DSGE models with financial frictions: frequency does matter

Claudia Foroni
Deutsche Bundesbank

Paolo Gelain
ECB and Norges Bank

Massimiliano Marcellino
Bocconi University, IGIER, and C.E.P.R.

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Motivation

- Researchers typically model economic decision making processes as if conducted at fixed specified intervals of time.
- However, the frequency at which economic agents make decisions not necessarily coincides with the frequency at which time series are released (see Christiano and Eichenbaum (1987) and Jorda (1999)).
- The mismatch between the time scale of models and the data used in their estimation translates into *identification problems*, *estimation bias*, and distortions in policy analysis. This holds in time series models and in DSGE models.
- The use of mixed-frequency data can help in solve or at least alleviate those problems.

Motivation

- With the Great Recession, it has become clear that financial factors are very relevant, they are crucial elements to account for, and especially to incorporate in DSGE models used for policy analysis.
- Financial variables used in the estimation of DSGE models (e.g. spreads or net worth) are available at higher than quarterly frequency, like monthly, weekly or even daily.
- Financial variables typically move fast so a quarterly average can wash out intra-quarterly effects. Similarly, end of quarter values can hide relevant information about the quarter.

In this paper

- We estimate a state-of-the-art DSGE with financial accelerator, e.g. Del Negro, Giannoni and Schorfheide (2015), using mixed-frequency data and performing Bayesian estimation.
- We (want to) deeply investigate identification issues, Iskrev (2009, 2017).
- We re-evaluate some of the findings in the literature:
    - relevance of accelerator
    - relevance of financial shocks
    - ...

Related literature

- Large literature in time series context: Foroni, Ghysels and Marcellino (2013).

- Still very small literature in DSGE context: Kim (2010), Rondeau (2012), Foroni and Marcellino (2014), Yau (2015), Christensen et al. (2016), Giannone et al. (2016), Bing (2017), Yau and Hueng (2017).

Preview of the results

The use of mixed-frequency data does matter.

- In general:
  - many estimated parameters change substantially.
  - So, implied dynamics (irfs, variance and historical decomposition) look very different.
- Big impact on standard results in the (financial frictions) literature:
  - Financial (risk) shock looses most of its importance to explain real variables variability.
  - For some shocks (monetary policy shock and investment specific shock) we find inverted accelerator effects.

Outline of the presentation

- Temporal aggregation issues
- Model
- Preliminary results

Estimation bias

- Assume the following monthly model:

$$y_t^* = \rho y_{t-1}^* + \varepsilon_t.$$

- The correct corresponding quarterly model is:

$$y_t = \rho^3 y_{t-3} + \rho^2 \varepsilon_{t-2} + \rho \varepsilon_{t-1} + \varepsilon_t,$$

- which can be written as

$$y_t = \rho^3 y_{t-3} + \widetilde{\varepsilon}_t,$$

- or equivalently assuming $\tau = 3t$

$$y_\tau = \rho^3 y_{\tau-1} + \widetilde{\varepsilon}_\tau.$$

Identification

- Assume the following monthly multivariate model:

$$Y_t^* = AY_{t-1}^* + \varepsilon_t.$$

- The correct corresponding quarterly model is:

$$Y_\tau = A^3 Y_{\tau-1} + \widetilde{\varepsilon}_\tau.$$

- The econometrician estimates

$$Y_\tau = CY_{\tau-1} + \widetilde{\varepsilon}_\tau,$$

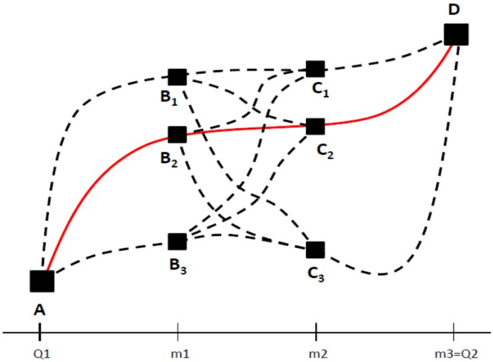
- To recover the monthly process, one needs to find a matrix A such that $A^3 = C$, or a cube root of C.
- Simplest case: $C = I_2$, hence $A = I_2$ is a cube root of C.
- But also any matrix

$$A = \begin{bmatrix} -d-1 & -\frac{1}{f}\left(d^2+d+1\right) \\ f & d \end{bmatrix}$$

is a cube root. IDENTIFICATION ISSUE.

