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News versus Surprise in Structural Forecasting Models: Central Bankers' Practical Perspective

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News versus Surprise in Structural Forecasting Models: Central Bankers' Practical Perspective

Karel Musil, Stanislav Tvrz, and Jan Vlček *

Abstract

The paper deals with the treatment of shocks in central banks' forecasts. Within the rational expectations (RE) concept, which is widely used in structural macroeconomic models, the paper highlights the differences between news and surprise shocks and argues that most shocks in central bank forecasts should be treated as news. The paper also points out some drawbacks of news shocks under the assumption of full information from the practical point of view of forecasting and policy decision-making at central banks. As a potential solution, the paper refers to the LIRE concept as introduced in Brázdik et al. (2020). The paper discusses the properties of the LIRE concept and finds it versatile and useful in dealing with news shocks without abandoning the RE framework. The paper concludes that LIRE can be effectively used for practical structural macroeconomic modelling.

Abstrakt

Tento článek zkoumá, jak je v prognózách centrálních bank nakládáno se šoky. V rámci konceptu racionálních očekávání, který je široce využíván ve strukturálních makroekonomických modelech, zdůrazňujeme rozdíl mezi očekávanými a neočekávanými šoky a argumentujeme, že s většinou šoků by v prognózách centrálních bank mělo být nakládáno jako s očekávanými. Z praktické perspektivy prognózování a měnověpolitického rozhodování centrálních bank také poukazujeme na některé nevýhody očekávaných šoků za předpokladu úplných informací. Jako na jedno z možných řešení odkazujeme na koncept LIRE, jak jej zavádí Brázdik a kol. (2020). Diskutujeme vlastnosti konceptu LIRE a považujeme jej za všestranný a užitečný pro nakládání s očekávanými šoky, aniž by bylo nutné opustit rámec racionálních očekávání. Docházíme k závěru, že LIRE lze efektivně použít pro praktické strukturální makroekonomické modelování.

JEL Codes: D58, D84, E37, E52.

Keywords: Anticipated shocks, conditional forecast, DSGE models, rational expectations.

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1. Introduction

Many central banks have built up their Forecasting and Policy Analysis Systems (FPAS) around a structural macroeconomic model with forward-looking economic agents (and monetary policy) forming expectations in line with the rational expectations hypothesis. In fact, Yagihashi (2020) finds an increase in the number of Dynamic Stochastic General Equilibrium (DSGE) models used by policy institutions, mainly central banks. All these structural forecasting models feature a prominent role of expectations about the course of monetary policy, prices and output. In most, if not all, cases, expectations are assumed to be rational. This confirms that rational expectations (RE) are still at the core of macroeconomics.

Shocks in RE model forecasts can be treated as 'news' (anticipated) or 'surprise' (unanticipated) shocks. Treating shocks as news should be a natural choice for central banks, as they need to react in advance. We label the concept of news under RE as full information RE (FIRE), as it assumes that agents have perfect knowledge not only about the structure of the economy/model and the parameters and properties of the system/model, but also about future (anticipated) shocks.

However, the FIRE concept – namely the assumption of perfect foresight or full information about future anticipated shocks – is often viewed as unrealistic in the literature. One of the implications of perfect foresight is the 'forward guidance puzzle'. In a related paper, Del Negro et al. (2012) showed that the macroeconomic effects of anticipated monetary policy shocks in the standard new Keynesian DSGE framework are stronger the further in the future these shocks are to occur, which can lead to counterintuitive results.

Another issue with the FIRE concept is that impulse responses to news shocks vary with the foreseen horizon. Therefore, not only the size of the shock, but also the length of the horizon matter. This presents an issue in consecutive forecasts, where the distance of the impact of a shock from the beginning of the forecast horizon differs. This means that different impulse response dynamics are used in each case, instead of simply moving along one fixed impulse response function when the forecast horizon changes.[1]

The contribution of this paper is twofold. First, it argues in favour of using news shocks in central bank forecasting practice. Despite the above-mentioned theoretical and practical challenges related to the use of news shocks in practical forecasting, news shocks should be a natural choice for central banks, as they need to react in a forward-looking manner, i.e. in advance. Furthermore, without news shocks, inflation forecasts might not reach the target within the policy horizon and thus would not provide guidance for the expectations of economic agents.[2]

Second, the paper describes the Limited Information Rational Expectations (LIRE) concept as used in the Czech National Bank's core forecasting model (Brázdik et al., 2020) for

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[1] For example a news shock occurring two periods ahead on the future/forecast horizon in the previous forecast corresponds to a shock in the first period of the current forecast. But since it enters the simulation right at its beginning, expectations become irrelevant and the impulse response to this shock becomes the same as if it were a surprise shock. Thus, the shape of the impulse response to this shock changes between the forecasts.

[2] In the case of inflation forecasts conditioned by a monetary policy response, an inflation forecast outside the target at the end of the forecast horizon might indicate the presence of surprise shocks, and vice versa. This is so because surprise shocks are not known in advance either to economic agents or to the monetary authority. As a result, monetary policy is not able to keep the inflation forecast at the target due to transmission lags.

incorporating limited information in the central bank's forecasting practice. Under the LIRE concept, information about future anticipated shocks enters the agents' information set in a controlled manner in line with pre-determined restrictions. This way, the previously mentioned issues related to the FIRE concept are effectively mitigated.

To the best of our knowledge, there is no literature overview or survey covering the nature of shocks in central bank forecasts, but anticipated shocks under RE have been studied in the academic literature. News was introduced as anticipated shocks in Schmitt-Grohé and Uribe (2012). They found that (anticipated) news shocks account for more than two thirds of the predicted aggregate fluctuations in the post-war US data. Similarly, the effects of news are analysed by Milani and Treadwell (2012), who find that news shocks have a greater role in influencing the business cycle than common unanticipated shocks. They argue that news shocks have larger, delayed and more persistent effects, and they also admit that the choice of anticipation horizon is crucial but uncertain.

There is a vast literature modifying the RE concept in order to bring structural models with RE to the actual data. However, news shocks are proposed only by Schmitt-Grohé and Uribe (2012) and Milani and Treadwell (2012), both of which highlight the importance of news shocks for proper interpretation of macroeconomic developments. Alternatively, higher discounting is proposed by Del Negro et al. (2012) to deal with the forward guidance puzzle. This naturally increases the effective discounting rate in the model and reduces the initial reaction to announced future monetary policy shocks (i.e. forward guidance shocks). Other modifications of RE either impose persistence directly on RE, as in Gelain et al. (2019), or add additional persistence outside RE, as pioneered by Fuhrer (2000). Finally, learning is used as a source of persistence, as summarized in Milani (2007).

The paper is structured as follows. First, after explaining the difference between surprise shocks and news shocks, we argue that central banks should treat shocks in their forecasts as news and not as surprises. Second, the paper discusses practical issues relating to the use of news shocks in central bank forecasts. In this regard, the paper refers to the LIRE concept as introduced in Brázdik et al. (2020). The properties of the LIRE concept and the treatment of expectations over the forecast horizon are discussed and guidelines for its calibration are suggested.

2. Surprise Shocks versus News Shocks

During practical forecasting exercises, forecasters need to decide what type of shocks to use in their structural models under RE: either surprise shocks (unanticipated) or news shocks (anticipated). Surprise shocks are not foreseen by the economic agents in a model until their realization. They are 'textbook' shocks, usually used for calibrating the model and assessing its properties. Conversely, news is foreseen in advance, so agents are able to gradually accommodate news shocks. Agents are surprised at the moment they learn of news set in the future, but not at the moment of realization of the shock.

A simple DSGE model is used in this paper to demonstrate the implications of surprise and news shocks. The model is a small open economy model derived from agents' optimization problems. This type of structural model, which is by definition well suited to understanding the role of expectations (unlike reduced-form econometric models), follows a New Keynesian approach and is solved under RE. With regard to the monetary policy regime, a floating exchange rate is implemented and the central bank conducts monetary policy under inflation targeting in a small open economy. The model is a simplified version of the g3+ model described in Brázdik et al. (2020) and following Andrle et al. (2009).

