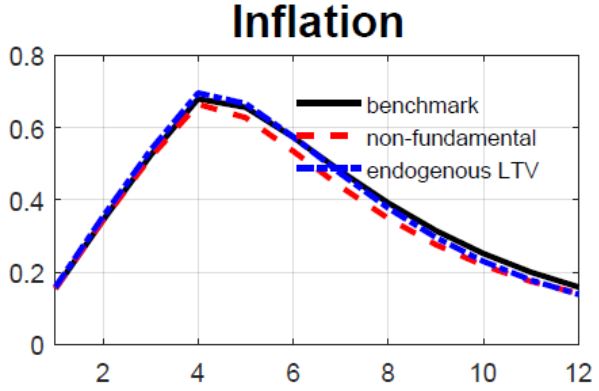












New trick #5:
Low-inflation regime: Modelling inflation expectations (1)

- At the zero lower bound, repeated downward revisions in inflation expectations may trigger a self-fulfilling deflationary spiral

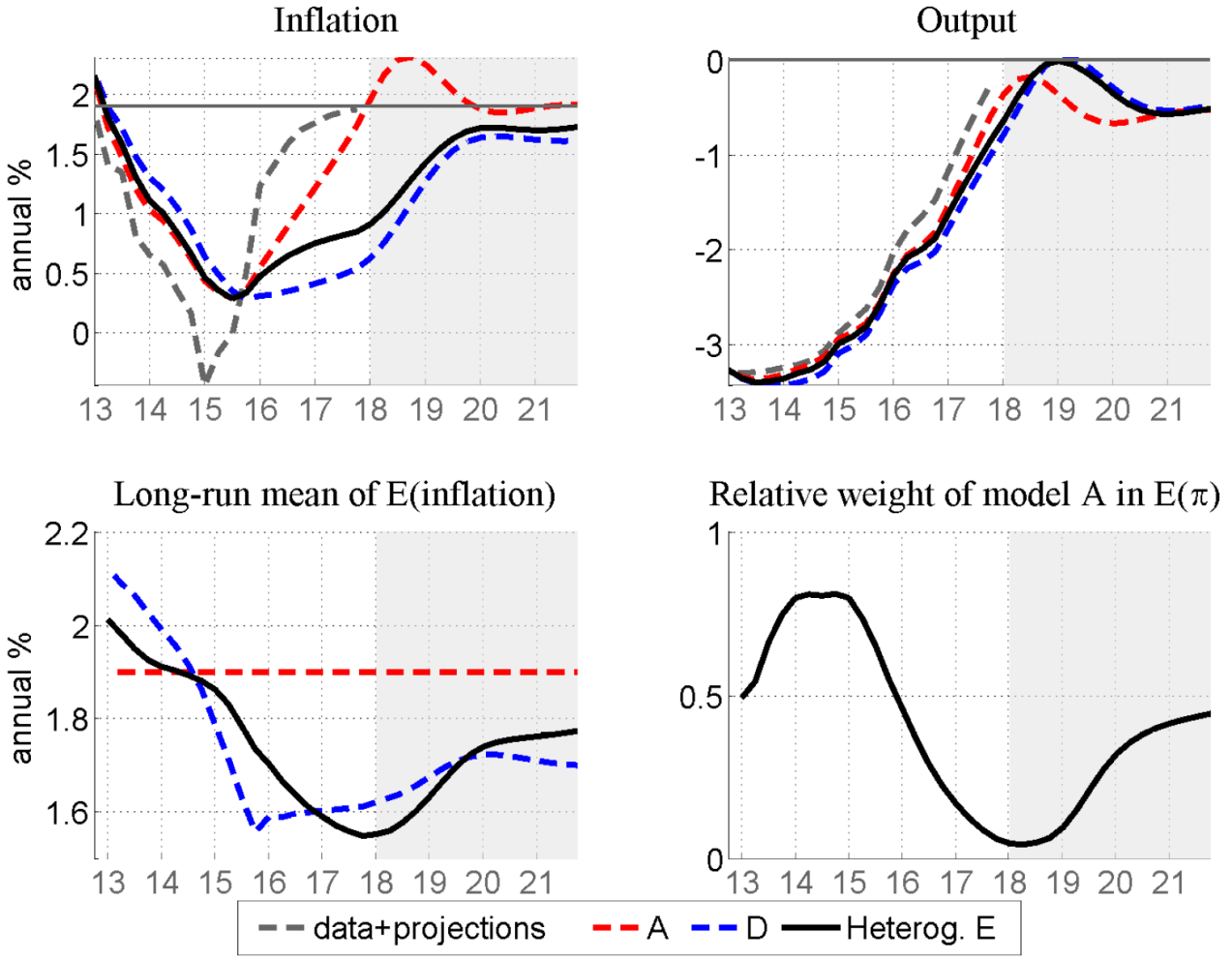
- Persistent differences between actual and expected inflation question the validity of the rational expectations assumption

- It is unlikely that households and firms can completely discount the effects of current and future policies in their demand and pricing decisions

- Macro models for policy analysis have largely ignored research on:
  - ✓ Learning mechanisms (Busetti et al. 2017)
  - ✓ Other: rational inattention, behavioural economics

New trick #5:
Low-inflation regime: Modelling inflation expectations (2)

Inflation expectations and price stability in the euro area
Rational expectations vs. adaptive learning (Busetti et al. 2017)

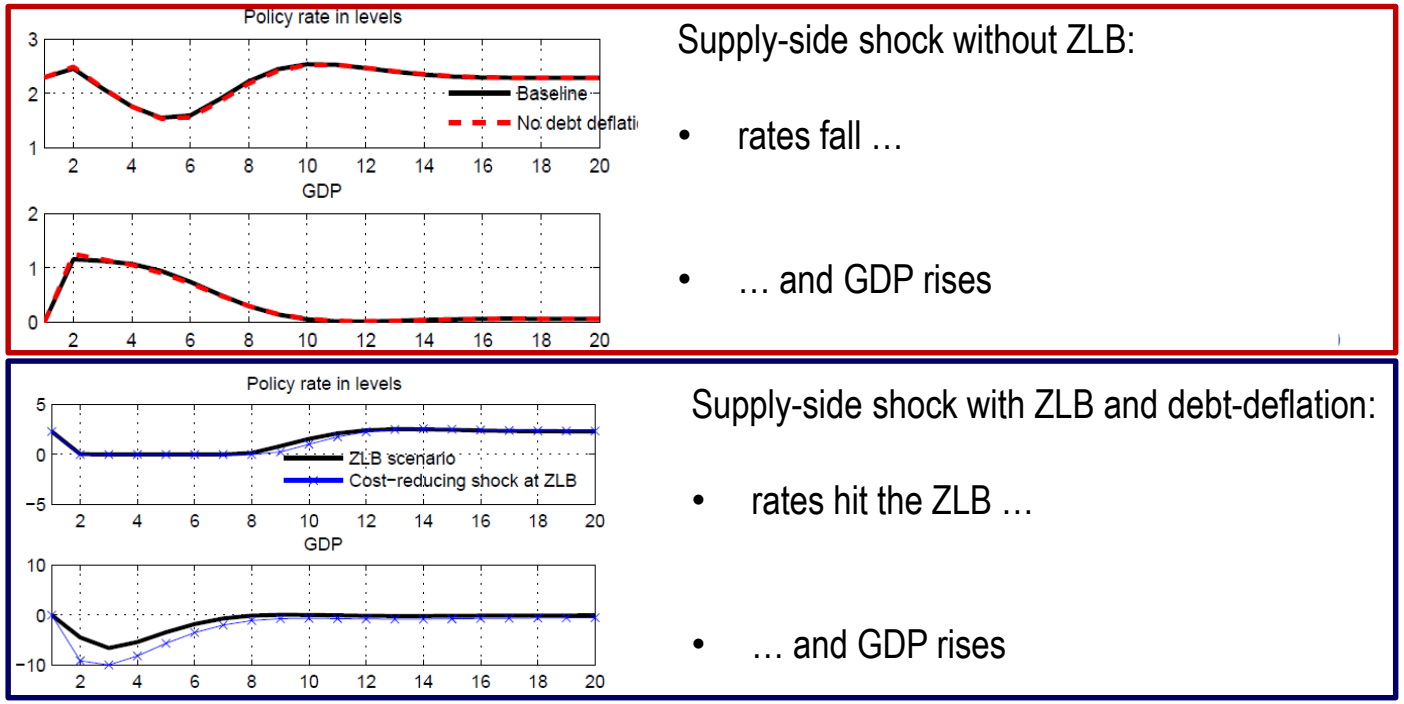


New trick #6
Zero lower bound

ZLB embedded in DSGE.

