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The Anatomy of Monetary Policy Transmission: A Structural Decomposition

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Abstract

We study the transmission of UK monetary policy using a medium-sized Bayesian VAR identified with an external instrument and estimated on monthly data (1998M2–2019M12) with an extensive financial-markets-and-expectations block. Using Transmission Channel Analysis (TCA), we formally define dynamic transmission channels and prove that the resulting effects through the channels are invariant to a large set of alternative thought experiments. Empirically, we find that the bulk of UK monetary policy transmission operates through the financial-market and expectations variables included in our model. Second- round (feedback) effects become important for services and prices at longer horizons, but are less relevant for retail sales. A full decomposition shows that housing-related wealth and cash-flow channels account for most of the real and price responses; equity wealth and expectations channels are meaningful, while the exchange-rate channel plays a limited role for aggregate consumer prices over the estimation period.

Keywords: UK Monetary Policy, Transmission Channels, Housing Wealth Channel, Cash-flow Channel, Equity Wealth Channel, Exchange Rate Channel
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1 Introduction

Aggregate effects of monetary policy are well documented. The mechanisms underlying those effects are, however, much contested. This is because in equilibrium models, "channels" are not uniquely defined objects (Dogra, 2024): they are defined by a thought experiment that holds some margins fixed while others are allowed to vary. Since the exact thought experiment differs across studies, finding consensus has been difficult. Moreover, these thought experiments are often not communicated explicitly, further complicating consensus formation. In this paper, we provide new insights into the transmission channels of UK monetary policy using the methodology of Wegner et al. (2025). We therefore provide an internally consistent decomposition of the total monetary policy effects that (i) is additive, (ii) is transparent about the thought experiment that holds some margins fixed, and (iii) can be replicated in models and in data, thereby facilitating consensus formation—at least within the chosen paradigm.

Our first contribution is a formal definition of monetary policy transmission channels within the framework of Wegner et al. (2025). Most descriptions of transmission channels are static and imprecise, and therefore do not clearly specify how channels operate dynamically across horizons or how they interact. Our formal definition makes the dynamic nature of channels explicit and defines channels as separate objects, thereby also clarifying how channels can interact. Moreover, using this formalism, we prove an invariance result: effects through our channels are invariant to a large set of alternative specifications—that is, alternative thought experiments. Thus, we provide a robust, formal baseline specification of monetary policy transmission channels.

Our second contribution is a joint empirical quantification of UK monetary policy transmission channels. We move beyond documenting significant asset-price and expectations responses to showing whether, and when, those responses actually transmit to activity and prices. Moreover, most channel narratives are one-way, focusing on how monetary policy transmits through a given channel to activity and prices; we instead quantify the feedback between activity, financial markets, and expectations, as well as its dynamic profile. Specifically, we address three empirical questions. First, we quantify how much of monetary policy transmission to real activity and prices operates through financial markets and expectations—often presumed to be the central mechanism. Second, we quantify the strength and sign of feedback from activity and prices back into financial markets and expectations, and whether this feedback amplifies or dampens transmission over time. Third, motivated by the HANK literature (Albuquerque et al., 2025; Auclert, 2019; Kaplan et al., 2018), we quantify the relative importance of cash-flow, wealth, expectations, and exchange rate channels across horizons.

We find that the aggregate channel through financial markets and expectations accounts for the bulk of monetary policy transmission. However, the early, rapid reaction of aggregate consumer prices remains unexplained by this channel. Splitting the aggregate financial-markets-and-expectations channel into its first-round and second-round (feedback) components, we find that second-round effects drive longer-horizon responses in services and consumer prices, but play a smaller role for retail sales. Decomposing the responses further, we find that cash-flow and wealth channels—particularly those related to housing—account for most of the responses of activity and consumer prices. Effects through the expectations channel reduce retail and services activity but have little impact on consumer prices. The exchange rate channel has substantial effects on producer input prices and, to a certain extent, on consumer goods prices, but its pass-through to aggregate consumer prices is weak.

Related Literature. Our analysis relates to a vast literature on monetary policy transmission. A comprehensive review is neither feasible within the scope of this paper, nor our primary objective. Instead, we organise the discussion around two questions: how transmission "channels" are defined in equilibrium settings, and what theoretical and empirical work concludes about their quantitative importance. We first review the main methodological approaches and clarify how they compare to the method we employ (Wegner et al., 2025). We then turn to related theoretical and empirical findings, with an emphasis on evidence for cash-flow, wealth, exchange rate, and expectations channels.

Traditionally, transmission channels are described using causal language. For example, Mishkin (1996) describes the interest rate channel of monetary policy as one in which "expansionary monetary policy [leads] to a fall in real interest rates, which in turn lowers the cost of capital, causing a rise in investment spending, thereby leading to an increase in aggregate demand and a rise in output". But in the equilibrium models commonly used for policy analysis, market clearing and enforced equilibrium at every instance imply that causal links between endogenous variables cannot, in general, be established (Dogra, 2024). An Euler equation, for instance, is neither a causal law of consumption given interest rates, nor a causal law of bond prices given consumption. In that sense, "channels" are not uniquely defined objects in general equilibrium models, often leading to contradictory conclusions about the main "channels" (Dogra, 2024; Kaplan et al., 2018; Rupert & Šustek, 2019). Yet, a large literature tries to open the black box of general equilibrium by providing narratives for total policy effects; our approach, developed by Wegner et al. (2025), belongs to this tradition but uses a different thought experiment.

Three common strategies stand out. First, typical textbook partial-equilibrium reasoning reads off transmission from key equations, such as the Euler equation (Galí, 2015; Woodford, 2004), corresponding to a thought experiment in which all but a single sector are treated as exogenous. This often suggests that monetary policy in traditional New Keynesian (NK) models mostly transmits through an intertemporal substitution channel, governed by the elasticity of intertemporal substitution (EIS). Second, counterfactual approaches "switch off" a specific model feature—often labelled a "channel"—by setting certain parameters or wedges to zero, or by comparing the original model to a nested frictionless model (Bernanke et al., 1999; Christiano et al., 2005; Iacoviello, 2005). The thought experiment behind these counterfactuals corresponds to a specific set of behavioural changes. Third, approaches commonly used in the HANK literature (Auclert, 2019; Bilbiie, 2020; Kaplan et al., 2018) define "channels" as formal mathematical objects, equivalent to a thought experiment in which the response of some variable to other variables is held fixed along a partial-equilibrium adjustment path. These methods can often be interpreted within a New Keynesian Cross (Bilbiie, 2020) paradigm.

While all three strategies correspond to well-defined thought experiments, they can be misleading about general equilibrium movements. Dogra (2024) shows that alternative Taylor rules or additional frictions in otherwise standard NK models can generate total effects of monetary policy shocks that are either completely independent of the EIS, or for which an increase in the EIS leads to weaker monetary policy effects. Thus, partial-equilibrium reasoning—which would imply that monetary policy becomes stronger as the EIS increases—can be misleading. Similar issues arise for counterfactual analysis: in those exercises, the EIS typically cannot "only" determine the strength of the intertemporal substitution channel. Instead, it must also govern other general-equilibrium adjustments that may offset the intertemporal substitution channel at all times. Dogra (2024) further shows that even formally defined channels of the "HANK type" can be misleading: direct effects can be arbitrarily large even as the EIS becomes irrelevant for the total equilibrium response. Moreover, all three approaches are difficult to implement empirically and therefore remain tied to

a specific theoretical model.

Compared to these approaches, the method introduced by Wegner et al. (2025) corresponds to a thought experiment that explains the dynamics of structural shocks using an as-if scenario in which the world is driven by the mechanisms encoded in the channels under investigation. Thus, if channels were to represent causal mechanisms—equivalently, if the partial-equilibrium equations were causal laws—then the analysis of Wegner et al. (2025) would be causally correct. Alternatively, the thought experiment can be interpreted in stages. A channel within the Wegner et al. (2025) framework can be read as a chain of deductions: we take an exogenous movement in one variable as given (say, interest rates), deduce how the output gap is expected to move given that movement, and then deduce how inflation is expected to move in response. Similar to the HANK literature (Auclert, 2019; Kaplan et al., 2018), Wegner et al. (2025) formalise their thought experiment and require formal definitions of channels as paths through a graph. This formalism enables sensitivity analysis with respect to the exact thought experiment. However, as with the other approaches, the critique of Dogra (2024) still applies: channels cannot generally be interpreted causally, nor are effects along specific channels driven by a single parameter in a structural model. Nonetheless, the approach of Wegner et al. (2025) is easily implemented in both empirical and theoretical settings. In the absence of a uniquely "best" approach, this method can therefore contribute to a pluralistic view on transmission channels from an empirical perspective and, at the same time, be used to discipline theoretical models.

With these methodological distinctions in place, we now turn to what the literature implies about which channels matter quantitatively. We review both theoretical results and empirical evidence that estimates the contribution of financial markets, expectations, cash-flow, wealth, and exchange-rate channels to the transmission of monetary policy.

First, our work relates to the literature using high-frequency instruments for monetary policy—both for the UK and beyond (see, e.g., Cesa-Bianchi et al., 2020; Jarociński & Karadi, 2020; Miranda-Agrippino & Ricco, 2021). Similar to that literature, we find a rapid initial decline in prices, while real activity variables react more sluggishly. Real-activity-related channels are therefore unlikely to explain the initial price reaction, and exchange rate or expectations effects may instead be the driving force. Our results, indicating that channels through financial markets (including exchange rates) or expectations cannot explain this initial reaction, suggest that other channels may be at play. Although our robustness checks use the poor-man restrictions of Jarociński and Karadi (2020) to separate monetary policy from information effects, this procedure is imperfect, and the rapid reaction may therefore still be driven by information effects.

At a more disaggregated level, our results relate to an active discussion about monetary policy transmission in RANK and HANK models. Kaplan et al. (2018) and Bilbiie (2020) argue that monetary policy is primarily transmitted through direct intertemporal substitution channels in RANK models. Rupert and Šustek (2019) take a different perspective, with a different underlying thought experiment, and conclude that even in RANK models, transmission operates primarily through channels other than intertemporal substitution. We find that the bulk of monetary policy transmission operates through cash-flow and wealth channels, with little evidence for a strong intertemporal substitution channel. This finding is also related to the redistribution channel emphasised by Auclert (2019). However, redistribution often implies asymmetries in the relevance of channels, which are beyond the scope of this paper.

Our findings on the mortgage cash-flow channel relate to Di Maggio et al. (2014), Flodén et al. (2021), Jappelli and Scognamiglio (2018), Keys et al. (2014), and La Cava et al. (2016), who find evidence of increased spending after mortgage rate declines, and therefore evidence of a mortgage cash-flow channel, in the US, Australia, Italy, and Sweden. However, Jappelli and Scognamiglio (2018) argue that the strength

of the spending response depends on how persistent households perceive the rate cut to be. Moreover, Di Maggio et al. (2014) and Keys et al. (2014) find evidence that some of the windfall is used for deleveraging rather than consumption. Thus, the mortgage channel may be weak if the average monetary policy shock is perceived to induce only a temporary decline in mortgage rates, or if households use the windfall largely to delever. Focusing on UK evidence, Cloyne et al. (2020) show that the expenditure response to monetary policy is largely driven by mortgagors, but argues that a reduction in mortgage payments is unlikely to be the reason. Contrary to these micro studies, we quantify the share of the mortgage cash-flow channel in the aggregate responses to monetary policy. We find that the mortgage cash-flow channel contributes substantially to the responses of real activity and moderately to prices, with the largest contribution to the response of retail sales.

Our mortgage cash-flow findings are also consistent with more aggregate evidence in Albuquerque et al. (2025), Calza et al. (2013), and Garriga et al. (2017). Calza et al. (2013) compare consumption responses to monetary policy across countries and find that countries with higher debt-to-GDP, greater ability to extract housing equity, and a higher share of adjustable-rate mortgages have stronger consumption responses. Albuquerque et al. (2025) and Garriga et al. (2017), on the other hand, explicitly model mortgage cash-flow channels in dynamic models. Using an estimated HANK model for the UK, Albuquerque et al. (2025) show that rents substantially contribute to a reduction in consumption. Similar to Calza et al. (2013), we provide empirical aggregate evidence. However, unlike their cross-country approach, our analysis focuses on one country and provides an internally consistent decomposition of the responses rather than relying on cross-sectional comparisons. Albuquerque et al. (2025) also provide an internally consistent decomposition following the approach of Kaplan et al. (2018). We add to this evidence empirically using an alternative thought experiment that can equally well be applied in linearised theoretical models and can therefore be used to further discipline these models.

Albuquerque et al. (2025) and Calza et al. (2013) also relate to our findings on housing wealth effects. Bracke et al. (2024) document frequent remortgaging by UK households and the ability to extract equity and extend the mortgage term at remortgaging. Combined with Calza et al. (2013), this points to strong housing wealth effects. We indeed find evidence of a strong housing wealth channel. Albuquerque et al. (2025) find similar evidence for a strong house-price (housing wealth) channel in their estimated HANK model for the UK. Similar to Albuquerque et al. (2025), our housing wealth effects are estimated to be stronger than our mortgage cash-flow effects. Our findings also provide aggregate evidence for the plentiful micro evidence on housing wealth effects (Bahaj et al., 2020; Bhutta & Keys, 2016; Campbell & Cocco, 2007; Cumming & Hubert, 2022; Mian & Sufi, 2011, 2014; Mian et al., 2013; Wong, 2019). Unlike the micro studies, however, we are unable to distinguish whether the housing wealth channel operates through equity extraction or collateral. Moreover, evidence in Eichenbaum et al. (2022) suggests that housing wealth effects may depend on the distribution of savings from refinancing and thus are likely state dependent; state dependence is beyond the scope of this paper.

Barrell et al. (2015) and Slacalek (2009) find that housing wealth effects are stronger than financial wealth effects in the UK. Similar evidence has been found internationally (Carroll et al., 2011; Case et al., 2001, 2013; Poterba, 2000). We find evidence that this also holds in the aggregate. Moreover, we find that the peak impact of the financial wealth channel occurs earlier than the peak impact of the housing wealth channel, consistent with financial wealth being more liquid than housing wealth.

Regarding the exchange rate channel, our results relate closely to the literature analysing exchange rate pass-through (ERPT) to import and consumer prices. Traditional approaches within this literature estimate

reduced-form distributed-lag regressions of import or consumer prices on exchange rates, often controlling for exporter costs and importer output gaps. The literature generally finds incomplete pass-through to both import and consumer prices, with pass-through to consumer prices weaker than to import prices (Campa & Goldberg, 2002; Gagnon & Ihrig, 2004; Jašová et al., 2016; Mumtaz et al., 2006; Savoie-Chabot & Khan, 2015). For the UK, Mumtaz et al. (2006) estimate ERPT to import prices of around 38–44% in the short run and 43–66% in the long run; Gagnon and Ihrig (2004) estimate ERPT of around 15% to CPI. International estimates are of similar magnitudes: Campa and Goldberg (2002) estimate ERPT to import prices of around 60% in the short run and 75% in the long run for OECD countries. Savoie-Chabot and Khan (2015) estimate ERPT to CPI of around 6% in the long run, with short-run estimates close to zero. Forbes et al. (2018) and Forbes et al. (2020) argue that reduced- form estimates can be misleading and that shock-dependent ERPT should instead be computed as the ratio between the price and exchange rate responses to a structural shock. They find that ERPT defined in this way is stronger for monetary policy shocks than for other shocks. For the UK, they estimate ERPT of around 70–85% on import prices and 10–20% on CPI for monetary policy shocks.

Similar to this literature, we find that the exchange rate channel has a stronger effect on import prices than on consumer prices. However, our estimates are smaller than those obtained with either of the aforementioned methods. This may be due to the observation period we use. The literature has generally found that ERPT declines over time, which has often been linked to a more stable monetary policy and inflation regime (Campa & Goldberg, 2002; Gagnon & Ihrig, 2004; Jašová et al., 2016; Mishkin, 2008; Mumtaz et al., 2006; Taylor, 2000). Moreover, unlike much of the literature, we strictly separate the exchange rate channel from other channels, which may explain the weaker pass-through. However, although we find weak pass-through to consumer prices, these results should not be taken as an indication of specific frictions in the economy. As McLeay and Tenreyro (2025) argue, exchange-rate pass-through is an equilibrium result; the critique of Dogra (2024) also applies, and no single friction parameter will, in general, govern the strength of the exchange rate channel.

Lastly, our findings on the expectations channel relate to a large literature that estimates the effects of monetary policy on inflation expectations and other expectations (Burr, 2025; De Fiore et al., 2021; Diegel & Nautz, 2021; Falck et al., 2021; Gambetti & Musso, 2017; Jarociński & Karadi, 2020; Lamla & Vinogradov, 2019), and to a literature that investigates whether higher inflation expectations lead to higher spending for consumers (Adams & Barrett, 2024; Bachmann et al., 2015; Burke & Ozdagli, 2023; Coibion et al., 2022, 2023; D'Acunto et al., 2016, 2018; Dräger & Nghiem, 2021; Duca-Radu et al., 2021; Ichiue & Nishiguchi, 2015) and to higher own-price plans for firms (Bottone & Rosolia, 2019; Di Pace et al., 2025; Enders et al., 2019). The results in both strands are mixed. For inflation expectations, Jarociński and Karadi (2020) and Diegel and Nautz (2021) find that contractionary monetary policy decreases inflation expectations, whereas Gertler and Karadi (2015), Gambetti and Musso (2017), Lamla and Vinogradov (2019), and De Fiore et al. (2021) find no significant response. Falck et al. (2021) shows that the reaction of inflation expectations to monetary policy is likely state dependent. Burr (2025) documents substantial heterogeneity in the UK: firms' and markets' inflation expectations fall after a contractionary monetary policy shock, while households' inflation expectations tend to rise. Whether it is firms, households, or market expectations that matter most for transmission is still an open question.

A related open question is whether higher household inflation expectations lead to higher spending. Coibion et al. (2022), D'Acunto et al. (2016, 2018), Dräger and Nghiem (2021), Duca-Radu et al. (2021), and Ichiue and Nishiguchi (2015) find that higher household inflation expectations are associated with higher

spending, while Adams and Barrett (2024), Bachmann et al. (2015), and Coibion et al. (2023) find the opposite. For firms, Baumann et al. (2024) and Di Pace et al. (2025) find that own-price expectations adjust as expected; however, Enders et al. (2019) show that this adjustment may be non-linear, with own-price expectations responding as predicted only for moderate monetary policy shocks, and Di Pace et al. (2025) shows that responses may be shock dependent, with own-price expectations not adjusting to high-frequency monetary policy surprises.

In contrast to the above literature, we quantify the expectations channel jointly with other channels, thereby separating what can be attributed to expectations alone. We find that expectations contribute substantially to the reduction in real activity, but that the effect on prices is negligible. The expectations channel is contractionary for activity and stronger for goods prices than for aggregate prices, but substantially positive for services prices. Thus, consistent with the literature, we find mixed evidence on the expectations channel.

Outline. The remainder of this paper is structured as follows. In Section 2, we discuss the methodology we use, including the Bayesian VAR (BVAR) and Transmission Channel Analysis (Wegner et al., 2025). Section 3 formalises the transmission channels, defines the exact objects we quantify, and provides invariance proofs to alternative thought experiments. We present our main results in Section 4 and conclude in Section 5.

2 Methodology

To uncover the channels through which monetary policy transmits to the real economy and prices, we build on a standard Bayesian structural VAR (SVAR) framework with external instruments for identification. Section 2.1 describes this baseline model and the identification of shocks via external instruments. Section 2.2 then introduces the Transmission Channel Analysis (TCA, Wegner et al., 2025) methodology, which we use to formally define our channels and to quantify the effects through the channels.

2.1 A Bayesian SVAR with External Instrument Identification

We consider a standard structural vector autoregression (SVAR) of order p,

$$\boldsymbol{A}_0\boldsymbol{y}_t = \boldsymbol{a} + \boldsymbol{A}_1\boldsymbol{y}_{t-1} + \ldots + \boldsymbol{A}_p\boldsymbol{y}_{t-p} + \boldsymbol{\varepsilon}_t, \tag{1}$$

where $\boldsymbol{y}_t$ is an $N \times 1$ vector of endogenous variables, $\boldsymbol{\varepsilon}_t$ is an $N \times 1$ vector of structural shocks, $\boldsymbol{A}_0$ is an $N \times N$ non-singular matrix describing contemporaneous relations among the endogenous variables, $\boldsymbol{A}_i$ for $i = 1, \ldots, p$ are $N \times N$ matrices capturing dynamic effects, and $\boldsymbol{a}$ is an $N \times 1$ vector of constants. The structural shocks $\boldsymbol{\varepsilon}_t$ are assumed to be serially uncorrelated and normally distributed with zero mean and unit variance, that is, $\boldsymbol{\varepsilon}_t \sim \mathcal{N}(\boldsymbol{0}, \boldsymbol{I})$ and $\mathbb{E}[\boldsymbol{\varepsilon}_{t-h}\boldsymbol{\varepsilon}_t'] = \boldsymbol{O}$ for $h \neq 0$. Because $\boldsymbol{A}_0$ is non-singular, the SVAR (1) can be expressed in reduced form as

$$\boldsymbol{y}_t = \boldsymbol{b} + \boldsymbol{B}_1\boldsymbol{y}_{t-1} + \ldots + \boldsymbol{B}_p\boldsymbol{y}_{t-p} + \boldsymbol{u}_t, \tag{2}$$

where $\boldsymbol{u}_t = \boldsymbol{A}_0^{-1}\boldsymbol{\varepsilon}_t$ are serially uncorrelated, normally distributed residuals with zero mean and covariance matrix $\boldsymbol{\Sigma}_u = \boldsymbol{A}_0^{-1}\boldsymbol{A}_0^{-1'}$, $\boldsymbol{B}_i = \boldsymbol{A}_0^{-1}\boldsymbol{A}_i$ for $i = 1, \ldots, p$, and $\boldsymbol{b} = \boldsymbol{A}_0^{-1}\boldsymbol{a}$.