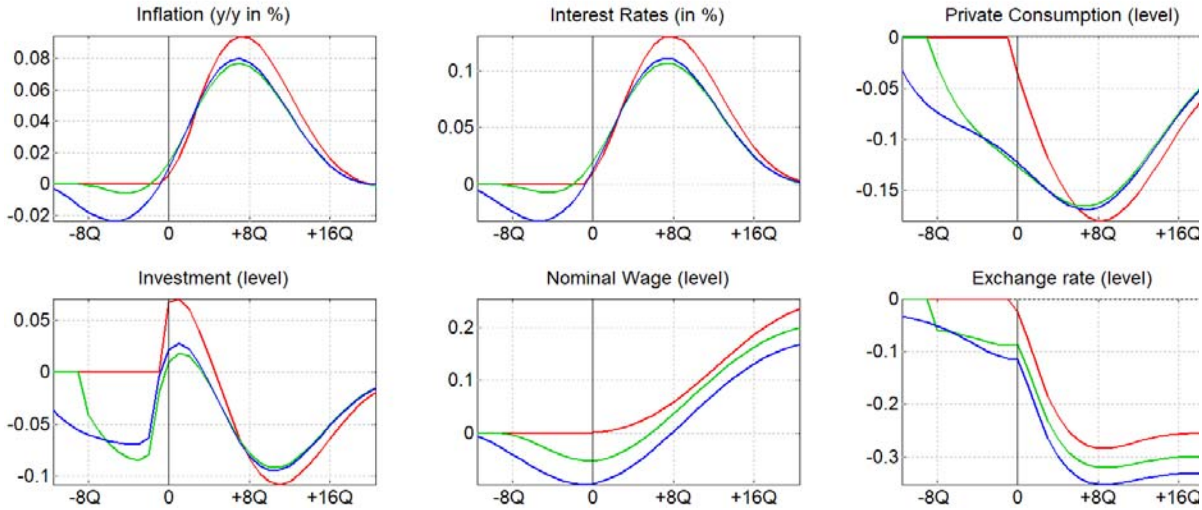
2.1 Comparison of Impulse Responses

A comparison of FIRE impulse responses to surprise and news shocks is presented for the cases of foreign and domestic cost-push shocks. The news version is considered over horizons of 8 and 12 quarters ahead.[3] These horizons are selected to demonstrate how the impulse responses to a news shock vary with the foreseen horizon. Naturally, economic agents have more time to react to and accommodate news with a longer horizon. However, this accommodation is hindered by rigidities and persistence in the economy. A more rigid economic system makes the adjustment more gradual, hence a longer foreseen horizon is needed to fully accommodate the news. If the horizon was not sufficient, the accommodation would be only partial and the impulse response would be closer to the surprise case. Hence, it is the length of the foreseen horizon and the persistence of the economic system that determine the dynamics of the impulse response to a news shock.

An unanticipated foreign cost-push shock induces inflationary pressures in the domestic economy via higher import prices (see Figure 1). The home country central bank reacts to the inflationary pressures by tightening monetary policy. The higher import prices imply lower demand for imports in the domestic economy. Conversely, external demand for domestic production increases as the relative price of home economy exports in foreign currency declines. However, domestic production can only be increased by employing more labour hours and more capital, at the cost of rising real wages and price of capital. In line with the higher demand for capital, household consumption needs to gradually decline to accumulate savings for investment (as no substitution of domestic and foreign goods is assumed in household consumption). Finally, the higher exports and lower imports lead to a positive trade balance, inducing a drop in the country risk premium, and the nominal exchange rate appreciates.

[3] A period of longer than three years is considered to be beyond the common span of central banks' forecasts and beyond the standard monetary policy horizon.

Figure 1: Impulse Responses to Expected Foreign Inflation Shock (Deviations from Steady State Values)



Note: IRFs to expected shocks: 12Q ahead – blue, 8Q ahead – green. IRFs to unexpected shocks – red.

A foreign cost-push shock implemented as news causes the nominal exchange rate to appreciate in advance and creates deflationary pressures. This appreciation reflects expectations of an improving trade balance. However, the initial nominal appreciation worsens the price competitiveness of domestic exports, which decline. The fall in exports prior to the realization of the shock reduces domestic production. Consistently with that, household consumption and investment also decline. Thus, lower domestic economic activity brings about deflationary pressures on top of declining import prices. The central bank reacts by reducing interest rates initially, prior to the realization of the foreign cost-push shock. Once the news shock materializes, the dynamics of the impulse responses resemble the surprise shock case.

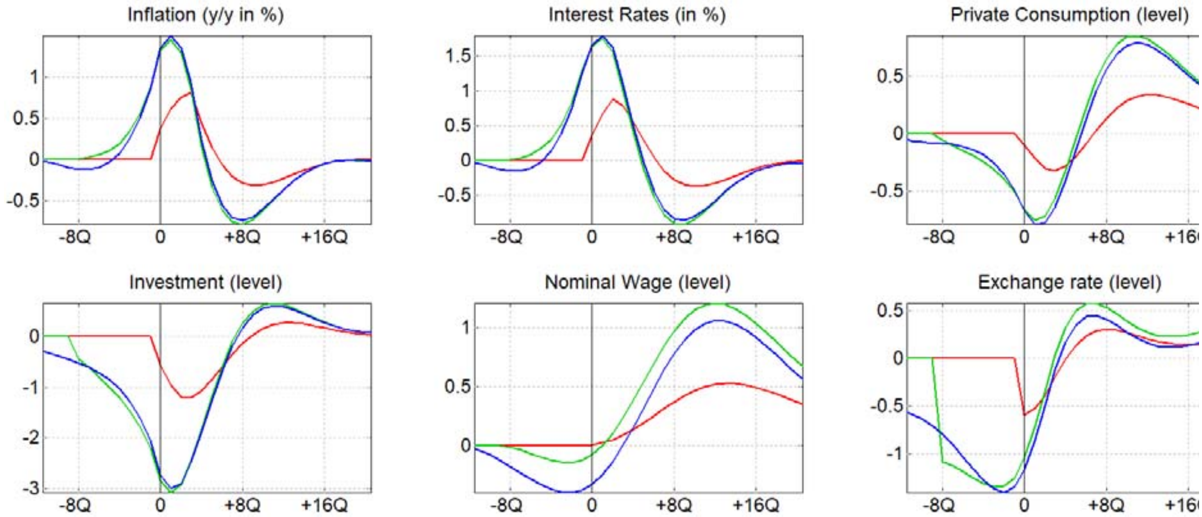
Similarly, a domestic cost-push news shock causes agents to react in advance compared to the surprise case (see Figure 2). An expected increase in consumption prices would lead to a reaction of the central bank, i.e. an increase in interest rates in advance of the shock *ceteris paribus*.[4] Monetary policy tightening through a higher real interest rate would lead to a decline in consumption and investment. A drop in productivity related to lower investment would translate into lower wages while at the same time increasing inflation.[5] Consumption and investment are further suppressed by a worsening of the net foreign asset position of the economy. Finally, the

[4] Given the monetary policy horizon of the central bank and the delay in monetary policy transmission, the policy reaction to an expected domestic cost-push shock is significantly larger than the response to a surprise shock. In the case of a surprise shock, the central bank has a much weaker incentive to adjust interest rates, because by the time its decision takes effect, domestic inflation will have returned to the target.

[5] A price increase is recorded one year prior to the realization of the shock regardless of the length of the foreseen horizon. However, for longer horizons – see, for example, the two-year horizon – prices decline on the back of lower consumption. Note, however, that this property is significantly affected by the model calibration and the specification of the Euler equation.

higher nominal interest rate causes the nominal exchange rate to appreciate. This results in lower demand for exports, and the external position of the country thus deteriorates.

Figure 2: Impulse Responses to Expected Domestic Cost-push Shock (Deviations from Steady State Values)



Note: IRFs to expected shocks: 12Q ahead – blue, 8Q ahead – green. IRFs to unexpected shocks – red.