- As a result of this non-linearity, effects of policy interventions and shock transmission may be substantially altered compared with the standard case
- Neri and Notarpietro (2016): a cost-reducing shock (=favorable supply-side shock), usually mildly expansionary, may become contractionary at the ZLB in the presence of the debt-deflation channel

Figure 2: A cost-reducing shock under normal conditions



Supply-side shock without ZLB:

- rates fall …
- … and GDP rises

Supply-side shock with ZLB and debt-deflation:

- rates hit the ZLB …
- … and GDP rises

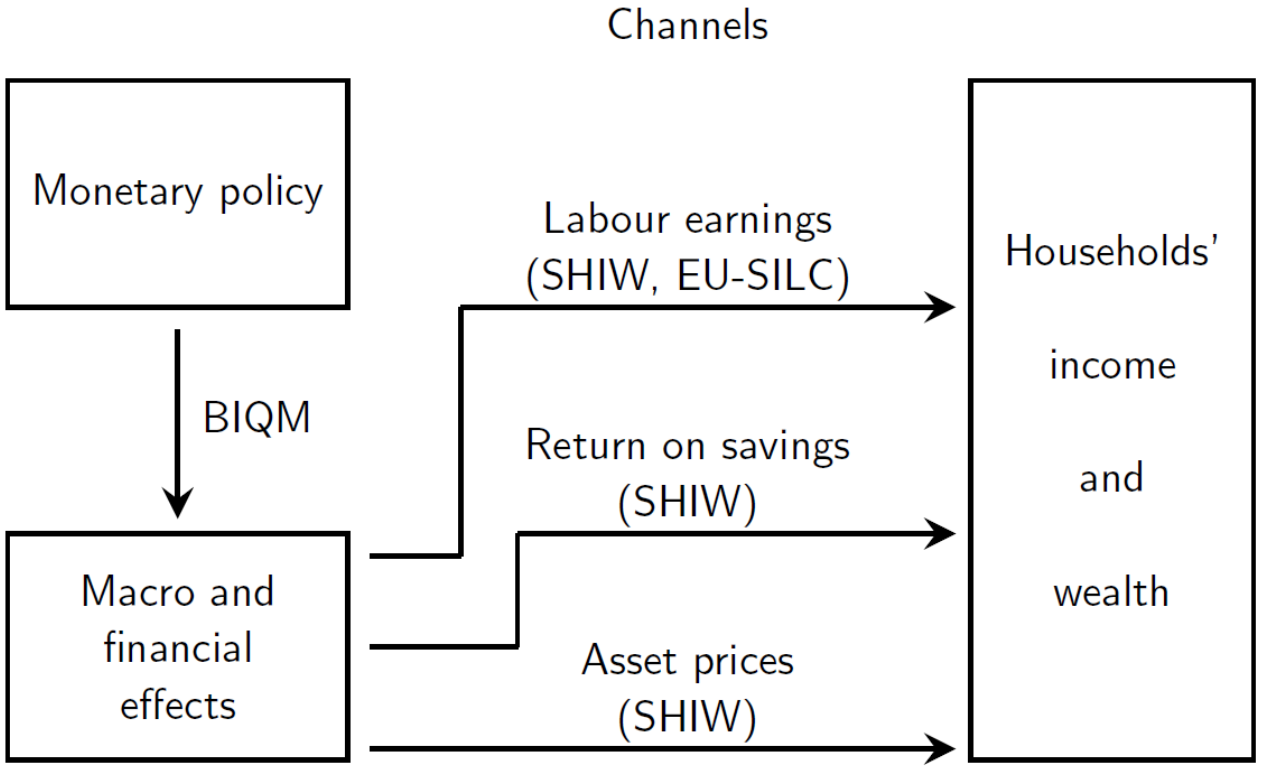
Source: Neri & Notarpietro (2016)

Has anything changed following the long crisis?
4. Further advances: New dogs for old bones?

Jointly exploiting micro and macro data
Example #1: Income distribution (1)

- Example 1:
  Distributional effects of unconventional monetary policy for Italian households (Casiraghi et al., 2016)

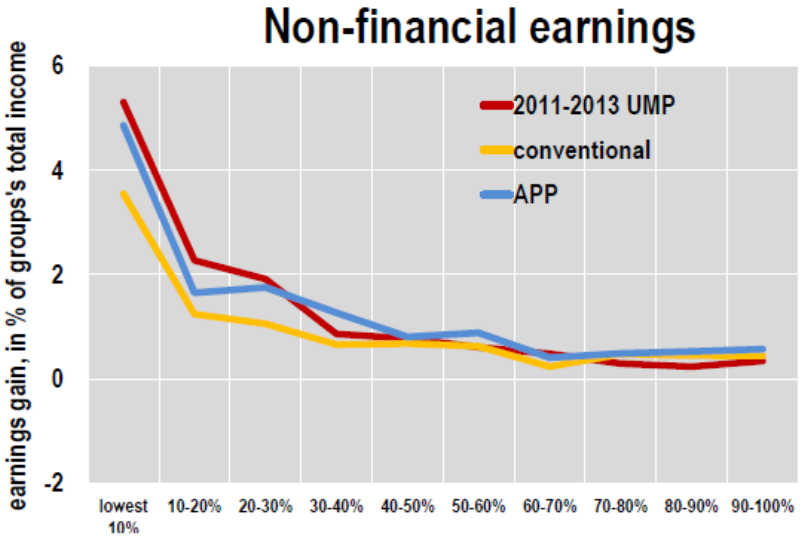
- Empirical strategy: 3-step approach
  - ✓ simulate aggregate effects of monetary policy using BIQM
  - ✓ map this impact onto income and wealth for each household (labor earning, returns on savings, capital gains)
  - ✓ compute inequality indexes

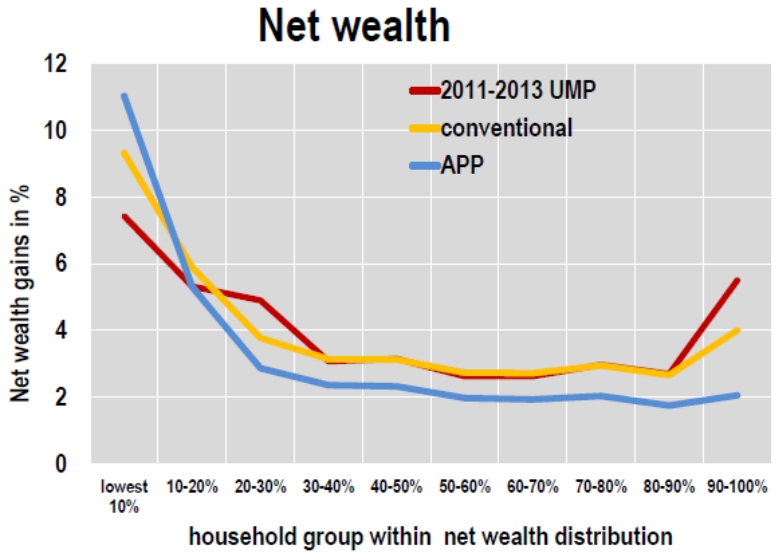


Jointly exploiting micro and macro data
Example #1: Income distribution (2)

Results: expansionary monetary policy…

- ✓ significantly lowers labor income inequality
- ✓ impact on wealth distribution is moderately U-shaped
- ✓ overall effect on inequality indices is negligible



