WORKING paper

BANQUE DE FRANCE
EUROSYSTÈME

Re-estimated FR-BDF: New Features and an Assessment of Monetary Policy Tightening in France

Ugo Dubois[1], Bruno Ducoudré[1], Raphaël Martin[1], Anna Petronevich[1], Caterina Seghini[1], Camille Thubin[1], Harri Turunen[1,2]

May 2026, WP #1044

Abstract

This paper presents the updated and re-estimated version of the Banque de France's semi-structural FR-BDF model, the institution's core framework for quarterly projections and policy scenario analysis. The update reflects major statistical and structural shifts, including INSEE's transition to a 2020 base year and the volatility during the COVID-19 period. The re-estimated model features a lower capital share, a weaker underlying productivity trend, a steeper price Phillips curve along with a flatter wage Phillips curve, while adding a credit block and an enhanced consumption equation that captures short-run income effects. The updated FR-BDF delivers stronger and faster real effects of monetary policy — with larger GDP and unemployment responses due to amplified transmission through long-term rates and the exchange rate — while nominal responses are more muted. Using the updated model, the recent monetary tightening is assessed to lower VA inflation by –0.6 pp and reduce GDP growth by 1 pp (at trough) under backward-looking expectations, whereas under forward-looking expectations the responses are more front-loaded and nearly three times larger. Under the more realistic hybrid expectations mode, VA inflation falls by about 1.2 percentage points and GDP growth by roughly 2 percentage points at the trough. These magnitudes remain broadly consistent with benchmark assessments reported in the literature.

Keywords: Semi-structural Modeling, Expectations, Monetary Policy

JEL classification: C54, E37

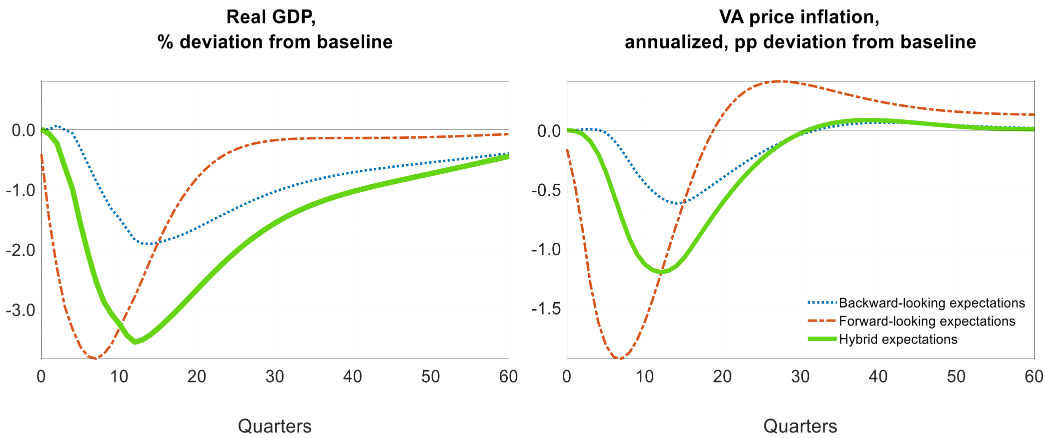
[1] Banque de France
[2] Corresponding author, harri.turunen@banque-france.fr

NON-TECHNICAL SUMMARY

Semi-structural macroeconomic models are key tools for central banks when producing economic projections and analysing policy scenarios. At the Banque de France, the FR-BDF model plays a central role in forecasting and in assessing the effects of economic shocks and policy measures on the French economy. However, such models need to be regularly updated to remain reliable. Since the last version of FR-BDF was released in 2019, the macroeconomic environment has changed significantly. The COVID-19 pandemic, the surge in inflation, and the sharp tightening of monetary policy have altered economic dynamics. In addition, the transition of French national accounts to a new statistical base year has modified the measurement and historical coverage of several macroeconomic series. Together, these developments call for a comprehensive update of the model.

This paper presents the revised version of the FR-BDF model used at the Banque de France. The update introduces several improvements designed to better capture recent developments in the French economy. In particular, the model now incorporates richer financial channels linking interest rates, credit conditions and balance sheets; a more detailed treatment of energy prices; and a stronger short-term link between household income and consumption. The model has also been fully re-estimated using the latest statistical data, while specific adjustments allow it to account for the exceptional economic fluctuations observed during the pandemic period. The revised model also serves as the structural foundation for the FR-BMEs forecasting tool currently used in the Bank of France interim projection exercises.

Figure 1. Responses to 2022-2025 monetary policy tightening under different types of expectations



Note: The figure shows the responses of real GDP (left) and VA annualized price inflation (right) to a monetary policy tightening in the euro area as observed during 2022-2025, under different expectation regimes. The hybrid expectation mode is defined as a combination of two other modes, where the financial markets are forward-looking while the rest of the economic agents are backward-looking. Importantly, in the hybrid mode, the information about the monetary policy shock is diffused progressively (contrary to the forward-looking expectation mode, where the agents are fully perfect foresight) and so the expectations are updated as the new information arrives (staggered expectations). For reference, the Banque de France's quarterly forecasting framework is based on backward-looking expectations.

To assess how these changes affect the behaviour of the model, the paper compares the responses of key macroeconomic variables to a set of standard shocks—such as interest rate, foreign demand and fiscal shocks—with those obtained in the 2019 version. These comparisons show how the revised

specifications modify the propagation of shocks in the model and help identify the mechanisms behind the changes in its macroeconomic responses.

Using the updated model, the paper evaluates the macroeconomic effects of the recent tightening of monetary policy. The results indicate that higher interest rates have sizeable effects on economic activity and inflation in France. However, the magnitude and timing of these effects depend strongly on how households, firms and financial markets form expectations about future interest rates. When economic agents react quickly to expected policy changes, the contraction in output and inflation is sharper and more front-loaded. When expectations adjust more gradually, the effects are smoother but remain persistent. Overall, the results confirm the importance of expectation formation in shaping the transmission of monetary policy. To better reflect real-world behaviour, the paper provides the evaluation of the effects in a hybrid framework that combines forward-looking financial markets with more gradual adjustments by households and firms and features progressive updating of expectations.

FR-BDF réestimé : nouvelles propriétés et évaluation du resserrement de la politique monétaire en France

RÉSUMÉ

Ce document présente la version actualisée et réestimée du modèle semi-structurel FR-BDF de la Banque de France, qui constitue le cadre central de l'institution pour l'élaboration des projections trimestrielles et l'analyse des scénarios de politique économique. Cette mise à jour reflète d'importantes évolutions statistiques et structurelles, notamment le passage de l'Insee à l'année de base 2020 ainsi que la forte volatilité observée durant la période liée à la pandémie de COVID-19. Le modèle réestimé se caractérise par une part du capital plus faible, une tendance sous-jacente de productivité plus modérée, une courbe de Phillips des prix plus pentue et, à l'inverse, une courbe de Phillips des salaires plus plate. Il intègre en outre un bloc de crédit et une équation de consommation enrichie, permettant de mieux capter les effets de revenu à court terme. La version actualisée du FR-BDF met en évidence des effets réels de la politique monétaire plus rapides et plus marqués — avec des réactions plus amples du PIB et du chômage, liées notamment à une transmission renforcée via les taux d'intérêt de long terme et le taux de change — tandis que les ajustements nominaux apparaissent plus contenus. Sur la base du modèle mis à jour, le resserrement monétaire récent conduirait, sous l'hypothèse d'anticipations rétrospectives, à une baisse de l'inflation du déflateur de la valeur ajoutée d'environ 0,6 point de pourcentage et à une réduction de la croissance du PIB d'environ 1 point de pourcentage au creux du cycle. En revanche, dans un cadre d'anticipations prospectives, les réponses sont plus précoces et d'une ampleur près de trois fois supérieure. Dans le régime d'anticipations hybrides, considéré comme plus réaliste, l'inflation en valeur ajoutée recule d'environ 1,2 point de pourcentage et la croissance du PIB d'environ 2 points de pourcentage au point bas. Ces ordres de grandeur demeurent globalement cohérents avec les évaluations de référence disponibles dans la littérature.

Mots-clés : modélisation semi-structurelle, anticipations, politique monétaire

Acknowledgments

The maintenance and development of the FR-BDF model rely on a collective effort of forecasters, modelers, and data managers, under the supervision of the heads of the SEMAP division.

Data management tasks are carried out by Lionel Giuliani and Frulgence Noumagnon, who ensure the consistent construction and update of the datasets underlying the model, as well as provide highly responsive support to all data-related questions. The forecasting team—Pierre Aldama, Alice Carroy, Juliette Guillotin, Raphaël Martin, Mylène Sabatini, and David Sabes—bring essential applied expertise as the primary users of the model for BdF macroeconomic projections, and their constructive, well-informed suggestions are key to guiding its operational improvements.

Several colleagues contributed at specific stages of the re-estimation process and the policy evaluation exercise. These contributions include expert comments and targeted inputs by Vladimir Borgy, Guillaume Gaulier, Yannick Kalantzis, Claire Le Gall, and Anastasia Zhutova. Additional high-quality analytical assistance during the initial phase of the project was provided by Kaoutar Fahraoui and Matheo Le Masson during their internship in the BdF. Maxence Martini offered exceptionally efficient operational assistance during his internship, giving a clear boost to the team's productivity during the re-estimation phase. Another important milestone in the evolution of FR-BDF between 2019 and 2025 was the translation of the model architecture from TROLL to Matlab-Dynare, a substantial and technically demanding undertaking, carried out by Ugo Dubois and Anastasia Zhutova, with significant operational input from Donald Kayo Waffo on the MCE mode during his internship.

The supervision and strategic orientation of the project are ensured by the current and former heads of the SEMAP division—Bruno Ducoudré, Matthieu Lemoine, and Camille Thubin—whose clear direction and prompt feedback helped to structure the work over time.

The modelling team—Ugo Dubois, Anna Petronevich, Caterina Seghini, and Harri Turunen—are the primary contributors to the re-estimation and to the preparation of this text, in line with their role in the ongoing development of the model.

The authors of this text express their deep appreciation for the committed and constructive participation of all the colleagues listed above.

Contents

1 Introduction: why update FR-BDF now? 4

2 A brief overview of FR-BDF 6

2.1 Model structure 6

2.2 Estimation approach 11

3 Overview of changes since 2019 12

3.1 Supply block 12

3.1.1 Market branches supply: theoretical framework and equilibrium . . . 12

3.1.2 Calibration 14

3.1.3 Long run output 21

3.2 Expectation formation 21

3.2.1 E-SAT model: updated parameter estimates 22

3.2.2 E-SAT Impulse responses 25

3.2.3 A brief reminder of the construction of expectations for VAR-based expectations 26

3.3 Value added price 27

3.4 Labor market 31

3.4.1 Labor supply 31

3.4.2 Other wage equations 35

3.4.3 Labor demand 37

3.5 Demand block 41

3.5.1 Household consumption 41

3.5.2 Household investment 45

3.5.3 Business investment 49

3.6 Demand deflators 57

3.6.1 Household consumption deflator 57

3.6.2 Household investment deflator 59

3.6.3 Business investment deflator 60

3.6.4 Harmonised Index of Consumer Prices 62

3.7 Financial block 62

3.7.1 Long-term government interest rates 62

3.7.2 Financial assets of households 64

3.7.3 Financial assets of non-financial corporations 67

3.7.4 Net property income and net asset positions 72

3.7.5 Exchange rates 75

3.8 External trade block 78

3.8.1 Volumes variables 79

3.8.2 Price variables 87

4 Impulse responses and changes since 2019 93

4.1 Short-term interest rate shock 94

4.2 Term premium shock 95

4.3 Exchange rate shock . . . 97
4.4 Government consumption shock . . . 98
4.5 Public wage shock . . . 99
4.6 Foreign demand shock . . . 100
4.7 Oil price shock . . . 102

5 Responses to selected shocks under different expectation modes 103
5.1 Short-term interest rate shock . . . 103
5.2 Government consumption shock . . . 105

6 Application: assessment of monetary policy tightening in France 106
6.1 Monetary policy shock . . . 106
6.2 Dual simulation framework . . . 108
6.3 Implementation . . . 109
6.4 Main results . . . 110
6.4.1 Responses under VAR-based and MCE expectations . . . 110
6.4.2 Responses under hybrid expectations . . . 114
6.4.3 Responses under hybrid mode and staggered expectations . . . 115
6.4.4 Comparative summary of peak and mean responses . . . 117

7 Conclusion 118

A Appendix: Household consumption auxiliary equations 124

B Appendix: Dynamic contributions 125

C Appendix: Short-term interest rate shock with an exogenous exchage rate 126

D Appendix: Government consumption shock with an exogenous debt stabilization rule 127

E Appendix: Energy price index shock 129

F Appendix: Government consumption shock under different expectation modes 130

1 Introduction: why update FR-BDF now?

Semi-structural macroeconomic models play a central role in medium-term policy analysis and forecasting, aiming to strike a balance between empirical fit and structural interpretability. They are widely used by the National Central Banks of the Eurosystem, with 18 institutions relying on them to construct baseline projections. For France, in addition to the FR-BDF model presented in this paper, semi-structural approaches are used in the French Treasury–INSEE model Mésange (Bardaji et al. (2017)) and the OFCE's quarterly macroeconometric model e-mod.fr (Chauvin et al. (2002)). At the Banque de France, the semi-structural FR-BDF model serves as the main quantitative framework for producing quarterly macroeconomic projections, conducting structural scenario analyses, and evaluating the transmission of shocks and policy measures. To remain relevant and reliable in fulfilling these functions, such a model must be periodically revised to incorporate structural changes in the economy, updates in statistical sources, and new empirical insights. The current juncture offers a clear rationale for reestimating the FR-BDF: it follows a period of profound macroeconomic disruption caused by the COVID-19 pandemic, heightened inflation volatility, and an unprecedented tightening of monetary policy. In parallel, the transition by INSEE to a new base year for national accounts has altered not only the levels of macroeconomic aggregates, but also their dynamics and—in some cases—the historical depth of the data. Together, these factors have changed the statistical and structural landscape to a degree that necessitates an updated version of the FR-BDF, in order to preserve its value as a tool for informing economic policy decisions.

This paper documents the evolution since 2019 of the FR-BDF semi-structural model, as initially presented in Lemoine et al. (2019), in line with best practices in model transparency and reproducibility. The revision rests on three main pillars. First, several modeling enhancements were introduced. These include the addition of a credit block capturing the relationship between interest rates, loan demand and financial variables[1]; the introduction of natural gas prices, which improves the transmission of energy shocks; and a short-run direct channel from wages and social transfers to household consumption, which better captures hand to mouth consumer behaviour in times of income shocks or fiscal support. These changes reflect lessons learned during recent periods of supply-side constraints and aggressive fiscal intervention, and they improve the model's ability to simulate policy scenarios with heightened realism.

Second, the entire model was reestimated following the transition of INSEE national accounts to a new base year (2020 instead of 2014). This change affects not only the levels of macroeconomic aggregate, but also their dynamics, especially in real terms. In some cases, the new statistical series are less profound, at least at the moment of the reestimation, with shorter historical spans than previous vintages. This creates breaks in time series coverage and requires greater attention to data treatment.

[1] This paper offers a concise description of the financial block; comprehensive details are presented in Bove et al. (2020) and Dees et al. (2022)

Third, equation specifications were refined to better account for the COVID-19 period. Rather than redesigning entire model blocks to accommodate the extreme volatility and policy responses of 2020–2021, a parsimonious treatment based on time dummies was implemented. This approach is consistent with other empirical macro studies and proved sufficient to isolate pandemic-specific deviations without distorting the model's structural relationships.

The revised framework provides a more solid foundation for addressing emerging policy questions, such as the effects of the implementation of fiscal policies or the consequences of climate transition policies.

Building on these revisions, the updated FR-BDF now serves as the backbone of the FR-BMEs model introduced in March 2024 for the Banque de France interim projections. This model has rapidly become a core component of the forecasting architecture (see Aldama et al. (2026)). Ensuring coherence between the two frameworks is essential, as FR-BMEs is a streamlined, reduced-form projection tool whose elasticities are directly inherited from the structural FR-BDF. In practice, FR-BMEs operates as a linearised, highly parsimonious replica of the full model: a quarterly semi-structural system built from FR-BDF conditional impulse responses (its Basic Model Elasticities) for a selected set of orthogonal shocks. Rather than generating a fully endogenous forecast, it provides a disciplined mechanism to update an exogenous baseline as new information—revised data, carry-over effects, short-term surprises, new technical and international assumptions, as well as fiscal assumptions—comes in. It also allows the forecaster to perform "residuals adjustment" almost as in FR-BDF, on a subset of core macro variables (household consumption, business investment, exports/imports, employment, wages, and deflator). This design makes FR-BMEs a very efficient and robust tool for timely forecast revisions and policy analysis, while still delivering FR-BDF-consistent adjustments and preserving the structural integrity of the broader projection framework.

Looking ahead, the FR-BDF model must evolve to support policy evaluation in an increasingly complex macroeconomic environment. One pressing challenge is the heightened uncertainty surrounding inflation dynamics, including potential shifts in expectations formation, price-setting behavior, and the responsiveness of inflation to economic slack. At the same time, the French economy continues to grapple with weak productivity growth (Devulder et al. (2024)), the drivers of which are still not fully understood and which may interact with structural reforms and labor market dynamics in nuanced ways. The green transition presents another major source of macroeconomic transformation, with potentially significant effects on investment patterns, relative prices, and sectoral energy intensity. In this context, the FR-BDF model has already been used in combination with complementary modelling tools to assess transition scenarios. Notably, it has been linked to the FR-GREEN model to simulate carbon pricing and green investment strategies (see Henriet et al. (2025)), and to the NiGEM model coupled with the multisector framework developed by Allen et al. (2025) and Devulder & Lisack (2020) to explore broader general equilibrium and sectoral implications. In the future, the FR-BDF framework may also serve as a basis for integrating simulations of physical climate risks, in order to assess their impact on growth, inflation, and public finances. Lastly, the need for credible fiscal consolidation in the aftermath of pandemic-related spending and rising debt ratios places renewed importance on understanding the interaction between fiscal policy, growth, and interest rates. Ensuring that the FR-BDF model remains equipped to address these issues is essential for providing robust, forward-looking policy advice.

This paper has three main objectives. First, it provides a comprehensive summary of the changes introduced to the FR-BDF model since its 2019 release, identifying updates to each model block and discussing their rationale. Second, it presents the reestimated equations and revised parameter values, highlighting where substantial changes occurred and explaining their implications for the model's behavior. Third, it applies the updated model to assess the effects of recent monetary policy tightening in France, through a scenario analysis calibrated on observed euro area policy rates and inferred financial conditions for France. In doing so, we contribute to the broader effort of understanding the transmission of monetary policy under new macroeconomic conditions and increased uncertainty.

The remainder of the paper is structured as follows. Section 2 provides a brief recap of the FR-BDF model architecture, indicating which components remain unchanged and which have evolved. Section 3 details the reestimation process and presents the major modifications by model block. Section 4 compares impulse response functions (IRFs) generated by the pre- and post-reestimation models. Section 5 compares the reaction to selected shocks under backward-looking, forward-looking and hybrid expectation modes. Section 6 applies the updated FR-BDF to assess the macroeconomic effects of monetary policy tightening in France. Finally, Section 7 concludes by discussing the model's policy implications and outlining directions for future development.

2 A brief overview of FR-BDF

2.1 Model structure

The FR-BDF model is a semi-structural, large-scale macroeconomic model designed to describe and project the French economy. As detailed in Section 2 of Lemoine et al. (2019), its architecture is directly inspired by the FRB/US model developed by the Federal Reserve Board (Brayton et al., 2014), with modifications that reflect the structure of the French economy and the institutional context of the euro area. The FR-BDF model combines empirical realism with theoretical rigor, making it suitable for both forecasting and policy simulations.

The use of *polynomial adjustment costs* (PAC) in most behavioral equations is one of the central features of the model. The foundation of the PAC framework is the assumption of m-th order polynomial adjustment costs agents face when making choices for key variables (e.g., employment, investment, prices). Under PAC cost function, not only it is quadratically costly (as in the formulation of Rotemberg (1982)) to deviate from the target, but also the m latest differences are penalized. This leads to gradual, persistent responses to shocks. Furthermore, the PAC framework implies an error correction equation – augmented with an expected present value of future changes in the target – that can be obtained by rearranging the first order condition associated with the cost function. These equations, where current decisions depend on both lagged variables and expected future paths thus embedding forward-looking behavior, are at the core of FR-BDF.[2]

Expectations formation plays a crucial role in shaping the model's dynamics. Two types of expectation mechanisms are supported: (i) a *VAR-based* approach, in which agents use a small vector autoregression to form projections of key variables, and (ii) *model-consistent expectations* (MCE), under which agents internalize the full model structure to form forward-looking forecasts. A hybrid setup is also possible, wherein some agents adopt MCE while other agents remain backward-looking. These expectations feed into the present-value terms that appear in the PAC-based behavioral equations, influencing decisions about consumption, investment, price-setting, and more. For the purpose of our macroeconomic projections, we adopt a VAR-based expectations framework, consistent with the prevailing practice among the majority of national central banks participating in the European Central Bank forecast exercise.[3]

At its core, the model is organized into a set of interdependent blocks—supply, demand, external trade, nominal price-wage block, financial block, and public finance—which are interconnected through a comprehensive and internally consistent system of national accounts, and are jointly influenced by an expectations mechanism that can be either backward-looking or forward-looking, depending on the simulation context. This modular structure supports flexibility in specification and estimation while preserving macroeconomic consistency. The system is closed via national accounting identities. Below is a synthetic description of the model's main blocks, as illustrated in Figure 2.1.1.

[2]For a more detailed description of the polynomial adjustment costs please refer to section 3.2 of the initial FR-BDF documentation by Lemoine et al. (2019)

[3]For a detailed description of the construction of the present values please refer to Lemoine et al. (2019).

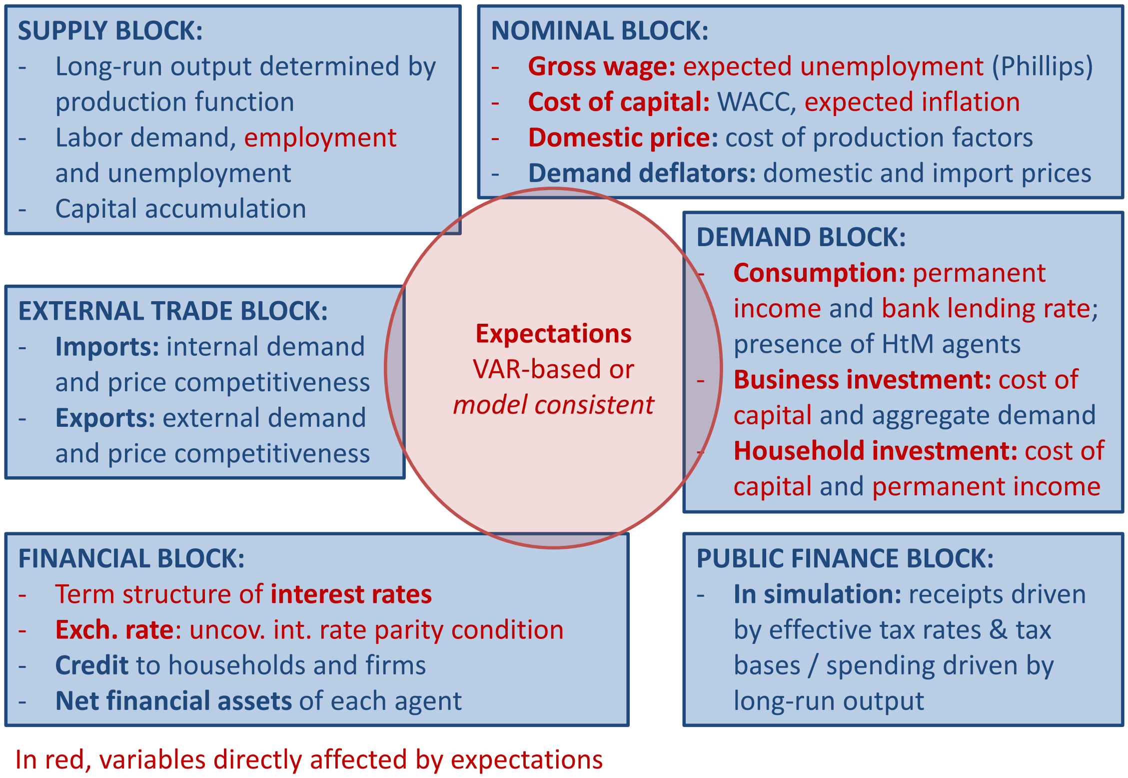


Figure 2.1.1: Overview of the FR-BDF model architecture

The supply block determines the long-run productive capacity of the economy through a CES production function that combines labor and capital inputs, augmented by an exogenous efficiency trend representing labor productivity. This efficiency term is critical in anchoring long-term output growth and reflects structural technological progress. Within this block, labor demand, employment, and capital accumulation evolve subject to adjustment frictions captured by polynomial adjustment costs (PAC), which give rise to gradual dynamics in response to shocks.

Private aggregate demand is disaggregated into consumption, business investment, and household investment, each modeled based on intertemporal decision rules under adjustment costs. Consumption depends on income and is sensitive to lending conditions, with the explicit inclusion of hand-to-mouth agents. Business investment is driven by the cost of capital—captured via the user cost—and aggregate demand. Household investment reacts similarly to changes in financing conditions and permanent income.

The model's treatment of external trade distinguishes between imports and exports. Both imports and exports depend on price competitiveness, with imports driven by domestic demand and exports driven by foreign demand. Within imports, we distinguish between energy and non-energy goods, each having its own behavioral equation and long-run target.

On the nominal side, wage dynamics depend on expected unemployment through a wage Phillips curve, while domestic prices are driven by the factor price frontier in the long run and mark-up dynamics in the short run (implicitly modeled via the output gap). The model also includes consistent determination of sector-specific deflators, which blend domestic and imported inflation according to expenditure weights. The cost of capital incorporates both real and nominal components, including expected inflation and financial conditions reflected in the weighted average cost of capital (WACC).

The financial block contains the determination of interest rates, exchange rates, and credit volumes. A term structure mechanism links short-term policy rates with long-term interest rates, embedding expectations about future monetary policy. The exchange rate follows an uncovered interest rate parity (UIP) condition, making it sensitive to domestic and foreign interest rate and inflation differentials. The model explicitly represents credit to households and firms, with financial assets and liabilities tracked by economic agent.

Finally, fiscal dynamics are captured in the public finance block. Revenues are generated endogenously from effective tax rates applied to their respective bases, while public spending evolves in relation to long-run output and, in simulations, may respond to policy feedback rules. The block ensures consistency between fiscal flows and stocks, enabling realistic simulation of deficit and debt dynamics.

A very detailed description of blocks is given in the Lemoine et al. (2019). With respect to the 2019 version of the model, major changes concern :

- Supply block: the calibrated value of the parameter that governs the relative weight of capital in production in our CES production function, α, declined from 0.26 to 0.21, indicating a structural shift toward higher labor intensity—consistent with the expansion of the service sector, where capital typically plays a smaller role in production. At the same time, the total factor productivity parameter γ fell from 0.34 to 0.26, reflecting the well-documented slowdown in productivity across advanced economies. As for the labor productivity, the efficiency trend has been revised in order to better reflect the observed slowdown in productivity growth in France. In the updated specification, an additional structural break is introduced in 2008Q3—complementing the existing break in 2002Q2—resulting in successive downward shifts in the trend growth rate of efficiency. These structural adjustments aim to capture more accurately both the timing and scale of the persistent decline in productivity dynamics observed over the past two decades. The introduction of these kinks allows to capture the decrease in the overall average annual growth rate of efficiency over the simulation horizon, which went down from 0.87% to 0.67%.

- Financial block: two complementary macro-financial sub-blocks were integrated: a residential housing and household credit sub-block, and an NFC sub-block. On the household side, we construct a stress indicator—the Debt Service Ratio—that captures purchasing power, credit conditions, and the distinction between new lending and amortisation, allowing us to assess borrower riskiness and the transmission of macroprudential measures. On the corporate side, we model the aggregate NFC balance sheet to derive a leverage indicator that drives risk premia and loan and bond spreads through financial-accelerator mechanisms. Embedding these components into FR-BDF enriches the representation of household and corporate balance-sheet dynamics and enhances the model's capacity for macro-financial scenario design and financial-stability analysis.

- Demand block: the specification of household consumption within the demand block has been enhanced by introducing a short-run direct channel from wages and social transfers to consumption. As a result, household consumption now responds not only to permanent income, as in the previous formulation, but also to current income, thereby capturing more realistically the short-term sensitivity of consumption to fluctuations in disposable income. Additionally, on the firm side, we have refined the way expectations influence behaviour to avoid excessive dampening. In the previous setup, long-term employment and investment targets were anchored to exogenous trends, which made firms' expectations too rigid and muted the model's responses. We have replaced these with quasi-endogenous anchors that adjust to prevailing economic conditions. This makes expectations more responsive to the business cycle and yields reaction patterns that align more closely with empirical benchmarks.

- External trade block: the specification of the non-energy imports equation has been revised, with the variety of foreign supply now approximated with world GDP instead of the world supply, an internally constructed aggregate that lacked transparency. This adjustment improves the economic interpretation of the trade equation.

In parallel, in response to the surge in natural gas prices in 2022, the nominal block of the model has been extended to explicitly incorporate natural gas prices. More precisely, gas prices now enter the model through a synthetic energy price index, which combines the prices of Brent crude oil and natural gas (both expressed in euros per barrel equivalent), using variable weights that reflect their respective shares in total French energy imports. By construction, this specification ensures that gas price shocks propagate through the same transmission channels as oil price shocks.

It is important to note that energy prices continue to influence the model only via the demand side. The energy composite does not enter the production function and therefore has no direct effect on production costs or potential output. As a result, the impact of energy shocks in the model is captured exclusively through their influence on household consumption, investment, and relative prices, rather than via supply-side cost pressures. To account for these omitted supply-side channels—such as energy-related changes in production efficiency or sectoral reallocation—the FR-BDF framework can be integrated with complementary models. Notably, Henriet et al. (2025) show how FR-BDF can be augmented with shocks obtained from an energy-augmented two-sector real model FR-GREEN, thereby allowing for a more comprehensive assessment of the macroeconomic effects of shocks due to climate policy, including those operating through supply-side mechanisms.

In section 3, we detail all the changes introduced in each block.

2.2 Estimation approach

The FR-BDF model is estimated sequentially, block by block, reflecting its modular structure and allowing for tailored estimation methods suited to the specific features of each component. While this decentralized approach avoids the need for a universal estimation methodology, the estimation process nevertheless follows a logical order dictated by the internal dependencies between certain core blocks.

The estimation begins with the supply block, where we calibrate the parameters of the aggregate production function. Parameter values are set so as to ensure consistency with the estimated factor demand equations and the factor-price frontier (see Section 3.1). From this, we derive an estimate of long-run potential output at the branch level, which in turn allows us to compute the output gap for the economy as a whole. The output gap plays a central role in the model, and is used as input in the expectations block.

Expectations in FR-BDF are modeled using the Expectation SATellite (E-SAT) model, a semi-structural VAR estimated using Bayesian techniques. Since E-SAT itself depends on the output gap, its estimation follows the calibration of the production function. E-SAT provides the expected values that enter most short-run equations via the polynomial adjustment cost (PAC) framework.

Once the core of the model—namely the production function and E-SAT—is estimated, the remaining blocks can be estimated in any order. This includes the short-run behavioural equations for households, firms, labour markets, and prices. These blocks are sufficiently independent from one another to allow flexible sequencing.

The estimation methods employed across the model vary according to the nature of the equations:

- Short-run equations (PAC-type) are estimated using iterative ordinary least squares (OLS). An initial guess of the PAC coefficients is used to compute a discounted expectations sequence from E-SAT, which is then included as an observable. The PAC coefficients are re-estimated based on this sequence, and the process is repeated until convergence.

- Long-run equations are estimated using simple OLS.

- The core E-SAT system is estimated using Bayesian methods, to address small-sample concerns and potential misspecification.

- Auxiliary expectation equations, used to extend E-SAT when additional expected variables are needed, are estimated with OLS.

The PAC-based equations require the specification of a discount factor, denoted β, which appears in the cost-minimization problem. Following the FRB/US methodology, we calibrate $\beta = 0.98$ in most blocks. This value corresponds to a real interest rate of approximately 8%, in line with historical averages observed in France and the United States (see Brayton et al. (1996), Garbinti et al. (2017)). An exception is made for household consumption, where a different calibration is used (see Section 3.5.1).

It is important to note that the estimation of the model is always performed under the assumption of backward-looking (VAR-based) expectations. In simulations using model-consistent expectations (MCE)[4], only the expectations mechanism is altered. The coefficients in the PAC equations remain unchanged. For instance, in the wage Phillips curve, the elasticity with respect to expected future unemployment gaps is estimated using E-SAT-based expectations. This elasticity is preserved under MCE, based on the assumption that the discounted sums of expected variables do not differ significantly between the two approaches over the historical estimation sample.

3 Overview of changes since 2019

3.1 Supply block

The supply block of the FR-BDF model is grounded in a fully specified, micro-founded framework that enables endogenous convergence toward the natural or long-run level of GDP, a key feature for defining the output gap. Built on a standard neoclassical growth model with monopolistic competition, it distinguishes between market and non-market branches. For market sectors, the supply side relies on a theoretical production function and equilibrium conditions without adjustment costs. In contrast, non-market output is treated as exogenous in conditional forecasts and assumed to grow in line with long-run real GDP in simulations. This section outlines the theoretical basis for determining target levels of business investment, employment, and the price of value added derived from first order conditions of the producer's maximisation function, and presents a model-consistent calibration of the aggregate production function.

3.1.1 Market branches supply: theoretical framework and equilibrium

In this subsection, we describe the production technology and the associated equilibrium conditions for capital services, labor input, and the value-added price, derived under the assumption of the absence of adjustment costs. For more details, please refer to Lemoine et al. (2019).

[4]For more details on the Model-consistent expectations in FR-BDF please refer to Lemoine et al. (2019)

Table 3.1.1: Variables used in Section 3.1

Notation	Description
Q_t	Value added of market branches, volume
$P_{Q,t}$	Value added deflator of market branches
K_t	Capital services, market branches excluding agricultural and real estate branches, volume
$\tilde{I}_t$	Investment, market branches excluding agricultural and real estate branches, volume
δ_t	Depreciation rate of capital
N_t	Total employment of market branches, thousands of persons
$N_{S,t}$	Salaried employment of market branches, thousands of persons
H_t	Working time per capita in market branches, hours
E_t	Solow Residual of market branches
Φ_t	Observed productivity of salaried labor in market branches
$\bar{E}_t$	Trend labor efficiency (labor-augmenting technological progress)
$\tilde{W}_t$	Total labor cost per worker, value, market branches
$\tilde{r}_{K,t}$	Real user cost of capital, excluding agricultural, real estate and public sector
$wacc_t$	Weighted average cost of capital
$\pi_{Q,t}$	Value added price inflation at time t conditional on information at time $t-1$, using E-SAT
$Q'_{K,t}$	Marginal product or return on capital, volume
$u_{N,t}$	Long run equilibrium level of unemployment, in percentage
$\bar{\psi}_t$	HP-trend share of market branches employment in total employment
$\overline{Pop}_t$	HP-trend of labor force, in thousands of persons
Q_t^{nm}	Non-market branches GDP, volume
Y_t	Total economy GDP, volume
$Q_{N,t}$	Market branches' long run value added, volume
$Y_{N,t}$	Total economy long run GDP, volume
$T_{1,t}$	Deterministic trend starting in 1990Q1
$T_{2,t}$	Deterministic trend starting in 2002Q2
$T_{3,t}$	Deterministic trend starting in 2008Q3
δ_{08Q3-}	Dummy step variable equal to 1 after 2008Q3 and 0 otherwise
δ_{20Q2-}	Dummy step variable equal to 1 after 2020Q2 and 0 otherwise
$\delta_{COVID,20q2}$	COVID-19 associated dummies

Note: tilde-marked variables are specific to this section. We use it to make a distinction between total business investment of market branches I_t and total business investment excluding agricultural, real estate and public branches investment $\tilde{I}_t$; the same applies to real user cost of capital services $\tilde{r}_{K,t}$. $\tilde{W}_t$ denotes total labor cost, i.e. gross wages *plus* employers' social contributions.

Production function Market branches' aggregate value added Q_t is determined by the following CES production function

$$Q_t = F(K_t, H_t N_t, E_t) \equiv \gamma \left[\alpha K_t^{\frac{\sigma-1}{\sigma}} + (1-\alpha)\left(E_t H_t N_t\right)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \tag{1}$$

The equilibrium investment, salaried employment and value added price equations are derived from the first order conditions and the factor price frontier, they take the form (2), (3) and (4), respectively:

$$\log \tilde{I}_t^* = a_0 + \log(Q_t) - \sigma \log\left(\frac{\tilde{r}_{K,t}}{P_{Q,t}}\right) + \log\left(\frac{\tilde{\delta}_t + g_t^K}{1+g_t^K}\right), \tag{2}$$

$$\log N_{S,t}^* = b_0 + \log(Q_t) - \log(\bar{E}_t) - \sigma \log \frac{\tilde{W}_t}{P_{Q,t}\bar{E}_t} + (\sigma - 1)\log(H_t), \tag{3}$$

$$\log(P_{Q,t}^*) = c_0 + \frac{\sigma}{1-\sigma}\log(1-\alpha) - \frac{1}{1-\sigma}\log\left[1 - \alpha^\sigma \left(\frac{\overline{Q'_{K,t}}}{\gamma}\right)^{1-\sigma}\right] + \log\frac{\tilde{W}_t}{\bar{E}_t H_t}, \tag{4}$$

where the real user cost of capital services is defined as:

$$\frac{\tilde{r}_{K,t}}{P_{Q,t}} = \left(wacc_t + \tilde{\delta}_t - PV(\pi_Q)_{t|t}\right)\frac{P_{\tilde{I},t}}{P_{Q,t}} \tag{5}$$

where $PV(\pi_Q)_{t|t}$ denotes the expected present-value of VA price inflation at time t conditional on information at time $t-1$ obtained from E-SAT, $wacc_t$ is the weighted average cost of capital and $P_{\tilde{I},t}/P_{Q,t}$ is the relative price of business investment to VA price.

Note that, as before, the Solow residual is replaced by trend labor efficiency $\bar{E}_t$ in the model equations to better capture labor-specific technical progress, as the Solow residual is volatile and influenced by both cyclical and structural factors, including capacity utilization. Instead, equilibrium conditions for labor, investment, and firm production function are evaluated using $\tilde{E}_t$, defined as efficiency at the long-run average utilization rate. This trend is estimated under three key assumptions: (i) it follows a deterministic trend with slope breaks; (ii) it includes a level shift in 2008-Q3 to reflect the lasting impact of the 2008–09 recession and an additional level shift in 2020-Q1 to incorporate the observed reduction in productivity after Covid-19 crisis; and (iii) it incorporates an autoregressive component to allow smooth adjustment to shocks. The annual trend growth rate is estimated at 2.4% before 2002-Q2, 1.4% between 2002-Q2 and 2008-Q3 and 0.7% afterwards, with the 2008-Q3 step estimated at -0.036% and the 2020-Q1 step calibrated at -0.059 %.

3.1.2 Calibration

This section updates the CES calibration procedure previously described in section 4.3.2 of Lemoine et al. (2019). While the general structure remains the same, several key components have been revised to improve the accuracy of the calibration and enhance computational time.

Overview of Previous Calibration Procedure In the previous version of the model, the CES production function was calibrated through a model-consistent procedure that jointly aligned the values of key production parameters (α, σ, γ), the markup μ, and the trend labor efficiency with the estimated long-run equilibrium conditions for business investment, employment, and value-added (VA) prices. The calibration exploited cross-equation restrictions derived from the intercepts of the theoretical equations of investment, labor and value added price in equilibrium (equations (2), (3) and (4), respectively), which were matched against their estimated values. The elasticity of substitution σ was calibrated from the firms' investment equation[5], while α and γ were selected through a grid search, their optimal values were those that minimize the deviations between the theoretical and empirical intercepts. This strategy allowed for internal consistency without requiring joint estimation, and explicitly avoided the use of normalized CES forms or "big ratios" (e.g., capital/output), which could violate the estimated behavioral equations.

Updates to the Calibration Procedure The update introduces three key innovations:

1. **Simplified Calibration of the Scale Parameter γ**

   As described above, the scale parameter γ was jointly identified with other production function parameters via a grid search. However, this procedure was computationally intensive due to the large size of the grid (over 40,000 points). To streamline the calibration process, we implemented a simplification[6], which consists in directly calibrating γ from observed macroeconomic ratios in a representative base year.

   More precisely, assuming that capital and efficiency-adjusted labor inputs are equal in the base year (i.e., $K_{T^*} = EN_{T^*}H_{T^*}$), where T^* is a base year, the CES function boils down to simply:

$$Q_{T^*} = \gamma K_{T^*} \quad \Rightarrow \quad \gamma = \frac{Q_{T^*}}{K_{T^*}}$$

   We apply this identity to calibrate γ using quarterly data for the year 2019. This year was chosen as the base year because it is close to the end of the estimation sample (2021Q4) but unaffected by the COVID-19 shock. In practice, γ is computed as the exponential of the mean log difference between value added and the capital stock:

$$\gamma = \exp\left(\frac{1}{4}\sum_{t=2019Q1}^{2019Q4}\left[\log(Q_t) - \log(K_t)\right]\right)$$

   This yields a value of $\gamma = 0.2561$, which proves to be robust to moderate changes in the choice of the base year.

[5] Note that in the business investment equation (2) we approximate the expectation term $PV(\pi_Q)_{t|t-1}$ entering the real cost of capital by the 2% annual target inflation rate, since technically the expectation terms can not be calculated before E-SAT is estimated. The details on the construction of the $wacc_t$ term are given in section 3.5.3

[6] We thank Yannick Kalantzis for this very useful suggestion

This simplification allows us to bypass the full grid search for γ, significantly reducing computational time while retaining empirical consistency with macroeconomic aggregates.

2. **Revised Estimation of the Elasticity of Substitution σ**

   The re-estimation of the substitution elasticity parameter σ over the extended sample horizon using the long-run business investment equation yielded economically unsatisfactory results. In particular, the estimated relationship between investment and the real cost of capital appeared structurally unstable, likely due to a breakdown in this correlation during the period of unconventional monetary policy and quantitative easing.

   To address this issue, σ is now estimated from the long-run equilibrium employment equation (3). This new approach exploits the role of production factors substitution in the model's structure, relies on a consistent estimate of trend labor productivity and yields a more stable and empirically plausible estimate of σ.

   However, at this preliminary stage of re-estimation, equation (3) cannot be directly estimated, as efficiency E_t—derived via inversion of the production function—depends on parameters that have yet to be identified. To circumvent this, we proxy unobserved efficiency using observed labor productivity, as defined below.

   Step 1: Estimation of Trend Labor Productivity.
   We define productivity per hour (*prodis*) as:

$$\Phi_t = \frac{Q_t}{N_{S,t} H_t}$$

   The trend component is estimated using a specification that mirrors the one used later for trend labor efficiency. It includes:

   - A persistence term;
   - A deterministic trend in three segment, with different growth rates before 2002Q2, between 2002Q3 and 2008Q2 and after 2008Q3;
   - A level shift in 2008Q3 related to the great financial crisis;
   - A COVID-related level shift in 2020Q1, calibrated to -4.3% in line with the evaluated permanent losses in labor productivity, as described in Devulder et al. (2024) and its recent update in the June 2025 Macroeconomic Projections of the Bank of France[7];
   - Dummy variables to take into consideration the outliers related to COVID-19 (Q1, Q2 and Q3 2020).

[7] Please refer to Box 3 of the June 2025 Macroeconomic Projections

The estimated trend equation is defined as:

$$\begin{aligned}\log(\Phi_t) = {} & z_1 \log(\Phi_{t-1}) + (1 - z_1)\left(z_2 + z_6\delta_{08Q3-} - 0.043\delta_{20Q2-21Q4}\right) \\ & + z_3(T_{1,t} - z_1 T_{1,t-1}) + z_4(T_{2,t} - z_1 T_{2,t-1}) \\ & + z_5(T_{3,t} - z_1 T_{3,t-1}) + z_7\delta_{COVID,20q2} \\ & + z_8(\delta_{COVID,20q1} + \delta_{COVID,20q3}) + \varepsilon_t \end{aligned} \quad (6)$$

Table 3.1.2 reports the estimated coefficients for the trend productivity equation.

