TECHNICAL APPENDIX for a blog on "A more resilient euro area navigates financial imbalances and macroeconomic instability"

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The analysis is based on a Markov regime-switching dynamic stochastic general equilibrium (DSGE) model with an endogenous financial crisis stemming from financial imbalances. In the model, the probability of a financial downturn depends on real private credit growth, real house prices, real equity prices, and real interest rates while the severity of the tail event increases with imbalances in private credit. Below are the details regarding the estimation of the probability function and the regime-switching DSGE model. More comprehensive work is forthcoming in the ESM working paper entitled "Financial Imbalances and Macroeconomic Tail Risks: A Structural Regime-Switching Investigation".

The effect of financial indicators on the probability and the severity of GDP tail events

The sample used for the estimation runs from Q1-2001 to Q4-2019, overs 21 advanced economies, and does not include the pandemic period. We estimate the probability of a financial downturn starting (defined as the 10th percentile of the real GDP growth for next three years) based on standard macro and financial variables. Our dependent variable takes the value of one if the tail event starts in country *I* at quarter *t* and zero otherwise. Using the logit specification, the probability of a weak GDP growth period starting is given by:

$$p_{i,t} = \frac{exp\left(\mu_i + \mu_L L_{i,t}\right)}{exp\left(\beta_{j,s}\lambda_{j,i,s}\right)} + \varepsilon_{j,i,t},$$

where μ_i are the country fixed effects. μ_L are the coefficients on the set of financial imbalances, including a set of macro controls such as lag GDP growth and inflation. The estimates suggest that the steady-state (annual) probability of a financial downturn starting is about 3.4%. Further, increases in the selected financial vulnerability measures (real private credit growth, real house prices, real equity prices, and real interest rates) raise the probability of a downturn. The theoretical model described below includes all these variables together with the estimated probability function.

We also estimate the *severity* of GDP tail events as a function of imbalances in private credit during financial downturns using local projection methods (Jorda, 2005). The local projections can accommodate the nonlinearities in our model specification estimated in a simple univariate framework, preserving valuable degrees of freedom. The severity of financial downturns in the regime-switching DSGE model below is calibrated based on the empirical findings from these nonlinear local projections.

A regime-switching DSGE model of financial imbalances

The theoretical framework we use is a New Keynesian DSGE model with banking and housing sectors as in Gerali et al. (2010) at its core. However, we extend the model to include endogenous financial crises based on financial imbalances via a Markov regime-switching framework as in Gerdrup et al. (2017) and Kockerols et al. (2023) and persistent financial cycles via hybrid house price expectations as in Gelain et al. (2013). The core of the model is calibrated and estimated using the euro area data.

The economy consists of two types of households, namely patient and impatient, along with entrepreneurs, intermediate-goods producing firms, capital and housing producers, final-goods firms, and a central bank. Both types of households consume, work, and demand housing services. Patient households save through deposits, whereas impatient households borrow from banks to buy houses.

Entrepreneurs use capital and labour to produce intermediate goods, and purchase capital from capital-goods producers.

Impatient households and entrepreneurs face collateral constraints when they borrow from the banking sector. Impatient households can borrow against the value of their houses, while entrepreneurs can borrow against the value of their physical capital. Banks collect deposits from patient households and combine it with their equity capital (retained earnings) to extend loans to impatient households and entrepreneurs. The banking sector is monopolistically competitive. They maximise their profits by setting deposit rates together with household and business lending rates.

Each household supplies a differentiated labour input through unions to the intermediate goods-producing firms. Wages are set by households under the assumption of monopolistic competition. In addition to entrepreneurs, capital-goods and housing producers set the market price for capital and houses. Finally, a monopolistically competitive retail sector purchases intermediate goods from entrepreneurs, differentiates them, and prices them subject to nominal rigidities.

The economy can be either in a normal state or in a crisis state at any point in time governed by a Markov process, given by the probability of a crisis starting and its duration, as explained above. We assume the crisis duration to be eight quarters, which reflects the mean unfiltered peak to trough duration of the financial cycle in Europe as defined in Schüler et al. (2015).

In our model, we want to capture the stylised fact that a build-up in financial imbalances precedes crisis episodes, and the size of the imbalances correlate with the severity of the following crisis. Therefore, the shock innovations for the structural shock processes consist of typical business cycle innovations and a crisis innovation.

$$log\left(Z_t^i\right) = \left(1-\rho^{Z^i}\right) log\left(Z_{ss}^i\right) + \rho^{Z^i} log\left(Z_{t-1}^i\right) + \epsilon_{Z,t}^i - \beta^{Z^i} log(crisis_t)$$

where Z_t^i is a generic business cycle shock, Z_{ss}^i is the steady-state level of the shock process, ρ^{Z^i} is the persistence parameter, $\epsilon_{Z,t}^i$ is the shock innovation, $crisis_t$ is a shock, β^{Z^i} is a scale factor for each crisis shock innovation, which is only active once the economy enters a crisis, and follows

$$log(crisis_t) = \rho_{crisis} log(crisis_{t-1}) + \Omega\kappa_t$$

where ρ_{crisis} is the persistence of the crisis shock and Ω is a crisis indicator variable. In normal times we have $\Omega = 0$, and in crisis times $\Omega = 1$. κ_t is a variable that captures the severity of crises. The severity, κ_t, is a function of credit imbalances, $B_{h,t}^{5y}$:

$$\kappa_t = (1-\Omega)\left(\gamma + \gamma_{B_h} B_{h,t}^{5y}\right) + \rho_\kappa \Omega \kappa_{t-1}$$

where $B_{h,t}^{5y}$ is five-year average real credit growth, γ governs a constant effect of credit imbalances on the respective crisis shock and γ_{B_h} governs the effect of the initial level of credit imbalances on crisis severity. β^{Z^i}, ρ_{crisis}, γ, and γ_{B_h} are calibrated to match the asymmetric effect of a crisis on each crisis shock, the persistence of crisis shocks, the baseline severity, and the additional severity of crises due to higher pre-crisis credit growth, respectively.

References

Gelain, P., K. J. Lansing, and C. Mendicino (2013): "House Prices, Credit Growth, and Excess Volatility: Implications for Monetary and Macroprudential Policy," International Journal of Central Banking, 9, 219–276.

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, 42, 107–141.

Gerdrup, K. R., Hansen, F., Krogh, T., and Maih, J. (2017). Leaning Against the Wind When Credit Bites Back. International Journal of Central Banking, 13(3), 287-320.

Jordá, Oscar. 2005. "Estimation and inference of impulse responses by local projections." American economic review, 95(1): 161–182.

Kockerols, T., Kravik, E. M. and Mimir, Y. (2023), "Leaning against financial cycles with occasional crises", ESM Working Papers, No. 56.

Schüler, Y. S., P. Hiebert, and T. A. Peltonen (2015): "Characterising the financial cycle: a multivariate and time-varying approach," Working Paper No 1846, European Central Bank.