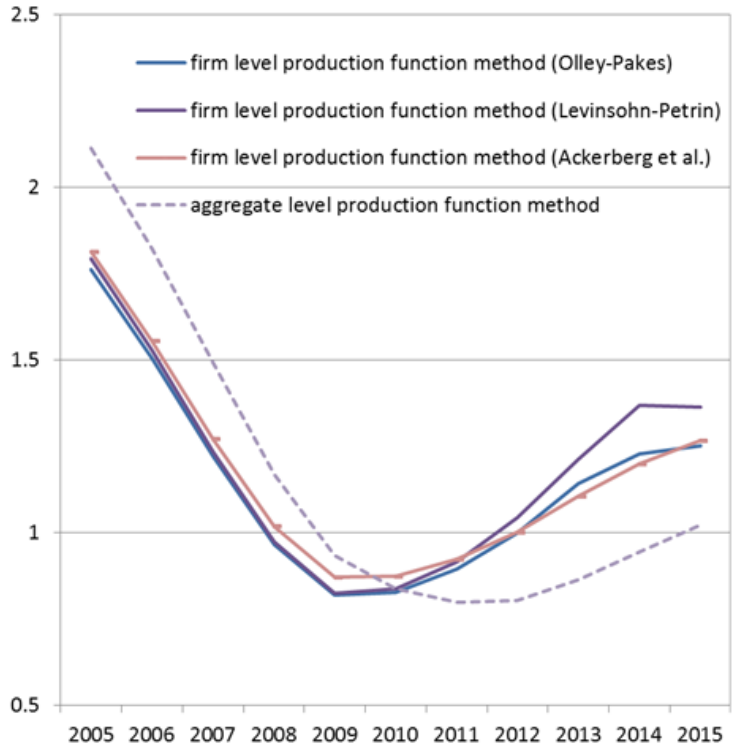


Jointly exploiting micro and macro data
Example 2: Potential output

Example 2 (Fantino, 2017):

- One of the ways to estimate potential output consists of applying a production function approach to aggregate labor and capital data
- This misses possible effects due to more or less efficient production factors allocation
- Idea: applying a production function approach to firm-level data. Estimates produced with this approach may differ from standard ones because of: aggregation bias, endogeneity, sector heterogeneity
- Results: a standard production function approach delivers overestimate of potential output growth before the crisis, but underestimate afterwards

Potential output estimates, Italy



Source: Fantino (2017)

Modelling non-central events (1)

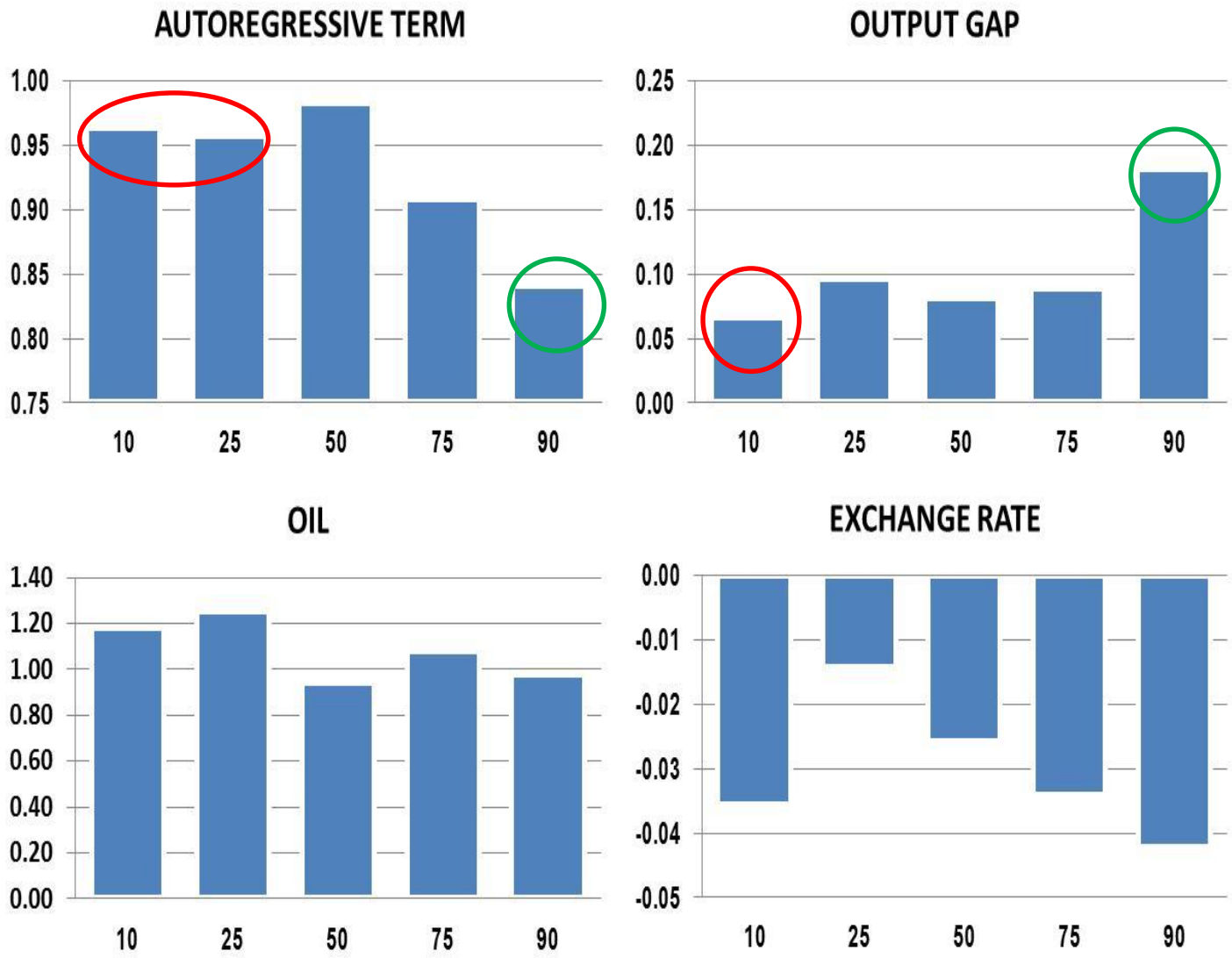
- In linear regressions (and vector autoregressions, etc.) we model the conditional mean of the distribution, i.e., the 'central response'
- But often the interest is also in **modelling events that are not at the center of the distribution**, e.g., we may want to know the probability of 'low inflation'
- Various ways of doing it
- Busetti, Caivano and Rodano (2015) use **'quantile regressions' to evaluate the properties of the conditional distribution of the euro area inflation**, as a function of standard determinants
- For the quantile of order α (with α =0.05, .10, …., .90, .95), the following equation is estimated with quarterly data (*h*=projection horizon)

$$\boldsymbol{Q_\alpha(\pi_{t+h}) = \beta_0(\alpha) + \beta_1(\alpha)\pi_t + \beta_2(\alpha)y_t + \beta_3(\alpha)oil_t + \beta_4(\alpha)ex_t}$$

π_t = y-o-y euro area inflation rate
y_t = euro area output gap
oil_t = change of oil prices in euro
ex_t = change of the nominal effective exchange rate of the euro

Modelling non-central events (2)

- Estimates show quite a lot of time variation in the distribution and heterogeneity in the responses of inflation in different areas of the distribution.
- **Inflation is more persistent in the lowest quantiles** of the distribution; **response to cycle is stronger at the upper quantiles**
- Overall, these results suggest it may be relatively harder to escape from 'a low inflation environment' – consistently with what we're seeing now



Big data/machine learning

- Big Data are emerging as the new frontier to analyze macro and financial variables.
- Internet, social networks, phone cells and other new, voluminous and timely data are becoming available almost in real time and can be used by National Statistical Institutes and Central Banks to improve their nowcasts and forecasts of key macro variables.
- In the meantime, “new techniques” from Machine Learning are employed to deal with high-dimensional models, where the number of parameters p is sometimes close if not greater that the number of variables n and traditional econometric techniques do not work any more.
- Here some forms of selection and shrinkage are needed (for example: LASSO techniques and its variants).