Three differences emerge when we compare the surprise and FIRE news shocks. First, the dynamics of the impulse responses to the same shock assuming surprise and news are different both quantitatively and in terms of the underlying story (qualitatively). There is a distinct difference in the period in advance of the shock, while the dynamics after the realization of the shock are comparable. Although both impulse responses can be explained using model equations, the news shock dynamics are relatively complex and might be challenging, especially if the directions of the impulse responses change. The dynamics of the impulse responses after the realization of the shock are qualitatively comparable for surprise and news shocks.

Second, there are even differences between news shocks, depending on how many quarters prior to realization they become known or anticipated by agents. Clearly there is more time for agents to accommodate a shock with a longer available horizon. In some cases, the impulse responses even change direction with the length of the foreseen horizon.

Third, it seems that treating foreign shocks as news instead of surprises smooths the impulse responses. However, the variability induced by domestic news shocks is higher. In other words, the immediate response to an expected shock that is known further in advance can be substantially larger than the response to a surprise shock. This observation is in line with the findings of Milani (2007), who observes higher variability of model variables under a news shock framework.

2.2 Surprise or News in Central Bank Forecasts?

There is no clear suggestion in the literature on whether surprise or news shocks should be used in practical forecasting. However, the choice is crucial, as it affects forecasts and their implications for monetary policy decisions.[6]

Shocks in a central bank forecast should be treated as news. There are at least two arguments in favour of news shocks. First, central banks have to collect all available information, including anticipated shocks, incorporate those shocks into the forecast and communicate them appropriately. This is a must, as there are transmission lags and monetary policy has to be forward-looking and react to shocks in advance. Anticipating shocks and publishing a forecast that incorporates them means that economic agents start to anticipate them. Treating them as surprises would be false and a policy error, as they would already be anticipated by economic agents. Take, for example, an external outlook conditioning a forecast for a small open economy. External outlooks are usually derived from market expectations, so it is hard to argue that they are not anticipated. Moreover, the central bank should steer the expectations of economic agents to ensure price stability.

Second, any inflation forecast assuming active monetary policy has to reach the target within the forecast horizon. Publishing a forecast in which the inflation target is not achieved would undermine the credibility of the central bank's price stability objective. This might happen in the case of surprise shocks, even abstracting from the case where the monetary policy responses are not strong enough to deliver the targeted level of inflation. When treating a shock as a surprise, there is a response to it only at the time of its realization. However, it may be too late to bring inflation to the target due to transmission lags. As a result, this inappropriate treatment of shocks – those related to external assumptions in particular – could lead to an inflation forecast which does not reach the target despite active monetary policy.

Surprise shocks should be used only rarely. Despite the arguments given above, there are events which might reasonably be treated as unanticipated. These might be shocks which are foreseen but are highly unlikely and contingent on further steps to be taken in the future. A tax change pending legal approval is one example. There are additional arguments in favour of surprise shocks. First, structural models are usually calibrated using unexpected shocks. Second, the filtration of historical data exploiting the commonly used Kalman filtration assumes unexpected shocks by default. However, both these arguments are rather technical and can hardly outweigh the economic arguments in favour of news shocks. Moreover, some of these technical issues might be addressed at least partly. For example, when calibrating structural models, we might inspect their properties in the face of expected shocks, although their number is enormous.[7] Similarly, anticipated shocks might be filtered out from the data, but this requires either amending the filtration procedure or adjusting the model.

Although using news shocks in central bank forecasts is advisable, there are challenges related to such practice. These issues were identified at the Czech National Bank during the period when

[6] The case of a central bank operating under inflation targeting is considered when discussing the appropriateness of news and surprise shocks. Inflation targeting means that an inflation forecast is used to inform monetary policy decisions and this forecast is conditional on an interest rate path bringing inflation back to the target.

[7] In theory, the number is unlimited. One could choose an arbitrarily far horizon for an expected shock. The response to any given shock would be generally different depending on its distance in the future.

the previous core forecasting model, g3, was used, and they motivated changes in the model and forecast simulation procedures as described in Brázdik et al. (2020).

First, some FIRE news shocks might exhibit strong effects with potentially opposite signs of the impulse responses compared to a common surprise shock. Although the change of signs might be correct in theory, it can be challenging to explain these responses. Based on the simulations presented above, this might be the case with domestic shocks, in particular those which induce higher volatility of the variables.

The second issue relates to changes between consecutive forecasts. Imagine a news shock applied in a forecast. In the next quarter, the forecast is updated and the forecast horizon shifts one quarter forward, but the magnitude and timing of the realization of the news shock are kept unchanged. Even in this case, a change would arise in the forecast trajectories due to a shortening of the anticipation horizon of the news shock, i.e. how many quarters in advance the shock is assumed to become known to the economic agents. As is clear from the discussion above (see Figures 1 and 2), the difference might be significant. Such a change in the forecast is difficult to communicate. The communication challenge is given by the switch from the original impulse response (IRF) to the IRF with a shorter foreseen horizon – a shift from one IRF to another, not a movement along a given IRF. A shift between IRFs is also caused by moving the end of the historical data sample one quarter ahead and treating all the historical shocks as surprise shocks in Kalman filtration, including those which were treated as news shocks in the previous forecasting round.

The need to use news shocks and avoid the above drawbacks calls for a novel approach. We discuss the approach suggested in Brázdik et al. (2020) and elaborate its motivation and properties in more detail. This approach can be incorporated into the concept of Limited Information Rational Expectations (LIRE), which extends the simple fixed expectations scheme. The LIRE extension is discussed further in this paper.

3. Limited Information Rational Expectations

Brázdik et al. (2020) introduced and implemented the concept of Limited Information Rational Expectations (LIRE). The LIRE concept preserves RE but reduces the variability of the responses to news shocks and ensures better consistency across consecutive forecasts. This section describes the evolution of the LIRE concept and highlights its main principles.

3.1 LIRE Concept

LIRE extends and generalizes the RE concept. Equation (1) describes the dynamic response of the model economy to a surprise shock ε_t and anticipated future shocks ε_{t+k}, $k=1, 2, 3, \ldots$ in the benchmark RE case.[8] The transition matrix F describes the transition from the past state given by the vector of model variables ξ_{t-1} to the current state ξ_t. The reaction of the model economy to surprise shocks is given by the response matrix $R^{[0]}$, and the reaction to anticipated shocks ε_{t+k} is

[8] There is no sense in distinguishing between anticipated and surprise shocks in the current period. Economic agents have no time left to adjust their plans before the shock hits the economy anyway. Therefore, any shock that takes place in the current period is a surprise shock. Or, put differently, only future shocks (relative to any point in time) may be anticipated. Thus, in the notation used here, a shock related to matrix $R^{[0]}$ is always a surprise shock.

given by the response matrices $R^{[k]}$, *k=1, 2, 3,…* This equation corresponds to the theoretical solution of the model with an infinite shock visibility horizon, i.e. full information rational expectations (FIRE).

$$\xi_t = F\xi_{t-1} + R^{[0]}\varepsilon_t + R^{[1]}\varepsilon_{t+1} + R^{[2]}\varepsilon_{t+2} + R^{[3]}\varepsilon_{t+3} + \dots \quad (1)$$

LIRE mitigates the issues with news shocks by assuming a limited visibility horizon. When simulating a forecast, one could decide that all shocks beyond period $t+k$, $k>0$, should be unanticipated. Departing slightly from FIRE, there is now a shock visibility horizon from time t to $t+k$, so only shocks until period $t+k$ are fully anticipated. Such a decision results in the model dynamics captured by Equations (2). The corresponding expectation scheme is depicted in Table 1.

$$\begin{aligned}
\xi_t &= F\xi_{t-1} + R^{[0]}\varepsilon_t \quad + R^{[1]}\varepsilon_{t+1} + R^{[2]}\varepsilon_{t+2} + \dots + R^{[k]}\varepsilon_{t+k}, \\
\xi_{t+1} &= F\xi_t \quad + R^{[0]}\varepsilon_{t+1} + R^{[1]}\varepsilon_{t+2} + R^{[2]}\varepsilon_{t+3} + \dots + R^{[k-1]}\varepsilon_{t+k}, \\
\xi_{t+2} &= F\xi_{t+1} + R^{[0]}\varepsilon_{t+2} + R^{[1]}\varepsilon_{t+3} + R^{[2]}\varepsilon_{t+4} + \dots + R^{[k-2]}\varepsilon_{t+k}, \\
&\vdots \\
\xi_{t+k} &= F\xi_{t+k-1} + R^{[0]}\varepsilon_{t+k}.
\end{aligned} \quad (2)$$

Table 1: Fixed Horizon Expectation Scheme

Period \ Horizon	year $y+1$				year $y+2$				year $y+3$				year $y+4$			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
current period	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
quarter $q+1$	P	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
quarter $q+2$	P	P	1	1	1	1	0	0	0	0	0	0	0	0	0	0
quarter $q+3$	P	P	P	1	1	1	0	0	0	0	0	0	0	0	0	0

Note: It is assumed that historical data are available until Q4 of year y. Therefore, the forecast in the current forecasting round starts in Q1 of year y+1. Columns represent the periods of the forecast horizon, while rows stand for the forecasted periods in the current forecasting round. The values show the proportion of the shock that is taken as anticipated. P stands for predicted value from previous period.

