# Quality-of-capital news versus TFP news*

Luis Herrera[a,b] and Jesús Vázquez[b]

February 2022

**ABSTRACT:** This paper contributes to two important strands of business cycle literature (news shocks and financial frictions) by assessing the importance of news shocks and their transmission through financial markets in explaining aggregate fluctuations. We consider an estimated medium-scale DSGE model augmented with financial frictions where two alternative sources of news shocks are considered. One is a standard non-stationary TFP news shock, the other is a quality-of-capital (QoC) news shock. The latter has a distinctive, amplifying impact on the financial market and an anticipated effect on the aggregate production function as TFP news shocks do. The inclusion of QoC news shocks greatly improves model fit. The improvement is especially substantial for hours, inflation, and investment growth rate. We also provide robust empirical evidence showing that pure QoC news shocks are a major source of aggregate fluctuations in real and financial variables.

JEL classification: E30, E32
Keywords: Financial shocks, News shocks, Credit channel, DSGE model, Bayesian estimation

***a*** IRES, Université catholique de Louvain

***b*** Universidad del País Vasco (UPV/EHU). Corresponding author: jesus.vazquez@ehu.es

---

*The authors would like to thank Vincent Bodart, Mikel Casares, Ferre de Graeve, Paolo Gelain, Luca Pensieroso, Frank Portier, Matthias Rottner, Rigas Oikonomou seminar participants at the 2021 Computation in Economics and Finance Meeting, 2021 IAAE Annual Conference, 2020 ASSET Meeting, III SMN Workshop, and DSE Winter School 2020 for useful comments and suggestions on preliminary versions of this paper. This research was supported by the Spanish Ministry of Science and Innovation under grant number PID2020-118698GB-I00, by the Spanish Ministry of Economy and Competition under grant number ECO2016-78749P, and by the Basque Government under grant number IT-1336-19. The first author also acknowledges financial support from the Spanish Ministry of Science, Innovation and Universities under scholarship grant FPU17/06331.

# 1 Introduction

This paper builds on the expectation-driven business cycle hypothesis, which has a long tradition. Pigou (1927) argued that the business cycle was driven by variations in the profit expectations of 'business men'.[1] More recently, Beaudry and Portier (2004) suggest a modeling approach for Pigou's theory of the business cycle which suggests that *anticipated* (news) shocks are a major source of business cycle fluctuations. Beaudry and Portier (2006) provide further empirical evidence supporting Pigou's view. They identify two shocks using VAR methods: One drives short-run fluctuations in stock prices and is orthogonal to innovations in TFP. This shock is closely correlated to a second shock that drives long-run movements in TFP. Moreover, Beaudry and Portier (2006) show that these two shocks anticipate TFP growth by several years. This empirical evidence strongly supports the idea of an expectation-driven business cycle in which the financial sector plays an important role.

This paper suggests a novel approach for modeling the type of news shocks described in Beaudry and Portier (2006) by considering quality-of-capital (QoC) news shocks in the medium-scale DSGE model of Smets and Wouters (2007) augmented with financial frictions à la Gertler and Karadi (2011). QoC news shocks have a distinctive, amplifying impact on financial markets and an anticipated effect on the aggregate production function (i.e. on the real economy) as standard TFP news shocks do. More precisely, we assess the relative importance of two alternative sources of news shocks by including both in the DSGE model: One is a standard non-stationary TFP news shock, while the other is a QoC news shock. We provide robust empirical evidence showing that QoC news shocks are a major source of aggregate fluctuations in the real and financial sectors of the economy in detriment to TFP news shocks.

A large body of news literature using DSGE and VAR approaches suggests that the anticipation by financial variables of future changes in production found in Beaudry and Portier (2006) is due

[1] Pigou (1927) also claimed that changes in those expectations were triggered by two 'impulses' which have also been considered by recent macroeconomic literature addressing the importance of news shocks: Fundamental impulses, captured by news shocks that end up realizing, and psychological impulses captured by revised and non-realized news.

to news on TFP. For instance, Beaudry and Lucke (2010) use short- and long-run restrictions to identify TFP news shocks as an important driver of the business cycle. Barsky and Sims (2011) suggest another strategy for identifying TFP news shocks in a VAR framework and also find them to be a significant source of fluctuations. Fujiwara et al. (2011) and Schmitt-Grohé and Uribe (2012) are two seminal papers that incorporate news shocks into a DSGE model. The former identifies TFP news shocks in the US and Japan as an important source of aggregate fluctuations in both countries, but especially in the US. Schmitt-Grohé and Uribe (2012) do not find TFP news shocks to be important.[2] However, Görtz and Tsoukalas (2017) show that Schmitt-Grohé and Uribe's findings are due to the specific assumptions of their model, more precisely to the abstraction from nominal rigidities and imperfect competition. When these features are considered TFP news shocks recover their role as the main source of news. Görtz and Tsoukalas (2017) also underlines the importance of considering an endogenous financial sector (as the one suggested in Gertler and Karadi (2011)) for identifying TFP news shocks. Gunn and Johri (2018) use a calibrated model to show that news shocks to future financial returns can create business cycles without recourse to other sources of news. More recently, Görtz et al. (2021) use VAR methods to find that TFP news are highly associated with credit spread indicators and that the dynamics of financial variables are critical for the amplification of TFP news shocks in a two-sector (consumption and investment) DSGE model. Our results also point in that direction, but we stress the importance of QoC news shocks, which not only have effects amplified by the endogenous financial sector but are also themselves a source of real and financial fluctuations.

Unanticipated QoC shocks are commonly considered in recent macro finance literature. Gertler and Karadi (2011) first refer to them as quality-of-capital shocks,[3] and Gertler et al. (2012) provide a sound microfoundation based on the productivity of capital already installed. QoC shocks represent qualitative appreciation (depreciation) of physical capital which trigger an exogenous change in the productivity of capital and also directly affect the balance sheet of financial intermediaries whose assets are collateralized by that capital. As indicated above, a QoC news shock affects

[2] They find that other shocks such as news to the wage markup are crucial in explaining the business cycle.
[3] Merton (1973) and Gertler et al. (2012) also call them asset price shocks.

the production function in a way similar to a TFP news shock, but it also acts as an exogenous trigger of asset price dynamics. For example, an anticipated upgrade in physical capital improves production expectations and the balance sheets of financial intermediaries that finance the expected upgrade. Similarly, when sector-specific capital is expected to become obsolete, production is expected to fall and agents may also anticipate the coming depreciation of capital (asset) value, making the level of debt excessive relative to the stock of capital.[4] From a modeling perspective, the fundamental difference between QoC and TFP news shocks is the amplifying effects on financial variables of the former, caused by their making the credit channel play a more important role. By estimating alternative model specifications of news shocks we shed light on the relative contribution of these two types of news shock in explaining macroeconomic dynamics.

Turning to estimation results, we show that when TFP news shocks and QoC news shocks are both included in the DSGE model the latter become the main driver of aggregate fluctuations while the former play a relatively minor role. This finding is supported by an improvement in model fit. That improvement is especially large for hours, inflation, and the investment growth rate. Thus, the data supports a news shock specification in which news directly affect the credit channel. The estimation results also show three main differences between these two alternative specifications of news shocks: (i) The response of financial variables is greater than that of real variables for QoC news shocks; (ii) the short-run response of consumption is much lower for QoC news shocks, and this underscores the transmission of QoC news through the investment/credit channel; and (iii) a positive QoC news shock triggers a mild negative response of inflation, which is in contrast to the positive response of inflation to a positive TFP news shock.

We further contribute to the recent literature analyzing news shocks in a DSGE framework by addressing an important question: Does the inclusion of QoC news shocks truly help to improve the characterization of agents' expectations? This question is important because identifying a news shock must by definition improve the fit of model expectations of forward-looking variables.

[4] The close link between TFP and financial shocks is also investigated in Moran and Queralto (2018) and Queralto (2020), who emphasize demand driven factors determining medium-term dynamics in TFP. Under this approach, financial shocks affect business innovation activities and consequently future TFP.

We show that a DSGE model that includes both QoC and TFP news shocks outperforms one that contains only the latter for all observable variables with counterparts reported in the Survey of Professional Forecasters, especially for the growth rate of investment. Including QoC news seems to enhance the importance of the credit channel, thus helping to improve the characterization of investment expectations, among others.

This paper also assesses the relative importance of the investment-specific-technology (IST) news shocks posited in Ben Zeev and Khan (2015) as a major driver of aggregate fluctuations. Further motivation for this assessment can be found in several papers which suggest that IST shocks seem to act as a veil, hiding the response of investment to changes in asset prices (e.g. Afrin 2017). Justiniano et al. (2010) also find evidence that IST shocks are strongly correlated with financial variables such as the interest rate spread. These findings might therefore be viewed as additional evidence reported in the recent literature that IST news shocks may be acting as a veil which may simply capture the risk premium fluctuations that affect the price of capital. Our estimation results confirm this view. This conclusion stems from (i) the results of the variance decomposition analysis, which show that IST news shocks play a negligible role in explaining aggregate fluctuations when QoC are also considered; and (ii) the finding that the model fit (measured by log marginal density) does not improve when IST news shocks are included in a DSGE model specification that also includes QoC and TFP news shocks. These findings can be easily understood by looking at the negative response of asset prices to IST news shocks, which results in a contraction of the credit supply that largely offsets their positive effect on investment. This is in sharp contrast to the strong positive responses of asset prices to both QoC and TFP news shocks.

The prominent role of QoC news shocks is further enhanced by the decomposition analysis of news shocks suggested by Sims (2016) to distinguish between pure and realized news shocks.[5] We find that *pure* QoC news shocks are one of the main drivers of aggregate fluctuations. This is

[5] More precisely, Sims (2016) proposes a method to distinguish between the effects of pure news and realized news shocks, with the former seen as the effects at horizons prior to the realization of the news and zero at horizons thereafter, i.e. realized news effects are just the effects of news shocks at horizons after the realization.

somewhat in contrast with Sims (2016) who finds that the empirical importance of the TFP news shocks estimated in Schmitt-Grohé and Uribe (2012) is due to their realized component.