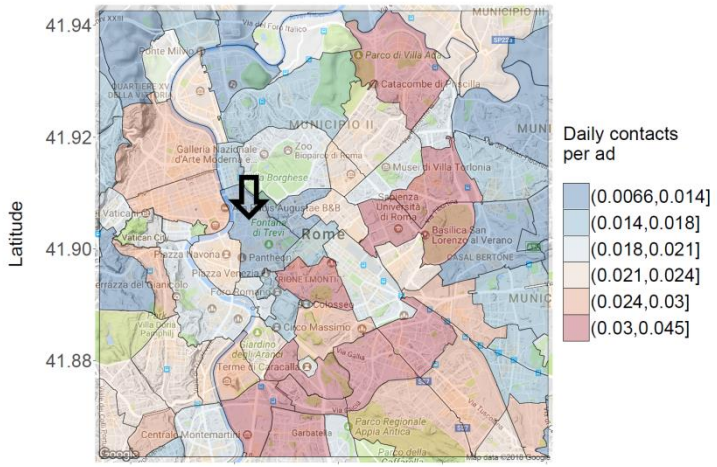
Example #1:
Using online housing sales ads to monitor housing market (1)

Pangallo and Loberto (2018)

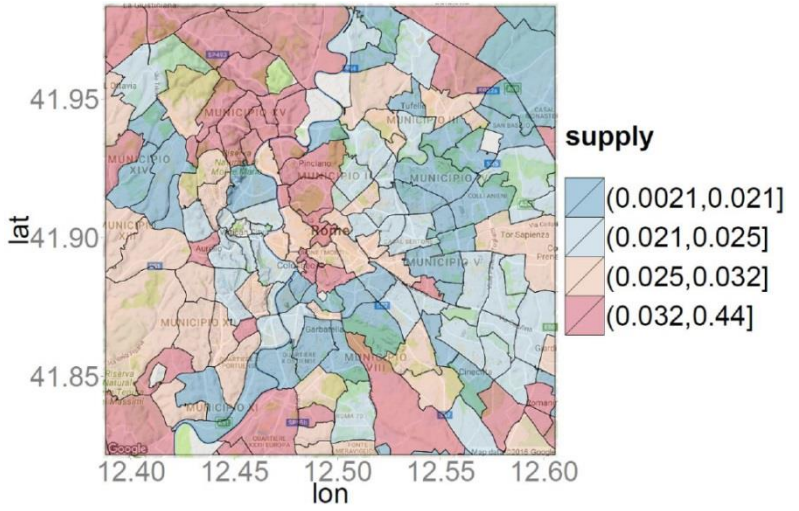
- Following an agreement with a large (possibly the largest) online housing sales ads website, the Bank of Italy has gained access to a huge database of housing sales ads (1.1 million ads, 2005Q1 to 2017Q2, with updates).
- Each ad includes info on date posted/removed, geolocation, floor area, rooms, floor,, energy class, garden garage, elevator, etc., (ask) price, full history of clicks and contacts.
- Machine learning techniques used to get rid of duplicates (due to, e.g., more than one agency receiving mandate to sell).
- Data allow to estimate time needed for a dwelling to be purchased and average discount (as well as other relevant aspects), and to monitor and nowcast real estate developments more effectively and in a more timely manner.
- Future extension: merge with other granular databases (e.g., notary deeds) to obtain other variables of interest (e.g.: loan-to-value ratio)

Example #1:
Using online housing sales ads to monitor housing market (2)

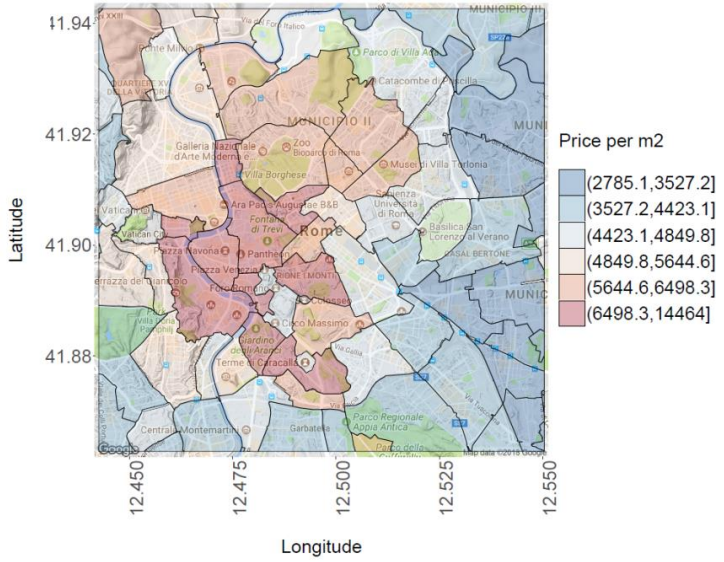
Clicks/contacts as proxy for demand



Ratio (unique) ads / stock of dwellings as proxy for supply



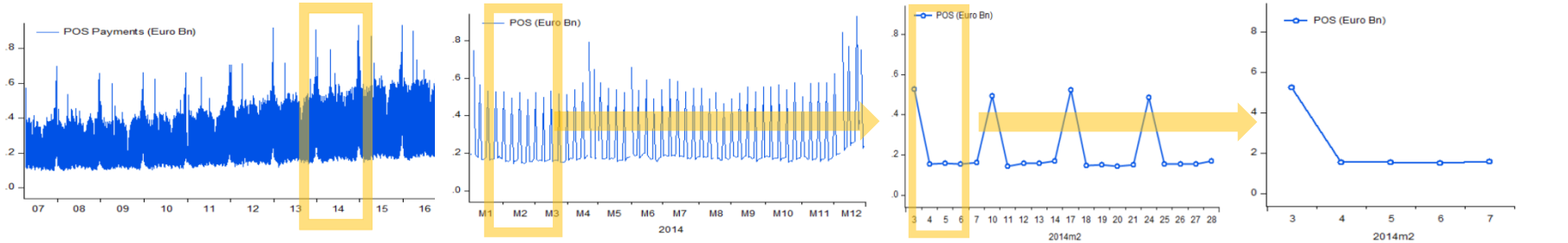
Price



Source: Pangallo & Loberto (2018)

Example #2:
Using payment system data to predict GDP and monitor household sentiment

- Huge database of ATM withdrawals and POS payments
- Daily data need careful cleaning of seasonal patterns and calendar effects. Example: POS purchases



WHOLE SAMPLE **ONE YEAR (2014)** **ONE MONTH (2014M2)** **ONE WEEK (2014M2W1)**

Source: Ardizzi, Emiliozzi, Marcucci & Monteforte (2018)

Findings:

- Ardizzi et al. (2018):