Additionally, LIRE allows for a discounting scheme (or decay of expectations) in periods beyond the full visibility horizon. With an increasing distance into the future, the proportion of the shocks taken as anticipated is reduced in line with some pre-determined scheme.[9] The model dynamics are then described by Equation (3), where $W^{[i]}$ stands for the weight matrices that describe the gradual fading out of expectations. The corresponding expectation scheme is depicted in Table 2. Note that both the fixed horizon expectation scheme and the fixed horizon expectation scheme

[9] The rest of the shocks (for example some domestic shocks) would be treated as surprise shocks. These surprise shocks would take effect only in the future and not influence the values of agents' expectations before they hit the economy.

with decay can be implemented in a given simulation/forecast by corresponding shock manipulation.[10]

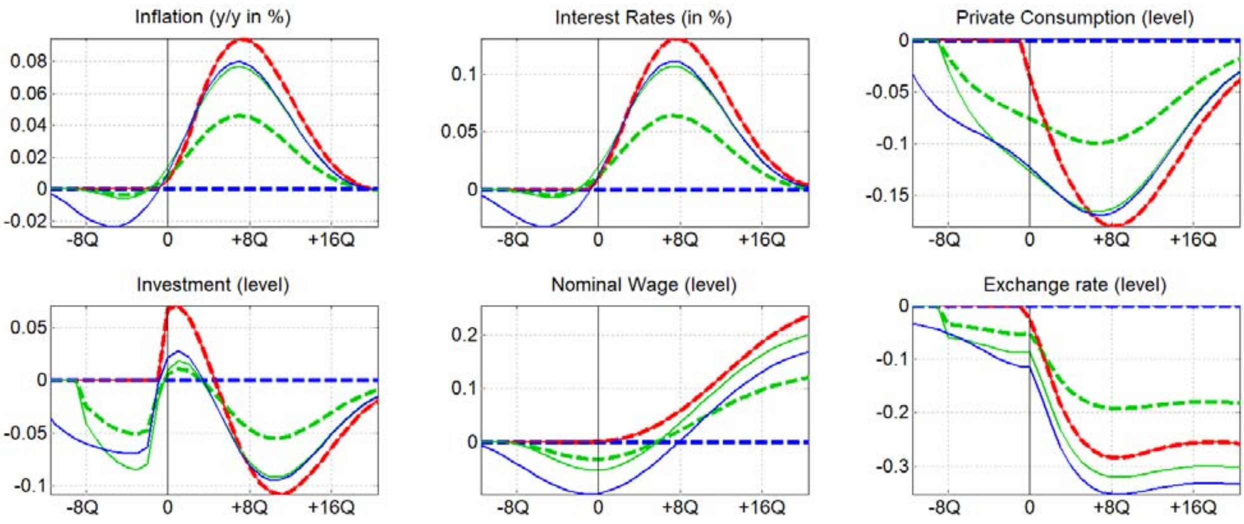
Table 2: Fixed Horizon Expectation Scheme with Decay

Period \ Horizon	year $y+1$				year $y+2$				year $y+3$				year $y+4$			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
current period	1	1	1	1	1	1	0.8	0.6	0.4	0.2	0	0	0	0	0	0
quarter $q+1$	P	1	1	1	1	1	0.8	0.6	0.4	0.2	0	0	0	0	0	0
quarter $q+2$	P	P	1	1	1	1	0.8	0.6	0.4	0.2	0	0	0	0	0	0
quarter $q+3$	P	P	P	1	1	1	0.8	0.6	0.4	0.2	0	0	0	0	0	0

Note: It is assumed that historical data are available until Q4 of year y. Therefore, the forecast in the current forecasting round starts in Q1 of year y+1. Columns represent the periods of the forecast horizon, while rows stand for the forecasted periods in the current forecasting round. The values show the proportion of the shock that is taken as anticipated. P stands for predicted value from previous period.

$$
\begin{aligned}
\xi_t &= F\xi_{t-1} + R^{[0]}W^{[0]}\varepsilon_t \quad + R^{[1]}W^{[1]}\varepsilon_{t+1} + R^{[2]}W^{[2]}\varepsilon_{t+2} + \cdots + R^{[k]}W^{[k]}\varepsilon_{t+k},\\
\xi_{t+1} &= F\xi_t \quad + R^{[0]}W^{[1]}\varepsilon_{t+1} + R^{[1]}W^{[2]}\varepsilon_{t+2} + R^{[2]}W^{[3]}\varepsilon_{t+3} + \cdots + R^{[k-1]}W^{[k]}\varepsilon_{t+k},\\
\xi_{t+2} &= F\xi_{t+1} + R^{[0]}W^{[2]}\varepsilon_{t+2} + R^{[1]}W^{[3]}\varepsilon_{t+3} + R^{[2]}W^{[4]}\varepsilon_{t+4} + \cdots + R^{[k-2]}W^{[k]}\varepsilon_{t+k},\\
&\vdots\\
\xi_{t+k} &= F\xi_{t+k-1} + R^{[0]}W^{[k]}\varepsilon_{t+k}.
\end{aligned}
\tag{3}
$$

Figure 3: Impulse Responses to Foreign Inflation Shock (Fully Expected vs. Fixed Horizon Expectation Scheme, Deviations from Steady State Values)



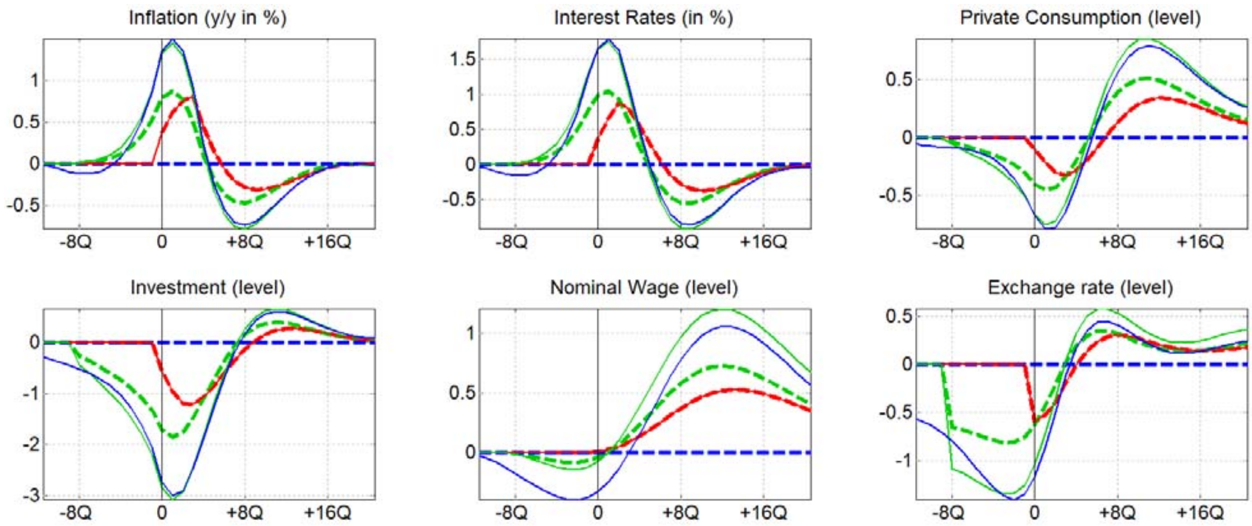
Note: IRFs to expected shocks: 12Q ahead – blue, 8Q ahead – green. IRFs to unexpected shocks – red. FIRE IRFs – thin solid line, fixed horizon expectation scheme IRFs – thick dashed line.