We estimate the reduced-form model (2) using standard Bayesian techniques, imposing a diffuse Normal

prior on the constants $\boldsymbol{b}$, a Minnesota prior on the autoregressive coefficients $\boldsymbol{B}_i$, and an inverse-Wishart prior on the covariance matrix $\boldsymbol{\Sigma}_u$. The hyperparameters of these priors are set to maximise the marginal likelihood, as in Giannone et al. (2015).[1]

However, to trace out the causal effects of a monetary policy shock, and therefore to quantify the transmission channels, we require estimates of the structural model (1) rather than of the reduced-form model (2). Without additional restrictions, moving from the reduced-form estimates to estimates of the structural model is not unambiguously possible. To illustrate this identification problem, decompose $\boldsymbol{A}_0 = \boldsymbol{Q}\boldsymbol{L}$, where $\boldsymbol{Q}$ is an $N \times N$ orthonormal matrix and $\boldsymbol{L}$ is an $N \times N$ lower-triangular matrix satisfying $\boldsymbol{L}^{-1} = \text{chol}(\boldsymbol{\Sigma}_u)$, with chol denoting the unique Cholesky decomposition.[2] Then, $\boldsymbol{A}_0^{-1} = \boldsymbol{L}^{-1}\boldsymbol{Q}' = \text{chol}(\boldsymbol{\Sigma}_u)\boldsymbol{Q}'$, implying $\boldsymbol{u}_t = \boldsymbol{L}^{-1}\boldsymbol{Q}'\boldsymbol{\varepsilon}_t$, or equivalently, $\boldsymbol{L}\boldsymbol{u}_t = \boldsymbol{Q}'\boldsymbol{\varepsilon}_t$. Hence, the second-moment information of the reduced-form model identifies only a rotation of the structural shocks and thus does not unambiguously identify the structural model (1).

To resolve this identification problem, we employ an external instrument z_t (Stock & Watson, 2018) that satisfies

$$\begin{aligned} &\mathbb{E}[\varepsilon_{1,t} z_t] = \alpha \neq 0 \quad \text{(Relevance)}, \\ &\mathbb{E}[\varepsilon_{i,t} z_t] = 0 \quad \forall i = 2, \ldots, N \quad \text{(Exogeneity)}. \end{aligned} \tag{3}$$

These conditions imply that $\mathbb{E}[\boldsymbol{L}\boldsymbol{u}_t z_t] = \mathbb{E}[\boldsymbol{Q}'\boldsymbol{\varepsilon}_t z_t] = [\boldsymbol{Q}']_{\cdot,1}\alpha$, where $[\boldsymbol{X}]_{\cdot,i}$ denotes the i-th column of matrix $\boldsymbol{X}$. The instrument z_t therefore identifies the first column of the rotation matrix $\boldsymbol{Q}'$, and thus the impact effects of the first structural shock, $[\boldsymbol{A}_0^{-1}]_{\cdot,1} = \boldsymbol{L}^{-1}[\boldsymbol{Q}']_{\cdot,1}$, up to scale. We compute the posterior of the relative impulse-response functions (IRFs) to $\varepsilon_{1,t}$ by regressing, for each draw i, the reduced-form residuals $\boldsymbol{u}_t^{(i)}$ on the instrument z_t to obtain the corresponding draw of the impact vector $[\boldsymbol{A}_0^{-1,(i)}]_{\cdot,1}$ up to scale.

We use the methodology outlined above to estimate a baseline VAR(12) including one-, five-, and ten-year Gilts; the FTSE All Share index; the Sterling Exchange Rate Index (SERI); investment- and non-investment-grade corporate bond spreads; fixed and floating rate mortgage rates; output (CIPS composite) and inflation expectations; retail volumes; monthly GDP (split into services, production, and construction); and CPIH (core).[3] The VAR is deliberately large to allow for a precise specification of the transmission channels. To identify monetary policy shocks, we use the target shock series of Braun et al. (2025) as an external instrument, normalising the size to a 25 bps increase in the one-year Gilt yield. The baseline model is estimated over the sample 1998M2–2019M12. Details regarding the data and transformations can be found in Appendix C.

2.2 Transmission Channel Analysis

The external instrument methodology outlined in the previous section allows us to estimate the dynamic causal effects of the structural shock $\varepsilon_{1,t}$. Wegner et al. (2025) show that these structural effects can be combined with reduced-form information to trace the propagation of shocks along specific transmission channels. This section introduces the Transmission Channel Analysis (TCA) framework in a simplified setting, using the intertemporal substitution channel of monetary policy as an illustrative example.

First, we introduce the intertemporal substitution channel and highlight, succinctly, the difference be-

[1] We use the replication code of Miranda-Agrippino and Ricco (2021) to implement the procedure.

[2] The decomposition is unique because the diagonal elements are normalised to be positive.

[3] Unless otherwise specified, we will refer to CPIH (core) as CPIH and prices interchangeably. Similarly, we will use retail volumes and retail sales interchangeably.

tween the partial-equilibrium and TCA thought experiments. Moreover, we emphasise that any transmission channel analysis must condition on a structural shock: asking how consumption responds to changes in interest rates is meaningless without knowing whether those rate changes stem from shifts in monetary policy, aggregate demand, or other factors. We then show how, within a simplified SVAR representation of a general equilibrium model, TCA can be used to quantify the effect through the intertemporal substitution channel, and how the channel can be formally defined in the TCA framework. The exposition follows Wegner et al. (2025) closely, and readers are referred to their paper for full technical details.

2.2.1 The Intertemporal Substitution Channel of Monetary Policy

Consider the log-linearised Euler equation of a standard consumption–savings model,

$$c_t = \mathbb{E}_t[c_{t+1}] - \frac{1}{\sigma} R_t = c_t^e - \frac{1}{\sigma} R_t, \tag{4}$$

where $c_t^e \equiv \mathbb{E}_t[c_{t+1}]$, c_t denotes consumption, R_t is the real gross return on bonds, and all variables are expressed as log-deviations from steady state. Rearranging gives

$$c_t^e - c_t = \frac{1}{\sigma} R_t, \tag{5}$$

so that a one percent increase in the interest rate raises expected future consumption relative to current consumption by $(1/\sigma)$ percent.

However, this relationship is not informative about the reaction of current consumption for two distinct reasons. First, whatever moves the interest rate will, in general, also move expectations about future consumption. Second, interest rates are generally endogenous, and therefore statements about "an increase in the interest rate" are meaningless unless the exogenous driving force behind that increase is specified. To be informative about the reaction of c_t, one must therefore consider a thought experiment in which an exogenous shock moves R_t while expected consumption is held constant.

This thought experiment is complicated by the fact that, in equilibrium, c_t^e and R_t will generally depend on each other and on c_t. Partial-equilibrium reasoning assumes this dependence away. Wegner et al. (2025) instead show that, even under these general-equilibrium interactions, there always exists a representation of the equilibrium solution for consumption of the form

$$c_t = c_t(c_t^e, R_t, \gamma_t^c), \tag{6}$$

where γ_t^c is generally a linear combination of all shocks in the system. Equation (6) is therefore, in general, not the same object as the Euler equation (4).

Taking the total derivative of (6) with respect to a shock ε_t^R—say a monetary policy shock—yields

$$\frac{dc_t}{d\varepsilon_t^R} = \frac{\partial c_t}{\partial c_t^e}\frac{dc_t^e}{d\varepsilon_t^R} + \frac{\partial c_t}{\partial R_t}\frac{dR_t}{d\varepsilon_t^R} + \frac{\partial c_t}{\partial \gamma_t^c}\frac{d\gamma_t^c}{d\varepsilon_t^R}. \tag{7}$$

The effect of the monetary policy shock on current consumption, holding everything except the interest rate fixed, is therefore $(\partial c_t/\partial R_t)(dR_t/d\varepsilon_t^R)$. This term represents the direct interest rate channel, which is the TCA analogue of the intertemporal substitution channel; henceforth we refer to it as the intertemporal substitution channel.

If the Euler equation (4) could be interpreted causally, requiring no enforced equilibrium and necessarily

a recursive dependence structure (Dogra, 2024), then the TCA and partial-equilibrium thought experiments would coincide and (6) would reduce to the Euler equation. In all other cases, TCA and partial equilibrium provide two imperfect narratives to general equilibrium dynamics. To compute partial-equilibrium effects, a fully specified theoretical model is required. To compute effects within the TCA framework, by contrast, only (6) is needed, which Wegner et al. (2025) show can be obtained in any SVARMA model—whether this model is fully microfounded or not.

To illustrate this result, assume, for expositional clarity, that the Euler equation (4) is embedded in a model that can be written as

$$\boldsymbol{A}_0 \boldsymbol{y}_t = \boldsymbol{\varepsilon}_t, \tag{8}$$

where $\boldsymbol{A}_0$ is non-singular, $\boldsymbol{y}_t' = (R_t, c_t^e, c_t)$, and $\boldsymbol{\varepsilon}_t' = (\varepsilon_t^R, \varepsilon_t^s, \varepsilon_t^d)$, with ε_t^R, ε_t^s, and ε_t^d being monetary policy, supply, and demand shocks, respectively.

Using the QL-decomposition introduced in Section 2.1, equation (8) can equivalently be written as

$$\boldsymbol{Q}\boldsymbol{L}\boldsymbol{y}_t = \boldsymbol{\varepsilon}_t \quad \Leftrightarrow \quad \boldsymbol{L}\boldsymbol{y}_t = \boldsymbol{Q}'\boldsymbol{\varepsilon}_t. \tag{9}$$

Define $\boldsymbol{D} = \text{diag}(\boldsymbol{L})^{-1}$, where $\text{diag}(\boldsymbol{X})$ denotes the diagonal matrix collecting the diagonal elements of $\boldsymbol{X}$. Then

$$\boldsymbol{y}_t = (\boldsymbol{I} - \boldsymbol{D}\boldsymbol{L})\boldsymbol{y}_t + \boldsymbol{D}\boldsymbol{Q}'\boldsymbol{\varepsilon}_t. \tag{10}$$

The last row of (10) corresponds to (6), with $\gamma_t^c = [\boldsymbol{D}\boldsymbol{Q}']_{3,\cdot}\boldsymbol{\varepsilon}_t$, where $[\boldsymbol{X}]_{i,\cdot}$ denotes the i-th row of $\boldsymbol{X}$. Hence, the intertemporal substitution channel in the general-equilibrium model (8), defined as $\frac{\partial c_t}{\partial R_t}\frac{dR_t}{d\varepsilon_t^R}$, equals

$$\frac{\partial c_t}{\partial R_t}\frac{dR_t}{d\varepsilon_t^R} = -L_{3,3}^{-1} L_{3,1} L_{1,1}^{-1} Q_{1,1}.$$

Thus, the effect can be computed within the simplified SVAR (8), provided the channel is a well-defined thought experiment. The next section clarifies this latter point.

2.2.2 Formalising Transmission Channel Analysis

In the previous section, we defined the effect through the intertemporal substitution channel in terms of partial and total derivatives. This definition is incomplete by itself, because it does not clarify the relationship between interest rates and expected consumption—that is, it does not fully specify the underlying thought experiment. Wegner et al. (2025) show that transmission channels are therefore better defined using potential outcomes and graphs, while keeping in mind the caveat and critique of Dogra (2024) that effects through transmission channels can never be interpreted as fully causal. In this approach, fully specifying the thought experiment requires a *transmission ordering* (or matrix), which corresponds to R_t, c_t^e, and c_t in the intertemporal substitution example.

Taking the monetary policy shock ε_t^R as the exogenous origin, and given a transmission ordering, each variable can be expressed as a (possibly nested) potential outcome. For instance, the potential outcome of the interest rate can be written as $R_t(e_1)$, where $\mathbb{E}[R_t(e_1)]$ denotes the expected interest rate if the monetary policy shock satisfies $\varepsilon_t^R = e_1$. A transmission effect is defined as the expected difference between two potential outcomes, $\mathbb{E}[R_t(e_1) - R_t(e_1')]$. The total effect of a unit increase in the monetary policy shock—commonly summarised by impulse response functions (IRFs)—is given by $\mathbb{E}[R_t(1) - R_t(0)]$ and is equivalent to the total derivative $dR_t/d\varepsilon_t^R$ in the general-equilibrium model (8).

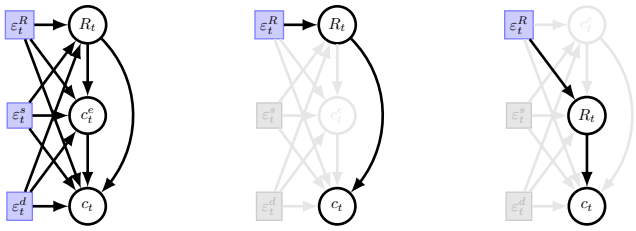


Figure 1: Directed acyclic graph (DAG) illustration of the intertemporal-substitution channel linking the real interest rate R_t, one-period-ahead consumption expectations c_t^e, and consumption c_t. Panel (a) shows the full contemporaneous system; panels (b)–(c) depict two alternative path-based definitions of the intertemporal-substitution channel.

In principle, the potential outcomes for expected consumption, c_t^e, and consumption, c_t, could be defined analogously. Such definitions, however, capture only total effects because they do not allow us to isolate how a shock propagates through one variable while holding others fixed. To analyse transmission channels—thought experiments that hold some margins fixed while others are allowed to vary—we therefore require a framework that can express the effect of a shock on a variable while keeping selected others constant. Following Wegner et al. (2025), this can be achieved using nested potential outcomes,

$$\begin{aligned} c_t^e(R_t(e_1), e_2) &= c_t^e(e_1, e_2), \\ c_t(R_t(e_1), c_t^e(R_t(e_2), e_3), e_4) &= c_t(e_1, e_2, e_3, e_4), \end{aligned} \tag{11}$$

where each nested potential outcome depends both directly on the shock and on how variables earlier in the transmission ordering respond to it. For example, e_1 in the potential outcome for expected consumption, c_t^e, controls how the interest rate reacts to the shock and therefore whether the shock affects expected consumption through interest rate movements; e_2 captures the direct effect of the shock on expected consumption itself. Combining both, $\mathbb{E}[c_t^e(0,1) - c_t^e(0,0)] = \partial c_t^e / \partial \varepsilon_t^R$, for instance, captures the transmission effect—under the TCA framework—of a unit monetary policy shock on expected consumption while holding the interest rate fixed. Likewise, $\mathbb{E}[c_t(1,0,0,0) - c_t(0,0,0,0)] = (\partial c_t / \partial R_t)(dR_t / d\varepsilon_t^R)$ represents the transmission effect of a unit monetary policy shock on consumption through interest rate movements only, corresponding to the intertemporal substitution channel discussed above. More generally, Wegner et al. (2025) show that each nested potential outcome corresponds one-to-one to a transmission channel.

While nested potential outcomes provide a formal definition of transmission channels, they quickly become cumbersome and unintuitive in larger and dynamic general-equilibrium models. Wegner et al. (2025) therefore link the potential-outcome framework to directed acyclic graphs (DAGs) and show that transmission effects can be represented as effects along subsets of paths connecting the shock to an outcome variable—a representation that is often more intuitive. To illustrate this, Figure 1a displays the DAG corresponding to the intertemporal substitution example.

The DAG contains a node for each shock and variable in the system, with shocks denoted by squares. In general, each shock node is connected to all variables within the same period, and each variable node is connected to all subsequent variables in the transmission ordering. Edges leaving a shock (e.g. $\varepsilon_i \to y_j$) and entering a variable have a ceteris paribus causal interpretation: the effect along such an edge equals the partial derivative $\partial y_j / \partial \varepsilon_i$. By contrast, edges leaving one variable and entering another (e.g. $y_i \to y_j$) have no direct causal interpretation, since the derivative $\partial y_j / \partial y_i$ is not defined with respect to an exogenous

cause but with respect to another endogenous variable. Thus, any path starting at a structural shock has a well-defined causal origin, but is itself not completely causal. If all paths from a shock to a variable are considered, the resulting effect corresponds to the total effect and thus to a causal effect; if only a subset of paths is selected, it corresponds to a transmission effect—a transmission channel.

For example, the intertemporal substitution channel, represented by the transmission effect $\mathbb{E}[c_t(1,0,0,0) - c_t(0,0,0,0)]$, corresponds to the path that starts at the monetary policy shock, passes through interest rates, and then reaches consumption directly, as highlighted in Figure 1b. This path captures the intuitive chain underlying intertemporal substitution: a monetary contraction raises interest rates, which in turn reduces consumption, while expectations remain constant since the path does not pass through expectations. Wegner et al. (2025) show that the effect along this path equals $\frac{\partial c_t}{\partial R_t}\frac{dR_t}{d\varepsilon_t^R} = \frac{\partial c_t}{\partial R_t}\frac{\partial R_t}{\partial \varepsilon_t^R}$, where the equality holds because interest rates depend only on structural shocks and not on other endogenous variables in the DAG of Figure 1a.

More generally, Wegner et al. (2025) show that the effect along any subset of paths, and therefore any transmission effect, can be computed either from a combination of structural and reduced-form IRFs or directly from the coefficients contained in $\boldsymbol{L}$ and $\boldsymbol{Q}$ of equation (9). Because $\boldsymbol{L}^{-1} = \text{chol}(\Sigma_u)$, identification is only required for the rotation matrix $\boldsymbol{Q}$. Moreover, if the focus is on the transmission of a single structural shock ε_i, only the edges departing from that shock need to be identified. These are captured by the column $[\boldsymbol{Q}']_{\cdot,i}$, which can be identified, up to scale, using an external instrument, as shown in Section 2.1. Because both total effects—i.e. IRFs—and effects through transmission channels are identified only up to scale, the remainder of this paper focuses on relative effects rather than those of a one-standard-deviation shock. The interpretation of these effects, however, depends on the chosen transmission ordering, to which we now turn.

Thus far, we have taken the transmission ordering as given. In practice, the ordering must be chosen by the researcher. Each ordering defines a logically consistent set of transmission channels that decomposes the total effect. Consequently, two transmission channels that cannot be analysed within the same ordering, and hence within the same DAG, rest on mutually incompatible thought experiments. While such channels can be analysed separately, any combination of them will fail to provide a coherent decomposition of the total effect.

To illustrate, consider the DAG in Figure 1c, in which the ordering of R_t and c_t^e is reversed. The highlighted path again starts at the monetary policy shock, passes through interest rates, and then reaches consumption without passing through expectations—a qualitatively similar definition of intertemporal substitution. However, while the initial ordering implied $dR_t/d\varepsilon_t^R = \partial R_t/\partial \varepsilon_t^R$, this no longer holds under the alternative ordering unless $\partial R_t/\partial c_t^e = 0$ or $dc_t^e/d\varepsilon_t^R = 0$, implying that either the edge $c_t^e \to R_t$ or $\varepsilon_t^R \to c_t^e$ is absent. In that case,

$$\frac{dR_t}{d\varepsilon_t^R} = \left(\frac{\partial R_t}{\partial c_t^e}\right)\left(\frac{dc_t^e}{d\varepsilon_t^R}\right) + \frac{\partial R_t}{\partial \varepsilon_t^R} = \frac{\partial R_t}{\partial \varepsilon_t^R}.$$

Hence, although the two channels are qualitatively similar, they represent incompatible thought experiments and thus incompatible narratives about general equilibrium dynamics. Consequently, no combination of channels that includes both can consistently decompose the total general-equilibrium effect. Importantly, however, neither ordering is "incorrect"; there is simply no unique representation of general equilibrium dynamics—a consequence of enforced equilibrium (Dogra, 2024).[4] TCA therefore requires researchers to state clearly the view—that is, the thought experiment—being taken and to define precisely the transmission channels as sets of paths within that view. The next section sets out the view and corresponding transmission

[4]Wegner et al. (2025) provide theoretical conditions under which effects through transmission channels are invariant to different orderings.

channels used in our analysis.