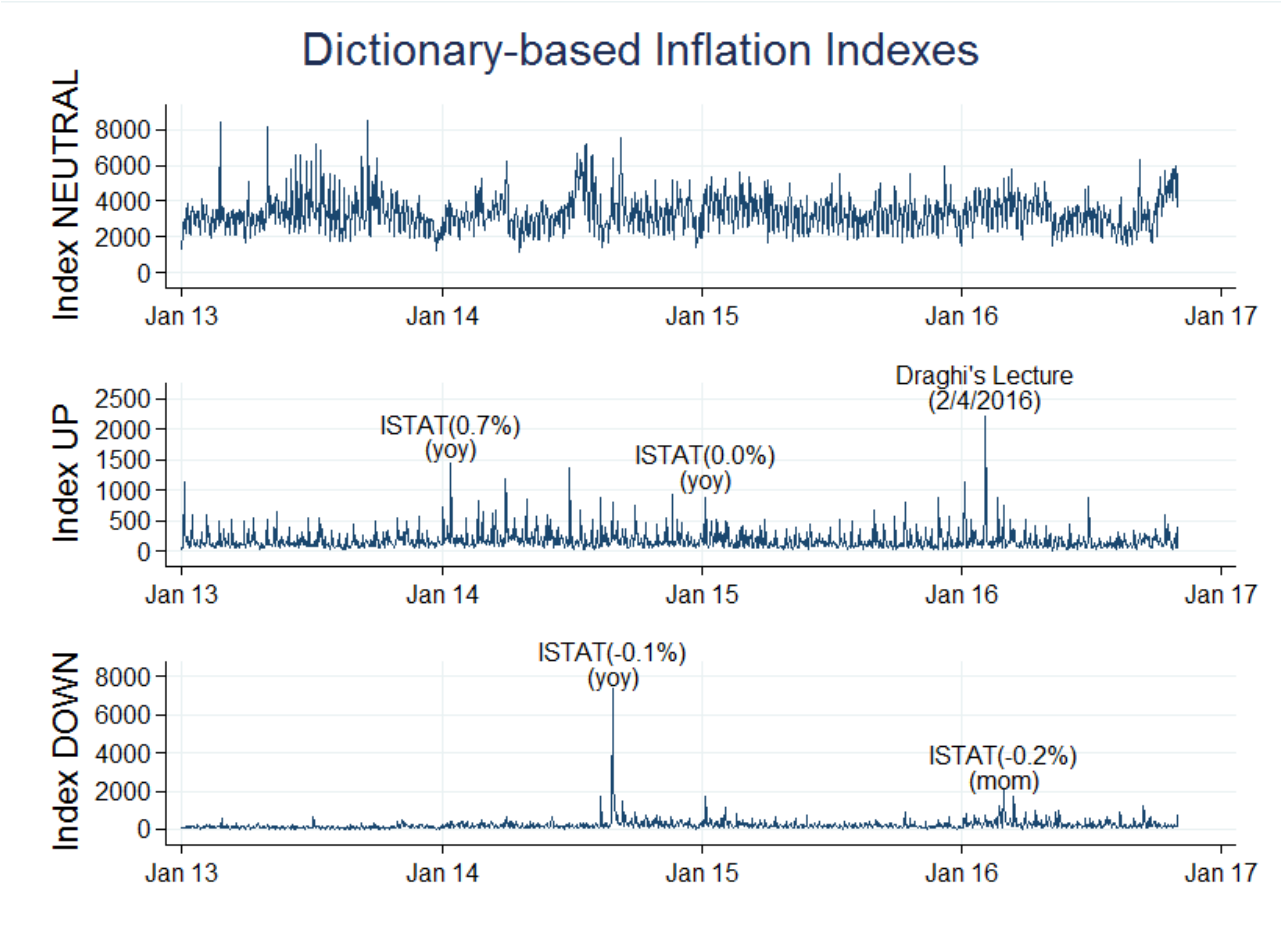
  Increase in uncertainty (as measured by both EPU and Twitter feeds) induces non negligible (although temporary) reduction in POS purchases and an increase in ATM withdrawals

- Aprigliano et al. (2017)

  A Dynamic factor & MIDAS model that includes payment data outperforms models that only include standard business cycle indicators

Example #3
Can Twitter feeds help predict inflation expectations?

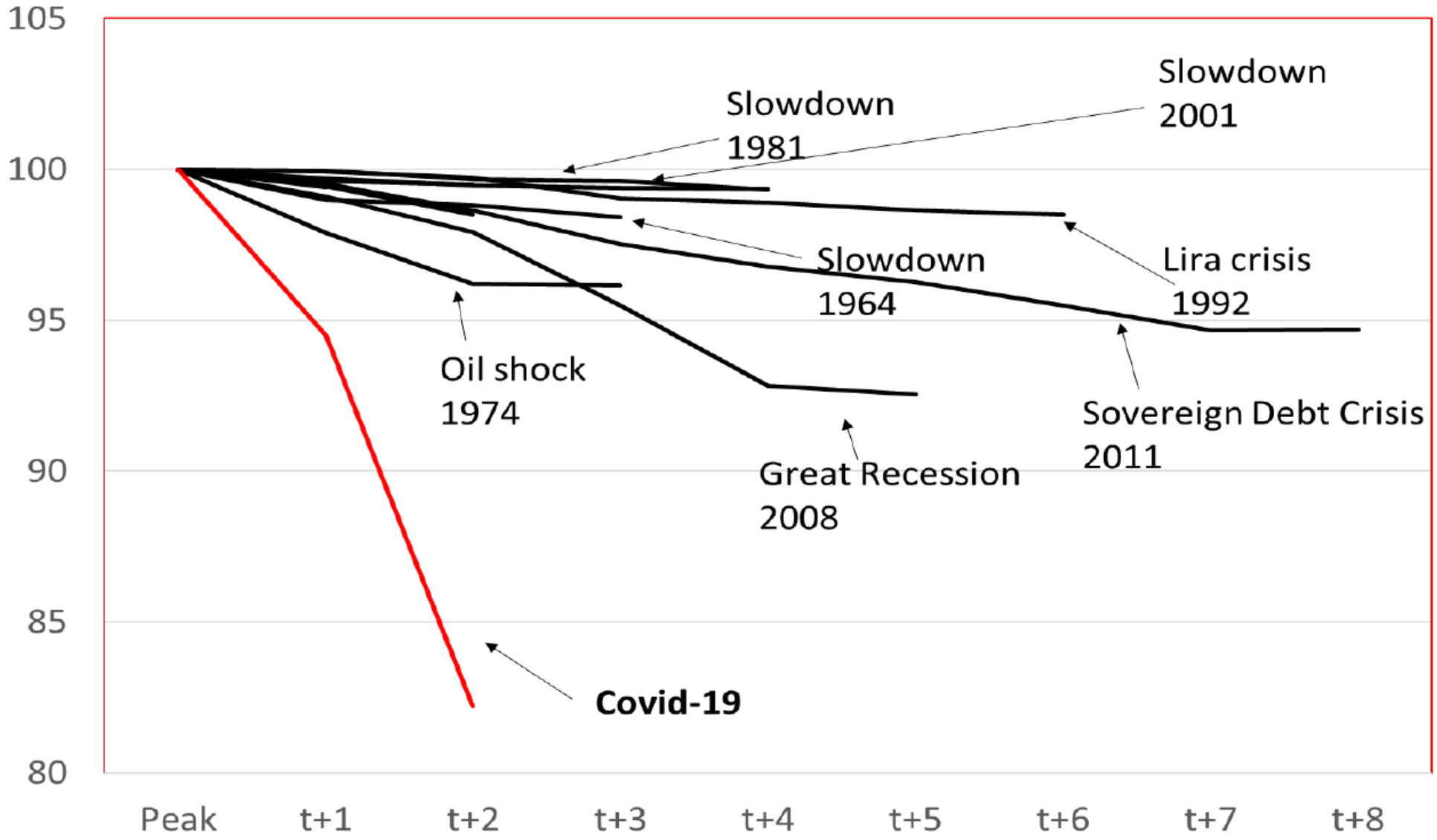
Internal research at the Bank of Italy is analyzing the text of Twitter feeds in Italian to construct indicators which can help predict inflation expectations (Angelico et al., 2017)



These indicators are significantly correlated with market-based measures of inflation expectations (inflation swaps - IT and EA) both contemporaneously and up to 30 leads

An unprecedented challenge for models: in comes the Covid-19 pandemic

The economic impact of the Covid-19 pandemic: an unprecedented recession



Very dispersed and volatile macroeconomic forecasts (with huge revisions)

Projections for GDP and Inflation in Italy in 2020

		GDP		Inflation
OECD	*2 March 2020*	0.0		
Confindustria	*6 April 2020*	-6.0	*6 April 2020*	0.2
Fitch Ratings	*6 April 2020*	-4.7	*24 March 2020*	0.6
Prometeia	*6 April 2020*	-6.5	*6 April 2020*	-0.4
REF Ricerche	*22 April 2020*	-8.3	*22 April 2020*	0.3
UniCredit	*6 April 2020*	-15.0	*6 April 2020*	-0.4
IMF	*6 April 2020*	-9.1	*6 April 2020*	0.2
Consensus average, 9 March		-0.8		0.5
Consensus average, 6 April		-7.5		-0.2

An unprecedented challenge for forecasters, for several reasons

- ✓ Unprecedented source of economic strain
- ✓ Unusual intensity, suddenness, duration and geographical extension of the crisis
- ✓ Lack of reliable timely indicators during the initial stages of the crisis (the crisis even impacted on the collection of economic data!)
- ✓ Difficulty in quantifying the economic impact of lockdown measures (and in foretelling how long they would last)
- ✓ Simultaneous occurrence of both supply and demand shocks, a factor that likely alters the usual comovement among macro variables
- ✓ More than likely structural breaks in the behaviors of some agents (e.g., consumers)