The impulse responses to news shocks without any restrictions (the FIRE case) and with the fixed anticipation scheme with decay (Table **2) are compared in Figure 3 (foreign inflation shocks) and Figure 4 (domestic cost-push shock).** One can observe that the fixed anticipation

[10] One could simply trim the vectors of the anticipated shocks to a given visibility horizon and/or multiply the vectors of the anticipated shocks by a pre-determined non-increasing vector representing the fade-out of expectations.

scheme does not affect the responses to shocks that are expected to occur in the near future (weights set to 1 in the scheme in Table *2*). The response to these shocks is identical to the unrestricted case, hence they are treated as fully anticipated news. The response to shocks further in the future is scaled down by the positive coefficients from the (0, 1) interval in the scheme. Shocks occurring beyond the horizon of the expectation scheme are treated as surprise shocks, i.e. they are not anticipated (zeros in the scheme).

Figure 4: Impulse Responses to Domestic Cost-push Shock (Fully Expected vs. Fixed Horizon Expectation Scheme, Deviations from Steady State Values)



Note: IRFs to expected shocks: 12Q ahead – blue, 8Q ahead – green. IRFs to unexpected shocks – blue. FIRE IRFs – thin solid line, fixed horizon expectation scheme IRFs – thick dashed line.

The fixed horizon anticipation scheme (with decay) reduces the variability imposed by news shocks, but the foreseen horizon would still vary across consecutive forecasts. The scheme introduced above certainly limits the variability of the model responses to shocks that are to occur far in the future, because these shocks are discarded from the anticipated information set. However, substantial changes between consecutive forecasts are still experienced due to shifts in the forecast horizon (or the end of history period) due to new information entering the forecast/simulation (shocks that were unanticipated in the previous forecast). Moreover, the response of the model economy to shocks that are treated as news inside the horizon of the expectation scheme varies as well, ranging from very small (coefficients close to zero) to fully expected (coefficients close to one). And finally, the response to fully anticipated news shocks in the near future depends on their distance in time and generally changes between consecutive forecasts in the same way as under FIRE.

The approach to LIRE processing is based on an assumption of a moving-horizon anticipation scheme. Under the LIRE approach, one still assumes a future time point beyond which all shocks will be taken as unanticipated and a horizon that allows for a gradual-fade out of anticipation. This holds in relative terms for each period of the forecast individually, not for the forecast as a whole. This is because the whole expectation scheme shifts forward along the forecast trajectory in each period of time[11] (see Tables 3 and 4). Therefore, the LIRE concept moves further from the simple manipulation of shocks in a forecast to a more general approach based on adjustment of the response matrices.

The LIRE concept ensures consistent treatment of news shocks in subsequent forecasts. As a result, the issue of the forecast changing between forecasting rounds due to the shifting foreseen horizon is effectively mitigated.[12] Under LIRE, each shock is treated the same way across the consecutive forecasting rounds.[13] Moreover, the information from the whole forecast horizon enters the forecast, but it does so only gradually (as the window moves). The dynamics of the model economy under the LIRE concept are captured by Equation (4). Notice that the indices of the weight matrices $W^{[i]}$ no longer correspond to shocks ε (as in Equation (2)) but rather to the response matrices R. Also note that the response matrices R are still obtained as a model solution under the assumption of fully rational expectations.

$$
\begin{aligned}
\xi_t &= F\xi_{t-1} + R^{[0]}W^{[0]}\varepsilon_t \quad + R^{[1]}W^{[1]}\varepsilon_{t+1} + R^{[2]}W^{[2]}\varepsilon_{t+2} + \cdots + R^{[k]}W^{[k]}\varepsilon_{t+k}, \\
\xi_{t+1} &= F\xi_t \quad + R^{[0]}W^{[0]}\varepsilon_{t+1} + R^{[1]}W^{[1]}\varepsilon_{t+2} + R^{[2]}W^{[2]}\varepsilon_{t+3} + \cdots + R^{[k]}W^{[k]}\varepsilon_{t+k+1}, \\
\xi_{t+2} &= F\xi_{t+1} + R^{[0]}W^{[0]}\varepsilon_{t+2} + R^{[1]}W^{[1]}\varepsilon_{t+3} + R^{[2]}W^{[2]}\varepsilon_{t+4} + \cdots + R^{[k]}W^{[k]}\varepsilon_{t+k+2}, \\
&\vdots \\
\xi_{t+s} &= F\xi_{t+s-1} + R^{[0]}W^{[0]}\varepsilon_{t+s} + R^{[1]}W^{[1]}\varepsilon_{t+s+1} + R^{[2]}W^{[2]}\varepsilon_{t+s+2} + \cdots + R^{[k]}W^{[k]}\varepsilon_{t+k+s} \\
&\vdots
\end{aligned}
\tag{4}
$$

Using the definition $R^{[i]}W^{[i]} = R^{*[i]}$, we can state the following general form:

$$
\begin{aligned}
\xi_t &= F\xi_{t-1} + R^{*[0]}\varepsilon_t \quad + R^{*[1]}\varepsilon_{t+1} + R^{*[2]}\varepsilon_{t+2} + \cdots + R^{*[k]}\varepsilon_{t+k}, \\
\xi_{t+1} &= F\xi_t \quad + R^{*[0]}\varepsilon_{t+1} + R^{*[1]}\varepsilon_{t+2} + R^{*[2]}\varepsilon_{t+3} + \cdots + R^{*[k]}\varepsilon_{t+k+1}, \\
\xi_{t+2} &= F\xi_{t+1} + R^{*[0]}\varepsilon_{t+2} + R^{*[1]}\varepsilon_{t+3} + R^{*[2]}\varepsilon_{t+4} + \cdots + R^{*[k]}\varepsilon_{t+k+2}, \\
&\vdots \\
\xi_{t+s} &= F\xi_{t+s-1} + R^{*[0]}\varepsilon_{t+s} + R^{*[1]}\varepsilon_{t+s+1} + R^{*[2]}\varepsilon_{t+s+2} + \cdots + R^{*[k]}\varepsilon_{t+k+s} \\
&\vdots
\end{aligned}
\tag{5}
$$

[11] For example, let's assume a news shock four quarters ahead in the forecast horizon (t+4). In the current quarter of the forecast t, the shock is thus treated as a news shock four quarters ahead (t, t+4). In the second quarter of the forecast, it is treated as a news shock three quarters ahead (t+1, t+4) and so on until it becomes a surprise shock in the quarter when it appears (t+4, t+4).

[12] For more distant anticipated shocks, which do not enter the forecast at the shorter end, the issue is eliminated. However, as the shocks become 'visible' under the given expectation scheme, the response of the model becomes sensitive to their distance in time. This is a feature inherited from RE, where the impulse responses to anticipated shocks are generally different, depending on the distance of the shock in the future. Thus, the impulse response to the same shock in the same period will be slightly different when the forecast horizon shifts forward. Since the reaction to an unanticipated shock is generally different from the response to an anticipated shock, the problem with the forecast changing under the same outlook can only be fully eliminated with anticipated shocks completely switched off, that is, only if $R^{[i]}=0$ for all $i>0$. In other words, it is possible to move along the IRF between consecutive forecasts only in the case of surprise shocks.

[13] For example, a news shock four quarters ahead (t+4) in one forecasting round (starting at time t) will be treated as a news shock three periods ahead in the second quarter of the same forecast (t+1, t+4). In the subsequent forecasting round that takes place one quarter later (and starts at time t+1), the same shock will be treated as a news shock three periods ahead (t+1, t+4), which means that this particular shock is treated the same way as in the previous forecasting round in period (t+1).