Table 3.1.2: Estimates of the Trend Productivity Equation

Coefficient	Estimate	Standard Error
z_1	0.490	0.133
z_2	-3.08	0.010
z_3	0.004	0.000
z_4	-0.001	0.001
z_5	-0.002	0.000
z_6	-0.020	0.009
z_7	0.131	0.004
z_8	-0.023	0.019

$R^2 = 0.99$

Step 2: Estimation from the Target Employment Equation.
The estimate of σ is then obtained from the long-run employment equation (3). Table 3.1.3 presents the estimation results.

Table 3.1.3: Estimates of the Long-Run Employment Equation

Parameter	Estimate	Standard Error
b_0	-0.322	0.109
σ	0.4951	0.168

$R^2 = 0.95$

Figure 3.1.1 plots the residuals of the employment equation over the estimation sample, illustrating the stability of the long-run relationship.

Several additional adjustments were made to ensure consistency of the trend estimates:

- The average hours worked series was corrected to exclude distortions from partial activity schemes during the COVID crisis.
- The cost of labor per head was extended using an indicator of partial activity correction, serving as a proxy for actual remuneration during the crisis period.

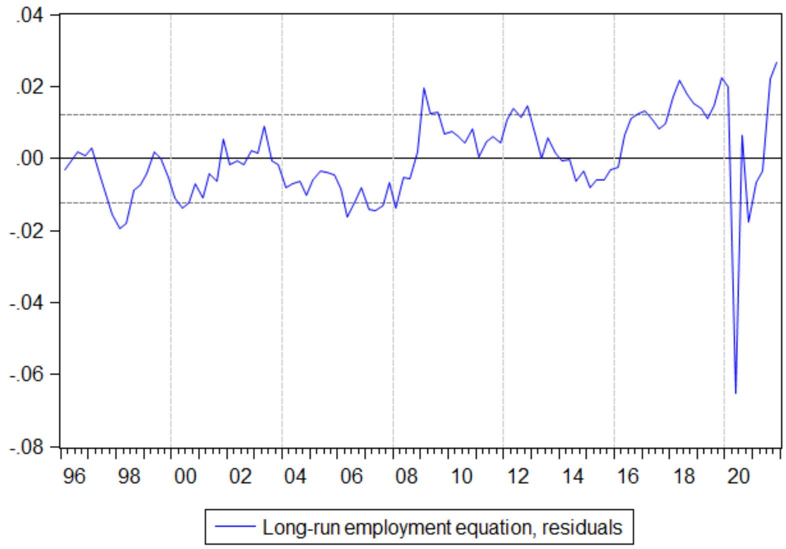


Figure 3.1.1: Residuals of the Long-Run Employment Equation

This revised approach to estimating σ enhances both the empirical robustness and theoretical consistency of the production block, particularly in light of structural changes in investment behavior post-2008.

Our re-estimated elasticity of substitution, $\hat{\sigma} = 0.5$, falls well within the range commonly reported in the empirical literature on aggregate CES production functions. As highlighted in the recent extensive meta-analysis by Knoblach & Stöckl (2020), estimates of σ exhibit considerable heterogeneity but tend to cluster between 0.3 and 0.8 for both the U.S. aggregate economy and manufacturing industries. One might have expected a higher value in our case, given that Knoblach & Stöckl (2020) report that elasticities estimated from the first-order condition (FOC) with respect to labor are typically above those derived from the capital-side condition. Nonetheless, our estimates of σ proved to be quite consistent across the two approaches. While the investment-based estimate showed instability across subsamples, the labor-side specification yielded a stable and robust estimate around 0.5. These results reinforce the now widespread consensus that the Cobb–Douglas benchmark of $\sigma = 1$ is not supported by the data. In line with findings of Knoblach et al. (2020), our estimate adds to the growing body of evidence favoring a sub-unitary elasticity of substitution.

3. **The trend of labor efficiency has been revised, affecting the calibration of α and μ.**
The assumed path for the trend of labor-augmenting technological change has been updated based on revised productivity data provided by INSEE with base-year 2020. In the new specification, shown in equation (7), we implement two simultaneous modifications designed to better align the deterministic trend with the dynamics implied

by a stochastic-trend benchmark model used for robustness validation:

- The inclusion of a second trend break after 2008Q3, in addition to a first break after 2002Q2 ;
- The post-Covid efficiency loss is calibrated at -0.059, exceeding the magnitude of the corresponding loss in labor productivity in equation (6) (-0.043). This difference reflects not only diminished labor efficiency but also incorporates the empirically observed capital-labor substitution dynamics. Alternatively, this difference can be explained by the Covid-induced level shift of the output–capital ratio, whereas this ratio is assumed to be stable in the theoretical framework underlying the FR-BDF model.

$$\begin{aligned}\log(\bar{E}_t) = {} & z_1 \log(\bar{E}_{t-1}) + (1 - z_1)\left(z_2 + z_3\delta_{08Q3-} - 0.059\delta_{20Q2-21Q4}\right) \\ & + z_4(T_{1,t} - z_1 T_{1,t-1}) + z_5(T_{2,t} - z_1 T_{2,t-1}) \\ & + z_6(T_{3,t} - z_1 T_{3,t-1}) + z_7\left(log\left(\frac{TUC_t}{avg(TUC)}\right) - z_1 log\left(\frac{TUC_{t-1}}{avg(TUC)}\right)\right) \\ & + z_8(\delta_{COVID,20q1} + \delta_{COVID,20q3}) + z_9\delta_{COVID,20q2} + \varepsilon_t \end{aligned} \tag{7}$$

These two modifications significantly improve the profile of the efficiency trend when estimated with the new INSEE data, compared to the results obtained with the old specification which included only a single trend break in 2002Q2. The specification also includes dummies related to the Covid crisis. A negative efficiency shock is observed in the first and third quarters of 2020, and a positive shock in the second quarter.

Table 3.1.4: Estimates of the Trend Efficiency Equation

Coefficient	Estimate	Standard Error
z_1	0.559	0.080
z_2	-1.964	0.014
z_3	-0.036	0.013
z_4	0.006	0.000
z_5	-0.002	0.001
z_6	-0.002	0.000
z_7	0.041	0.103
z_8	-0.025	0.014
z_9	0.103	0.034

$R^2 = 0.99$

Compared to 2019 version of FR-BDF, this new estimation leads to a lower persistence of 0.56 (instead of 0.77) and a lower long-term efficiency growth rate of 0.67 (instead of 0.87). The result largely reflects how the new efficiency specification better captures both the structural productivity losses following the 2008 crisis and the labor market disruptions during the Covid period. The lower efficiency growth rate, in turn, weighs on the long-term growth rate—which is calculated as the sum of the efficiency growth rate and the (unchanged) population growth rate.

As shown in Figure 3.1.2, the profile of the efficiency trend is also very close to the one obtained using a stochastic trend specification, including the same dummies for 2020Q2, 2020Q3, and 2020Q4. The specification of the efficiency estimation equation with two trend breaks also implies a more centered output gap, particulary during the period preceding Covid-19, very close to the one obtained using the stochastic trend efficiency.

These modifications affect the Solow residual and, in turn, the calibrated values of the capital share parameter α and the markup μ. Specifically, a slower trend in efficiency growth increases the implied contribution of capital to output, resulting in a higher calibrated markup and a shift in factor income shares.

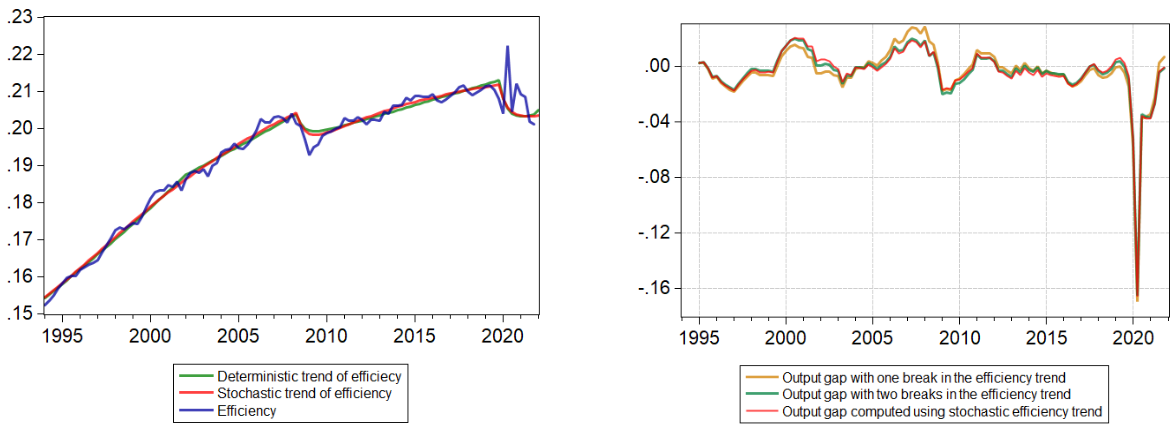


Figure 3.1.2: The reestimated efficiency trend and the output gap

These revisions aim to improve the empirical realism of the CES production function while preserving consistency with the estimated long-run equilibrium relationships in the model. Full calibration results and comparisons with the previous version are reported in Table 3.1.5.

Table 3.1.5: Calibration of the FR-BDF production function

	σ	α	γ	μ
Previous calibration	0.53	0.26	0.34	1.31
Updated calibration	0.50	0.21	0.26	1.33

3.1.3 Long run output

As before, in FR-BDF, the long-run output of market branches is derived from a production function that depends on three key components: the trend of the labor force, trend labor efficiency $\tilde{E}_t$, and the actual level of capital services (assumed to be close to its long-run value). Labor supply is constructed from HP-filtered trend hours per worker, the trend share of market employment in total employment, and the long-run unemployment rate, which is estimated using a Kalman filter applied to a Phillips curve specification.

The long-run output of non-market branches—including public services and NPISH sectors—is not based on a production function. Instead, it is computed as the residual between total GDP and market value added. Its trend is determined using an HP filter, ensuring mechanical closure of the output gap over time in line with the treatment of other trend components in the model.

The total economy's long-run output is obtained by chained-price aggregation of market and non-market components. It evolves along a balanced growth path with a constant annual growth rate of $\tilde{y}_N = 0.87\%$, which results from the sum of the estimated trend growth in labor efficiency (0.67%) and trend growth in the labor force (0.2%), based on Insee projections for the period 2015–2045.

3.2 Expectation formation

Expectations play a central role in FR-BDF, as decisions such as consumption, investment, and wage-setting depend on anticipated future values. We distinguish three types of expectations formation:

- VAR-based expectations (baseline): agents use a simplified model (E-SAT) with limited information to form expectations.
- Model-consistent expectations: agents are fully informed and optimize based on the full model.
- Hybrid expectations: some agents are fully informed whereas others have limited information.

In this section, we briefly recall how agents form expectations in the FR-BDF model and explain how these expectations enter behavioral equations through present values due to polynomial adjustment costs. We focus on the baseline setup in which expectations are backward-looking and based on a small VAR model, Expectation SATellite model – E-SAT. As the mechanisms of construction of the Model-consistent expectations is not affected by the reestimation of FR-BDF, we do not cover them in this document.[8] Note that, as before, FR-BDF allows for hybrid expectations, where agents use model-consistent expectations while others rely on E-SAT forecasts.

[8] For more details please refer to Lemoine et al. (2019)

Agents form expectations for 11 variables in the FR-BDF model. These enter behavioral equations via adjustment costs (e.g., household consumption and investment), asset pricing, and discounting.

3.2.1 E-SAT model: updated parameter estimates

The specification of the E-SAT model remains unchanged from the previous version. This is a structural VAR model in the spirit of Rudebusch & Svensson (1999), where we add shifting endpoints of inflation and the interest rate. It consists of eight semi-structural equations (8)-(15) in two blocks (France and euro area), including two IS curves, two Phillips curves, and a Taylor rule for the interest rate, as well as equations for the long run anchor of the short-term interest rate and inflation:

$$(1-\lambda_q L)\hat{y}_t = -\sigma_q(i_{t-1} - \pi_{Q,t-1} - \bar{\imath}_{t-1} + \bar{\pi}_{t-1}) + \delta_q \hat{y}_{ea,t} + \varepsilon_{q,t} \tag{8}$$

$$(1-\lambda_\pi L)(\pi_{Q,t} - \bar{\pi}_t) = \kappa_\pi \hat{y}_{t-1} + \varepsilon_{\pi,t} \tag{9}$$

$$(1-\lambda_i L)(i_t - \bar{\imath}_t) = (1-\lambda_i)(\alpha_i(\pi_{ea,t-1} - \bar{\pi}_{t-1}) + \beta_i \hat{y}_{ea,t-1}) + \varepsilon_{i,t} \tag{10}$$

$$(1-\lambda_{q,ea} L)\hat{y}_{ea,t} = -\sigma_{q,ea}(i_{t-1} - \pi_{ea,t-1} - \bar{\imath}_{t-1} + \bar{\pi}_{ea,t-1}) + \varepsilon_t^{q,ea} \tag{11}$$

$$(1-\lambda_{\pi,ea} L)(\pi_{ea,t} - \bar{\pi}_{ea,t}) = \kappa_{\pi,ea} \hat{y}_{ea,t-1} + \varepsilon_t^{\pi,ea} \tag{12}$$

$$(1-\lambda_{\bar{\imath}} L)(\bar{\imath}_t - \bar{\imath}) = \varepsilon_{\bar{\imath},t} \tag{13}$$

$$(1-\lambda_{\bar{\pi}} L)(\bar{\pi}_t - \bar{\pi}) = \varepsilon_{\bar{\pi},t} \tag{14}$$

$$(1-\lambda_{\pi,\bar{e}a} L)(\bar{\pi}_{ea,t} - \bar{\pi}_{ea}) = \varepsilon_{\bar{\pi},ea,t} \tag{15}$$

This core E-SAT system is not sufficient when agents form expectations about variables not explicitly included in the baseline specification. In such cases, it is necessary to introduce auxiliary equations to account for expectations related to these additional target variables. For example, if expectations are required for a target variable n_t^*, agents must anticipate the evolution of its cyclical component $\hat{n}_t^*$. This can be modeled by augmenting the E-SAT system with two additional equations: one governing the dynamics of $\hat{n}_t^*$ as a function of the output gap, the real interest rate, and the inflation gap; and another assuming a random walk in the growth rate of the trend component $\bar{n}_t^*$. For more details on the extension of the E-SAT with auxiliary equations refer to Lemoine et al. (2019) .

Estimation The estimation methodology remains unchanged. We use Bayesian techniques to estimate the core equations on de-trended data, taking advantage of prior distributions to mitigate issues related to small sample size and potential model misspecification. See Lemoine et al. (2019) for the detailed description of priors for each parameter.[9]

The estimation sample for equations (13)-(15) spans the period from 1999Q1 to 2019Q4. The choice of the starting date corresponds to the introduction of the euro, which marked a structural break in the monetary and financial environment of the euro area. The end of

[9] Note that E-SAT can be split in two blocks corresponding to the short-run dynamics (equations (8) -(12)) and the long-run anchors (equations (13)-(15)). These two blocks can be estimated separately, which is computationally efficient.

the sample precedes the COVID-19 crisis in order to avoid the distortions in macroeconomic relationships that emerged during and immediately after the pandemic. While using a longer sample, such as up to 2021Q4, might be tempting for consistency across model components, we consider that the immediate post-COVID years remain too close to the crisis to be treated reliably without specific adjustments. Such a strategy of simply dropping Covid-related observations for the parameter estimation has been validated by Lenza & Primiceri (2022).[10]

Changes to variables We update the time series used for estimation as follows:

- The series for the target of the short-term interest rate $\bar{i_t}$ is now calculated using 3-month OIS rate instead of 3-month Euribor rate. Note that we center this series by demeaning it to ensure convergence.
- The inflation target for both France $\bar{\pi}$ and $\bar{\pi}_{ea}$ the euro area is now 2% annually, consistent with the ECB's current objective.
- The short-term interest rate now corresponds to the 3-month overnight index swap (OIS) rate (instead of 3-month Euribor as before), interpolated with Eonia for the pre-1999 period. When the observed 3-month OIS turns negative, it is replaced by a synthetic proxy rate in the spirit of Choi et al. (2022) constructed for France by the BdF as described in Jude & Levieuge (2024). This proxy rate provides a more accurate measure of the effective monetary policy stance at the zero lower bound, as it maps the full set of observed market rates capturing financing conditions in France into an equivalent 3-month OIS level.
- All other series are constructed as before, with updated vintages: the French output gap is computed as the deviation of actual value added from its estimated long-run level. For the euro area, both the output gap and inflation are sourced from Eurostat, with inflation measured using the GDP deflator. French inflation is defined as the quarterly growth rate of the value added deflator. Long-run inflation expectations for both France and the euro area are drawn from Consensus Economics forecasts, based on an average horizon of 5 to 10 years. For the euro area, long-run expectations prior to 2002 are constructed using a weighted average of five countries: France, Germany, Italy, the Netherlands, and Spain.

Updated estimation results Table 3.2.1 shows the updated posterior estimates.

The re-estimated parameters exhibit several noteworthy shifts relative to the original estimation, suggesting a model with more responsive short-run dynamics and stronger interactions between domestic and euro area variables, potentially enhancing the empirical

[10] For future updates of the E-SAT model, the approach proposed by Lenza & Primiceri (2022) offers a promising solution. Their method explicitly accounts for the sharp increase in shock volatility observed during the COVID-19 period, leveraging the fact that the timing of this volatility shift is known. Compared to standard models of time-varying volatility, their framework is both more flexible and easier to implement, making it particularly well-suited for integration into the E-SAT structure.

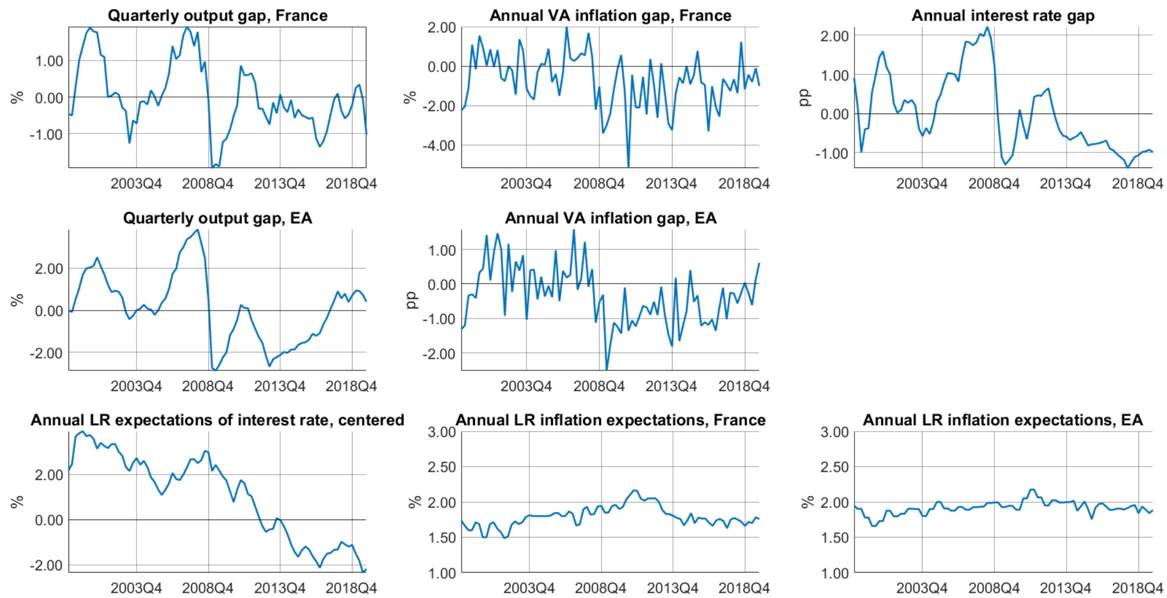


Figure 3.2.1: Updated time series used for the estimation of E-SAT

relevance of E-SAT under current macroeconomic conditions. The following changes are worth noting.

The new set of estimates features a general decline in persistence parameters across nearly all equations, including a marked decrease in λ_q, which implies that French output is now estimated to be less persistent over time. In macroeconomic terms, this translates into a more reactive economy, in which output adjusts more quickly in response to shocks. This increased responsiveness may reflect structural changes, improved adjustment mechanisms, or simply a better empirical fit to updated data.

The increase in δ_q points to a stronger correlation between the French and euro area output gaps, indicating deeper cyclical integration within the euro area. This suggests that French economic activity is increasingly shaped by broader euro area conditions, which aligns with the open-economy framework of the FR-BDF model.

On the inflation side, the rise in κ_π implies that French inflation now reacts more strongly to fluctuations in the domestic output gap. This is consistent with a steeper Phillips curve, in which deviations from potential output have a more immediate effect on inflation dynamics. Such a shift may reflect changes in price-setting behaviour or greater supply-side sensitivity.

Finally, changes in the Taylor rule parameters—specifically, a lower α (inflation responsiveness) and a higher β (output gap responsiveness)—suggest a rebalancing in the monetary policy reaction function. The updated estimates place relatively more weight on stabilising real activity and slightly less on inflation. This may reflect the empirical behaviour of

Table 3.2.1: Full Comparison of E-SAT Parameters

Parameter	Interpretation	Previous value	Reestimated value
λ_{π}	Persistence of inflation, FR	0.5751	0.4018
$\lambda_{\bar{\pi}}$	Persistence of long-term inflation, FR	0.9371	0.9468
$\lambda_{\bar{\pi},ea}$	Persistence of long-term EA inflation	0.9341	0.7649
$\lambda_{\bar{\imath}}$	Persistence of long-term interest rates	0.9850	0.9850
λ_{q}	Persistence of output, FR	0.7278	0.6014
$\lambda_{q,ea}$	Persistence of EA output	0.9318	0.9283
$\lambda_{\pi,ea}$	Persistence of EA inflation	0.3539	0.3185
λ_{i}	Persistence of interest rate	0.9243	0.8994
κ_{π}	Slope of the Phillips curve, FR	0.0759	0.0979
σ_{q}	IS curve slope, FR	0.2798	0.2624
$\sigma_{q,ea}$	IS curve slope, EA	0.5445	0.5757
$\kappa_{\pi,ea}$	Slope of the EA Phillips curve	0.0350	0.0507
α	Inflation coefficient in Taylor rule	1.1854	1.0411
δ_{q}	Spillover effect from EA output	0.0784	0.1942
β	Output gap coefficient in Taylor rule	0.0914	0.1263
i_{bar}	Long-run anchor of the interest rate	0.0092	0.0077
π_{bar}	Long-run anchor of the inflation	0.0048	0.0050

monetary policy in recent years, particularly in the context of the effective lower bound. Note that, as in the previous version, the parameter $\lambda_{\bar{\imath}}$ is calibrated to 0.985 to generate a term premium within FR-BDF that aligns with the term structure model used at the Banque de France. Upon verification, this value continues to yield a term premium consistent with the output of that model.

3.2.2 E-SAT Impulse responses

To visualise the effect of the changes in the E-SAT block, we recompute the impulse response functions using the new estimates and compare them to their 2019 counterparts. Figures 3.2.2 and 3.2.3 show the responses of variables to the interest rate shock and EA output shock.

The updated impulse response functions reflect the revised parameter estimates, most notably a general decline in persistence across equations, as captured by the lower values of the λ parameters. In the case of a monetary policy (interest rate) shock, the dynamic responses remain broadly in line with those from the previous estimation: the new IRFs lie well within the confidence bands of the earlier specification, indicating limited change in transmission mechanisms.

In contrast, the responses to an output gap shock in the euro area exhibit more pronounced differences. The increased sensitivity of the French output gap reflects a higher estimated value for δ_q, suggesting stronger cross-country spillovers. A stronger interest rate response is attributable to the upward revision of β, while the larger inflation response in the euro area

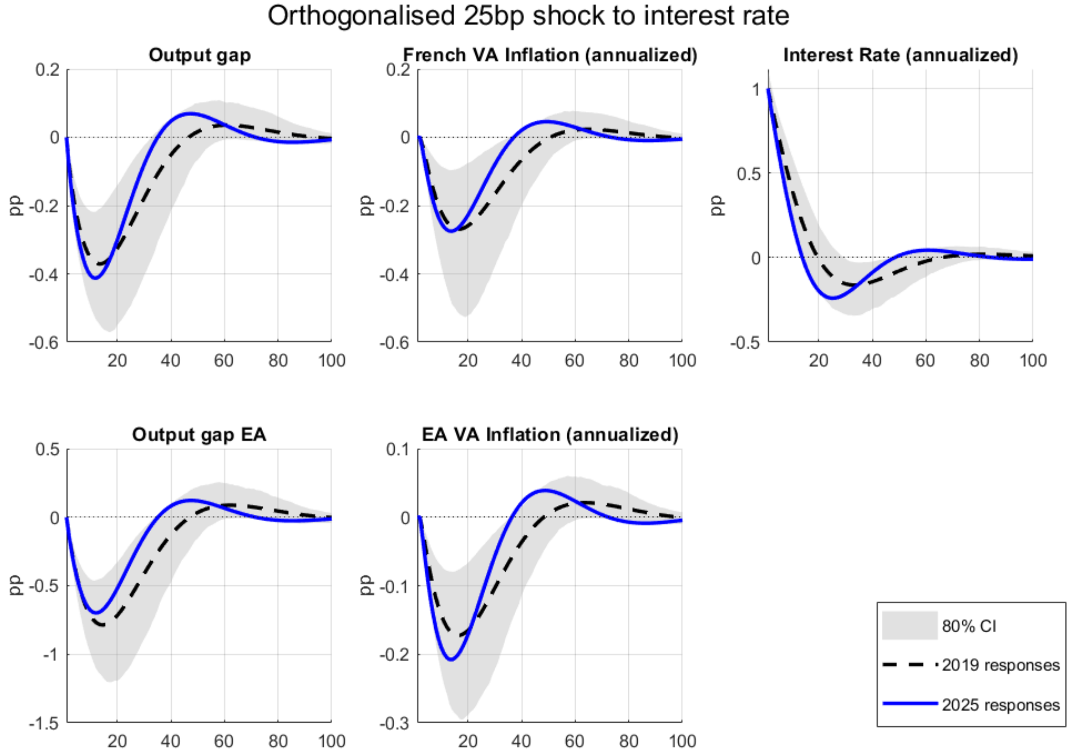


Figure 3.2.2: Impulse responses for E-SAT of French and euro area variables to an interest rate shock

Note: Blue lines correspond to the IRFs using the reestimated parameters, black dashed lines and shaded areas correspond to IRFs as in Lemoine et al. (2019) and their 80% confidence intervals.

is consistent with a higher value of $\kappa_{\pi,ea}$, indicating a steeper Phillips curve.

3.2.3 A brief reminder of the construction of expectations for VAR-based expectations

To generate expectations for FR-BDF variables outside those entering the core vector autoregression, E-SAT is augmented with auxiliary equations that map the additional variable to core observables. For example, business investment depends on expectations of the deviation of market value added from its trend; accordingly, an auxiliary equation links the deviation of current value added to its own lag and to the output gap embedded in the E-SAT core. These auxiliary equations are estimated separately and do not affect the core E-SAT coefficients.

Operationally, expectation formation in E-SAT deviates from conventional DSGE implementations: the model is solved forward, and agents form expectations over infinite discounted sums of the relevant variables, starting one period ahead and extending to the long run. Within each short-run behavioural equation, these discounted long-horizon objects are com-

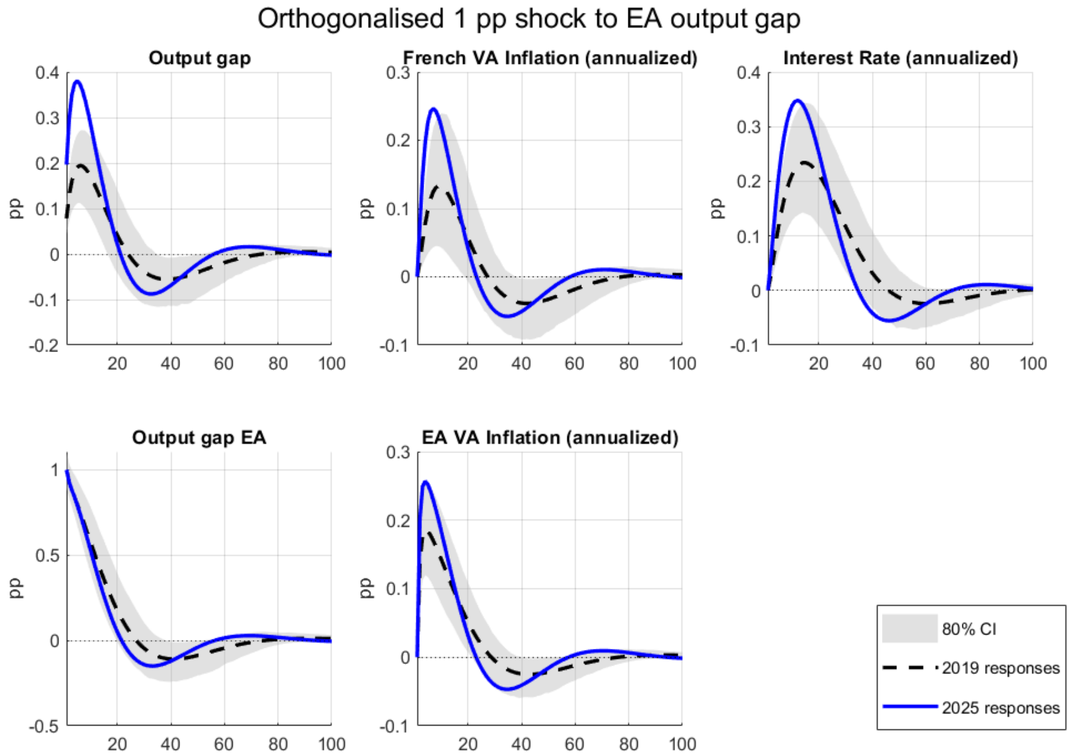


Figure 3.2.3: Impulse responses for E-SAT of French and euro area variables to a shock to euro area output gap

Note: Blue lines correspond to the IRFs using the reestimated parameters, black dashed lines and shaded areas correspond to IRFs as in Lemoine et al. (2019) and their 80% confidence intervals.

puted projecting forward the core E-SAT matrix augmented with coefficients arising from the auxiliary equations, with effective discount factors estimated jointly with the other parameters of the equation to internalize the presence of adjustment costs. Thus, when factor adjustment—e.g., labour—is costly, agents optimally attach greater weight to future economic conditions relative to the contemporaneous stance.

Technically, in the VAR-based expectations mode, expectations are computed as policy functions obtained from the inversion of the estimated core E-SAT, supplemented by the auxiliary equations when required. The coefficients of the policy functions are thus informative on the factors driving the expectations, and we therefore report these updated coefficients alongside the estimated parameters of the long-term and short-term equations.

3.3 Value added price

The value-added price equation is a central component of FR-BDF, as its deflator feeds into the determination of all other price equations. It provides the channel through which expectations influence price setting.

Neither the target equation nor the short-term equation have undergone any structural modification relative to the 2019 version of this block. The sole adjustment concerns the short-term equation, where the inclusion of dummy variables serves to improve empirical fit.

Table 3.3.1: Variables used in section 3.3

Notation	Description
$\overline{Q'_{K,t}}$	Hodrick-Prescott filter of marginal product or return on capital, volume
H_t	Working time per capita (in hours)
$\tilde{W}_t$	Total labor cost per capita, gross wages plus employers' social contributions, value
$\bar{E}_t$	Long run efficiency
$\Delta\bar{e}_t$	Efficiency trend, $\Delta log(\bar{E}_t)$
$p_{Q,t}$	Value added price of market branch (in log)
$p^*_{Q,t}$	Target of the value added price (in log)
$\bar{\pi}^*_{Q,t}$	Hodrick-Prescott filter of $\pi^*_{Q,t}$
$\bar{\pi}_t$	Long run anchor of inflation
$\pi_{Q,t}$	Value added price inflation
$\hat{y}_t$	Output gap
$\pi_{W,t}$	Growth rate of wage per capita of market branches (without employer social contributions)
$PV(\pi^*_Q)_t$	Present value of the expected growth rate of the value added price target
$\bar{\pi}$	Long run value of inflation
δ_i	Dummy variables for quarter i
$\tilde{\pi}_{W,t}$	Efficient wage inflation
$\hat{u}_t$	Unemployment gap

Target The long-run behavior of the VA price is determined by the price frontier. It is formalized in equation (4), discussed in detail in section 3.1, where the logarithm of the price target is a function of the marginal productivity of capital and the efficient hourly labor cost:

$$p^*_{Q,t} = c_0 + \frac{\sigma}{1-\sigma}\log(1-\alpha) - \frac{1}{1-\sigma}\log\left[1-\alpha^\sigma\left(\frac{\overline{Q'_{K,t}}}{\gamma}\right)^{1-\sigma}\right] + \log\frac{\tilde{W}_t}{\bar{E}_t H_t}$$

As explained in section 3.1.2, all the parameters of this equation are calibrated with the exception of the constant, which is estimated on the 1995q1-2021q4 sample. The values, both calibrated and estimated, are given in Table 3.3.2.

Table 3.3.2: Estimates and calibrated parameters, value added price, long run

	Coef.	s.e.
σ	0.4951	-
α	0.21	-
γ	0.26	-
c_0	1.64	0.001
$R^2 = 0.97$		

Short run equation The short run is estimated using the PAC framework on the 1998Q1-2021Q4 sample. As in the case of the short-run equation of the business equation described in section 3.5.3, the equation contains a contemporaneous demand term $\hat{y}_t$ which is supposed to capture in a reduced form the behavior of non-optimizing firms. Several dummies are added to improve the empirical fit of the equation. The term $\bar{\pi}^*_{Q,t}$ corresponds to the long run anchor of the inflation and is computed using the Hodrick-Prescott filter of the long-run inflation. The parameter estimates are presented in Table 3.3.3.

$$\begin{aligned}\pi_{Q,t} = PV(\pi^*_Q)_{t|t-1} + \beta_0\left[p^*_{Q,t-1} - p_{Q,t-1}\right] + \beta_1\pi_{Q,t-1} + \beta_2\hat{y}_t + (1-\beta_1-\omega)\bar{\pi}^*_{Q,t-1} \\ +\beta_3\delta_{03Q2} + \beta_4\delta_{10Q4} + \beta_5\delta_{COVID,20Q1} + \beta_6\delta_{COVID,20Q2} \\ +\beta_7\delta_{COVID,20Q3} + \beta_8\delta_{COVID,21Q1} + \beta_9\delta_{06Q3} + \beta_{10}\delta_{08Q1} + \epsilon_t\end{aligned} \tag{16}$$

Table 3.3.3: Estimates and calibrated parameters, value added price, short run

	Coef.	s.e.
β_0	0.05	0.02
β_1	0.20	0.08
β_2	0.09	0.03
ω	0.62	-
β_3	0.01	0.00
β_4	-0.01	0.00
β_5	0.01	0.00
β_6	0.03	0.01
β_7	-0.01	0.00
β_8	-0.01	0.00
β_9	0.01	0.00
β_{10}	0.01	0.00
$R^2 = 0.61$		

The parameter values remain broadly consistent with their 2019 counterparts. The most notable adjustment concerns the lag coefficient, β_1, which decreased from 0.5 to 0.2, indicating somewhat greater volatility in the VA inflation rate toward the end of the estimation sample.

Expectations As in the previous version, the construction of expectations for the growth rate of the value-added price target requires the inclusion of three auxiliary equations in the core of the E-SAT model. The specifications of these equations remain unchanged; they have simply been re-estimated on the updated sample. For ease of reference, we report them below:

Target dynamics:

$$\pi^*_{Q,t} = \beta_0(\pi_{W,t} - \Delta\bar{e}_t) + (1-\beta_0)\bar{\pi}^*_{Q,t} + \epsilon_t \tag{17}$$

Phillips curve, linking the real effective wage to the unemployment gap:

$$(1-\rho L)\left[\pi_{W,t} - \Delta\bar{e}_t - \bar{\pi}^*_{Q,t}\right] = \beta_0\hat{u}_t + \epsilon_t \tag{18}$$

where L is a lag operator.

Okun's law, relating the unemployment gap to the output gap with an AR(1) process in residuals:

$$\begin{cases} \hat{u}_t = \beta_0\hat{y}_t + \eta_t \\ \eta_t = \rho\eta_{t-1} + \epsilon_t \end{cases} \Rightarrow \hat{u}_t = \beta_0(\hat{y}_t - \rho\hat{y}_{t-1}) + \rho\hat{u}_{t-1} + \epsilon_t \tag{19}$$

The fourth auxiliary equation is purely technical and defines the dynamics of the long-term efficiency:

$$\Delta\bar{e}_t = \Delta\bar{e}_{t-1} + \epsilon_t. \tag{20}$$

The estimated parameters are available in Table 3.3.4.

Table 3.3.4: Policy function of the growth rate of the value added price target

Regressors	**Policy function** $PV(\pi^*_Q)_{t\|t-1}$	**Aux. equation** $\pi^*_{Q,t}$ **(eq (17))**	**Aux. equation** $\tilde{\pi}_{W,t}$ **(eq (18))**	**Aux. equation** $\hat{u}_t$ **(eq (19))**
E-SAT Model variables				
$\hat{y}_{t-1}$	$-2.1 \cdot 10^{-3}$	-	-	0.18
$i_{t-1} - \bar{i}_{t-1}$	$-3.5 \cdot 10^{-3}$	-	-	-
$\pi_{Q,t-1} - \bar{\pi}_{Q,t-1}$	$3 \cdot 10^{-4}$	-	-	-
$\hat{y}_{EA,t-1}$	$6.5 \cdot 10^{-4}$	-	-	-
$\pi_{EA,t-1} - \bar{\pi}_{EA,t-1}$	$1.2 \cdot 10^{-4}$	-	-	-
$\hat{u}_{t-1}$	$-1.4 \cdot 10^{-2}$	-	-	0.96 [0.03]
$\tilde{\pi}_{W,t-1}$	$0.5 \cdot 10^{-2}$	-	0.12 [0.1]	-
$\bar{\pi}^*_{Q,t-1}$	0.62	-	-0.12 [0.1]	-
$\hat{y}_t$	-	-	-	−0.18 [0.06]
$\hat{u}_t$	-	-	−0.04 [0.05]	-
$\tilde{\pi}_{W,t}$	-	0.71 [0.12]	-	-
$\bar{\pi}^*_{Q,t}$	-	0.29 [0.12]	-	-
		$R^2 = 0.42$	$R^2 = 0.01$	$R^2 = 0.94$

Note: standard errors in brackets. $\tilde{\pi}_{W,t} = \pi_{W,t} - \Delta\bar{e}_t$.

With respect to the previous estimates, β_0 from the Okun's law in equation ((19)) has become lower in absolute value (from -0.24 to -0.18) but still within the marginal error of estimation and in line with the discussion in subsection 3.4.1. The slope of the long-run Phillips curve measured by the ratio $\frac{\beta_0}{1-\rho}$ from equation (18) has lowered from 0.53 to 0.46, consistent with the lower β_0 from the Okun's law, but still lies in the boundaries of commonly accepted values. This reassessment complements the steeper Phillips curve estimated within the E-SAT block, which should be interpreted as capturing short-run rather than long-run link between inflation and economic activity. The policy function shows that the dynamics of the expected target value-added price inflation is driven to a large extent by the trend of the target value-added price, unemployment rate target and the deviation of the wage inflation from its trend.

Dynamic contributions Figure 3.3.1 describes how the various components contribute dynamically to the variation in the value-added price. The blue line traces the observed annual growth rate of the value-added price, while the stacked bars report the estimated contributions of the main structural and cyclical determinants.

Labor-related components account for a substantial share of the variation in VA price inflation. In particular, efficiency-adjusted wage is the most prominent contributor and exerts a persistently positive influence on VA price growth over the entire sample. Cyclical demand conditions, captured by the output gap, provide more transient contributions. Positive output-gap effects support higher inflation during periods of strong activity—particularly in the early and mid-2000s—while downturns such as 2009 and 2020 generate sizable negative contributions. Other determinants, including the real cost of capital and expectations generally play a modest yet steady role, with the latter acting as a dampening factor when shocks affect the VA price target.

3.4 Labor market

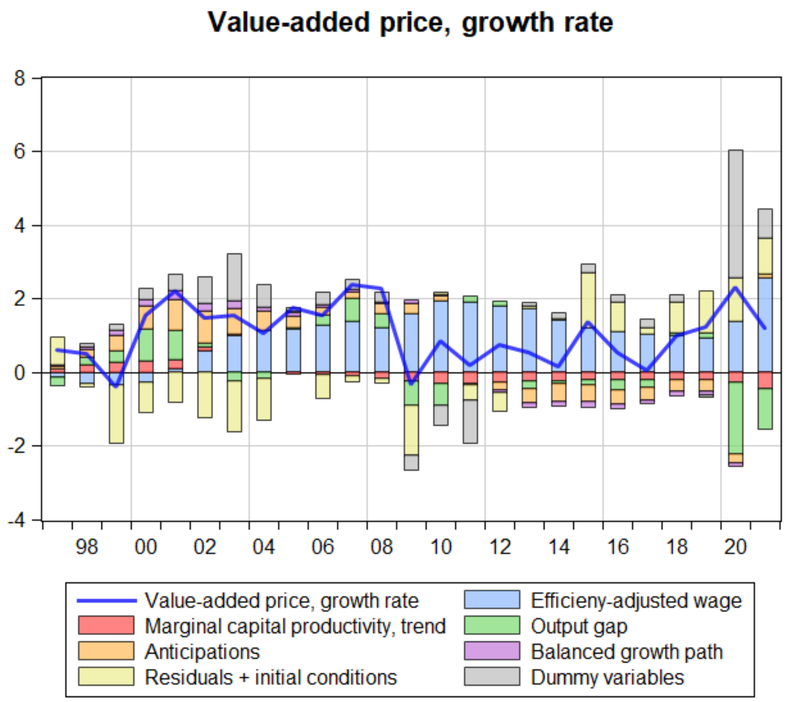
The labor market section consists of two components:(i) Labor supply, represented by the wage Phillips curve, which describes the relationship between wage inflation and the expected unemployment gap (subsection 3.4.1); and (ii) Labor demand, captured by the employment equation, which links employment to labor costs and overall demand, accounting for adjustment costs (subsection 3.4.3).

3.4.1 Labor supply

In the long run the labor supply curve is vertical: the wage elasticity of supply is zero. The unemployment rate is anchored to an exogenously defined long run level, $u_{N,t}$.

In the short run, the labor supply in FR-BDF is defined by a wage Phillips curve. The equation is augmented with hybrid indexation to take on board a role for the expected unemployment gap. The wage equation is microfounded. It is derived from the first order condition of agents' optimization problem with respect to leisure. It is important to bear in mind that as FR-BDF is a semi-structural model, the wage equation is not derived jointly

Figure 3.3.1: Dynamic contributions, value added price, pp of growth rate



with the consumption/saving decision, i.e. we do not impose cross-restrictions between coefficients. We follow Gali et al. (2011), and consider the following New Keynesian wage Phillips curve with indexation:

$$\pi_{W,t} - x_{t-1} = \alpha + \beta E_{t-1}\left(\pi_{W,t+1} - x_t\right) - \lambda(u_t - u_{N,t}) \tag{21}$$

where the variable x_{t-1} captures the indexation of households unable to optimize their wage in the current period. This indexation variable is determined by the following equation:

$$x_{t-1} = c_1\pi_{C,t-1} + c_2\left(\pi_{W,t-1} - c_1\pi_{C,t-2}\right) \tag{22}$$

For notations see Table 3.4.1.