The rest of the paper is structured as follows. Section 2 describes the canonical DSGE model augmented with financial frictions. Section 3 briefly describes the data set, the prior distributions, and the parameters calibrated. Section 4 discusses the estimation results, comparing QoC and TFP news shocks, assesses the importance of and differences in IST news shocks compared to QoC and TFP news shocks, and examines relative importance of pure and realized components of QoC news shocks. Section 5 concludes.

## 2 The model

This paper considers a medium-scale DSGE model with several sources of rigidity and both news and surprise (unanticipated) shocks. The model is similar to the workhorse New Keynesian DSGE model suggested in Smets and Wouters (2007), augmented with the financial frictions suggested by Gertler and Karadi (2011). This model has been widely used in recent macro finance literature (e.g. Afrin 2017, Gelain and Ilbas 2017, Sanjani 2014, Villa 2016, Görtz and Tsoukalas (2017)).

This section provides a brief overview of the model.[6] The demand side of the model economy is formed by households which choose consumption and hours worked and hold riskless assets such as bank deposits and government bonds. Hours worked are homogeneously supplied by households to an intermediate labor entity that differentiates and supplies labor to labor packers, who subsequently sell labor services to the intermediate goods sector.

Intermediate goods firms choose their production inputs (labor services and effective capital) and sell a differentiated good to the final sector, which sells a homogeneous good to households in a perfectly competitive market. Both intermediate goods firms and the labor entity supply differentiated inputs (goods/labor) used in the production of the final consumption good, so they are assumed to have some degree of market power. This assumption also enables nominal rigidities

[6] An appendix presents a more detailed description of the model and shows the set of (log) linearized equations that characterize the equilibrium.

à la Calvo (1983) to be included. Capital services producers acquire physical capital produced by capital-goods producers and assemble it into effective capital, which is rented to intermediate goods firms. Capital services producers finance their acquisition of capital by borrowing funds from financial intermediaries in a perfectly competitive market. Hence, financial frictions are introduced from the credit supply through bank balance sheets as suggested in Gertler and Karadi (2011).[7] Clearly, news on the quality of capital services financed by banks has a direct impact on their balance sheets, which further affects the supply of credit.

The DSGE model with financial frictions considers that banks lend funds, obtained from household deposits, to non-financial firms. They therefore act as intermediaries that assist firms in channeling funds from household deposits to investors. However, banks would like to expand their assets by borrowing additional funds from households indefinitely since the discounted risk premium that they face is always positive by construction. To restrict their ability to do this, a moral hazard problem is introduced. The banks decide whether to divert a fraction of their assets and transfer them to the households to which they belong. The cost for banks of diverting assets is that the depositor can force them into bankruptcy and recover the remaining fraction of assets. Therefore, households only deposit their savings up to the point where the gain of banks from diverting assets is equal to the gain of not doing so. This incentive constraint introduces a credit supply rigidity.

Next, we describe how two types of news shock are included in the DSGE model and the main differences between them. A description of the whole model can be found in the appendix.

**Production channel**

As is standard in the literature, we consider that intermediate good firms produce goods according to a Cobb-Douglas production function, where the endogenous inputs are capital and labor. This production function is affected by three different shocks. Two of them are the stationary and the non-stationary shocks that compound the standard TFP shock, and it is assumed that news arises from the latter. In addition, we consider QoC shocks. As explained above, these represent

[7] This approach of introducing financial frictions contrasts with the approach suggested in Bernanke et al. (1999), which builds on the financial accelerator.

qualitative appreciation (or depreciation) of physical capital, so they trigger exogenous changes in the productivity of capital, affecting the production function in a way very similar to a TFP shock. Formally, the production function is as follows:

$$Y_t = TFP_t \left[ \left( QoC_t \right) K_{t-1} U_t \right]^{\alpha} L_t - \phi_p, \tag{1}$$

where $TFP_t = \epsilon_t^a + A_t$, $\epsilon_t^a$ is the aforesaid transitory TFP shock, $A_t$ is the permanent TFP shock, and its growth rate is denoted by $a_t = \frac{A_t}{A_{t-1}}$. $QoC_t$ captures exogenous shocks in the quality of capital, $K_{t-1}$ is capital, $U_t$ is the capital utilization rate, and $\phi_p$ is the share of fixed costs involved in production.

**Financial channel**

The main difference between a TFP news shock and a QoC news shock is the amplifying effect of the latter on the price of assets (which in the model is equivalent to the price of capital), so that there is a distinctive impact on the balance sheets of financial intermediaries. The rationale is that the valuation of asset prices by stock investors is highly influenced by incoming information on capital quality upgrades (obsolescence).

Capital services firms purchase physical capital at the end of period $t$ at a price $Q_t$ and sell the undepreciated component to capital good producers at the end of period $t+1$ at a price $Q_{t+1}$. They also decide capital utilization considering the cost of adjustment and the rate at which they rent the installed capital to the intermediate good firms. Moreover, capital services firms finance their purchase of capital at the end of each period with funds from financial intermediaries, considering that the funding is obtained by issuing claims that are equal to the value of the capital purchased, the price of which is the same ($Q_t S_t = Q_t K_{t+1}$). Thus, the profit maximizing problem of these agents is

$$\begin{aligned}
&\max_{K_{t+1}} \left\{ r_{t+1}^k U_{t+1} K_{t+1} \left( QoC_{t+1} \right) - a \left( U_{t+1} \right) K_{t+1} \left( QoC_{t+1} \right) + (1-\delta) Q_{t+1} K_{t+1} \left( QoC_{t+1} \right) - R_{t+1}^k Q_t S_t \right\} \\
&st. \qquad Q_t S_t = Q_t K_{t+1},
\end{aligned}$$

where $r_t^k$ is the rental rate of capital in period $t$, $a(U_t)$ is the capital utilization adjustment cost function, and $R_t^k$ is the return of each claim.

The optimal decision obtained from the above problem implies that the price of assets (capital) depends *directly* on QoC shocks:

$$Q_t = \frac{r_{t+1}^k U_{t+1} - a(U_{t+1}) + (1-\delta)Q_{t+1}}{R_{t+1}^k} (QoC_{t+1}). \tag{2}$$

That is, both TFP and QoC shocks affect $Q_t$ through general equilibrium, but QoC shocks also have a direct effect.

**Shock processes**

The model considers eight types of purely unanticipated (surprise) shocks and two shock processes that include both unanticipated and news shock components. The unanticipated shocks are stationary TFP shocks, price and wage markup shocks, monetary policy shocks, preference shocks, net worth shocks, IST shocks, and public spending shocks. Each shock follows an AR(1) process:

$$\epsilon_t^x = \rho^x \epsilon_{t-1}^x + \eta_t^x,$$

where $x = a, p, w, m, b, nw, IST, g$. Nonstationary TFP and QoC shocks have two components: An unanticipated shock and a news shock. The formulation of news shocks follows the seminal paper by Schmitt-Grohé and Uribe (2012):

$$\epsilon_t^z = \rho^z \epsilon_{t-1}^z + \sum_i \eta_{t,t-i}^z,$$

where $z = TFP, QoC$; and $i = 0, 1, 4, 8, 12$. Therefore, $\eta_{t,t-i}^z$ is a $z$ news shock which is expected to realize at time $t$ but is forecasted $i$ periods before (i.e. at period $t-i$). For instance, $\eta_{t,t-8}^z$ is a $z$-innovation realized at time $t$ but anticipated eight periods in advance. Consequently, agents react in advance to future forecast shocks (i.e. agents react to newly obtained information about future shocks even though nothing fundamental has yet changed). More precisely, agents forecast future values of $\epsilon^z_{t+k}$ as follows:

$$E_t \epsilon^z_{t+k} = (\rho^z)^k \epsilon^z_t + \begin{cases} \eta^z_{t+k,t} + \eta^z_{t+k,t-1} + \eta^z_{t+k,t-4} + \eta^z_{t+k,t-8} + \eta^z_{t+k,t-12}, & for\ k = 0, \\ \eta^z_{t+k,t-1} + \eta^z_{t+k,t-4} + \eta^z_{t+k,t-8} + \eta^z_{t+k,t-12}, & for\ k = 1, \\ \eta^z_{t+k,t-4} + \eta^z_{t+k,t-8} + \eta^z_{t+k,t-12}, & for\ 1 < k \leq 4, \\ \eta^z_{t+k,t-8} + \eta^z_{t+k,t-12}, & for\ 4 < k \leq 8, \\ \eta^z_{t+k,t-12}, & for\ 8 < k \leq 12, \\ 0, & for\ k > 12. \end{cases} \tag{3}$$

This specification enables agents to revise their expectations about future exogenous shocks, which provides additional flexibility by allowing for anticipated future shocks that fail to materialize. For the purpose of the analysis presented here, we start with a model specification in which QoC news shocks are muted. In a second step we then estimate a model that considers both TFP news shocks and QoC news shocks. In Section 4.5 below IST news shocks are also included to assess their potential role as a source of aggregate fluctuations once QoC news are considered.

# 3 Data and estimation

The estimation procedure for the different model specifications uses US data for nine macroeconomic variables: Output growth, consumption growth, investment growth, wage growth, hours worked, inflation, the nominal interest rate, the spread (risk premium),[8] and the growth rate of the net worth of banks. The set of observables is the same as that in Smets and Wouters (2007), with the addition of the spread and the net worth of banks, which seek to provide information about financial reaction to alternative shocks. Financial variables have shown a remarkable power to predict future economic activity (e.g. Espinoza et al. 2012), which in our case may help to identify the news component from the unanticipated component of shocks. The predictive power of these

[8]The spread is defined as the difference between the yields associated with the Moody's Seasoned Baa Corporate Bond and the 10-Year Treasury Constant Maturity bond.

variables is due to their flexibility in adjusting more rapidly to shifts in expectation shifts than other (macroeconomic) observables that exhibit a rather high degree of persistence (sluggishness). Moreover, given that the sample period considered in the estimation includes the Great Recession, which started around 2008, we have replaced those values of the Fed funds rate that reach the zero lower bound by the shadow rate constructed by Wu and Xia (2016).[9] The sample considered includes the period 1987q1-2018q4, where the starting quarter is determined by data availability for all the time series considered in the empirical analysis. All the time series used in the estimation procedure are transformed into (log) deviations from their respective means, so the measurement equations are straightforward. Sample means and long-term growth rates are removed because low frequencies may affect the estimation of the business cycle dynamics[10] The Bayesian estimation procedure follows standard techniques (see, for instance, Fernández-Villaverde 2010, for a detailed description) and is implemented with the Dynare toolbox.