In a sense, the LIRE approach can be adjusted to represent the RE approach. One can imagine FIRE as LIRE with $k = \infty$ and the weight matrices set to identity matrices. The moving horizon scheme being applicable to both approaches, LIRE deviates from FIRE in assuming a finite visibility horizon k and allowing for the weight matrices to fade out. This means that LIRE effectively works similarly to RE, with some notable exceptions. Most importantly, LIRE prevents anticipated shocks placed very far in the future from affecting the immediate periods of the simulation/forecast. Nevertheless, these shocks will influence a part of the trajectory that is close enough to the shock in question.

3.2 Parametrization of LIRE

There are some settings that need to be properly chosen. These include the length of the expectation scheme and the decay scheme, if it is used. Both are captured by matrices $W^{[i]}$.

In general, the set of the proposed LIRE weight matrices $W^{[i]}$ follows these assumptions:

1. The weight matrix $W^{[0]}$ corresponding to surprise shocks (for the current period) is an identity matrix.
2. The weight matrices are diagonal, because the structural shocks are uncorrelated.
3. The diagonal elements of the weight matrices take values between zero and one only.
4. The elements of the weight matrices at given coordinates do not increase with increasing horizon.
5. There is a finite horizon beyond which all shocks are taken as unanticipated and thus matrix $W^{[i]}$ is a zero matrix.

Depending on the parametrization, the LIRE concept allows for fully anticipated and surprise shocks, as well as any combination in between. The expectation scheme setting equivalent to full information rational expectations would require the weight matrices $W^{[i]}$ to be equal to an identity matrix for an infinite horizon (or a sufficiently large visibility horizon k). At the same time, one can easily collapse the concept into the unexpected shock case by setting the weight matrices to zero (except for matrix $W^{[0]}$, which is always kept equal to an identity matrix).

The visibility horizon and the decay of expectations under LIRE can be set independently for each type of shock in the model. When setting the weight matrices $W^{[i]}$, one defines how the model economy reacts to all the anticipated shocks. However, this does not mean that all the shocks in the model must follow the same expectation scheme. On the contrary, the LIRE concept allows for a different visibility horizon and decay of expectations across exogenous shocks.[14] On the other hand, the LIRE approach does not allow for different expectation schemes across economic agents of the DSGE model.

The length of the expectation scheme for LIRE should cover at least the monetary policy horizon in general for key shocks determining the story of the forecast. This will ensure that monetary policy and all agents in the economy are not surprised by the available set of information

[14] For example, a group of shocks can have a more distant visibility horizon and slower decay of expectations (shocks fixing the foreign outlook) than the others (domestic fiscal policy shocks), while at the same time there can be some fully anticipated shocks (inflation target shock).

inside the monetary policy horizon. At the same time, the central bank reacts to this outlook, which is a prerequisite for it to reach its monetary policy objectives within the required horizon.

The LIRE concept ensures that all the available information is taken into account when producing the macroeconomic forecast. The LIRE approach allows this to happen in an efficient and controlled manner. As the LIRE expectation scheme moves along the forecast trajectory within the simulation, all the information is eventually incorporated into the forecast. In other words, the LIRE algorithm ensures that all the agents in the economy will eventually learn the whole trajectory of the exogenous outlook. Nevertheless, they will react only to a subset of the whole outlook at any given time. Therefore, it makes sense for the monetary policy response of the central bank to take into account the same information set, that is, the information that is relevant to the whole economy at that time.

One possible moving horizon for the LIRE expectation scheme with diminishing weights is demonstrated in Table 3. Note that in this approach the expectation scheme is valid for all agents in the economy, including the central bank. Under this assumption, the full information horizon is set to cover six quarters fully, with linear decay beyond. This scheme is set far enough to cover the monetary policy horizon, which is one to one and a half years.

Table 3: Moving Horizon Expectation Scheme with Decay – Foreign Variables Outlook

Horizon	year $y+1$				year $y+2$				year $y+3$				year $y+4$			
Period	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
current period	1	1	1	1	1	1	0.8	0.6	0.4	0.2	0	0	0	0	0	0
quarter $q+1$	P	1	1	1	1	1	1	0.8	0.6	0.4	0.2	0	0	0	0	0
quarter $q+2$	P	P	1	1	1	1	1	1	0.8	0.6	0.4	0.2	0	0	0	0
quarter $q+3$	P	P	P	1	1	1	1	1	1	0.8	0.6	0.4	0.2	0	0	0

Note: It is assumed that historical data are available until Q4 of year y. Therefore, the forecast in the current forecasting round starts in Q1 of year y+1. Columns represent the periods of the forecast horizon, while rows stand for the forecasted periods in the current forecasting round (as well as for subsequent forecasting rounds beginning with the given period). The values show the proportion of the shock that is taken as anticipated. P stands for predicted value from previous period.

Another example of an expectation scheme with a shorter horizon and quicker decay is presented in Table 4. This may reflect frequent changes and revisions to the outlooks for some variables. It can also be chosen in cases of less reliable outlooks for certain variables.

Table 4: Moving Horizon Expectation Scheme with Decay – Domestic Variables Outlook

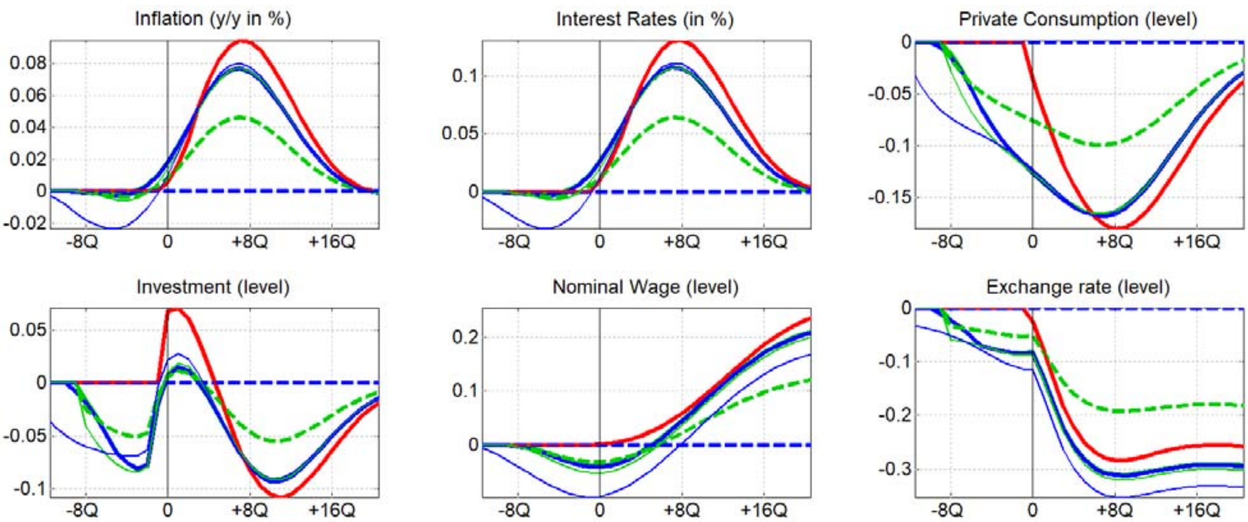
Horizon	year $y+1$				year $y+2$				year $y+3$				year $y+4$			
Period	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
current period	1	0.75	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0
quarter $q+1$	P	1	0.75	0.5	0	0	0	0	0	0	0	0	0	0	0	0
quarter $q+2$	P	P	1	0.75	0.5	0	0	0	0	0	0	0	0	0	0	0
quarter $q+3$	P	P	P	1	0.75	0.5	0	0	0	0	0	0	0	0	0	0

Note: It is assumed that historical data are available up until Q4 of year y. Therefore, the forecast in the current forecasting round starts in Q1 of year y+1. Columns represent the periods of the forecast horizon, while rows stand for the forecasting round (as well as for subsequent forecasting rounds beginning with the given period). The values show the proportion of the shock that is taken as anticipated. P stands for predicted value from previous period.