3 Definition of Transmission Channels

The previous sections introduced the general methodology and established how transmission channels can be defined using potential outcomes and graphs. We now specify the channels relevant for our analysis of UK monetary policy and the transmission ordering that enables us to analyse them jointly—that is, we specify the exact joint thought experiment. This requires selecting a directed acyclic graph (DAG) and subsets of paths within that graph, which define the transmission channels. We begin with a discussion of the broad financial-markets-and-expectations channels. The subsequent section then zooms in on narrower mechanisms, such as wealth and cash-flow channels. For expositional clarity, we focus throughout on effects up to horizon one, while Appendix A provides the formal definitions for higher horizons.

3.1 Financial Markets and Expectations

Monetary policy is typically assumed to transmit through financial conditions and expectations to the real economy and prices (see, e.g. Burr, 2025). In principle, however, a monetary policy shock could also have direct effects on prices and real activity. We use TCA to quantify the extent to which UK monetary policy transmits through the financial-markets-and-expectations and direct-price channels to the real economy and prices.

To define the financial-markets-and-expectations channel, we partition the vector of endogenous variables, $\boldsymbol{y}_t$, into a block of financial-markets-and-expectations variables, $\boldsymbol{y}_{1:F,t}$, and a block of real-economy-and-price variables, $\boldsymbol{y}_{(F+1):N,t}$. Hence, $\boldsymbol{y}_t' = (\boldsymbol{y}_{1:F,t}', \boldsymbol{y}_{(F+1):N,t}')$. The real-economy-and-price block consists of real retail sales, real GDP services, real GDP production, real GDP construction, and the CPIH (core) price index—with this order defining our baseline transmission ordering. We place the price index last, as it is our main outcome variable. This is also consistent with most discussions of monetary policy transmission (see, e.g. Burr, 2025), which consider channels running from financial markets and the real economy to prices. By placing retail sales and GDP services—our proxies for goods and services consumption—before GDP production and construction, we adopt a view in which production responds to consumption. As shown in Appendix A, our results are invariant to the ordering within the financial-markets-and-expectations block—they are invariant to a large set of alternative thought experiments. The ordering within the real-economy-and-price block therefore provides a sufficiently complete specification of the transmission ordering for the analysis below.

Given this transmission ordering, we can define the first set of channels. The financial-markets-and-expectations channel is the set of paths that pass through any financial-markets-and-expectations variable in at least one period. Figure 2a depicts this channel in the DAG corresponding to our thought experiment for horizon zero. For clarity, the financial-markets-and-expectations and GDP blocks are represented as clouds rather than individual nodes. The highlighted paths correspond to the financial-markets-and-expectations channel: they start at the monetary policy shock, ε, enter the financial-markets-and-expectations block, and then are allowed to propagate freely. In particular, once inside this block, all paths leading from it to the remaining variables are included.

For horizons greater than zero, the financial-markets-and-expectations channel further decomposes into first-round and second-round channels, depicted in Figures 3a and 3b for horizon one, respectively. The first-round channel (Figure 3a) captures all paths that move from the shock directly into the financial-markets-

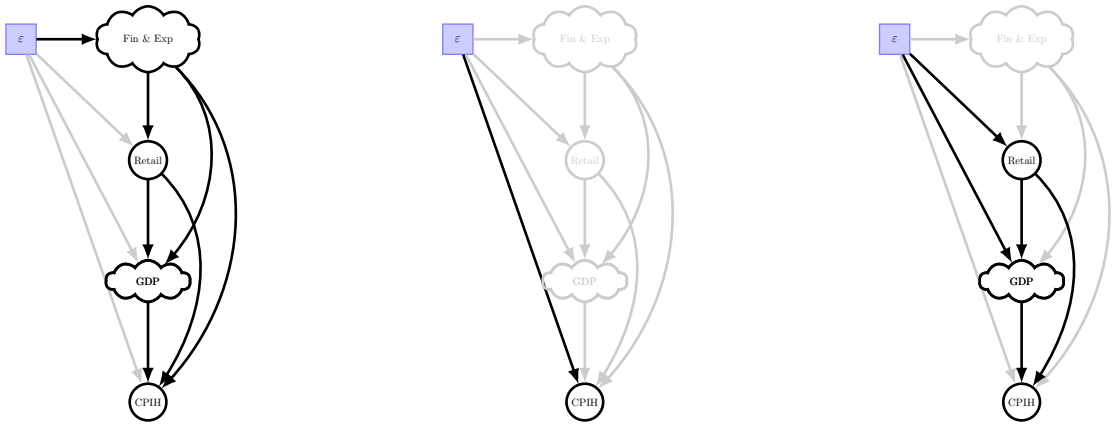


Figure 2: Contemporaneous (impact) path-based definitions of (a) the financial-markets-and-expectations channel, (b) the direct-price channel, and (c) other direct effects. Clouds denote collections of variables; grey nodes and edges are excluded from the corresponding path sets. For clarity, shocks other than the monetary policy shock are omitted.

and-expectations block. From there, the effect either continues propagating within that block or moves to the real-economy-and-price block, from where it is free to propagate onwards. However, the first-round channel excludes all paths that feed back from the real-economy-and-price block to the financial-markets-and-expectations block. That interaction is captured by the second-round channel (Figure 3b), which isolates feedback from the real-economy-and-price block to the financial-markets-and-expectations block.

As an example, a first-round channel could involve a contractionary monetary policy shock that appreciates the domestic currency, raises imports, reduces exports, and thereby dampens domestic demand and prices. The subsequent feedback from weaker output and prices to the exchange rate, and onwards to output and prices again, would be part of the second-round channel. Note that contemporaneously, and more generally within a single period, first- and second-round channels cannot be analysed jointly because no single logically consistent transmission ordering exists: any thought experiment must specify whether financial-markets-and-expectations variables affect real-economy-and-price variables or vice versa. Under our chosen transmission ordering—placing financial-markets-and-expectations variables before real-economy-and-price variables—all contemporaneous effects are therefore classified as first-round effects.

While most discussions of monetary transmission emphasise financial-markets-and-expectations channels, a monetary policy shock could, in principle, directly affect the real-economy-and-price block. We further decompose these direct effects into a direct-price channel and an other-direct channel. The direct-price channel, shown in Figure 2b for horizon zero, consists of paths running directly from the monetary policy shock, ε, to prices and propagating only within prices. The other-direct channel, highlighted in Figure 2c, captures paths running directly from the monetary policy shock to the real-economy variables and then propagating within the real-economy-and-price block. A priori, we expect both channels to be negligible, capturing primarily noise. Together, the effects through the first-round, second-round, direct-price, and other-direct channels decompose the total effect. Appendix A further proves that the effects through these channels are invariant to the ordering within the financial-markets-and-expectations block; a large set of alternative thought experiments therefore leads to the same conclusions.

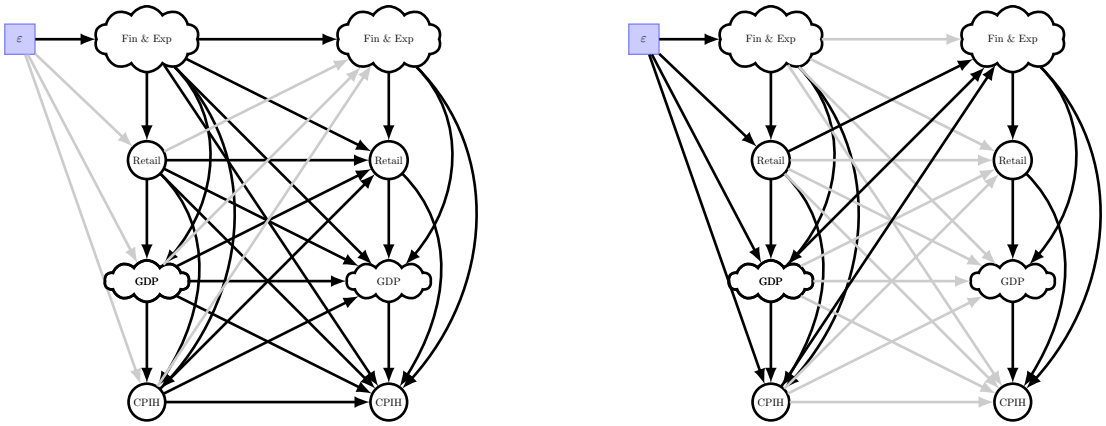


Figure 3: Horizon-one path-based definitions of (a) first-round effects through financial markets and expectations and (b) second-round (feedback) effects through financial markets, expectations, activity, and prices. Panels (a) and (b) sum to the financial-markets-and-expectations channel contribution at horizon 1. Clouds denote collections of variables; grey nodes and edges are excluded from the corresponding paths. For clarity, shocks other than the monetary policy shock are omitted.

3.2 Cash-Flow, Wealth, and Other Channels

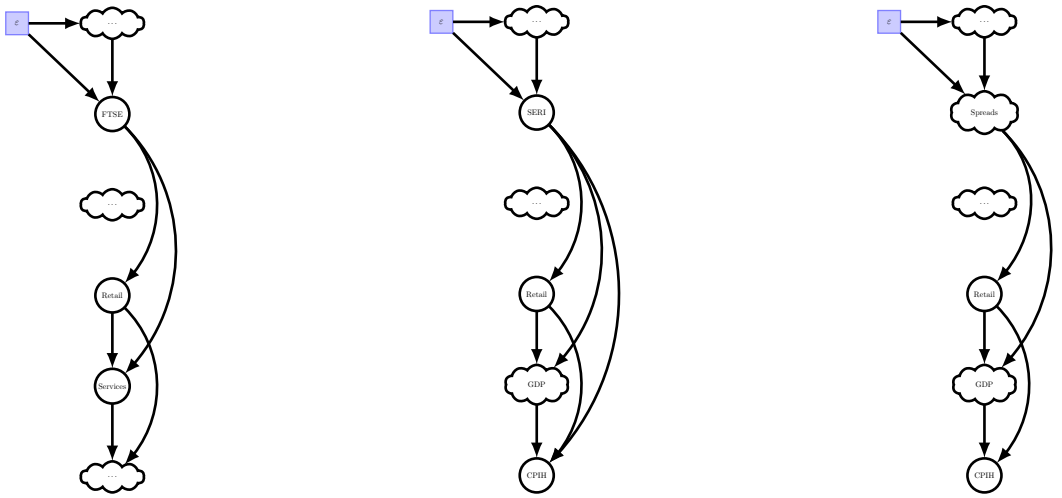
The previous section focused on broad financial-markets-and-expectations and direct channels. Here, we zoom in further and decompose the financial-markets-and-expectations channel into narrower, commonly discussed mechanisms such as cash-flow and wealth channels. For clarity, we restrict attention to effects up to horizon one. Appendix A provides formal definitions of these channels for higher horizons.

As before, we adopt a transmission ordering that places the financial-markets-and-expectations block before the real-economy-and-price block, using the same ordering within the latter. Appendix A shows that our analysis is invariant to the ordering within the financial-markets-and-expectations block, implying that the transmission ordering of the previous section provides a sufficient specification for analysing the narrow channels that follow.

Focusing first on the contemporaneous horizon, the channels can be grouped into three types, illustrated in Figure 4. For clarity, variables that are not directly relevant for a given channel are represented as clouds rather than individual nodes. Since the analysis is invariant to the ordering within the financial-markets-and-expectations block, we do not specify which variables appear in the first and second cloud.

The first group includes the equity wealth, housing wealth, and mortgage cash-flow channels. In the equity wealth channel, a contractionary monetary policy shock raises interest rates, lowering equity prices (proxied by the FTSE All Share Index) and thereby reducing household wealth. The resulting decline in consumption depresses aggregate demand and, consequently, prices. To capture this mechanism as closely as possible, we define the equity wealth channel contemporaneously as the set of paths that pass from the monetary policy shock, ε_t, through equity prices, directly to retail sales or GDP services—our proxies for goods and services consumption—and then freely propagate to prices. Figure 4a highlights these paths.

Replacing equity prices with house prices yields the housing wealth channel: a contractionary monetary policy shock lowers house prices and, through reduced wealth, lowers consumption and prices. Formally, we define it analogously to the equity wealth channel, replacing equity with house prices. Figure 4a illustrates the resulting paths when equity prices are replaced by house prices.



(a) (b) (c)

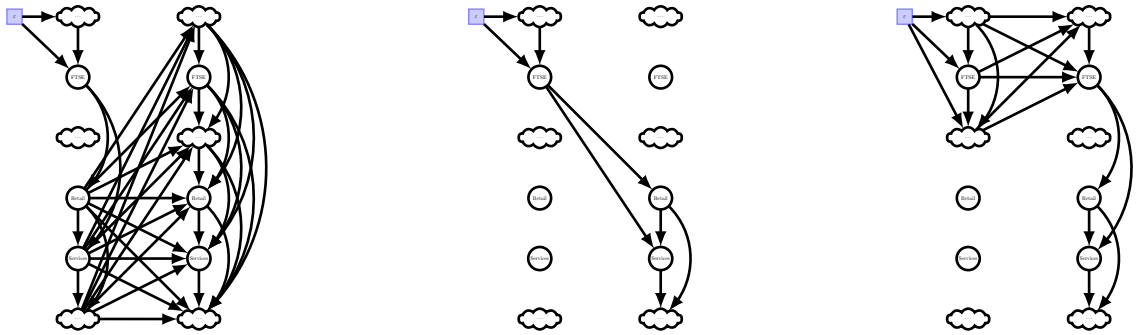
Figure 4: Contemporaneous (impact) path-based definitions of the equity-wealth, housing-wealth, mortgage-cash-flow, exchange-rate, expectations, and credit channels. Panel (a) depicts the equity-wealth channel; replacing FTSE with house prices yields the housing-wealth channel, and replacing FTSE with mortgage rates yields the mortgage-cash-flow channel. Panel (b) depicts the exchange-rate channel; replacing SERI with expectations yields the expectations channel. Panel (c) depicts the credit channel. Clouds denote collections of variables. For clarity, only edges included in the corresponding paths are shown and shocks other than the monetary policy shock are omitted.

Similarly, replacing equity prices with mortgage rates yields the mortgage cash-flow channel. A contractionary monetary policy shock raises mortgage rates, increasing debt-service costs, which reduces disposable income, consumption, and prices. We therefore define this channel as the set of paths that pass through mortgage rates directly to retail sales or GDP services and then freely propagate to prices. Figure 4a depicts these paths for the contemporaneous horizon when equity prices are replaced by mortgage rates.

The second group includes channels that directly affect the entire real-economy-and-price block, such as the exchange rate and expectations channels. In the exchange rate channel, a contractionary monetary policy shock appreciates the domestic currency, making foreign goods cheaper. Substitution away from domestic goods to foreign goods contracts the domestic real economy and therefore prices. In addition, the appreciation directly lowers consumer prices. We define the exchange rate channel contemporaneously as the set of paths that pass through exchange rates—as proxied by the Sterling Exchange Rate Index (SERI)—directly to any real-economy-and-price variable, from which the effect can freely propagate to prices. Figure 4b highlights these paths.

Analogously, the expectations channel captures the effects of changes in inflation and output expectations. A contractionary monetary policy shock typically reduces expected inflation and output, which directly influences consumption, production, and price-setting behaviour. We define the expectations channel as the set of paths that pass through expectations directly to the real-economy-and-price variables and then freely propagate to prices. Figure 4b illustrates these paths when exchange rates are replaced by expectations.

The third group includes channels that primarily affect real activity but not prices directly, such as the credit channel. The credit channel operates through one of two sub-channels. First, the bank-lending channel (Disyatat, 2011; Van den Heuvel, 2007): higher interest rates increase default risk, deteriorate banks' balance sheets, and tighten credit supply, reducing real activity and prices. Second, the balance-sheet channel



(a) (b) (c)

Figure 5: Dynamic extension of the equity-wealth channel to horizon one. Panels (a)–(c) show the three sets of paths that together define the horizon-one equity-wealth channel. Other channels are extended analogously. Clouds denote collections of variables. For clarity, only edges included in the corresponding paths are shown and shocks other than the monetary policy shock are omitted.

(Bernanke et al., 1999): higher interest rates lower the value of collateral, raise borrowing costs, and dampen investment and output. In principle, these effects operate mainly through investment. However, because monthly investment data are unavailable, we define the credit channel more broadly as the set of paths that pass through credit conditions—proxied by corporate bond spreads— directly to the real-economy variables and then freely propagate to prices (Figure 4c). Since the channel is not defined as paths through investment, it may be misspecified, a point we revisit in the next section.

Thus far, the discussion has focused on the contemporaneous horizon. To decompose the total effect of a monetary policy shock at higher horizons, we extend these definitions to horizon one. Consider again the equity wealth channel, defined contemporaneously as all paths that pass through equity prices directly to retail sales or GDP services and freely propagate from there. Because the shock can freely propagate once leaving retail sales or GDP services, it will eventually reach prices in period one. The contemporaneous definition therefore extends naturally to a valid definition of the channel at horizon one. The paths corresponding to this dynamic extension are shown in Figure 5a, in which the left column represents the contemporaneous period and the right column represents period one.

If, however, consumption adjusts with a lag to a reduction in equity prices, for instance due to habit formation or frictions in consuming out of wealth, then including only paths from equity prices to consumption within the same period will understate the importance of the equity wealth channel. We therefore augment the definition to include paths that pass through equity prices contemporaneously, then directly to retail sales or GDP services in period one, and freely propagate from there. Figure 5b illustrates the paths corresponding to this extension.

Finally, equity prices may themselves respond beyond impact. Consumption in period one may therefore also depend on equity prices in period one. We include paths that pass through equity prices in period one and then go directly to retail sales or GDP services in period one, freely propagating thereafter. To remain consistent with the qualitative description of the channel, in which equity prices adjust before the real economy and prices, we restrict these paths to those in which the shock propagates only within the financial-markets-and-expectations block before reaching equity prices in period one. Including paths that pass through the real-economy-and-price block would allow real-economy-and-price variables to adjust before equity prices, contradicting the qualitative description. Figure 5c illustrates the paths corresponding to this final extension.

Together, the paths highlighted in Figure 5 define the equity wealth channel at horizon one. We extend the remaining channels analogously to horizon one. Appendix A provides the corresponding definitions for higher horizons and proves that the effects through these channels—both contemporaneously and dynamically—are invariant to reordering variables within the financial-markets-and-expectations block. Our channel definitions are therefore robust to a wide range of alternative thought experiments and provide a solid baseline for future research. Note also that Transmission Channel Analysis (TCA) requires formally defined channels at all horizons. Such formal definitions are not usually present in the existing literature, complicating comparisons between existing estimates and the results we present in the next section.

4 Results

This section presents the empirical results of our transmission channel analysis for UK monetary policy. Section 4.1 begins by documenting the estimated impulse response functions (IRFs), which are broadly consistent with theoretical predictions and previous findings. Section 4.2 then shows that monetary policy is transmitted primarily through financial markets and expectations, with second-round effects operating through either financial markets or expectations becoming more important at longer horizons. Finally, Section 4.3 decomposes the responses into specific transmission channels. Housing-related channels—both cash-flow and wealth—emerge as the most important, followed by equity wealth and expectations, although their relative importance depends on the outcome variable considered. Appendix A.3 presents a range of robustness checks; overall, the results are robust across alternative log-level specifications and to using different instruments.

4.1 Total Effects of Monetary Policy

We start by documenting the total effects of a contractionary monetary policy shock in the baseline model. The VAR is estimated over the sample 1998M2–2019M12 and includes one-, five-, and ten-year Gilts; the FTSE All Share index; the Sterling Exchange Rate Index (SERI); investment- and non-investment-grade corporate bond spreads; fixed and floating rate mortgage rates; output (CIPS composite) and inflation expectations; retail volumes; monthly GDP (split into services, production, and construction); and CPIH (core).

Figure 6 reports impulse response functions (IRFs) to a contractionary monetary policy shock, normalised to raise the one-year Gilt yield by 25 bps on impact. The responses are broadly consistent with theoretical predictions and with previous findings. Gilt yields rise immediately, with stronger effects at the short end. Equity prices fall on impact, with the trough reached after around eight months. Exchange rates appreciate, as predicted by theory, but depreciate from month ten onwards, although this latter response is insignificant. Both investment- and non-investment-grade corporate bond spreads widen, peaking around ten months after the shock. Mortgage rates broadly follow the path of Gilt yields. House prices decline, with a trough of about one percent, consistent with Albuquerque et al. (2025), although the response is more persistent than in their study. Output and inflation expectations both decrease, with troughs around seven and ten months, respectively. Retail sales and other real activity measures react more sluggishly and generally decline, with production being the only real activity variable to display a significant puzzle. Prices (CPIH core) exhibit the familiar quick response documented for high-frequency instruments in the UK and the US (Cesa-Bianchi et al., 2020; Miranda-Agrippino & Ricco, 2021).