**Calibration and priors**

The DSGE model seeks to reproduce business cycle features, so several parameters that govern long-run growth are calibrated due to lack of identifiability. Table 1 shows the parameters calibrated and their specific values. The discount factor $\beta$ is 0.99, which implies a quarterly real interest rate of one percent. Both wage and price markup are assumed to be 0.2. The quarterly depreciation rate is 0.025 and the share of government spending is assumed to be 0.2. The parameters associated with the financial sector, such as the time survival rate of bankers, the steady-state fraction of funds given to new bankers, and the fraction of funds that bankers may divert are set to achieve the same steady state values as in Gertler and Karadi (2011).[11]

The prior distribution of the structural parameters estimated is the same as in Smets and Wouters (2007). The prior distributions of all innovations are also assumed to follow inverse

[9] Recent papers (e.g. Wu and Zhang 2019; Mouabbi and Sahuc 2019; Aguirre and Vázquez 2020) use the shadow rate instead of the federal funds rate in the estimation of New-Keynesian frameworks. The estimation exercise was also conducted with the Fed funds rate and analogous results were obtained, showing its robustness.

[10] Del Negro et al. (2007) suggest this low frequency misspecification issue and several other papers in the related literature also follow this data treatment (e.g. Christiano et al. 2014; Görtz and Tsoukalas 2017).

[11] The results are robust to alternative calibrated values, but the model fit deteriorates somewhat.

gamma distributions with a mean of 0.1 and a standard deviation of 2.[12]

Table 1: Calibration of fixed parameters

| Parameters | | Calibrated value |
|---|---|---|
| Discount factor | $\beta$ | 0.99 |
| Capital depreciation rate | $\delta_k$ | 0.025 |
| Wage mark-up | $\epsilon_w$ | 0.2 |
| Price mark-up | $\epsilon_p$ | 0.2 |
| S.S. goverment spending share | $g/y$ | 0.20 |
| Fraction of capital that can be diverted | $\lambda$ | 0.381 |
| Transfer to the entering bankers | $\omega$ | 0.002 |
| Survival rate of the bankers | $\theta$ | 0.972 |

# 4 Estimation Results

This section presents the results for the estimation of the DSGE model for the alternative news shock specifications analyzed in this paper. The first model specification mutes QoC news shocks, but the second specification includes them. This exercise of estimating alternative news specifications lets the data determine whether considering a distinctive impact of news shocks on the financial sector as implied by QoC news is a more suitable assumption.

## 4.1 Model fit

The upper panel of Table 2 shows the (log) marginal data density (MDD) associated with each model specification of news. Fernández-Villaverde and Rubio-Ramírez (2004) show that MDD favors the model specification that is closest to the true data generating process. The specification that includes QoC news shocks outperforms the specification that includes only TFP news shocks by almost 60 points. This major improvement in model fit underscores the importance of QoC news shocks.

In order to identify the sources of the major improvement in model fit, the middle-left panel

[12]The results are robust to more conservative priors for news shocks, such as those chosen in Christiano et al. (2014), which impose priors so that the variance of the unanticipated component is 50% of the total variance of the shock. The posterior estimates of standard deviations featuring news shocks are much lower than those associated with surprise shocks, which implies that the data is informative about the low variability of news shocks relative to other shocks.

of Table 2 shows the RMSE-statistics associated with each filtered variable generated by the two specifications studied: (i) The specification including TFP news shocks alone; and (ii) the baseline specification including QoC news shocks in addition to TFP news shocks. The improvement in model fit is observed to be especially large for hours, inflation, and the investment growth rate (i.e. the RMSE-statistics decrease by 22.2%, 17.4%, and 11.4% respectively when QoC news shocks are included), but more modest for the rest of the observable variables (i.e. the reduction in the RMSE-statistic is less than 10%). This table also contains a column showing the RMSE-statistics of the one-quarter ahead forecast provided by the Survey of Professional Forecasters (SPF) with respect to actual data.[13] Comparing the model-implied RMSE-statistics with those implied by the SPF, we conclude that the model with QoC news shocks outperforms the one that ignores them for all observable variables that have an SPF counterpart, and especially for inflation and the growth rate of investment. In short, these results suggest that the improvement in fit triggered by the inclusion of QoC news shocks is mainly due to their ability to fit macroeconomic variables.

The middle-right and bottom panels of Table 2 show several actual and theoretical second moments derived from the posterior distribution of the estimated parameters. More precisely, the standard deviation, the first-order autocorrelation, and the correlation with output growth for each observable variable obtained from actual data and from the two estimated specifications are shown. The results for the second-moment statistics are in line with those obtained by comparing the log-density across the two news shock specifications: The specification that includes QoC news shocks performs better than the one with TFP news shocks alone in terms of matching most of the second-moment statistics considered, since the latter seems in general to induce too much volatility across observed variables.

Beyond the improvement in both model fit and the matching of the second-moment statistics provided by a specification that includes QoC news shocks, we also contribute to the related literature by assessing how QoC news shocks help to shape the expectations of forward-looking variables. This is an important assessment because the improvement in model fit must be closely

[13] This survey is conducted by the Federal Reserve Bank of Philadelphia and is publicly available on their website.

related to the ability of new shocks to characterize model expectations of observed (forward-looking) variables used in the estimation procedure of the DSGE model. The performance of expectations built on news shocks can be further assessed by using external information sources. Thus, the empirical validity of expectations based on news shocks can be assessed by studying their ability to match the forescasts reported in the Survey of Professional Forecasters. The middle-column in the second panel shows the RMSE statistics of the one-quarter-ahead forecasts of the observable variables with respect to the forecasts reported in the Survey of Professional Forecasters (SPF). We find that the expectations generated by a model specification that amplifies the effects of the credit channel via QoC news shocks are much closer to SPF forecasts, revealing that this specification is better at capturing actual agents' expectations as reported in the SPF.

Table 2: Model fit assessment

| | | TFP | QoC | | | | | |
|---|---|---|---|---|---|---|---|---|
| MDD | | -1051.70 | -996.05 | | | | | |
| | RMSE | | | RMSE to SPF | | Standard deviation | | |
| | TFP | QoC | SPF | TFP | QoC | Actual | TFP | QoC |
| Output growth | 0.58 | 0.56 | 0.50 | 0.19 | 0.09 | 0.59 | 1.08 | 0.99 |
| Consumption growth | 0.57 | 0.52 | 0.50 | 0.79 | 0.79 | 0.56 | 0.97 | 0.57 |
| Investment growth | 1.67 | 1.48 | 1.44 | 0.19 | 0.09 | 1.84 | 3.87 | 3.40 |
| Hours | 0.54 | 0.42 | - | - | - | 4.30 | 4.30 | 3.20 |
| Wage growth | 0.87 | 0.86 | - | - | - | 0.86 | 1.14 | 0.92 |
| Inflation | 0.23 | 0.19 | 0.19 | 0.03 | 0.02 | 0.24 | 0.42 | 0.33 |
| Spread | 0.17 | 0.16 | - | - | - | 0.25 | 0.56 | 0.43 |
| Interest rate | 0.09 | 0.09 | - | - | - | 0.79 | 0.61 | 0.52 |
| Net worth growth | 2.10 | 2.20 | - | - | - | 1.53 | 8.52 | 6.36 |
| | Autocorrelation | | | | | Correl. with output growth | | |
| | Actual | TFP | QoC | | | Actual | TFP | QoC |
| Output growth | 0.29 | 0.63 | 0.38 | | | 1 | 1 | 1 |
| Consumption growth | 0.33 | 0.74 | 0.34 | | | 0.66 | 0.67 | 0.51 |
| Investment growth | 0.68 | 0.64 | 0.60 | | | 0.66 | 0.66 | 0.71 |
| Hours | 0.99 | 0.98 | 0.97 | | | 0.21 | 0.46 | 0.18 |
| Wage growth | -0.15 | 0.28 | 0.14 | | | -0.04 | 0.41 | 0.19 |
| Inflation | 0.62 | 0.74 | 0.71 | | | 0.05 | 0.25 | -0.08 |
| Spread | 0.89 | 0.80 | 0.81 | | | -0.57 | -0.43 | -0.36 |
| Interest rate | 0.98 | 0.98 | 0.97 | | | 0.13 | 0.40 | 0.20 |
| Net worth growth | 0.22 | -0.05 | 0.02 | | | 0.04 | 0.30 | 0.35 |

## 4.2 Parameter estimates

Table 3 shows the prior distribution, the posterior mean, and the 90% higher posterior density interval (between brackets) of the structural parameters and the estimated standard deviations of news shocks. A noteworthy finding is that the estimated persistence of TFP news shocks is greatly reduced when QoC news shocks are considered. This suggests that the high persistence of TFP shocks is due to the omission of an important source of news, in the form of QoC news shocks. Moreover, the reduction in persistence of TFP news shocks explains their relative lack of importance in the variance decomposition analysis carried out below when QoC news shocks are included in the DSGE model. Interestingly, the structural parameter estimates are rather robust across the alternative specifications of the DSGE model with news shocks, but there a few noticeable differences. Thus, habit formation and the response of the nominal interest rate to output are estimated as larger under the specification that includes QoC new shocks. By contrast, the elasticity of capital utilization adjustment cost and, as highlighted above, the persistence of TFP shocks decrease greatly in this baseline specification with QoC news shocks.