3.3 LIRE Properties

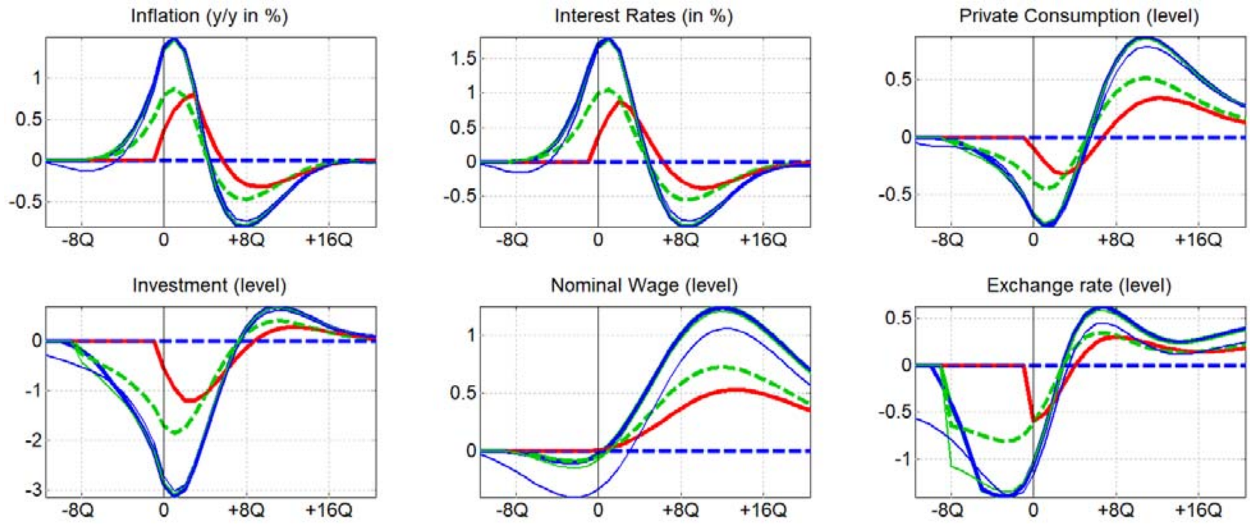
A comparison of the impulse responses to different approaches to handling news shocks clearly reveals the contrast in their impacts. There are different types of unrestricted news shocks: news shocks under the fixed expectation scheme with decay (Table 2) and news shocks under the moving horizon expectation scheme with decay (LIRE – Table 3), depicted in Figure 5 (foreign inflation shock) and Figure 6 (domestic cost-push shock). Among these three alternatives, the LIRE approach is best suited to reducing the issues with news shocks. The LIRE approach combines the best of both worlds. In the period before the shock hits the economy, the variability of the impulse responses is limited by excluding very distant shocks from the expectation information set. Therefore, the LIRE approach avoids overreactions to shocks that are anticipated to occur in the future in a similar way to the fixed expectation scheme approach. On the other hand, in the period after the shock occurs, the response under LIRE is very similar to the unrestricted case of news shocks under perfect information. This is the better case, since the impulse response to fully anticipated shocks after the shock actually hits the economy is often quite similar. This was not the case under the fixed expectation scheme, where the scaling of the impulse responses increased the impulse response variability after the occurrence of the shock.

Figure 5: Impulse Responses to Foreign Inflation Shock (Fully Expected vs. Fixed Horizon Expectation Scheme vs. LIRE, Deviations from Steady State Values)



Note: IRFs to expected shocks: 12Q ahead – blue, 8Q ahead – green. IRFs to unexpected shocks – red. FIRE IRFs – thin solid line, fixed horizon expectation scheme IRFs – thick dashed line, LIRE IRFs – thick solid line.

Figure 6: Impulse Responses to Domestic Cost-push Shock (Fully expected vs. Fixed Horizon expectation Scheme vs. LIRE, Deviations from Steady State Values)

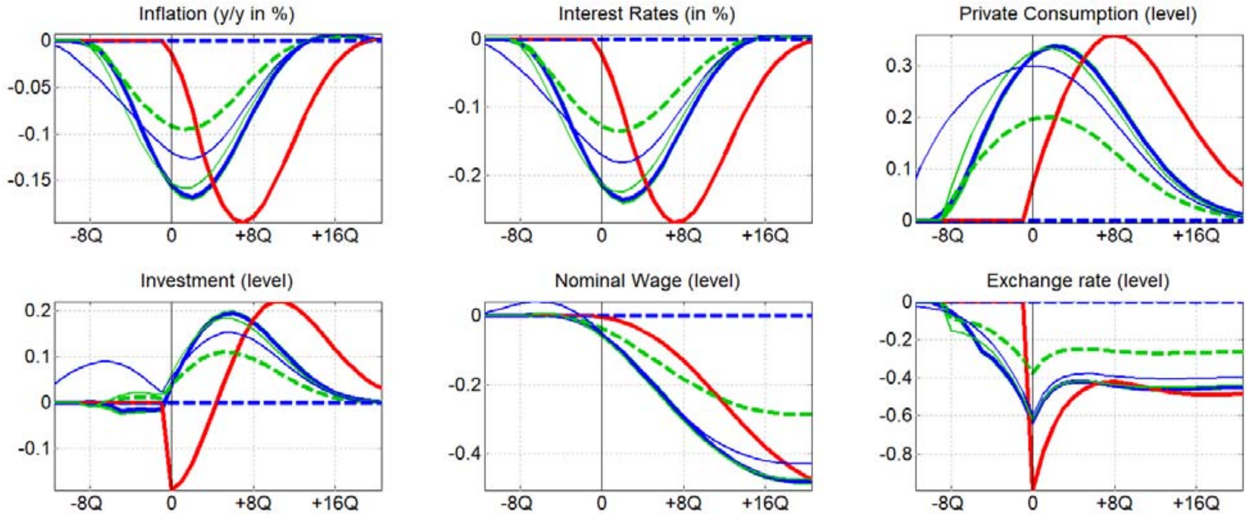


Note: IRFs to expected shocks: 12Q ahead – blue, 8Q ahead – green. IRFs to unexpected shocks – red. FIRE IRFs – thin solid line, fixed horizon expectation scheme IRFs – thick dashed line, LIRE IRFs – thick solid line.

3.4 Implications for Forecasting

One of the main practical advantages of the proposed LIRE approach is reduced variability of responses to the same anticipated shocks between subsequent forecasts stemming solely from the change in the forecast horizon (or a shift in the starting period of the forecast). In cases where the assumptions of the previous forecast were exactly right, it makes no sense to make substantial changes to the next one just because the shocks that correspond to those assumptions are now one quarter closer. Nevertheless, there is also a trade-off; shocks that are expected in the near future need to be anticipated appropriately. This is required in order for monetary policy to be sufficiently forward-looking in the model to be able to drive inflation back to the target at the monetary policy horizon. In other words, LIRE makes the IRFs to the same news shock that differs only in its distance in the future more similar to each other, especially for longer horizons of anticipation. For shorter horizons, such as the monetary policy horizon, the impulse responses will remain as dissimilar as in the FIRE case.

Figure 7: Impulse Responses to Negative Foreign Monetary Policy Shock (Fully Expected vs. Fixed Horizon expectation Scheme vs. LIRE, Deviations from Steady State Values)



Note: IRFs to expected shocks: 12Q ahead – blue, 8Q ahead – green. IRFs to unexpected shocks – red. FIRE IRFs – thin solid line, fixed horizon expectation scheme IRFs – thick dashed line, LIRE IRFs – thick solid line.

Also, the LIRE approach allows for more realistic treatment of announced or expected fiscal and monetary policy actions by mitigating the 'forward guidance puzzle'. In the current circumstances, with many states around the world incurring large public deficits, subsequent fiscal consolidation has become a crucial part of baseline forecast scenarios. Due to the limited credibility of such policy and the high uncertainty of current situation, the immediate effects of an expected fiscal consolidation will probably differ depending on its distance in the future. Even a publicly announced fiscal consolidation will probably influence the behaviour of economic agents only marginally or not at all at present if it is supposed to take place several years ahead. On the other hand, a fiscal consolidation announced for the next year will have much greater credibility and economic agents will probably take this information into account when making their economic decisions today. Similarly, the immediate effects of forward guidance in monetary policy will in fact be less pronounced for very distant horizons, because these are practically irrelevant for most economic agents today – see the comparison of the impulse responses to an expected negative foreign monetary policy shock in Figure 7.