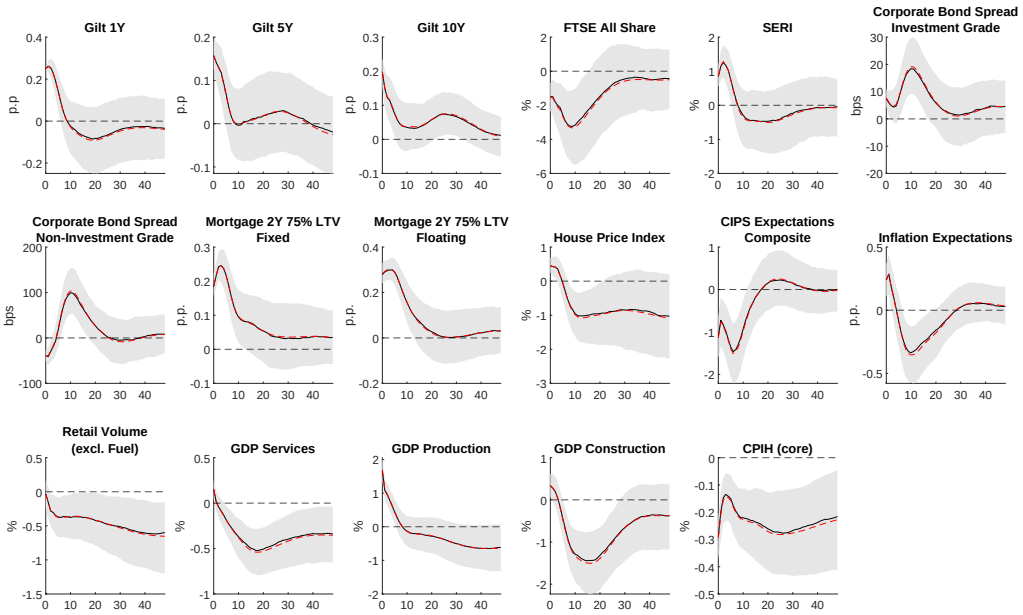


Figure 6: Impulse response functions to a monetary policy shock normalised to raise the one-year Gilt yield by 25 bps on impact. The red line shows the posterior mean, the black line the posterior median, and shaded bands pointwise 68% credible intervals. The horizontal axis reports months after the shock.

Although financial market variables and expectations—the first two rows of Figure 6—react quickly and significantly, this alone does not guarantee that monetary policy is transmitted through them. A significant total effect is neither necessary nor sufficient: offsetting channels can imply a zero effect, while a non-zero effect need not propagate to other variables. Thus, while equity prices decline, mortgage rates rise, and house prices fall, these responses do not by themselves establish the presence of equity wealth, housing wealth, or mortgage cash-flow channels that contribute materially to the reactions of output and prices—the last row of Figure 6. The following sections therefore use Transmission Channel Analysis (TCA, Wegner et al., 2025) to identify the channels through which UK monetary policy transmits to the real economy and prices at different horizons.

4.2 Transmission via Financial Markets and Expectations

A standard view is that monetary policy transmits mainly through financial markets and expectations to the real economy and prices (see, e.g. Burr & Willems, 2024). Although financial markets are forward looking and thus largely shaped by expectations, expectations can represent a distinct transmission mechanism rather than merely a driver of financial prices. Expectations enter directly into wage and price setting, and the Euler-equation logic suggests that expected future conditions can affect consumption decisions beyond what is already captured by observed financial rates. Moreover, different agents—financial markets, professional forecasters, firms, and households—may hold different expectations and these may respond differently to monetary policy shocks (Burr, 2025). As a result, the expectations variables included in our VAR may capture dynamics beyond what is already reflected in financial-market variables. To obtain a first view on monetary policy transmission, this section groups financial markets and expectations together, while the next

section decomposes this block further and separates the expectations channel from specific financial-market channels.

Recall from Section 3 that the financial-markets-and-expectations channel is defined as the set of all paths that pass at least once through any financial-market or expectations variable (Figure 2a). For horizons greater than zero, this channel can be decomposed into first- and second-round effects (Figure 3). First-round effects capture paths that enter financial markets or expectations and then propagate to output or prices, excluding feedback from the real economy-and-price block. Second-round effects capture this feedback among financial markets, expectations, output, and prices. The remaining effects, not explained by financial markets or expectations, are split into direct price effects and other direct effects, reflecting respectively the direct impact of the shock on prices (and propagation within prices) and its direct impact on real activity (and propagation within the real-economy-and-price block).

Figure 7 shows this decomposition for Retail Volumes, Services, and CPIH (core)—the variables we focus on most—for the baseline VAR estimated in Section 4.1. Figure B.1 reports the analogous decompositions for the remaining real variables. The black scatter-line shows the total response computed at the posterior mean of the VAR coefficients; it is close to the posterior mean and median IRFs in Figure 6. The bars report the contributions of the four channels and sum to the total at each horizon. Blue bars denote effects through financial markets and expectations, with dark and light blue distinguishing first- and second-round effects. Yellow and grey bars show direct price and other direct effects, respectively. All objects are computed at the posterior mean of the VAR coefficients, ensuring internal consistency with the total response.

The decomposition shows that UK monetary policy transmits primarily through financial markets and expectations, as reflected in the combined dark and light blue bars. Second-round effects (light blue) become important for services and prices from around ten months after the shock and increase thereafter, while remaining small for retail sales, construction, and production. Overall, the transmission through financial markets and expectations is relatively sluggish, with troughs around ten to twenty months after the shock. By contrast, the large contemporaneous responses of prices and production are largely accounted for by direct channels, with direct price effects dominating the early price response.

In principle, expectations and exchange-rate channels could also generate fast price responses. If these channels are not well captured by our model, direct price effects may be overstated. We therefore estimated augmented VARs designed to better capture exchange-rate and expectations channels (Appendix A.5). Adding USD–GBP and EUR–GBP exchange rates alongside the SERI leaves the results largely unchanged (Figure A.3a). Similarly, including GfK expectations on major purchases and savings, to better capture household expectations, does not materially alter the role of direct price effects, but it does affect the magnitude of second-round effects (Figure A.3b). Large direct price effects are therefore a robust feature of the data; understanding these effects better is an important direction for future research.

This section has shown that monetary policy in the UK is primarily transmitted through the financial-market and expectations variables captured by our model. However, these channels remain broad and encompass several distinct theoretical mechanisms. For instance, falling equity and house prices may reduce consumption through wealth effects, while rising mortgage rates may operate through cash-flow and disposable income. Our analysis so far does not disentangle these mechanisms. The next section therefore examines which specific transmission channels drive the responses of output and prices.

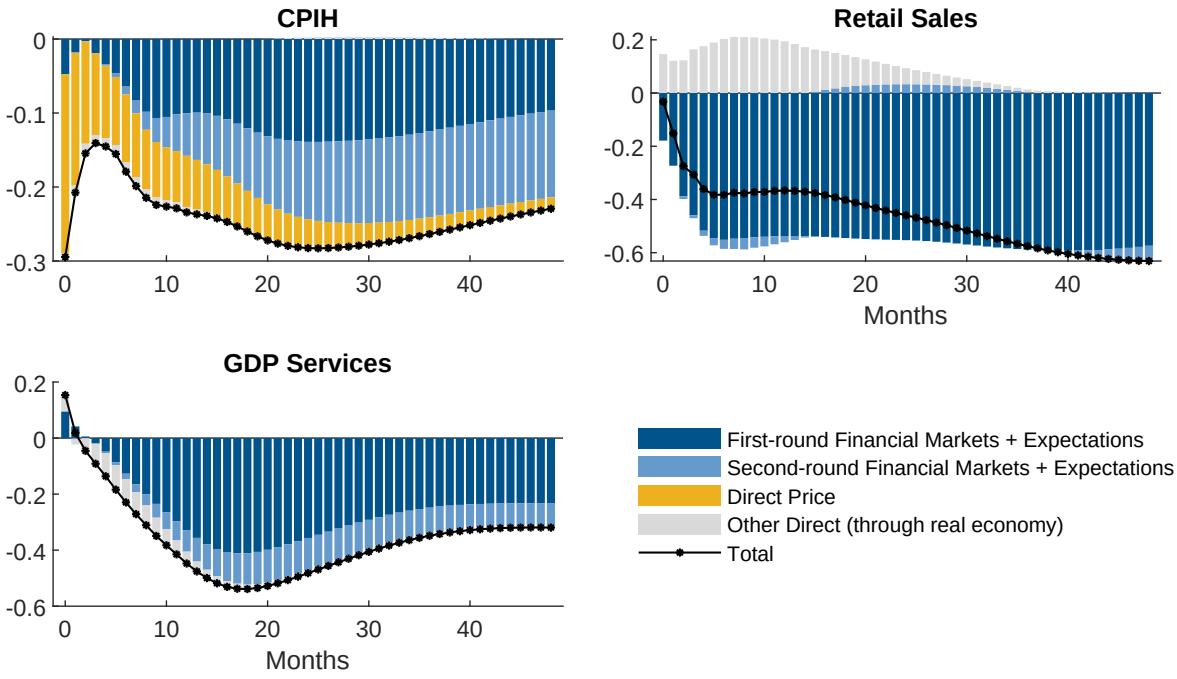


Figure 7: Decomposition of the total responses to the monetary policy shock in Figure 6. The black scatter-line shows the total response computed at the posterior mean of the VAR coefficients. Bars report the contributions of the corresponding transmission channels and sum to the total at each horizon.

4.3 Decomposition into Cash-Flow, Wealth, and Other Channels

Which channels drive the responses of output and prices after a monetary policy shock? To address this question, we further decompose the broad channel through financial markets and expectations into specific transmission channels. We find that housing is the key channel of monetary policy transmission, followed by equity wealth and expectations, although their relative importance depends on the outcome variable considered. Figures 8 and B.2 summarise these results. They show the total effects (IRFs) as a black scatter-line and the channel contributions as bars, all computed at the posterior mean of the baseline model coefficients from Section 4.1. The remainder of this section discusses the decompositions in detail, examining each transmission channel in turn.

4.3.1 Housing

Monetary policy can transmit through housing to real activity and prices in several ways. On the one hand, higher mortgage rates reduce households' free cash-flow, lowering consumption—or, more generally, spending (Di Maggio et al., 2014; Flodén et al., 2021; Jappelli & Scognamiglio, 2018; Keys et al., 2014; La Cava et al., 2016). On the other hand, declining house prices reduce household wealth directly and limit the equity that can be extracted at remortgaging, dampening spending. Moreover, lower house prices reduce collateral values, further depressing household spending and—if households are directors of small- to medium-sized enterprises—firm investment (Bahaj et al., 2020; Bhutta & Keys, 2016; Bracke et al., 2024; Campbell & Cocco, 2007; Cumming & Hubert, 2022; Mian & Sufi, 2011, 2014; Mian et al., 2013; Wong, 2019). Garriga et al. (2017) and Albuquerque et al. (2025) provide theoretical models that capture aspects

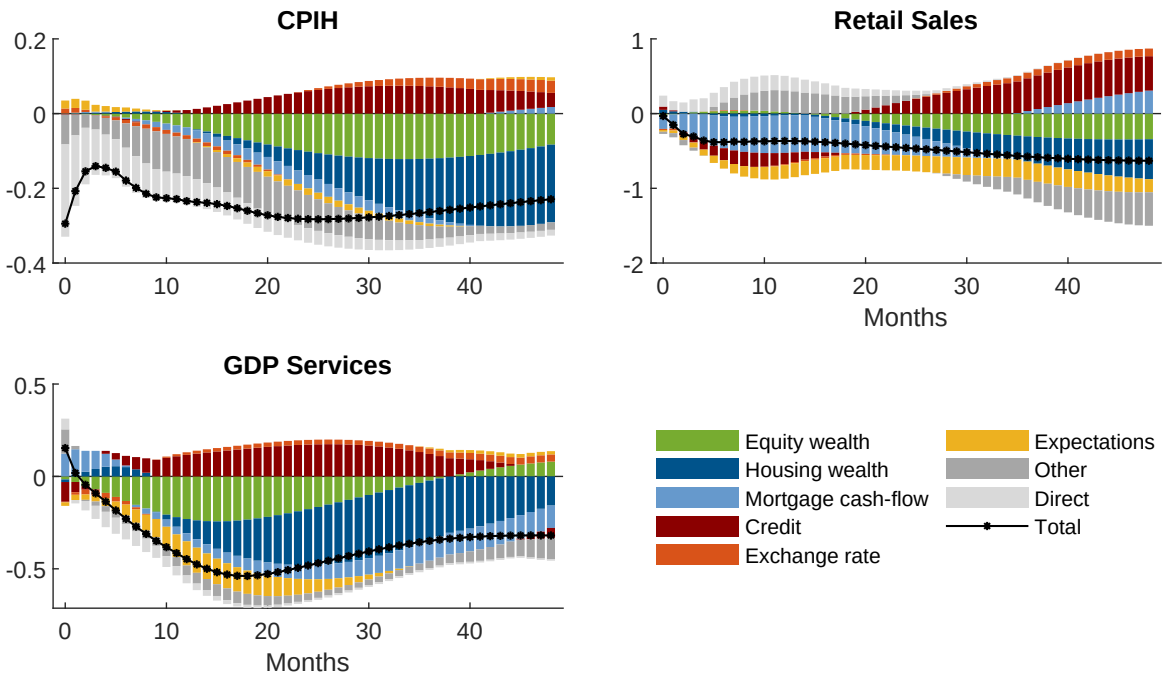


Figure 8: Decomposition of the total responses to the monetary policy shock in Figure 6. The black scatter-line shows the total response computed at the posterior mean of the VAR coefficients. Bars report the contributions of the corresponding transmission channels and sum to the total at each horizon.

of these mechanisms. We group all channels linked to mortgage rates under *mortgage cash-flow* and those linked to house prices under *housing wealth*. Figure 4a in Section 3 provides a conceptual overview of the corresponding paths. In our decomposition, housing wealth and mortgage cash-flow channels are shown as dark- and light-blue bars in Figure 8, respectively.

Housing-related channels play a central role in the transmission of UK monetary policy. Mortgage cash-flow effects (light blue) account for much of the initial decline in retail sales and still contribute substantially to services but only moderately to prices. Housing wealth effects, by contrast, are more important for prices and for real activity overall, although they operate at somewhat longer horizons. Together, mortgage cash-flow and housing wealth account for the bulk of the transmission to output and prices, with cash-flow dominating at short horizons for retail sales and housing wealth dominating at medium- to long horizons for services and prices.

To understand why housing wealth transmits more strongly to prices than mortgage cash-flow, despite the early price response being driven by goods prices, we replace CPIH with CPIH goods and CPIH services separately (Appendix A.6). Mortgage cash-flow effects, while depressing retail sales, have little pass-through to CPIH goods and never turn negative (Figure A.6a). Housing wealth, in contrast, generates large declines in services with strong pass-through to CPIH services (Figure A.6b). Since services account for about 60% of CPIH, this helps explain why housing wealth effects dominate in the aggregate price response.

Our findings are consistent with Albuquerque et al. (2025), who show, in a HANK model estimated on UK data, that housing accounts for roughly half of the total transmission of monetary policy to consumption. They also align with evidence from the UK NMG survey[5], which suggests that an increase of £100 in

[5]https://www.bankofengland.co.uk/bank-overground/2023/how-are-households-adjusting-to-rising-mortgage-costs

mortgage payments reduces spending by about £50, with households already cutting back in anticipation of higher rates. More broadly, our results are consistent with international micro evidence. Di Maggio et al. (2014), Flodén et al. (2021), Jappelli and Scognamiglio (2018), Keys et al. (2014), and La Cava et al. (2016) find that exogenous declines in mortgage rates are associated with increased household spending, while Bahaj et al. (2020), Bhutta and Keys (2016), Campbell and Cocco (2007), Cumming and Hubert (2022), Mian and Sufi (2011, 2014), Mian et al. (2013), and Wong (2019) document housing wealth effects through equity extraction or collateral. By contrast, our results differ from Slacalek et al. (2020), who conclude for the euro area that housing wealth plays only a minor role in the transmission of monetary policy shocks.

Despite this consistency with the broader literature, the results should be interpreted with caution and may not be informative for monetary policy in all states of the economy. Since we rely on linear models, the estimates reflect average transmission in the UK over the sample. However, Eichenbaum et al. (2022) finds evidence that housing wealth effects are state-dependent, varying with the potential savings from refinancing. Transmission through housing wealth may therefore differ substantially in environments characterised by a prolonged period of high interest rates followed by a rapid cutting cycle. This may be further amplified if households use part of the windfall from lower mortgage rates to delever (Di Maggio et al., 2014; Keys et al., 2014). If a prolonged high-rate period leads to higher household debt, households may allocate a larger share of subsequent mortgage-payment reductions to deleveraging, weakening the mortgage cash-flow channel. Similarly, Jappelli and Scognamiglio (2018) find that the mortgage cash-flow channel may depend on the perceived persistence of the shock. Central bank communication that increases perceived persistence of a rate cut may therefore strengthen transmission through the mortgage cash-flow channel.

4.3.2 Equity Wealth

Similar to housing wealth, a decline in equity prices reduces household wealth, which can lower consumption and, indirectly, prices (Burr & Willems, 2024). Ludwig and Sløk (2002) discuss several ways in which this mechanism can operate, including realised and unrealised wealth effects, budget-constraint effects, and liquidity-constraint effects. We collectively refer to these mechanisms as the *equity wealth* channel. In the decomposition in Figure 8, its contribution is shown by the green bars (see also Figure 4a in Section 3 for the corresponding conceptual paths).

Equity wealth effects are visible across all real activity and price variables. They emerge earliest for services and appear with a delay for the other outcomes. Consistent with equity wealth being more liquid than housing wealth, equity wealth effects typically lead housing wealth effects, although their peak impact is smaller. In contrast to the mortgage cash-flow channel, but consistent with the housing wealth channel, the equity wealth contribution to goods and services prices is nearly identical (Appendix A.6).

These findings align with Barrell et al. (2015), Carroll et al. (2011), Case et al. (2013), Chodorow-Reich et al. (2019), Di Maggio et al. (2020), and Dynan and Maki (2001), who report significant equity wealth effects, but contrast with Case et al. (2001), Ludvigson et al. (2002), and Slacalek et al. (2020), who find insignificant effects. Our estimates are also larger than those reported for the euro area by Slacalek et al. (2020) and contrast with the view of Cloyne et al. (2020) that wealth effects are unlikely to matter because they are concentrated among high-wealth households with limited spending responses. Consistent with our results, the literature often finds that housing wealth effects are stronger than equity wealth effects (Barrell et al., 2015; Carroll et al., 2011; Case et al., 2013; Slacalek, 2009; Slacalek et al., 2020). One way to rationalise this asymmetry is through the behaviour of (rich) hand-to-mouth (HtM) households, as in Auclert et al. (2021) and Kaplan et al. (2018). If HtM households have a higher marginal propensity to consume out of

wealth and hold disproportionately more housing than financial wealth, then the aggregate housing wealth channel will be stronger than the financial wealth channel. Some evidence in this direction is provided by Di Maggio et al. (2020), who show that the bottom 50% of the wealth distribution in Sweden have a marginal propensity to consume out of unrealised capital gains of about 23%, while the top 30%—those unlikely to be HtM households—have a marginal propensity to consume out of unrealised capital gains of 3%. The marginal propensities to consume out of dividends are estimated to be larger but less divergent across the two groups.

4.3.3 Expectations

Section 4.2 highlighted that, although financial markets are largely shaped by expectations, measured expectations may still represent a distinct transmission channel. However, Section 4.2 did not quantify this channel. In this section, we therefore examine whether changes in measured inflation and output expectations constitute a separate channel. We refer to this mechanism as the *expectations channel*. Its contribution is shown by the yellow bars in Figure 8. Recall from Section 3 that, unlike the wealth and cash-flow channels, the expectations channel can directly affect all real activity and price variables (Figure 4b). It therefore captures effects on consumption (via retail sales and services), on production and investment decisions (via production and construction), and on wage and price setting (via prices).

The expectations channel is comparable in size to the mortgage cash-flow channel for most real activity variables, though it is weaker for retail sales. This is broadly consistent with evidence that higher inflation expectations are associated with higher spending (Coibion et al., 2022; D'Acunto et al., 2016, 2018; Dräger & Nghiem, 2021; Duca-Radu et al., 2021; Ichiue & Nishiguchi, 2015). For prices, however, the estimated contribution is much smaller, despite evidence that UK inflation expectations respond significantly to monetary policy shocks (Burr, 2025; Di Pace et al., 2025). One possible explanation is that Di Pace et al. (2025) find that firms' own-price expectations do not respond significantly to high-frequency shocks. Since our baseline identification relies on high-frequency shocks, this may help explain the small price contribution. Consistent with this interpretation, robustness results using the narrative series of Cloyne and Hürtgen (2016) yield stronger, albeit positive, effects through the expectations channel on CPIH (Appendix A.4).