Table 3: Selected parameter estimates

| Parameter | Prior distribution | | Posterior Mean | |
|---|---|---|---|---|
| | Type | Mean/Std | TFP | QoC |
| Structural parameters | | | | |
| Investment adjustment cost | Normal | 4/1.5 | 1.19 [0.71,1.64] | 0.74 [0.47,0.98] |
| Habit formation | Normal | 0.7/0.1 | 0.68 [0.62,0.74] | 0.94 [0.90,0.98] |
| Calvo probability for wages | Beta | 0.5/0.1 | 0.77 [0.70,0.85] | 0.79 [0.72,0.86] |
| Elasticity of labor supply | Normal | 2/0.5 | 1.09 [0.25,1.88] | 1.69 [0.91,2.40] |
| Calvo probability for prices | Beta | 0.5/0.1 | 0.94 [0.93,0.95] | 0.94 [0.93,0.95] |
| Indexation of past inflation in wages | Beta | 0.5/0.15 | 0.38 [0.15,0.60] | 0.21 [0.08,0.33] |
| Indexation of past inflation in inflation | Beta | 0.5/0.15 | 0.21 [0.07,0.34] | 0.19 [0.07,0.30] |
| Utilization adjustment cost | Gamma | 0.5/0.15 | 0.95 [0.91,0.98] | 0.69 [0.51,0.88] |
| Fixed cost in production | Normal | 1.25/0.125 | 1.73 [1.58,1.88] | 1.65 [1.48,1.81] |
| Capital share in production | Normal | 0.3/0.05 | 0.19 [0.15,0.22] | 0.24 [0.20,0.28] |
| Monetary policy parameters | | | | |
| Interest rate smoother | Beta | 0.75/0.1 | 0.80 [0.75,0.84] | 0.80 [0.76,0.84] |
| Response to inflation | Normal | 1.5/0.25 | 1.11 [1.00,1.24] | 1.19 [0.71,1.64] |
| Response to output | Normal | 0.125/0.05 | 0.08 [0.04,0.14] | 0.36 [0.30,0.42] |
| Response to output growth | Normal | 0.125/0.05 | 0.18 [0.11,0.25] | 0.15 [0.08,0.22] |
| TFP news shocks | | | | |
| Persistence of TFP | Beta | 0.5/0.2 | 0.95 [0.92 , 0.98] | 0.31 [0.18 , 0.44] |
| Std of TFP news shock - 1 quarter ahead | Gamma | 0.1/2 | 0.06 [0.03 , 0.08] | 0.10 [0.02 , 0.19] |
| Std of TFP news shock - 4 quarter ahead | Gamma | 0.1/2 | 0.07 [0.03 , 0.11] | 0.06 [0.02 , 0.10] |
| Std of TFP news shock - 8 quarter ahead | Gamma | 0.1/2 | 0.08 [0.03 , 0.14] | 0.07 [0.02 , 0.11] |
| Std of TFP news shock - 12 quarter ahead | Gamma | 0.1/2 | 0.12 [0.05 , 0.18] | 0.17 [0.08 , 0.27] |
| QoC news shocks | | | | |
| Std of QoC news shock - 1 quarter ahead | Gamma | 0.1/2 | - | 0.05 [0.03 , 0.08] |
| Std of QoC news shock - 4 quarter ahead | Gamma | 0.1/2 | - | 0.05 [0.02 , 0.07] |
| Std of QoC news shock - 8 quarter ahead | Gamma | 0.1/2 | - | 0.06 [0.03 , 0.10] |
| Std of QoC news shock - 12 quarter ahead | Gamma | 0.1/2 | - | 0.11 [0.03 , 0.19] |

## 4.3 News shocks as driving force of the business cycle

Figure 1 shows the proportion of the variance decomposition explained by the two types of news shock for the set of observable variables considered in the estimation across alternative forecast horizons. Figure 1a shows the model where TFP new shocks are estimated alone, while Figure 1b shows the proportion of the variance decomposition explained by QoC (black solid line) and TFP (red dashed line) news shocks when both types are included in the DSGE model estimated. The results shown in Figure 1a are in line with those reported in the related literature, where TFP news shocks are highlighted as a significant driving force of the business cycle (Beaudry and Portier 2006; Fujiwara et al. 2011; Görtz and Tsoukalas 2017).

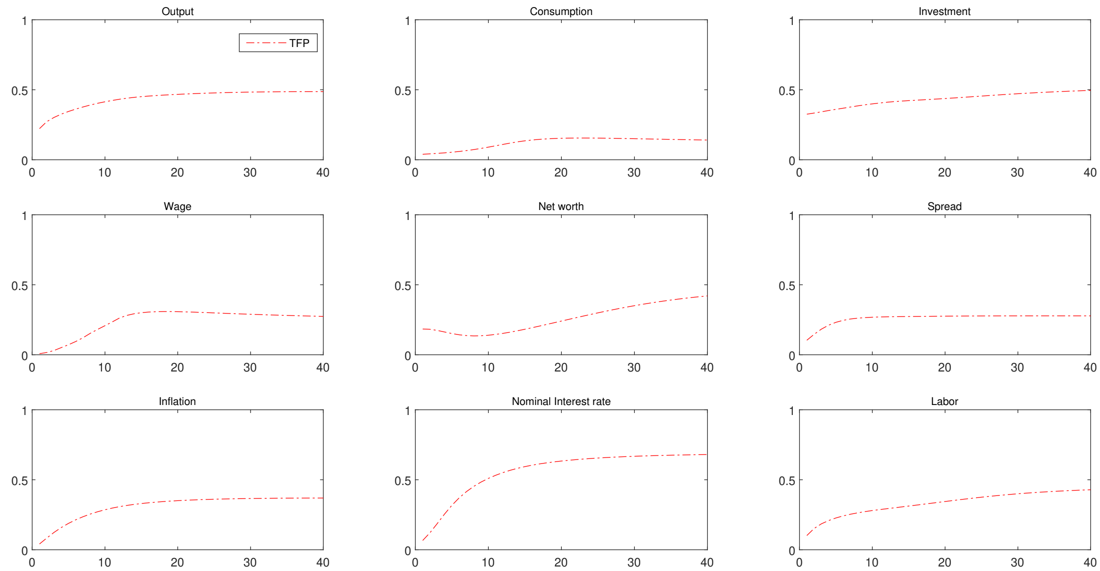
The main finding of this analysis is that the data support the inclusion of QoC news shocks in the estimated DSGE model in detriment to TFP news shocks, whose importance as a driving force of the business cycle is substantially reduced, as shown in Figure 1b. Thus, when TFP news shocks are considered alone they explain a substantial proportion of the variability of all observed variables. More precisely, they explain around 50% of output, investment, and nominal interest rate fluctuations and one third of wage, inflation, and labor fluctuations. They also explain a large proportion of the variability associated with the two financial variables considered (approximately one third for both across medium- and long-term forecast horizons). In sharp contrast, the inclusion of QoC news shocks in addition to TFP news shocks results in a large drop in the relative importance of the latter in explaining the variability of many macroeconomic and financial variables, but they turn out to be still quantitatively very important in explaining inflation, wage, and short-run consumption fluctuations. Nonetheless, QoC news shocks are in general much more significant than TFP news shocks in explaining aggregate fluctuations.

These results are clearly due to the financial impact of QoC news shocks. Consider, for instance, that agents anticipate a positive QoC four quarters in advance. This positive news shock affects the economy through two different channels: The production function and the credit channel. On the one hand, positive QoC and TFP news shocks have an equivalent effect on the production function since both types of news increase expected future productivity (see Equation 1). On the other hand, in the financial market a positive realization of QoC news shock results in a rise in asset prices since agents anticipate an improvement in the quality of capital, as shown by Equation (2). This rise in asset prices has an immediate impact on the balance sheets of banks since the assets that they hold become more valuable. Moreover, banks' expected profits increase further due to the expected rise in the value of capital, which increases both credit supply and investment. Some subtle differences aside, this view is largely consistent with the results in Beaudry and Portier (2006), where news shocks are identified with shocks impacting the financial market (stock prices) and anticipating future movements in TFP.[14]

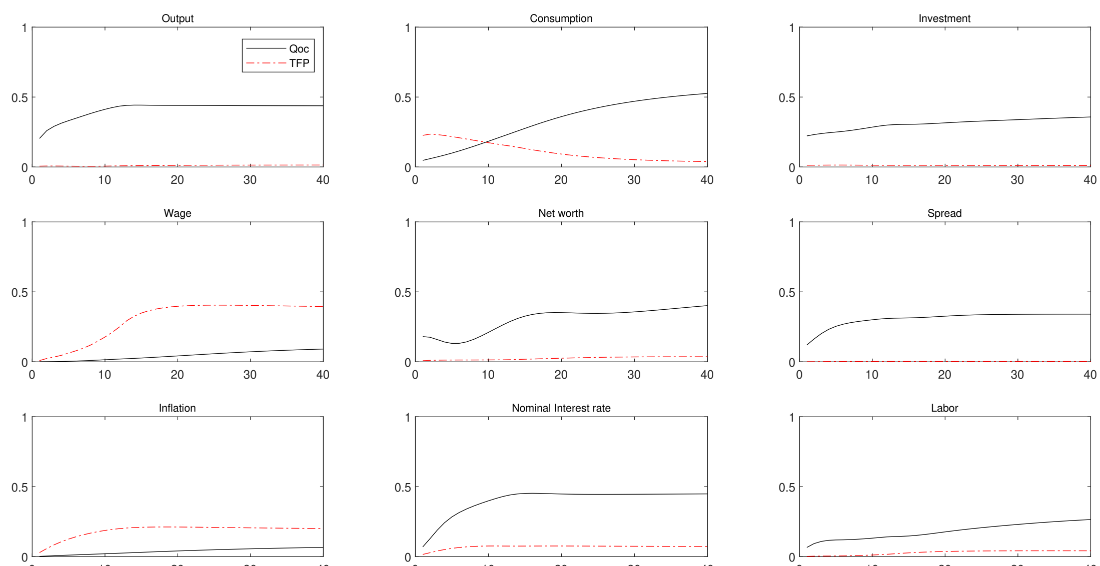
[14]Many studies have stressed the predictability of future economic activity using financial variables. Gilchrist et al. (2009) determine that credit market factors from corporate bond spreads predict future movements in output, employment, and industrial output. Espinoza et al. (2012) show that shocks to financial variables influence real activity. Gilchrist and Zakrajsek (2012) construct a new corporate bond credit spread index that robustly predicts

Figure 1: Conditional variance decomposition: Assessing the importance of TFP news vs QoC news

(a) DSGE model including TFP news shocks alone




(b) DSGE model including TFP and QoC news shocks




future economic activity. Aguilar and Vázquez (2021) and Vázquez and Aguilar (2021) show that the term spread plays an important role in the characterization of adaptive learning dynamics in DSGE models.