Along with indexation, we also add a real efficient minimum wage, computed as the minimum wage per capita adjusted for labor efficiency and long run anchor of inflation. It enters the equation as a year-on-year growth rate (Δ_4) in order to solve the seasonality issue. The minimum wage centered by its trend ($\pi_{C,t} + \Delta\bar{e}_t$) is endogenized as follows. First we compute the hourly minimum wage:

$$w_t^{hm} = \delta_{q1}\left(\pi_{4,C,t-1} + \Delta_4\bar{e}_{t-1} + 0.5\left(\pi_{4,W^h,t-2} - \pi_{4,C,t-2} - \Delta_4\bar{e}_t\right)\right) + \epsilon_t \tag{23}$$

where δ_{q1} is a dummy that takes on a value of 1 in the first quarter of each year; $\pi_{4,C,t}$ is year on year consumer price inflation and $\pi_{4,W^h,t}$ is year on year hourly wage inflation. Similarly to the government's indexation formula, the specification of this equation takes into account

Table 3.4.1: Variables used in section 3.4.1

Notation	Description
wage Phillips curve	
w_t^h	Gross wage per hour of market branches(in log)
w_t	Gross wage per head of market branches(in log)
$\pi_{W,t}$	Wage inflation
w_t^{hm}	Gross hourly minimum wage(in log)
w_t^m	Gross per capita minimum wage(in log)
$\pi_{C,t}$	Growth rate of the consumption deflator
$p_{C,t}$	Consumption price(in log)
$\bar{e}_t$	Long-run efficiency(in log)
$\Delta\bar{e}$	The long run anchor of the efficiency growth rate
$PV(\hat{u})_{t\|t-1}$	Present value of the expected average of future unemployment gaps
u_t	Unemployment rate
$u_{N,t}$	Long-run trend of the unemployment rate
$\bar{\pi}_t$	Long-run anchor of inflation
$\delta_{COVID,i}$	COVID-associated dummies
E-SAT	See Table 3.2.1
$\hat{u}_t$	Unemployment gap

the sensitivity of the minimum wage to consumer price inflation and to real wages with lags. However, we made some changes compared to the government formula: we used variables for prices and wages directly available from the model as proxies for variables actually used by the government (consumer price index excluding tobacco of the first income quintile and manual workers basic hourly wage); we included long run anchors in the formula for ensuring the long run stability of the ratio of the minimum wage with respect to the average wage, while this long run stability is ensured by the government through additional positive exogenous shocks referred to as "coups de pouce". Then we compute the average per capita minimum wage w_t^m used to compute the real efficient minimum wage. To improve the forecasting process of wages, we also added an alternative equation for the monthly basic wage. This series is used as a proxy for the manual workers' basic hourly wage and is intended to be closer to the government formula during forecasting exercises. See 3.4.2 for details.

Solving forward equation (21), ignoring the explosive solution and accounting for the balanced growth path, we obtain the wage Phillips curve that we take to the data, augmented with dummy variables to account for the Covid crisis:

$$\pi_{W,t} = \beta_0 + [\Delta\bar{e}_t + \bar{\pi}_t] + \beta_1(\pi_{C,t-1} - \bar{\pi}_{t-1}) + \beta_2[\pi_{W,t-1} - \Delta\bar{e}_{t-1} - \bar{\pi}_{t-1} - \beta_1(\pi_{C,t-2} - \bar{\pi}_{t-2})]$$
$$+\beta_3\bigg(\Delta_4(w_{t-1}^m - e_{t-1}) - \bar{\pi}_{t-1}\bigg) + \beta_4 PV(\hat{u})_{t-1|t-2} + \beta_5\delta_{COVID,20q1} + \beta_6\delta_{COVID,20q3} + \epsilon_t^w \quad (24)$$

In equation (24) presented above, we had to include β_0 in the specification in order to center the residuals which were negative on average. We used only one long run trend ($\bar{\pi}_t$) for all inflation types, including wage inflation. This trend was computed using the Consensus forecast of consumer price inflation. The mean of the latter was higher than the mean of any other inflation over the estimation sample period (1997Q2 - 2021Q4), implying that the wage inflation trend $[\Delta \bar{e}_t + \bar{\pi}_t]$ was on average higher than the mean of this series during this period, which leads to negative residuals. In FR-BDF we modify equation (24) so that the constant disappears with time and $\pi_{W,t}$ converges toward the balanced growth path.

Note that the present value of the expected sum of future unemployment gaps $PV(\hat{u})_{t-1|t-2}$ enters the equation in $t-1$ and hence is based on the information of $t-2$. In order to compute this variable, we added an auxiliary equation to the core of E-SAT that is in line with Okun's law:

$$\begin{cases} \hat{u}_t = \beta_0 \hat{y}_{t-1} + \epsilon_{u,t} \\ \epsilon_{u,t} = \rho \epsilon_{u,t-1} + \epsilon_t \end{cases} \Rightarrow \hat{u}_t = \beta_0(\hat{y}_{t-1} - \rho \hat{y}_{t-2}) + \rho \hat{u}_{t-1} + \epsilon_t \quad (25)$$

The estimates of the policy function, together with those of the auxiliary equation, are available in Table 3.4.2. The estimated value of β_0 – the key coefficient of this equation – is at -0.20 somewhat lower than in the 2019 version of the FR-BDF model, where it was estimated to be -0.27.

Table 3.4.2: Policy function of the expected discounted sum of future unemployment gaps

VAR Model variables	**Policy function** $\boldsymbol{PV(\hat{u})_{t\|t-1}}$	**Auxiliary equation** $\boldsymbol{\hat{u}_t}$
$\hat{y}_{t-1}$	-0.01	-0.20 [0.07]
$i_{t-1} - \bar{i}_{t-1}$	0.08	-
$\pi_{Q,t-1} - \bar{\pi}_{Q,t-1}$	0.005	-
$\hat{y}_{EA,t-1}$	-0.01	-
$\pi_{EA,t-1} - \bar{\pi}_{EA,t-1}$	-0.002	-
$\hat{y}_{t-2}$	0.06	-
$\hat{u}_{t-1}$	0.30	0.95 [0.033]

Note: standard errors in brackets. $R^2 = 0.94$ for the auxiliary equation.

The estimates of equation (24) are presented in Table 3.4.3. The wage Phillips curve strongly influences the relation between the unemployment rate and inflation of the model. Using estimated parameters, we compute the Phillips slope $\left(\frac{\partial \pi_t}{\partial u_t}\right)$ in partial equilibrium making the following assumptions:

- to account for price indexation, we assume that a 1 pp change in $\pi_{W,t}$ results in a 1 pp change in $\pi_{C,t}$.

- we set the Okun's law parameter to 3.7 (which is consistent with an estimate of the auxiliary equation), i.e. a 1 pp increase in the output gap leads to a 0.37 pp decrease in the unemployment gap.

$$\frac{\partial \pi_t}{\partial u_t} = \frac{-0.31 \cdot [3.7 \cdot (-0.01) - 0.30]}{(1 - (0.25 + 0.31 \cdot (1 - 0.25)))} = 0.21 \tag{26}$$

This leads to an elasticity of inflation with respect to the output gap of 0.2 in annual terms, which is quite below the one obtained in the 2019 FR-BDF model.

Table 3.4.3: Coefficients and standard errors of the wage Phillips curve equation

	Coef.	s.e.
β_0	$-6 \cdot 10^{-4}$	$3 \cdot 10^{-4}$
β_1	0.25	0.08
β_2	0.17	0.1
β_3	0.12	0.1
β_4	-0.31	0.16
β_5	0.015	$9 \cdot 10^{-4}$
β_6	0.019	$6 \cdot 10^{-4}$

$R^2 = 0.97$

3.4.2 Other wage equations

Table 3.4.4: Variables used in section 3.4.2

Notation	**Description**
Negotiated wages	
$\pi_{Wneg,t}$	Annual growth rate of negotiated wages, y-o-y
W_t^{hm}	Gross hourly minimum wage, level
$P_{C,t}$	Consumption price, level
Monthly basic wage	
W_t^b	Monthly basic wage, level

Two additional equations have been added recently to the FR-BDF labor block: one describing the dynamics of negotiated wage and one describing the dynamics of the monthly basic wage. The dynamics of negotiated wages and wage drift provide useful information for forecasters to predict the short-term evolution of wages per head. As mentioned above, the monthly basic wage is also used as a proxy for the manual workers basic hourly wage, which in France is part of the formula for indexing the minimum wage.

Negotiated wage

As described in (27), the dynamics of the negotiated wage are described in terms of its annual growth rate $\pi_{Wneg,t}$, which is related to the lagged unemployment gap $\hat{u}_{t-1}$, consumer prices and the minimum wage via the year-on-year inflation terms $\left(\frac{P_{t-2}}{P_{t-6}} - 1\right)$ and $\left(\frac{W_t^{hm}}{W_{t-4}^{hm}} - 1\right)$ and to a large set of dummies related to the COVID-19 episode. The associated estimation results are presented in Table 3.4.5.

$$\begin{aligned}\pi_{Wneg,t} = \beta_0 + 100\beta_1\hat{u}_{t-1} + 100\beta_2\left(\frac{P_{t-2}}{P_{t-6}} - 1\right) + 100\beta_3\left(\frac{W_t^{hm}}{W_{t-4}^{hm}} - 1\right) + \beta_4\pi_{Wneg,t-1} \\ +\beta_5\delta_{COVID,20Q1} + \beta_6\delta_{COVID,20Q2} + \beta_7\delta_{COVID,20Q3} + \beta_8\delta_{COVID,20Q4} \\ +\beta_9\delta_{COVID,21Q1} + \beta_{10}\delta_{COVID,21Q3} + \beta_{11}\delta_{COVID,21Q4}\end{aligned} \tag{27}$$

Table 3.4.5: Coefficients and standard errors of the negotiated wage equation

	Coef.	s.e.
β_0	0.36	0.08
β_1	-0.14	0.04
β_2	0.06	0.03
β_3	0.05	0.03
β_4	0.67	0.06
β_5	-0.14	0.03
β_6	-0.28	0.03
β_7	-0.16	0.04
β_8	-0.3	0.05
β_9	-0.46	0.06
β_{10}	-0.25	0.06
β_{11}	-0.4	0.09

$R^2 = 0.94$

Monthly basic wage

Equation (28) relates the inflation (approximated with a log difference) of the monthly basic wage to similar approximating terms of consumer price inflation (contemporaneous and first and fourth lags), contemporaneous inflation of the minimum wage and the first lag of the inflation of the monthly basic wage itself. The equation also includes $\delta_{Q1,post-1998}$, a dummy-like variable that equals one in the first quarter of every year after 1998. The estimation results are presented in Table 3.4.6.

$$\begin{aligned}\Delta\text{log}W_t^b = \beta_0 + \beta_1\Delta\text{log}P_t + \beta_2\Delta\text{log}P_{t-1} + \beta_3\Delta\text{log}P_{t-4} + \beta_4\hat{u}_t + \beta_5\Delta\text{log}W_t^{hm} \\ +\beta_6\delta_{Q1,post-1998} + \beta_7\Delta\text{log}W_{t-4}^b\end{aligned} \tag{28}$$

Table 3.4.6: Coefficients and standard errors of the monthly basic wage equation

	Coef.	s.e.
β_0	0.002	0.0002
β_1	0.08	0.03
β_2	0.08	0.02
β_3	0.09	0.03
β_4	-0.05	0.01
β_5	0.06	0.008
β_6	0.003	0.0004
β_7	0.29	0.07

$R^2 = 0.87$

3.4.3 Labor demand

In FR-BDF, labor demand is rooted in firms' first-order condition that sets the marginal product of labor equal to the markup-adjusted marginal cost of labor, so the long-run level of salaried employment is modelled as a cointegrating relationship in which value added, trend efficiency and the efficient real hourly wage (deflated by the value-added price) jointly determine the long-run employment.

In the short-run, around this target, employment adjusts through a fourth-order partial-adjustment error-correction equation that (i) feeds back on last period's deviation from target, (ii) incorporates the growth rate of the market-branches value-added gap to capture a short-run Okun effect, and (iii) adds a growth-neutrality term so that employment ultimately grows at the trend pace of its target. Compared with the earlier vintage of the model, the only material change in the short-run equation is the inclusion of dummy variables to improve empirical fit.

Expectations enter the short-term equation and are split into a low-frequency component (expected trend growth of the target, modeled as a unit-root process) and a gap component (expected change in the target gap, produced by an auxiliary AR(1) equation driven mainly by the output gap); this split allows the equation to reproduce labor-hoarding behaviour whereby firms, anticipating a rebound of temporarily depressed level of desired employment, shed fewer workers than a myopic model would predict. However, in its initial form, this expectations setup produced an overly strong dampening effect. To address this, in simulation, instead of anchoring the long-term employment to a fixed exogenous path, we now use a quasi-endogenous target that better reflects current economic conditions. This change makes firms' expectations more responsive to the business cycle and brings the model's reactions more in line with observed data.

As in previous versions, the employment equation is estimated using salaried employment in market branches ($n_{S,t}$) rather than total employment (n_t). Although the two series are

Table 3.4.7: Variables used in section 3.4.3

Notation	**Description**
n_t	Total employment of market branches, thousands of persons (in log)
$n^*_{S,t}$	Target salaried employment of market branches, thousands of persons (in log)
$n_{S,t}$	Salaried employment of market branches, thousands of persons (in log)
$n_{NS,t}$	Non-salaried employment of market branches, thousands of persons (in log)
q_t	Value added of market branches, volume (in log)
$\hat{q}_t$	Market branches output gap
$p_{Q,t}$	Value added price of market branches (in log)
h_t	Hours per workers (in log)
$\bar{e}_t$	Trend labor efficiency (in log)
$\bar{n}^*_t$	HP-trend target salaried employment (in log)
$\hat{n}^*_t$	Gap of target salaried employment relative to $\bar{n}^*_t$ (in log)
$\delta_{COVID,i}$	COVID-associated dummies

highly correlated, the specification based on salaried employment provides a better empirical fit than one based on total employment.

Long-run equation Derived from the first order condition for labor which equals marginal productivity to marginal cost of labor augmented by a mark-up (see (3), the target level of salaried employment $n^*_{S,t}$ is defined by

$$n^*_{S,t} = b_0 + q_t - \bar{e}_t - h_t - \sigma(\tilde{w}_t - p_{Q,t} - \bar{e}_t - h_t) \tag{29}$$

Note that the only estimated parameter of the equation (29) is the constant, as the parameter σ has been estimated from a very similar equation 3.1.3, where the efficiency trend, unobserved at that point of the estimation process, is replaced by the observed labor productivity. The estimate of the constant is reported in Table 3.4.8.

Table 3.4.8: Coefficient and standard errors for the salaried employment target equation

Coefficient	**Estimate**	**s.e.**
b_0	0.31	0.001

$R^2 = 0.95$

One major change in this block concerns the way the long-term employment target is modelled in simulation. Previously, in simulation the dynamics of the trend was anchored to exogenous demographic processes defined by the historical rates of active population, structural unemployment and share of salaried employment in total employment. This modelling choice allowed to have a desirable feature of reducing the oscillations generated in model simulations; however, it rendered employers virtually neutral to the current economic conjuncture and attributed them an overly strong belief in the speed of adjustment of the labor market. To attenuate this effect, the dynamics of the labor demand trend is now anchored to the long-term target of employment as given by the first order condition of the producer's maximisation function (3), but with replacing the value added of market branches q_t by its filtered value, in order to keep the desirable property of the absence of the oscillations in simulations.

Short-run equation The equation (30) presents the short-run equation of the demand for salaried employment, whereas Table 3.4.9 reports the estimated coefficients. The equation is estimated using the 1997Q1-2021Q4 sample.

$$\begin{aligned} \Delta n_{S,t} &= \beta_0\big(n^*_{S,t-1} - n_{S,t-1}\big) \\ &\quad + PV(\Delta\bar{n}^*_S)_{t|t-1} + PV(\Delta\hat{n}^*_S)_{t|t-1} \\ &\quad + \beta_1 \Delta n_{S,t-1} + \beta_2 \Delta n_{S,t-2} + \beta_3 \Delta n_{S,t-3} \\ &\quad + (1-\beta_1-\beta_2-\beta_3-\omega)\Delta\bar{n}^*_{S,t-1} \\ &\quad + \beta_4 \Delta\hat{q}_t + \beta_5 \delta_{COVID,20Q2} + \beta_6 \delta_{COVID,20Q3} + \varepsilon_t \end{aligned} \tag{30}$$

Table 3.4.9: Coefficients and standard errors for the salaried employment short run equation

Coefficient	**Estimate**	**s.e.**
β_0	0.07	0.02
β_1	0.44	0.03
β_2	0.12	0.03
β_3	0.12	0.02
β_4	0.13	0.03
β_5	-0.02	0.00
β_6	0.02	0.00
ω	0.34	-

$R^2 = 0.95$

In comparison to the previous estimates, no important differences can be signalled. The inclusion of the dummy variables in 2020Q2 and 2020Q3 is important as it allows to provide a better fit and a decent significance to the coefficients.

Expectations The auxiliary equation that links labor demand to E-SAT is given in (31) with its estimates given in Table 3.4.10. Compared to its previous specification, the auxiliary equation has been streamlined by removing the interest rate gap and the inflation gap, whose coefficients were not statistically significant.

As mentioned before, in order to model the dampening effect of labor hoarding, the expectation term in the short-run equation is decomposed into the expectation of the trend of the labor demand and the expectation of the cyclical component of the labor demand.

The policy function of the trend component of expectations, being modelled as a calibrated unit-root process for $\bar{n^*}_{S,t-1}$, did not change either and is given in equation (32). The new estimates of the policy function for the cyclical component are given in Table 3.4.10. Relative to the previous specification, the coefficients have nearly doubled in absolute value, reflecting a stronger sensitivity of expectations to macroeconomic conditions.

$$\hat{n}^*_{S,t} = \beta_0 \hat{y}_{t-1} + \beta_3 \hat{n}^*_{S,t-1} + \varepsilon_t \tag{31}$$

$$PV(\Delta \bar{n}^*_S)_{t|t-1} = \omega \Delta \bar{n}^*_{S,t-1} \tag{32}$$

Table 3.4.10: Coefficients of policy function and auxiliary equation for expectation of the change in the target employment gap

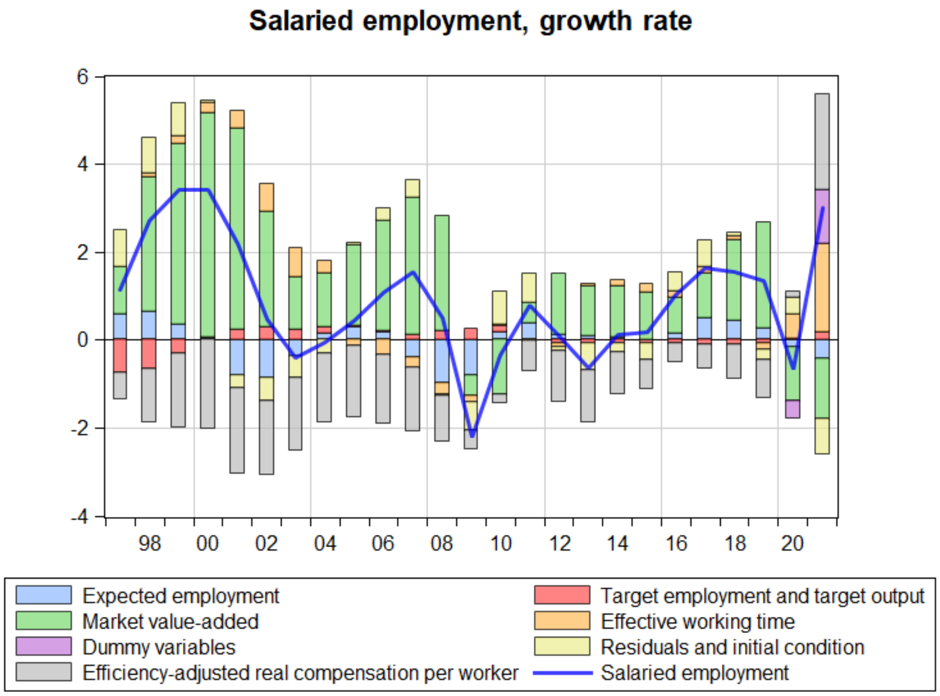
VAR model	**Policy function** $\boldsymbol{PV(\Delta \hat{n}^*_S)_{t\|t-1}}$	**Auxiliary equation** $\boldsymbol{\hat{n}^*_{S,t}}$
$\hat{y}_{t-1}$	0.01	0.29 [0.10]
$i_{t-1} - \bar{i}_{t-1}$	-0.04	-
$\pi_{Q,t-1} - \bar{\pi}_{Q,t-1}$	0.01	-
$\hat{y}_{EA,t-1}$	0.01	
$\pi_{EA,t-1} - \bar{\pi}_{EA,t-1}$	0.01	
$\hat{n}^*_{S,t-1}$	-0.06	0.60 [0.11]

Note: standard errors are in brackets. $R^2 = 0.75$ for the auxiliary equation.

Dynamic contributions Figure 3.4.1 displays the dynamic decomposition of the growth rate of salaried employment. The blue line shows the observed annual growth rate of salaried employment, while the stacked bars represent the contributions of the key determinants embedded in the employment block of the model.

Employment dynamics are primarily driven by two components. Market value-added is the dominant source of variation. It generates strong positive contributions during phases of robust activity—such as the late 1990s, the mid-2000s, and the sustained expansion from 2013 to 2020—and sharp negative contributions during downturns, most notably in 2009–10 and 2020-2021 when firms rapidly adjusted labor input to collapsing demand. Efficiency-adjusted real compensation per worker tends to contribute negatively throughout the estimation sample.

Figure 3.4.1: Dynamic contributions, salaried employment, pp of growth rate



3.5 Demand block

The demand block is composed of three main components: household consumption, household investment and business investment.

3.5.1 Household consumption

In the FR-BDF model, household consumption is shaped by a combination of long-run structural drivers and short-run dynamic factors. The drivers of long run household consumption are permanent income and a real interest rate gap, where the gap is defined as the difference between the real household bank lending rate and the long-run anchor of the real short-term interest rate.

The short run dynamics of consumption are determined with a first order PAC equation augmented with a wealth effect modelled with the change in the interest rate gap. Additionally, in the updated version of FR-BDF, the short-run equation benefits from a new feature which allows to take into consideration the behavior of rule-of-thumb consumers reacting

Table 3.5.1: Variable notations

Notation	Description
c_t	Household consumption, volume (in log)
$y_{H,t}$	Household disposable income, volume (in log)
$r_{LH,t}$	Real household bank lending rate
$\bar{r}_{LH}$	Steady-state of real household bank lending rate
y_t	Gross domestic product, volume (in log)
$\bar{y}_t$	Long run trend of the volume of gross domestic product (in log)
$W_{H,t}$	Total wages received by households
$TG_{H,t}$	Government transfers to households
$p_{C,t}^{VAT}$	Consumer price including VAT (in log)
$\tilde{y}_t$	Hodrick-Prescott trend of output growth
$\delta_{COVID,i}$	COVID-associated dummies
$\Delta w_{eff,t}$	Growth rate of real efficient wage
$\hat{u}_t$	Unemployment gap

Note : the steady-state real household bank lending rate is defined by a spread over the short-term real interest rate and is equal to $(\bar{i} - \bar{\pi}) + \bar{s}_{LH}$ where $\bar{s}_{LH}$ is the term premium.

directly to wages and government transfers. The updated estimates imply that household consumption is now more responsive to interest rate shocks and exhibits a faster convergence toward its long-run equilibrium path.

Expectation terms enter the dynamics of household consumption both in long term and short term equations. In the long run, the expected household income is the major factor of consumption dynamics. In the short term, household consumption is affected by the expectations of the permanent income and the expectations of the interest rate gap .

More details are given below.

Long run equation Household consumption in the long run is defined by a consumption target c_t^*, which is influenced by a measure of permanent income $\text{PV}\left(y_H\right)_{t|t-1}$ and a real interest rate gap as presented in equation (33).

$$c_t^* = \alpha_0 + \text{PV}\left(y_H\right)_{t|t-1} + \alpha_1\left(r_{LH,t} - \left(\bar{i}_t - \bar{\pi}_t\right)\right) \tag{33}$$

The permanent income term – as described in (34) – is represented by a transformation of a standard expectation of the ratio of real disposable household income $y_{H,t}$ to real long run GDP $\bar{y}_t$.

$$\text{PV}\left(y_H\right)_{t|t-1} = \text{PV}\left(y_H - \bar{y}\right)_{t|t-1} + \bar{y}_t \tag{34}$$

The second term of the target equation of c_t^* relates consumption to a real interest rate gap to capture long run effects of interest rates on consumption.

The two coefficients of the equation – the constant term α_0 and the sensitivity to the interest rate α_1 – are estimated as -0.15 (previously -0.16) and -1.15 (previously -0.95), respectively. The increase in α_1 reflects a higher sensitivity of the long term consumption to interest rate shocks.

Short run equation Equation (36) presents the short run equation of household consumption, with the associated estimated coefficients given in Table 3.5.2. This specification includes adjustments toward the long-run target, effects from lagged consumption, interest rate gap, expectation terms and a PAC term. Besides, compared to the earlier model, key structural changes include the replacement of an output growth term with the sum of wage income and government transfers, thus allowing the model to take account of the rule of thumb consumers. Additionally, the dummy variable associated with the "prime a la casse"[11] policy has been removed and introduced a set of COVID-19 dummy variables in 2020Q1 – 2020Q4.

$$
\begin{aligned}
\Delta c_t = {} & \beta_0 \left(c^*_{t-1} - c_{t-1}\right) + \beta_1 \Delta c_{t-1} \\
& + \mathrm{PV}^2 \left(y_H - \bar{y}\right)_{t|t-1} \\
& + \alpha_1 \left(\mathrm{PV}\left(r_{LH}\right)_{t|t-1} - \left(\mathrm{PV}\left(\bar{i}\right)_{t|t-1} - \mathrm{PV}\left(\bar{\pi}\right)_{t|t-1}\right)\right) \\
& + \beta_{PAC} \left(\Delta \bar{y}_{t-1}\right) \\
& + \beta_2 \left[\Delta \left(\log\left(W_{H,t} + TG_{H,t}\right) - p^{VAT}_{C,t}\right) - \tilde{y}_t\right] + \beta_3 \left(\Delta r_{LH,t} - \left(\Delta \bar{i}_t - \Delta \bar{\pi}_t\right)\right) \\
& + \beta_4 \delta_{COVID,20Q1} + \beta_5 \delta_{COVID,20Q2} + \beta_6 \delta_{COVID,20Q3} + \beta_7 \delta_{COVID,20Q4}
\end{aligned}
\tag{35}
$$

The estimated coefficients show some variation relative to earlier estimates. In particular, the speed of adjustment β_0 is now noticeably larger at 0.29 than the 0.12 of the earlier model version. Table 3.5.2 shows that we also now find a positive β_1 coefficient for the lag term (0.17 vs -0.08 earlier) and a significant and large coefficient β_3 for the interest rate term (-1.07 vs -0.71 earlier). Note that the coefficient α_1 is estimated in the long-run household consumption equation. β_{PAC} represents the weight on the PAC stationarity condition, somewhat modified as the non-stationary component of expectations is zero for expectations of gap terms.

Expectations Expectations are essential in determining permanent income and interest rate effects. There are a total of five expectation terms that appear in the various equations of the household consumption block. For the consumption block, the most important are the expectations of the ratio of real disposable income to real output, $\mathrm{PV}\left(y_H - \bar{y}\right)_{t|t-1}$, which are used to model permanent income.

The *expectation* – denoted by the square of the PV – of the expected income-output ratio $\mathrm{PV}^2\left(y_H - \bar{y}\right)_{t|t-1}$ is used in the short run equation. Its policy function is also dependent on the growth rate of wages and the unemployment gap. Also present in the short run equation are the expectation terms related to the interest rate gap, $\mathrm{PV}\left(i_{LH}\right)_{t|t-1}$, $\mathrm{PV}\left(\bar{i}\right)_{t|t-1}$ and $\mathrm{PV}\left(\bar{\pi}\right)_{t|t-1}$.

[11]This dummy is the result of a particular government policy in effect at the time, referred to colloquially as "prime à la casse" in French. The purpose of the policy was to subsidize the purchase of new vehicles, like the "cash for clunkers" policy implemented in the United States in 2009.

Table 3.5.2: Coefficients and standard errors of the short run equation for household consumption

Coefficient	Estimate	s.e.
β_0	0.29	0.07
β_1	0.17	0.10
β_2	0.32	0.10
β_3	-1.07	0.52
β_4	-0.055	0.001
β_5	-0.09	0.005
β_6	0.14	0.009
β_7	-0.10	0.017

$R^2 = 0.95$

The coefficients of the policy functions associated with $\mathrm{PV}\,(y_H - \bar{y})_{t|t-1}$, $\mathrm{PV}^2\,(y_H - \bar{y})_{t|t-1}$ and $\mathrm{PV}\,(i_{LH})_{t|t-1}$ are presented in Table 3.5.3, while Table 3.5.4 presents the policy functions for $\mathrm{PV}\,(\bar{i})_{t|t-1}$ and $\mathrm{PV}\,(\bar{\pi})_{t|t-1}$. The related auxiliary equations can be found in A.0.2 and A.0.3.

Table 3.5.4: Coefficients of policy functions for expectations of $\bar{i}_t$ and $\bar{\pi}_t$

VAR model	Policy function $\mathbf{PV}\,(\Delta\bar{i})_{t\mid t-1}$	Policy function $\mathbf{PV}\,(\Delta\bar{\pi})_{t\mid t-1}$
$\bar{i}_{t-1} - \bar{i}$	-0.022	-
$\bar{\pi}_{t-1} - \bar{\pi}$	-	-0.038

Note: Policy function defined with E-SAT core equations.

Dynamic contributions Figure 3.5.1 displays the dynamic decomposition of the growth rate of the household consumption. Household consumption dynamics are dominated by two structural drivers. Long-run GDP growth (light blue), through its impact on permanent income, provides a stable and substantial positive contribution throughout the sample. This component reflects the anchoring role of long-term income prospects in household spending decisions and explains much of the persistence in consumption growth during both expansions and slowdowns. Expectations (red) also play an important role: they contribute positively during periods of improving economic sentiment—such as the mid-2000s and the gradual recovery after 2013—and turn negative when households revise their outlook downward, notably during the global financial crisis and in 2020. Other determinants exert more limited influence. Dummy variables and residuals capture specific episodes, including the pronounced negative residual in 2020 associated with the pandemic-related collapse in consumption and the subsequent rebound in 2021.

Table 3.5.3: Coefficients of the policy functions for expectations of $\text{PV}\left(y_H - \bar{y}\right)_{t|t-1}$, $\text{PV}^2\left(y_H - \bar{y}\right)_{t|t-1}$ and $\text{PV}\left(i_{LH}\right)_{t|t-1}$

VAR model	**Policy function**		
	$\mathbf{PV}\left(y_H - \bar{y}\right)_{t\vert t-1}$	$\text{PV}^{\mathbf{2}}\left(y_H - \bar{y}\right)_{t\vert t-1}$	$\mathbf{PV}\left(i_{LH}\right)_{t\vert t-1}$
Intercept	-0.30	-0.094	0.0003
$\hat{y}_{t-1}$	-0.03	-0.010	-0.0010
$i_{t-1} - \bar{i}_{t-1}$	-0.05	-0.016	0.0252
$\pi_{t-1} - \bar{\pi}_{t-1}$	0.004	0.001	-0.010
$\hat{y}_{EA,t-1}$	0.008	0.002	0.0004
$\pi_{EA,t-1} - \bar{\pi}_{EA,t-1}$	-0.0004	-0.001	0.002
$y_{H,t-1} - \bar{y}_{t-1}$	0.42	-0.16	0.00
$\Delta w_{eff,t-1}$	0.16	0.043	0.00
$\hat{u}_{t-1}$	-0.20	-0.062	0.00
$\text{PV}\left(y_{H,t-1} - \bar{y}_{t-1}\right)$	-	-0.29	-
$\bar{i}_{t-1} - \bar{i}$	-	-	0.0612
$\bar{\pi}_{t-1} - \bar{\pi}$	-	-	-0.0506
$r_{LH,t-1}$	-	-	-0.06

Note: Auxiliary equations are described in Section A.

3.5.2 Household investment

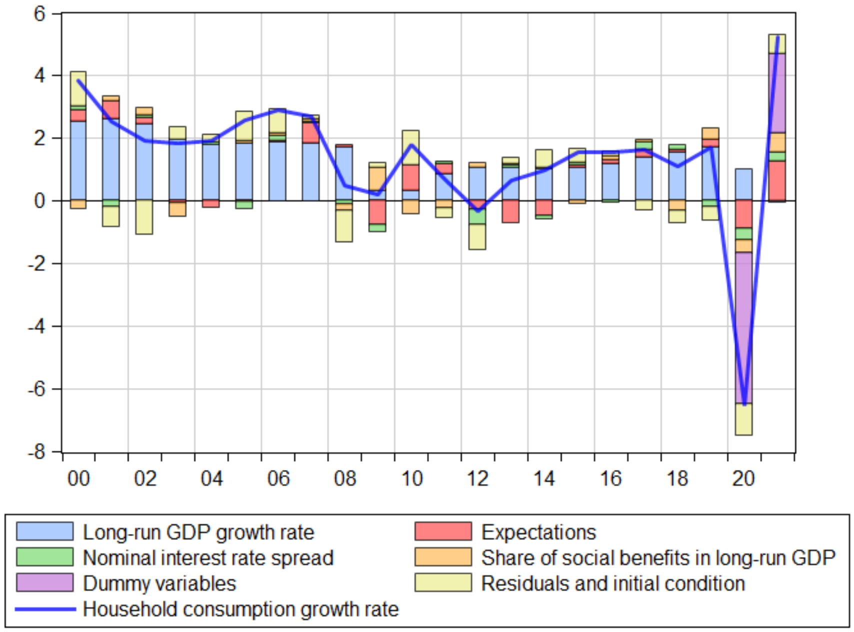
Target The household's target for investment follows (36). The associated estimation results can be found in Table 3.5.6. The desired level of investment by households is assumed to depend on the permanent income term $\text{PV}\left(y_H\right)_{t|t-1}$, as defined in equation (34). The investment target is also affected by the prices of new ($p_{IH,t}$) and existing ($p_{SH,t}$) housing relative to the price of the consumption good $p_{C,t}$. The final term represents the real user cost of housing investment, where δ_H is the households' depreciation rate and is calibrated at 1.8% per year.

In contrast to the earlier specification, the price terms and the terms appearing in the real user cost are now contemporaneous, instead of being lagged by two periods. Furthermore, the user cost term is now centered with the term $(\bar{i}_t - \bar{\pi}_{Q,t})$, which changes the interpretation and the estimated coefficient, which was previously -0.071. The other estimated terms have also been revised – in earlier estimation the γ_0, γ_1 and γ_2 were -2.3, -2.2 and 0.55, respectively.

$$\begin{aligned}\log I^*_{H,t} &= \gamma_0 + \text{PV}\left(y_H\right)_{t|t-1} \\ &\quad + \gamma_1\left(p_{IH,t} - p_{C,t}\right) + \gamma_2\left(p_{SH,t} - p_{C,t}\right) \\ &\quad + \gamma_3\left(i_{LH,t} - \text{PV}\left(\pi_Q\right)_{t|t-1} + \delta_H - \left(\bar{i}_t - \bar{\pi}_{Q,t}\right)\right)\end{aligned} \tag{36}$$

Short run equation The short run dynamics of household investment are described by (37), while Table 3.5.7 presents the relevant estimation results. We assume that $m = 2$,

Figure 3.5.1: Dynamic contributions, Household consumption, pp of growth rate



i.e. implying a single lag of household investment on the right hand side of the equation. Expectations regarding changes in the target have been split into gap and trend components. As the trend component is present in the specification, the standard PAC specification for ensuring growth neutrality is applied, with ω, the share of the nonstationary component in expectations present in the equation.

The equation also contains two *ad hoc* terms. The first is the contemporaneous change in the output gap, to account for liquidity contrained households and direct effects of demand. The second is the contemporaneous change in the deflator of existing housing, centered by its trend, to account for short-term dynamics of housing prices. Notice that both of these terms has been revised notably from the specification applied earlier, where the first term was represented with the change in the output gap and the second with the contemporaneous change in the deflator of existing housing, centered by its trend.

The estimated coefficients have also changed notably. The coefficients corresponding directly to those appearing in the earlier specification, β_0 and β_1, have been re-estimated to be 0.11 (previously 0.056) and 0.19 (previously 0.62), indicating a faster convergence to target and a weaker dependence on the lagged growth of investment. Partly due to the change in specification, the coefficients corresponding to the *ad hoc* terms, β_2 and β_3, are now estimated to be 0.49 and 0.05, instead of 0.34 and 0.32, respectively.

Table 3.5.5: Variables used in section 3.5.2

Notation	Description
$I_{H,t}$	Household investment, volume
$y_{H,t}$	Household disposable income, volume (in log)
$i_{LH,t}$	Nominal household bank lending rate
y_t	Gross domestic product, volume (in log)
$\bar{y}_t$	Long run trend of the volume of gross domestic product (in log)
$\tilde{y}_t$	Hodrick-Prescott trend of output growth
$p_{IH,t}$	Deflator, new housing investment (in log)
$p_{SH,t}$	Deflator, existing housing stock (in log)
$p_{C,t}$	Deflator, household consumption (in log)
$i_{10,t}$	Yield on 10-year French government bonds
$\delta_{COVID,i}$	COVID-associated dummies
E-SAT	See Table 3.2.1

Table 3.5.6: Coefficients and standard errors of the long run equation for household investment

Coefficient	Estimate	s.e.
γ_0	-4.11	0.37
γ_1	-1.43	0.23
γ_2	0.38	0.07
γ_3	-11.6	2.90

$R^2 = 0.82$

$$\begin{aligned}\Delta \log I_{H,t} \quad = \quad & \beta_0 \log\left(\frac{I^*_{H,t-1}}{I_{H,t-1}}\right) + \beta_1 \Delta \log I_{H,t-1} \\ & + \text{PV}\left(\Delta \log \hat{I}^*_H\right)_{t|t-1} - \text{PV}\left(\Delta \log \bar{I}^*_H\right)_{t|t-1} \\ & + (1 - \beta_1 - \omega)\, \Delta \log \bar{I}^*_{H,t} \\ & + \beta_2 \left(\Delta y_t - \tilde{y}_t\right) \\ & + \beta_3 \left[(p_{SH,t-1} - p_{IH,t-1}) - (p_{SH,t-5} - p_{IH,t-5})\right] \\ & + \beta_4 \delta_{COVID,20Q1} + \beta_5 \delta_{COVID,20Q2} + \beta_6 \delta_{COVID,20Q3} + \beta_7 \delta_{COVID,21Q2}\end{aligned} \tag{37}$$

Expectations Expectations regarding changes in the target for household investment have been split into two different components: the trend of the target and a gap term measuring deviations from this trend. The estimation results for the policy function of the gap term can

Table 3.5.7: Coefficients and standard errors of the short run equation for household investment

Coefficient	Estimate	s.e.
β_0	0.12	0.04
β_1	0.18	0.08
β_2	0.50	0.11
β_3	0.05	0.03
β_4	-0.05	0.001
β_5	-0.16	0.002
β_6	0.26	0.006
β_7	0.05	0.003

$R^2 = 0.89$

be found in Table 3.5.8. The policy function for the trend component is a Hodrick-Prescott trend with the growth rate of the investment target as a long-run anchor.

Table 3.5.8: Coefficients of the policy function of the gap of the household investment target

VAR model	Policy function PV $\left(\Delta \log \hat{I}^*_H\right)_{t\|t-1}$
$\hat{y}_{t-1}$	0.0075
$i_{t-1} - \bar{i}_{t-1}$	-0.1945
$\pi_{t-1} - \bar{\pi}_{t-1}$	0.0073
$\hat{y}_{EA,t-1}$	-0.0076
$\pi_{EA,t-1} - \bar{\pi}_{EA,t-1}$	-0.0263
$\log \hat{I}^*_{H,t-1}$	-0.0710

Note: Auxiliary equations are described in Table A.0.3.

Bank lending rate for households The dynamics of $i_{LH,t}$ are described by (38), which is unchanged in this revision of the model. Change in the bank lending rate is related to the difference between the rate and the 10-year government rate via an error correction mechanism, with α_0 representing a long run premium over the public rate. The associated estimated coefficients are presented in Table 3.5.9

$$\Delta i_{LH,t} = \alpha_1 \left(i_{LH,t-1} - i_{10,t-1} - \alpha_0\right) + \alpha_2 \Delta i_{10,t} + \alpha_3 \Delta i_{10,t-1} + \alpha_4 \Delta i_{LH,t-1} + \alpha_5 \Delta i_{10,t-2} \quad (38)$$

Table 3.5.9: Coefficients and standard errors of the equation for household bank lending rate

Coefficient	Estimate	s.e.
α_0	0.001	0.0005
α_1	-0.04	0.018
α_2	0.077	0.027
α_3	0.25	0.036
α_4	0.67	0.071
α_5	-0.19	0.08
$R^2 = 0.81$		

Price of housing stock The modelling of the price of the existing housing stock, $p_{SH,t}$, was revised from the setup presented in Lemoine et al. (2019) – based on a relatively simple $AR(2)$ process for the change of the logarithm of the price level – to a more complicated structural setup presented in Bove et al. (2020). Our discussion here focuses primarily on changes relative to Bove et al. (2020).

The current specification is presented in equations 39 and 40. The overall structure is based on an error correction mechanism: the first equation describes the dynamics of the target for the level of the price with the ratio of permanent income to existing housing stock $\frac{\mathrm{PV}(y_H)_{t|t-1}}{K_t^H}$ as the key determinant. The second relates the change in the price on lagged deviations from the target and the lagged change in household mortgage debt c_{t-1^H}. Both equations also depend on transformations of the real user cost of housing $i_{LH,t} + d_t - \mathrm{PV}(\pi_Q)_{t|t-1}$. We include also a total of six dummies to deal with the COVID period.

$$p^*_{SH,t} = \alpha_0^P + \log\left(\frac{\mathrm{PV}(y_H)_{t|t-1}}{K_t^H}\right) + \alpha_1^P\left(i_{LH,t} + d_t - \mathrm{PV}(\pi_Q)_{t|t-1}\right) \tag{39}$$

$$\begin{aligned}
\Delta p_{SH,t} \quad = \quad & \left(1-\gamma_1^P\right)\left(p^*_{SH,t-1} - p_{SH,t-1}\right) + \gamma_1^P \Delta p_{SH,t-1} && (40)\\
& +\gamma_2^P \Delta\left(i_{LH,t-1} + d_{t-1} - \mathrm{PV}(\pi_Q)_{t-1|t-2}\right) + \gamma_3^P \Delta c_{t-1}^H && (41)\\
& +\beta_1\delta_{COVID,20q1} + \beta_2\delta_{COVID,20q2} + \beta_3\delta_{COVID,20q4} && (42)\\
& +\beta_4\delta_{COVID,21q1} + \beta_5\delta_{COVID,21q2} + \beta_6\delta_{COVID,21q4} && (43)
\end{aligned}$$

Table 3.5.10 presents the estimates of these two equations. Notice that we estimate these two equations jointly in a single step by inserting the definition of $p^*_{SH,t}$ into (40).

3.5.3 Business investment

As before, the business investment in FR-BDF includes all firm types (financial, non-financial, and individual entrepreneurs). Its target level is derived from the firm's first-order

Table 3.5.10: Coefficients and standard errors of the equations for the price of housing stock, long- and short-run equations

Coefficient	**Estimate**	**s.e.**
α_0^P	7.31	0.058
α_1^P	-16.95	11.46
γ_1^P	0.79	0.06
γ_2^P	-2.05	1.34
γ_3^P	0.017	0.007
β_1^P	0.008	0.001
β_2^P	0.007	0.002
β_3^P	0.011	0.005
β_4^P	-0.005	0.001
β_5^P	0.01	0.002
β_6^P	0.005	0.002
$R^2 = 0.91$		

condition under a CES production function. Short-run dynamics follow a second-order PAC equation, supplemented by an ad hoc term to capture cyclical demand from non-optimizing firms. Expectations are modeled by splitting the target into deviations from trend, which dampens partial equilibrium responses to expectation-driven shocks.

Target The functional form of the target investment equation remains unchanged and is given by:

$$\log I^*_{B,t} = \alpha_0 + q_t - \sigma \log r_{KB,t-1} + \log \frac{I^*}{K^*} \tag{44}$$

In this specification, the elasticity of substitution σ is calibrated, as detailed in Section 3.1.2, and takes the value 0.4951. The steady-state log investment–capital ratio, $\log \frac{I^*}{K^*}$, has been marginally revised downward from -3.47 to -3.55. The sole estimated parameter in the equation, α_0, has been re-estimated upward, from 0.016 to 0.085.

The real cost of capital relates the Weighted Average Cost of Capital (WACC), depreciation δ_t and the ratio of the price of investment goods to the price of value added, and is defined as

$$r_{KB,t} = \left[wacc_t + \delta_t - \mathrm{PV}\left(\pi_Q\right)_{t|t-1} \right] \frac{P_{IB,t}}{P_{Q,t}}. \tag{45}$$

We describe the construction of the WACC term below.
The expected inflation term $PV(\pi_Q)$ is obtained from inversion of the E-SAT. The coefficients of the corresponding policy function are given in Table 3.5.12. With respect to their 2019 values, they remained mostly unchanged, with the exception for the coefficient of the interest rate gap and euro area inflation which have somewhat lowered.