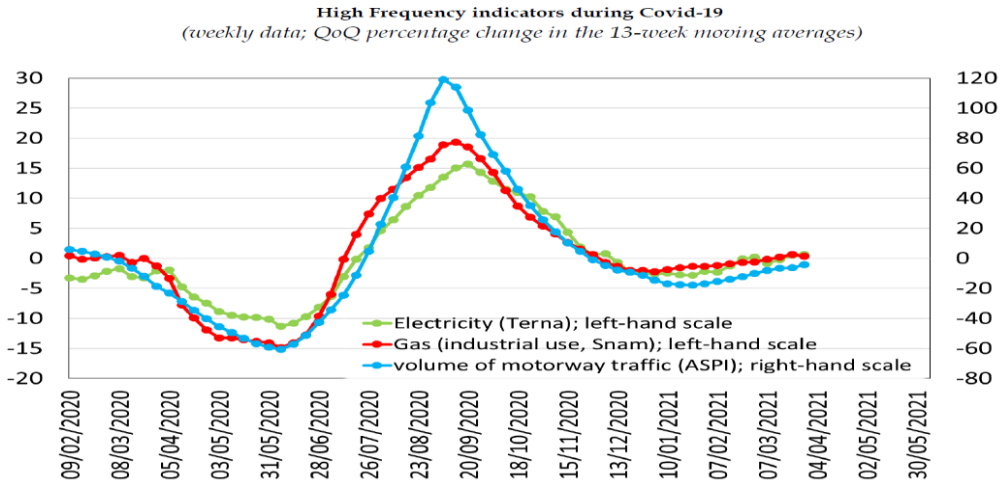
We raised the stake and developed a weekly indicator of economic activity

Delle Monache, Emiliozzi and Nobili (2021): B-ITWEI (Bayesian Italian Weekly Economic activity Index)

Starting point: a wide set of (mixed frequency and readily available) data. Data were partly already in use, while partly had never used before. Both daily and monthly series were used (corresponding weekly series for the latter were obtained by applying the Expectation Maximization algorithm by Dempster, Laird and Rubin, 1977). More series will likely be added in the future (e.g. : taxes, textual data, high-frequency labor market flows, stringency index).

B-ITWEI was then obtained as the first latent common factor of the 13 weekly series (re-scaled to match quarterly GDP growth over the sample).

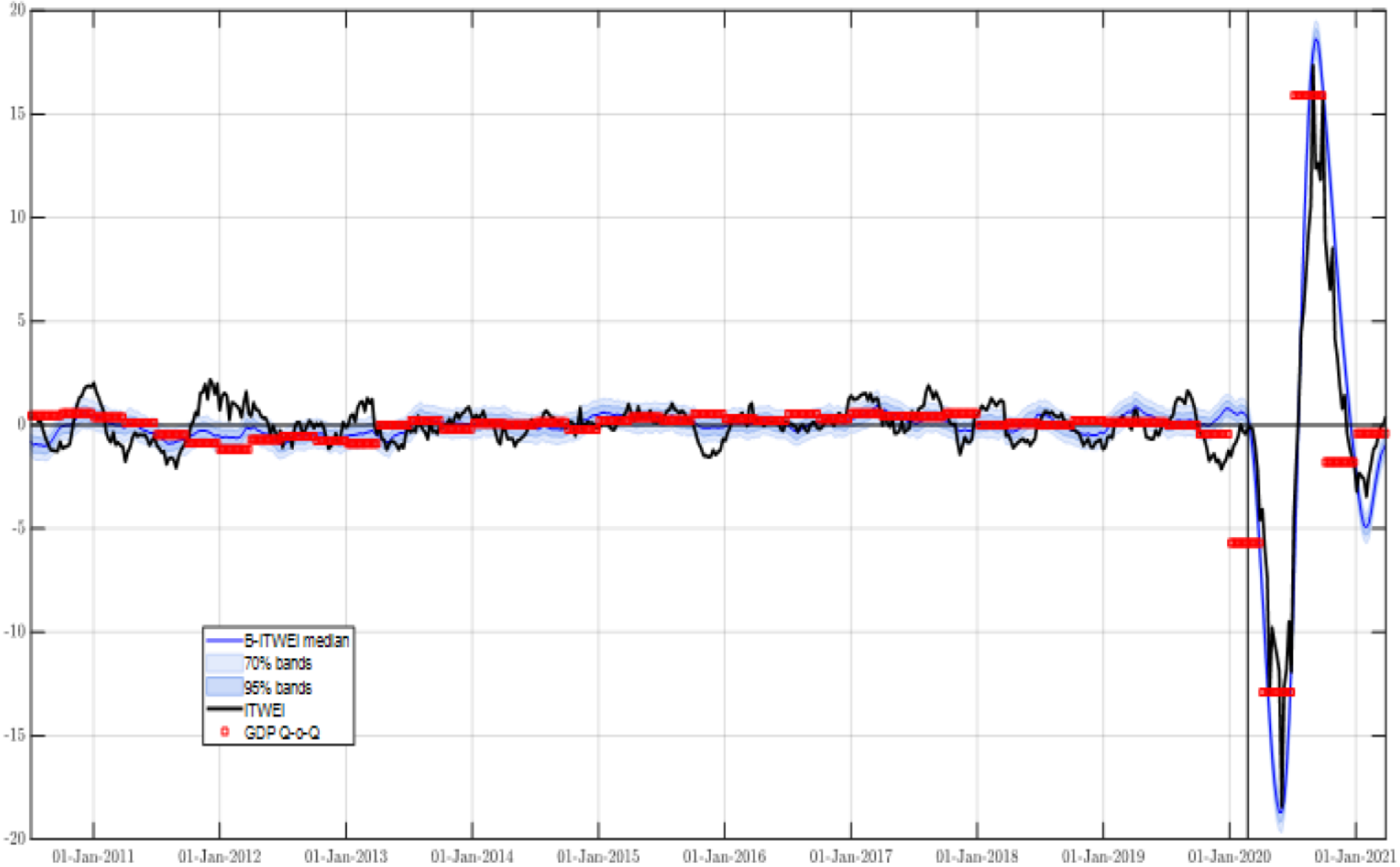
	Number	Description	Start	Frequency	Release date	Block
	1	Debit cards expenditure (POS)	1 jan 2010	daily	t+1 days	Consumer Expenditure
	2	Credit cards expenditure - index	1 may 2014	daily	t+15 days	Consumer Expenditure
●	3	Electric consumption	1 jan 2010	daily	t+1 days	Manif
●	4	Gas to industrial sector	1 jan 2010	daily	t+1 days	Manif
	5	Google Trends short-time work index	1 jan 2010	daily	t+1 days	Labor
●	6	Traffic flows - Cargo & Trucks	2010m1	monthly	t+10 days	Manif
	7	ConfCommercio - services expenditure	2010m1	monthly	t+10 days	Services
	8	ConfCommercio - goods expenditure	2010m1	monthly	t+10 days	Services
	9	ConfCommercio - total expenditure	2010m1	monthly	t+10 days	Services
	10	PMI manifacturing	2010m1	monthly	t+2 days	Manif
	11	PMI services	2010m1	monthly	t+2 days	Services
	12	Short-time work subsidies	2010m1	monthly	t+35 days	Labor
	13	VAT on imported goods & Services	2010m1	monthly	t-3 days	Fiscal