To better understand the role of expectations for prices, we replace CPIH with CPIH goods and CPIH services (Appendix A.6). While the expectations channel reduces services output, the estimated effect on CPIH services is positive (Figure A.6b), whereas the effects on CPIH goods and retail sales are mostly negative (Figure A.6a). As with mortgage cash-flow effects, the weaker role of expectations for aggregate prices can therefore be traced to differing responses in goods and services prices.

An additional consideration is that if expectations are partly backward looking, the expectations channel would operate not only directly but also through interactions with real activity and prices: other channels reduce output and prices, which then lower expectations, feeding back into activity and prices. Under our current specification, these interaction effects are not separately captured. The expectations channel may therefore be underestimated, and the true effect on prices—in particular on services prices—may be more negative. The second-round effects in Figure 7 do not resolve this issue, as they combine expectations feedback with other feedback effects. Further splitting the second-round effects is possible in principle, but it is technically complex; we defer such refinements to future research.

Finally, the measurement of expectations is itself challenging. If the included variables do not fully capture the expectations relevant for households and firms, the estimated effects may be imprecise. This is particularly relevant in our sample, where we rely on a principal component constructed from several survey

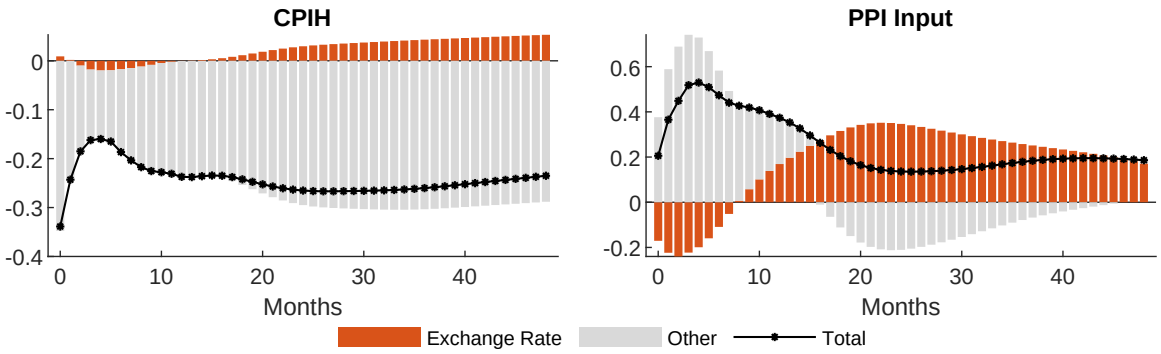


Figure 9: Decomposition of the total responses to the monetary policy shock in Figure 6 into the exchange-rate channel and the combined contribution of all other channels. The black scatter-line shows the total response computed at the posterior mean of the VAR coefficients. Bars report channel contributions and sum to the total at each horizon.

measures (Appendix C), many of which are only available for part of the sample. As expectations data improve, estimates of the expectations channel may become more precise and potentially stronger.

4.3.4 Exchange Rate

The response of the exchange rate to a contractionary monetary policy shock, shown in Figure 6, can affect real activity and prices through both indirect and direct channels (Burr & Willems, 2024). Indirectly, an appreciation of Sterling makes exports less competitive and imports more attractive, reducing real activity and thereby affecting prices. Directly, the appreciation lowers the cost of imported goods and services in the consumption basket. Importantly, these mechanisms can be present even under dollar pricing, as shown by McLeay and Tenreyro (2025). We refer to the combined direct and indirect mechanisms as the *exchange rate channel*. Its contribution is shown by the orange bars in Figure 8. Recall from Section 3 that, like the expectations channel, the exchange rate channel can directly influence all real activity and price variables, allowing us to capture both direct and indirect effects.

Despite the openness of the UK economy, our baseline estimates assign only a small role to the exchange rate channel in transmitting monetary policy to activity and consumer prices. Augmenting the baseline VAR with PPI input and output prices, however, reveals substantial effects on input prices: Sterling appreciations induced by monetary policy feed through to lower input costs, while depreciations raise them (Figure 9). The latter effect is likely insignificant given that the depreciation of the SERI is estimated to be insignificant. Consistent with stronger pass-through to input prices, we also find somewhat larger—though still small—effects through the exchange rate channel on goods prices than on services prices (Appendix A.6). Overall, while the exchange rate channel matters for input prices, its contribution to consumer price inflation remains limited in our sample.

The broader literature, largely based on reduced-form regressions, also finds stronger exchange rate pass-through to input prices than to consumer prices, both in the UK and internationally (Campa & Goldberg, 2002; Gagnon & Ihrig, 2004; Hjortsoe & Lewis, 2020; Jašová et al., 2016; Mortimer-Lee, 2022; Mumtaz et al., 2006; Savoie-Chabot & Khan, 2015). Even relative to these lower consumer-price pass-through estimates, our results are small. One reason may be that we strictly separate the exchange rate channel from other channels, whereas reduced-form approaches may still mix exchange-rate effects with other mechanisms that

co-move with exchange rates after a monetary policy shock. Another consideration is that exchange rate pass-through to consumer prices has been found to decline over time and to be smaller in environments with greater central bank credibility and clear inflation targeting (Campa & Goldberg, 2002; Gagnon & Ihrig, 2004; Jašová et al., 2016; Mishkin, 2008; Mortimer-Lee, 2022; Mumtaz et al., 2006; Taylor, 2000). Since the Bank of England gained operational independence in 1997, our sample lies entirely within a period of strong credibility and inflation targeting, consistent with modest average pass-through to consumer prices through the exchange rate channel.

4.3.5 Credit

Monetary policy can affect real activity and prices through credit conditions in at least two ways. First, the bank lending channel (Disyatat, 2011; Van den Heuvel, 2007): higher interest rates raise borrowers' default risk, worsening the quality of outstanding loans and deteriorating banks' capital positions. To repair their balance sheets, banks may reduce lending, tightening credit supply and thereby lowering real activity and prices. Second, the balance sheet channel (Bernanke et al., 1999): higher interest rates reduce the value of household and firm assets, raising default probabilities and the risk premia required by banks. This increases borrowing costs and reduces real activity and prices. Following the literature, we group both mechanisms under the *credit channel* (Bernanke & Gertler, 1995), shown as dark-red bars in Figure 8. Recall from Section 3 that, unlike the wealth and cash-flow channels, the credit channel can directly affect all real activity variables but, unlike the expectations and exchange rate channels, it cannot directly affect prices.

In the baseline decomposition, the estimated credit channel contribution is mixed. Retail sales and services rise, implying upward pressure on prices, which is contrary to the standard theoretical prediction. By contrast, production and construction—at least initially—contract, consistent with theory. These mixed results likely reflect the difficulty of specifying the credit channel in our monthly VAR. Both the lending and balance sheet channels are thought to operate primarily through investment, yet no suitable monthly investment series is available. Moreover, our credit conditions are proxied by spreads on publicly traded corporate debt, whereas monetary policy may affect default risk and borrowing constraints more strongly for small, private, and financially constrained firms. The included spreads may therefore be an imperfect proxy for the credit conditions most relevant for this channel.

With this in mind, we consider an alternative specification that includes bank lending to households and private non-financial corporations (PNFCs), and restricts the channel to pass from credit spreads into lending before propagating to real activity (Appendix A.5). This refinement is closer to the final stage of the credit channel, in which tighter credit conditions translate into lower lending. The resulting estimated contributions are, however, negligible for real activity and prices (Figure A.4). One limitation is that the available series measure net lending, which may conflate changes in lending with changes in repayments, and may therefore mix the credit channel with other mechanisms that weaken household and firm balance sheets. The refined channel is thus also likely misspecified, and the credit-channel results should be interpreted with caution.

The weak estimated effects may also reflect that credit operates primarily as a second-round mechanism: other channels contract the economy, which then worsens credit conditions and activates the credit channel. Such second-round credit effects are not captured in either specification, with or without lending. As discussed for the expectations channel, the second-round effects in Figure 7 cannot be used to quantify this underestimation because they combine multiple feedback mechanisms. However, the relatively slow responses of spreads and lending compared with other financial variables suggest that second-round effects

may be important. Given the technical difficulty of disentangling these dynamics, we defer a more precise analysis to future research.

Overall, the credit channel is likely misspecified under both specifications, and we therefore caution against interpreting its estimated contribution. Importantly, however, the estimated effects through the other channels are nearly identical across the two specifications. This suggests that any misspecification of the credit channel has limited spillovers to the estimated contributions of the remaining channels, which appear relatively stable.

5 Conclusion

We estimate a medium-sized BVAR over the period 1998M2–2019M12, including an extensive financial-markets-and-expectations block, and identify monetary policy shocks using external instruments. The total effects—the impulse response functions—are largely consistent with theoretical predictions. Using this BVAR, we quantify the channels through which monetary policy transmits to the real economy and prices using Transmission Channel Analysis (TCA; Wegner et al., 2025). Within this framework, we formally define a range of transmission channels—including an aggregate financial-markets-and-expectations channel and narrower cash-flow, wealth, expectations, and exchange-rate channels. We further prove that the effects through these channels are invariant to a large class of alternative thought experiments. Hence, our definitions provide a robust baseline specification for future research on monetary policy transmission that can be implemented in both structural time-series and DSGE models.

Consistent with theoretical predictions, we find that the bulk of monetary policy transmission operates through the financial-market and expectations variables captured by our model. Second-round effects—capturing feedback between the real economy, financial markets, and expectations—amplify the transmission to prices and GDP services but are negligible for retail sales. Moreover, second-round effects lag first-round effects, increasing in importance at longer horizons. Neither first- nor second-round effects can account for the initial rapid reaction in prices, which is instead attributed to direct-price effects. This finding is robust across a wide set of alternative monetary policy instruments and to extensions of the expectations and exchange-rate blocks.

Zooming in on specific channels, we find that wealth and cash-flow effects, particularly those related to housing, account for most of UK monetary policy transmission. Housing wealth emerges as the single most important channel for GDP services and prices, while the mortgage cash-flow channel explains almost the entire initial reduction in retail sales. We hypothesise that housing-related channels are especially important in the UK because of short mortgage maturities, frequent remortgaging, and a high degree of flexibility in mortgage refinancing. Economies with longer mortgage terms or fewer refinancing options may therefore exhibit different transmission patterns. A systematic comparison of our estimates with those for other advanced economies is an important avenue for future research.

The equity-wealth channel also exerts a substantial influence on prices and real activity. Moreover, equity-wealth effects lead housing-wealth effects, consistent with housing being less liquid despite relatively frequent remortgaging. Effects through the expectations channel reduce retail sales and GDP services but are small for prices. Similarly, the exchange-rate channel is negligible for consumer prices, despite substantial effects on producer input prices. Our results therefore imply limited pass-through to aggregate consumer prices, although we find somewhat stronger pass-through to consumer goods prices.

The small estimated effects of the exchange-rate and expectations channels on prices may reflect state

dependence in these channels. The expectations channel is likely stronger when expectations are more responsive, and the exchange-rate channel may depend on firms' ability to pass through cost changes. Such state dependence is not captured by our empirical approach, which reflects average channel importance over the estimation period. Future research should therefore explore extensions that allow for state dependence and non-linearities in monetary policy transmission. Nonetheless, since our sample covers major economic episodes—including the Great Recession and the Brexit period—we expect our results to remain informative for most UK policy environments.

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Appendix A Formally Defining the Transmission Channels

In Section 3, we described our channel definitions and the corresponding paths for horizons 0 and 1. In this appendix, we follow Wegner et al. (2025) and formalise our transmission channels using Boolean statements. The use of Boolean statements adds rigour to the analysis and allows for a precise definition of the included paths at higher horizons. We also use this formalism to prove that the effects through our transmission channels are invariant to alternative transmission orderings that permute variables within the financial-markets-and-expectations block. For an overview of Boolean statements, see Appendix A.1 in Wegner et al. (2025).

A.1 Channel Definition and Invariance

A.1.1 Cash-Flow, Wealth, and Other Channels

To define the narrow transmission channels, such as cash-flow and wealth channels, using Boolean statements, we partition the endogenous variables into a block of financial-market and expectations variables, $\boldsymbol{y}_{1:F,t}$ and a block of real-economy and price variables, $\boldsymbol{y}_{F+1:N,t}$. Hence, $\boldsymbol{y}_t' = (\boldsymbol{y}_{1:F,t}', \boldsymbol{y}_{F+1:N,t}')$. Let $f \in \{1, \dots, F\}$, $e \in \{F+1, \dots, N\}$, $n_f, n_e \geq 0$ such that $f + n_f \leq F$ and $e + n_e \leq N$, $b_i^f = \vee_{k=0}^{n_f} y_{f+k,t+i}$ for all $i = 0, \dots, h$, and $b_j^e = \vee_{k=0}^{n_e} y_{e+k,t+j}$ for all $j = 0, \dots, h$. The Boolean statement describing the paths corresponding to our narrow transmission channels at horizon h is then given by

$$q_h = \vee_{i=0}^{h} \vee_{j=i}^{h} q_{i,j}(b_i^f, b_j^e), \tag{A.1}$$

where

$$q_{i,j}(b_i^f, b_j^e) = \begin{cases} \text{false} & \text{if } j < i \\ (\wedge_{k=F+1}^{N} \wedge_{l=0}^{i-1} \neg y_{k,t+l}) \wedge b_i^f \wedge (\wedge_{k=f+n_f+1}^{e-1} \neg y_{k,t+i}) \wedge b_j^e & \text{if } j = i \\ (\wedge_{k=F+1}^{N} \wedge_{l=0}^{i-1} \neg y_{k,t+l}) \wedge b_i^f \wedge (\wedge_{k=f+n_f+1}^{N} \neg y_{k,t+i}) & \\ \quad \wedge (\wedge_{k=1}^{e-1} \neg y_{k,t+j}) \wedge b_j^e & \text{if } j = i+1 \\ (\wedge_{k=F+1}^{N} \wedge_{l=0}^{i-1} \neg y_{k,t+l}) \wedge b_i^f \wedge (\wedge_{k=f+n_f+1}^{N} \neg y_{k,t+i}) & \\ \quad \wedge (\wedge_{k=1}^{N} \wedge_{l=i+1}^{j-1} \neg y_{k,t+l}) \wedge (\wedge_{k=1}^{e-1} \neg y_{k,t+j}) \wedge b_j^e & \text{if } j > i+1. \end{cases} \tag{A.2}$$

Each $q_{i,j}(b_i^f, b_j^e)$ describes a set of paths that propagate within the financial-markets-and-expectations block until they reach one of the variables in b_i^f. From there, the paths move directly to one of the variables in b_j^e, after which they propagate freely to the outcome variable of interest. For example, if f is the index of equity prices, $n_f = 0$, e is the index of goods consumption, $e+1$ is the index of services consumption, and $n_e = 1$, then $q_{0,0}(b_0^f, b_0^e)$ represents the equity-wealth channel. The paths satisfying this Boolean statement are precisely those shown in Figures 4a and 5a. Similarly, $q_{0,1}(b_0^f, b_0^e)$ corresponds to the paths in Figure 5b, and $q_{1,1}(b_0^f, b_0^e)$ to those in Figure 5c.

Following Wegner et al. (2025), let $\mathcal{P}_{u,v}$ denote the set of all paths connecting variable or shock u to variable v, and let $P_{u,v}(b) \subseteq \mathcal{P}_{u,v}$ denote the subset of paths from u to v that satisfy the Boolean statement b. The effect transmitted through the paths $P_{u,v}(b)$ is then defined as $\mathcal{Q}[P_{u,v}(b)]$. Accordingly, $P_{\varepsilon_{1,t}, y_{N,t+h}}(q_h)$ captures all paths corresponding to a given transmission channel from the monetary policy shock, $\varepsilon_{1,t}$, to prices, $y_{N,t+h}$, at horizon h, assuming that prices are ordered last. The associated effect through this transmission channel is $\mathcal{Q}[P_{\varepsilon_{1,t}, y_{N,t+h}}(q_h)]$. Since $q_{i,j}(b_i^f, b_j^e)$, for all $i, j = 0, \dots, h$, describe mutually disjoint

sets of paths, Lemma A.1. of Wegner et al. (2025) implies that

$$\mathcal{Q}[P_{\varepsilon_{1,t},y_{N,t+h}}(q_h)] = \sum_{i=0}^{h}\sum_{j=i}^{h} \mathcal{Q}[P_{\varepsilon_{1,t},y_{N,t+h}}(q_{i,j}(b_i^f, b_j^e))]. \tag{A.3}$$

In general, the effect $\mathcal{Q}[P_{\varepsilon_{1,t},y_{N,t+h}}(q_{i,j}(b_i^f, b_j^e))]$ for each $i, j = 0, \ldots, h$ depends on the chosen transmission ordering and therefore the effect $\mathcal{Q}[P_{\varepsilon_{1,t},y_{N,t+h}}(q_h)]$ also depends on this ordering. However, as stated in the next theorem, the effect $\mathcal{Q}[P_{\varepsilon_{1,t},y_{N,t+h}}(q_{i,j}(b_i^f, b_j^e))]$ is invariant to permutations of variables within the financial-markets-and-expectations block (conditions 1 and 2), provided that the variables in b_i^f remain in consecutive order (condition 3). Consequently, the overall effect through our transmission channels, $\mathcal{Q}[P_{\varepsilon_{1,t},y_{N,t+h}}(q_h)]$, is invariant to such permutations. The proof is provided in Appendix A.2.

Theorem 1. Let $b_i^f = \vee_{k=0}^{n_f} y_{f+k,t+i}$, $b_j^e = \vee_{k=0}^{n_e} y_{e+k,t+j}$, with $f \in \{1, \ldots, F\}$, $e \in \{F+1, \ldots, N\}$, $n_f, n_e \geq 0$, $f + n_f \leq F$, $e + n_e \leq N$, and σ be a permutation of the variables in $\boldsymbol{y}_t$ satisfying

1. $k \leq F \Leftrightarrow \sigma(k) \leq F$
2. $k = \sigma(k)$ for all $k = F + 1, \ldots, N$
3. $\max_{k=0,\ldots,n_f} \sigma(f + k) = \min_{k=0,\ldots,n_f} \sigma(f + k) + n_f$.

Then, $Q[P_{\varepsilon_{1,t},y_{N,t+h}}(q_{i,j}(b_i^f, b_j^e))] = Q^\sigma[P_{\varepsilon_{1,t},y_{N,t+h}}(q_{i,j}(b_i^f, b_j^e))]$, where $Q^\sigma[\cdot]$ denotes the transmission effect under the alternative transmission ordering σ.

A.1.2 Financial Markets and Expectations

In the previous appendix, we used Boolean statements to precisely define the sets of paths captured by our narrow transmission channels, such as the equity wealth channel. Analogously, in this appendix we use Boolean statements to define the paths associated with our broad transmission channels, such as the first-round and second-round channels through the financial-markets-and-expectations block. As for the narrow channels, we show that each of these broad channels is invariant to re-ordering of the variables within the financial-markets-and-expectations block. All proofs are deferred to Appendix A.2.

Financial-markets-and-expectations channel. We begin with the channel through the financial-markets-and-expectations block, which captures all paths that pass through at least one variable in that block within the first h periods. Formally, this set of paths is given by $P_{\varepsilon_{1,t},y_{N,t+h}}(\vee_{k=1}^{F} \vee_{l=0}^{h} y_{k,t+l})$, and the corresponding effect equals $\mathcal{Q}[P_{\varepsilon_{1,t},y_{N,t+h}}(\vee_{k=1}^{F} \vee_{l=0}^{h} y_{k,t+l})]$. For horizon zero, these paths correspond to those depicted in Figure 2a. Theorem 2 establishes that the effect through this block is invariant to any re-ordering of the variables within it.

Theorem 2. Let σ be defined as in Theorem 1 and satisfying the same three conditions. Then $\mathcal{Q}[P_{\varepsilon_{1,t},y_{N,t+h}}(\vee_{k=1}^{F} \vee_{l=0}^{h} y_{k,t+l})] = \mathcal{Q}^\sigma[P_{\varepsilon_{1,t},y_{N,t+h}}(\vee_{k=1}^{F} \vee_{l=0}^{h} y_{k,t+l})]$, where $\mathcal{Q}^\sigma[\cdot]$ denotes the transmission effect under the alternative transmission ordering σ.

First-round and second-round channels. For horizons $h > 0$, the effect through the financial-markets-and-expectations block can be decomposed into first-round and second-round effects. First-round effects

capture the transmission of a monetary policy shock through financial markets or expectations to the real-economy and price variables, excluding any feedback from those variables back to financial markets or expectations. Second-round effects, in turn, capture the interaction between financial-markets-and-expectations variables and real-economy-and-price variables.

Because first-round and second-round effects together decompose the total effect through the financial-markets-and-expectations block, it suffices to define the first-round channel explicitly; the second-round channel is then implicitly defined as the set difference between the paths forming the overall financial-markets-and-expectations channel and those forming the first-round channel.