Table 3.5.11: Variables used in section 3.5.3

Notation	**Description**
$I_{B,t}$	Investment, volume, NFCs, FCs and sole proprietors
$r_{KB,t}$	Real user cost of capital for firms
$wacc_t$	Weighted average cost of capital
δ_t	Depreciation of firm capital stock
$P_{CI,t}$	Deflator, business investment good
$P_{Q,t}$	Deflator, value added
q_t	Value added, market branches, in log
DF_t	Total demand excluding business investment
$\delta_{COVID,i}$	COVID-associated dummies

Table 3.5.12: Coefficients of the policy function for expected inflation

VAR model	**Coefficient PV $(\pi_Q)_{t\|t-1}$**
Constant	0.003
$\hat{Y}_{t-1}$	0.02
$i_{t-1} - \bar{i}_{t-1}$	-0.12
π_{t-1}	0.042
$\bar{\pi}_{t-1}$	0.44
$\hat{y}_{EA,t-1}$	0.018
$\pi_{EA,t-1} - \bar{\pi}_{EA,t-1}$	-0.001

Short run equation The short-run dynamics of investment are modeled using a second-order PAC specification. This framework incorporates the error-correction term, two autoregressive lags, expectations block, a growth-neutrality constraint, a term linking investment to total demand to capture non-optimizing behavior, and three dummy variables accounting for the Covid-19 period (see (46)).

Relative to the previous version, several modifications have been implemented. First, the proxy for cyclical demand has been revised. Instead of relying on the cyclical component of total value-added growth, the model now employs a synthetic aggregate of final demand net of business investment (DF_t). This variable is constructed as a chain-linked volume aggregate of household and NPISH consumption, household and government investment, and exports. The adjustment is intended to mitigate potential endogeneity concerns in the specification.

Second, the expectation block has been refined. It now incorporates not only expectations of the output gap and the capital cost gap (i.e., deviations of the cost of capital from its trend), but also expectations of the trend growth rate of value added and of capital costs. Trend values are computed using the Hodrick-Prescott filter.

Additionally, we recalibrated the expectation block to mitigate the excessive attenuation induced by the original specification. Previously, firms' long-run investment targets were deterministically tied to the exogenous trend of the user cost of capital, thereby imposing an overly rigid anchor that suppressed the propagation of shocks. We now substitute this mechanism with quasi-endogenous anchor processes that co-move with contemporaneous macroeconomic conditions. This adjustment enhances the cyclical elasticity of investment and allows to generate response profiles more consistent with empirical benchmarks (e.g., ECB-BASE (see Angelini et al. (2019)), Mésange (see Bardaji et al. (2017)).

Finally, a set of dummy variables has been added to capture the distortions arising during the Covid-19 period, thereby improving the empirical fit of the equation.

The estimated coefficients are reported in Table 3.5.13.

$$\begin{aligned}\Delta \log I_{B,t} \quad = \quad & \beta_0 \log\left(\frac{I^*_{B,t-1}}{I_{B,t-1}}\right) + \beta_1 \Delta \log I_{B,t-1} + \beta_2 \Delta \log I_{B,t-2} \\ & + \mathrm{PV}\left(\Delta \hat{q}\right)_{t|t-1} + \mathrm{PV}\left(\Delta \bar{q}\right)_{t|t-1} \\ & - \sigma \mathrm{PV}(\Delta \log(\hat{r}_{KB}))_{t|t-1} \\ & - \sigma \left(\mathrm{PV}(\Delta log(\bar{r}_{KB})_{t|t-1}) + (1-\beta_1-\beta_2-\omega)\Delta log(\bar{r}_{KB,t-1})\right) \\ & + (1-\beta_1-\beta_2-\omega)\Delta(\bar{q}_{t-1}) + \beta_3(\Delta df_t - \Delta \bar{df}_t) \\ & + \beta_4 \delta_{COVID,20q1} + \beta_5 \delta_{COVID,20q2} + \beta_6 \delta_{COVID,20q3}\end{aligned} \tag{46}$$

Overall, the estimated parameters display a high degree of robustness to the extension of the estimation window. The speed-of-adjustment parameter, β_0, increased marginally from 0.085 to 0.096, consistent with a slightly faster convergence towards the long-run equilibrium

Table 3.5.13: Coefficients and standard errors of the short run equation for business investment

Coefficient	**Estimate**	**s.e.**
β_0	0.096	0.026
β_1	0.33	0.05
β_2	0.11	0.04
β_3	0.69	0.31
β_4	-0.03	0.02
β_5	0.00	0.05
β_6	0.11	0.04

$R^2 = 0.83$

level of investment. By contrast, the coefficient on the second lag of the investment growth rate β_2 declined markedly, from 0.20 to 0.11, pointing to a reduced degree of persistence in the dynamic adjustment process. Moreover, the inclusion of *Covid*-19 dummy variables, the decomposition of expectations into their stationary and non-stationary components, and a refined specification of the total demand factor collectively enhanced the explanatory power of the model, as reflected in the substantial increase in the coefficient of determination (R-squared) from 0.52 to 0.83.

Expectations The expectation terms are now decomposed into their trend and cyclical components. The associated policy functions are reported in Tables 3.5.14. Relative to the previous version, parameter estimates remain broadly stable, with only limited revisions consistent with the updates introduced in E-SAT. In particular, the expected French value-added gap exhibits a stronger correlation with the euro area output gap (coefficient increasing from 0.015 to 0.027) and a weaker correlation with French inflation (coefficient decreasing from 0.027 to 0.014). Moreover, the policy function governing the expected user cost of capital displays attenuated sensitivities to the interest rate gap and the euro area inflation gap, with the corresponding coefficients roughly halved.

Table 3.5.14: Coefficients of the policy function and auxiliary equation for the expectation of market value added

VAR model	Policy function $\mathrm{PV}\,(\Delta\hat{q})_{t\mid t-1}$	Auxiliary equation
$\hat{y}_{t-1}$	0.021	
$i_{t-1} - \bar{i}_{t-1}$	-0.102	
$\pi_{t-1} - \bar{\pi}_{t-1}$	0.014	
$\hat{y}_{EA,t-1}$	0.027	
$\pi_{EA,t-1} - \bar{\pi}_{EA,t-1}$	-0.012	
$\hat{r}_{KB,t-1}$	0	
$\hat{q}_{t-1}$	-0.082	0.56 [0.078]
$\hat{y}_t$	-	0.52 [0.010]

Note: standard errors in brackets. $R^2 = 0.90$ for the auxiliary equation.

Table 3.5.15: Coefficients of policy function and auxiliary equation for expectation of user cost of capital

VAR model	Policy function $\mathrm{PV}\,(\Delta\log\hat{r}_{KB})_{t\mid t-1}$	Auxiliary equation
$\hat{y}_{t-1}$	0	
$i_{t-1} - \bar{i}_{t-1}$	0.13	2.28 [2.31]
$i_{t-2} - \bar{i}_{t-2}$	-0.08	
$\pi_{t-1} - \bar{\pi}_{t-1}$	0	
$\hat{y}_{EA,t-1}$	0.011	
$\pi_{EA,t-1} - \bar{\pi}_{EA,t-1}$	0.025	
$\hat{r}_{KB,t-1}$	-0.060	0.80 [0.05]
$\hat{q}_{t-1}$	0	

Note: standard errors in brackets. $R^2 = 0.67$ for the auxiliary equation.

The two additional expectation terms $\mathrm{PV}\,(\Delta\bar{q})_{t\mid t-1}$ and $\mathrm{PV}(\Delta log(\bar{r}_{KB})_{t\mid t-1})$ are modelled as an AR(1) with the estimated coefficient 0.53.

Weighted average cost of capital (WACC) The weighted average cost of capital $wacc_t$ – a key component of the user cost of capital – is determined as a weighted average of the main components of funding used by French firms: Cost of Equity (COE) $i_{COE,t}$, the firm bank lending rate $i_{LB,t}$ and a bond rate $i_{BBB,t}$ which is represented by the rate on BBB-rated corporate bonds, as computed by Merrill Lynch-Bank of America.

$$wacc_t = 0.51 i_{COE,t} + 0.35 i_{LB,t} + 0.14 i_{BBB,t} \tag{47}$$

In the updated calibration of the weighted average cost of capital (WACC), the relative weights of the financing components have been revised. Based on consolidated net liabilities of non-financial corporations over the extended estimation sample 1996Q1–2021Q4, the average weights are now estimated at 0.51 for equity, 0.35 for bank debt, and 0.14 for bond debt. This represents a marginal increase in the share of equity (from 0.5) and a more pronounced rise in the contribution of bank debt (from 0.3), offset by a decline in the weight of bond financing (from 0.2). The reallocation reflects the observed relative stability in capital structure since the late 2000s, once intra-group and cross-border positions are consolidated, and justifies the continued use of static weights in the construction of the WACC.

The observed series for $i_{COE,t}$ used in the estimation have been computed using the methodology of Carluccio et al. (2019). The computation is based on an extension of the standard dividend-discount model, which is used to compute the risk premium $R_{m,t}$ for French firms. Combining this with separately estimated sensitivities to risk - i.e. Capital Asset Pricing Model (CAPM) betas - makes it possible to construct observed $i_{COE,t}$.

In simulation all the components of the WACC are determined as the sum of a spread term $s_{j,t}$ with $j \in \{COE, BL, BBB\}$ and the 5-year public interest rate $i_{5,t}$:

$$i_{j,t} = s_{j,t} + i_{5,t} \tag{48}$$

$s_{COE,t}$, the spread related to cost of equity, follows the same process as in Lemoine et al. (2019), i.e. an AR(1):

$$s_{COE,t} = (1 - \kappa_1)\,\kappa_0 + \kappa_1 s_{COE,t-1} \tag{49}$$

However, the two spreads associated with the bank lending rate and corporate bonds are determined using processes set out in Dees et al. (2022), presented in equation (50). They relate the spread to corporate leverage – measured with the ratio of debt D_t to equity E_t, or equivalently net market leverage – in order to capture the associated feedback effect in the form of a financial accelerator mechanism.

$$s_{j,t} = \kappa_0 + \kappa_1 \frac{D_t}{E_t} + u_t \tag{50}$$

Furthermore, we assume that the residual u_t has AR(1) dynamics with estimated persistence κ_2. The estimation results for equation (49) and the two equations of the form (50) are presented in Table 3.5.16.

Table 3.5.16: Coefficients and standard errors, spread equations

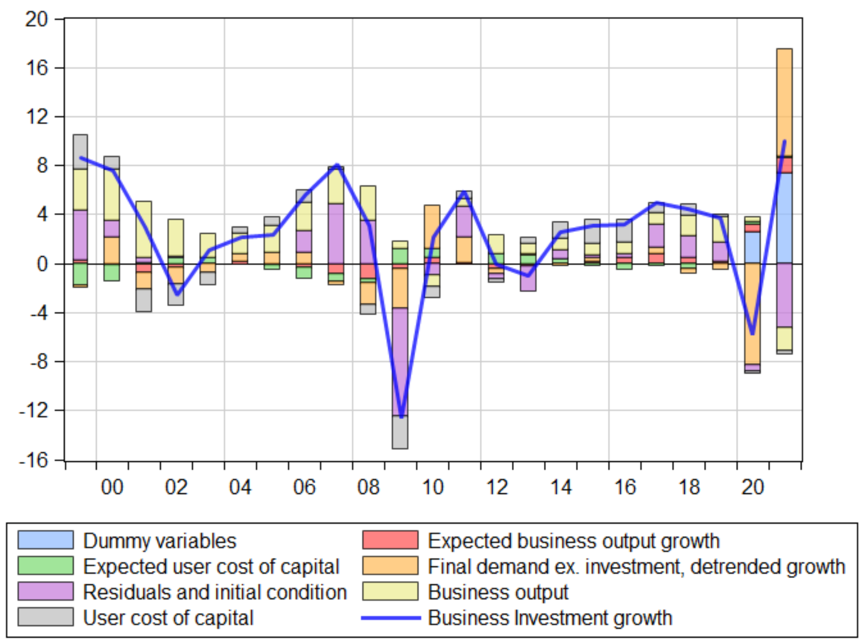
Coef.	**COE**	**BLR**	**BBB**
κ_0	0.016 [0.002]	-0.0003 [0.001]	-0.0004 [0.001]
κ_1	0.93 [0.04]	0.005 [0.001]	0.004 [0.001]
κ_2	–	0.81 [0.05]	0.75 [0.073]
R^2	0.86	0.79	0.67

Note: standard errors in brackets.

Dynamic contributions Figure 3.5.2 describes how the various components contribute dynamically to the variation in business investment. We group them around three major channels: the impact through the target investment, the current macroeconomic conjuncture and the expectations. The major factors of the target investment being the levels of business value-added and user cost of capital, they play a major role during relatively calm periods (e.g. prior to the 2008–09 financial crisis and before the Covid-19 shock). This pattern reflects the fact that, when uncertainty is low, firms' decisions are more closely aligned with the microeconomic mechanisms embedded in the core model.

When economic conditions become more turbulent, investment dynamics are increasingly driven by contemporaneous final demand, which provides the largest contribution during crisis episodes. Among the expectation channels, the role of the user cost of capital is particularly significant. In 2009, for example, it contributed positively, reflecting firms' anticipation that the surge in financing costs would be short-lived; as a result, investment was reduced less sharply than suggested by the observed user cost. In this way, expectations regarding financing conditions often dampen the immediate impact of cost shocks. Expectations of output growth also play an important role, acting as a leading indicator of investment by capturing firms' forward-looking behaviour in their decision-making.

Figure 3.5.2: Dynamic contributions, business investment, in pp of growth rate



3.6 Demand deflators

There are three demand deflators in the model: one for household consumption, one for household investment and one for business investment, all three are modeled as error correction equations. For these three equations, we model their homologies excluding VAT, they are then linked to the former (including VAT variables) through an exogenous tax rate. For example, let the household consumption deflator including and excluding VAT respectively be $\pi_{C+vat,t}$ and $\pi_{C,t}$, and the tax rate τ_C, then their relation is simply presented as:

$$P_{C+vat,t} = (1 + \tau_C)P_{C,t}$$

The main common drivers for all three demand deflators are the VA price, the energy import price and the import price excluding energy. The ISBLSM deflator is not presented here as it is straightforwardly derived from the business investment deflator.

With respect to the 2019 verison, the only addition is a new block in which we derive the Harmonized Index of Consumer Prices (HICP), it comes in addition to the Consumer Price Index (CPI) which is simply deduced from the consumption deflator.

3.6.1 Household consumption deflator

Table 3.6.1: Variables used in section 3.6.1

Notation	Description
$\pi_{C,t}$	Consumer price inflation excluding VAT
$p^*_{C,t}$	Target of consumer price (in log)
$\pi_{Q,t}$	Value added price inflation of market branches
$p_{C,t}$	Consumer price excluding VAT (in log)
$p_{M,t}$	Import price (total) (in log)
$p_{MNRJ,t}$	Energy import price
$p_{MHNRJ,t}$	Import price excluding energy (in log)
$\bar{P}_t$	Exogenous trend price
$\bar{\pi}_{Q,t}$	Long run anchor of inflation
T_t	Time-varying trend
$\delta_{COVID,i}$	COVID-associated dummies
δ_i	other dummies

Short run equation The revised version of the short run equation now includes $P_{MHNRJ,t}$ and a three new COVID-related dummies (2020Q3, 2021Q1, Q3 and Q4), the short run equation and the target are still estimated separately (two step ECM) on the new 2000Q1-2021Q4 sample.

$$\begin{aligned}\pi_{C,t} \quad = \quad & (1-\beta_0-\beta_1-\beta_3)\bar{\pi}_{Q,t} + \beta_0\pi_{Q,t-1} + \beta_1\pi_{Q,t} + \beta_2\Delta(P_{MNRJ,t}/\bar{P}_t) \\ & +\beta_3\Delta p_{MHNRJ,t} + \beta_4\left[p_{C,t-1} - p^*_{C,t-1}\right] + \beta_5\delta_{08Q4} \\ & +\beta_6\delta_{09Q2} + \beta_7\delta_{COVID,20Q3} + \beta_8\delta_{COVID,21Q2} \\ & +\beta_9\delta_{COVID,21Q3} + \beta_{10}\delta_{COVID,21Q4} + \epsilon_t \end{aligned} \tag{51}$$

Table 3.6.2: Coefficients and standard errors of the household consumption deflator excluding VAT short term equation

Coefficient	**Estimate**	**s.e**
β_0	0.224	0.06
β_1	0.385	0.052
β_2	0.023	0.002
β_3	0.061	0.031
β_4	-0.072	0.033
β_5	-0.003	0.001
β_6	-0.003	0.001
β_7	-0.006	0.001
β_8	-0.005	0.001
β_9	-0.006	0.001
β_{10}	-0.012	0.001

$R^2 = 0.81$

Target The long term anchor remains unchanged over its 2019 version, as follows:

$$p^*_{C,t} = (1-\beta_0)p_{Q,t} + \beta_0 p_{M,t} + \beta_1 T_t + \beta_2 \tag{52}$$

Table 3.6.3: Coefficients and standard errors of the household consumption deflator excluding VAT target equation

Coefficient	**Estimate**	**s.e**
β_0	0.78010	
β_1	0.00042	0.0001
β_2	-0.03897	0.0042

$R^2 = 0.99$

The dynamic contributions can be found in Appendix B Figure B.1. As the figure shows, the main drivers are the domestic value-added deflator (with a dominant role up until the 2011 European debt crisis) and the import price. All these variables contribute positively over the entire horizon, except for the import price in 2009 and between 2012 and 2016.

3.6.2 Household investment deflator

Table 3.6.4: Variables used in section 3.6.2

Notation	Description
$\pi_{IH,t}$	Household investment deflator (in dlog)
$p^*_{IH,t}$	Target of household investment price (in log)
$\pi_{Q,t}$	Value added price inflation of market branches
$p_{M,t}$	Import price (total, in log)
$p_{IH,t}$	Household investment price (in log)
$T_{08Q3,t}$	Time-varying trend from 1995Q1, a constant after 2008Q3.
T_t	Time-varying trend
$\bar{\pi}_{Q,t}$	Long run trend of the value added price inflation
$\delta_{COVID,i}$	COVID-associated dummies
δ_i	other dummies

Short run equation is now estimated simultaneously with the target (one step ECM) over the new 2000Q1-2021Q4 sample. The new additions all revolve around the integration of the long term anchor as well as the inclusion of two COVID-related dummies (2020Q2 and 2021Q2).

$$\begin{aligned}\pi_{IH,t} \quad = \quad & (1-\beta_0-\beta_1-\beta_2)\bar{\pi}_{Q,t}+\beta_0\pi_{Q,t}+\beta_1\Delta p_{M,t} \\ & +\beta_3(\pi_{IH,t-1}-(\beta_4+\beta_5 T_{08q3,t}+\beta_6 T_{t-1}+(1-d_0)p_{Q,t-1}+d_0 p_{M,t-1})) \\ & +\beta_2 p_{IH,t-1}+\beta_7\delta_{08Q1,t}+\beta_8\delta_{COVID,20q2}+\beta_9\delta_{COVID,21q2}+\epsilon_t\end{aligned} \tag{53}$$

Target The long term anchor remain unchanged over its 2019 version and reads as follows:

$$p^*_{IH,t}=\beta_4+(1-d_0)p_{Q,t}+d_0 p_{M,t}+\beta_5 T_{08q3,t}+\beta_6 T_t \tag{54}$$

Table 3.6.5: Coefficients and standard errors of the household investment deflator

Coefficient	Estimate	s.e
β_0	0.237	0.106
β_1	0.227	0.031
β_2	0.176	0.064
β_3	-0.276	0.065
β_4	-0.398	0.012
β_5	0.003	0.001
β_6	0.002	0.001
β_7	0.009	0.001
β_8	-0.008	0.002
β_9	0.008	0.001
d_0	0.171	

$R^2 = 0.66$

The dynamic contributions can be found in Appendix B Figure B.2. As can be seen in the figure, the main positive drivers are the VA price and the residual, initial conditions and trends component. The import deflator plays an important and mostly positive role as well, except in the late 90s, the early 2000s as well as in 2009 and from 2013 to 2017.

3.6.3 Business investment deflator

Table 3.6.6: Variables used in section 3.6.3

Notation	Description
$\pi_{IB,t}$	Business investment deflator (in dlog)
$p^*_{IB,t}$	Target of business investment price (in log)
$p_{IB,t}$	Business investment price (in log)
$\pi_{Q,t}$	Value added price inflation of market branches
$p_{MNRJ,t}$	Energy import price (in log)
$p_{MHNRJ,t}$	Import price excluding energy (in log)
$\bar{\pi}_{Q,t}$	Long run trend of the value added price inflation
$T_{15Q1,t}$	Time-varying trend from 1995Q1, a constant after 2015Q1.
T_t	Time-varying trend
$\pi_{M,t}$	Import price inflation (total)
$\delta_{COVID,i}$	COVID-associated dummies

Target The Business investment deflator target sees the addition of two trend terms (making it more consistent with the two other demand deflators): the time varying T_t used to center the residuals, as well as $T_{15q1,t-1}$, used to better reflect the trend behavior starting from 2015Q1.

$$p^*_{IB,t} = (1 - d_0 - d_1)p_{MHNRJ,t} + d_0 p_{MNRJ,t} + d_1 p_{Q,t} + \beta_4 + \beta_7 T_t + \beta_8 T_{15q1,t-1} \quad (55)$$

Short run equation The short run and target equations are still estimated simultaneously (one step ECM) now over the new 2000Q1-2021Q4 sample. The main changes revolve around the integration of the target in the short run equation as well as the addition of three COVID-related dummies (2020Q1, Q2 and Q4).

$$\begin{aligned}\pi_{IB,t} \;=\; & (1 - \beta_0 - \beta_1 - \beta_2)\bar{\pi}_{Q,t} + \beta_0 \pi_{M,t} + \beta_1 \pi_{IB,t-1} + \beta_2 \pi_{Q,t} \\ & + \beta_3 (p_{IB,t-1} - (1 - d_0 - d_1) p_{MHNRJ,t-1} + d_0 p_{MNRJ,t-1} + d_1 p_{Q,t-1} \\ & + \beta_4 + \beta_7 T_{t-1} + \beta_8 T_{15q1,t-1}) + \beta_5 \delta_{COVID,20q1} + \beta_6 \delta_{COVID,20q2} + \\ & + \beta_9 \delta_{COVID,20q4} + \epsilon_t\end{aligned}$$

Table 3.6.7: Coefficients and standard errors of the business investment deflator

Coefficient	**Estimate**	**s.e**
β_0	0.144	0.018
β_1	0.301	0.104
β_2	0.151	0.074
β_3	-0.131	0.048
β_4	-0.073	0.012
β_5	0.0032	0.001
β_6	0.0003	0.001
β_7	0.0008	0.0002
β_8	-0.0007	0.0006
β_9	0.0038	0.0009
d_0	0.0071	
d_1	0.7170	

$R^2 = 0.66$

The dynamic contributions can be found in Appendix B Figure B.3. We can see in the figure that the main drivers are the VA price and the imports deflator. The VA price always plays a positive role constituting the dominant and persistent contribution over the cycle. Import prices play a key amplifying role during episodes of external shocks—most notably in 2014-2016 reflecting the sharp collapse in global commodity and energy prices combined with subdued global demand, as well as in 2020 marking the Covid-19 related collapse in global demand. Residuals and temporary factors (including dummies) capture sharp but short-lived disturbances.

3.6.4 Harmonised Index of Consumer Prices

A new HICP block has been added to the FR-BDF model to provide, as output, not only the Consumer Price Index (CPI), simply derived from the household consumption deflator $p_{C,t}$, but also the Harmonised Index of Consumer Prices (HICP). Total HICP before taxes is modeled as a weighted average of three components: core inflation (e.g., services and industrial goods), energy inflation, and food inflation. The weights assigned to each component vary over time and are retrieved from the annual series provided by Eurostat, ensuring that the model reflects the most recent household consumption patterns. Core inflation is driven by value-added prices and import prices. Energy inflation is directly linked to changes in a composite energy price index. Food inflation responds to its own past dynamics, average nominal wage per employee adjusted for the job retention scheme, agricultural commodity prices, and the energy price index—highlighting how energy shocks can indirectly influence food prices. The energy price index is constructed as a weighted average of oil and gas prices in euros, with time-varying weights derived from annual energy import data published in the French Energy Balance (SDES) for mainland France (see equation (115)). Importantly, the updated model captures how oil price shocks propagate through the economy, affecting not only energy inflation but also food inflation, reflecting broader and more complex transmission channels.

3.7 Financial block

This section presents the financial block of FR-BDF, and consists of descriptions of the equations describing the dynamics of long-term government interest rates – key drivers of private interest rates – the property income of the various economic agents and the determination of exchange rates. In contrast to Lemoine et al. (2019), we also present revised estimates for our models for the financial assets of households and non-financial corporations, which were originally presented in Bove et al. (2020) and Dees et al. (2022).

3.7.1 Long-term government interest rates

Table 3.7.1: Variables used in section 3.7.1

Notation	Description
$i_{N,t}$	Interest rate on N-year government bonds
E-SAT	See Table 3.2.1

We model two components of the yield curve: the return on 10-year French government bonds, used to determine the return on financial assets and the nominal bank lending rate for households, and the return on 5-year French government bonds, used to determine the components of the WACC, described in equation (47).

Their dynamics are determined by the term structure equation (56) which relates the N-year rate $i_{N,t}$ to an expectation component $\text{PV}\,(i_N)_{t|t}$ and the lagged difference between the interest rate and the expectation component. Notice that the information set used to compute this expectation is in fact that available to the agents at t, instead of that available at date $t-1$ under the assumptions used in the original model, as we assume instead that agents in financial markets revise their beliefs with within-quarter information. This change is denoted by adjusting the indexing of the term $\text{PV}(i_N)_{t|t-1}$ to $\text{PV}(i_N)_{t|t}$. The estimation results are presented in Table 3.7.2.

$$i_{N,t} = \rho_{0,N}(1-\rho_{1,N}) + \text{PV}(i_N)_{t|t} + \rho_{1,N}\left(i_{N,t-1} - \text{PV}(i_N)_{t-1|t-1}\right) \tag{56}$$

Table 3.7.2: Coefficients and standard errors, equations for 5- and 10-year government interest rates

Coef.	**Estimate**	**s.e.**
$\rho_{0,5}$	0.0013	0.0003
$\rho_{1,5}$	0.7	0.12
$\rho_{0,10}$	0.0018	0.0008
$\rho_{1,10}$	0.91	0.044

$R^2 = 0.97$ for i_5 and $R^2 = 0.98$ for i_{10}

The two expectation terms are determined with E-SAT. As these two expectations are not associated with any short-run equation, we can compute their values using simple geometric discounting, with the discount weight determined by the duration of the bond in question, computed as $wt_{10} = 0.97$ and $wt_5 = 0.95$ for the 10- and 5-year bonds, respectively. See Brayton et al. (2000) and Lemoine et al. (2019) for further details into these computations and the determination of the discount weights based on bond durations. Thus we compute the $\text{PV}(i_N)_{t|t}$ terms with the formula

$$\text{PV}(i_N)_{t|t} = (1-wt_N)\,\bar{\text{PV}}(i_N)_{t|t} \tag{57}$$

where the terms $\bar{\text{PV}}(i_N)_{t|t}$ represent policy functions obtained from E-SAT. The estimated coefficients of these two functions are presented in Table 3.7.3.

Table 3.7.3: Coefficients of policy functions associated with the 10- and 5-year bond rates

VAR model	$\bar{\text{PV}}(i_{10})_{t\|t}$	$\bar{\text{PV}}(i_5)_{t\|t}$
Intercept	0.11	0.05
$\hat{y}_t$	0	0
i_t	3.29	3.68
$\bar{i}_t$	12.92	8.68
π_t	0	0
$\bar{\pi}_t$	0	0
$\hat{y}_{EA,t}$	1.03	0.84
$\pi_{EA,t}$	1.31	1.18
$\bar{\pi}_{EA,t}$	-1.31	-1.18

3.7.2 Financial assets of households

Table 3.7.4: Variables used in section 3.7.2

Notation	Description
D_t^H	Stock of housing debt
F_t	Net flows of loans to households
M_t^H	New household mortgages
dsr_t	Debt Service Ratio
R_t^H	Household debt repayments
p_t^H	Deflator, existing housing stock (in log)
$i_{LH,t}$	Nominal household bank lending rate
$\pi_{Q,t}$	Inflation, value added deflator
$\bar{\pi}_{Q,t}$	Trend inflation, value added deflator
Y_t	Nominal value added
$\tilde{Y}_t$	Nominal household disposable income
δ_t	Time-varying debt amortization rate
i_t^*	Trend effective interest rate
ν_t	Ratio of new mortgages to existing debt stock
$tx_{C^O,\tilde{Y}_t}$	Ratio of total other credit to households and NPISH relative to household income
C_t	Total debt stock of households and NPISH
C_t^H	Total mortgage stock of households and NPISH
C_t^O	Total stock of other debt of households and NPISH
$\delta_{COVID,i}$	COVID-associated dummies
E-SAT	See Table 3.2.1

The total stock of household debt consists of two main components: mortgages and other debt. We present here a brief, simple overview of the current state of the equations describing their dynamics; for more information, see Bove et al. (2020), which presents in detail the assumptions, technical derivation and original estimation of this component of FR-BDF, not present in the version of the model described in Lemoine et al. (2019).

The accounting framework for household mortgages is based on two relatively simple identities, which relate the stock of housing debt D_t^H, i.e. the outstanding amount of loans, to lending flows F_t, which are in turn determined by the difference of new mortgages M_t^H and household debt repayments R_t^H:

$$D_t^H = D_{t-1}^H + F_t \tag{58}$$

$$F_t = M_t^H - R_t^H \tag{59}$$

New mortgages The evolution of the stock of new mortgages is modelled with error correction equations. The dynamics of the target for new mortgages m_t^{H*} (in logarithms) is given by (60), relating the target to house prices p_t^H, residential investment I_t^H, the real interest rate $i_{LH,t} - \mathrm{PV}\left(\pi_Q\right)_{t|t-1}$ and the Debt Service Ratio dsr_t, which we discuss in detail below. The associated coefficient estimates are presented in Table 3.7.5. Notice that we estimate this equation jointly with the associated short run equation (61).

$$m_t^{H*} = \alpha_0^H + p_t^H + I_t^H + \alpha_1^H dsr_t + \alpha_2^H \left(i_{LH,t} - \mathrm{PV}\left(\pi_Q\right)_{t|t-1}\right) \tag{60}$$

We note that there are no notable change to the estimate of α_1^H, which was previously estimated at -0.15. In contrast, due to the change in the measurement of interest rates, our current estimate α_2^H is very different from the previous one and can't be meaningfully compared.

Table 3.7.5: Coefficients and standard errors of the long- and short-run equations for desired new mortgages

Coefficient	Estimate	s.e.
α_0^H	-2.68	0.13
α_1^H	-0.21	0.016
α_2^H	-137.09	7.57
γ_0^H	0.67	0.1
γ_1^H	0.3	0.07
γ_2^H	0.29	0.06
γ_3^H	-104.32	16
γ_4^H	-0.24	0.013
β_1	-0.068	0.015
β_2	0.91	0.057
β_3	0.29	0.11
β_4	-0.87	0.026
β_5	0.28	0.02
β_6	-0.14	0.02
$R^2 = 0.69$		

The short run dynamics of new mortgages are determined with (61). This equation features an error correction term, i.e. the lagged deviation of realized mortgage debt m_t^H from target debt $\left(m_t^{H*} - m_t^H\right)$, and two lags of the change in debt m_t^H. The equation also features the real interest rate $i_t^l - \mathrm{PV}\left(\pi_Q\right)_{t|t-1}$, a dummy corresponding to the Great Financial Crisis (δ_{GFC}) and six dummies introduced to help account for the COVID period. The associated coefficient estimates are also presented in Table 3.7.5.

In contrast to earlier results, the estimates associated with the current revision of the model are almost unchanged, except for γ_0^H which is now significantly larger (0.67) than before (0.55). Similar to the coefficients associated with the interest rate term in the long-run equation, the interpretation of γ_3^H has changed due to changes in the measurement of interest rates.

$$\begin{aligned}\Delta m_t^H &= \gamma_0^H\left(m_{t-1}^{H*}-m_{t-1}^H\right)+\gamma_1^H\Delta m_{t-1}^H+\gamma_2^H\Delta m_{t-2}^H \\ &+\gamma_3^H\Delta\left(i_{LH,t}^l-\mathrm{PV}\left(\pi_Q\right)_{t|t-1}\right)+\gamma_4^H\delta_{GFC} \\ &+\beta_1\delta_{COVID,20Q1}+\beta_2\delta_{COVID,20Q3}+\beta_3\delta_{COVID,20Q4} \\ &+\beta_4\delta_{COVID,21Q1}+\beta_5\delta_{COVID,21Q2}+\beta_6\delta_{COVID,21Q4}\end{aligned} \tag{61}$$

The dynamics of the Debt Service Ratio dsr_t, which relates the lagged debt stock D_{t-1}^H to value added Y_t, are determined with

$$dsr_t=\frac{\left(\delta_t+i_t^*\right)D_{t-1}^H}{Y_t} \tag{62}$$

where $\delta_t=\left(1-\nu_{t-1}\right)\delta_{t-1}^{\alpha}+\nu_{t-1}\kappa_{t-1}$ and $i_t^*=\left(1-\nu_{t-1}\right)i_{t-1}^*+\nu_{t-1}i_{LH,t-1}$ are the time-varying effective debt amortization rate and the trend effective interest rate, respectively, with $\nu_t=M_t^H/D_t^H$, i.e. the ratio of new debt to the existing stock. Finally, κ_t is used to induce time-variation in the amortization rate. While some authors, such as Kydland et al. (2016) assume it to be a constant parameter, we assume it to be time-varying, enabling us to obtain a better empirical fit. More concretely, we assume

$$\kappa_t=\frac{i_{LH,t}\left(1+i_{LH,t}\right)^{-M_t}}{1-\left(1+i_{LH,t}\right)^{-M_t}} \tag{63}$$

where M_t is the maturity of new mortgage debt. Finally, α is a parameter calibrated to 0.9936. See Bove et al. (2020) for further details.

Debt repayments Equation (64) is used for determining debt repayments r_t. It relates them to the long run trend of VA price inflation $\bar{\pi}_{Q,t}$ and the lagged deviation of repayments from their trend $\tilde{r}_t$, which is determined with the time-varying amortization rate δ_t, as seen from equation (65). The results of the joint estimation of these two equations are presented in Table 3.7.6.

$$\Delta r_t=\bar{\pi}_{Q,t}+\beta^R\left(\tilde{r}_{t-1}-r_{t-1}\right) \tag{64}$$

$$\tilde{r}_t=\alpha^{CR}+\log\left(\delta_t D_t^H\right) \tag{65}$$

Table 3.7.6: Coefficients and standard errors associated with debt repayments

Coefficient	Estimate	s.e.
β^R	0.23	0.071
α^{CR}	0.23	0.073

$R^2=0.11$

Other loans We model all other loans C_t^O to households and NPISH as simple total credit flows relative to disposable income $\tilde{Y}_t$ due to lack of detailed, available data. The specification seen in equation (66) relates these flows $tx_{C^O,\tilde{Y}_t} = C_t^O/\tilde{Y}_t$ to the change of the real short interest rate, with δ_{GFC}, a dummy associated with a law passed in 2010 that tightened credit conditions and six dummies that we apply during the COVID period.

$$\begin{aligned} tx_{C^O,\tilde{Y}_t} \;=\; & \gamma_0^O + \gamma_1^O \Delta\left(i_t - \pi_t\right) + \gamma_2^O \delta_{GFC} \\ & + \beta_1 \delta_{COVID,20Q1} + \beta_2 \delta_{COVID,20Q3} + \beta_3 \delta_{COVID,20Q4} \\ & + \beta_4 \delta_{COVID,21Q1} + \beta_5 \delta_{COVID,21Q2} + \beta_6 \delta_{COVID,21Q4} \end{aligned} \tag{66}$$

The level of other loans is then determined as the product of this ratio and income, i.e. $C_t^O = tx_{C^O Y,t} \tilde{Y}_t$.

Table 3.7.7: Coefficients and standard errors associated with other household loans

Coefficient	**Estimate**	**s.e.**
γ_0^O	0.008	0.0004
γ_1^O	-0.22	0.075
γ_2^O	-0.006	0.001
β_1	-0.01	0.0004
β_2	0.003	0.0004
β_3	-0.007	0.0005
β_4	-0.008	0.0007
β_5	-0.007	0.0007
β_6	0.0007	0.0009

$R^2 = 0.41$

Aggregation with NPISH We compute the total sums of the debt of households and the non-profit sector using a set of simple accounting identities. The total stock of all debt of these two sectors C_t is the sum of housing debt and other debt:

$$C_t = C_t^H + C_t^O \tag{67}$$

where the aggregate stock of housing debt C_t^H is determined using the housing debt of the households via $C_t^H = \tau_{C^H,t} M_t^H$ and $\tau_{C^H,t} = C_t^N / M_t^H$; in simulation this ratio is assumed constant.

3.7.3 Financial assets of non-financial corporations

The block describing the dynamics of corporate financial assets has been completely revised relative to Lemoine et al. (2019). These revisions and their theoretical and empirical underpinnings are described in detail in Dees et al. (2022); we present here only a brief overview

Table 3.7.8: Variables used in section 3.7.3

Notation	**Description**
L_t^e	New corporate bank loans
$B_{F,t}$	Corporate financing need
LY_t	New corporate bank loans relative to value added
$B_F Y_t$	Corporate financing need relative to value added
$i_{BL,t}$	Corporate bank lending rate
B_t^C	Stock of corporate bonds
D_t^C	Total stock of corporate debt
BD_t^C	Corporate bonds relative to corporate debt
$i_{BBB,t}$	Interest rate on corporate BBB-rated bonds
R_t^C	Revaluations, non-financial corporate equity
RY_t^C	Corporate equity revaluations relative to value added
$CAC40$	Value, CAC40 equity index
E_t	Value, non-financial corporate equity
$F2_t$	Corporate currency holdings
$F8_t$	Other corporate financial assets
L_t^C	Stock of corporate bank loans
$\delta_{COVID,i}$	COVID-associated dummies
E-SAT	See Table 3.2.1

of the key arguments. The primary motivation of the changes to this block is to introduce a mechanism relating firm net asset position and the interest rates they face, i.e. a financial accelerator, which enriches the channels of propagation of monetary policy shocks. A key component of this mechanism is the direct relationship between debt leverage and investment costs, described in Section 3.5.3, specifically equations (48) and (50) which relate the interest rates corporations face to their debt leverage ratio.

In this section we focus on the modelling of dynamics of the assets themselves. The key components are firm financing needs, stemming from the desire to invest and the self-capacity to finance that investment, and the financial choices regarding external financing, in particular between different forms of debt. Furthermore, to compute the degree of firm leverage – i.e. the ratio of debt to equity – we need to model the dynamics of firm equity, which we implement by relating the value of firm assets to stock market dynamics through revaluation.

Bank loans relative to output We model the dynamics of new bank credit L_t^e with equation (68), which associates the bank credit flows of NFCs relative to GDP, $LY_t = \frac{L_t^e}{Y_t}$, with corporate financing needs relative to GDP, $B_F Y_t = \frac{B_{F,t}}{Y_t}$, and a spread between the corporate bank lending rate $i_{BL,t}$ and the 5-year sovereign bond yield $i_{5,t}$. The dummies are intended to capture unusual investment dynamics during the internet bubble of the early

2000s, the GFC and the COVID-19 crisis.

$$LY_t = \alpha_0 + \alpha_1 B_F Y_t + \alpha_2 (i_{BL,t} - i_{5,t}) + \alpha_3 LY_{t-1} + \alpha_4 LY_{t-2} + \beta_1 \delta_{01q4} + \beta_2 \delta_{05q1} + \beta_3 \delta_{09q2} + \beta_4 \delta_{20q1} + \beta_5 \delta_{20q2} + \beta_6 \delta_{20q3} \quad (68)$$

We present the estimated coefficients in Table 3.7.9. The estimates have changed only little, in contrast to estimates presented in Dees et al. (2022), e.g. the largest change is in the estimated sensitivity of the credit flows-to-GDP ratio to the interest rate spread. It is now estimated at -3.86, only slightly smaller in absolute value than the -4.05 estimated earlier.

Table 3.7.9: Coefficients and standard errors associated with the corporate loans-to-GDP ratio

Coefficient	Estimate	s.e.
α_0	0.004	0.003
α_1	0.54	0.12
α_2	-3.86	0.64
α_3	0.23	0.09
α_4	0.15	0.05
β_1	-0.04	0.002
β_2	-0.02	0.001
β_3	-0.03	0.001
β_4	0.08	0.005
β_5	-0.03	0.008
β_6	0.052	0.002

$R^2 = 0.78$

Bonds relative to total debt Our model for the dynamics of the ratio of the stock of corporate bonds B_t^C to total corporate debt D_t^C, i.e. $BD_t^C = \frac{B_t^C}{D_t^C}$ is based on an equation that associates the contemporaneous change in the ratio to the previous-period deviation of the ratio from its long-run average $\bar{BD}_t^C$ and the cost differential between the two types of debt financing, i.e. the spread between the interest rates on bank loans and bonds, $i_{BL,t} - i_{BBB,t}$. The estimated coefficients, presented in Table 3.7.10, have not changed noticeably compared to those presented in Dees et al. (2022).

$$\Delta BD_t^C = \alpha_0 + \alpha_1 \left(BD_{t-1}^C - \bar{BD}_t^C \right) + \alpha_2 (i_{BL,t} - i_{BBB,t}) + \beta_1 \delta_{06q1} + \beta_2 \delta_{07q4} + \beta_3 \delta_{16q1} \quad (69)$$

Table 3.7.10: Coefficients and standard errors associated with the ratio of bonds to total debt

Coefficient	Estimate	s.e.
α_0	0.001	0.0008
α_1	-0.029	0.026
α_2	1.56	0.71
β_1	-0.02	0.001
β_2	-0.015	0.002
β_3	-0.027	0.001

$R^2 = 0.39$

Revaluations We model corporate equity revaluations R_t^C relative to long-run nominal output $RY_t^C = \frac{R_t}{\bar{Y}_t}$ by relating them empirically to the dynamics of a French stock market index, the CAC40, expressed in logarithms in the term $cac40_t$. This process, based on maximizing empirical fit, follows

$$RY_t^C = \alpha_0 + \alpha_1 \Delta cac40_t + \alpha_2 \Delta cac40_{t-2} + \alpha_3 \Delta cac40_{t-3} + \beta_1 \delta_{99q2} + \beta 2 \delta_{20q2} \tag{70}$$

The estimation results are presented in 3.7.11.

Table 3.7.11: Coefficients and standard errors associated with revaluations

Coefficient	Estimate	s.e.
α_0	0.02	0.014
α_1	1.31	0.19
α_2	0.33	0.17
α_3	-0.46	0.22
β_1	0.49	0.03
β_2	0.24	0.04

$R^2 = 0.47$

Stock prices The dynamics of the value of the stock market index CAC40, expressed in logarithms, are modeled with an error-correction equation that relates them to the cost of equity COE_t, to the firm gross operating surplus and to the trend real growth rate g and the long-run inflation anchor $\bar{\pi}_t$. We present the estimation results in Table 3.7.12.

$$\Delta cac40_t = (1-\alpha_0)(g+\bar{\pi}) + \lambda(cac40_{t-1} - \alpha_1 - gos_{t-1} + \log(COE_{t-1} - (\bar{\pi}_{t-1} + g)) \tag{71}$$

$$+\alpha_0 \Delta cac40_{t-1} + \alpha_2 \Delta \log(COE_t - (\bar{\pi}_t + g)) \tag{72}$$

$$+\beta_1 \delta_{02q3} + \beta_2 \delta_{08q4} + \beta_3 \delta_{16q1} + \beta_4 \delta_{20q2})$$

Table 3.7.12: Coefficients and standard errors associated with the stock market index

Coefficient	Estimate	s.e.
α_0	0.32	0.07
α_1	-7.09	0.1
α_2	-0.42	0.1
λ	-0.069	0.03
β_1	-0.17	0.02
β_2	-0.17	0.02
β_3	-0.09	0.01
β_4	-0.3	0.03

$R^2 = 0.58$

Value of equity We compute the total value of net equity via the identity

$$\Delta E_t = \Delta\left(A_t\right) + \Delta\left(F2_t\right) + \Delta\left(F8_t\right) - \Delta\left(B_t^C\right) - \Delta\left(L_t^C\right) \tag{73}$$

i.e. the change in net equity is the sum of changes in the value of net assets $A_t = R_t^C - B_{F,t}$ (equity revaluations, which accounts for the majority of the revaluations of firms net assets, less financing need), currency holdings $F2_t$, other assets $F8_t$, less the change in debt in the forms of bonds B_t and bank loans L_t. We model the dynamics of Fj_t (where $j \in \{2, 8\}$) via identities which relate them to the stock of net assets A_t

$$Fj_t = A_t \frac{Fj_t}{A_t} \tag{74}$$

and the econometric equations which relate the change in assets to their past levels and a time trend T_t

$$\Delta \frac{Fj_t}{A_t} = \alpha_0 \left(\frac{Fj_{t-1}}{A_{t-1}} - \gamma + \lambda T_t \right) + \alpha_1 \Delta \frac{Fj_{t-2}}{A_{t-2}} \tag{75}$$

Both of these equations also include a set of dummies. In the case $F2$ they appear in 1997Q4, 1999Q4, 2020Q1, 2020Q2 and 2021Q3 and for $F8$ we have them in 1992Q2, 2003Q1, 2018Q4 and 2020Q1. The estimation results are reported in Table 3.7.13.