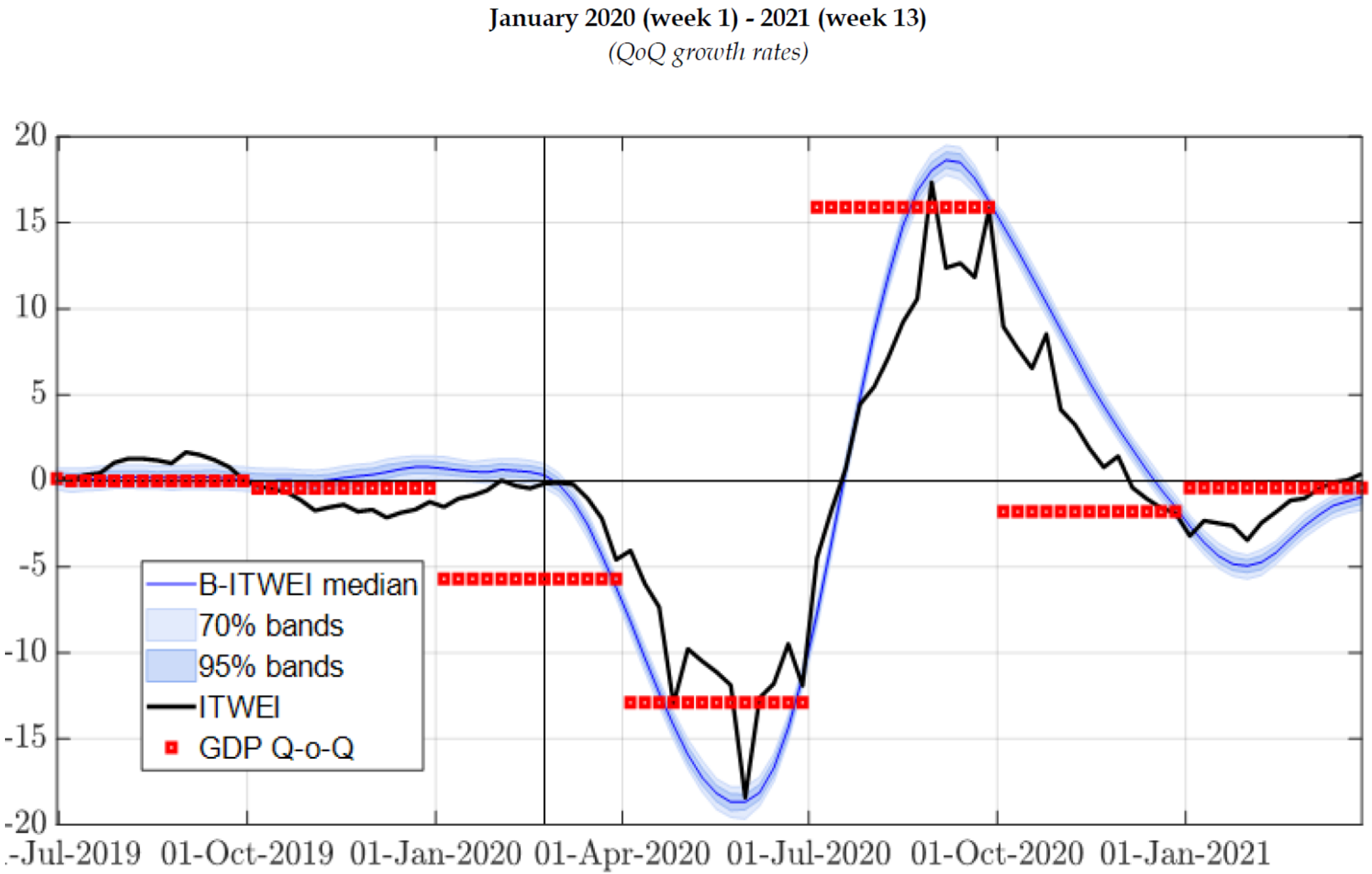
Weekly indicator of economic activity in Italy: Whole sample

July 2010 (week 26) – March 2021 (week 13)

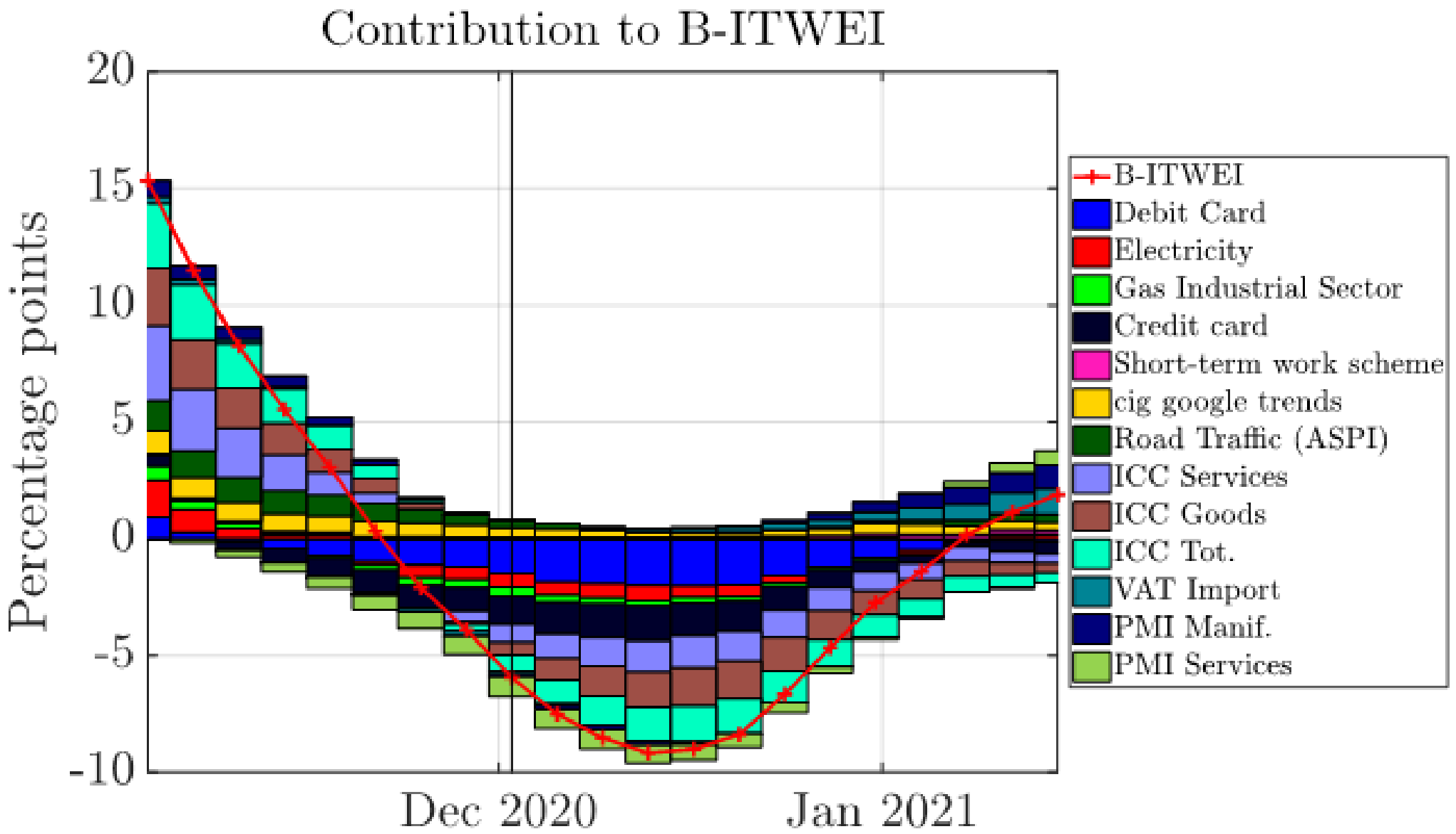
(QoQ growth rates)