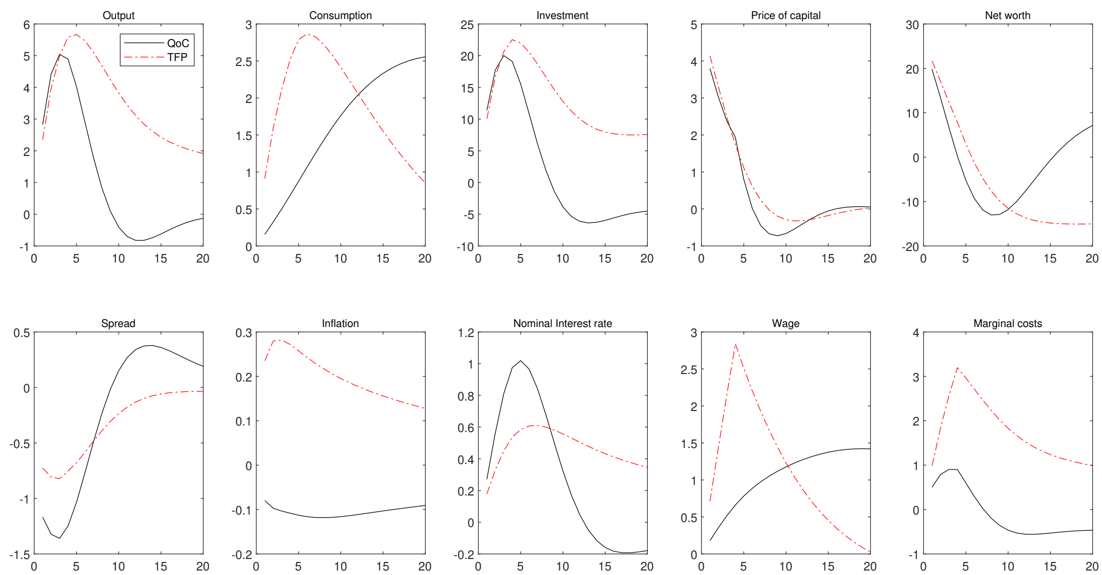
### 4.4 Impulse response functions

The previous sections provide evidence favoring QoC news shocks to the detriment of TFP news shocks. This section provides further insights into this result through an impulse-response function (IRF) analysis. Figure 2 shows the responses of output, consumption, investment, asset prices (price of capital), net worth, interest rate spread, inflation, the nominal interest rate, and hours worked to alternative one-percent news shocks. The solid black line represents the IRF of each variable to a four-quarter QoC news shock, while the dashed red line shows the IRF to a four-quarter non-stationary TFP news shock.

It is noticeable that both QoC and TFP news shocks can generate sound, positive comovements between output, consumption and investment. However, the transmission mechanism is substantially different. In general, a TFP news shock results in a greater response of the real variables triggering a milder reaction of the financial markets. In contrast, QoC news shocks are able to produce large movements of the risk premium (spread) with not such a large effect on the real side of the economy. Thus, TFP news shocks produce a response of consumption at impact, whereas the reaction of consumption is much slower for QoC news shocks. This implies that a positive QoC news shock results in a greater boost for investment relative to consumption than TFP news shocks. More precisely, a positive TFP news shock leads agents to anticipate higher output in the future and, consequently, to increase their consumption in advance, while a positive QoC news shock has the same effect as a TFP news shock (recall that both TFP and QoC news shocks are tantamount when only looking at the production function) but also leads to a much lower spread that mainly affects the real side of the economy through an expansion in credit supply.

Another noteworthy difference between QoC and TFP news shocks is the response of inflation. This turns out to be mildly negative for QoC news shocks, while there is an inflationary response to TFP news shocks. This inflationary response to TFP shocks is due to two main effects: (i) The greater reaction of marginal costs to a TFP news shock; and (ii) the milder reaction of the nominal interest rate to such shocks. The reaction of marginal cost is larger for TFP news because real variables need to overreact to produce high fluctuations in financial markets, triggering an inflationary process. The greater reaction of the nominal interest rate in the case of QoC news shocks also enables inflation expectations to be anchored. Both effects together give rise to a change from an inflationary to a deflationary response when the effects of TFP and QoC news shocks are compared. Importantly, this deflationary response of QoC news shocks is in line with the VAR analysis carried out in Görtz et al. (2021).

Figure 2: IRF to QoC and TFP news shocks




## 4.5 Why do QoC news shocks fit better than IST news shocks?

The previous sections show that by having an amplifying effect on financial markets through the credit channel, QoC news shocks induce a stronger propagation mechanism than TFP news shocks. More precisely, this is due to the more pronounced effect of QoC news shocks on interest rate spreads and thus on the credit supply. IST and QoC news shocks are expected to have similar effects on real macroeconomic variables. Indeed, using a VAR approach, Ben Zeev and Khan (2015) also find that IST news shocks reduce the importance of TFP news shocks, as QoC news shocks do in our analysis based on DSGE modeling. To shed light on this matter, we estimate a model specification that includes QoC and IST news shocks in addition to TFP news shocks.

Figure 3 shows the proportion of aggregate variability explained by IST, QoC, and TFP news shocks. It is noteworthy that IST news shocks play no role in explaining aggregate fluctuations while QoC news shocks remain highly important. Moreover, the (log) marginal data density when IST news shocks are included (-997.43) is roughly similar to the baseline case where they are omitted (-996.05). These results indicate that IST news shocks add nothing when QoC news shocks are already considered in the analysis.

In short, our empirical findings suggest that the results of Ben Zeev and Khan (2015), showing that IST news shocks displace TFP news shocks, can be viewed as a veil of the financial effects captured by QoC news shocks. The reason why the data favors QoC news shocks in DSGE modeling lies in the effect of IST news shocks on the price of assets, which is ignored in a VAR analysis. Figure 4 shows the IRFs of asset prices for a one-percent positive (i) QoC news shock; (ii) TFP news shock; and (iii) IST news shock, each one anticipated 4-quarters in advance. It is noteworthy that QoC and TFP news shocks have positive effects on asset prices, so the supply of credit rises, thus pushing up investment (although the response of investment is larger for QoC, as discussed above). By contrast, IST news shocks negatively affect asset prices. Therefore, the rise in investment triggered by IST news shocks is partially offset by the contraction of the credit supply induced by the drop in asset prices.

Figure 3: Variance Decomposition of the DSGE model with QoC, TFP and IST news shocks

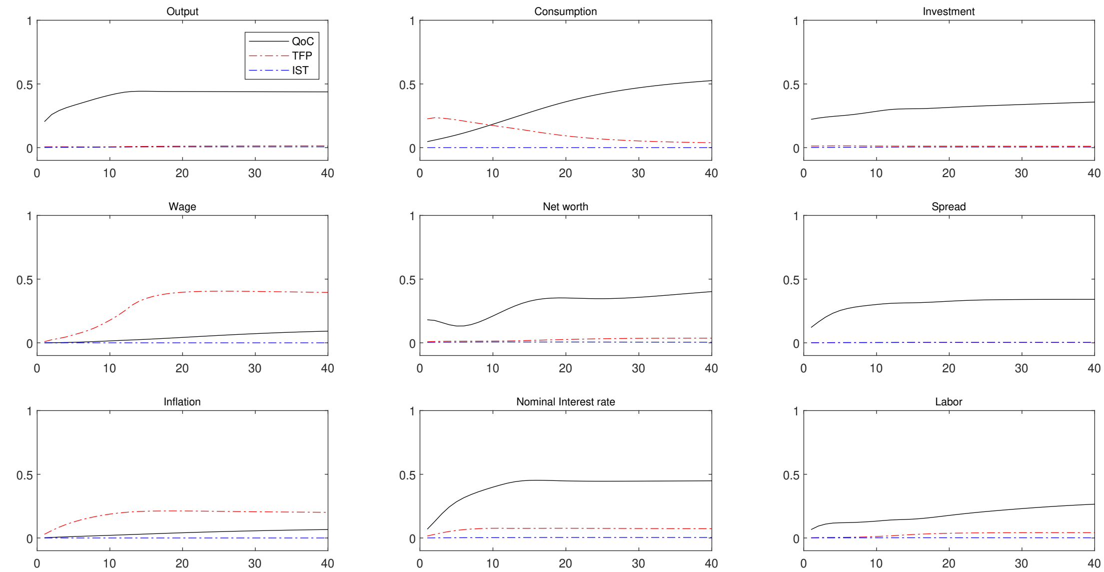
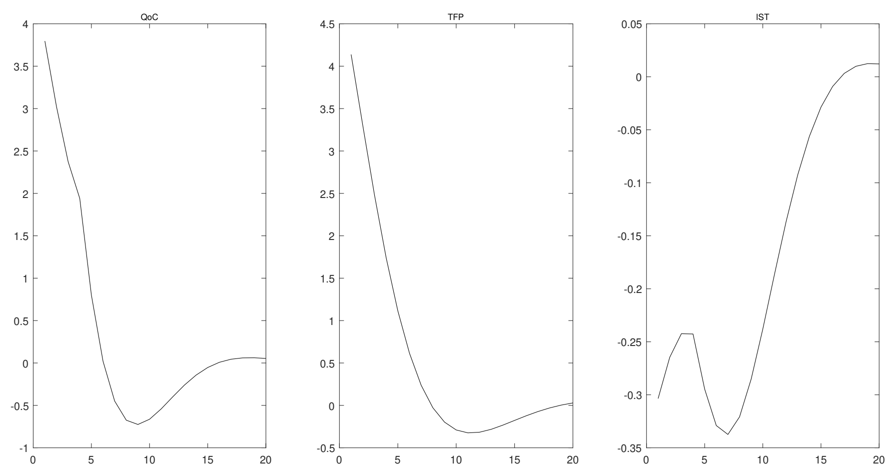



Figure 4: IRF of the price of capital to QoC, TFP and IST news shocks




## 4.6 The role of pure news

A distinctive feature of news shocks is that they affect aggregate variables without changing fundamentals. They do so through agents' expectations. However, in the standard specification (also followed in this paper) all innovations ends up realizing, though other news innovations can offset (revise) their effects, characterizing the news revision process and non-realized news. Sims (2016) argues that an analysis of the importance of news shocks through variance decomposition may be biased because it accounts for the pure news effects of each innovation but also for the effect of the shock once it is realized (in which case the effects are not substantially different from those of a standard surprise shock). To assess whether pure news shocks matter and whether news shocks affect aggregate variables without changing fundamentals, Sims (2016) suggests a method for separating these two effects. More precisely, he distinguishes between two impulse response functions: Those associated with pure news and those based on realized news shocks. A pure news IRF is equal to the IRF associated with a news shock at horizons before the realization of that news and zero at horizons thereafter. On the other hand, a realized news IRF takes a value of zero before the realization of the news shock and takes on the values of the IRF for news shocks at horizons thereafter.