Net market leverage The leverage term $\frac{D_t^C}{E_t}$ appearing in equation (50) is defined using the accounting identity

$$\frac{D_t^C}{E_t} = \frac{B_t^C + L_t^C}{E_t} c \tag{76}$$

Table 3.7.13: Coefficients and standard errors associated with other assets

Coefficient	F2	F8
α_0	-0.2 [0.06]	-0.18 [0.04]
α_1	0.17 [0.08]	0.12 [0.07]
γ	-0.36 [0.03]	-0.23 [0.03]
λ	0.004 [0.0003]	0.003 [0.0002]
β_1	0.013 [0.001]	0.03 [0.001]
β_2	-0.02 [0.002]	0.03 [0.002]
β_3	0.05 [0.003]	0.02 [0.001]
β_4	0.04 [0.003]	-0.01 [0.0008]
β_5	0.01 [0.002]	–

F2: $R^2 = 0.50$. F8: $R^2 = 0.44$. Standard errors in brackets.

where B_t^C, L_t^C and E_t are the stocks of corporate bonds, bank loans and equity, respectively. The dynamics of B_t^C are obtained from (69) using the relationship $B_t^C = L_t^C BD_t^C / \left(1 - BD_t^C\right)$[12]. Similarly, the dynamics of the stock of bank loans L_t^C are defined by equation (68) and the transformation $L_t^C = L_{t-1}^C + LY_t Y_t$.

3.7.4 Net property income and net asset positions

Table 3.7.14: Variables used in section 3.7.4

Notation	Description
$Y_{Fj,t}$	Net property income for sector j
$i_{Fj,t}$	Rate of return on the net stock of financial wealth for sector j
$W_{j,t}$	Stock of financial wealth for sector j
$B_{j,t}$	Net financing capacity of sector j
$R_{j,t}$	Revaluation of the financial assets of sector j
$\bar{Y}_t$	Nominal long-run output
$\delta_{COVID,i}$	COVID-associated dummies
E-SAT	See Table 3.2.1

Net property income The framework for determining the net property income $Y_{Fj,t}$ of the various agents $j \in \{$Firms, Government, Households, Non-profit organizations$\}$ of the model is unchanged compared to the previous revision of the model. Notice that our definition of firms in this section includes both financial and non-financial corporations. Our model for

[12]Notice that this relationship can be inverted into $B_t^C = BD_t^C \left(B_t^C + L_t^C\right)$ and that $B_t^C + L_t^C = D_t^C$.

the net property income of agent j is based on

$$Y_{Fj,t} = i_{Fj,t} W_{j,t-1} \tag{77}$$

where $i_{Fj,t}$ is the agent-specific rate of return on the net stock of financial wealth $W_{j,t-1}$ of agent j. We denote the four agents with the subscripts F, G, H and N for brevity. We deviate from the baseline set out in Equation (77) as necessary. More specifically, we assume that for firms

$$Y_{FF,t} = i_{FF,t} W_{F,t-1} - \tau_{TF,t} \bar{Y}_t \tag{78}$$

where the term $\tau_{TF,t}\bar{Y}_t$ represents the real financial transfers made by the firms to households in order to stabilize their net asset ratio. Similarly, the financial income of non-profit organizations is modified to account for transfers $\tau_{TN,t}\bar{Y}_t$ between them and households:

$$Y_{FN,t} = i_{FN,t} W_{N,t-1} - \tau_{FN,t} \bar{Y}_t \tag{79}$$

The households' financial income is then

$$Y_{FH,t} = i_{FH,t} W_{H,t-1} + \tau_{TF,t} \bar{Y}_t \bar{P}_{\bar{Y},t} + \tau_{FN,t} \bar{Y}_t \tag{80}$$

i.e. they receive payments directly from their stock of wealth $W_{H,t-1}$ and as transfers from firms and non-profit organizations.

Financial wealth The stocks of financial wealth $W_{j,t}$ are assumed to evolve following

$$\Delta W_{j,t} = B_{j,t} \tag{81}$$

where $NF_{j,t}$ is the net financing capacity of agents of type j, with the exception of firms and households, for whom we also model the revaluations $R_{F,t}$ and $R_{H,t}$ of their asset stock so that

$$\Delta W_{F,t} = B_{F,t} + R_{F,t} \tag{82}$$

and

$$\Delta W_{H,t} = B_{H,t} + R_{H,t} \tag{83}$$

where the revaluations for firms are determined with

$$R_{F,t} = \bar{Y}_t \left(\frac{R_{F,t-1}}{\bar{Y}_{t-1}} + \gamma_1 \left(\frac{R_{F,t-1}}{\bar{Y}_{t-1}} - \gamma_0 \right) + \gamma_2 \Delta RY_t^C \right) \tag{84}$$

and with

$$R_{H,t} = \bar{Y}_t \left(\gamma_0 + \gamma_1 \frac{R_{H,t-1}}{\bar{Y}_{t-1}} + \gamma_2 \left(\frac{CAC40_t}{CAC40_{t-1}} - 100 \right) + \gamma_3 \delta_{08Q2} \right) \tag{85}$$

for households. In these two equations $CAC40_t$ is the value of the CAC40 stock index, RY_t^C represents the revaluation of firms' financial assets, determined with equation (70), and δ_{08Q2} is a dummy set to 1 in the second quarter of 2008. We present the estimation results associated with equations (84) and (85) in Table 3.7.15. Note that we estimate γ_0 in the firm equation separately as the historical average of the change in firm net financial assets less firm financing capacity, relative to nominal GDP.

Table 3.7.15: Coefficients and standard errors associated with firm and household asset revaluations

Coefficient	Firms	Households
γ_0	-0.053	0.02 [0.008]
γ_1	-0.51 [0.09]	-0.49 [0.14]
γ_2	-0.83 [0.09]	0.01 [0.001]
γ_3	–	-0.26 [0.03]

Firms: $R^2 = 0.49$. Households: $R^2 = 0.55$.
Standard errors in brackets.

Stabilization of assets and debt We ensure the convergence of the model to a balanced growth path with levels of assets and stocks of debt that stabilize relative to output with a set of rules governing transfers of income between the agents, particularly from the government and firms to households, i.e. social security payments and dividends. Notice that these rules are not applied in forecasts, where the transfers are determined outside of the model.

The transfer policies of firms and non-profit organizations are given by

$$\begin{aligned}\tau_{TF,t} &= (1-\rho_{stab,1})\,\tau_{TF,t-1} + \rho_{stab,1}\tau^*_{TF} \\ &\quad -\rho_{stab,2}\left(\frac{-B_{F,t}+\gamma\bar{Y}_t\bar{P}_{\bar{Y}_t}}{Y_tP_{Y,t}} + \frac{W_F}{Y}\frac{\exp(g+\bar{\pi})-1}{\exp(g+\bar{\pi})}\right)\end{aligned} \tag{86}$$

$$\tau_{TN,t} = (1-\rho_{stab,1})\,\tau_{TN,t-1} + \rho_{stab,1}\tau^*_{TN} - \rho_{stab,2}\left(\frac{-B_{N,t}}{Y_tP_{Y,t}} + \frac{W_N}{Y}\frac{\exp(g+\bar{\pi})-1}{\exp(g+\bar{\pi})}\right) \tag{87}$$

where $\rho_{stab,1} = 0.1$ and $\rho_{stab,2} = 0.1$ are calibrated. $\tau^*_{TF} = 0.02$ and $\tau^*_{TN} = -0.0003$ are exogenous long run targets – constructed using a simulation method – for the rate at which dividends and transfers are paid to households. $\frac{W_F}{Y} = -0.95 * 4$ and $\frac{W_N}{Y} = 0.02 * 4$ are exogenous, calibrated targets for the ratio of assets to nominal output for firms and non-profit organizations, respectively. Note that these two rules are strongly based on a similar policy rule used by the government to ensure that its net financial asset-to-GDP ratio is stable in the long run:

$$\tau_{TG,t} = (1-\rho_{stab,1})\,\tau_{TG,t-1} + \rho_{stab,1}\tau^*_{TG} - \rho_{stab,2}\left(\frac{-B_{G,t}}{Y_tP_{Y,t}} + \frac{W_G}{Y}\frac{\exp(g+\bar{\pi})-1}{\exp(g+\bar{\pi})}\right) \tag{88}$$

where $\frac{W_G}{Y} = -0.4 * 4$ and $\tau^*_{TG} = 0.12$ are constructed similarly to their counterparts in equations (86) and (87). The key difference is that this rule is not used to regulate financial transfers, but to determine the share of social transfers excluding unemployment benefits and social transfers in kind relative to nominal GDP.

Return on assets The rates of return on net financial assets $i_{Fj,t}$ are assumed to follow for all agents j an autoregressive distributed lag process relative to the interest rate on 10-year government bonds $i_{10,t}$

$$i_{Fj,t} = \rho_{j,0}\left(1-\rho_{j,1}\right) + \left(1-\rho_{j,1}\right) i_{10,t} + \rho_{j,1} i_{Fj,t-1} \tag{89}$$

the coefficients of which are shown in Table 3.7.16. We assume that for all types of agents $\rho_{j,1} = 0.983$ – calibrated so that the process has a half-life of 40 quarters – and that $\rho_{G,0} = 0$ to ensure convergence to $i_{10,t}$. The long run premia are estimated from data as the historical means of the ratio of total asset income to total asset stock minus the mean of $i_{10,t}$ and are exogenous in any model simulation.

Table 3.7.16: Coefficients, asset return processes

Coefficient	Estimate
$\rho_{F,0}$	-0.002
$\rho_{G,0}$	0
$\rho_{H,0}$	0.0007
$\rho_{N,0}$	-0.002

Finally, due to the requirements of accounting appropriately for government finances, we model separately the interest payments made by the public sector - $Y_{IGP,t}$ - and asset income payments excluding interest income made by the public sector, i.e. $Y_{OGP,t}$, where "O" stands for "other". First, the interest payments are computed as

$$Y_{IGP,t} = Y_{IGR,t} - Y_{IG,t}$$

i.e. as the difference between interest payments received $Y_{IGR,t}$ and net interest income $Y_{IG,t}$. We assume that interest payments received $Y_{IGR,t}$ are a constant share - 0.011% - of long run output $\bar{Y}_t$, while the net interest income is computed as

$$Y_{IG,t} = Y_{FG,t} - Y_{OG,t}$$

i.e. as the difference between total net asset income $Y_{FG,t}$ (described above) and net asset income excluding interest payments $Y_{OG,t}$. This, in turn is simply the difference between receipts and payments, i.e.

$$Y_{OG,t} = Y_{OGR,t} - Y_{OGP,t}$$

both of which are assumed to be constant shares of $\bar{Y}_t$ - 0.006 and 0.05 percent, respectively.

3.7.5 Exchange rates

There are two exchange rates in FR-BDF: the exchange rate between the dollar and the euro and the effective exchange rate of the euro area vis-a-vis a bundle of other currencies of key trading partners. We present here a sketch of the derivation of the equations describing their dynamics starting from a theoretical foundation resting on uncovered interest rate parity (UIP) conditions. A more detailed description is presented in Lemoine et al. (2019) for the interested reader.

These conditions imply that the exchange rates are defined as functions of the countries' interest rate differentials:

$$\frac{\Xi_{t+1}}{\Xi_t} = \frac{(1+i_t^*)}{(1+i_t)} \tag{90}$$

where Ξ_t stands for the direct nominal exchange rate (i.e. units of foreign currency per unit of domestic currency), i_t and i_t^* are domestic and foreign short run interest rates, respectively. We define the log real exchange rate q_t:

$$q_t \equiv \xi_t + p_{EA,t} - p_{F,t} \tag{91}$$

where $p_{EA,t}$ and $p_{F,t}$ are respectively the logarithms of euro area and foreign prices. We can rewrite the UIP condition for the real exchange rate, in terms of interest rate and inflation rate differentials, in logarithms:

$$\begin{aligned} q_t - (p_{EA,t} - p_{F,t}) &= q_{t+1} - (p_{EA,t+1} - p_{F,t+1}) + (i_t - i_t^*) \\ q_t &= q_{t+1} + (i_t - i_t^*) - (\pi_{EA,t+1} - \pi_{t+1}^*) \end{aligned} \tag{92}$$

Solving forward equation (92) and using the definition of the log real exchange rate (91), we obtain equation (93).

$$\xi_t + p_t^{EA} - p_t^* = \sum_{\kappa=0}^{\infty} \left(i_{t+\kappa} - i_{t+\kappa}^* \right) - \sum_{\kappa=0}^{\infty} \left(\pi_{EA,t+1+\kappa} - \pi_{t+1+\kappa}^* \right) \tag{93}$$

Table 3.7.17: Variables used in section 3.7.5

Notation	Description
$\xi_{EA,t}$	Effective exchange rate of the euro area (in log)
$\xi_{\$,t}$	Dollar/Euro exchange rate (in log)
i_t/i_t^*	Domestic/foreign short run interest rate
$p_{EA,t}/p_t^*$	Euro area/foreign GDP deflator (in log)
$\pi_{EA,t}/\pi_t^*$	Euro area/foreign quarterly inflation rate (GDP deflator)
$P_{cm,t}/P_{cx,t}$	Foreign competitors' price (import/export)
$\Xi_{FR,X,t}/\Xi_{FR,M,t}$	French exchange rate on export/import side
E-SAT variables	See Table 3.2.1

The infinite sums of the short run interest rates and inflation rates are computed as non-discounted present values (PV_{nd}) by inverting the corresponding models: the E-SAT model in the case of i_t and $\pi_{EA,t+1}$ and AR(1) models for i_t^* and π_{t+1}^* (see equations (95) and (97)). Notice that we assume that agents compute all exchange rate-related expectations terms using information available at date t instead of the standard assumption of $t-1$. This change is denoted by adjusting the indexing of the term $PV_{nd}(X)_{t|t-1}$ to $PV_{nd}(X)_{t|t}$, where X refers to any of the relevant variables in this section.

The exchange rate of the euro against the dollar and the effective exchange rate ($\xi_{\$,t}$ and $\xi_{EA,t}$ respectively) are estimated using (94), with $x \in \{\$, EA\}$:

$$\begin{aligned}\xi_{x,t} + p_t^{EA} - p_t^* &= \phi + \Big[\big(PV_{nd}(i)_{t|t} - PV_{nd}(i^*)_{t|t}\big) \\ &\quad -\big(PV_{nd}(\pi_{EA})_{t+1|t} - PV_{nd}(\pi^*)_{t+1|t}\big)\Big] + \eta_t\end{aligned}$$

with $(1-\rho L)\eta_t = \epsilon_t$, which can be rewritten as follows:

$$\begin{aligned}(1-\rho L)(\xi_{x,t} + p_t^{EA} - p_t^*) &= (1-\rho)\phi + (1-\rho L)\Big[\big(PV_{nd}(i)_{t|t} - PV_{nd}(i^*)_{t|t}\big) \\ &\quad -\big(PV_{nd}(\pi_{EA})_{t+1|t} - PV_{nd}(\pi^*)_{t+1|t}\big)\Big] + \epsilon_t \qquad (94)\end{aligned}$$

The estimated coefficients are presented in Table 3.7.18. Policy functions of the present value of non-discounted sums of future domestic short run interest rates ($PV_{nd}(i)_{t|t}$) and of future domestic inflation rate ($PV_{nd}(\pi_{EA})_{t+1|t}$) are given in Table 3.7.19. In order to construct $PV_{nd}(i^*)_{t|t}$, we require a model for foreign short run interest rates. To this end, we apply the Federal Reserve's 3-month interest rate modeled as an AR(1) process with mean reversion:

Table 3.7.18: Coefficients and standard errors of exchange rate equations

	$\xi_{\$,t}$		$\xi_{EA,t}$		i_t^*	π_t^*	$\Xi_{FR,X,t}$	$\Xi_{FR,M,t}$
	Coef.	s.e.	Coef.	s.e.	Coef.	Coef.	Coef.	Coef.
ϕ	0.07	0.24	0.02	0.22	-	-	0.048	0.057
γ	-	-	-	-	-	-	0.59	0.46
ρ	0.95	0.04	0.96	0.03	0.98	0.64	-	-

$$i_t^* = \rho_i i_{t-1}^* + (1-\rho_i)\bar{i} + \epsilon_t \qquad (95)$$

This implies the following present value of non-discounted sums of future foreign short run interest rates:

$$PV_{nd}(i^*)_{t|t} = \sum_{\kappa=0}^{\infty}(i_{t+\kappa}^* - \bar{i}) = \frac{\rho_i}{(1-\rho_i)}(i_{t-1}^* - \bar{i}) \qquad (96)$$

We apply the method to construct the $PV_{nd}(\pi^*)_{t+1|t}$. We proxy the foreign price level and inflation rate using the US GDP deflator and estimate the following AR(1) process:

$$\pi_t^* = \rho_\pi \pi_{t-1}^* + (1-\rho_\pi)\bar{\pi} + \epsilon_t \qquad (97)$$

where $\bar{\pi}$ is the steady-state inflation rate. This implies that

$$PV_{nd}(\pi^*)_{t+1|t} = \sum_{\kappa=0}^{\infty}(\pi_{t+1+\kappa}^* - \bar{\pi}) = \frac{\rho_\pi}{(1-\rho_\pi)}(\pi_{t-1}^* - \bar{\pi}) \qquad (98)$$

Table 3.7.19: Coefficients of policy functions associated with exchange rates

VAR Model variables	Policy function $\boldsymbol{PV_{nd}(i)}$	Policy function $\boldsymbol{PV_{nd}(\pi_{EA})}$
$i_t - \bar{i}$	1.97	-2.91
$\bar{i}_t - \bar{i}$	31.3	2.91
$\hat{y}_{EA,t}$	1.4	0.5
$\pi_{EA,t} - \bar{\pi}$	1.48	0.45
$\bar{\pi}_{EA,t} - \bar{\pi}$	-1.48	2.8
$\hat{y}_t$	-	-
$\pi_{Q,t} - \bar{\pi}_{Q,t}$	-	-

French effective exchange rates on the export and import sides ($\Xi_{FR,X,t}$ and $\Xi_{FR,M,t}$ respectively) are endogenized using linear relationships with respect to the effective exchange rate of the euro area:

$$\Xi_{FR,X,t} = \phi + \gamma(100/\Xi_{EA,t}) + \epsilon_t \tag{99}$$

$$\Xi_{FR,M,t} = \phi + \gamma(100/\Xi_{EA,t}) + \epsilon_t \tag{100}$$

with calibrated parameters provided in Table 3.7.18.

Foreign competitors' prices of exports and imports expressed in euros ($P_{cx,t}$ and $P_{cm,t}$ respectively) are modeled as a ratio of the effective exchange rate of the euro area and foreign competitors' prices of exports and imports expressed in foreign currencies ($P_{cx,F,t}$ and $P_{cm,F,t}$ respectively):

$$P_{cx,t} = \frac{P_{cx,F,t}}{\Xi_{EA,t}} + \epsilon_t \tag{101}$$

$$P_{cm,t} = \frac{P_{cm,F,t}}{\Xi_{EA,t}} + \epsilon_t \tag{102}$$

Oil prices in euros are modeled as a product of oil prices in dollars and the dollar/euro exchange rate $\Xi_{\$,t}$:

$$P_{oil,t} = \frac{P_{oil,\$,t}}{\Xi_{\$,t}} \tag{103}$$

3.8 External trade block

The external trade block has been updated with revisions affecting both estimation strategy and selected structural components. Most equations have been re-estimated over extended and harmonised samples (2001Q1–2021Q4 for volumes and 2000Q1–2021Q4 for deflators), incorporating, when necessary, dummies to account for the dynamics during periods of crisis (financial crisis as well as Covid-19 crisis), adopting one-step estimation procedures, and including a long-run constant where previously omitted. Beyond this harmonisation effort, several targeted structural modifications were introduced: the global product variety indicator in non-energy imports is replaced by filtered world GDP, energy price transmission is refined through the introduction of the gas price, and the specifications of energy import

deflators and non-energy import deflators are revised accordingly. These changes induced coefficient updates, including a stronger sensitivity of export volumes to world demand, weaker error-correction dynamics in non-energy import volumes and energy import deflators, and a reduced role for domestic inflation in the export deflator equation.
Although the ECMs are estimated using a one-step procedure, we present the equations by distinguishing between the long-run and short-run equations. However, all reported estimation results correspond to the one-step approach.

3.8.1 Volumes variables

As shown below, we obtain relatively high estimates for the price elasticities in the export and non-energy import equations compared to what can be found in the literature for France based on macroeconomic data (Hooper et al. (1998), Crane et al. (2007)). The re-estimated elasticities are slightly lower than those obtained in the previous specification, yet they continue to imply a strong volume response to relative price movements, consistent with the long-run trade balance adjustment predicted by the Marshall–Lerner condition and J-curve dynamics.

Table 3.8.1: Variables used in section 3.8.1

Notation	Description
X_t	Exports (volume)
WD_t	World demand addressed to France (volume)
$P_{X,t}$	Export price
$P_{CX,t}$	Foreign competitors price' (export side)
Ω_t	Weight of emerging countries (in log)
WS_t	World supply for France (volume)
$\Delta\bar{q}$	Long run anchor of the output growth rate
$M_{O,t}$	Non-energy imports
$D_{MO,t}$	Import intensity-adjusted measure of aggregate demand (IAD) for imports other than energy
$P_{MO,t}$	Import price, other than energy
$Q_{N,t}$	Long run value added, market sector
$M_{NRJ,t}$	Energy imports (volume)
$D_{MNRJ,t}$	Import intensity-adjusted measure of aggregate demand (IAD) for energy imports
$P_{MNRJ,t}$	Energy import price
$P_{Q,t}$	Value added price
$\delta_{COVID,i}$	COVID-associated dummies
$\bar{T}_t$	Time-varying trend
C_t	Household consumption, volume
$I_{B,t}$	Investment, volume, NFC, FC and sole proprietor
$I_{H,t}$	Household investment, volume
$C_{G,t}$	Government consumption, volume
$I_{G,t}$	Government investment, volume

Exports The real export equation has been re-estimated using a one-step ECM approach over the period 2001Q1–2021Q4, whereas initial specifications relied on a two-step procedure.

Target We impose a unit coefficient in front of the world demand variable[13] to satisfy the balanced growth path condition. The difference between export prices ($p_{X,t}$) and foreign competitors prices ($p_{CX,t}$) in the target is used as a price competitiveness indicator specific to exports. The weight of emerging countries (ω_t) is also used here to reveal the competitiveness of French producers not captured by the price difference.[14]

$$x_t^* = \beta_0 + wd_t + \beta_1 \left(p_{X,t} - p_{CX,t}\right) + \beta_2 \omega_t \tag{104}$$

[13] By world demand we mean the weighted sum of imports by trade partners. For more details about computational aspects of these variables see Hubrich & Karlsson (2010).

[14] This variable captures the fact that a share of foreign demand is not "addressed" to France but is met by emerging economies whose competitiveness is not adequately measured by our price competitiveness indicator, possibly because these countries expand at the extensive margin (new varieties, new destinations) rather than at the intensive margin (increased price competitiveness on existing markets and products).

Table 3.8.2: Long-run parameter estimates and associated standard errors of the exports equation

Coefficient	Estimate	s.e.
β_0	11.96	0.03
β_1	-1.097	0.37
β_2	-0.63	0.08
$R^2 = 0.92$		

Short run equation The short run is determined by world demand and by a long run anchor of the output growth rate. To satisfy the balanced growth path condition, their coefficient sum to one. Compared to the previous estimation of the model, we obtain higher estimated coefficients for the world demand variable (0.97 vs 0.85). The specification also includes dummies related to the Covid crisis.

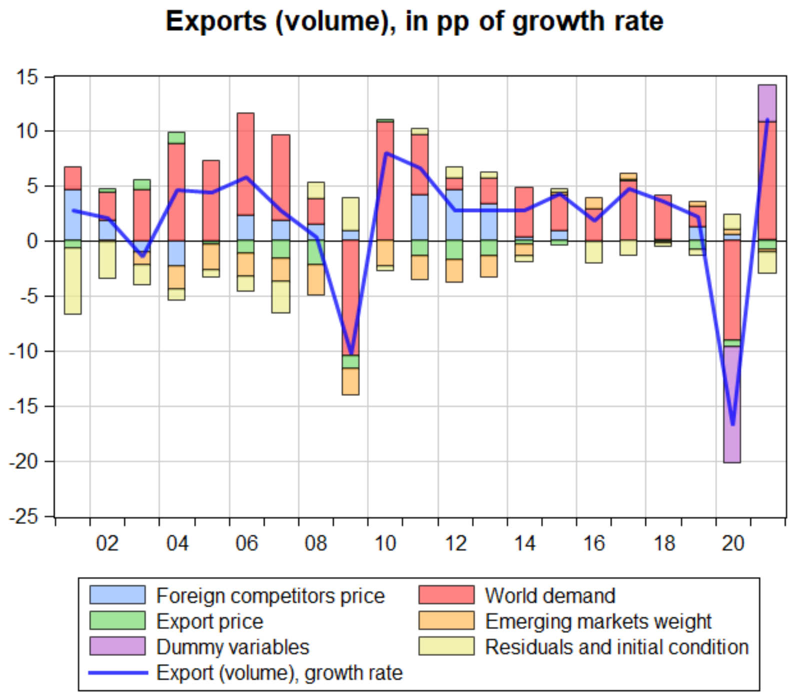
$$\Delta x_t = \beta_0 \Delta d_{WD,t} + (1 - \beta_0)\,\Delta \bar{q} + \beta_1 \left[x_{t-1} - x^*_{t-1}\right] + \beta_2 \delta_{COVID,20Q1} + \beta_3 \delta_{COVID,20Q2} + \epsilon_t \quad (105)$$

Table 3.8.3: Short-run parameter estimates and associated standard errors of the exports equation

Coefficient	Estimate	s.e.
β_0	0.97	0.13
β_1	-0.14	0.05
β_2	-0.05	0.01
β_3	-0.10	0.02
$R^2 = 0.92$		

Dynamic contributions Figure 3.8.1 describes how the various components contribute dynamically to the variation in real exports. Consistent with the initial specification, world demand continues to be the dominant driver of French export dynamics. However, the re-estimated version shows a markedly different pattern for export prices: while their contribution alternated between negative and positive values in the original specification, they now appear as a persistently negative influence over most of the sample. Moreover, the Covid-related dummy variables, together with the sharp fluctuations in world demand, account for the exceptional movements observed in 2020 and 2021. Finally, the contribution of the residuals is noticeably smaller than in the initial version, indicating an overall improvement in model fit and a better attribution of exports fluctuations to its associated determinants.

Figure 3.8.1: Dynamic contributions, real exports, pp of growth rate



Imports We model separately volumes for energy and non-energy imports. The choice to split the total import volume and price is due to the heterogeneity in coefficients of adjustment (for price) and elasticities of substitution (for volumes). Total imports are then simply modeled through a chained price aggregation.
As in the initial specifications, import intensity-adjusted measures of aggregate demand (IAD) for non-energy and energy imports play an important role in the equations. They are computed with weights based on INSEE input-output tables assuming imports can be directly re-exported, as shown in equations (106) and (107).

$$D_{MO,t} = 0.193C_t + 0.106C_{G,t} + 0.276I_{B,t} + 0.205I_{G,t} + 0.161I_{H,t} + 0.337X_t \tag{106}$$

$$D_{MNRJ,t} = 0.027C_t + 0.008C_{G,t} + 0.007I_{B,t} + 0.009I_{G,t} + 0.001I_{H,t} + 0.014X_t \tag{107}$$

Non-energy imports The real non-energy imports equation has been re-estimated using a one-step ECM approach over the period 2001Q1–2021Q4, whereas initial specifications relied on a two-step procedure.

Target

$$m^*_{O,t} = \beta_0 + d_{MO,t} + \beta_1 (p_{X,t} - p_{MO,t}) + \beta_2 (ws_t - q_{N,t}) \tag{108}$$

The variable $ws_t - q_{N,t}$ is a proxy for the variety of foreign goods relative to the variety of French supply.[15] The former is approximated by filtered real-world GDP, while the latter corresponds to the long-run value added of French market branches. This represents a change from the initial specification of the equation, in which we used a weighted average of exports from countries supplying France. Using filtered real-world GDP appeared to be a simpler and more straightforward way to proxy variety of foreign goods. This change in the proxy variable does not lead to a substantial change in the associated coefficient.

Table 3.8.4: Long-run parameter estimates and associated standard errors of the non-energy imports equation.

Coefficient	Estimate	s.e.
β_0	4.70	2.34
β_1	1.05	1.16
β_2	0.56	0.28

$R^2 = 0.87$

Short run equation The coefficient of the import intensity-adjusted measure of aggregate demand for imports other than energy is constrained to one in order to satisfy the balanced growth path condition. Following the revision of the variable $d_{MO,t}$, the estimated coefficient β_1 is lower than prior estimates (-0.12 compared to -0.20).

$$\Delta m_{O,t} = \Delta d_{MO,t} + \beta_1 \left[m_{O,t-1} - m^*_{O,t-1} \right] + \epsilon_t \tag{109}$$

Table 3.8.5: Short-run parameter estimates and associated standard errors of the non-energy imports equation.

Coefficient	Estimate	s.e.
β_1	-0.12	0.04

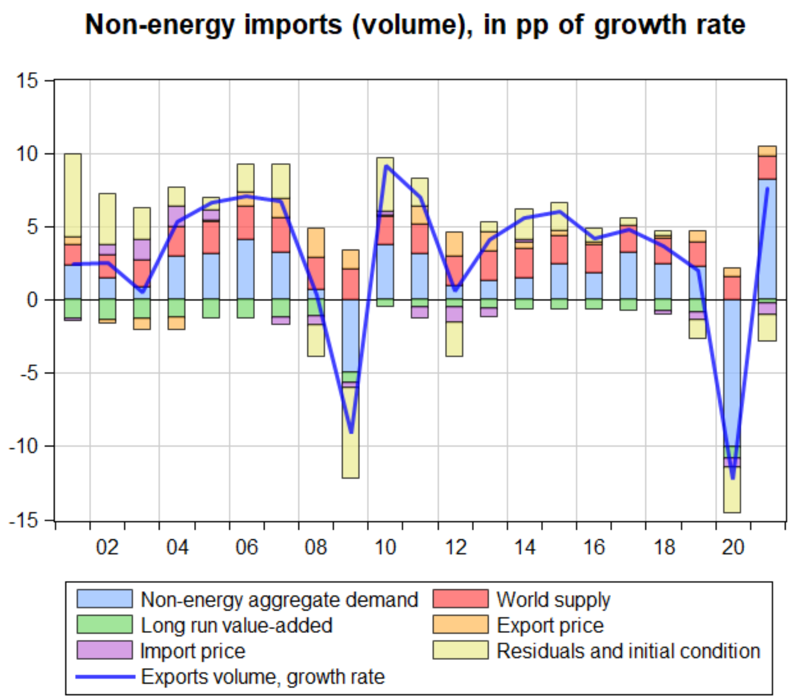
$R^2 = 0.87$

Dynamic contributions Figure 3.8.2 reports the dynamic contributions of the main determinants to fluctuations in real non-energy imports. In line with the initial specification,

[15] This variable is intended to capture the impact of the emergence of new goods and product varieties on trade flows. Accounting for this effect is particularly relevant in recent decades, as the rise of emerging economies has significantly expanded the range and diversity of goods offered on world markets. Ignoring this dimension would induce a bias in the estimate of the responsiveness of import volumes to relative prices, since part of the observed increase in imports reflects substitution toward newly available varieties rather than pure price effects.

the intensity-adjusted measure of aggregate demand remains the primary driver of these imports. However, the re-estimated model assigns a more substantial role to the proxy capturing the variety of foreign goods, which now explains a larger share of the dynamics than in the original version.

Figure 3.8.2: Dynamic contributions, real non-energy imports, pp of growth rate



Energy imports This equation has been re-estimated as a one-step ECM over the sample period 2001Q1–2021Q4.

Target

$$m^*_{NRJ,t} = d_{MNRJ,t} + \beta_0 \left(p_{MNRJ,t} - p_{Q,t}\right) + \beta_1 + \beta_2 \bar{T}_t \tag{110}$$

Table 3.8.6: Long-run parameter estimates and associated standard errors of the energy imports equation.

Coefficient	Estimate	s.e.
β_0	-0.19	0.09
β_1	0.31	0.07
β_2	-0.004	0.001

$R^2 = 0.50$

Note: β_0 was estimated separately.

Short run equation

$$\begin{aligned}\Delta m_{NRJ,t} &= (1-\beta_0-\beta_1)\Delta\bar{y} + \beta_0\Delta d_{MNRJ,t} + \beta_1\Delta m_{NRJ,t-1} \\ &+\beta_2\Big[m_{NRJ,t-1} - m^*_{NRJ,t-1}\Big] + \beta_3\delta_{COVID,20Q3} + \beta_4\delta_{COVID,21Q1} + \epsilon_t\end{aligned} \quad (111)$$

This specification is the same as in the previous version of the model, and estimated coefficients display no significant changes. The only change is that the specification now proposes to include dummies related to the Covid crisis.

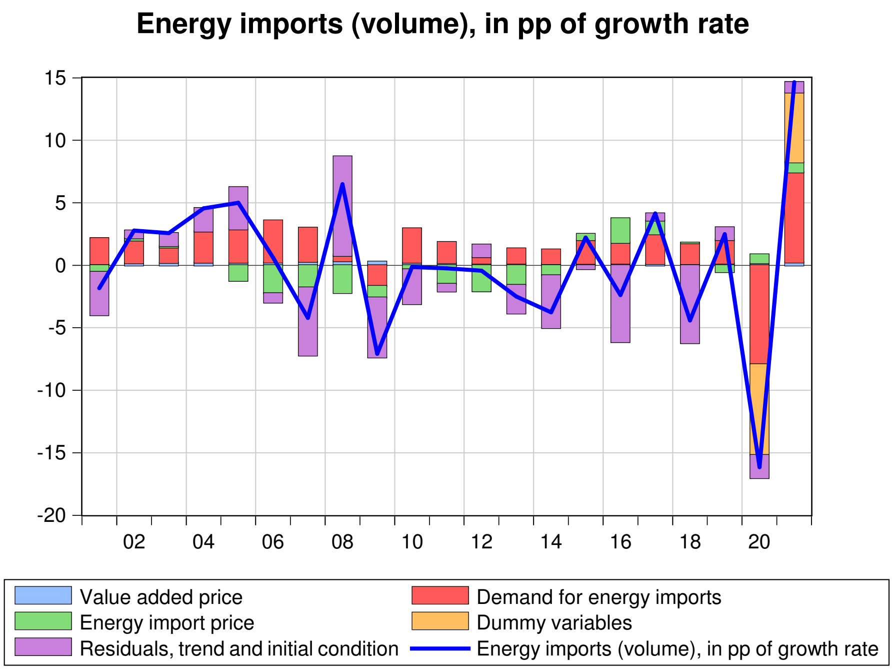
Table 3.8.7: Short-run parameter estimates and associated standard errors of the energy imports equation.

Coefficient	Estimate	s.e.
β_0	1.26	0.09
β_1	-0.38	0.06
β_2	-0.11	0.04
β_3	-0.21	0.03
β_4	0.13	0.01

$R^2 = 0.50$

Dynamic contributions Figure 3.8.3 reports the dynamic contributions of the main determinants to fluctuations in real energy imports. The intensity-adjusted measure of aggregate demand remains the primary driver of these imports. In addition, the contribution of the residuals is noticeably smaller than in the initial version due to an overall improvement in the model fit.

Figure 3.8.3: Dynamic contributions, real energy imports, pp of growth rate



3.8.2 Price variables

Table 3.8.8: Variables used in section 3.8.2

Notation	Description
$p_{X,t}$	Export prices (in log)
$p_{Q,t}$	Value added prices (in log)
$p_{MO,t}$	Non energy import prices (in log)
$p_{MNRJ,t}$	Energy import prices (in log)
$p_{CX,t}$	Foreign competitors' prices (in log)
$\pi_{X,t}$	Export price inflation
$\hat{\pi}_{Q,t}$	Long run trend of the value added price inflation
$\pi_{Q,t}$	Value added price inflation
$\pi_{M,t}$	Import price inflation (total)
$p_{M,t}$	Import prices (in log)
Ω_t	Weights of emerging countries
$\pi_{SEI,t}$	synthetic energy price index inflation
$p_{SEI,t}$	synthetic energy price index (in log)
$p_{oil,t}$	Oil price in euro (Brent, in log)
$p_{gaz,t}$	Gaz price in euro (per MWh, in log)
usd_t	Dollar/euro exchange rate (in log)
$\delta_{COVID,i}$	COVID-associated dummies

Exports deflators The growth rate of the export deflator, $\pi_{X,t}$, has been re-estimated using a one-step ECM over the extended estimation period 2000Q1–2021Q4.

Target The specification for the long-term anchor of foreign competitors' export price $p^*_{X,t}$ remains the same, i.e. a weighted sum of domestic value-added and import prices, except for the addition of a constant term. The parameter β_0 is calibrated to be consistent with IAD weights, i.e. with the import content of exports. The notation is provided in 3.8.8, while the estimated and calibrated parameters are reported in 3.8.9.

$$p^*_{X,t} = (1 - \beta_2) \left[(1 - \beta_0)p_{Q,t} + \beta_1 p_{MO,t} + (\beta_0 - \beta_1)p_{MNRJ,t}\right] + \beta_2 p_{CX,t} + \beta_3 \tag{112}$$

Table 3.8.9: Long-run parameter estimates and associated standard errors of the export prices equation.

Coefficient	Estimate	s.e.
β_0	0.35	
β_1	0.28	0.05
β_2	0.31	0.11
β_3	-0.01	0.01
$R^2 = 0.89$		

Short run equation Two dummy variables related to the Covid crisis are introduced in the new specification. The re-estimation indicates a lower sensitivity of export prices to domestic inflation ($\pi_{Q,t}$), with the coefficient decreasing from 0.88 to 0.52.

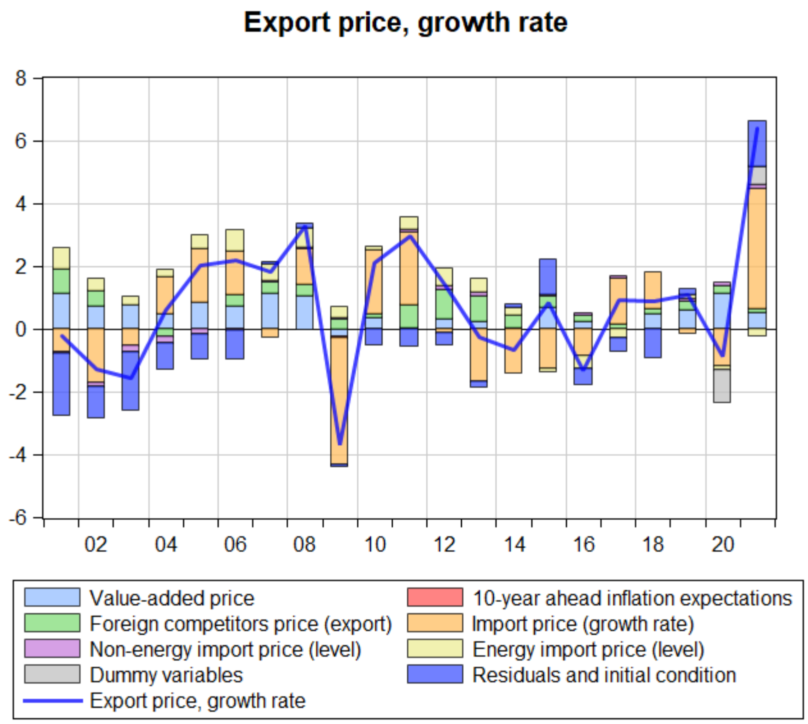
$$\begin{aligned}\pi_{X,t} = (1-\beta_0-\beta_1)\bar{\pi}_{Q,t} + \beta_0\pi_{Q,t} + \beta_1\pi_{M,t} + \beta_2\left[p_{X,t-1} - p^*_{X,t}\right] \\ +\beta_3\delta_{COVID,20Q2} + \beta_4\delta_{COVID,21Q3} + \epsilon_t\end{aligned} \tag{113}$$

Table 3.8.10: Short-run parameter estimates and associated standard errors of the export prices equation.

Coefficient	Estimate	s.e.
β_0	0.52	0.10
β_1	0.56	0.04
β_2	-0.07	0.04
β_3	-0.01	0.00
β_4	0.01	0.00
$R^2 = 0.89$		

Dynamic contributions Figure 3.8.4 reports the dynamic contributions of the main determinants to fluctuations in export prices. As in the initial specification, import prices continue to be the dominant driver of French export prices dynamics.

Figure 3.8.4: Dynamic contributions, export prices, pp of growth rate



Import deflators

Non-energy import price The non-energy import price equation has been re-estimated as a one-step ECM over the sample period 2001Q1–2021Q4, whereas initial specifications were based on a two-step approach.

Target Relative to the 2019 version, the target for non-energy import prices ($p^*_{MO,t}$) remains virtually unchanged: it continues to depend on value-added prices ($p_{Q,t}$), competitors' import prices ($p_{cm,t}$), and the share of emerging economies in world trade (ω_t), which reflects the influence of new products whose prices are not yet embedded in competitors' price indices.

$$p^*_{MO,t} = \beta_0 p_{Q,t} + (1 - \beta_0) p_{CM,t} + \beta_1 \omega_t + \beta_2 \tag{114}$$

Table 3.8.11: Long-run parameter estimates and associated standard errors of the non-energy import prices equation.

Coefficient	**Estimate**	**s.e.**
β_0	0.60	0.13
β_1	-0.29	0.04
β_2	0.028	0.02
$R^2 = 0.76$		

Short run equation The updated specification incorporates dummy variables to account for the effects of the Covid crisis. It also introduces the lagged synthetic energy price index inflation ($\pi_{SEI,t-1}$) to capture the short-term impact of energy price fluctuations on import prices. The synthetic energy price index (equation (115)) is constructed as a weighted average of oil and gas gross prices, where gas prices are first multiplied by 1.7 to account for the conversion of megawatt-hours into oil-equivalent units based on relative calorific content. The oil weight γ_t varies over time and is derived from annual energy import data reported in the French Energy Balance (SDES) for mainland France.

$$p_{SEI,t} = \gamma_t p_{OIL,t} + (1-\gamma_t)(1.7 \cdot p_{gas,t}) \tag{115}$$

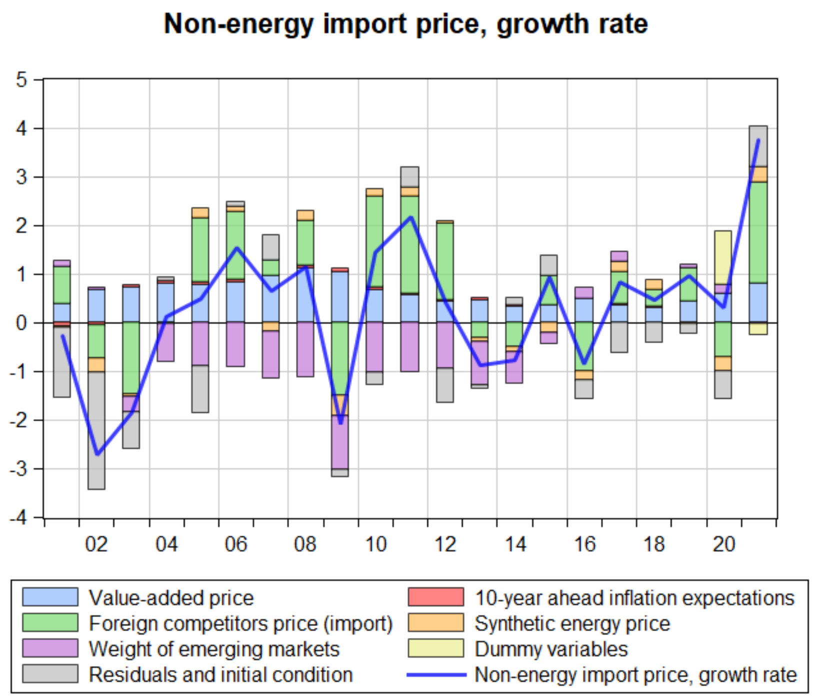
$$\begin{aligned} \pi_{MO,t} &= (1-\beta_0-\beta_1-\beta_2)\bar{\pi}_t + \beta_0\pi_{CM,t} + \beta_1\pi_{MO,t-1} + \beta_2 * \pi_{SEI,t-1} \\ &\quad +\beta_3\left[p_{MO,t-1} - p^*_{MO,t}\right] + \beta_4\delta_{COVID,20Q2} + \beta_5\delta_{COVID,20Q3} + \epsilon_t \end{aligned} \tag{116}$$

Table 3.8.12: Short-run parameter estimates and associated standard errors of the non-energy import prices equation.