Define $z_t = \wedge_{k=1}^{F} \neg y_{k,t}$ and $w_j = (\wedge_{k=F+1}^{N} \wedge_{l=0}^{j-1} \neg y_{k,t+l}) \wedge \neg z_{t+j} \wedge (\wedge_{l=j+1}^{h} z_{t+l})$. The first-round channel at horizon h is then described by the Boolean statement $w^h = \vee_{l=0}^{h} w_l$. Theorem 3 states that the effect through this first-round channel is invariant to re-ordering of the variables within the financial-markets-and-expectations block. Since the first-round and second-round effects together decompose the effect through the financial-markets-and-expectations block, and since both the effect through the financial-markets-and-expectations block and the effect through the first-round channel are invariant to permutations of $\boldsymbol{y}_{1:F,t}$, the second-round effect must also satisfy this invariance. This is stated in Corollary 1.

Theorem 3. Let σ be defined as in Theorem 1 and satisfying the same three conditions. Then $\mathcal{Q}[P_{\varepsilon_{1,t},y_{N,t+h}}(w^h)] = \mathcal{Q}^{\sigma}[P_{\varepsilon_{1,t},y_{N,t+h}}(w^h)]$, where $\mathcal{Q}^{\sigma}[\cdot]$ denotes the transmission effect under the alternative transmission ordering σ

Corollary 1. Let σ be defined as in Theorem 1 and satisfying the same three conditions. Moreover, let $\bar{P}_1 = P_{\varepsilon_{1,t},y_{N,t+h}}(\vee_{k=1}^{F} \vee_{l=0}^{h} y_{k,t+l})$ and $\bar{P}_2 = P_{\varepsilon_{1,t},y_{N,t+h}}(w^h)$, and define $\bar{P}_3 = \mathcal{P}_{\varepsilon_{1,t},y_{N,t+h}} \setminus \{\bar{P}_1 \cup \bar{P}_2\}$. Then $\mathcal{Q}[\bar{P}_3] = \mathcal{Q}^{\sigma}[\bar{P}_3]$, where $\mathcal{Q}^{\sigma}[\cdot]$ denotes the transmission effect under the alternative transmission ordering σ

Direct-price channel. Section 3 also defines a direct-price channel, consisting of all paths that go directly from the shock to prices and then propagate only within prices. At horizon h, this set of paths is captured by the Boolean statement $\wedge_{k=1}^{N-1} \wedge_{l=0}^{h} \neg y_{k,t+l}$. As with the previous channels, the effect through the direct-price channel is invariant to re-ordering of the variables within the financial-markets-and-expectations block, as stated in Theorem 4.

Theorem 4. Let σ be defined as in Theorem 1 and satisfying the same three conditions. Then $\mathcal{Q}[P_{\varepsilon_{1,t},y_{N,t+h}}(\wedge_{k=1}^{N-1} \wedge_{l=0}^{h} \neg y_{k,t+l})] = \mathcal{Q}^{\sigma}[P_{\varepsilon_{1,t},y_{N,t+h}}(\wedge_{k=1}^{N-1} \wedge_{l=0}^{h} \neg y_{k,t+l})]$, where $\mathcal{Q}^{\sigma}[\cdot]$ denotes the transmission effect under the alternative transmission ordering σ.

Other-direct channel. Finally, Section 3 defines the "other-direct" channel, which includes all remaining paths not captured by either the financial-markets-and-expectations channel or the direct-price channel. Because the total effect is invariant to all re-orderings, and the effects through both the financial-markets-and-expectations and direct-price channels are invariant to re-ordering of variables in $\boldsymbol{y}_{1:F,t}$, the effect through the "other-direct" channel must be invariant as well. This result is stated formally in Corollary 2.

Corollary 2. Let $\bar{P}_1 = P_{\varepsilon_{1,t},y_{N,t+h}}(\wedge_{k=1}^{N-1} \wedge_{l=0}^{h} \neg y_{k,t+l})$ and $\bar{P}_2 = P_{\varepsilon_{1,t},y_{N,t+h}}(\vee_{k=1}^{F} \vee_{l=0}^{h} y_{k,t+l})$, and define $\bar{P}_3 = \mathcal{P}_{\varepsilon_{1,t},y_{N,t+h}} \setminus \{\bar{P}_1 \cup \bar{P}_2\}$. Then $\mathcal{Q}[\bar{P}_3] = \mathcal{Q}^{\sigma}[\bar{P}_3]$, where $\mathcal{Q}^{\sigma}[\cdot]$ denotes the transmission effect under the alternative transmission ordering σ.

A.2 Proofs

A.2.1 Cash-Flow, Wealth, and Other Channels

Theorem 1 states that the effect through our transmission channels, $\mathcal{Q}[P_{\varepsilon_{1,t},y_{N,t+h}}(q_h)]$, is invariant to permutations of variables within the financial-markets-and-expectations block, provided the variables in b_i^f remain in consecutive order. We now prove this result.

First, note that

$$\begin{aligned}
q_{0,0}(b_0^f, b_0^e) &= \left[(\vee_{k=0}^{n_f-1} y_{f+k,t}) \wedge (\wedge_{k=f+n_f+1}^{e-1} \neg y_{k,t}) \wedge b_0^e\right] \vee \left[y_{f+n_f,t} \wedge (\wedge_{k=f+n_f+1}^{e-1} \neg y_{k,t}) \wedge b_0^e\right] \\
&= \left[(\vee_{k=0}^{n_f-1} y_{f+k,t}) \wedge (\wedge_{k=f+n_f}^{e-1} \neg y_{k,t}) \wedge b_0^e\right] \vee \left[(\vee_{k=0}^{n_f-1} y_{f+k,t}) \wedge y_{f+n_f,t} \wedge (\wedge_{k=f+n_f+1}^{e-1} \neg y_{k,t}) \wedge b_0^e\right] \\
&\quad \vee \left[y_{f+n_f,t} \wedge (\wedge_{k=f+n_f+1}^{e-1} \neg y_{k,t}) \wedge b_0^e\right] \\
&= \left[(\vee_{k=0}^{n_f-1} y_{f+k,t}) \wedge (\wedge_{k=f+n_f}^{e-1} \neg y_{k,t}) \wedge b_0^e\right] \vee \left[y_{f+n_f,t} \wedge (\wedge_{k=f+n_f+1}^{e-1} \neg y_{k,t}) \wedge b_0^e\right],
\end{aligned} \tag{A.4}$$

where the final equality follows because the term in the second brackets of the preceding line implies the term in the third brackets. Applying this argument recursively yields

$$q_{0,0}(b_0^f, b_0^e) = \vee_{k_f=0}^{n_f} \left[y_{f+k_f,t} \wedge (\wedge_{k=f+k_f+1}^{e-1} \neg y_{k,t}) \wedge b_0^e\right]. \tag{A.5}$$

Analogously,

$$\begin{aligned}
q_{0,0}(b_0^f, b_0^e) &= \left[b_0^f \wedge (\wedge_{k=f+n_f+1}^{e-1} \neg y_{k,t}) \wedge (\vee_{k=1}^{n_e} y_{e+k,t})\right] \vee \left[b_0^f \wedge (\wedge_{k=f+n_f+1}^{e-1} \neg y_{k,t}) \wedge y_{e,t}\right] \\
&= \left[b_0^f \wedge (\wedge_{k=f+n_f+1}^{e} \neg y_{k,t}) \wedge (\vee_{k=1}^{n_e} y_{e+k,t})\right] \vee \left[b_0^f \wedge (\wedge_{k=f+n_f+1}^{e-1} \neg y_{k,t}) \wedge y_{e,t} \wedge (\vee_{k=1}^{n_e} y_{e+k,t})\right] \\
&\quad \vee \left[b_0^f \wedge (\wedge_{k=f+n_f+1}^{e-1} \neg y_{k,t}) \wedge y_{e,t}\right] \\
&= \left[b_0^f \wedge (\wedge_{k=f+n_f+1}^{e} \neg y_{k,t}) \wedge (\vee_{k=1}^{n_e} y_{e+k,t})\right] \vee \left[b_0^f \wedge (\wedge_{k=f+n_f+1}^{e-1} \neg y_{k,t}) \wedge y_{e,t}\right],
\end{aligned} \tag{A.6}$$

where the last equality again follows because the term in the second brackets in the preceding line implies the term in the third brackets. Applying this reasoning recursively gives

$$q_{0,0}(b_0^f, b_0^e) = \vee_{k_e=0}^{n_e} \left[b_0^f \wedge (\wedge_{k=f+n_f+1}^{e+k_e-1} \neg y_{k,t}) \wedge y_{e+k_e,t}\right] \tag{A.7}$$

Combining the two results, we obtain

$$q_{0,0}(b_0^f, b_0^e) = \vee_{k_f=0}^{n_f} \vee_{k_e=0}^{n_e} \left[y_{f+k_f,t} \wedge (\wedge_{k=f+k_f+1}^{e+k_e-1} \neg y_{k,t}) \wedge y_{e+k_e,t}\right]. \tag{A.8}$$

so that $q_{0,0}(b_0^f, b_0^e)$ can be expressed in disjunctive normal form (DNF), with each conjunction defining a mutually disjoint set of paths.

Define

$$q^*_{i,j}(f,e) = \begin{cases} \text{false} & \text{if } j < i \\ (\wedge_{k=F+1}^{N} \wedge_{l=0}^{i-1} \neg y_{k,t+l}) \wedge y_{f,t+i} \wedge (\wedge_{k=f+1}^{e-1} \neg y_{k,t+i}) \wedge y_{e,t+j} & \text{if } j = i \\ (\wedge_{k=F+1}^{N} \wedge_{l=0}^{i-1} \neg y_{k,t+l}) \wedge y_{f,t+i} \wedge (\wedge_{k=f+1}^{N} \neg y_{k,t+i}) & \\ \quad \wedge (\wedge_{k=1}^{e-1} \neg y_{k,t+j}) \wedge y_{e,t+j} & \text{if } j = i+1 \\ (\wedge_{k=F+1}^{N} \wedge_{l=0}^{i-1} \neg y_{k,t+l}) \wedge y_{f,t+i} \wedge (\wedge_{k=f+1}^{N} \neg y_{k,t+i}) & \\ \quad \wedge (\wedge_{k=1}^{N} \wedge_{l=i+1}^{j-1} \neg y_{k,t+l}) \wedge (\wedge_{k=1}^{e-1} \neg y_{k,t+j}) \wedge y_{e,t+j} & \text{if } j > i+1 \end{cases} \tag{A.9}$$

By analogous reasoning to above,

$$q_{i,j}(b_i^f, b_j^e) = \vee_{k_f=0}^{n_f} \vee_{k_e=0}^{n_e} q^*_{i,j}(f + k_f, e + k_e). \tag{A.10}$$

Because the conjunctions define mutually disjoint sets of paths, Lemma A.1 of Wegner et al. (2025) implies that the transmission effect decomposes as

$$\mathcal{Q}[P_{\varepsilon_{1,t}, y_{N,t+h}}(q_{i,j}(b_i^f, b_j^e))] = \sum_{k_f=0}^{n_f} \sum_{k_e=0}^{n_e} \mathcal{Q}[P_{\varepsilon_{1,t}, y_{N,t+h}}(q^*_{i,j}(f + k_f, e + k_e))]. \tag{A.11}$$

Hence, to prove Theorem 1, it suffices to show that $\mathcal{Q}[P_{\varepsilon_{1,t}, y_{N,t+h}}(q^*_{i,j}(f + k_f, e + k_e))]$ satisfies the stated invariance properties.

To show that $\mathcal{Q}[P_{\varepsilon_{1,t}, y_{N,t+h}}(q^*_{i,j}(f,e))]$ for all $i, j \geq 0$, $f \in \{1, \ldots, F\}$, and $e \in \{F+1, \ldots, N\}$ satisfies the invariance properties, we decompose it into three stages. The first stage consists of paths that propagate freely within the financial-markets-and-expectations block until reaching $y_{f,t+i}$. This set of paths is represented by $P_{\varepsilon_{1,t}, y_{f,t+i}}((\wedge_{k=F+1}^{N} \wedge_{l=0}^{i-1} \neg y_{k,t+l}))$. The second stage captures the direct path from $y_{f,t+i}$ to $y_{e,t+j}$ and is described by $P_{y_{f,t+i}, y_{e,t+j}}(\tilde{b})$, where

$$\tilde{b} = \begin{cases} y_{f,t+i} \wedge (\wedge_{k=f+1}^{e-1} \neg y_{k,t+i}) \wedge y_{e,t+j} & \text{if } j = i \\ y_{f,t+i} \wedge (\wedge_{k=f+1}^{N} \neg y_{k,t+i}) \wedge (\wedge_{k=1}^{e-1} \neg y_{k,t+j}) \wedge y_{e,t+j} & \text{if } j = i+1 \\ y_{f,t+i} \wedge (\wedge_{k=f+1}^{N} \neg y_{k,t+i}) \wedge (\wedge_{k=1}^{N} \wedge_{l=i+1}^{j-1} \neg y_{k,t+l}) \wedge (\wedge_{k=1}^{e-1} \neg y_{k,t+j}) \wedge y_{e,t+j} & \text{if } j > i+1. \end{cases} \tag{A.12}$$

The third stage includes all paths connecting $y_{e,t+j}$ to $y_{N,t+h}$ and is therefore represented by $\mathcal{P}_{y_{e,t+j}, y_{N,t+h}}$.

Since the concatenation of these three stages forms the set of paths in $P_{\varepsilon_{1,t}, y_{N,t+h}}(q^*_{i,j}(f,e))$, we can follow Wegner et al. (2025) and express the overall effect as

$$\mathcal{Q}[P_{\varepsilon_{1,t}, y_{N,t+h}}(q^*_{i,j}(f,e))] = \mathcal{Q}[P_{\varepsilon_{1,t}, y_{f,t+i}}((\wedge_{k=F+1}^{N} \wedge_{l=0}^{i-1} \neg y_{k,t+l}) \wedge y_{f,t+i})] \mathcal{Q}[P_{y_{f,t+i}, y_{e,t+j}}(\tilde{b})] \mathcal{Q}[\mathcal{P}_{y_{e,t+j}, y_{N,t+h}}]. \tag{A.13}$$

Hence, the effect $\mathcal{Q}[P_{\varepsilon_{1,t}, y_{N,t+h}}(q^*_{i,j}(f,e))]$ satisfies the invariance properties if each of $\mathcal{Q}[P_{\varepsilon_{1,t}, y_{f,t+i}}((\wedge_{k=F+1}^{N} \wedge_{l=0}^{i-1} \neg y_{k,t+l}) \wedge y_{f,t+i})]$, $\mathcal{Q}[P_{y_{f,t+i}, y_{e,t+j}}(\tilde{b})]$, and $\mathcal{Q}[\mathcal{P}_{y_{e,t+j}, y_{N,t+h}}]$ do.

We next establish a set of lemmas before concluding this section with the proof of Theorem 1.

Lemma A.1. Let b be a Boolean formula consisting of only conjunctions and negations of the variables $y_{k,t+h}$ for $k \geq j$ and $h \geq 0$. Moreover, let $\boldsymbol{\Phi} = [\boldsymbol{\Phi}^{(0)}; \boldsymbol{\Phi}^{(1)}; \ldots, \boldsymbol{\Phi}^{(h)}]$ and $\tilde{\boldsymbol{\Phi}} = [\tilde{\boldsymbol{\Phi}}^{(0)}; \tilde{\boldsymbol{\Phi}}^{(1)}; \ldots, \tilde{\boldsymbol{\Phi}}^{(h)}]$ where $\boldsymbol{\Phi}^{(k)}$ and $\tilde{\boldsymbol{\Phi}}^{(k)}$ are the structural and orthogonalised impulse response matrices for horizon k, respectively. Then,

$\mathcal{Q}[P_{\varepsilon_{i,t},y_{N,t+h}}(b)]$ can be computed using $\boldsymbol{\Phi}$ and the columns $j:N$ of the orthogonalised impulse response matrix $\tilde{\boldsymbol{\Phi}}$, i.e. $[\tilde{\boldsymbol{\Phi}}]_{\cdot,j:N}$.

Proof. If b has no negations, then the result immediately follows from Lemma A.1. (ii) and Theorem 3 in Wegner et al. (2025). If b consists of a single negation, then we may write $\mathcal{Q}[P_{\varepsilon_{1,t},y_{N,t+h}}(b)] = \mathcal{Q}[P_{\varepsilon_{1,t},y_{N,t+h}}(b' \wedge \neg y_{k,t+l})]$ for some $k,l \geq 0$, where b' consists of only conjunctions. By Lemma A.1. in Wegner et al. (2025), $\mathcal{Q}[P_{\varepsilon_{1,t},y_{N,t+h}}(b' \wedge \neg y_{k,t+l})] = \mathcal{Q}[P_{\varepsilon_{1,t},y_{N,t+h}}(b')] - \mathcal{Q}[P_{\varepsilon_{1,t},y_{N,t+h}}(b' \wedge y_{k,t+l})]$. Since b' and $b' \wedge y_{k,t+l}$ consist of only conjunctions, the statement holds true. Next, assume the statement is true if b contains $m-1$ negations and suppose b contains m negations. Then we may again write $\mathcal{Q}[P_{\varepsilon_{1,t},y_{N,t+h}}(b)] = \mathcal{Q}[P_{\varepsilon_{1,t},y_{N,t+h}}(b' \wedge \neg y_{k,t+l})]$ for some $k,l \geq 0$ and where b' contains $m-1$ negations. Applying Lemma A.1. in Wegner et al. (2025), this simplifies to $\mathcal{Q}[P_{\varepsilon_{1,t},y_{N,t+h}}(b' \wedge \neg y_{k,t+l})] = \mathcal{Q}[P_{\varepsilon_{1,t},y_{N,t+h}}(b')] - \mathcal{Q}[P_{\varepsilon_{1,t},y_{N,t+h}}(b' \wedge y_{k,t+l})]$ where b' and $b' \wedge y_{k,t+l}$ consist of $m-1$ negations. Thus, by the induction hypothesis, the statement holds true if b contains m negations. By the principles of mathematical induction, the statement holds for any $m \in N$ and thus for all b consisting of only conjunctions and negations. □

Lemma A.2. Let $b = \wedge_{k=F+1}^{N} \wedge_{l=0}^{i-1} \neg y_{k,t+l}$. Then $\mathcal{Q}[P_{\varepsilon_{1,t},y_{f,t+i}}(b)]$ is invariant to permutations of the variables $1,2,\ldots,F$ for all $f = 1,\ldots,F$ and $i \geq 0$.

Proof. By Lemma A.1, $\mathcal{Q}[P_{\varepsilon_{1,t},y_{f,t+i}}(b)]$ can be computed using $\boldsymbol{\Phi}$ and $[\tilde{\boldsymbol{\Phi}}]_{\cdot,(F+1):N}$ where $\boldsymbol{\Phi}$ and $\tilde{\boldsymbol{\Phi}}$ are defined as in Lemma A.1. Since total effects are not affected by the transmission ordering, $\boldsymbol{\Phi}$ is invariant to the re-ordering. Moreover, by Lemma 3 of Wegner et al. (2025), $[\tilde{\boldsymbol{\Phi}}]_{\cdot,k}$ is invariant to re-ordering of variables $1,\ldots,k-1$. Thus, $[\tilde{\boldsymbol{\Phi}}]_{\cdot,(F+1):N}$ is invariant to re-ordering of variables $1,\ldots,F$. The result immediately follows. □

Lemma A.3. Let σ be a permutation of the variables in $\boldsymbol{y}_t$ satisfying $\sigma(j) = j$ and $i < j \Leftrightarrow \sigma(i) < j$. Let $\boldsymbol{T}$ be the corresponding row-permutation matrix, and let $\boldsymbol{A}_0 = \boldsymbol{Q}\boldsymbol{L}$ and $\boldsymbol{A}_0\boldsymbol{T}' = \tilde{\boldsymbol{Q}}\tilde{\boldsymbol{L}}$, where $\boldsymbol{Q}$ and $\tilde{\boldsymbol{Q}}$ are orthonormal matrices, and $\boldsymbol{L}$ and $\tilde{\boldsymbol{L}}$ are lower-triangular matrices. Then $[\boldsymbol{L}]_{j,i} = [\tilde{\boldsymbol{L}}]_{j,\sigma(i)}$.