We carry out the decomposition proposed by Sims (2016) to assess whether pure QoC news is a major source of macroeconomic fluctuations or whether its importance in the variance decomposition is due to realized news shocks. Figure 5 shows the conditional variance decomposition for alternative forecast horizons.

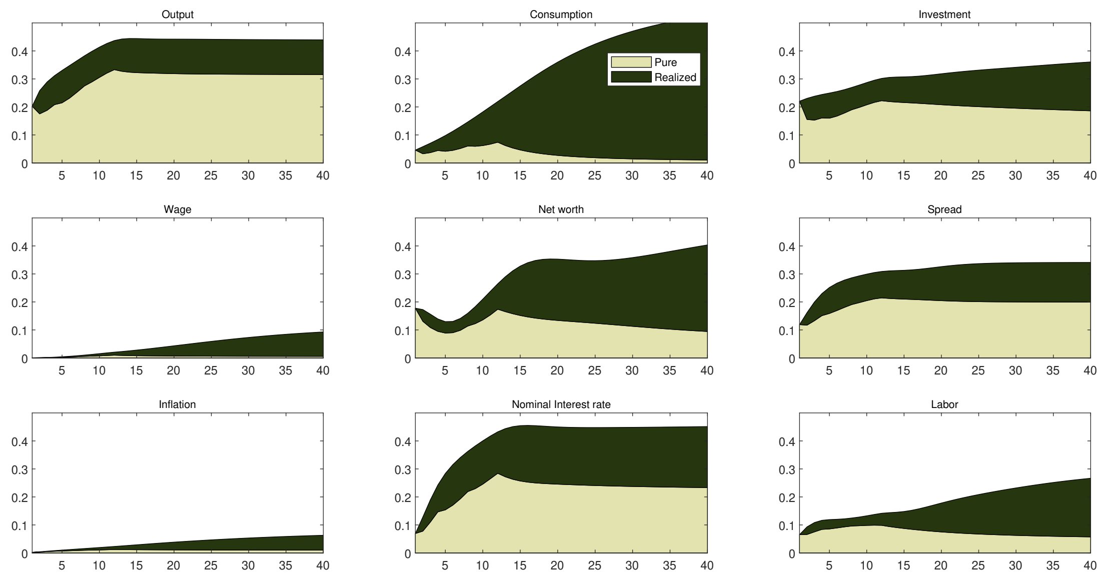
In the long-run pure QoC news shocks account for 31% of output fluctuations, which make up 73% of the total contribution of news shocks. Pure QoC news shocks account for roughly 20% for investment, interest rate spread, and the nominal interest rate fluctuations. By contrast, the proportion of pure QoC news that explains long-run consumption fluctuations is very modest. The news decomposition suggests that pure news has an initial impact on investment through the credit channel and the effect on consumption is mainly due to the reaction of investment to news. This result underscores the importance of the credit channel in producing an expectation-driven business cycle as suggested by Pigou (1927).[15]

In short, our findings reveal the importance of considering a financial sector and QoC news

[15] The importance of pure QoC news is somewhat in contrast to that found by Sims (2016) on analyzing the importance of pure TFP news in a rather different framework (i.e. using the real business cycle model of Schmitt-Grohé and Uribe (2012)). Indeed, he finds that pure TFP news is relatively unimportant, suggesting that such news shocks are not qualitatively different from surprise shocks.

shocks that have an amplifying effect on the credit channel in explaining aggregate fluctuations in both the real economy and financial markets.[16]

Figure 5: Pure vs. realized QoC news shocks




# 5 Conclusions

The importance of news shocks as a major driver of economic fluctuations has been stressed in recent literature (e.g. Beaudry and Portier 2006, Fujiwara et al. 2011, Görtz and Tsoukalas 2017, Schmitt-Grohé and Uribe 2012). This paper finds that it is crucial to consider the financial impact of such shocks. We provide evidence that actual data supports a version of a standard DSGE model with financial frictions à la Gertler and Karadi (2011) in which quality-of-capital (QoC) news shocks have an impact on financial markets by affecting the price of assets and the balance sheets of banks, and thus triggering an amplifying effect through the credit channel.

More precisely, this paper contributes to two important strands of the literature (namely, news shocks and financial frictions) in three significant ways. First, it shows that by having

[16] Sims (2016) also argues that under this analysis the role of pure news could be underestimated since the variance decomposition analysis does not account for the effects of unrealized news (surprise shocks that offset news shocks are interpreted as unrealized news but are accounted for in the variance decomposition as surprise shocks).

an amplifying effect on financial markets QoC news shocks displace standard TFP news shocks as a driving force of the business cycle. This result can be understood through the distinct qualitative and quantitative effects of each type of shock on real variables such as investment and consumption: TFP news shocks affect both variables on impact, but QoC news shocks mainly affect the investment decision. Moreover, the effects of the latter on credit are much larger than those of TFP news. This is also noticeable in the greater effects of QoC news shocks on financial variables than on real macroeconomic variables. Thus, TFP news shocks need to be much larger than QoC news shocks in order to fit financial data.

Second, we show that investment-specific-technology (IST) news shocks act as a veil by hiding the financial effects of QoC news shocks. When they are both included in the DSGE model, IST news shocks play no role at all in explaining aggregate fluctuations. This result arises from the negative response of asset prices to IST news shocks, which largely offsets their positive effect on investment.

Finally, the paper provides empirical evidence on the importance of pure QoC news. We show that the effects of QoC news shocks are mainly driven by pure news rather than realized news through the methodology proposed by Sims (2016). This is also a noteworthy finding since previous research, including that by Sims (2016) himself, finds that pure TFP news is relatively unimportant.

To sum up, this paper provides robust empirical evidence suggesting that QoC news shocks provide a proper way to model expectations-driven business cycles. This empirical evidence is in line with Beaudry and Portier (2006), who find that news shocks are identified with shocks impacting the financial market (stock prices) and anticipating future movements in TFP, and more generally with Pigou (1927) by showing that, by affecting *businessmen's* expectations, news is an important driver of aggregate fluctuations.

# References


Afrin, S.: 2017, The role of financial shocks in business cycles with a liability side financial friction, *Economic Modelling* **64**, 249–269.

Aguilar, P. and Vázquez, J.: 2021, An estimated DSGE model with learning based on term structure information, *Macroeconomic Dynamics* **25**(7), 1635–1665.

Aguirre, I. and Vázquez, J.: 2020, Learning, parameter variability, and swings in US macroeconomic dynamics, *Journal of Macroeconomics* **66**, 103240.

Barsky, R. B. and Sims, E. R.: 2011, News shocks and business cycles, *Journal of Monetary Economics* **58**(3), 273–289.

Beaudry, P. and Lucke, B.: 2010, Letting different views about business cycles compete, *NBER Macroeconomics Annual* **24**(1), 413–456.

Beaudry, P. and Portier, F.: 2004, An exploration into Pigou's theory of cycles, *Journal of Monetary Economics* **51**(6), 1183–1216.

Beaudry, P. and Portier, F.: 2006, Stock prices, news, and economic fluctuations, *American Economic Review* **96**(4), 1293–1307.

Ben Zeev, N. and Khan, H.: 2015, Investment-specific news shocks and US business cycles, *Journal of Money, Credit and Banking* **47**(7), 1443–1464.

Bernanke, B. S., Gertler, M. and Gilchrist, S.: 1999, The financial accelerator in a quantitative business cycle framework, *Handbook of Macroeconomics* **1**, 1341–1393.

Calvo, G. A.: 1983, Staggered prices in a utility-maximizing framework, *Journal of monetary Economics* **12**(3), 383–398.

Christiano, L. J., Motto, R. and Rostagno, M.: 2014, Risk shocks, *American Economic Review* **104**(1), 27–65.

De Graeve, F.: 2008, The external finance premium and the macroeconomy: US post-WWII evidence, *Journal of Economic Dynamics and Control* **32**(11), 3415–3440.

Del Negro, M., Schorfheide, F., Smets, F. and Wouters, R.: 2007, On the fit of new Keynesian models, *Journal of Business and Economic Statistics* **25**(2), 123–143.

Espinoza, R., Fornari, F. and Lombardi, M. J.: 2012, The role of financial variables in predicting economic activity, *Journal of Forecasting* **31**(1), 15–46.

Fernández-Villaverde, J.: 2010, The econometrics of DSGE models, *SERIEs Journal of the Spanish Economic Association* **1**(1-2), 3–49.

Fernández-Villaverde, J. and Rubio-Ramírez, J. F.: 2004, Comparing dynamic equilibrium models to data: a Bayesian approach, *Journal of Econometrics* **123**(1), 153–187.

Fisher, I.: 1933, The debt-deflation theory of great depressions, *Econometrica* **1**(4), 337–357.

Fujiwara, I., Hirose, Y. and Shintani, M.: 2011, Can news be a major source of aggregate fluctuations? A Bayesian DSGE approach, *Journal of Money, Credit and Banking* **43**(1), 1–29.

Gelain, P. and Ilbas, P.: 2017, Monetary and macroprudential policies in an estimated model with financial intermediation, *Journal of Economic Dynamics and Control* **78**, 164–189.

Gertler, M. and Karadi, P.: 2011, A model of unconventional monetary policy, *Journal of Monetary Economics* **58**(1), 17–34.

Gertler, M., Kiyotaki, N. and Queralto, A.: 2012, Financial crises, bank risk exposure and government financial policy, *Journal of Monetary Economics* **59**, S17–S34.

Gertler, M. L.: 1988, Financial structure and aggregate economic activity: an overview, *Technical report*, National Bureau of Economic Research.