Coefficient	**Estimate**	**s.e.**
β_0	0.25	0.03
β_1	0.31	0.06
β_2	0.01	0.00
β_3	-0.07	0.02
β_4	0.02	0.00
β_5	-0.01	0.00
$R^2 = 0.76$		

Dynamic contributions Figure 3.8.5 reports the dynamic contributions of the main determinants to fluctuations in non-energy import prices. As in the initial specification, the evolution of non-energy import prices is largely driven by competitors' import prices, while the increasing share of emerging economies continues to exert downward pressure on price developments.

Figure 3.8.5: Dynamic contributions, non-energy import prices, pp of growth rate



Energy import price The energy import price equation is estimated using a one-step ECM over the 2000Q1–2021Q4 period. In the revised specification, the oil price term has been replaced with the synthetic energy price index ($p_{SEI,t}$), allowing gas price developments to be taken into account.

Long run equation

$$p^*_{MNRJ,t} = (1 - \beta_0)p_{Q,t} + \beta_0 p_{SEI,t} + \beta_1 \quad (117)$$

Table 3.8.13: Long-run parameter estimates and associated standard errors of the energy import prices equation.

Coefficient	Estimate	s.e.
β_0	0.90	0.03
β_1	-3.19	0.12

$R^2 = 0.86$

Short run equation Compared to the initial specification, the revised equation includes gas price inflation (expressed in euros) into the short-run dynamics. Gas prices have become a critical determinant of overall energy price movements, influencing electricity and heating costs for households and industry alike. Moreover, recent geopolitical shocks have amplified volatility in gas markets, making their inclusion essential for capturing inflationary pressures and policy-relevant dynamics. Incorporating gas prices affects the adjustment process as deviations from the long-run equilibrium now correct more slowly (-0.39 versus -0.65 in the initial specification), indicating greater persistence in short-run fluctuations when gas price shocks are accounted for.

$$\begin{aligned} \pi_{MNRJ,t} &= (1-\beta_0-\beta_1)\bar{\pi}_t + \beta_0 \Delta p_{OIL,t} + \beta_1 \Delta p_{gas,t} \\ &\quad + \beta_2 \left[p_{MNRJ,t-1} - p^*_{MNRJ,t} \right] + \epsilon_t \end{aligned} \tag{118}$$

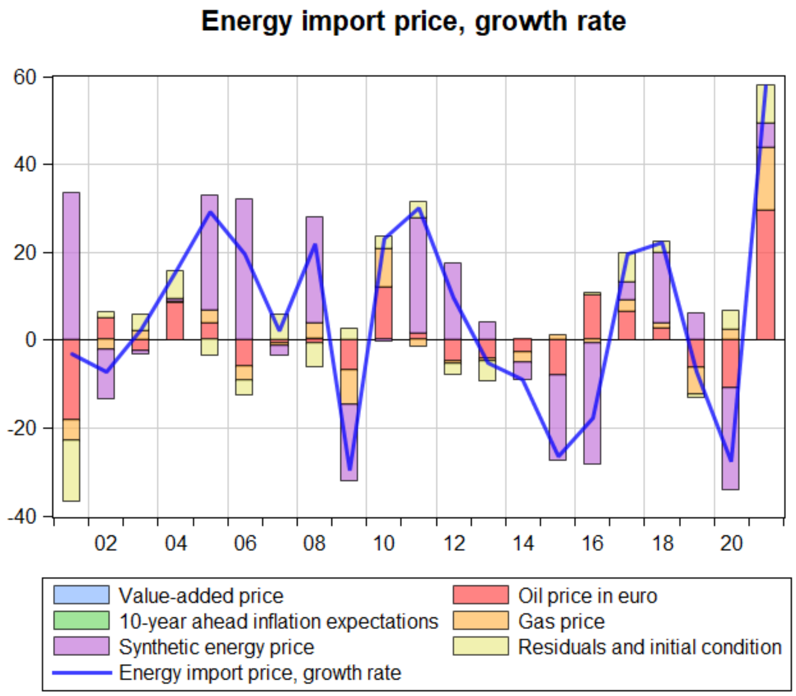
Table 3.8.14: Short-run parameter estimates and associated standard errors of the energy import prices equation.

Coefficient	Estimate	s.e.
β_0	0.48	0.03
β_1	0.12	0.02
β_2	-0.39	0.08

$R^2 = 0.86$

Dynamic contributions Figure 3.8.6 presents the dynamic contributions of the main determinants to fluctuations in energy import prices. The synthetic energy price index accounts for a substantial share of the overall movements. However, during periods of sharp increases in energy prices, the short-term oil and gas price indicators play a crucial role, allowing the model to capture large short-run dynamics.

Figure 3.8.6: Dynamic contributions, energy import prices, pp of growth rate



4 Impulse responses and changes since 2019

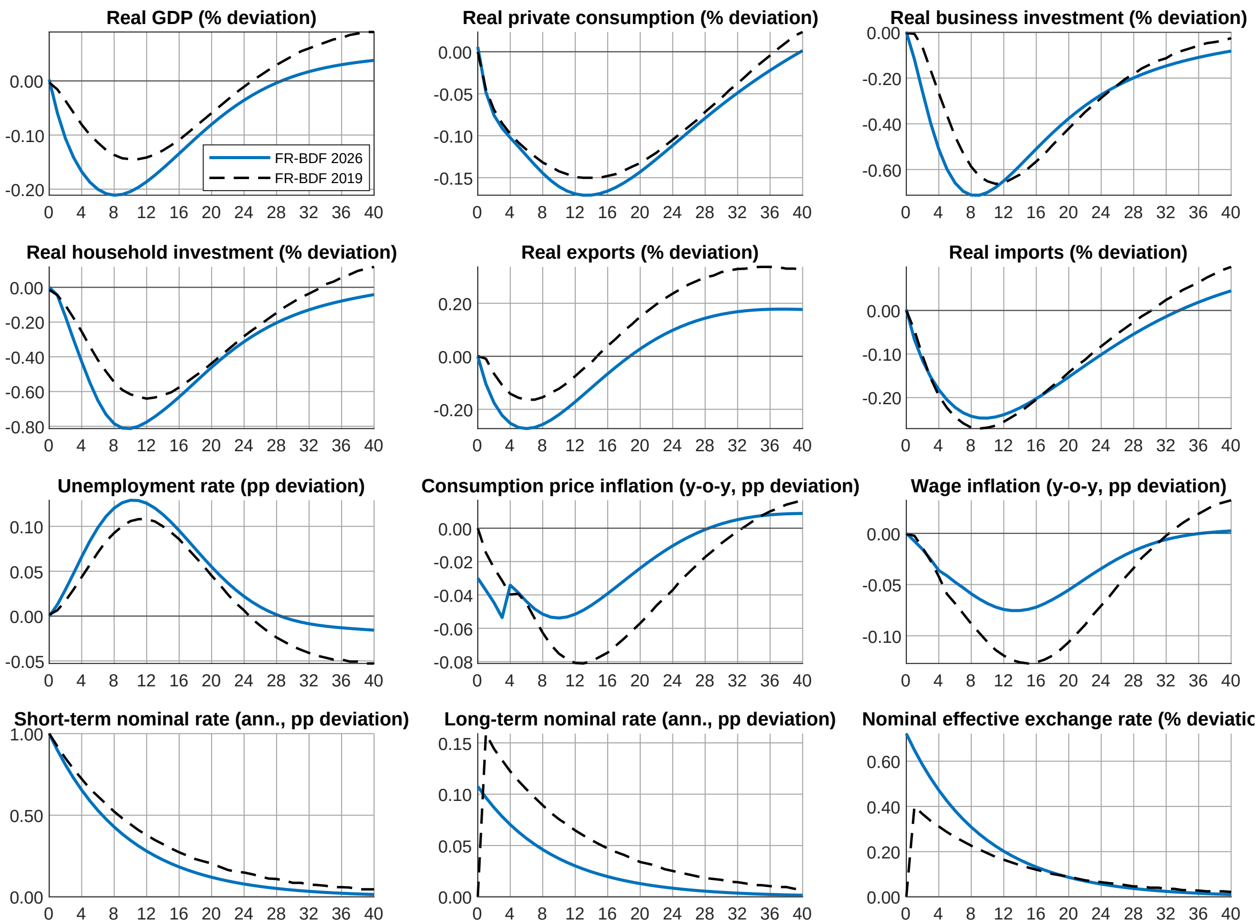
In this section, we present the main properties of the baseline version of the model, where expectations are assumed to be VAR-based, using impulse response functions (IRFs). We analyze three financial shocks – namely, a short-term interest rate shock, a term-premium shock on the long-term interest rate, and an exchange rate shock – as well as three demand shocks: a foreign demand shock, a government spending shock, and a public wage shock. Finally, we illustrate IRFs for an oil price shock as an example of a supply shock. All simulations are performed around the balanced-growth path of the model. Our baseline consists of an unconditional simulation spanning 2024Q2 to 2294Q4. To assess the impact of shocks, we run an alternative simulation from 2150Q1 to 2294Q4, introducing the shock in 2150Q1. IRFs are then computed as either percentage changes or absolute deviations, depending on the variable type, between the alternative and baseline paths. In what follows, we benchmark our results, when possible, against the impulse responses reported in Lemoine et al. (2019), shown as dashed black lines and labeled "FR-BDF 2019".[16]

[16] Comparison is possible only for the set of shocks also presented in Lemoine et al. (2019): short-term interest rate, term-premium, foreign demand, and government spending shock. We refer interested readers to Lemoine et al. (2019) for a detailed presentation of the original IRFs.

4.1 Short-term interest rate shock

The monetary policy shock is modeled as a one-period increase of 100 basis points in the annualized short-term interest rate. The endogenous persistence of the shock in the Taylor rule is slightly lower than in the original model of Lemoine et al. (2019): $\lambda_i = 0.89$ (see Section 3.2.1). Transmission occurs through the expectations block in E-SAT, since the short rate does not appear directly in any other block. It then propagates endogenously to the long-term rate via the term-structure equation and to the nominal effective exchange rate via the uncovered interest parity (UIP) condition, through the expectations terms in these equations.

Figure 4.1.1: Short-term interest rate shock



Note: The short-term interest rate shock is modeled as a one-period increase of 100 basis points in the annualized short-term interest rate.

Figure 4.1.1 shows the responses of FR-BDF's core variables to a short-rate shock. First, regarding financial variables, the long-term rate increases by 0.11 percentage points (pp), while the nominal effective exchange rate appreciates by 0.72%.[17] This limited reaction

[17] In our IRFs, an increase in the nominal exchange rate reflects an appreciation of the domestic currency, as the nominal effective exchange rate for French exporters is expressed using indirect rather than direct quotation.

reflects the VBE framework, where agents continuously anticipate a rapid return to the steady state, leading to muted responses in both the long-term rate and the exchange rate. Both now react contemporaneously to the shock, rather than with a one-period lag as in Lemoine et al. (2019).[18] Via its impact on expectations through E-SAT, the shock also influences investment via the real user cost of capital, which depends on expected inflation and long-term rates, and affects consumption through real interest rates and permanent income. In the short term, the appreciation of the exchange rate leads to a decline in real exports, which in turn contributes to the reduction in GDP. As shown in Appendix C, this external channel plays an important role in the transmission of the monetary policy shock. On the nominal side, it drives down consumer price and wage inflation, respectively through expected inflation and output gap, and the expected unemployment gap.

We observe a peak negative impact of –0.21% on real GDP after eight quarters, and –0.05 pp on year-on-year consumer price inflation after ten quarters, along with an increase of 0.13 pp in the unemployment rate. These peak impacts occur more rapidly than in the original model, and show stronger real responses alongside weaker nominal ones.[19] A key mechanism behind this outcome is the lower persistence embedded in both the Taylor rule and E-SAT. The responses are also consistent with a Phillips curve that is steeper in the short run and flatter in the long run. In the short run, the steeper E-SAT Phillips curve influences dynamics through the PAC equations, while in the long run, VA price adjustments are driven by wages. These wage adjustments follow a wage Phillips curve that is less sensitive to the expected unemployment gap (see Section 3.4.1). Indeed, wage inflation declines by a similar magnitude even as the unemployment rate rises more sharply than in the original specification, in reaction to a monetary shock.

Afterwards, disinflation rapidly strengthens price competitiveness, leading to a depreciation of the real effective exchange rate relative to the baseline after 12 quarters. This improvement in external competitiveness drives a marked increase in net exports, which lifts real GDP above the baseline after 30 quarters.

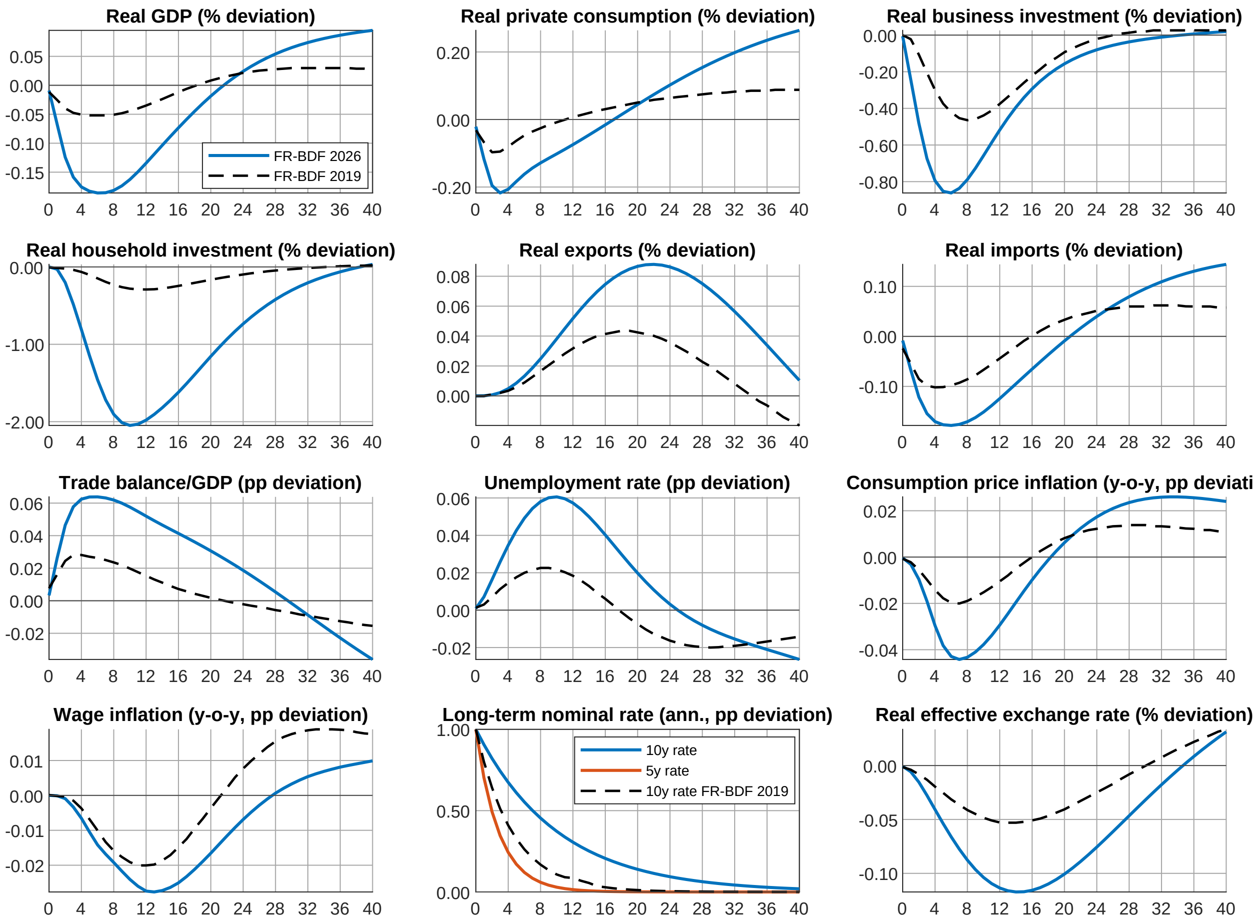
4.2 Term premium shock

The term premium shock is defined as a 100 basis point increase in the annualized nominal long-term interest rate, incorporating a persistence $\rho_{1,10} = 0.91$ (see Table 3.7.2 in Section 3.7), estimated to be higher than in the original specification (Lemoine et al., 2019). Unlike shocks to the short term interest rate, which remains unchanged, the long rate shock does not directly influence expectations; specifically, the nominal effective exchange rate remains unaffected. The shock is transmitted endogenously to bank lending rates and user costs of capital. It is amplified by the model's financial accelerator mechanism introduced into FR-BDF by Dees et al. (2022). An increase in sovereign yields raises firms' cost of external

[18]This change results from modifying the equation for the expected short rate in the UIP condition so that it depends on the current, rather than the lagged, short rate (Section 3.7.5). The new formulation was introduced to better reflect the behavior of financial markets, which typically react almost instantly to new information. It also corrects the unrealistic exchange rate response that would occur with the lagged specification in the companion EA version of our model (EA-BDF) following cost-push shocks.

[19]In Lemoine et al. (2019), we had a peak impact of -0.15% on real GDP, + 0.1 pp on the unemployment rate and -0.08 pp on consumer price inflation after 12 quarters.

Figure 4.2.1: Term-premium shock



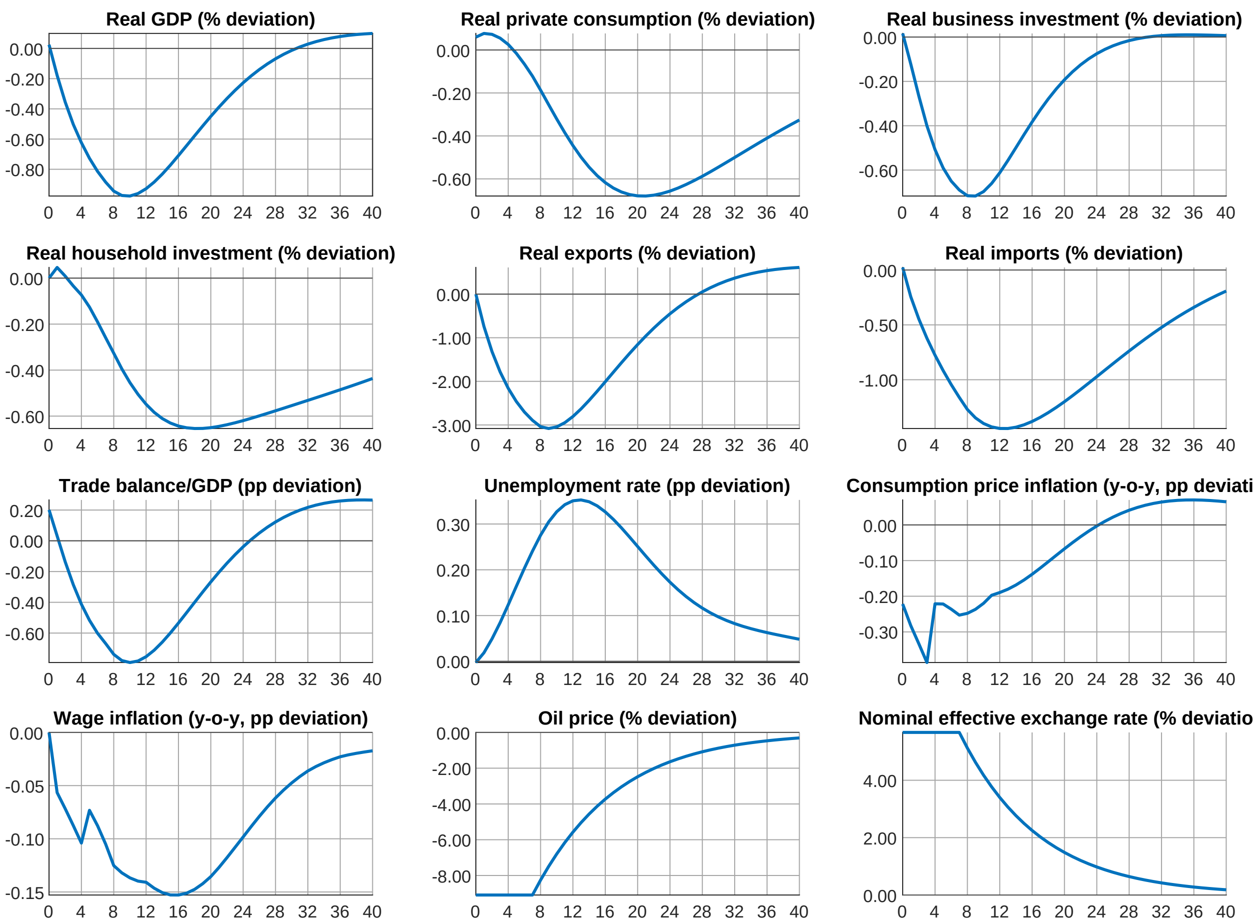
Note: The term premium shock is defined as a 100 basis point one-period increase in the annualized nominal long-term interest rate.

finance, depresses equity valuations, and mechanically increases leverage (via a denominator effect); higher leverage then widens bank lending spreads and the weighted average cost of capital (WACC), further dampening corporate investment. These mechanisms also operate in response to the preceding short-rate shock, but in that case their quantitative contribution is not material.

As illustrated in Figure 4.2.1, the rise in the real user cost of capital for both businesses and households leads to a pronounced decline in investment, by 0.86% after six quarters and 2.05% after ten, respectively. The response of household consumption and investment is more than twice as strong as in the original model, primarily due to the stronger impact of the bank lending rate ($i_{LH,t}$) in the long-term equations (33) and (36). This results in more substantial effects across the broader economy, with peak impacts of –0.19% on real GDP, a 0.06 pp increase in the unemployment rate, and a 0.04 pp decline in consumer price inflation. The downward pressure on inflation also induces a real depreciation, which in turn supports net exports in the short run. Compared to a short rate shock, the term premium shock exerts a stronger negative influence on real private consumption in the short term, but turns positive over the medium to long run, as rising real income—especially financial income—supports household spending. This channel should be interpreted with caution, however, as it may overstate the consumption response if households exhibit a lower propensity to consume out of financial income (or wealth) than out of labor income (Carroy et al., 2025).

4.3 Exchange rate shock

Figure 4.3.1: Exchange rate shock



Note: The exchange rate shock is modeled as a 10% appreciation of the euro maintained for eight quarters.

The exchange rate shock is modeled as a 10% appreciation of the euro, maintained for eight quarters, followed by a gradual return to baseline with persistence calibrated at $\rho = 0.9$.

Figure 4.3.1 displays the simulation results. The euro-denominated oil price declines by 9.09% during the first eight quarters. This reduction is transmitted to energy import prices and consumer inflation, with the latter reaching its trough at –0.39 pp after three quarters. Because import prices fall more sharply than export prices, the trade balance initially improves by 0.20 pp of GDP. However, it turns negative after two quarters, hitting its lowest point at –0.79 pp after ten quarters. This reversal reflects the delayed response of real exports to price changes: exports gradually decline to –3.08% after nine quarters, exceeding the contraction in real imports, which reach –1.44% after twelve quarters. Consequently, real GDP falls progressively, reaching –0.98% after ten quarters. This contraction translates into lower household and business investment. Consumption, which initially rises by 0.06% due to lower consumer prices, quickly follows GDP downward as social benefits and financial transfers from firms weaken, due to net asset stabilization rules for government and corporations. The loss of competitiveness erodes corporate margins and increases firms' indebtedness. To counteract this potentially destabilizing dynamic, firms reduce transfers to households (dividend payouts), which helps stabilize their net asset positions. Similarly, the government cuts social transfers to offset the revenue shortfall induced by the adverse shock, thereby limiting the increase in the public debt ratio (see *Stabilization of assets and debt* in Section 3.7.4). On the nominal side, wages fall more moderately than prices, peaking at –0.15 pp after ten quarters.

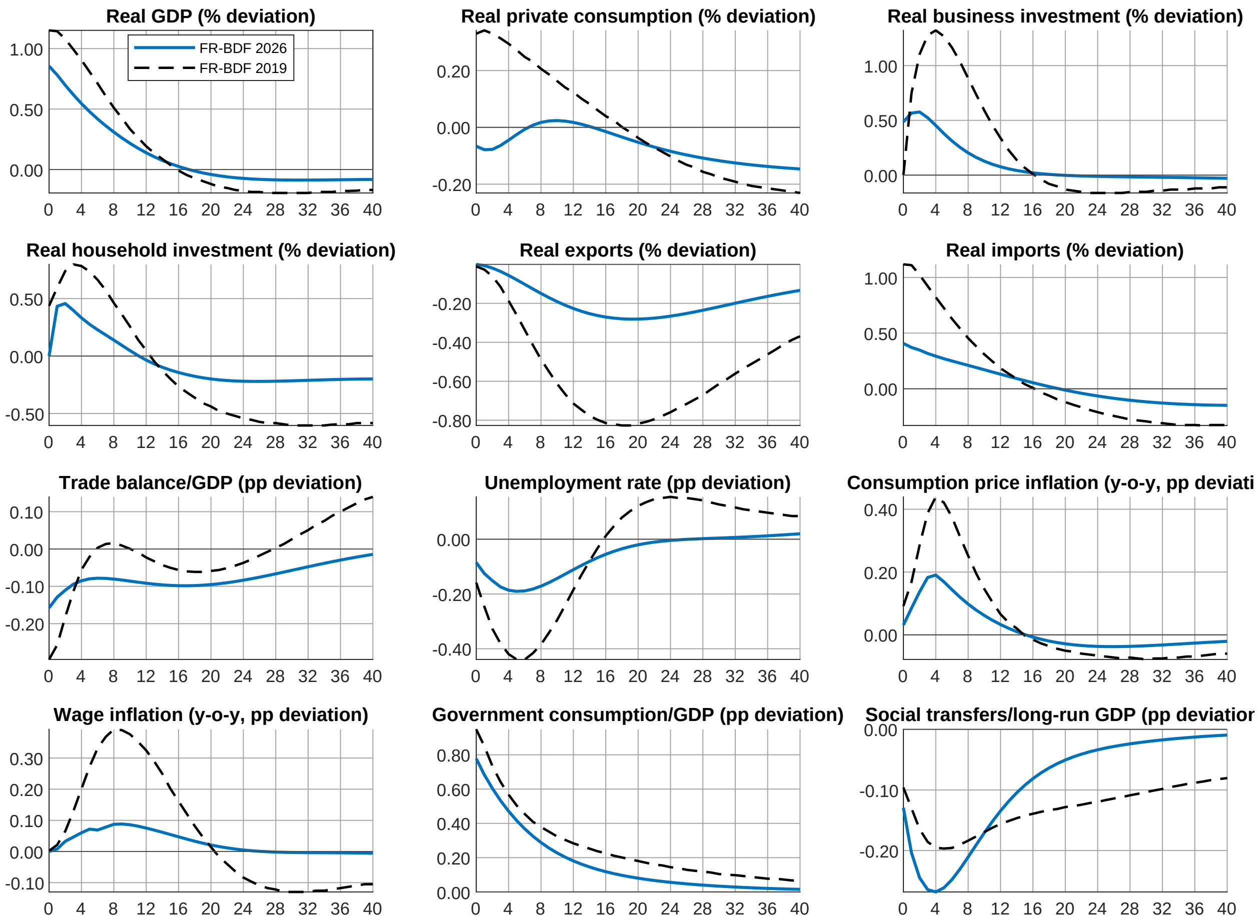
In the medium term, after twenty-three quarters, the real exchange rate deviation turns negative as the shock on the nominal exchange rate vanishes, leading to an improvement in the trade balance and a subsequent positive output gap.

4.4 Government consumption shock

The government consumption shock is defined as an increase in public administration intermediate consumption equal to 1% of GDP on impact, decaying thereafter with persistence calibrated at $\rho = 0.9$. Public sector wages remain unchanged. This shock leads to an ex-post 0.78 percentage point increase in the ratio of total government expenditure to GDP, reflecting a mechanical dilution mechanism (public administration intermediate consumption is only one entry of total expenditure) and an instantaneous rise in the GDP denominator.

As illustrated in Figure 4.4.1, real GDP rises by approximately 0.85% on impact, before gradually returning to baseline and turning negative after 18 quarters. Unemployment falls by 0.08 pp initially, reaching a peak decline of 0.19 pp six quarters after the shock. Consumer price inflation increases by 0.03 pp on impact and peaks at 0.19 pp after four quarters. Both exhibit hump-shaped responses. On the real side, household investment responds positively, peaking at +0.45% after three quarters. The trade balance, however, worsens sharply on impact due to increased real imports and an appreciation of the real exchange rate, driven by higher VA price inflation. On the nominal side, the rise in price inflation lowers the real user cost of capital for both households and firms. Notably, wages respond less than prices, leading to a reduction in real labor costs. This boosts employment in the short term but also compresses real household income, resulting in a temporary decline in consumption. The government spending multiplier, above 1 on impact, is consistent with findings in the empirical literature. A key feature is the short-run crowding-in of investment, driven by non-Ricardian household behavior and not offset by monetary or financial responses. This reflects two assumptions: the ECB does not react to French inflation, an assumption commonly adopted in national forecasting exercises, and long-term interest rates remain unaffected by the temporary increase in public debt. However, differently from the original model, an initial crowding-out of consumption characterizes the government spending shock. This outcome is shaped by two key features of the model configuration: (i) The short-run consumption equation now responds directly to changes in wages and social transfers, rather than to the current change in the output gap. This adjustment enhances the sensitivity of household consumption to disposable income fluctuations. (ii) A more stringent fiscal rule governs social

Figure 4.4.1: Government consumption shock



Note: The government consumption shock is defined as an increase in public administration intermediate consumption equal to 1% of GDP on impact.

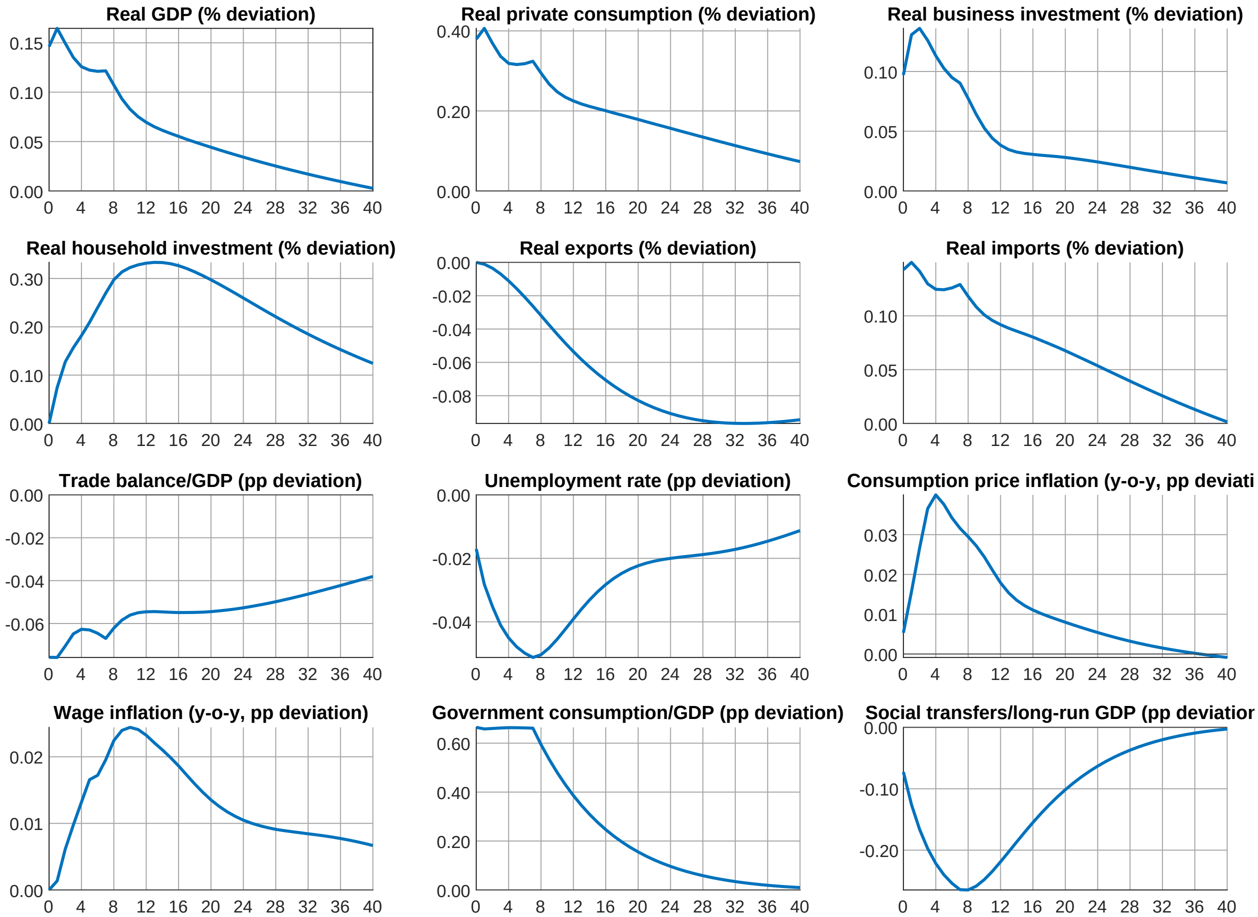
transfers, meaning that these transfers are adjusted more actively to help stabilize public debt. In practice, this implies that when public debt rises, social transfers are reduced, which can dampen the short-term stimulative effects of fiscal expansion. Appendix D presents a scenario in which the debt stabilization rule is suspended for the first two years after the shock, highlighting the role of the decline in social transfers in dampening the positive response of consumption.

4.5 Public wage shock

The public wage shock is defined as an increase in the public sector wage bill equivalent to 1% of GDP, while keeping public employment constant. The shock persists for eight quarters and then gradually declines, with a persistence parameter calibrated at $\rho = 0.9$. This shock results in a 0.66 pp increase in the ratio of total government expenditure to GDP.

As shown in Figure 4.5.1, real GDP increases by about 0.15% on impact before gradually returning to its baseline. Both unemployment and consumer price inflation display hump-shaped dynamics, with unemployment reaching a trough of -0.05 pp after seven quarters and

Figure 4.5.1: Public wage shock



Note: The public wage shock is defined as an increase in the public sector wage bill equivalent to 1% of GDP maintained for eight quarters, while keeping public employment constant.

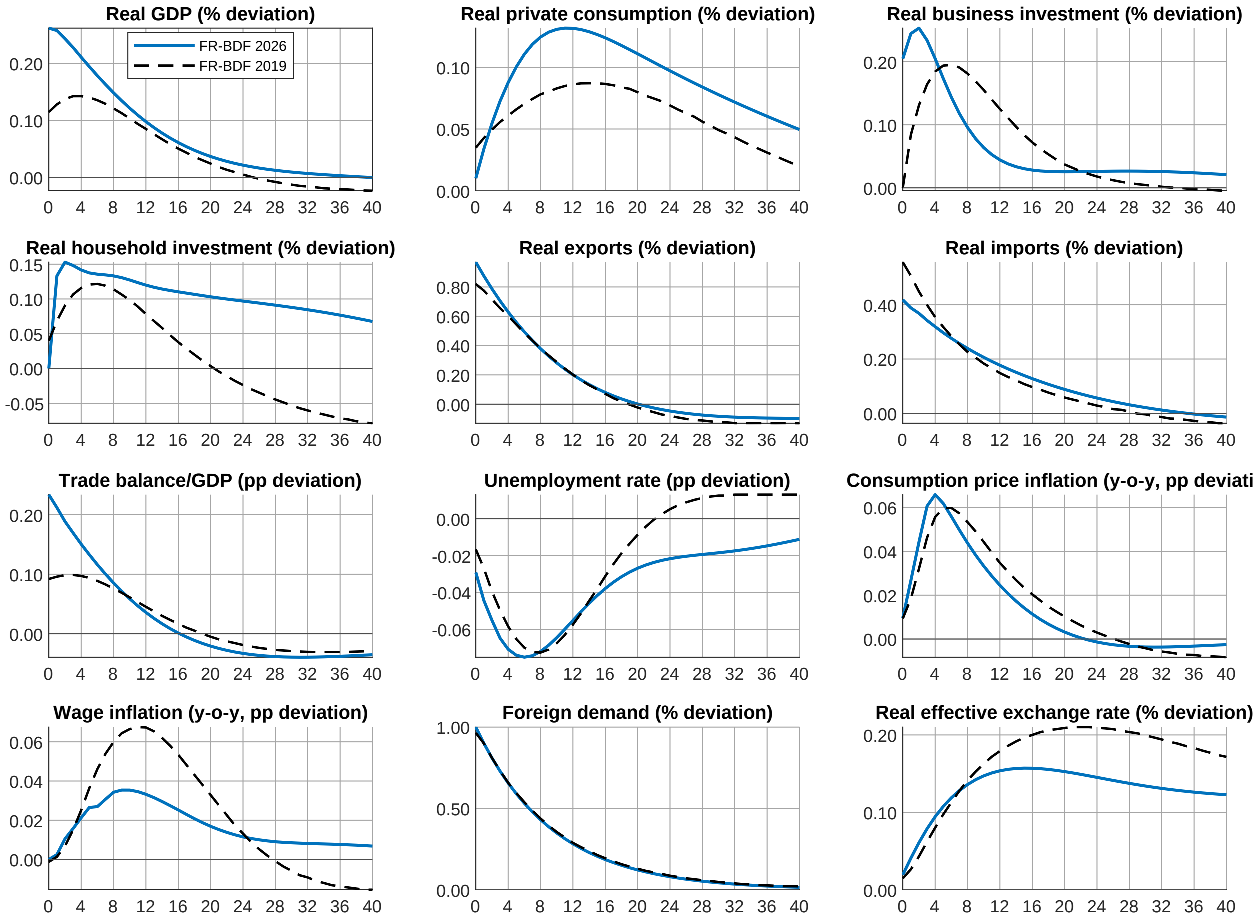
consumer price inflation peaking at 0.04 pp after four quarters. On the real side, business and household investment respond positively, peaking at +0.13% after two quarters and +0.33% after thirteen quarters, respectively. In contrast, the trade balance deteriorates by nearly 0.08 pp on impact, driven by higher real imports and an appreciation of the real exchange rate induced by rising VA price inflation. Unlike the previous government spending shock, household consumption is crowded in, reaching a peak of 0.40% one quarter after the shock. Despite a reduction in social transfers, implemented through the fiscal rule to stabilize public debt, the increase in public wages boosts consumption, reflecting the heightened short-run sensitivity of household spending to total wage income.

4.6 Foreign demand shock

The foreign demand shock is modeled as a one-time 1% increase in the volume of external demand directed toward French exporters, with a persistence parameter calibrated at $\rho = 0.9$.

Figure 4.6.1 presents the simulation results. Real exports rise by 0.97% on impact, slightly exceeding the response in the original model due to a higher sensitivity of exports to

Figure 4.6.1: Foreign demand shock

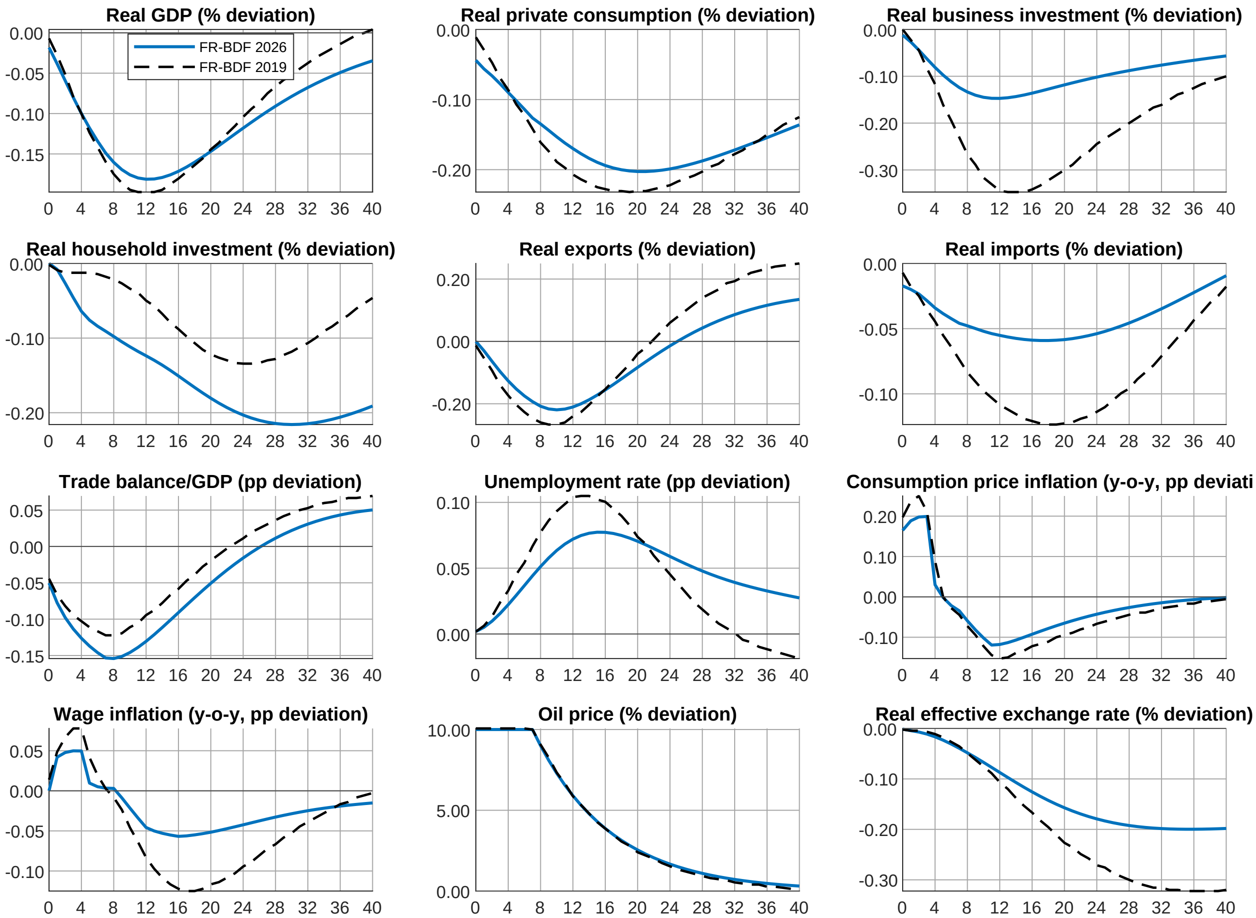


Note: The foreign demand shock is modeled as a one-time 1% increase in the volume of external demand directed toward French exporters.

foreign demand (see equation (105)). In contrast, imports increase by only 0.41%, reflecting a reduced short-run elasticity of non-energy imports to import-adjusted demand (IAD), now constrained to unity in this updated version of FR-BDF. Consequently, the trade balance improves by 0.23 pp of nominal GDP, a stronger adjustment than in the previous version of the model, which contributes to a higher increase in real GDP (+0.26% on impact). This GDP boost translates into faster and stronger responses in household consumption and investment, driven by real disposable income or the GDP growth gap in their respective short-run equations, which incorporate rule-of-thumb behavior. Consumption peaks at +0.13% after 11 quarters, while household and business investment reach their respective peaks of +0.15% and +0.25% after 3 quarters. On the nominal side, the shock induces slightly stronger effects on consumer price inflation (which peaks at +0.07 pp after 4 quarters), due to more pronounced short-run Phillips curve dynamics. However, after 10 quarters, wage inflation rises by only +0.03 pp, despite a comparable decline in the unemployment rate (-0.07 pp after 4 quarters). This effect stems from a lower elasticity of wages with respect to the present value of the gap between the unemployment rate and the NAIRU (Non-Accelerating Inflation Rate of Unemployment), in the wage Phillips Curve (Section 3.4.1).