The LIRE approach delivers lower forecast errors on average than the FIRE concept, especially when a longer horizon is used to condition the forecast. To check the implications of the LIRE approach for the forecast error, we compute recursive in-sample simulations for the CNB's core forecasting DSGE model, g3+. The forecast is conditioned by the foreign outlook. In the case of LIRE, the expectation scheme from Table 3 is applied. The squared forecast error is summed over the forecast horizon up to 8 quarters ahead over the horizon of 2000 Q4 to 2019 Q4. Horizons of 8, 12, 16 and 20 quarters of conditioning information about foreign variables on the forecast are compared. The results are presented in Tables 5 and 6.

Table 5: In-sample Simulations – Cumulative RMSE Comparison

Cumulative RMSE	LIRE	FIRE	LIRE	FIRE	LIRE	FIRE	LIRE	FIRE
Conditioning horizon	*8 quarters*		*12 quarters*		*16 quarters*		*20 quarters*	
Interest Rate	242	240	230	241	233	242	200	211
CPI Inflation	1265	1282	1244	1266	1208	1225	1178	1196
Exchange Rate	283	292	232	242	213	228	179	185
Private Consumption	507	500	474	456	453	448	406	430
Investment	3129	3130	2704	2707	2425	2425	2333	2358
Exports	2400	2402	2189	2200	2170	2184	2116	2138
Imports	2342	2341	2146	2141	2105	2095	2068	2059
Consumption Deflator	430	430	406	403	370	368	350	352
Investment Deflator	1201	1201	1016	1012	981	965	936	916
Export Deflator	1356	1352	1187	1148	1189	1157	1095	1083
Import Deflator	1363	1357	1136	1142	1104	1128	999	1040
Real Wage	641	641	641	644	875	884	928	968

Table 6: In-sample Simulations – Relative RMSE Comparison (in % of LIRE Cumulative RMSE)

Relative FIRE vs. LIRE	FIRE - LIRE	FIRE - LIRE	FIRE - LIRE	FIRE - LIRE
Conditioning horizon	*8 quarters*	*12 quarters*	*16 quarters*	*20 quarters*
Interest Rate	-0.83	4.78	3.86	5.50
CPI Inflation	1.34	1.77	1.41	1.53
Exchange Rate	3.18	4.31	7.04	3.35
Private Consumption	-1.38	-3.80	-1.10	5.91
Investment	0.03	0.11	0.00	1.07
Exports	0.08	0.50	0.65	1.04
Imports	-0.04	-0.23	-0.48	-0.44
Consumption Deflator	0.00	-0.74	-0.54	0.57
Investment Deflator	0.00	-0.39	-1.63	-2.14
Export Deflator	-0.29	-3.29	-2.69	-1.10
Import Deflator	-0.44	0.53	2.17	4.10
Real Wage	0.00	0.47	1.03	4.31
Cumulative total	1.65	4.02	9.72	23.72
Average per variable	0.14	0.34	0.81	1.98

In general, extending the conditioning information set helps to reduce the forecast error for most of the variables (see Table 5). Thus, the comparison of the cumulative RMSE in absolute terms demonstrates the usefulness of news shocks. One prominent exception is real wage growth, which is quite persistent in the Czech economy. In the model, however, wages react to the foreign outlook quite significantly, so the situation actually gets worse when the conditioning information set is extended.

LIRE concept outperforms FIRE on average, with the improvement getting more substantial when the conditioning horizon is longer (see Table 6). In order to show the benefits of restricting expectations to LIRE, we calculated the relative difference in the cumulative RMSE under FIRE and LIRE. The results show that FIRE delivers a higher cumulative RMSE on average. The differences become more substantial when the conditioning set spans longer horizons. This makes sense, because for shorter horizons the LIRE expectation scheme is deliberately kept very close to FIRE. It is only when information further in the future is used to condition the forecast that the differences between LIRE and FIRE become apparent. In the case of LIRE, this rather distant information is discounted and the reaction of the model variables is limited. The issues similar to the 'forward guidance puzzle' are thus less likely to arise.

We believe that the LIRE approach better reflects the limitations on the formation of expectations that we observe in reality. It is thus able to deliver more intuitive results than pure FIRE. Under LIRE, economic agents react to an expected shock only when it gets close enough.[15] Very distant shocks are irrelevant to their present behaviour.

4. Conclusion

Surprise and news shocks under RE exhibit significantly different impulse response patterns. News shocks imply that economic agents react in advance of announced future shocks. A movement in economic variables is thus observed prior to the shock. As a result, there are three key differences between surprise and news shocks. First, the impulse responses are both quantitatively and qualitatively different. Second, the impulse responses to news shocks vary with the length of the foreseen period. Third, given the examples introduced in this paper, news shocks tend to raise the variability of some macroeconomic variables compared to surprise shocks in the case of domestic shocks, but might reduce the variability in the case of foreign shocks.

Central banks' forecasts should treat most shocks as news shocks. First, the central bank needs to take all the available information into account when compiling a forecast and subsequently respond to shocks over the forecast horizon in order to fulfil its price stability objective. When treating shocks over the forecast horizon as surprise shocks, the primary objective might not be fulfilled, as the shocks would present an unexpected surprise even for the central bank. Such a forecast would not provide sufficient guidance for market expectations and would threaten the credibility of the central bank.

However, news shocks under the assumption of full information (FIRE news) have several practical drawbacks. First, the pass-through of news shocks might be too strong and challenging to explain. Even news shocks at the end of the forecast horizon affect the dynamics of the variables at the very beginning of a forecast, which can lead to the 'forward guidance puzzle' in the case of monetary policy shocks. Second, two consecutive forecasts assuming exactly the same news shocks differ due to the shift of the foreseen horizon. Thus, the new forecast does not move further along the original impulse response but rather implies a generally different shape of the impulse response corresponding to the shorter foreseen horizon.

The LIRE approach modifies the original FIRE, making it more versatile and closer to economic intuition. In many practical applications, the FIRE approach leads to unrealistic results. Under LIRE, additional assumptions can be imposed on the model behaviour in response to expected shocks. These assumptions are formalized in a form of an expectation scheme and treated within the forecast in a consistent way. An expected shock will influence the behaviour of economic agents only in periods that are close enough to the shock in question. Nevertheless, even very distant shocks will eventually influence the forecast trajectory at some point along the forecast horizon.

[15] It is, of course, an empirical question what 'close enough' is. Here, it means 'according to the expectation scheme', which may generally be different for different shocks.

The logic and intuition behind the presented approaches to the treatment of expectations can be explained using a simple driving analogy. Imagine a driver on a racetrack in foggy weather. First, the FIRE concept assumes that the driver knows the shape of the racetrack perfectly from the start. She is thus bothered by the fog only if something unexpected happens, such as a rabbit running across the track or a tree branch falling on the road. The driver can also take the most efficient and smooth path through the bends. Second, the fixed horizon expectation scheme approach can be likened to a distracted driver. The driver doesn't really know the racetrack and only looks through the windscreen from time to time. Thus, each time the road is checked (the forecast horizon is extended/shifted forward), the driver learns about the next turn or two. Sometimes, the driver is surprised by the shape of the track ahead and has to adjust her path quickly. Third, the moving horizon expectation scheme, or LIRE, is similar to a driver who does not know the racetrack in advance but who pays attention and watches the road ahead continuously. The driver does not have the path figured out from the start but learns about the road ahead as soon as it emerges from the fog in front of her. The necessary path adjustments are carried out on the fly, making them easy enough. So, which driver fits central banks' monetary policy in the best way?

Further research should be directed at finding a structural treatment of LIRE that would potentially eliminate the problem with the changing shape of the impulse responses to news shocks between consecutive forecasts. The LIRE approach as presented here is implemented on top of a model solved under the assumption of FIRE. A natural next step would be to introduce LIRE directly into the model. In this regard, the model structure would encompass information about the shape of expectations. Such an approach would allow the Kalman filter to identify news shocks over history and thus deal with the issues concerning shifting the end of history. This would allow the simulated trajectories to move along the given IRF of a news shock between consecutive forecasts rather than switching between IRFs with different foreseen horizons.

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