Proof. From $\boldsymbol{A}_0\boldsymbol{T}' = \tilde{\boldsymbol{Q}}\tilde{\boldsymbol{L}}$ follows that $\tilde{\boldsymbol{Q}}'\boldsymbol{A}_0\boldsymbol{T}' = \tilde{\boldsymbol{L}}$ and therefore $[\tilde{\boldsymbol{L}}]_{j,\cdot} = [\tilde{\boldsymbol{Q}}']_{j,\cdot}\boldsymbol{A}_0\boldsymbol{T}'$. By Lemma 1 in Wegner et al. (2025), $[\tilde{\boldsymbol{Q}}']_{j,\cdot} = [\boldsymbol{Q}']_{j,\cdot}$. Thus, $[\tilde{\boldsymbol{L}}]_{j,\cdot} = [\boldsymbol{Q}']_{j,\cdot}\boldsymbol{A}_0\boldsymbol{T}' = [\boldsymbol{L}]_{j,\cdot}\boldsymbol{T}'$. This implies $[\tilde{\boldsymbol{L}}]_{j,\sigma(i)} = [\boldsymbol{L}]_{j,i}$. □

Lemma A.4. Let σ be the same permutation of the endogenous variables as in Lemma A.3 and let $\boldsymbol{T}$ be the corresponding row-permutation matrix. Let $\boldsymbol{y}_t$ be the variables in the original order and $\tilde{\boldsymbol{y}}_t = \boldsymbol{T}\boldsymbol{y}_t$ be the variables in permuted order. Denote $\omega_{v,u}$ the path coefficient on the edge $u \to v$. Then

1. $\omega_{y_{j,t},y_{i,t-h}} = \omega_{\tilde{y}_{j,t},\tilde{y}_{\sigma(i),t-h}}$ for all $h \geq 0$ and all $i = 1,\ldots,N$
2. $\omega_{y_{j,t},\varepsilon_{i,t}} = \omega_{\tilde{y}_{j,t},\varepsilon_{i,t}}$ for all $i = 1,\ldots,N$.

Proof. Let $\boldsymbol{A}_0 = \boldsymbol{Q}\boldsymbol{L}$, $\boldsymbol{A}_0\boldsymbol{T}' = \tilde{\boldsymbol{Q}}\tilde{\boldsymbol{L}}$, $\tilde{\boldsymbol{A}}_i = \boldsymbol{A}_i\boldsymbol{T}'$, $\boldsymbol{D} = \operatorname{diag}(\boldsymbol{L})^{-1}$ and $\tilde{\boldsymbol{D}} = \operatorname{diag}(\tilde{\boldsymbol{L}})^{-1}$, where $\boldsymbol{Q}$ and $\tilde{\boldsymbol{Q}}$ are orthonormal matrices, $\boldsymbol{L}$ and $\tilde{\boldsymbol{L}}$ are lower-triangular matrices, and $\operatorname{diag}(\boldsymbol{X})$ is a diagonal matrix containing the diagonal of matrix $\boldsymbol{X}$. Then $[\boldsymbol{D}\boldsymbol{L}]_{j,i} = [\boldsymbol{L}]_{j,j}^{-1}[\boldsymbol{L}]_{j,i} = [\tilde{\boldsymbol{L}}]_{j,j}^{-1}[\tilde{\boldsymbol{L}}]_{j,\sigma(i)} = [\tilde{\boldsymbol{D}}\tilde{\boldsymbol{L}}]_{j,\sigma(i)}$ where the second equality follows from Lemma A.3. Additionally, $[\boldsymbol{D}\boldsymbol{Q}']_{j,\cdot} = [\boldsymbol{L}]_{j,j}^{-1}[\boldsymbol{Q}']_{j,\cdot} = [\tilde{\boldsymbol{L}}]_{j,j}^{-1}[\tilde{\boldsymbol{Q}}']_{j,\cdot} = [\tilde{\boldsymbol{D}}\tilde{\boldsymbol{Q}}']_{j,\cdot}$, where the second equality follows from Lemma A.3 and Lemma 1 in Wegner et al. (2025). Thus, $[\boldsymbol{I} - \boldsymbol{D}\boldsymbol{L}]_{j,i} = [\boldsymbol{I} - \tilde{\boldsymbol{D}}\tilde{\boldsymbol{L}}]_{j,\sigma(i)}$, $[\boldsymbol{D}\boldsymbol{Q}'\boldsymbol{A}_k]_{j,i} = [\tilde{\boldsymbol{L}}]_{j,j}^{-1}[\tilde{\boldsymbol{Q}}']_{j,\cdot}[\boldsymbol{A}_k]_{\cdot,i} = [\tilde{\boldsymbol{L}}]_{j,j}^{-1}[\tilde{\boldsymbol{Q}}']_{j,\cdot}[\boldsymbol{A}_k\boldsymbol{T}']_{\cdot,\sigma(i)} = [\tilde{\boldsymbol{D}}\tilde{\boldsymbol{Q}}'\tilde{\boldsymbol{A}}_k]_{j,\sigma(i)}$, and $[\boldsymbol{D}\boldsymbol{Q}']_{j,i} = [\tilde{\boldsymbol{D}}\tilde{\boldsymbol{Q}}']_{j,i}$. Since these matrices define all the path coefficients of edges coming into $y_{j,t}$ (see Section 3 in Wegner et al., 2025), the proof is complete. □

Proof of Theorem 1. By conditions two and three, variables in b_i^f and b_j^e are ordered consecutively under both the original and alternative ordering, σ. Thus, under both orderings, decomposition (A.11) applies. Moreover, by equation (A.13), it suffices to show that each of $\mathcal{Q}[P_{\varepsilon_{1,t},y_{f,t+i}}((\wedge_{k=F+1}^{N}\wedge_{l=0}^{i-1}\neg y_{k,t+l})\wedge y_{f,t+i})]$, $\mathcal{Q}[P_{y_{f,t+i},y_{e,t+j}}(\tilde{b})]$, and $\mathcal{Q}[\mathcal{P}_{y_{e,t+j},y_{N,t+h}}]$ satisfy the invariance properties.

By Lemma A.2, $\mathcal{Q}[P_{\varepsilon_{1,t},y_{f,t+i}}((\wedge_{k=F+1}^{N}\wedge_{l=0}^{i-1}\neg y_{k,t+l})\wedge y_{f,t+i})]$ satisfies the invariance properties. Moreover, since $P_{y_{f,t+i},y_{e,t+j}}(\tilde{b})$ consists of only the direct edge $y_{f,t+i}\to y_{e,t+j}$, Lemma A.4 implies that $\mathcal{Q}[P_{y_{f,t+i},y_{e,t+j}}(\tilde{b})]$ satisfies the invariance properties. Lastly, $\mathcal{P}_{y_{e,t+j},y_{N,t+h}}$ consists of all paths connecting $y_{e,t+j}$ and $y_{N,t+h}$. By Wegner et al. (2025) this implies that $\mathcal{Q}[\mathcal{P}_{y_{e,t+j},y_{N,t+h}}]$ can be computed using $[\tilde{\boldsymbol{\Phi}}]_{\cdot,e}$, where $\tilde{\boldsymbol{\Phi}}$ is defined as $\tilde{\boldsymbol{\Phi}}=[\tilde{\boldsymbol{\Phi}}^{(0)};\tilde{\boldsymbol{\Phi}}^{(1)};\dots,\tilde{\boldsymbol{\Phi}}^{(h)}]$ with $\tilde{\boldsymbol{\Phi}}^{(k)}$ being the orthogonalised impulse response matrix for horizon k. By Lemma 3 in Wegner et al. (2025), $[\tilde{\boldsymbol{\Phi}}]_{\cdot,e}$ satisfies the invariance properties. □

A.2.2 Financial Markets and Expectations

Proof of Theorem 2. To prove that $\mathcal{Q}[P_{\varepsilon_{1,t},y_{N,t+h}}(\vee_{k=1}^{F}\vee_{l=0}^{h}y_{k,t+l})]$ satisfies the invariance property, it suffices to show that the negation satisfies these properties. Thus, consider the paths $P_{\varepsilon_{1,t},y_{N,t+h}}(\wedge_{k=1}^{F}\wedge_{l=0}^{h}\neg y_{k,t+l})$. These paths only involve variables in $\boldsymbol{y}_{F+1:N,t}$ and thus only edges coming into $y_{k,t+l}$ for $k\geq F+1$ and $l\geq 0$. By Lemma A.4 these edges satisfy the invariance property. Thus, $\mathcal{Q}[P_{\varepsilon_{1,t},y_{N,t+h}}(\wedge_{k=1}^{F}\wedge_{l=0}^{h}\neg y_{k,t+l})]$, and therefore $\mathcal{Q}[P_{\varepsilon_{1,t},y_{N,t+h}}(\vee_{k=1}^{F}\vee_{l=0}^{h}y_{k,t+l})]$, satisfy the invariance property. □

Proof of Theorem 3. Following similar steps as for the narrow channels in Appendix A.2.1, we can write

$$\begin{aligned} w_j &= (\wedge_{k=F+1}^{N}\wedge_{l=0}^{j-1}\neg y_{k,t+l})\wedge\neg z_{t+j}\wedge(\wedge_{l=j+1}^{h}z_{t+l}) \\ &= \vee_{k_1=1}^{F}\left[y_{k,t+j}\wedge(\wedge_{k_2=k_1+1}^{F}\neg y_{k_2,t+j})\wedge(\wedge_{k=F+1}^{N}\wedge_{l=0}^{j-1}\neg y_{k,t+l})\wedge(\wedge_{l=j+1}^{h}z_{t+l})\right]. \end{aligned} \tag{A.14}$$

Since the conjunctions in the last line are mutually disjoint, it suffices to show that the effect through the paths satisfying the Boolean statement $y_{k,t+j}\wedge(\wedge_{k_2=k_1+1}^{F}\neg y_{k_2,t+j})\wedge(\wedge_{k=F+1}^{N}\wedge_{l=0}^{j-1}\neg y_{k,t+l})\wedge(\wedge_{l=j+1}^{h}z_{t+l})$ satisfy the invariance property. These paths can be split into two stages. First, the paths propagate freely within the financial-markets-and-expectations block until they reach $y_{k_1,t+j}$, captured by the set $P_{\varepsilon_{1,t},y_{k_1,t+j}}(\wedge_{k=F+1}^{N}\wedge_{l=0}^{j-1}\neg y_{k,t+l})$. The effect along this set of paths satisfies the invariance property by Lemma A.2. Second, the paths directly move from $y_{k_1,t+j}$ to a variable within the real-economy-and-price block, and propagate within that block until they reach the outcome variables, captured by the set $P_{y_{k_1,t+j},y_{N,t+h}}(y_{k,t+j}\wedge(\wedge_{k_2=k_1+1}^{F}\neg y_{k_2,t+j})\wedge(\wedge_{l=j+1}^{h}z_{t+l}))$. These paths only involve edges that enter variables $y_{k,t+l}$ for $k\geq F+1$ and $l\geq j$. Lemma A.4 implies that these edges satisfy the invariance property. Thus, the effect along the second stage satisfies the invariance property. Since both stages satisfy the invariance property and since the concatenation of the two stages makes up all paths describing the first-round channel, the first-round channel also satisfies the invariance property. □

Proof of Corollary 1. By Lemma A.1. of Wegner et al. (2025), $\mathcal{Q}[\bar{P}_3]=\mathcal{Q}[\text{true}]-\mathcal{Q}[\bar{P}_1]-\mathcal{Q}[\bar{P}_2]$. Since $\mathcal{Q}[\text{true}]$ is the total effect, which is invariant to all re-ordering, Theorems 2 and 3 immediately imply the result. □

Proof of Theorem 4. The paths $P_{\varepsilon_{1,t},y_{N,t+h}}(\wedge_{k=1}^{N-1}\wedge_{l=0}^{h}\neg y_{k,t+l})$ involve only edges coming into $y_{N,t+h}$. By Lemma A.4 these satisfy the invariance property. Thus, $\mathcal{Q}[P_{\varepsilon_{1,t},y_{N,t+h}}(\wedge_{k=1}^{N-1}\wedge_{l=0}^{h}\neg y_{k,t+l})]$ satisfies the invariance property. □

Proof of Corollary 2. By Lemma A.1. of Wegner et al. (2025), $\mathcal{Q}[\bar{P}_3] = \mathcal{Q}[\text{true}] - \mathcal{Q}[\bar{P}_1] - \mathcal{Q}[\bar{P}_2]$. Since $\mathcal{Q}[\text{true}]$ is the total effect, which is invariant to all re-ordering, Theorems 2 and 4 immediately imply the result. □

A.3 Robustness Checks

In this appendix, we present a range of robustness results to complement the baseline analysis in Section 4. Appendix A.4 reports results from our baseline specification, replacing the baseline external instrument with alternative external instruments commonly used to identify UK monetary policy shocks. Appendix A.5 then presents results from our baseline model under alternative channel specifications, including extensions to the financial-markets-and-expectations channel and refinements to the credit channel. Finally, Appendix A.6 reports results from alternative VAR specifications that include CPIH goods and CPIH services separately, as well as a specification in growth rates rather than levels.

A.4 Alternative Monetary Policy Instruments

Our baseline results rely on the target shock of Braun et al. (2025) as an external instrument. As with the impulse-response functions (IRFs), the transmission channel decomposition necessarily depends on the chosen instrument. We therefore assess the robustness of our baseline findings to alternative instruments, which we group into two categories: (i) high-frequency instruments and (ii) narrative instruments.

The first group consists of instruments constructed from high-frequency methods. These include: (i) the target shock of Braun et al. (2025) using only MPC announcements and excluding press conferences, (ii) the shocks of Braun et al. (2025) restricted to satisfy the "poor-man's" sign restrictions of Jarociński and Karadi (2020) to remove potential information effects, and (iii) the instrument of Cesa-Bianchi et al. (2020). Figures A.1a, A.1b, and A.1c plot the transmission through the financial-markets-and-expectations channels, while Figures A.2a, A.2b, and A.2c provide the detailed decompositions for these instruments. The decompositions remain close to the baseline results, suggesting that our conclusions are robust to alternative high-frequency instruments for the UK.

The second group consists of instruments based on narrative methods, represented by the shock series of Cloyne and Hürtgen (2016). Figures A.1d and A.2d show the effect through the financial-markets-and-expectations channel and the detailed decomposition using this instrument, respectively. Relative to the baseline, the total effect on retail sales appears more immediate, the effect on GDP services more delayed, while the effect on prices is qualitatively similar. However, other-direct effects become more prominent across all three outcome variables. Nevertheless, monetary policy still predominantly transmits through financial-markets-and-expectations, and the initial response of prices continues to be explained primarily by direct-price effects.

Using the narrative series of Cloyne and Hürtgen (2016) also affects the detailed channel decomposition (Figure A.2d), although the broad qualitative patterns remain intact. Cash-flow and wealth channels continue to account for the largest share, though the importance of housing wealth declines and equity wealth rises. In addition, all detailed channels together explain a smaller share of price movements than under the high-frequency instruments. Finally, expectations effects become clearly visible, but they appear inflationary rather than deflationary, contrary to theoretical predictions.

Overall, we conclude that our baseline results are broadly robust to alternative identification schemes. Robustness is strongest for alternative high-frequency instruments, but even narrative instruments deliver

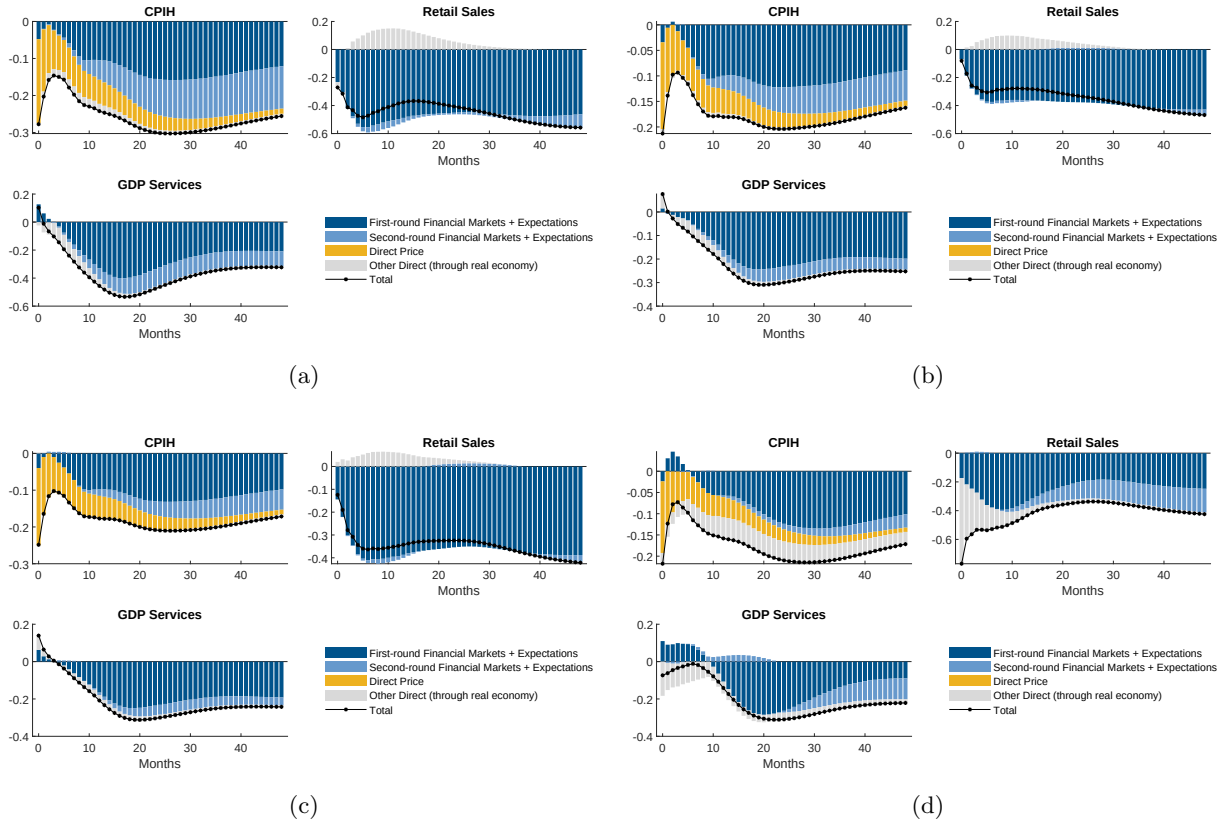


Figure A.1: Robustness of Figure 7 to alternative monetary policy shock measures. The baseline uses the target shock of Braun et al. (2025). Panels (a)–(d) instead use: Braun et al. (2025) restricted to MPC announcements; Braun et al. (2025) with "poor-man" sign restrictions (Jarociński & Karadi, 2020); Cesa-Bianchi et al. (2020); and Cloyne and Hürtgen (2016).

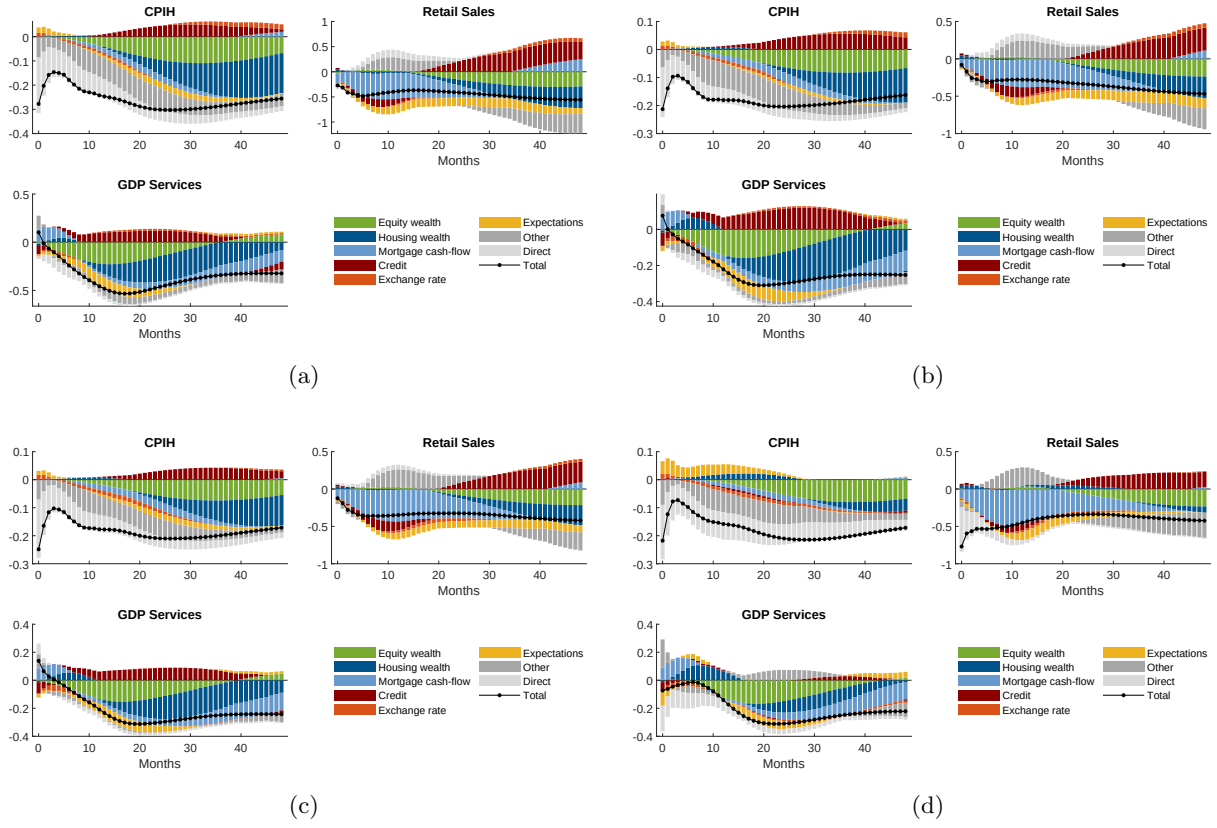


Figure A.2: Robustness of Figure 8 to alternative monetary policy shock measures. The baseline uses the target shock of Braun et al. (2025). Panels (a)–(d) instead use: Braun et al. (2025) restricted to MPC announcements; Braun et al. (2025) with "poor-man" sign restrictions (Jarociński & Karadi, 2020); Cesa-Bianchi et al. (2020); and Cloyne and Hürtgen (2016).