Gilchrist, S., Yankov, V. and Zakrajšek, E.: 2009, Credit market shocks and economic fluctuations: Evidence from corporate bond and stock markets, *Journal of Monetary Economics* **56**(4), 471–493.

Gilchrist, S. and Zakrajšek, E.: 2012, Credit spreads and business cycle fluctuations, *American Economic Review* **102**(4), 1692–1720.

Görtz, C. and Tsoukalas, J. D.: 2017, News and financial intermediation in aggregate fluctuations, *Review of Economics and Statistics* **99**(3), 514–530.

Görtz, C., Tsoukalas, J. D. and Zanetti, F.: 2021, News shocks under financial frictions, *American Economic Journal: Macroeconomics (forthcoming)* .

Gunn, C. M. and Johri, A.: 2018, Financial news, banks, and business cycles, *Macroeconomic Dynamics* **22**(2), 173–198.

Gurley, J. G. and Shaw, E. S.: 1955, Financial aspects of economic development, *American Economic Review* **45**(4), 515–538.

Iacoviello, M.: 2015, Financial business cycles, *Review of Economic Dynamics* **18**(1), 140–163.

Justiniano, A., Primiceri, G. E. and Tambalotti, A.: 2010, Investment shocks and business cycles, *Journal of Monetary Economics* **57**(2), 132–145.

Merola, R.: 2015, The role of financial frictions during the crisis: An estimated DSGE model, *Economic Modelling* **48**, 70–82.

Merton, R. C.: 1973, An intertemporal capital asset pricing model, *Econometrica* **41**(5), 867–887.

Moran, P. and Queralto, A.: 2018, Innovation, productivity, and monetary policy, *Journal of Monetary Economics* **93**, 24–41.

Mouabbi, S. and Sahuc, J.-G.: 2019, Evaluating the macroeconomic effects of the ECB's unconventional monetary policies, *Journal of Money, Credit and Banking* **51**(4), 831–858.

Nolan, C. and Thoenissen, C.: 2009, Financial shocks and the us business cycle, *Journal of Monetary Economics* **56**(4), 596–604.

Pigou, A. C.: 1927, *Industrial fluctuations*, London: Macmillan.

Queralto, A.: 2020, A model of slow recoveries from financial crises, *Journal of Monetary Economics* **114**, 1–25.

Sanjani, M. T.: 2014, *Financial frictions and sources of business cycle*, number 14-194, International Monetary Fund.

Schmitt-Grohé, S. and Uribe, M.: 2012, What's news in business cycles, *Econometrica* **80**(6), 2733–2764.

Sims, E.: 2016, What's news in news? A cautionary note on using a variance decomposition to assess the quantitative importance of news shocks, *Journal of Economic Dynamics and Control* **73**, 41–60.

Slobodyan, S. and Wouters, R.: 2012, Learning in a medium-scale dsge model with expectations based on small forecasting models, *American Economic Journal: Macroeconomics* **4**(2), 65–101.

Smets, F. and Wouters, R.: 2007, Shocks and frictions in US business cycles: A Bayesian DSGE approach, *American Economic Review* **97**(3), 586–606.

Vázquez, J. and Aguilar, P.: 2021, Adaptive learning with term structure information, *European Economic Review* **134**, 103689.

Villa, S.: 2016, Financial frictions in the Euro Area and the United States: A Bayesian assessment, *Macroeconomic Dynamics* **20**(5), 1313–1340.

Wu, J. C. and Xia, F. D.: 2016, Measuring the macroeconomic impact of monetary policy at the zero lower bound, *Journal of Money, Credit and Banking* **48**(2-3), 253–291.

Wu, J. C. and Zhang, J.: 2019, A shadow rate new keynesian model, *Journal of Economic Dynamics and Control* **107**, 103728.

# Appendix

This appendix describes the DSGE model augmented with financial frictions à la Gertler and Karadi (2011).

**Households**

The representative household $i$ decides consumption, hours worked, and savings in riskless assets to maximize a utility function that incorporates internal habit formation. Formally,

$$E_t \sum_{k=0}^{\infty} \beta^k \epsilon_{t+k}^b \left[ ln\left(C_{t+k}(i) - hC_{t+k-1}\right) - \frac{L_{t+k}(i)^{1+\sigma_l}}{1+\sigma_l} \right], \tag{4}$$

where $\beta$ is the household discount factor, $h$ represents the degree of habit persistence, $\sigma_l$ is the elasticity of labor supply (i.e. the Frisch elasticity), and $\epsilon_{t+k}^b$ is an exogenous process that affects the intertemporal preferences of households. Household savings are represented by deposit liabilities in banks and government bonds. These riskless assets, $B$, are perfect substitutes and pay the same nominal interest rate, $R^n$. Households also obtain dividends from intermediate goods firms, capital goods producers, and labor unions, $D$. Hence, the budget constraint is given by

$$C_{t+k}(i) + \frac{B_{t+k}(i)}{R_{t+k}^n P_{t+k}} - T_{t+k} = \frac{W_{t+k}(i) L_{t+k}(i)}{P_{t+k}} + \frac{B_{t+k-1}(i)}{P_{t+k}} + \frac{D_{t+k}}{P_{t+k}}, \tag{5}$$

where $T$ represents lump-sum taxes and $W$ is the nominal wage.

**Labor unions and wage decision**

As in Smets and Wouters (2007), households supply homogeneous labor to intermediate labor unions that differentiate labor services. Those intermediate labor unions then set wages to sell labor services to a labor packer who aggregates the differentiated labor and resells it to intermediate goods firms. Aggregation of labor services follows

$$L_t = \left[ \int_0^1 L_t(i)^{\frac{1}{1+\epsilon_t^w}} di \right]^{1+\epsilon_t^w},$$

where $1+\epsilon_t^w$ is the desired markup of wages over the household's marginal rate of substitution, which is assumed to follow a stochastic process around its steady-state value. Labor packers maximize profits in a perfectly competitive market

$$max_{L_t(i)} W_t L_t - \int_0^1 W_t(i) L_t(i),$$

where $L_t$ is subject to the labor aggregation function, $W_t$ is the aggregate wage that intermediate firms pay for labor services, and $W_t(i)$ is the wage that labor packers pay for the differentiated labor. This optimization problem gives rise to the following labor demand function

$$L_t(i) = \left( \frac{W_t(i)}{W_t} \right)^{-\frac{1+\epsilon_t^w}{\epsilon_t^w}} L_t.$$

The labor demand function and the labor services aggregation function jointly result in the wage aggregation function

$$W_t = \left( \int_0^1 W_t(i)^{\frac{1}{\epsilon_t^w}} di \right)^{\epsilon_t^w}. \tag{6}$$

Following Calvo's lottery scheme, it is assumed that labor unions can only adjust prices with probability $1 - \xi_w$. The fraction of labor unions $\xi_w$ that cannot adjust prices is assumed to follow the indexation rule, $W_{t+1}(i) = W_t(i) \left( \frac{P_t}{P_{t-1}} \right)^{\iota_w}$. Hence, the labor unions choose an optimal $W$ to maximize

$$E_t \sum_{k=0}^{\infty} \beta^k \xi_w^k \left[ \Lambda_{t+k} W_t(i) L_{t+k}(i) - \epsilon_{t+k}^b \frac{L_{t+k}(i)^{1+\sigma_l}}{1+\sigma_l} \right], \tag{7}$$

subject to labor demand and the indexation rule.

**Final goods firms**

Competitive final goods producers buy intermediate goods and assemble them to finally sell homogeneous goods to households. The intermediate goods aggregation follows

$$Y_t = \left[ \int_0^1 Y_t(i)^{\frac{1}{1+\epsilon_t^p}} di \right]^{1+\epsilon_t^p},$$

where $Y_t$ is the homogeneous good, $Y_t(i)$ is the heterogeneous good supplied by firm $i$, and $1 + \epsilon_t^p$

is the desired markup of prices over the marginal costs of firms, which is assumed to follow a stochastic process around its steady-state value. Final goods firms maximize profits in a perfectly competitive market

$$max_{Y_{t(i)}} P_t Y_t - \int_0^1 P_t(i) Y_t(i) di,$$

where $Y_t$ is subject to the goods aggregation function, $P_t(i)$ is the price for differentiated goods, and $P_t$ is the aggregate price index. The optimal condition of this maximization problem results in the following goods demand function for goods:

$$Y_t(i) = \left( \frac{P_t(i)}{P_t} \right)^{-\frac{1+\epsilon_t^p}{\epsilon_t^p}} Y_t. \tag{8}$$

Hence, the goods demand function and the intermediate goods aggregator result in the following price aggregator

$$P_t = \left[ \int_0^1 P_t(i)^{\frac{1}{\epsilon_t^p}} di \right]^{\frac{1}{1-\epsilon_t^p}}. \tag{9}$$

**Intermediate goods firms**

As in the labor market, it is assumed that intermediate goods firms can only adjust prices with probability $\xi_p$. Those firms which cannot adjust prices in period $t$ simply reset their prices according to the indexation rule: $P_{t+1}(i) = P_t(i) \left( \frac{P_t}{P_{t-1}} \right)^{\iota_p}$. Firms able to decide their optimal prices $P_t^*$ at time $t$ choose them by maximizing current and future expected profits. Denoting the marginal costs by $MC_t$ and the inflation rate by $\pi_t$, the price setting optimization problem faced by intermediate goods firms is

$$E_t \sum_{k=0}^{\infty} \beta^k \xi_p^k \Lambda_{t+k} \frac{P_t}{P_{t+k}} \left[ P_t^*(i) \prod_{l=1}^{k} \pi_{t+l-1}^{\iota_p} - MC_{t+k} \right] Y_{t+k}(i), \tag{10}$$

subject to the price indexation rule and the demand function for goods.

In addition to setting prices, intermediate goods firms decide on the output of goods. They choose the amount of production inputs by maximizing the flow of discounted profits

$$E_t \left\{ \beta \Lambda_{t+1} \left[ Y_{t+1}(i) - r^k_{t+1} K^s_{t+1}(i) - \frac{W_{t+1}}{P_{t+1}} L_{t+1}(i) \right] \right\}, \tag{11}$$

where $\beta \Lambda_{t+1} = \frac{\beta \lambda_{t+1}}{\lambda_t}$ is the stochastic discount factor and $\lambda_t$ is the marginal utility of consumption for households at time $t$, $r^k_{t+1}$ is the rental rate of capital, and $K^s_{t+1}(i)$ denotes capital services.