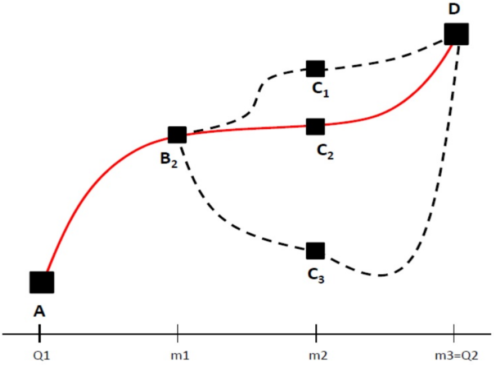
Identification: A graphical representation

- Monthly process: $A \longrightarrow B_2 \longrightarrow C_2 \longrightarrow D$
- Quarterly data: we can only see A and D



Identification: A graphical representation

- Monthly process: $A \longrightarrow B_2 \longrightarrow C_2 \longrightarrow D$
- Some monthly data $\Longrightarrow$ Mitigation of identification problem



Model description

- State-of-the-art DSGE (Smets and Wouters, 2007) embedded with financial accelerator (Del Negro, Giannoni and Schorfheide, 2015).
- Several bells and whistles: price and wages rigidities, investment adjustment costs, habits formation, variable capital utilization, financial frictions.
- Several shocks: technology, investment specific, risk premium, government spending, price mark up, wage mark up, monetary policy, risk.

Model description: Accelerator

- Entrepreneurs need external funds to run projects on top of their internal funds n_t.

- Projects are risky and entrepreneurs are subject to idiosyncratic productivity shocks ω_t. These are log-normally distributed with 0 mean and standard deviation $\widetilde{\sigma}_{\omega,t}$.

- Productivity dispersion (risk shock) $\widetilde{\sigma}_{\omega,t} = \rho_{\sigma_\omega} \widetilde{\sigma}_{\omega,t} + \sigma_{\sigma_\omega} \varepsilon_t^{\sigma}$, with $\varepsilon_t^{\sigma} \sim i.i.d.N\left(0,1\right)$.

- Need a contract with creditor (because of asymmetric information): Costly State Verification.
  - If shocks are above a threshold entrepreneurs are successful and pay their debt. If not they fail and creditor can check entrepreneur situation and keep what found (net of verification costs).

- Every period a fraction of entrepreneurs exits, so the remaining are γ_*.

Model description: Accelerator

The optimal contract prescribes that entrepreneurs have to pay an external finance premium S_t, positively related to the entrepreneur's leverage $q_t^k + \bar{k}_t - n_t$

$$S_t = E_t \left[\widetilde{R}^k_{t+1} - R_t \right] = b_t + \zeta_{sp,b} \left(q_t^k + \bar{k}_t - n_t \right) + \widetilde{\sigma}_{\omega,t},$$

$\widetilde{R}^k_t$ is the return on capital,

R_t the policy rate,

b_t the risk premium shock,

q_t^k is the price of capital,

$\bar{k}_t$ is the capital stock,

net worth law of motion is

$$\begin{aligned} n_t &= \zeta_{n,\widetilde{R}^k} \left(\widetilde{R}^k_t - \pi_t \right) - \zeta_{n,R} \left(R_{t-1} - \pi_t \right) + \zeta_{n,qk} \left(q^k_{t-1} + \bar{k}_{t-1} \right) \\ & + \zeta_{n,n} n_{t-1} - \frac{\zeta_{n,\sigma_\omega}}{\zeta_{sp,\sigma_\omega}} \widetilde{\sigma}_{\omega,t-1} - \gamma_* \frac{v_*}{n_*} \widehat{z}_t, \end{aligned}$$

π_t is the inflation rate

$\widehat{z}_t$ is the technology shock.