4.7 Oil price shock

Figure 4.7.1: Oil price shock



Note: The oil price shock is designed as a +10% shock to the brent oil price, during 8 quarters. Foreign competitors' prices are left unchanged, i.e. the shock is asymmetric.

The oil price shock is designed as a +10% shock to the brent oil price, during 8 quarters, with a persistence calibrated at $\rho = 0.9$ afterward. Foreign competitors' prices are left unchanged, i.e. the shock is asymmetric.

As illustrated in Figure 4.7.1, the effects of the shock are slightly more muted compared to those in the original model. Real GDP declines by up to 0.18% at its peak after 12 quarters, while unemployment rises by 0.07 pp after 15 quarters. The main transmission channel operates through energy import prices and consumer inflation, with the latter peaking at +0.19 percentage points after three quarters. This reflects the re-estimated energy import price equation and the introduction of gas prices in the synthetic index of gross energy prices, which results in a lower sensitivity to oil price changes. For a comparison with an energy price index shock, see Appendix Section E.

At first, wages react incompletely and with a lag to the increase in consumer price inflation, which will reduce real household income in the short run. Wage inflation then declines by -0.06 pp after 16 quarters, due to the rise in unemployment. On one hand, households' purchasing power will decline in the short run, due to the strong increase in the consumer price, while on the other, the real labor cost will rise and reduce labor-demand.

On the real side, all aggregate demand components fall after the shock. Household consumption and investment decrease progressively due to lower purchasing power and higher unemployment. Real business investment decreases due to the decline in the VA of market branches. Finally, real exports decline in the short run (-0.22% after 10 quarters), due to competitiveness losses and the asymmetric nature of the shock. Meanwhile, real imports fall progressively to -0.06%, along with aggregate demand components, due to the import content of exports. In the medium run, the decrease in prices progressively restores price competitiveness and the trade balance rises above the baseline after 27 quarters.

5 Responses to selected shocks under different expectation modes

This section compares the dynamic responses of the model under three alternative expectation schemes: *VAR-based (VBE)*, *Model-consistent (MCE)*, and *Hybrid expectations*. The objective is to assess how the expectation formation shapes the transmission and persistence of selected shocks.

Under VAR-based expectations, all agents form expectations in a backward-looking manner, relying on reduced-form forecasting rules. This specification generates gradual and persistent responses, as agents adjust only after observing realized developments.

Under Model-Consistent expectations, all agents are forward-looking and internalize the full structure of the model. Expectations incorporate the entire future path of endogenous variables implied by the shock. As a result, adjustments tend to be immediate and more front-loaded. A detailed description of the modifications to the model equations under forward-looking expectation mode can be found in Lemoine et al. (2019).

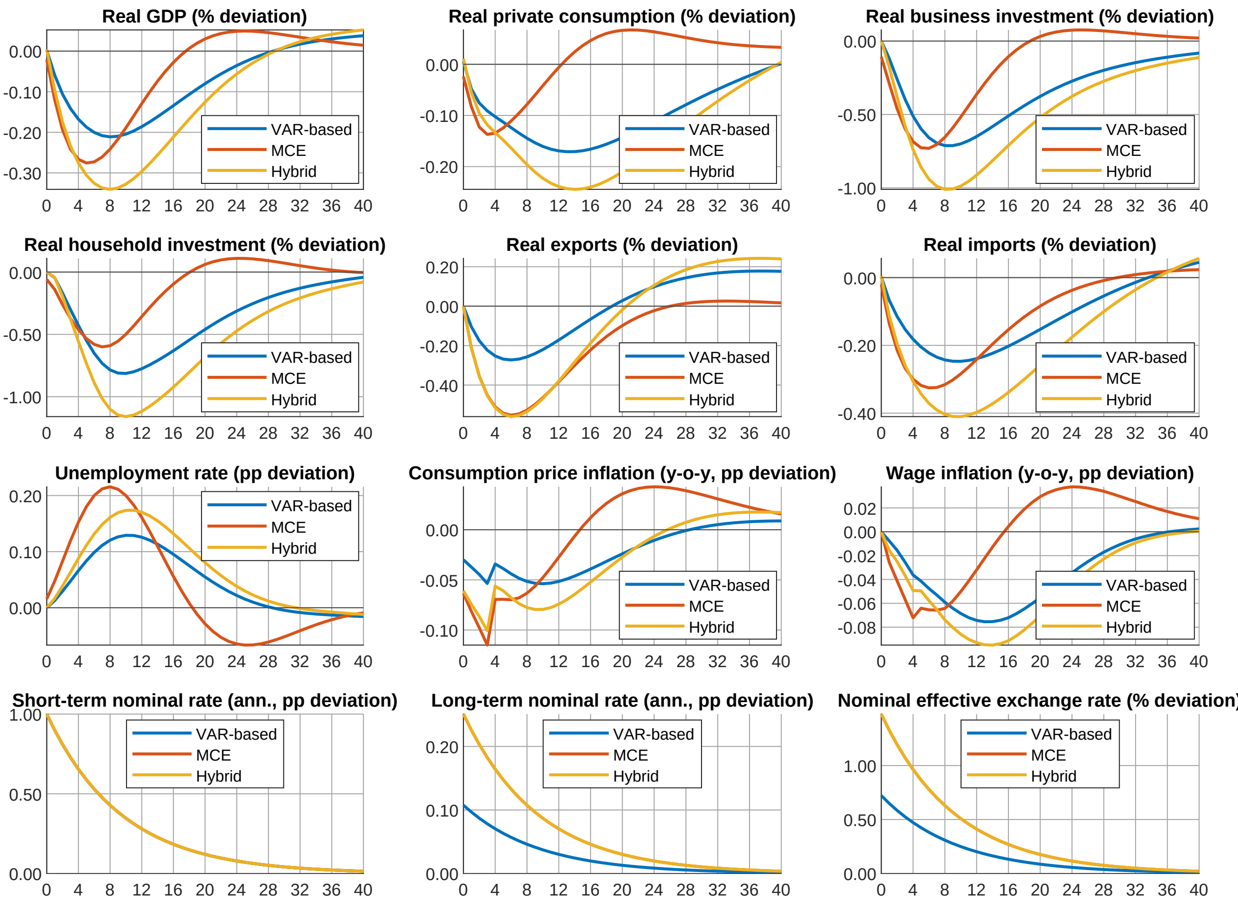
The hybrid expectation scheme combines backward-looking expectations for non-financial sector agents (households and firms) with forward-looking expectations for financial market participants. This configuration preserves inertia in real decisions while allowing asset prices and long-term interest rates to react immediately to anticipated future conditions. Among the considered specifications, this framework arguably delivers the closest approximation to the empirically relevant expectation formation process.

5.1 Short-term interest rate shock

We first consider a 100 basis point exogenous increase in the short-term policy rate. Figure 5.1.1 reports the impulse responses under VBE, MCE, and Hybrid expectations.

Under MCE, the shock is immediately internalized by all agents. The entire expected path of tighter policy rate is incorporated into current decisions. As a result, long-term interest

Figure 5.1.1: Response to a 100 bp (annualised) short-term interest rate shock under different expectation modes



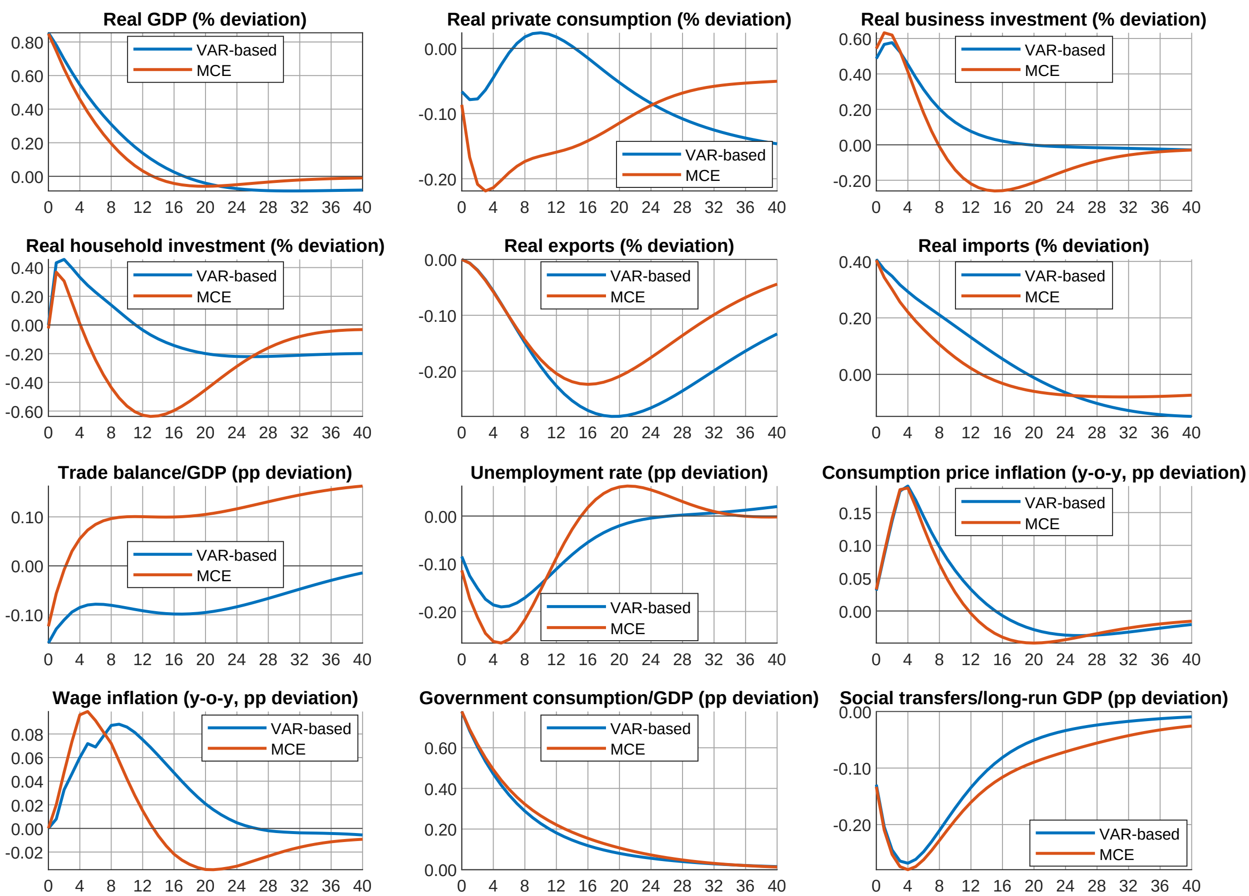
Note: The short-term rate shock corresponds exactly to the one presented in section 4.1.

rates and exchange rate increase more strongly on impact with respect to the VBE case described in 4.1, leading to a rapid increase in the real cost of capital and cost of lending. Real variables respond in a more front-loaded manner compared to VBE. GDP and consumption prices display a faster initial adjustment than in the VBE case. Importantly, however, the overall orders of magnitude for GDP and prices remain broadly similar across the two expectation modes. The key difference lies in the timing rather than the amplitude of the responses: adjustments are more front-loaded under MCE.

The Hybrid configuration generates a distinct propagation pattern, as there are two amplification mechanisms at play. First, relative to VBE, the forward-looking behavior of the financial sector induces a stronger and faster reaction of long-term interest rates and the exchange rate, exactly as in the MCE case. This strengthens the transmission through financial channel while preserving the dynamic profile of responses of macro variables similar to the VBE case. Second, relative to MCE, the reaction of real activity is amplified because households and firms do not internalize future changes in income and adjustment costs: expectations formed through the E-SAT mechanism are more pessimistic, as agents fail to anticipate the eventual end of the shock. Overall, while financial markets react strongly and instantly, the real-sector agents adjust with some delay, generating larger and more persistent responses of output and its components.

5.2 Government consumption shock

Figure 5.2.1: Response to a government consumption shock under MCE versus VBE



Note: The government consumption shock corresponds exactly to the one presented in section 4.4.

As shown in Figure 5.2.1, the comparison between VAR-based expectations (VBE) and model-consistent expectations (MCE) shows that forward-looking expectation formation makes the transmission of the government consumption shock more front-loaded and induces a stronger reallocation across demand components. Although real GDP increases on impact in both cases by about 0.85%, the response is somewhat less persistent under MCE, with output returning to baseline and turning negative slightly earlier. The main difference concerns private domestic demand: under MCE, private consumption falls immediately by about 0.08% and reaches nearly -0.22% after 3 quarters, reflecting a strong Ricardian intertemporal wealth effect, driven by the anticipation of future fiscal adjustment, whereas under VBE consumption declines only modestly on impact and even turns temporarily positive, peaking at around +0.03% after 8 quarters, before falling gradually thereafter. Investment also adjusts more sharply under MCE: after a short-lived crowding-in effect, business investment falls to about -0.24% and household investment to around -0.62%, compared with much milder declines under VBE. By contrast, external demand provides a partial offset to weaker domestic absorption: the sharper compression of imports under MCE leads the trade balance to improve by about 0.1 percentage point of GDP after a few quarters, partly compensating for the decline in private demand. Under VBE, instead, the more persistent expansion of domestic demand sustains imports and results in a prolonged deterioration of the trade balance, which remains negative over most of the horizon. As shown in Figure F.7 in the Appendix, the response under hybrid expectations is virtually identical to that obtained under VBE. This reflects the fact that the transmission of this shock is primarily driven by the behaviour of households and firms, whose expectations remain backward-looking in both specifications. Since short-term interest rates, long-term interest rates, and exchange rates are assumed not to respond to this temporary government consumption shock, making financial-market participants forward-looking in the hybrid setup does not materially affect the dynamics of private demand or output.

6 Application: assessment of monetary policy tightening in France

Building on the theoretical analysis and the impulse response functions to fundamental shocks presented in Section 4, we now turn to an applied simulation exercise. In this section, the structural features of the model introduced above are employed to quantify the macroeconomic impact on France of the recent monetary policy tightening implemented by the ECB.

6.1 Monetary policy shock

We consider a contractionary monetary policy shock, modeled as an exogenous transitory increase in the short-term nominal policy rate. The trajectory of the shock is defined as the deviation between the expected terminal policy rate path embedded in the December 2021 BMPE[20]—reflecting market expectations just before the generalized acceleration in inflation—and the December 2024 BMPE. The segment covering the period from 2021Q4 to 2024Q4 corresponds to the observed evolution of the policy rate, while the subsequent portion, from 2025Q1 onwards, reflects changes in market-implied expectations.

The shock is simulated around the steady state of the model. The duration of the disturbance is set to sixteen quarters, after which the short-term rate gradually converges back to its steady-state level according to the re-estimated Taylor-rule persistence parameter of 0.90. The shock is assumed to be fully unanticipated by agents so that they do not receive any signal about the shock prior to its realization. Its perceived path, however, depends on the

[20] BMPE (Broad Macroeconomic Projection Exercise) designates a projection round in which several structural and empirical models (from both the ECB and NCBs) are jointly used to analyse the macroeconomic outlook and policy transmission. In contrast, the regular Macroeconomic Projection Exercise (MPE) is conducted primarily by the ECB staff.

expectation mechanism. Under backward-looking expectations, agents treat each period's deviation as a surprise, reacting only to realized rate movements. Under model-consistent forward-looking expectations, agents perfectly anticipate the entire future trajectory of the shock from the moment it occurs, embedding the full adjustment path into their decisions. In the hybrid configuration, financial variables react in a forward-looking perfect-foresight manner while real-sector agents adjust more gradually based on backward-looking expectations. While analytically convenient, the perfect-foresight assumption embedded in model-consistent and hybrid expectations may appear strong in practice; Section 6.4.2 therefore considers an alternative specification with staggered expectations, in which forward-looking agents update their information set progressively.

In this exercise, we abstract from the impact of the other policy instruments implemented by the ECB during the tightening phase, such as balance sheet operations or forward guidance. However, an important aspect implicitly related to forward guidance that must be incorporated in this experiment concerns the upward revision of terminal-rate expectations induced by the rapid tightening cycle in the euro area and globally. Survey evidence—such as the ECB Survey of Monetary Analysts—indicates a significant increase (by 1.25 pp at peak) in long-horizon policy-rate medium term forecast with respect to its level as of December 2021, signalling a reassessment of the long-run policy stance. We capture this mechanism by *augmenting the baseline disturbance with a simultaneous shock to the policy-rate target* $\bar{i}_t$ toward which the short-term nominal rate is assumed to converge over the medium term. During the tightening window, this target is shifted upward in line with the revision in terminal-rate expectations as in the Survey of Monetary Analysts; subsequently, both the target and the short-term rate revert gradually to their respective long-run anchors.

The trajectories of the two shocks are depicted in Figure 6.1.1.

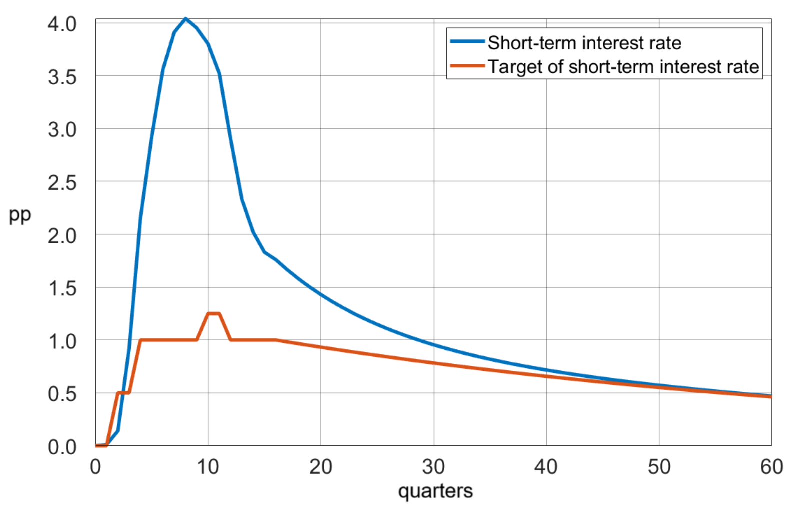


Figure 6.1.1: Shocks to the short-run interest rate and its expectations (annualized)

6.2 Dual simulation framework

Understanding how agents form expectations is central to the transmission of monetary policy. To assess the sensitivity of FR-BDF propagation mechanisms to the expectation channel, we conduct simulations under the VAR-based expectations (VBE) framework and the MCE framework. Let us briefly remind the differences between the two approaches.

In the VBE, agents form beliefs on the basis of historically observed dynamics, as captured by E-SAT. Expectations are thus backward-looking: agents extrapolate from past regularities and update their beliefs only gradually in response to new information. This approach provides a pragmatic, empirically anchored benchmark that reflects inertia in expectation formation and allows the structural model to align with the impulse-response patterns observed in French and euro area data.
In contrast, the MCE framework assumes that agents are fully forward-looking and internalise the model's equilibrium law of motion immediately after the monetary policy shock. Although the information about the shock comes as a surprise, once it is revealed, the agents are assumed to be informed about the exact trajectory of the shock and to re-optimise instantaneously on the basis of the model-consistent transition path, ensuring dynamic consistency between expectations and realised outcomes.

In both configurations, the shock to the short-term nominal rate is transmitted instantaneously to longer maturities through the expectations hypothesis: the long-term rate adjusts roughly as the average of expected future short-term rates. In parallel, the exchange rate responds immediately via uncovered interest parity conditions (UIP), reflecting the adjustment of expected interest-rate differentials and thus the expected relative return on domestic versus foreign assets. Consequently, the exchange rate depreciation (or appreciation) materialises as agents revise their expectations of future monetary conditions.

A key mechanical difference in propagation between the VBE and MCE frameworks arises in the expectations channel. Under the VBE specification, the E-SAT block generates an additional layer of transmission: the short-term rate enters the core VAR system (8)–(15), thereby feeding into the empirical expectation terms that underpin several short-run behavioural equations. As a result, the shock diffuses through a dense network of estimated expectation linkages, amplifying its short-horizon effects across a broad set of endogenous variables. By contrast, in the MCE framework the short-term rate affects the economy exclusively through the structural transmission channels. The shock is propagated to long-term interest rates via the term structure and to the exchange rate through uncovered interest parity. Beyond these structural linkages, the short-term rate does not activate an additional expectations channel, since agents internalise the entire path of future rates and do not rely on an empirical expectations block.

Introducing a simultaneous shift in the expected terminal policy rate path alters the propagation of the short-term nominal rate shock described in Section 4.1 in three ways.

First, in backward-looking expectations mode, the shock propagates less through the expectations channel. In this environment, the short-term nominal rate enters the expectation block in deviation from its expected terminal value. When both the actual and expected terminal short-term rate are shocked contemporaneously, the implied gap is narrowed, mechanically reducing the impulse transmitted through the expectations core. Consequently, the policy functions deliver a more muted response relative to a shock applied solely to the short-term rate. This attenuation does not arise under model-consistent expectations, where agents internalize the full structure of the disturbance and, as the E-SAT block is absent in the MCE mode, by construction the deviation of the short-term rate from the expected terminal short-term rate simply does not enter into play.

Second, the response of long-term rates is modified through the term structure channel. Since long rates are determined by discounted expectations of future short term rates, an upward revision to the expected terminal short-term rates induces a more persistent and quantitatively larger increase in long-term yields than a purely transitory short-rate shock. This strengthens the tightening of financial conditions and amplifies the contractionary effects on interest-sensitive components of aggregate demand.

Finally, the exchange rate channel becomes stronger. By raising the expected return on domestic currency assets, the upward shift in expected terminal short-term rates increases the interest-rate differential vis-à-vis foreign economies, generating a more pronounced appreciation relative to a shock to the short-term rate alone.

Running both frameworks in parallel allows us to bracket the empirically plausible range of behavioural responses—from inertial, backward-looking expectations to fully rational, forward-looking behaviour. This dualisation is particularly relevant for the French economy and the euro area, where empirical evidence on the degree of forward-looking behaviour remains mixed. Recent studies show that French households and firms display systematic deviations from full-information rational expectations, exhibiting persistent biases and sluggish adjustments (Gautier & Montornès, 2022; Savignac, 2024), while survey- and VAR-based analyses point to a gradual adaptation of expectations in response to monetary shocks (Fuhrer, 2017). At the same time, cross-country evidence also highlights substantial heterogeneity in expectation formation across agents and institutional sectors within the euro area, including France (Adjemian et al., 2023). Behavioural mechanisms such as recency bias and salience effects further contribute to these deviations, implying that actual expectation formation likely lies between the two theoretical polar cases of VAR-based and model-consistent expectations (Cornand et al., 2025).

6.3 Implementation

As mentioned above, the simulations are performed around the steady state of the model, rather than from the observed macroeconomic position at the onset of the 2021Q4 monetary policy tightening episode.

This choice reflects several considerations:

- It isolates the pure propagation mechanism of the monetary policy shock, abstracting from contemporaneous shocks and transitory imbalances. In late 2021, the euro area economy was still adjusting to post-pandemic distortions, with relative price misalignments and ongoing supply constraints; replicating that exact environment would obscure the identification of the policy transmission channel.

- The model's steady state provides a clean benchmark to interpret deviations as percentage or level effects and allows a cleaner comparison of reactions in VBE and MCE modes.

Hence, while the historical tightening episode provides context, our analysis focuses on structural responses rather than the reconstruction of actual events. Two caveats are worth noting. First, we isolate the impact of euro-area monetary policy by abstracting from foreign policy reactions and associated spillovers. Concretely, the concurrent increase in US policy rates and their expectations is switched off by keeping them at steady state. This assumption mechanically amplifies the exchange rate channel, since—as stated in equation (94)—the exchange rate responds to differentials in expected policy rates and inflation, and the foreign component is held constant.

Second, euro-area aggregates and the euro-area Taylor rule are treated as exogenous in the simulations. In practice, the euro-area output and policy rate are kept exogenous, so that France behaves as a small open economy facing an externally given monetary stance. This modelling choice reflects the structure of the model, which is not designed to capture endogenous feedback from the French economy to euro-area-wide variables. Endogenising such interactions would require a different modelling framework, such as the one developed by Aldama et al. (2022), which extends FR-BDF by explicitly incorporating a fully specified euro-area block. As a result, the simulations should be interpreted as conditional responses to an exogenous euro-area monetary tightening, rather than as a general equilibrium exercise in which France influences the aggregate euro-area stance.

Finally, we abstract from potential balance-sheet effects associated with the ECB's asset holdings; although these effects are generally assessed to be limited, incorporating them would require an additional set of assumptions outside the scope of the present exercise.

6.4 Main results

6.4.1 Responses under VAR-based and MCE expectations

Figures 6.4.1 displays the impulse responses of output and the value added deflator to the monetary policy shock as defined above. While both simulations exhibit the canonical transmission of a policy tightening, the amplitude and timing of the responses differ markedly between the VAR-based expectations and the model-consistent expectations cases. Under MCE (orange), real GDP reaches a trough of about –3.5% around period 15, compared with a milder –1.9% decline under VBE (blue) at a similar horizon. These evaluations in level correspond to –1 pp effect on GDP growth, at trough, for the VBE mode and –3 pp for the MCE mode. The year-on-year inflation exhibits a comparable divergence: the MCE response drops to roughly –1.7 pp in period 15, whereas the VBE response bottoms out around

–0.6 pp. Each series displays a single pronounced trough and then gradually converges toward the steady state. These estimates are broadly consistent with benchmark assessments of the transmission of monetary policy shocks reported in the literature (see notably Kamps et al. (2025), where the cumulative disinflationary effects typically range from –0.5 to –3 pp across models.

A more complete set of charts is provided in Figure 6.4.2.

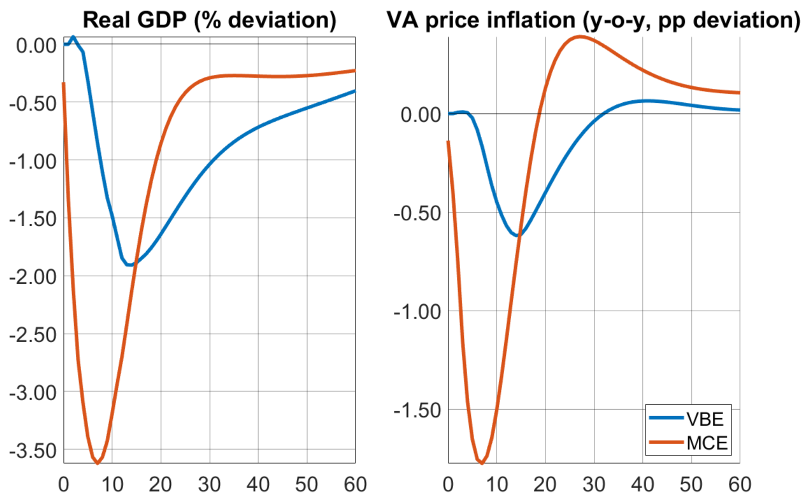


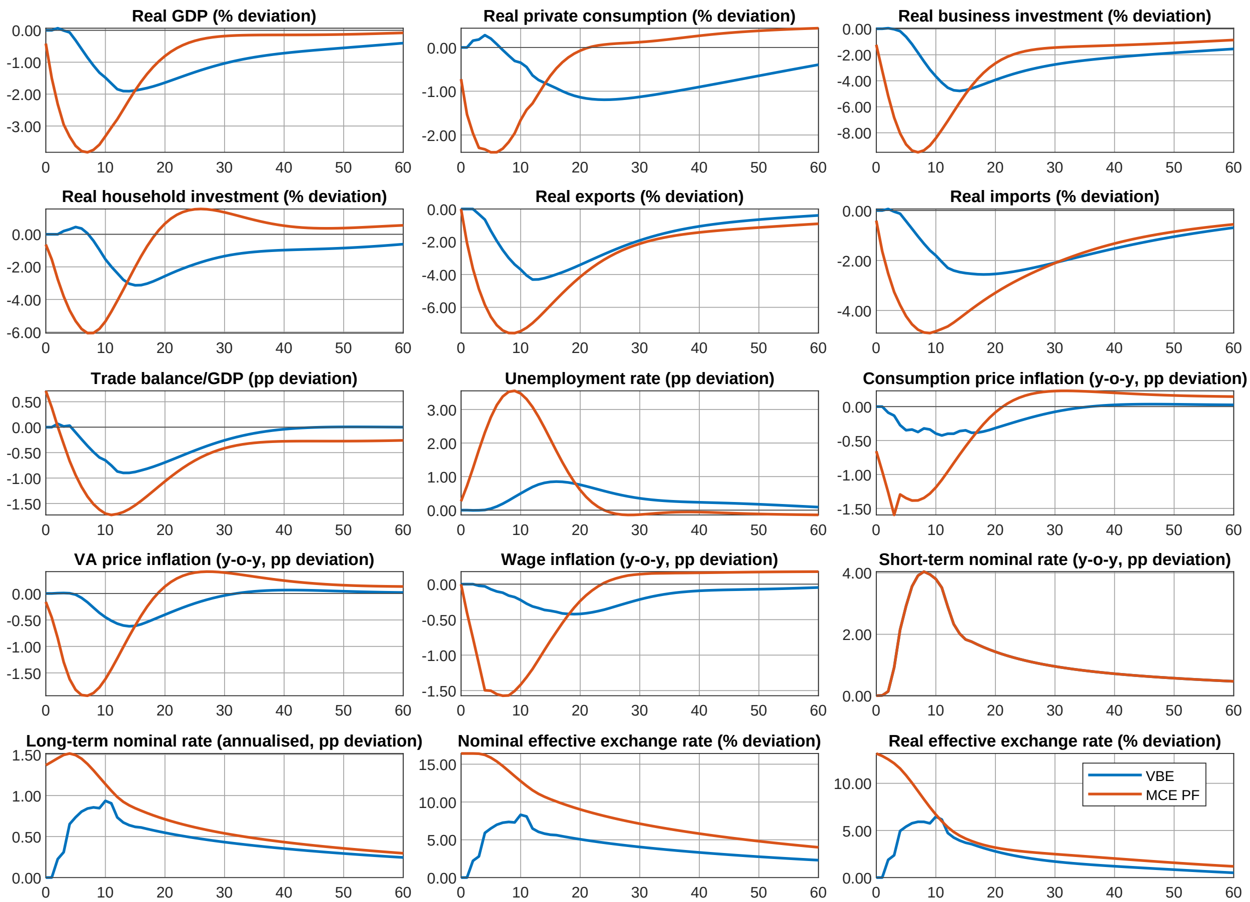
Figure 6.4.1: Responses to the monetary policy shock (policy rate and its expectations)

Overall, the figure illustrates that expectation formation plays a central quantitative role, with MCE generating deeper and more frontloaded responses than the smoother and more muted dynamics observed under VBE.

In the VAR-based case, because agents only gradually revise their beliefs about future rates and prices, the tightening is perceived as less persistent in the short term, attenuating the immediate impact on demand. The contraction in GDP, consumption, and investment is thus smaller initially but more persistent over the medium term. Inflation declines more slowly and remains below baseline for longer, as the gradual adjustment of price and wage expectations sustains nominal rigidities. The nominal and real exchange rate appreciate moderately and revert gradually, producing a delayed improvement in net exports once domestic demand weakens.

In contrast, in the MCE case, as the short-term policy rate increases, long-term rates rise immediately through the term structure channel, tightening financial conditions and compressing investment and consumption. The output response is therefore frontloaded: real GDP and its demand components—particularly business and housing investment—decline sharply in the short run. The exchange rate appreciates strongly via uncovered interest parity, dampening exports and amplifying the contraction in activity. Lower aggregate demand feeds into labour demand, resulting in a pronounced increase in unemployment. The disinflation process is faster with respect to the VAR-based case: value-added, wage and consumption price inflation fall rapidly, reaching their trough after three to six quarters. Once expectations of future easing stabilise, output and inflation converge smoothly back to steady state. Note that these impacts are reinforced by the perfect-foresight assumption for MCE agents, who know perfectly well the entire path of the shocks once the disturbances occur. This assumption will be relaxed in Section 6.4.2 with the introduction of staggered expectations.

Figure 6.4.2: Response to the tightening of the policy interest rate



In the MCE simulations, the assumed duration of the policy disturbance plays a pivotal role, as it informs agents about the persistence of the tightening regime. When the short-term nominal rate and its expected path are held at their 2025Q4 levels for an additional ten quarters, the extended persistence of the shock mechanically strengthens the forward-looking component of the transmission mechanism. A longer-lived tightening produces a proportionally larger adjustment in long-term rates and amplifies the macroeconomic response. Quantitatively, the longer-duration experiment generates peak output losses roughly 15 percent larger than in the baseline MCE simulation, while the maximum inflation response increases by around 25 percent.

Figures 6.4.3 and 6.4.4 illustrate how the expected terminal rate shock complements and reshapes the transmission of the initial short-term policy-rate disturbance by decomposing the responses of GDP and value-added inflation under both the VBE and MCE frameworks. The expected terminal rate shock contributes markedly to the overall adjustment—close to one half of the peak responses of GDP and HICP inflation, except in the VBE case for value-added inflation —highlighting the importance of revisions to the forward target policy-rate path.

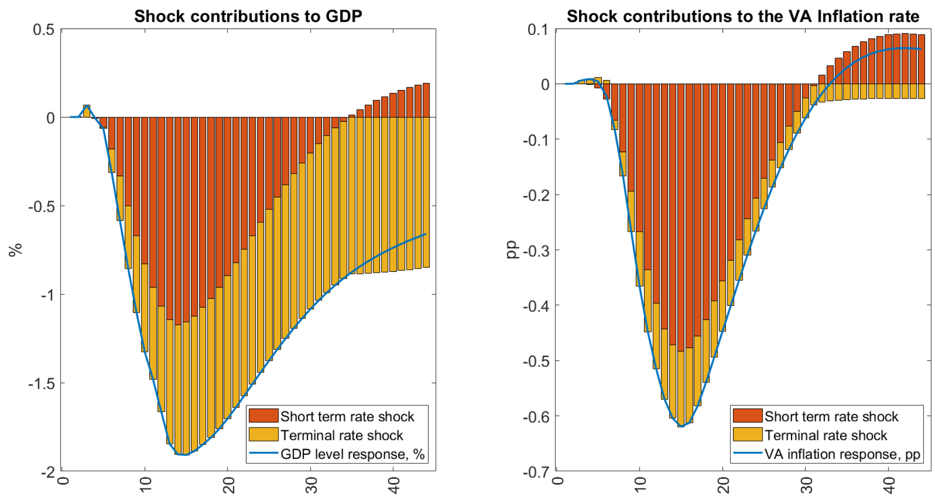


Figure 6.4.3: Decomposition of responses by shock, VBE mode

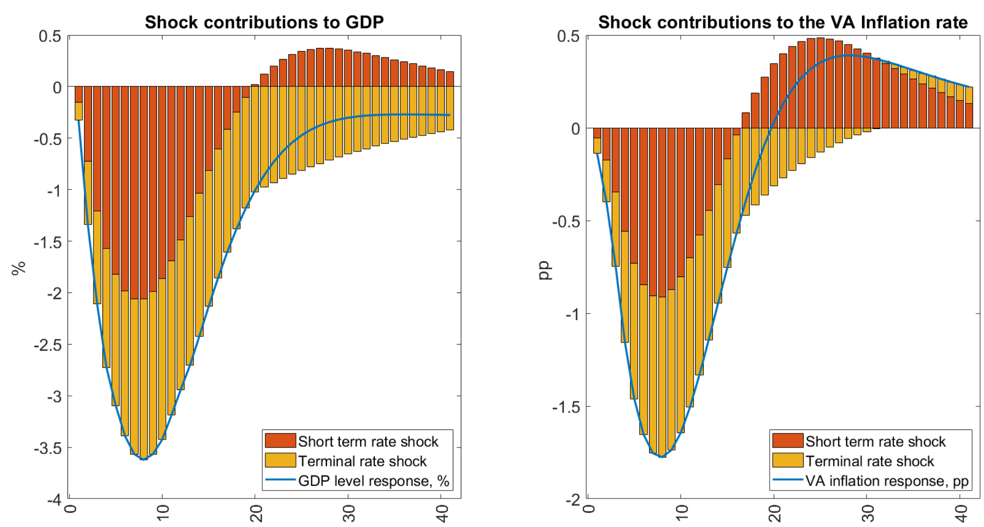


Figure 6.4.4: Decomposition of responses by shock, MCE mode

Overall, these results illustrate the crucial role of expectation formation in the monetary transmission mechanism. When expectations are forward-looking and model-consistent, policy shocks trigger rapid and frontloaded real and nominal adjustments. When expectations are backward-looking, the economy exhibits more persistence and a longer disinflation process. This contrast implies that expectation rigidity dampens the short-run real contraction associated with monetary tightening while stretching its macroeconomic impact over a longer horizon, while delaying its full disinflationary effects.

6.4.2 Responses under hybrid expectations

Figure 6.4.5 reports the responses to the double shock under hybrid expectations scheme. Compared to the standard monetary policy shock analysed previously in subsection 5.1, the inclusion of a shock to the terminal rate modifies both the transmission mechanism and the relative ranking of responses across expectation regimes.

In the case of a standardised 100 bp shock to the short-term rate, the hybrid regime typically generated the strongest real contraction, reflecting the interaction between forward-looking financial markets and backward-looking real agents. With the terminal short-term rate shock, however, hybrid responses become comparable to those under MCE, and in some cases even weaker—particularly for price variables and corporate investment. This contrasts with the ranking obtained under the standard shock and shows that the relative performance of expectation regimes depends on the nature of the policy disturbance. When tightening operates through expected terminal rates on top of short-term rates, these expectations are also formed by backward-looking real-sector agents, thereby reducing the informational wedge with financial markets. As a result, the asymmetry that underpins the amplification mechanism in the hybrid configuration is partly internalised.

More precisely, for financial market participants, the mechanism remains essentially unchanged. Since these agents are forward-looking in both the MCE and hybrid regimes, long-term interest rates and the exchange rate respond immediately to the revised expected path of policy rates. The term structure incorporates the higher terminal rate on impact, and the exchange rate adjusts through the expected interest rate differential channel. As a result, the responses of long rates and the exchange rate in the Hybrid regime remain close to those observed under MCE. For backward-looking agents in the hybrid mode, the introduction of the terminal rate shock generates two simultaneous and partially offsetting effects. On the one hand, relative to the pure VBE regime, these agents face a stronger tightening because of the immediate reaction of the financial markets. On the other hand, because backward-looking agents form expectations through E-SAT, they react to the spread between the realised short rate and its anticipated target level. A simultaneous shock to the short-term rate and its expected terminal level reduces the spread relative to a short-rate-only shock, leading to a weaker transmission through expectations.

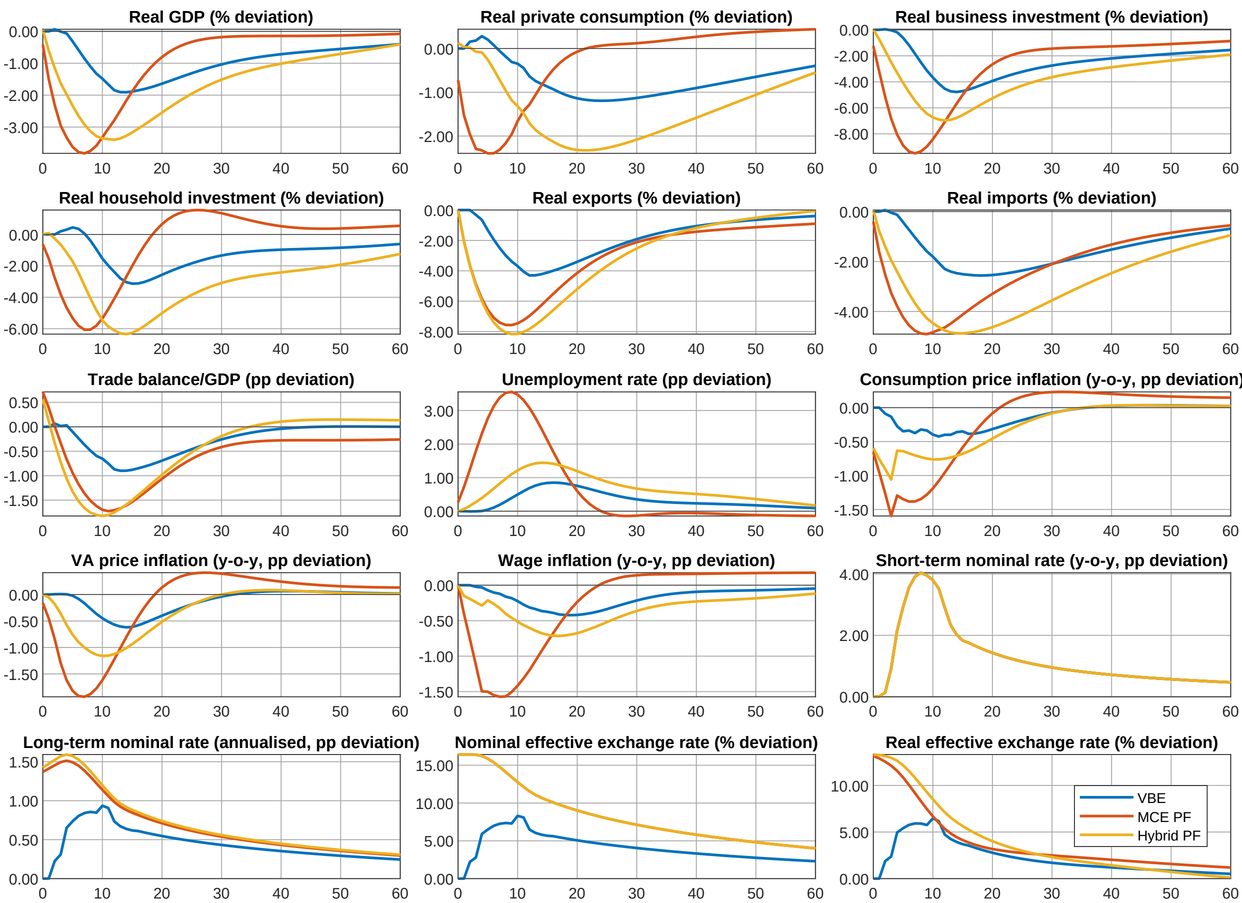


Figure 6.4.5: Model responses under VAR-based, MCE and Hybrid modes

6.4.3 Responses under hybrid mode and staggered expectations

We now consider a variant of the hybrid specification in which information about the monetary policy shock arrives gradually. This extension is designed to increase the realism of the exercise by relaxing the perfect-foresight information assumption. Under perfect foresight scenario studied before, agents immediately internalise the full future path of both the contemporaneous policy rate shock and the terminal rate shock. In practice, however, information about the expected path of policy rates is revealed and incorporated progressively.

In the staggered expectations setting, expectations are updated sequentially at each period. Both components of the double shock—the current short-rate increase and the revision in the terminal rate—are incorporated gradually as new information becomes available. Figure 6.4.6 illustrates this mechanism. At each quarter, agents revise their expectations about the future path of the policy rate and the terminal rate. In the left-hand panel, each line combines realised observations up to the cut-off date indicated in the legend with market-implied expectations for the future path of the short-term rate thereafter. The right-hand panel reports the corresponding terminal rate levels from the Survey of Monetary Analysts for each projection round. Figure 6.4.6 reveals an interesting feature: throughout 2022 and 2023 expectations for 2024q4 and 2025 were higher than in December 2024. Over this period staggered expectations push long term rates and the exchange rate higher than in perfect information case discussed in the previous subsection. Since the term structure reflects expected future short rates, upward revisions in distant horizons initially push long-term yields higher. When those expectations are later revised downward, long-term rates adjust accordingly. Through uncovered interest parity, similar mechanisms operate for the exchange rate, which reacts to evolving expected interest rate differentials.