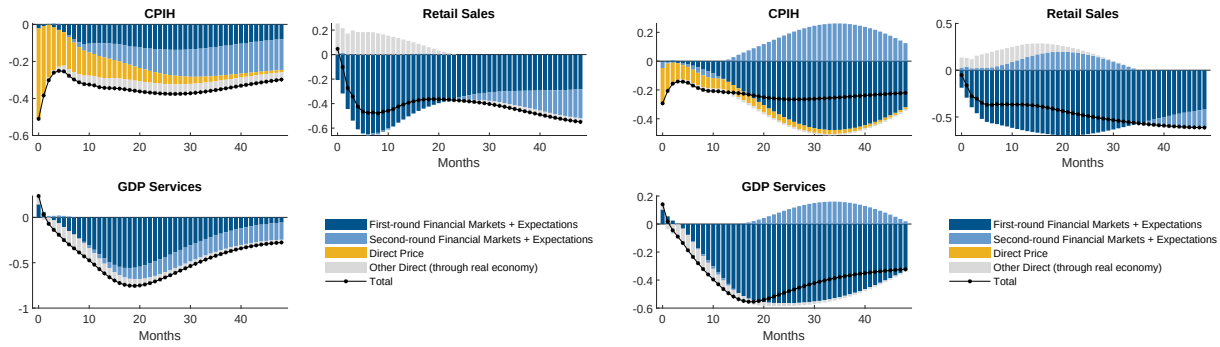


Figure A.3: Robustness of Figure 7 to expanding the exchange-rate and expectations blocks. Panel (a) adds USD/GBP and EUR/GBP exchange rates; panel (b) adds GfK expectations on major purchases and savings.

qualitatively similar conclusions.

A.5 Alternative Channel Specifications

Our baseline results in Section 4 show that the initial rapid reaction of prices is almost entirely explained by the direct-price channel. However, in theory, such rapid price responses could also arise through the exchange rate or expectations channels. This appendix therefore extends the exchange rate and expectations blocks to examine whether these extensions reduce the importance of the direct-price channel and increase the financial-markets-and-expectations channel. In addition, the baseline results indicated counter-theoretical effects through the credit channel, which we traced back to a likely misspecification of that channel. We therefore also refine the credit channel specification by including a lending variable in the model. We begin with the extensions to the exchange rate and expectations blocks.

Figure A.3a presents the effects through the financial-markets-and-expectations block when the US-dollar-to-Sterling and Euro-to-Sterling exchange rates are added. Relative to the baseline results, other-direct effects become more prominent for prices, and second-round effects appear at higher horizons for retail sales. Nevertheless, direct-price effects remain the key driver behind the initial rapid reaction of prices.

Similarly, Figure A.3b shows the results when GfK expectations on major purchases and savings are added to the baseline specification. Compared with the baseline, second-round effects now act as a dampening rather than an amplifying force. However, our baseline conclusion regarding direct-price effects remains unchanged. Thus, neither extending the exchange rate block nor the expectations block helps explain the initial rapid price reaction, although the second-round effects appear somewhat sensitive to these extensions.

Turning to the credit channel, our baseline specification defined it as all paths passing through credit spreads to the real economy and propagating from there (see Section 3). This definition likely misrepresents the credit channel, which is generally thought to operate through investment and lending. While no monthly investment series is available for the UK, a monthly net-lending variable is. We therefore extend the baseline specification by including net lending as the first variable in the real-economy-and-price block. The credit channel is then defined as all paths passing through credit spreads directly to net lending and propagating from there, with its dynamic extension defined analogously to that in Section 3. Figure A.4 presents the resulting detailed decomposition including the alternative credit channel.

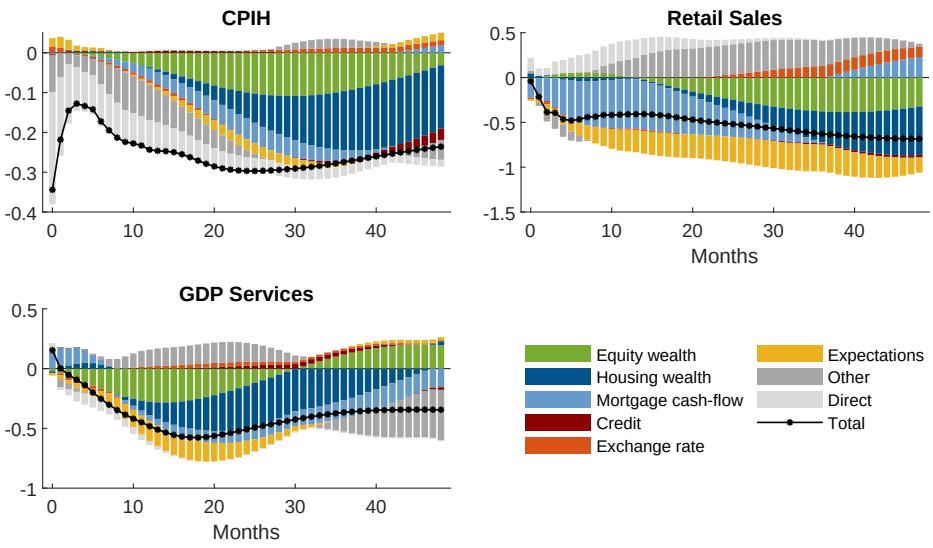


Figure A.4: Robustness of Figure 8 to an alternative definition of the credit channel.

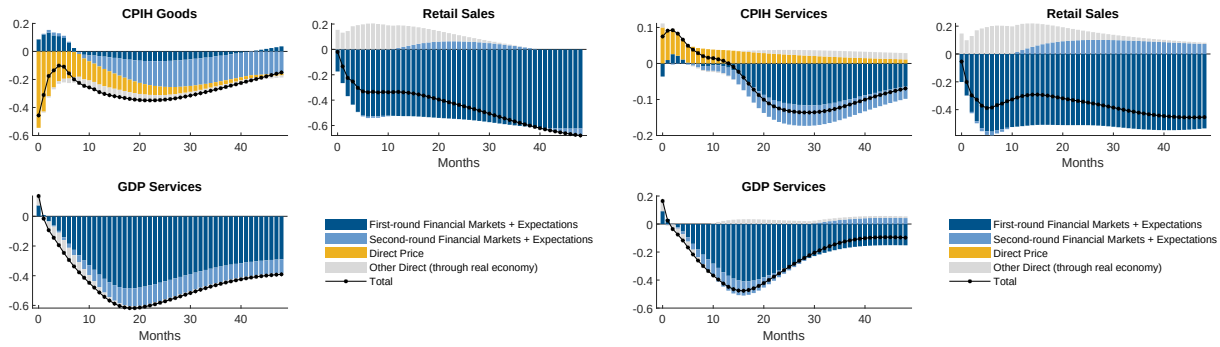
Defining the credit channel as operating through lending yields an estimated effect close to zero for all outcome variables. Hence, while the baseline specification implied counter-theoretical effects, the alternative specification suggests that the credit channel plays a negligible role. However, even this alternative specification may still be misspecified, since defining the channel through net lending may conflate the true credit channel with other mechanisms operating through reduced repayment. We therefore caution against placing too much weight on the estimated credit-channel effects under either specification.

A.6 Alternative VAR Specifications

Our baseline VAR includes CPIH as the price variable. To examine whether the results differ between goods and services prices, we re-estimated the VAR – and hence the decompositions – replacing CPIH with CPIH goods and CPIH services in turn. Additionally, our baseline specification includes several variables in (log) levels (see Appendix C). While this approach is standard in the literature, we assess the sensitivity of our results to this choice by re-estimating an alternative VAR in growth rates. We begin with the results for goods and services prices.

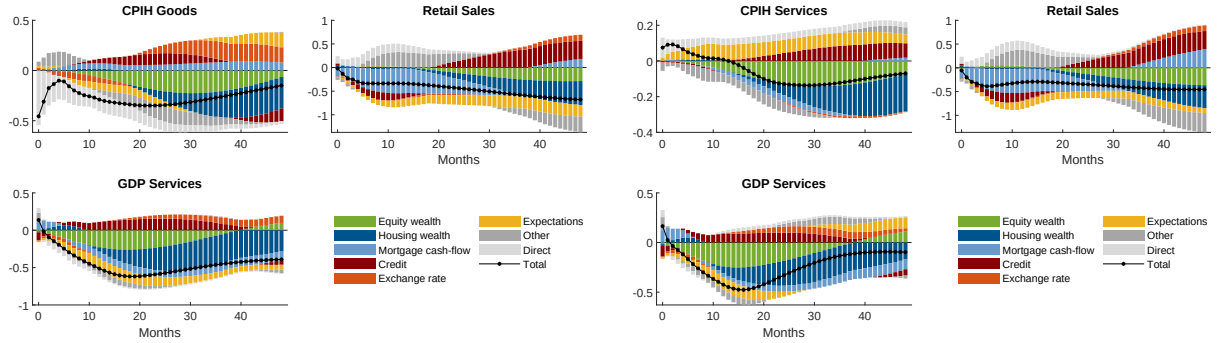
Figure A.5 depicts the effects through the financial-markets-and-expectations channel when replacing CPIH with CPIH goods and CPIH services. The decompositions for retail sales and GDP services remain largely unchanged, although second-round effects become somewhat more pronounced for retail sales and more muted for GDP services. The total effect for CPIH goods displays the same rapid initial response as CPIH, while CPIH services show an initial price puzzle. Hence, the sharp initial response of aggregate CPIH is driven by goods prices. Both the price puzzle for services and the rapid response of goods prices are almost entirely explained by direct-price effects. Consistent with the baseline specification, effects transmitted through financial markets and expectations remain sluggish and cannot account for either the price puzzle or the initial rapid price reaction.

Turning to the detailed decompositions, Figure A.6 presents the results when replacing CPIH with CPIH goods and CPIH services. The decompositions for retail sales and GDP services again remain broadly similar. Although the mortgage cash-flow channel contributes substantially to the reduction in retail sales,



(a) (b)

Figure A.5: Robustness of Figure 7 to replacing CPIH with CPIH Goods (panel (a)) and CPIH Services (panel (b)).



(a) (b)

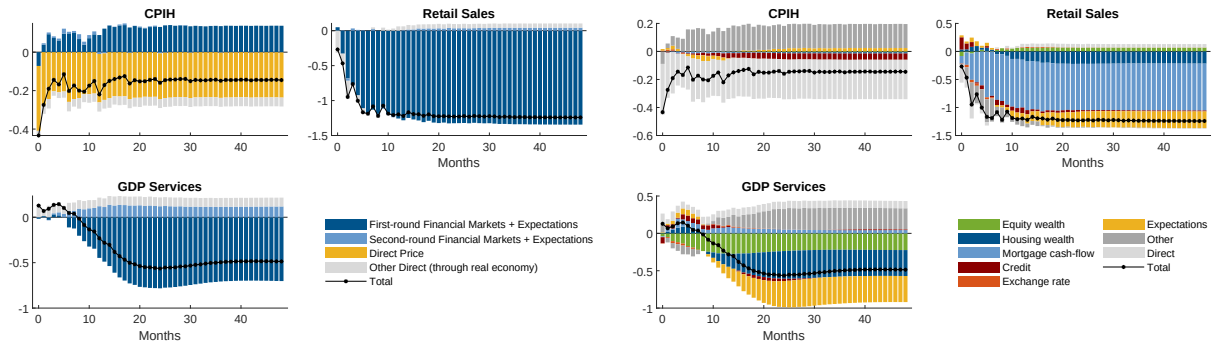
Figure A.6: Robustness of Figure 8 to replacing CPIH with CPIH Goods (panel (a)) and CPIH Services (panel (b)).

its effect on goods prices is estimated to be inflationary. Similarly, while the expectations channel reduces GDP services, it increases services prices. Nevertheless, the equity and housing wealth channels remain key drivers of both goods and services prices. Thus, while monetary policy has similar effects through wealth channels on goods and services prices, transmission through other channels differs across goods and services. Moreover, channels that contract retail sales or GDP services do not necessarily lead to lower goods or services prices.

The results above and the baseline results are obtained from a specification in which many variables are included in (log) levels. To assess the robustness of our baseline findings, we re-estimated the model with all non-stationary variables expressed in growth rates and recomputed all decompositions. Figure A.7 presents the resulting decompositions. All effects are cumulative effects to facilitate comparison to the baseline results.

Figure A.7a presents the effects through the financial-markets-and-expectations channel. The cumulative total responses are qualitatively similar to those of the baseline, although GDP services react somewhat more slowly. Effects through financial markets and expectations remain the main drivers of the responses in retail sales and GDP services, while second-round effects now dampen the transmission to GDP services. However, the decline in prices is estimated to be driven entirely by direct-price effects, with the financial-markets-and-expectations channel exhibiting inflationary effects.

Figure A.7b further shows that our key channels of interest explain only a negligible share of the price



(a) (b)

Figure A.7: Robustness of Figures 7 and 8 to estimating the VAR in growth rates (rather than log levels) for non-stationary variables.

response. In contrast, mortgage cash-flow effects become much stronger for retail sales, and expectations effects become much stronger for both retail sales and GDP services. Wealth effects remain important for GDP services.

Overall, moving from a (log) level specification to a growth-rate specification produces quantitatively different estimates, although cash-flow and wealth effects remain central drivers of retail sales and GDP services. However, estimating the VAR in growth rates likely removes important information about price levels. Moreover, transmission channels are generally discussed in terms of prices rather than inflation, as firms set prices – not inflation rates. We therefore view the (log) level specification, which is standard in the related literature, as the more appropriate benchmark for analysing transmission channels.

Appendix B Additional Figures

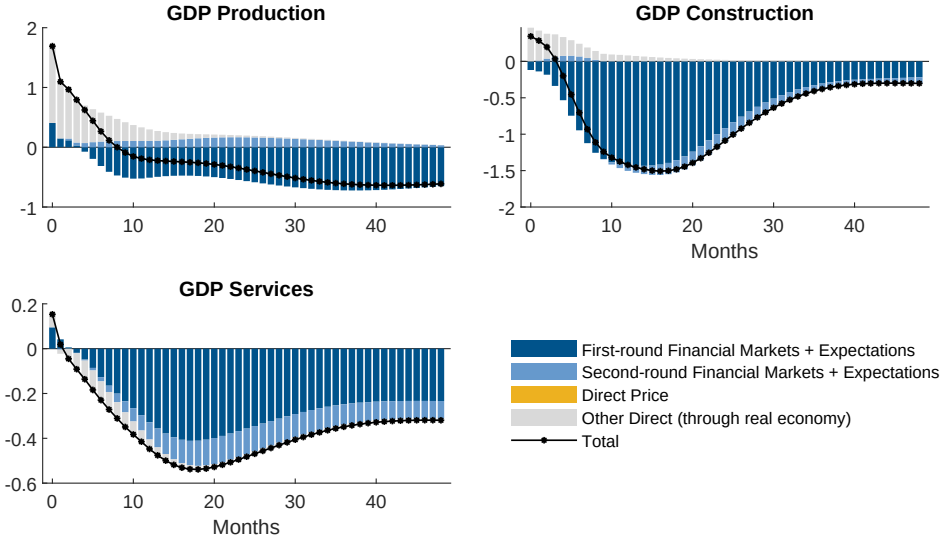


Figure B.1: Decomposition of the total responses to the monetary policy shock in Figure 6. The black scatter-line shows the total response computed at the posterior mean of the VAR coefficients. Bars report the contributions of the corresponding transmission channels and sum to the total at each horizon.

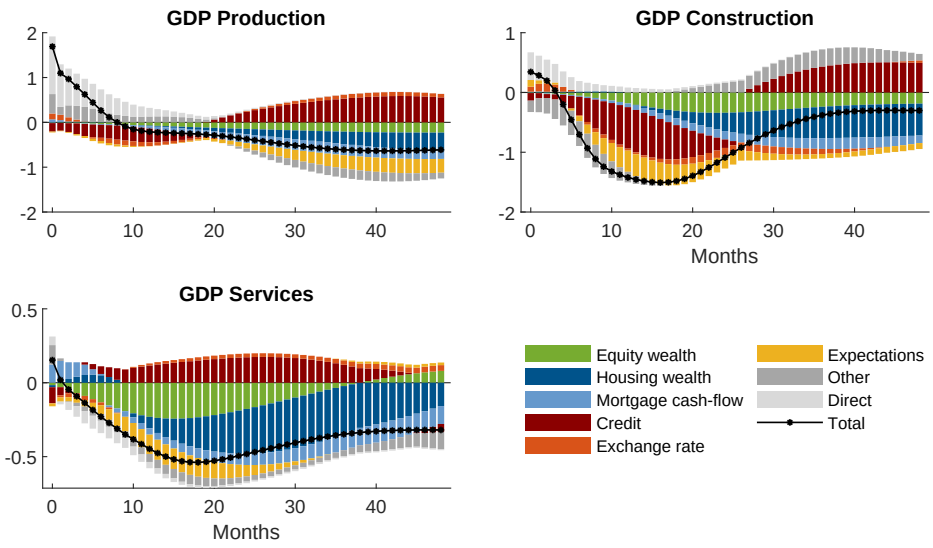


Figure B.2: Decomposition of the total responses to the monetary policy shock in Figure 6. The black scatter-line shows the total response computed at the posterior mean of the VAR coefficients. Bars report the contributions of the corresponding transmission channels and sum to the total at each horizon.

Appendix C Data Sources and Transformations

Table C.1: Variable Descriptions, Sources, and Transformations

Variable	Description	Source	Transformation
FTSE All Share	FTSE All Share Index	Bloomberg	Log
Corporate Bond Spread Investment Grade	Corporate Bond Spreads	Datastream	—
Corporate Bond Spread Non-investment Grade	Corporate Bond Spreads (Non-investment grade)	Datastream	—
House Price Index	House Price Index, UK Region	HM Land Registry	Log
Inflation Expectations	First principal component from short-term inflation expectations. The principal component was constructed similar to Burr (2025), using an EM algorithm.	Citigroup/YouGov; GfK; HMT; Authors' Calculation	—
GDP Production	Production Industries - Total (Index 1dp), CVM SA	ONS	Log
GDP Services	Service Industries - Total (Index 1dp), CVM SA	ONS	Log
GDP Construction	Construction (Index 1dp), CVM SA	ONS	Log
CPIH (core)	CPIH Index excl. energy, food, alcohol & tobacco (2015=100)	ONS	Log
CPIH Goods	CPIH Goods Index (2015=100)	ONS	Log
CPIH Services	CPIH Services Index (2015=100)	ONS	Log
Retail Volume (excl. Fuel)	RSI: Volume SA: All Retailers ex fuel: All Business Index	ONS	Log
Mortgage 2Y 75% LTV Fixed	Monthly interest rate (2Y, 75% LTV, fixed)	Bank of England Database	—
Mortgage 2Y 75% LTV Floating	Monthly interest rate (2Y, 75% LTV, variable)	Bank of England Database	—
SERI	Sterling Effective Exchange Rate Index (Jan 2005 = 100)	Bank of England Database	Log
EURGBP	Euro to Sterling Exchange Rate (Monthly Average of Spot)	Bank of England Database	Log
USDGBP	US Dollar to Sterling Exchange Rate (Monthly Average of Spot)	Bank of England Database	Log
CIPS Expectations Composite	CIPS expectations composite for all sectors	CIPS Survey	—
GFK Major Purchases Expectations	Gfk question 9, major purchases over next 12 months (seasonally adjusted)	GfK Survey	—
GFK Savings Expectations	Gfk question 11, savings over next 12 months (seasonally adjusted)	GfK Survey	—
M4 Lending Households	Monthly changes of monetary financial institutions' sterling net lending to households	Bank of England Database	—
M4 Lending PNFC	Monthly changes of monetary financial institutions' sterling net lending to PNFCs	Bank of England Database	—
PPI (Input)	PPI INDEX INPUT - C Inputs into production of Manufactured products, excluding Climate Change Levy (2015=100)	ONS	Log
PPI (Output)	PPI INDEX OUTPUT DOMESTIC - C Manufactured products, excluding Duty (2015=100)	ONS	Log
Gilt 1Y	Gilts spot yield (1-year)	Bank of England Database	—
Gilt 5Y	Gilts spot yield (5-year)	Bank of England Database	—
Gilt 10Y	Gilts spot yield (10-year)	Bank of England Database	—