Estimation

- US (quarterly) data from 1964q1 to 2008q3: real GDP, real consumption, real investments, real wage, hours worked, inflation, federal funds rate, and spread (Baa Corporate - 10-year Treasury).
- Hours worked, inflation, federal funds rate, and spread are also available at monthly frequency.
- Calibrated parameters: capital depreciation $\delta = 0.025/3$, $\gamma_* = (1 - 0.01/3)$.
- Estimated parameters: growth rate of the economy γ, $\bar{l}$, r_*, and $\pi^* \Longrightarrow$ prior mean divided by 3, while the steady state external finance premium SP_* $\Longrightarrow$ prior mean divided by 12.

Measurement equations

- The time scale is monthly, $t = 1$ month.
- Measurement equation for monthly variables:
    - Hours worked $= \bar{l} + 100 l_t$,
    - inflation $= \pi^* + 100\pi_t$,
    - federal funds rate $= r_* + 100 R_t$,
    - spread $= SP_* + 100 E_t \left[\widetilde{R}^k_{t+1} - R_t \right]$.

Measurement equations

- For quarterly variables we need some aggregation. Let's start from the levels:

$$Y_t^q = Y_t^m + Y_{t-1}^m + Y_{t-2}^m.$$

- We observe

$$\begin{aligned}
\Delta \widehat{\widetilde{y}}_t^{q,obs} &= 100 \log \frac{Y_t^q}{Y_{t-3}^q} \\
&= 100 \log \left(\frac{Y_t^q}{Y_{t-3}^q} \frac{Z_t}{Z_t} \frac{Z_{t-1}}{Z_{t-1}} \frac{Z_{t-2}}{Z_{t-2}} \frac{Z_{t-3}}{Z_{t-3}} \right) \\
&= 100 \left(\widehat{\widetilde{y}}_t^q - \widehat{\widetilde{y}}_{t-3}^q + z_t + z_{t-1} + z_{t-2} + 3\widetilde{\gamma} \right).
\end{aligned}$$

Measurement equations

How do we define $\widehat{\widetilde{y}}_t^q$?

$$\frac{Y_t^q}{Z_t} = \frac{Y_t^m}{Z_t} + \frac{Y_{t-1}^m}{Z_t} + \frac{Y_{t-2}^m}{Z_t}.$$

$$\begin{aligned}\widehat{\widetilde{y}}_t^q \quad = \quad & \frac{\widetilde{y}^m}{\widetilde{y}^q}\widehat{\widetilde{y}}_t^m + \frac{\widetilde{y}^m}{\widetilde{y}^q e^{\widetilde{\gamma}}}\widehat{\widetilde{y}}_{t-1}^m + \frac{\widetilde{y}^m}{\widetilde{y}^q e^{2\widetilde{\gamma}}}\widehat{\widetilde{y}}_{t-2}^m \\ & - \frac{\widetilde{y}^m}{\widetilde{y}^q e^{\widetilde{\gamma}}} z_t - \frac{\widetilde{y}^m}{\widetilde{y}^q e^{2\widetilde{\gamma}}} z_{t-1} - \frac{\widetilde{y}^m}{\widetilde{y}^q e^{2\widetilde{\gamma}}} z_{t-2},\end{aligned}$$

where $\frac{\widetilde{y}^m}{\widetilde{y}^q} = \frac{1}{1+\frac{1}{e^{\widetilde{\gamma}}}+\frac{1}{e^{2\widetilde{\gamma}}}}$.