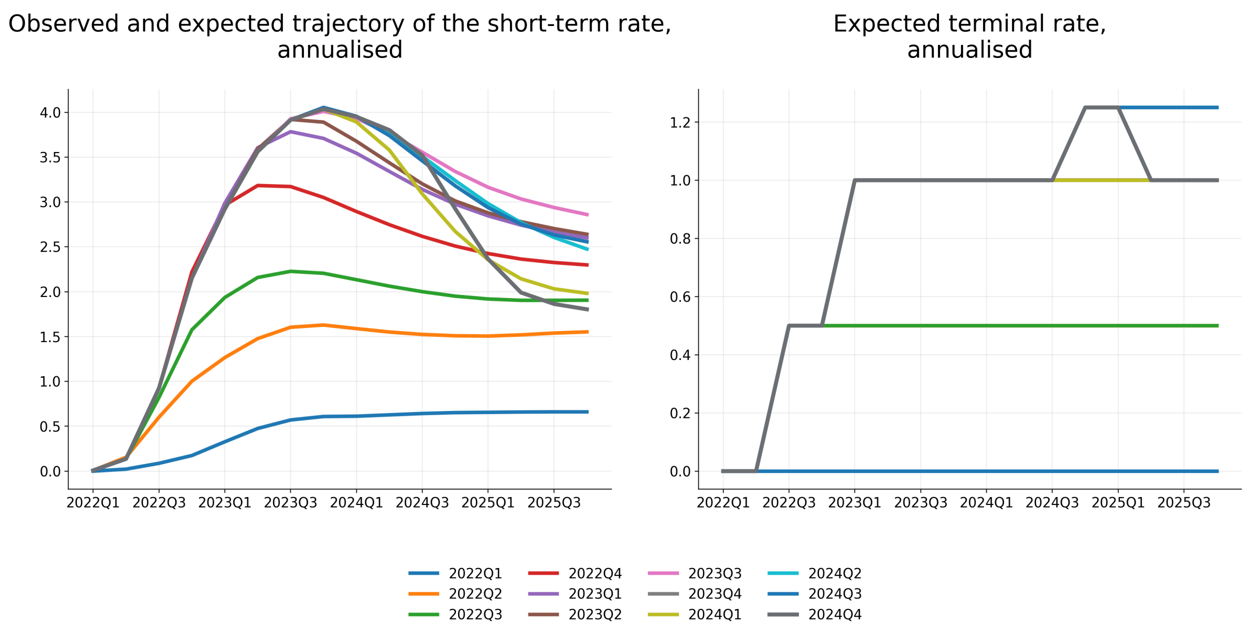


Figure 6.4.6: Update of the information set in staggered expectation setting

Note: In the left-hand panel, each line combines realised observations up to the cut-off date indicated in the legend with market-implied expectations for the future path of the short-term rate thereafter. The right-hand panel reports the corresponding terminal rate levels from the Survey of Monetary Analysts for each projection round.

In figure 6.4.7, we compare the hybrid expectation mode under perfect foresight and under staggered expectations. The overall patterns are remarkably similar. The double shock is progressively incorporated by forward-looking financial markets as they internalise the new information over time. As a result, the initial tightening is weaker than under perfect foresight. This gradual incorporation implies that the macroeconomic reaction is slightly delayed relative to the hybrid perfect foresight case. Output, prices, and other real variables adjust somewhat more slowly in the early periods. However, the overall amplitude of the responses remains broadly unchanged. Once the full information has been incorporated, the cumulative effect of the double shock converges to a magnitude comparable to that obtained under hybrid perfect foresight.

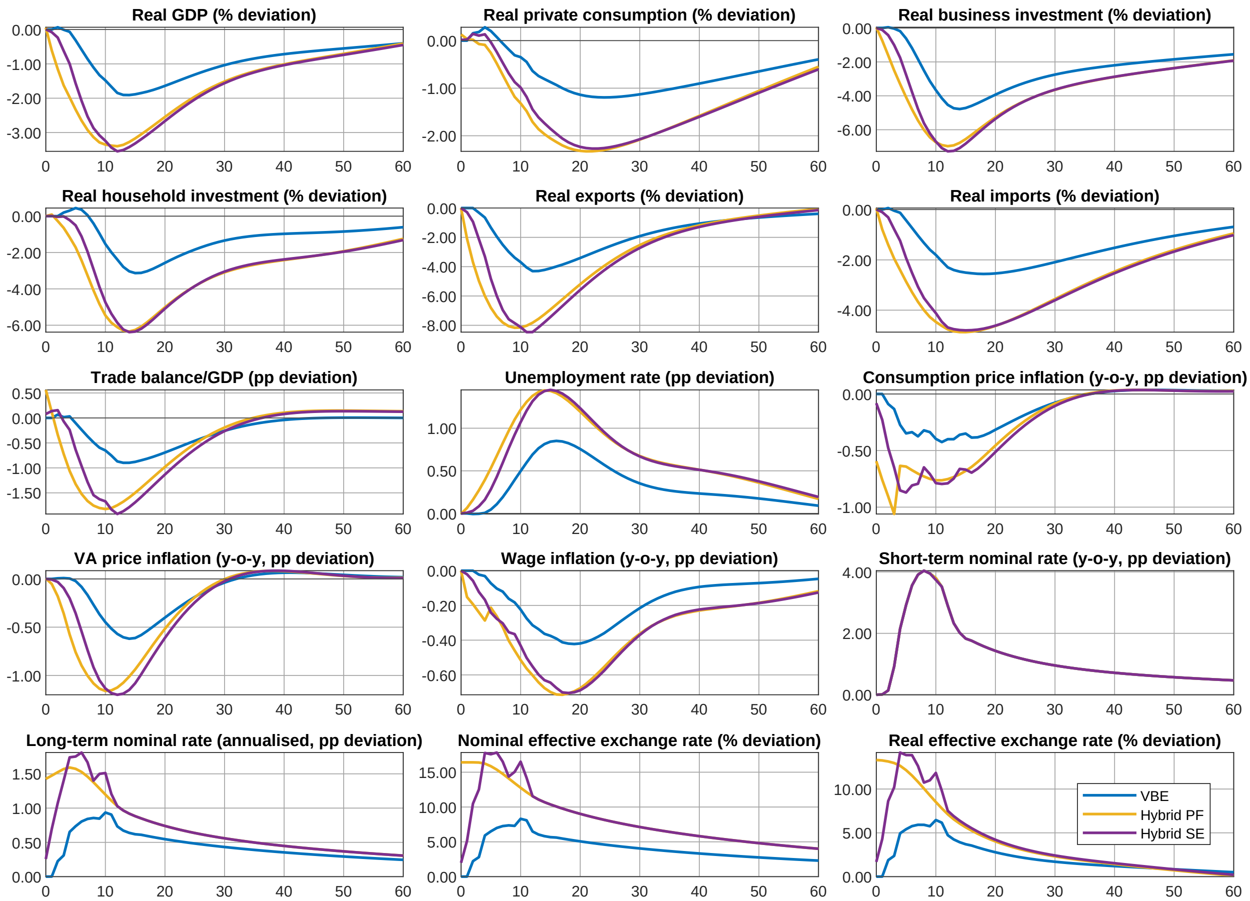


Figure 6.4.7: Model responses under VAR-based, Hybrid (perfect foresight) and Hybrid (staggered expectations) expectation modes

In sum, introducing staggered expectations mainly affects the timing of the transmission rather than its ultimate strength. The adjustment is smoother and more progressive, but the medium-term macroeconomic impact remains close to that obtained under the baseline hybrid expectation mode.

6.4.4 Comparative summary of peak and mean responses

Taken together, the results across the different shock specifications and expectation regimes highlight that the transmission of monetary policy in the model is highly sensitive to the interaction between the nature of the disturbance and the information structure. Under the standard policy shock, differences across VBE, MCE and hybrid modes primarily reflect the role of forward-looking behaviour in financial markets and the resulting amplification through long-term interest rates. The hybrid regime tends to generate stronger real responses due to the asymmetry between forward-looking financial agents and backward-looking real agents. When the shock explicitly includes a revision in the expected path of terminal rate, however, the hierarchy of responses is altered: hybrid outcomes become closer to those under MCE, and in some cases even slightly weaker for price variables and corporate investment, reflecting the attenuation of the expectations channel for backward-looking agents. Finally, relaxing the full-information assumption through staggered expectations mainly redistributes the adjustment over time. The gradual incorporation of the double shock smooths the initial response but leaves the medium-term amplitude broadly unchanged. These results indicate that the responses under VBE, MCE, hybrid and hybrid staggered expectations are not invariant to the structure of the policy disturbance. The amplification mechanisms depend crucially on whether monetary tightening operates through current rates, expected terminal rate, or both, and on how quickly agents internalise new information.

Quantitatively, the results of the four simulation modes can be compared along two complementary dimensions: the trough, which measures the maximum intensity of the contraction, and the mean, which captures the persistence of the response and therefore the overall macroeconomic cost over the horizon considered (Table 6.4.1):

- Under VBE, the adjustment is the weakest overall. GDP falls by −1.9 percent at the trough, while VA inflation decline by and −0.6 pp, respectively. The mean responses are also relatively small (GDP −0.9 percent, VA inflation −0.3 pp), indicating both a less sharp shock and a limited cumulative macroeconomic cost.

- With fully forward-looking expectations (MCE), the responses are much more front-loaded. GDP falls by −3.5 percent at the trough, while VA inflation decline by and −1.7 pp, respectively. Mean responses remain sizeable (GDP −2.8 percent, VA inflation −1.3 pp), reflecting the strong and immediate adjustment implied by forward-looking behaviour.

- The Hybrid PF specification also generates large trough effects, with GDP falling by −3.3 percent and VA inflation by −1.2 pp. Mean responses remain substantial (GDP −2.5 percent, VA inflation −0.8 pp), indicating that the contraction is not only strong but also relatively persistent when financial markets react quickly while households and firms adjust more gradually.

- Finally, Hybrid SE smooths the adjustment by introducing staggered information updating. Trough effects remain sizeable (GDP −3.3 percent, VA inflation −1.2 pp), but mean responses are smaller (GDP −2.1 percent, VA inflation −0.7 pp), reflecting a less abrupt but still very persistent transmission of the shock.

Overall, while VBE generates the most muted response, and MCE delivers the sharpest contraction, the hybrid regime occupy an intermediate position, producing sizeable peak effects while exhibiting more persistent adjustment dynamics. Independently of this ranking, staggered hybrid expectations provide the most credible benchmark in terms of information structure, as they combine a realistic assumption on expectation formation across agents with a plausible assumption on the gradual diffusion of information over time.

7 Conclusion

This revision of the FR-BDF model adresses profound structural and statistical changes in the French economy, strengthening its role as a policy analysis and forecasting tool. By integrating updated national accounts, including the Covid period, refining behavioral equations,

Table 6.4.1: Peak and mean responses under alternative expectation formation modes

	Through			Mean over 16 quarters		
	GDP level	GDP growth	VA inflation	GDP level	GDP growth	VA inflation
VBE	-1.9	-1.0	-0.6	-0.9	-0.5	-0.3
MCE	-3.5	-3.0	-1.7	-2.8	-0.6	-1.3
Hybrid PF	-3.3	-2.0	-1.2	-2.5	-0.8	-0.8
Hybrid SE	-3.3	-1.9	-1.2	-2.1	-0.9	-0.7

*Note:*The reported values are computed relative to the corresponding no-shock baseline simulated under the same expectations regime. GDP level responses are expressed as percent deviations from baseline, while GDP growth and inflation responses are reported in percentage-point deviations. The GDP growth rate and VA inflation rate are computed as year-on-year changes.

and introducing new features (such as the credit block, gas prices and short-run hand-to-mouth income effects), the model achieves greater empirical realism while preserving its semi-structural foundations. The reestimation highlights key shifts: a lower capital share, a slower productivity trend, and a steeper Phillips curve along with a flatter wage Phillips curve, all consistent with long-term transformations in production and price-setting behavior. These enhancements improve the robustness of baseline projections.

Compared to Lemoine et al. (2019), the updated model delivers sharper real effects of monetary tightening, while nominal variables exhibit more muted responses. Following a 100 bp short rate shock with endogenous persistence, GDP falls more than in the original 2019 version (–0.21% vs. –0.15%) and earlier (after 8 quarters vs. 12), while unemployment rises more sharply (+0.13 pp vs. +0.10 pp). The faster response reflects lower endogenous persistence in the E-SAT block. By contrast, medium-run nominal adjustments are weaker due to a flatter wage Phillips curve, which counterbalances the short-run effects of a steeper price Phillips curve. The transmission of the shock to the exchange rate is now stronger, amplifying the external trade channel of monetary policy. The model also features a stronger financial propagation due to the added financial accelerator mechanism. Therefore, following a term premium shock, a stronger pass-through from bank lending rates in the consumption and investment equations make households and firms more sensitive to real interest rates, resulting in more than twice the decline in investment and consumption.

Simulations using the updated FR-BDF suggest that the recent ECB tightening generates sizeable and expectation-dependent effects on the French economy. Under backward-looking expectations, output and inflation adjust gradually, with real GDP reaching a trough of about -1.9% (-1 pp of y-o-y growth rate) and year-on-year VA inflation declining by around -0.6 pp. Under fully forward-looking expectations, the contraction is substantially sharper and more front-loaded, with GDP falling by roughly -3.5% (-3 pp of y-o-y growth rate)and VA inflation by -1.7 pp. Hybrid expectations yield intermediate but still pronounced responses: when financial markets are forward-looking while households and firms remain backward-looking, GDP declines by about -3.3% (-2 pp of y-o-y growth rate) and VA inflation by about -1.2 pp at the trough. Introducing staggered information updating smooths the initial adjustment while leaving peak effects broadly unchanged. This hybrid staggered specification likely provides the most plausible representation of monetary transmission, as it combines forward-looking financial markets with gradual information diffusion among real-sector agents. Overall, the results highlight the central role of expectation formation in shaping both the magnitude and the timing of the macroeconomic effects of monetary tightening.

Looking ahead, the FR-BDF framework provides a robust platform for addressing emerging challenges, including inflation uncertainty, weak productivity growth, and the macroeconomic implications of climate transition and fiscal consolidation. These developments, combined with the prospect that structural parameters may shift as AI-driven technological change reshapes productivity patterns, highlight the need to revisit coefficient stability and model robustness on a regular basis. Continued integration with complementary models will be essential to maintain its relevance for policy evaluation in an increasingly complex environment.

References

Adjemian, S., Bokan, N., Pariès, M. D., Müller, G., & Zimic, S. (2023). *ECB-(RE)BASE: Heterogeneity in expectation formation and macroeconomic dynamics*. ECB Working Paper 2965, European Central Bank.

Aldama, P., Carroy, A., Ducoudré, B., Martin, R., Sabatini, M., & Sabes, D. (2026). *An Update of FR-BDF's Basic Model Elasticities and the FR-BMEs model: A simplified forecasting platform for Banque de France's macroeconomic interim projections*. Working papers 1045, Banque de France.

Aldama, P., Gaulier, G., Lemoine, M., Robert, P.-A., Turunen, H., & Zhutova, A. (2022). *The EA-BDF Model and Government Spending Multipliers in a Monetary Union*. Working papers 883, Banque de France.

Allen, T., Boullot, M., Dées, S., de Gaye, A., Lisack, N., Thubin, C., & Wegner, O. (2025). Using short-term scenarios to assess the macroeconomic impacts of climate transition. *Energy Economics*, 148, 108663.

Angelini, E., Bokan, N., Christoffel, K. P., Ciccarelli, M., & Zimic, S. (2019). *"Introducing ECB-BASE: The blueprint of the new ECB semi-structural model for the euro area*. Working Paper 2315, European Central Bank.

Bardaji, J., Campagne, B., Khder, M.-B., Lafféter, Q., Simon, O., Dufernez, A.-S., Elezaar, C., Leblanc, P., Masson, E., & Partouche, H. (2017). *The MESANGE macroeconometric model: re-estimation and innovations*. Documents de Travail de l'Insee - INSEE Working Papers g2017-04, Institut National de la Statistique et des Etudes Economiques.

Bove, G., Dees, S., & Thubin, C. (2020). *House Prices, Mortgage Debt Dynamics and Economic Fluctuations in France: A Semi-Structural Approach*. Working papers 787, Banque de France.

Brayton, F., Davis, M., & Tulip, P. (2000). *PAC in FRB/US*. Technical report, Federal Reserve Board.

Brayton, F., Laubach, T., & Reifschneider, D. L. (2014). *The FRB/US Model: A Tool for Macroeconomic Policy Analysis*. FEDS Notes 2014-04-03, Board of Governors of the Federal Reserve System (U.S.).

Brayton, F., Tinsley, P., Bomfim, A., Reifschneider, D., von zur Muehlen, P., Tetlow, B., & Williams, J. (1996). *A Guide to FRB/US: A Macroeconomic Model of the United States*. Technical report, Federal Reserve Board.

Carluccio, J., Mazet-Sonilhac, C., & Mesonnier, J.-S. (2019). *Investment and the WACC: new micro evidence for France*. Working Paper Series 710, Banque de France.

Carroy, A., Delamarre, F., Thubin, C., & Villetelle, J.-P. (2025). Comment expliquer l'augmentation du taux d'épargne des ménages français depuis la période pré-covid ? *Revue d'économie financière*, 158(2), 31–46.

Chauvin, V., Dupont, G., Heyer, E., Plane, M., & Timbeau, X. (2002). Le modèle france de l'ofce. la nouvelle version : e-mod.fr. *Revue de l'OFCE*, 81(2), 245–300.

Choi, J., Doh, T., Foerster, A., & Martinez, Z. (2022). Monetary policy stance is tighter than federal funds rate. *FRBSF Economic Letter*, 2022(30), 1–5.

Cornand, C., Hubert, P., & Portier, F. (2025). *Behavioral Underpinnings of Overreaction in Inflation Expectations Across Economic Agents*. OFCE Working Paper 2025-10, OFCE – Sciences Po.

Crane, L. D., Crowley, M. A., & Quayyum, S. (2007). Understanding the evolution of trade deficits: trade elasticities of industrialized countries. *Economic Perspectives*, 31(Q IV), 2–17.

Dees, S., Gebauer, S., Goncalves, T., & Thubin, C. (2022). *The Financing Structure of Non-Financial Corporations and Macro-Financial Implications in France*. Working papers 880, Banque de France.

Devulder, A., Ducoudré, B., Lemoine, M., & Zuber, T. (2024). Explaining productivity losses observed in France since the pre-Covid period [Comment expliquer les pertes de productivité observées en France depuis la période pré-Covid ?]. *Bulletin de la Banque de France*, (251).

Devulder, A. & Lisack, N. (2020). *Carbon Tax in a Production Network: Propagation and Sectoral Incidence*. Technical Report WP760, Banque de France.

Fuhrer, J. C. (2017). Expectations as a source of macroeconomic persistence: Evidence and theory. *Journal of Macroeconomics*, 52, 186–200.

Gali, J., Smets, F., & Wouters, R. (2011). *Unemployment in an Estimated New Keynesian Model*. Working Paper w17084, National Bureau of Economic Research.

Garbinti, B., Goupille-Lebret, J., & Piketty, T. (2017). *Accounting for Wealth Inequality Dynamics: Methods, Estimates and Simulations for France (1800-2014)*. Working Paper 633, Banque de France.

Gautier, E. & Montornès, J. (2022). Household inflation expectations in france: Measurement and determinants. *Économie et Statistique / Economics and Statistics*, (534-535), 35–52.

Henriet, F., Kalantzis, Y., Lemoine, M., Lisack, N., & Turunen, H. (2025). *Bridging the Gap in Macroeconomic Analysis of the Energy Transition: Combining Medium- and Long-Term Approaches*. Technical Report WP1000, Banque de France.

Hooper, P., Johnson, K. H., & Marquez, J. R. (1998). *Trade elasticities for G-7 countries*. International Finance Discussion Papers 609, Board of Governors of the Federal Reserve System (U.S.).

Hubrich, K. & Karlsson, T. (2010). Trade consistency in the context of the eurosystem projection exercises: an overview. *ECB occasional paper*, 108.

Jude, C. & Levieuge, G. (2024). *The pass-through of past monetary policy tightening to financing conditions [Les effets du resserrement monétaire sur les conditions de financement].* Eco Notepad 354, Banque de France.

Kamps, C., Bussiere, M., Niessner, B., Tristani, O., Christoffel, K., Kapadia, S., Ferrero, G., Gilbert, N., Vlassopoulos, T., Motto, R., & Gerke, R. (2025). *Report on monetary policy tools, strategy and communication.* Occasional Paper Series 372, European Central Bank.

Knoblach, M., Roessler, M., & Zwerschke, P. (2020). The elasticity of substitution between capital and labour in the us economy: A meta-regression analysis. *Oxford Bulletin of Economics and Statistics*, 82(1), 62–82.

Knoblach, M. & Stöckl, F. (2020). What determines the elasticity of substitution between capital and labor? a literature review. *Journal of Economic Surveys*, 34(4), 847–875.

Kydland, F. E., Rupert, P., & Šustek, R. (2016). Housing dynamics over the business cycle. *International Economic Review*, 57(4), 1149–1177.

Lemoine, M., Turunen, H., Chahad, M., Lepetit, A., Zhutova, A., Aldama, P., Clerc, P., & Laffargue, J.-P. (2019). *The FR-BDF Model and an Assessment of Monetary Policy Transmission in France.* Working papers 736, Banque de France.

Lenza, M. & Primiceri, G. E. (2022). How to estimate a vector autoregression after march 2020. *Journal of Applied Econometrics*, 37(4), 688–699.

Rotemberg, J. J. (1982). Sticky prices in the united states. *Journal of Political Economy*, 90(6), 1182–1211.

Rudebusch, G. & Svensson, L. E. (1999). Policy Rules for Inflation Targeting. In *Monetary Policy Rules*, NBER Chapters (pp. 203–262). National Bureau of Economic Research, Inc.

Savignac, F. (2024). Firms' inflation expectations: New evidence from france. *Journal of the European Economic Association*, 22(6), 2748–2782.

A Appendix: Household consumption auxiliary equations

Table A.0.2: Coefficients of auxiliary equations for the expectation of the income-output ratio, the real efficient wage and the unemployment gap

VAR model	**Auxiliary equations**		
	$\boldsymbol{y_{H,t} - \bar{y}_t}$	$\boldsymbol{\Delta w_{eff,t}}$	$\boldsymbol{\hat{u}_t}$
Constant	$-0.52\,(1-0.94)$ [0.01]		
$\hat{y}_{t-1}$			-0.96 [0.03]
$y_{H,t-1} - \bar{y}_{t-1}$	0.93 [0.02]		
$\Delta w_{eff,t-1}$	0.22 [0.17]	0.40 [0.15]	
$\hat{u}_{t-1}$		-0.12 [0.06]	0.96 [0.03]
$\hat{y}_t$			-0.18 [0.06]

Note: standard errors in brackets. $R^2 = 0.93$ for the auxiliary equation of $y_{H,t} - \bar{y}_t$ $R^2 = 0.22$ for $\Delta w_{eff,t-1}$ and $R^2 = 0.94$ for $\hat{u}_{t-1}$

The structure of the auxiliary equation for $i_{LH,t}$ is described by equation (A.1) and the estimated coefficients are presented in Table A.0.3.

$$r_{LH,t} = \beta_0 r_{LH,t-1} + (1-\beta_0)\left(\bar{i}_{t-1} - \bar{\pi}_{t-1} + \beta_3\right) + \beta_1\left(i_{t-1} - \bar{i}_{t-1}\right) + \beta_2\left(\bar{\pi}_{t-1} - \pi_{t-1}\right) \quad \text{(A.1)}$$

Table A.0.3: Coefficients and standard errors of the auxiliary equation for the household real bank lending rate

Coefficient	**Estimate**	**s.e**
β_0	0.904	0.021
β_1	0.043	0.023
β_2	-0.028	0.015
β_3	0.004	0.001

$R^2 = 0.99$

B Appendix: Dynamic contributions

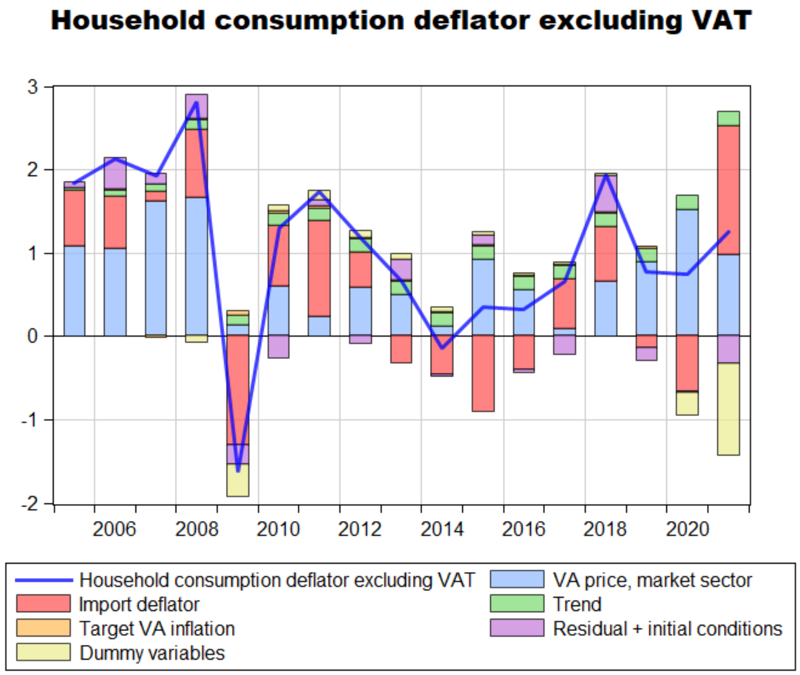


Figure B.1: Household consumption deflator excluding VAT - dynamic contributions

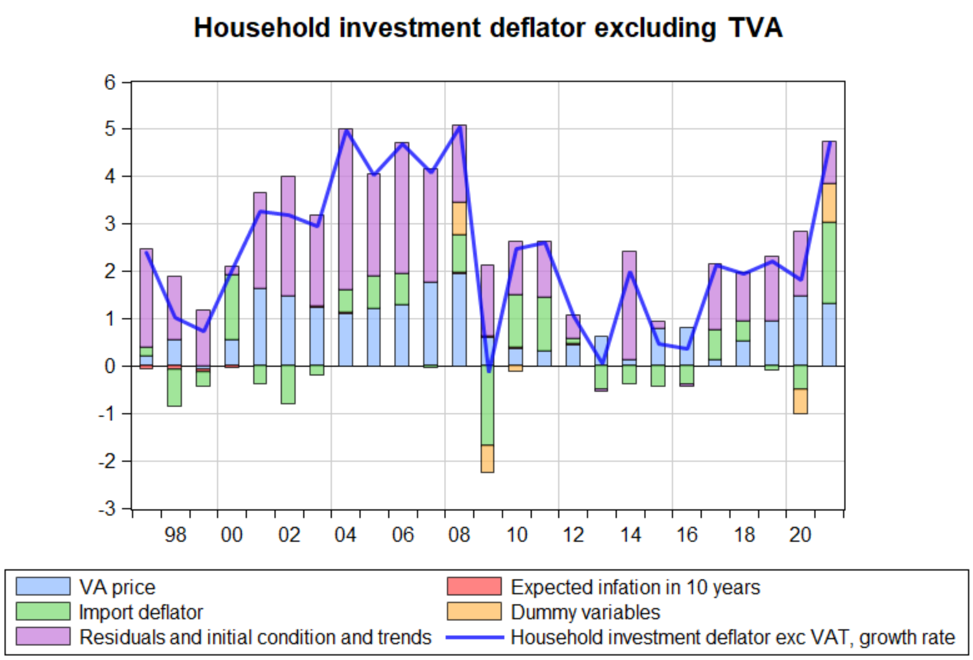


Figure B.2: Household investment deflator - dynamic contributions

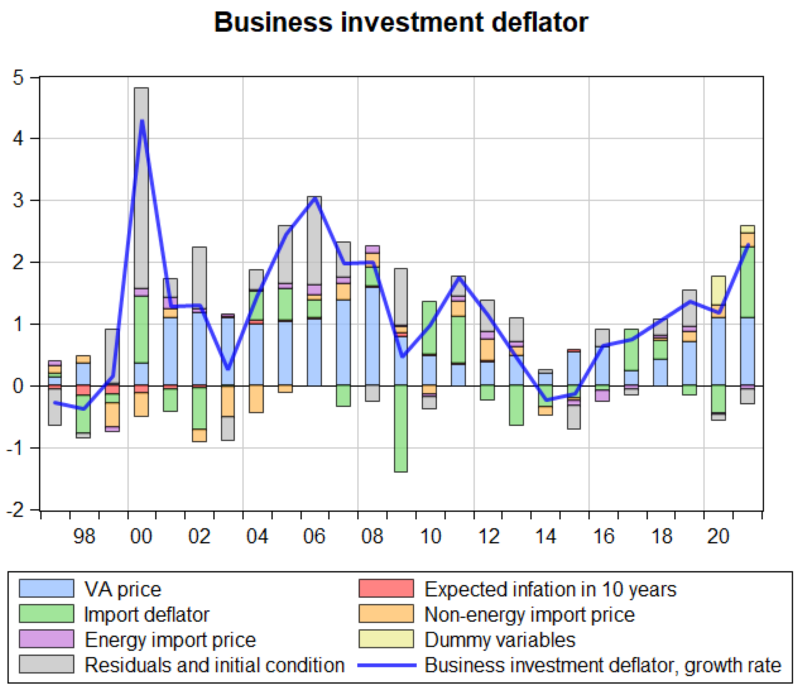


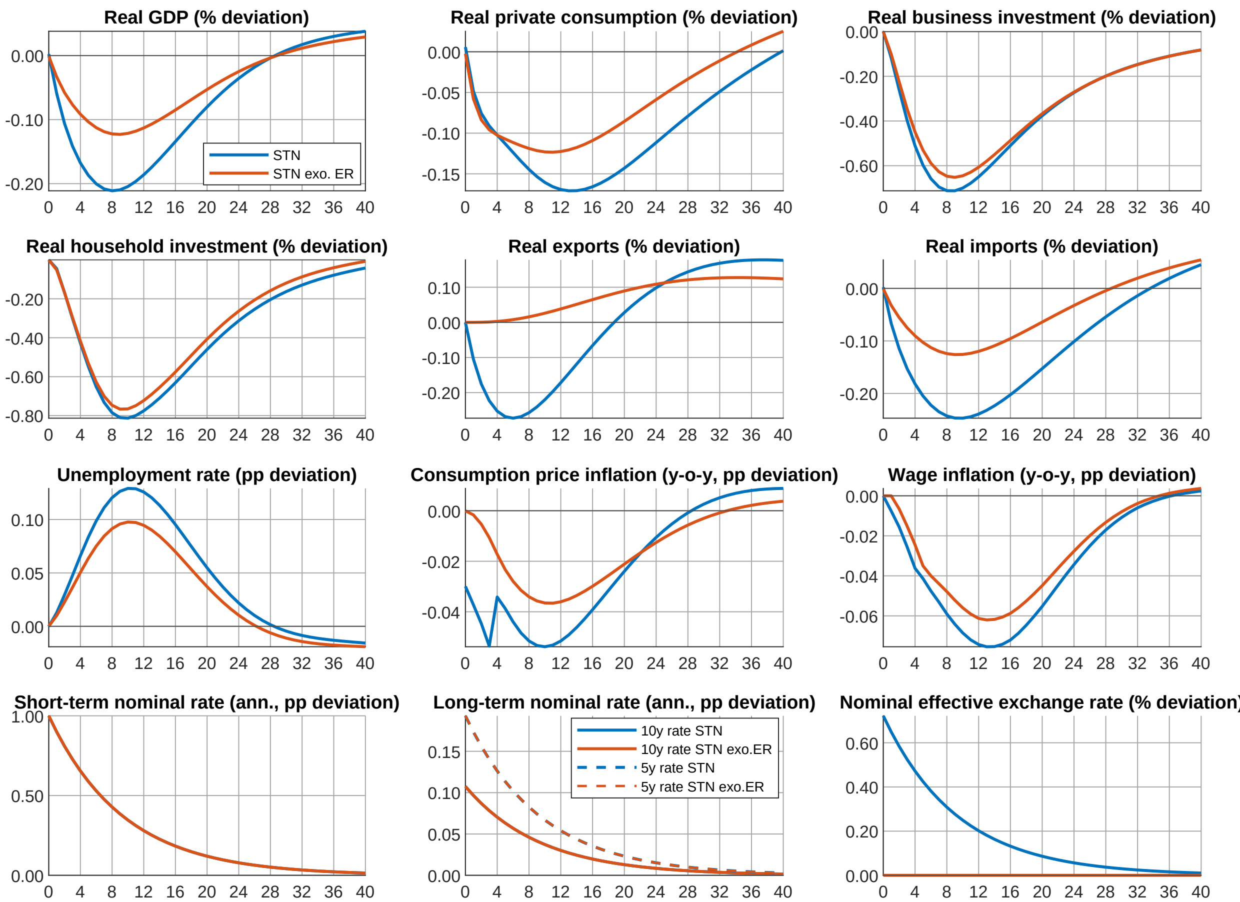
Figure B.3: Business investment deflator - dynamic contributions

C Appendix: Short-term interest rate shock with an exogenous exchage rate

When the nominal effective exchange rate is treated as exogenous (orange IRFs in Figure C.4), the transmission of the short-rate shock (STN) changes markedly relative to the baseline STN case (blue), where the exchange rate appreciates by 0.72% on impact and then gradually mean-reverts. By shutting down this UIP-driven appreciation, the immediate external-price channel is muted. In the baseline, real exports contract sharply, reaching a trough of a 0.27% decline after 6 quarters, whereas with an exogenous exchange rate they stay close to zero on impact and turn positive in the medium run (slowly increasing to a 0.04% increase after 12 quarters, peaking near a 0.13% increase later on). Real imports still fall as domestic demand weakens, but much less than in the baseline (a trough decline around 0.13% after 9 quarters, versus 0.25% after 10 quarters under STN). As a result, net exports contribute more favorably to activity and the downturn is substantially attenuated: real GDP reaches a trough decline of 0.12% (after 9 quarters), compared with 0.21% (after 8 quarters) in the baseline, and the peak increase in unemployment is smaller (0.10 pp versus 0.13 pp, both around 10 quarters).

On the nominal side, disinflation is weaker and more delayed. CPI inflation falls to a trough of 0.037 pp after 11 quarters with an exogenous exchange rate, compared with a larger trough decline of 0.054 pp after 10 quarters in the baseline, consistent with inflation being driven mainly by domestic slack and gradual wage and price adjustment rather than rapid exchange-rate pass-through. Wage inflation shows a similar pattern, with a trough decline of 0.062 pp (versus 0.075 pp) at roughly 13 quarters. Consumption declines by less, with a trough decline of 0.12% (around 11 quarters) rather than 0.17% (around 13 quarters), reflecting the milder downturn and a smaller hit to real disposable income. By contrast, investment responses remain very similar across the two specifications, consistent with dynamics largely governed by the user cost of capital and bank-lending rate channels.

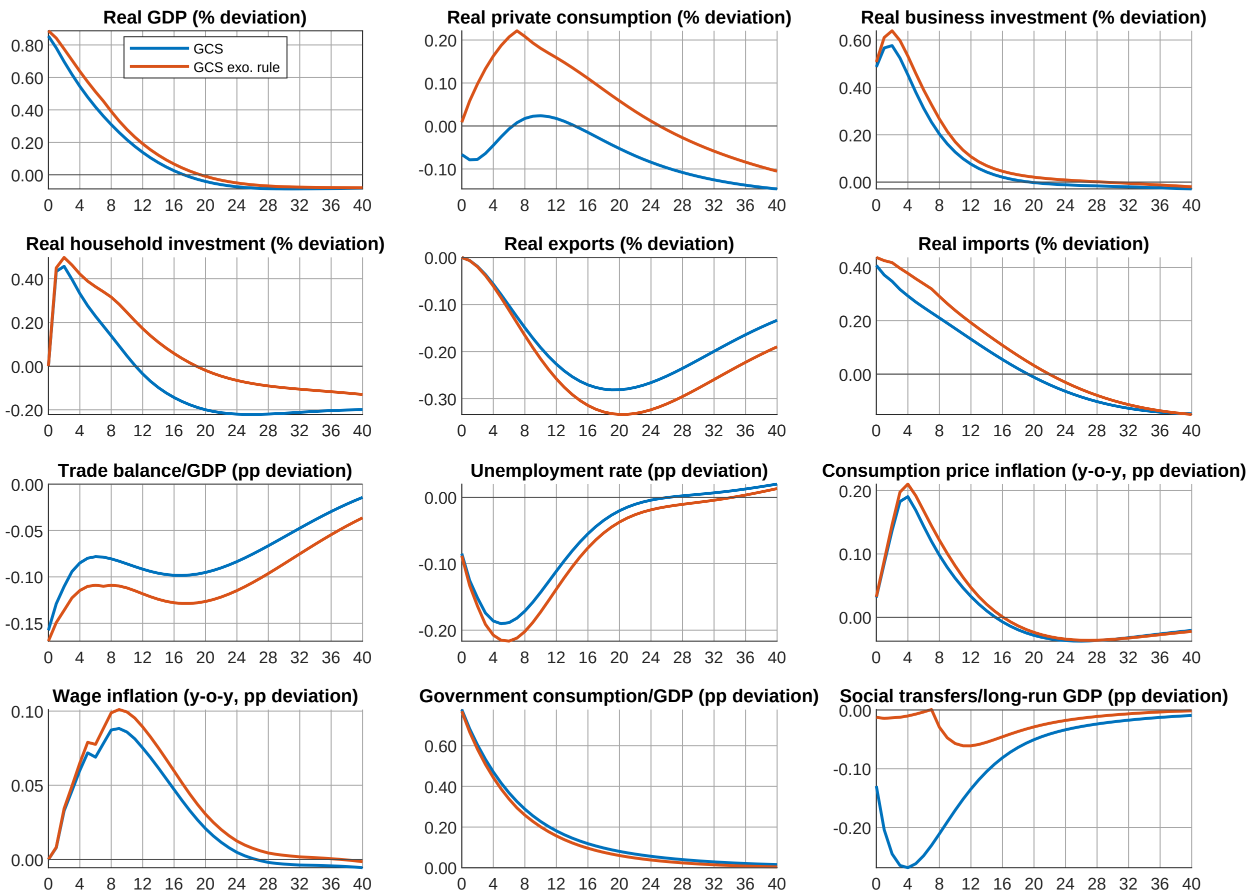
Figure C.4: Short-term interest rate shock (STN) with an endogenous vs. exogenous exchange rate



D Appendix: Government consumption shock with an exogenous debt stabilization rule

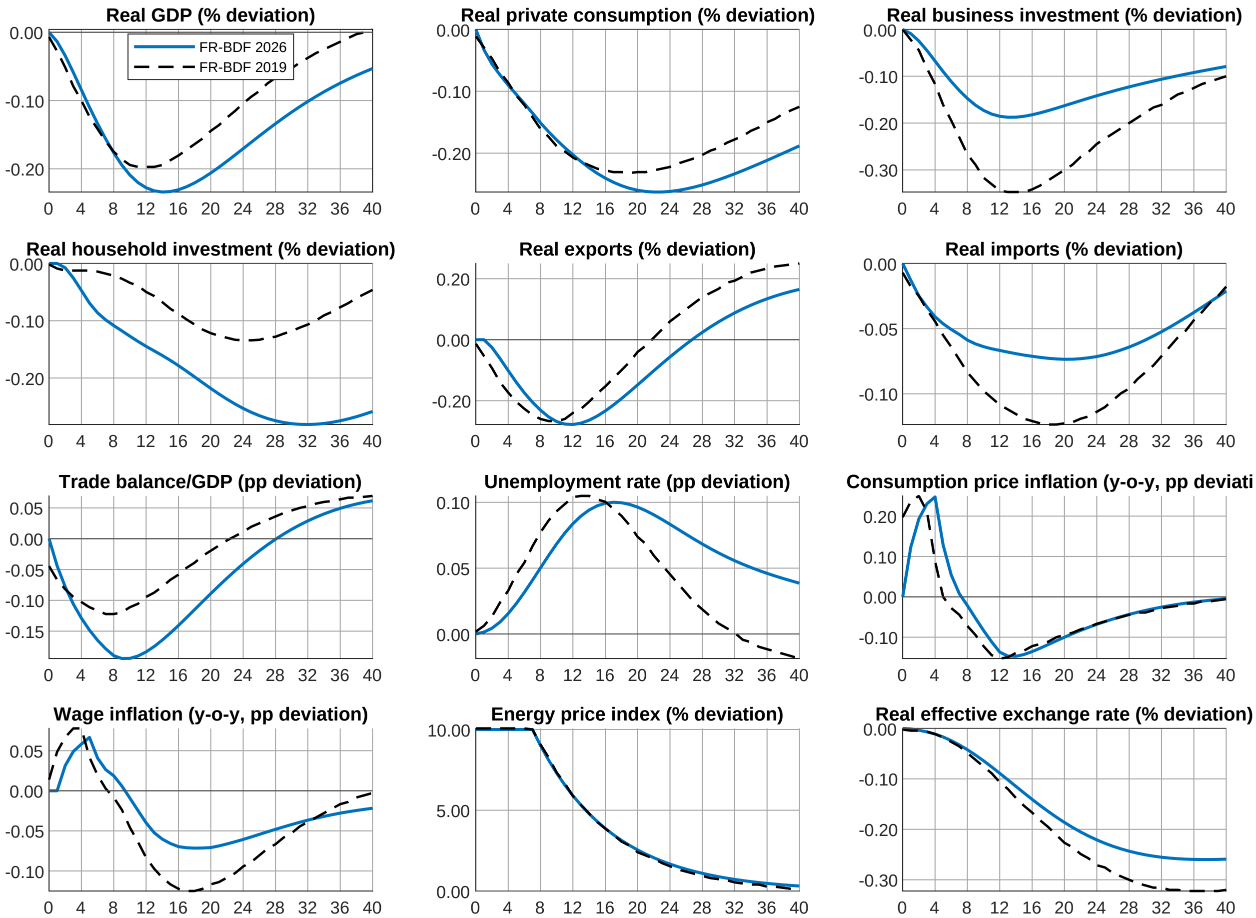
When the debt-stabilization rule operating through social transfers is suspended for the first two years (orange IRFs), the fiscal feedback that normally offsets the spending expansion is temporarily shut down. Social transfers barely move on impact and reach a trough decline of 0.061 pp when the rule is reactivated, compared with an on-impact decline of 0.129 pp and a trough decline of 0.268 pp under the endogenous rule (blue). As a result, most responses remain close, but private demand strengthens: household consumption is crowded in rather than dampened by an immediate cut in transfers, and household investment also increases. The crowding-in of consumption is initially muted because wages adjust more slowly than prices, temporarily compressing real disposable income, but it becomes more visible as income catches up, rising to 0.222% after 8 quarters (versus 0.024% after 11 quarters in the baseline). Household investment also strengthens, peaking at 0.497% after 3 quarters (versus 0.457%), while remaining otherwise similar in shape. The stronger demand comes with a larger external deterioration: the trade balance-to-GDP falls by 0.169 pp on impact (versus 0.158 pp), reflecting a larger increase in imports on impact (0.437% versus 0.407%) and a deeper export trough later on (a 0.333% decline versus 0.281%). As a result, the response of real GDP is virtually unchanged, peaking at 0.887% on impact (versus 0.855%) and exceeding the baseline by 0.094 percentage point in quarter 6 (0.573% versus 0.479%). On the nominal side, price responses are slightly stronger, with CPI inflation peaking at 0.210 pp after 5 quarters (versus 0.190 pp) and wage inflation peaking at 0.101 pp after 10 quarters (versus 0.088 pp), consistent with wages initially lagging behind prices and delaying the full strength of consumption crowding-in.

Figure D.5: Government consumption shock (GCS) with an endogenous vs. exogenous debt stabilization rule



E Appendix: Energy price index shock

Figure E.6: Energy price index shock



The energy price shock is designed as a +10% shock to the energy price index, during 8 quarters, with a persistence calibrated at $\rho = 0.9$ afterward. Foreign competitors' prices are left unchanged, i.e. the shock is asymmetric.

As illustrated in Figure E.6, the real consequences of this shock are a bit stronger compared to those in the equivalent oil price shock in the original model (before the introduction of gas prices). Real GDP declines by up to 0.23% at its peak after 14 quarters, while unemployment rises by 0.10 pp after 17 quarters. The main transmission channel operates through energy import prices and consumer inflation, with the latter peaking at +0.25 pp after four quarters, similarly to the original model.

At first, wages react incompletely and with a lag to the increase in consumer price inflation, which will reduce real household income in the short run. Wage inflation then declines by -0.07 pp after 18 quarters, due to the rise in unemployment. On one hand, households' purchasing power will decline in the short run, due to the strong increase in the consumer price, while on the other, the real labor cost will rise and reduce labor-demand.

On the real side, all aggregate demand components fall after the shock. Household consumption and investment decrease progressively due to lower purchasing power and higher unemployment. Real business investment decreases due to the decline in the VA of market branches. Finally, real exports decline in the short run (-0.28% after 12 quarters), due to competitiveness losses and the asymmetric nature of the shock. Meanwhile, real imports fall progressively to -0.07%, along with aggregate demand components, due to the import content of exports. In the medium run, the decrease in prices progressively restores price competitiveness and the trade balance rises above the baseline after 28 quarters.

F Appendix: Government consumption shock under different expectation modes

Figure F.7: Government consumption shock under different expectation modes