Weekly indicator of economic activity in Italy: Covid-19 pandemic



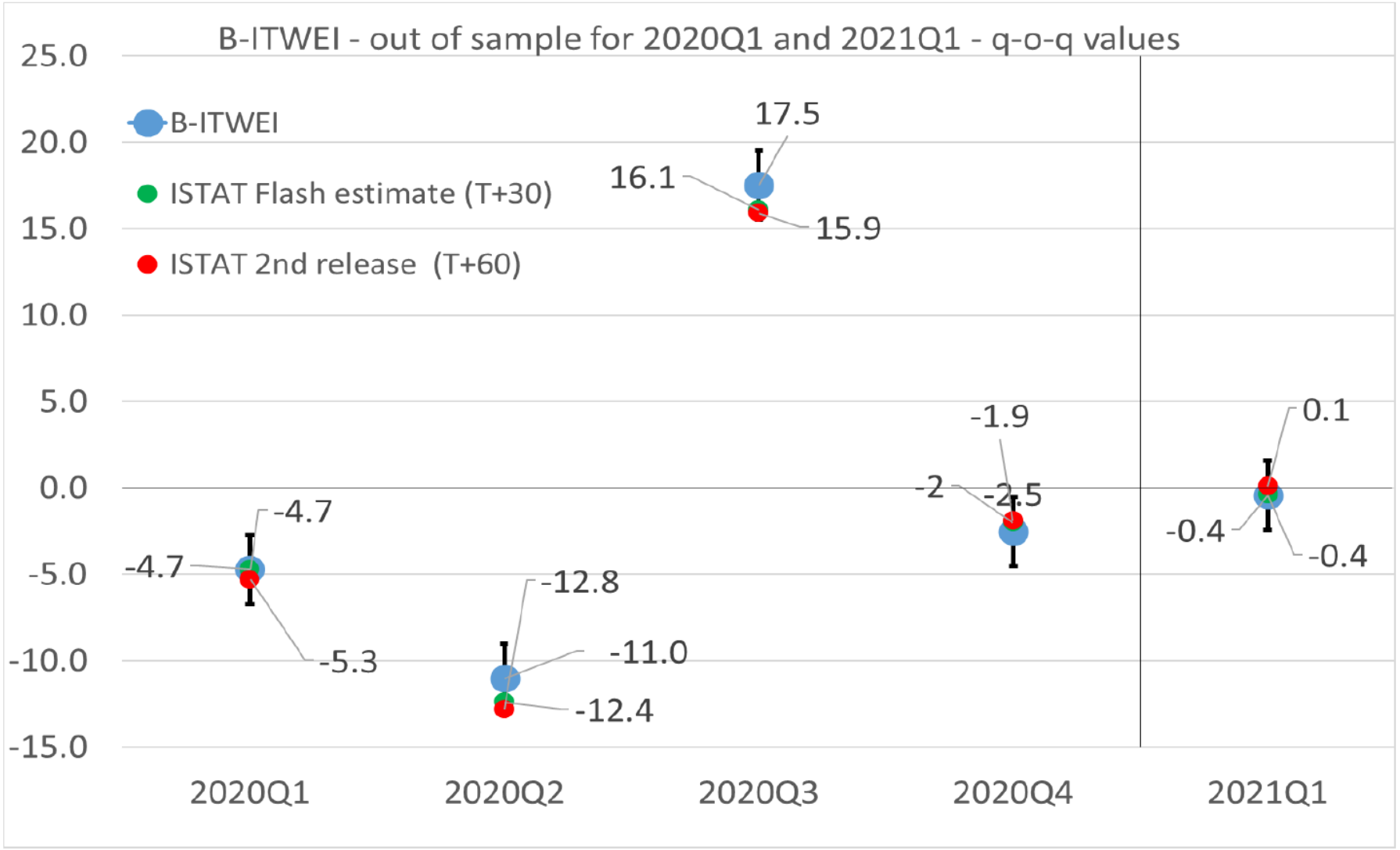
Weekly indicator of economic activity in Italy: Contributions



Weekly indicator of economic activity in Italy: Actual real-time projections

Uncertainty around real-time out-of-sample forecasts for real GDP

(quarterly data; QoQ changes)



Final excursus: Are forecasts used?
("Are forecasts useful?" is a much tougher question)

Can we tell whether the policy-maker actually makes use of the forecasts?

- ✓ Models are not used in a mechanical way
- ✓ If they were (set targets, invert model to derive appropriate instrument values), answer to question above would be easy: if actual instrument settings and model prescriptions coincide, then policy-maker relies on it; otherwise he doesn't
- ✓ But models are not used mechanically (policy-maker's objective function not known; some transmission channels are known to be missing); forecasts are usually produced under assumption of unchanged policy stance (so that policy-maker may asses the latter's appropriatedness in future)
- ✓ Idea: verify whether monetary policy was in accordance with the forecasts the policy-maker had just been given (Siviero, Terlizzese, Visco (1999))

Forecasts and monetary policy

p^* = inflation objective (announced)

pf = forecast

If the forecast was used, then one should observe:

- monetary tightening ($\Delta i > 0$) if $pf > p^*$
- monetary easing ($\Delta i < 0$) if $pf < p^*$

Regression equation:

$\Delta i = f\ (\ pf\text{-}p^*,\ i\text{-}1,\ exch.\ rate,\ forecasts\ by\ others)$

Results (Italy, data up to end 1997)

constant	0.334 (0.851)	0.288 (0.812)	-0.151 (0.724)	2.906 (1.281)	1.071 (0.969)	2.545 (1.144)	2.600 (0.920)
dummy (1996.01)	-0.619 (0.268)	-0.648 (0.237)	-0.591 (0.207)	-0.517 (0.196)	-0.435 (0.215)	-0.614 (0.178)	-0.504 (0.190)
i_{-1}	-0.066 (0.121)	-0.045 (0.086)	-0.009 (0.077)	-0.548 (0.195)	-0.252 (0.164)	-0.455 (0.178)	
$\hat{p}$	0.548 (0.287)						
p^*	-0.507 (0.376)						
$\hat{p} - p^*$		0.574 (0.261)	0.495 (0.229)	0.412 (0.198)	0.490 (0.217)	0.402 (0.199)	0.368 (0.165)
$100 \cdot \log(e / e_{-1})$			0.083 (0.030)	0.054 (0.028)	0.070 (0.030)	0.058 (0.028)	0.057 (0.026)
$\hat{p}^C$				0.184 (0.164)	0.307 (0.172)		
p_{-1}				0.329 (0.143)		0.382 (0.136)	
$\hat{p}^C - p_{-1}$							0.215 (0.144)
$i_{-1} - p_{-1}$							-0.514 (0.175)
R^2	0.386	0.384	0.558	0.714	0.625	0.693	0.711
σ	0.231	0.225	0.196	0.167	0.185	0.168	0.163

Long-run specification

$$r = 5.06 + 1.72 \cdot (pf - p^*)$$

- robust with respect to additional variables
- implies forward-looking behaviour (even when last available inflation figure is included in equation)

Pro memoria: Taylor Rule:

$$i = (r^* + p^*) + 1.5 \cdot (p - p^*) + 0.5 \cdot (\text{output gap})$$

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(can’t find what you’re looking for? stefano.siviero@bancaditalia.it)

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Thanks / Merci

Reserve slides

Eurocoin estimation: Two-step procedure

1st step:

Estimation of the **regressors space** via the **generalized dynamic factor model** à la Forni, Hallin, Lippi and Reichlin (2005)

$$x_{it} = \chi_{it} + \xi_{it} \quad with \quad \chi_{it} = B(L)w_t$$

where w_t and its lags are **generalized principal components** estimated over a medium term frequency band.

2nd step:

Projection via OLS in **frequency domain** of the **target** c_t on the **regressors space** $w_t = (w_{1t}, \dots, w_{rt})'$ **generated in the 1st step**, selecting **medium to long term frequencies**.

$$\widehat{c_t} = \hat{\mu} + \widehat{\Sigma_{cw}}\widehat{\Sigma_w}^{-1} w_t$$

back

Jorge Luis Borges, ‘On Exactitude in Science,’ 1946

In that empire, the art of Cartography reached such perfection that the map of a single province occupied the whole of a city, and the map of th empire took up an entire province. With time, those exaggerated maps no longer satisfied, and the Colleges of Cartographers came up with a map of the empire that had the size of the empire itself, and coincided with it point by point. Less addicted to the study of Cartography, succeeding generations understood that this extended map was useless, and without compassion, they abandoned it to the inclemencies of the sun and of the winters. In the deserts of the west, there remain tattered fragments of the map, inhabited by animals and beggars; in the whole country there are no other relics of the geographical disciplines.

Suárez Miranda: Viajes de varones prudentes, libro cuarto, cap. XLV, Lérida, 1658.

Lewis Carroll, 'Sylvie and Bruno Concluded,' 1893

'That's another thing we've learned from your Nation," said Mein Herr, "map-making. But we've carried it much further than you. What do you consider the largest map that would be really useful?"

"About six inches to the mile."

"Only six inches!" exclaimed Mein Herr. "We very soon got to six yards to the mile. Then we tried a hundred yards to the mile. And then came the grandest idea of all! We actually made a map of the country, on the scale of a mile to the mile!"

"Have you used it much?" I enquired.

"It has never been spread out, yet," said Mein Herr: "the farmers objected: they said it would cover the whole country, and shut out the sunlight! So we now use the country itself, as its own map, and I assure you it does nearly as well."