Estimated parameters and Variance decomposition

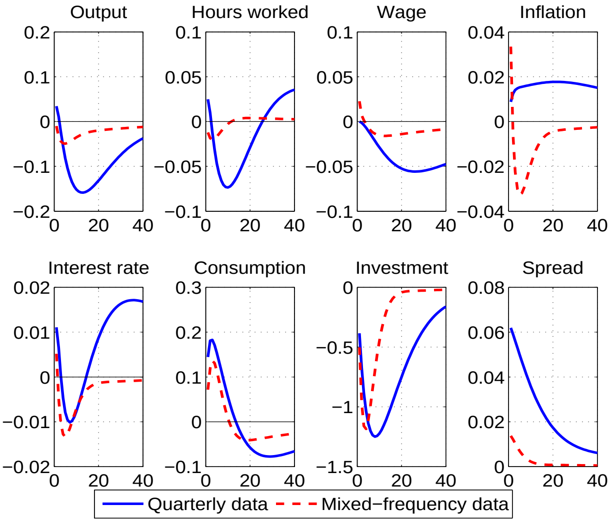
Table: Selected estimated parameters

	Quarterly		Mixed frequency		values of DGS
	Post. median	90% HPD	Post. median	90% HPD	Post. median
std risk shock	0.0575	0.0499-0.0654	0.0144	0.0138-0.0151	0.057
ar1 risk shock	0.9953	0.9857-0.9998	0.9977	0.9947-0.9999	0.99
elasticity	0.053	0.0464-0.0600	0.0457	0.0394-0.0521	0.044

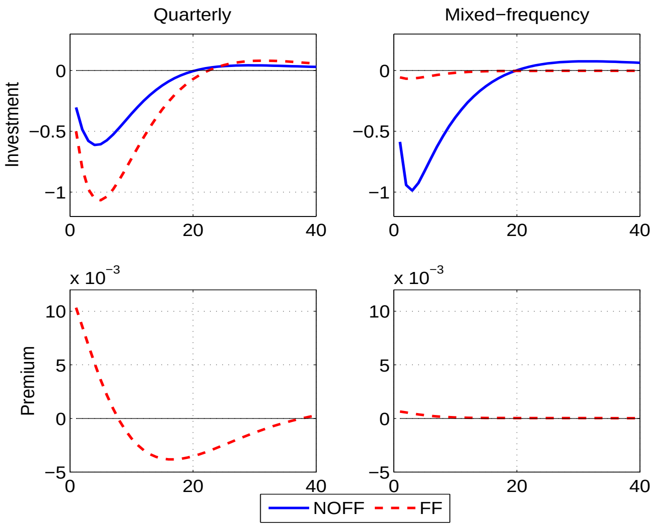
Table: Variance Decomposition of output

	gov	risk prem	invest spec	tech	price mk	wage mk	mon pol	risk (CMR)
Q no ff	13.24	17.1	22.92	12.42	11.71	11.96	10.66	-
Q ff	8.46	24.63	32.33	5.27	6.4	3.02	18.69	1.2
MX no ff	11.39	17.63	3.31	35.28	9.34	0.27	22.77	-
MX ff	8.02	0.13	5.39	31.59	34.69	12.75	6.19	1.24

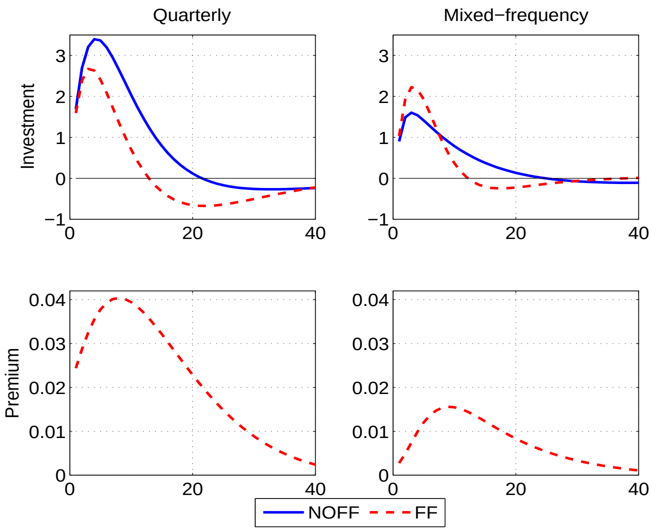
IRFs risk shock



Accelerator: Monetary policy shock



Accelerator: Investment specific shock



Conclusions

- Frequency does really matter!
- Using mixed-frequency data to estimate a DSGE with financial frictions
  - financial shock greatly looses importance in explaining real variables variability
  - accelerator effect can be inverted