The production function is assumed to follow a Cobb-Douglas technology:

$$Y_t = TFP_t \left[ (QoC_t) K_{t-1} U_t \right]^{\alpha} L_t - \phi_p, \tag{12}$$

where $\phi_p$ is the share of fixed costs involved in production, and the disturbance $QoC_t$ captures exogenous changes in the quality of capital. Notice that QoC shocks are somewhat equivalent to TFP shocks. The difference between them is made clear below because shocks in the quality of capital have not only a direct impact on the real economy via the production process, as TFP shocks do, but also an amplifying effect through the credit channel. The optimal inputs decision results in the following optimal conditions:

$$r^k_t = \alpha \left( K^s_t \right)^{\alpha - 1} L_t^{1-\alpha}, \tag{13}$$

$$\frac{W_t}{P_t} = (1 - \alpha) \left( K^s_t \right)^{\alpha} L_t^{-\alpha}. \tag{14}$$

**Capital services firms**

Capital services firms purchase physical capital from capital goods producers and turn it into effective capital by choosing the utilization rate, $U_t$:

$$K^s_t = U_t K_{t-1} \left( QoC_t \right). \tag{15}$$

Capital services firms decide the optimal capital utilization rate and face a utilization cost. They solve the following maximization problem:

$$max_{U_t}\left[r_t^k U_t - a\left(U_t\right)\right] K_{t-1}\left(QoC_t\right),$$

where $a\left(U_t\right)$ is the utilization cost function. The optimal solution implies

$$r_t^k = a'\left(U_t\right). \tag{16}$$

This equilibrium condition meas that the degree of capital utilization is a function of the rental rate of capital. It is assumed that the utilization cost function features the following standard properties $U = 1$, $a(U) = 0$, and $\frac{a''(U)}{a'(U)} = \psi$ in the steady state. Hence, the parameter $\psi$ is a positive function of the elasticity of the capital utilization cost, and is normalized to be between zero and one. A higher value of $\psi$ implies a higher cost of adjustment in capital utilization.

Capital services firms finance their physical capital acquisition by borrowing from financial intermediaries. At equilibrium, the following condition holds:

$$Q_t K_{t+1} = Q_t S_t, \tag{17}$$

indicating that state-contingent claims, $S_t$, are equal to the number of units of physical capital acquired, $K_{t+1}$, where firms price their claims at the price of one unit of capital, $Q_t$. Each claim pays the stochastic return $R_{t+1}^k$ over period $t$. Capital services firms operate in a perfectly competitive market, so the revenue from renting effective capital must be equal to the cost of purchasing physical capital. Hence, the optimal capital demand satisfies

$$R_{t+1}^k = \frac{r_{t+1}^k U_{t+1} - a\left(U_{t+1}\right) + Q_{t+1}(1-\delta)}{Q_t}\left(QoC_{t+1}\right), \tag{18}$$

which shows that the expected real interest rate on external funds is equal to the marginal return on capital. Notice that the return on financial claims is also determined by the quality-of-capital shock.

### Capital goods producers

Capital goods producers turn out physical capital and sell it to capital services firms at price $Q_t$. Investment goods are purchased from final good producers. Capital goods producers are assumed to face quadratic adjustment costs, $S(I_t/I_{t-1})$. This adjustment costs function is assumed to be a strictly increasing twice differentiable function. Thus, the optimization problem of the capital goods producers is

$$max_{I_t} E_t \left\{ \sum_{k=0}^{\infty} \beta^k \Lambda_{t+k} \left[ Q_{t+k} I_{t+k} \epsilon^i_{t+k} - I_{t+k} - Q_{t+k} I_{t+k} \epsilon^i_{t+k} S\left( \frac{I_{t+k}}{I_{t+k-1}} \right) \right] \right\}, \tag{19}$$

where $S(.)$ is assumed to have the properties $S(1) = S'(1) = 0$, $S''(1) = \varphi > 0$. Therefore, the parameter $\varphi$ captures the degree of investment adjustment cost, and the disturbance $\epsilon^i_t$ is the investment specific-technology shock. Capital accumulation evolves following the standard equation

$$K_t = (1-\delta) K_{t-1} (QoC_t) + \left[ 1 - S\left( \frac{I_t}{I_{t-1}} \right) \right] I_t. \tag{20}$$

### Financial intermediaries

Görtz and Tsoukalas (2017) find that the financial sector is crucial for identifiying TFP news shocks. We closely follow their characterization of financial intermediaries, based on Gertler and Karadi (2011). A fixed fraction of households is assumed to comprise bankers, who do not supply labor but act as financial intermediaries. They face a survival probability, $\theta$, and in order to keep the proportion of bankers constant further households become bankers in each period.

The financial intermediaries finance the acquisition of physical capital by purchasing claims $S_t$. Those purchases are funded through household liabilities. Hence, the balance sheets of financial intermediaries are

$$Q_t S_t = N_t + B_{t+1},$$

where $N_t$ is the net worth of the bankers. Given than the return on financial claims is $R^k_t$ and the cost of liabilities is $R_t$, the net worth of the intermediaries evolves as follows:

$$N_{t+1} = R^k_{t+1} Q_t S_t - R_t B_{t+1} = \left(R^k_{t+1} - R_t\right) Q_t S_t + R_t N_t.$$

Let $\beta\Lambda_{t+1}$ be the stochastic discount factor of the financial intermediaries. The bankers' decisions are endogenously determined in the model through a problem in which they maximize future expected terminal wealth

$$V_t = max\ E_t \sum_{i=0}^{\infty} (1-\theta)\, \theta^i \beta^i \Lambda_{t+i+1} N_{t+i+1} =$$

$$max\ E_t \sum_{i=0}^{\infty} (1-\theta)\, \theta^i \beta^i \Lambda_{t+i+1} \left[\left(R^k_{t+i+1} - R_{t+i}\right) Q_{t+i} S_{t+i} + R_{t+i} N_{t+i}\right].$$

However, a moral hazard issue arises in this maximization problem because $\beta^i \left(R^k_{t+i} - R_{t+i-1}\right) \geq 0$. Otherwise bankers would not be willing to purchase assets. Thus, bankers have an incentive to keep borrowing additional funds indefinitely from households. In order to restrict their ability to do this, an enforcement cost is introduced: At the beginning of the period bankers can divert a proportion $\lambda$ of the funds available. In that case the depositors can recover a fraction $(1-\lambda)$ of the assets. Hence, for lenders to be willing to supply funds to bankers the following incentive constraint must be satisfied:

$$V_t \geq \lambda Q_t S_t,$$

where $V_t$, the gain from not diverting assets, can be expressed as follows

$$V_t = \nu_t Q_t S_t + \eta_t N_t,$$

with

$$\nu_t = E_t \left[(1-\theta)\, \Lambda_{t+1} \left(R^k_{t+1} - R_t\right) + \beta\theta x_{t,t+1} \nu_{t+1}\right], \tag{21}$$

$$\eta_t = E_t \left[(1-\theta)\, \Lambda_{t+1} R_t + \beta\theta z_{t,t+1} \eta_{t+1}\right], \tag{22}$$

where $\nu_t$ is the marginal gain from expanding assets with net worth held constant, $\eta_t$ is the expected value of one additional future unit of wealth net worth with assets held constant, $x_t = Q_{t+i}S_{t+1}/Q_tS_t$ is the gross growth rate of assets, and $z_t = N_{t+i}/N_t$ is the gross growth rate of net worth.

In equilibrium the incentive constraint holds with equality

$$Q_tS_t = \frac{\eta_t}{\lambda - \nu_t}N_t = \phi_t N_t, \tag{23}$$

where $\phi_t$ is the leverage ratio of bankers. Thus, from the net worth evolution equation and the incentive constraint, net worth can be rewritten as

$$N_{t+1} = \left[\left(R^k_{t+1} - R_t\right)\phi_t + R_t\right]N_t.$$

Based on this equation, the gross growth rates of assets and net worth can be expressed as

$$z_{t,t+1} = N_{t+1}/N_t = \left(R^k_{t+1} - R_t\right)\phi_t + R_t, \tag{24}$$

and

$$x_{t,t+1} = Q_{t+1}S_{t+2}/Q_tS_{t+1} = \left(\phi_{t+1}/\phi_t\right)\left(N_{t+1}/N_t\right) = \left(\phi_{t+1}/\phi_t\right)z_{t,t+1}. \tag{25}$$

Finally, the law of motion of bankers' net worth is given by the law of motion of the net worth of existing bankers plus the net worth of households that become bankers in this period:

$$\tilde{N}_t = N^e_t + N^n_t, \tag{26}$$

with

$$N^e_t = \theta\left[\left(R^k_{t+1} - R_t\right)\phi_t + R_t\right]N_{t-1}, \tag{27}$$

$$N^n_t = \omega Q_t S_{t-1}, \tag{28}$$

$$\tilde{N}_t = N_t \epsilon_t^{nw}, \tag{29}$$

where $\omega$ is the fraction of the total assets that households transfer to new bankers, which enable them to start operating in the banking sector, and the disturbance $\epsilon_t^{nw}$ captures exogenous variations in the net worth of bankers (due, for instance, to exogenous changes in bank profits).

**Market clearing condition**

The market clearing condition is

$$Y_t = C_t + I_t + a(U_t) + \epsilon_t^g, \tag{30}$$

where $\epsilon_t^g$ is an exogenous process that captures government spending and exogenous net export shocks.

**The central bank**

The model is completed with a Taylor rule in which the nominal interest rate set by the central banker reacts to inflation, output, and output growth (where all variables are measured in deviations from their steady-state values):

$$\frac{R_t^n}{R^n} = \left[\frac{R_{t-1}^n}{R^n}\right]^{\rho} \left\{\left[\frac{\pi_t}{\pi}\right]^{r_\pi} \left[\frac{Y_t}{Y}\right]^{r_y}\right\}^{1-\rho} \left[\frac{Y_t}{Y_{t-1}}\right]^{r_{\Delta y}}. \tag{31}$$