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Global inflation dynamics and inflation expectations☆

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A B S T R A C T

In this paper we investigate dynamics of inflation and short-run inflation expectations. We estimate a global vector autoregressive (GVAR) model using Bayesian techniques. We then explore the effects of three source of inflationary pressure that could drive up inflation expectations: domestic aggregate demand and supply shocks as well as a global increase in oil price inflation. Our results indicate that inflation expectations tend to increase as inflation accelerates. However, the effects of the demand and supply shocks are short-lived for most countries. When global oil price inflation accelerates, however, effects on inflation and expectations are often more pronounced and long-lasting. Hence, an assessment of the link between observed inflation and inflation expectations requires disentangling the underlying sources of inflationary pressure. We also examine whether the relationship between actual inflation and inflation expectations changed following the global financial crisis. The transmission between inflation and inflation expectations is found to be largely unaffected in response to domestic demand and supply shocks, while effects of an oil price shock on inflation expectations are smaller post-crisis.

1. Introduction

Inflation expectations are a pivotal variable in providing insights about likely future economic conditions. While the decades long debate about the degree to which monetary policy is forward looking has not abated (e.g., Friedman, 1968; Woodford, 2003a) there is little doubt that policy makers devote considerable attention to the economic outlook. Hence, the dynamics of the relationship between inflation and inflation expectations continues to pre-occupy the monetary authorities and central bankers. Even before the full impact of the global financial crisis (GFC) of 2008–9 was felt in the US, and in many other parts of the globe, central bankers such as Bernanke (2007) highlighted the importance of inflation expectations since "… the state of inflation expectations greatly influences actual inflation …". More recently, Yellen (2016) also underscores the crucial role played by expectations while bemoaning the fact that the profession must confront gaps in our knowledge about the relationship between observed inflation and the short-run inflation expectations that lies at the heart of many theoretical macroeconomic models. It is not difficult to come across speeches by central bankers

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who, on a regular basis, touch upon the subject of the formation and implications of inflation expectations.[1]

A main, but not sole, driver of inflation expectations is past inflation. At the risk of some over-simplification, inflation can be thought of as being driven by two sets of determinants, namely local or domestic factors versus international or global forces.[2] The local determinants would include technical progress and changes in productivity, demographic factors, institutional considerations such as the adoption of inflation targeting and central bank independence and, since 2008, the adoption and maintenance of unconventional monetary policies in systemically important economies. More generally, however, economists tend to make the distinction between aggregate demand and supply sources of changes in inflation pressure. In what follows, we retain this distinction to allow for greater comparability with the extant literature as well as because it provides us with a vehicle to present new insights into the underlying drivers of inflation and ultimately about the likelihood that inflation expectations can be anchored.

Globalization in both the trading of good and services and in finance is often also touted as a critical driver of the international component that influences domestic inflation rates. As a result, the extant literature has diverged wherein some argue that models of inflation are too nation centric (e.g., Borio & Filardo, 2007; Ahmad & Civelli, 2016; Auer, Borio, & Filardo, 2017, Kabukçuoğlu & Martínez-García, 2018) while others place greater emphasis on the various local factors mentioned above.[3]

The current literature generally focuses on a homogeneous set of countries (e.g., advanced or emerging market economies; see the following section). We depart from this norm to consider 42 economies that span a wide range in terms of their size, success at controlling inflation, monetary strategies in place, and the extent to which they were directly implicated or not in the GFC. To fully exploit the potential for cross-border spillovers in inflation we use the Global VARs (GVAR) methodology (Pesaran & Chudik, 2016). This methodology is well suited to address the domestic impact of changing inflation on expectations dynamics controlling for international spillovers through cross-border inter-linkages.

Often, global factors are constructed using some indicator of trade openness to aggregate country-specific series. Nevertheless, there is disagreement about whether this is the appropriate vehicle to estimate global versus local influences on domestic inflation (e.g., Kabukçuoğlu & Martínez-García, 2018; Ahmad & Civelli, 2016). Instead, we propose a novel set of weights in estimating the GVAR obtained from the forecast error variance decompositions estimated via the methodology of Diebold and Yilmaz (DY, 2009) developed to measure the degree of connectedness. Since the debate about local versus global determinants of inflation expectations partly centers around the extent to which countries are linked to each other the DY technique is a natural one to use in the present circumstances. Indeed, the foregoing combination of methodologies permits us to highlight two neglected aspects of the debate about what drives inflation and inflation expectations. First, that the relative importance of local versus global factors is likely a function of the policy horizon. Second, the globalization of observed inflation is also reflected in a globalization of expected inflation. While the GVAR methodology provides a very rich set of potential shocks that may be analyzed, we focus on two sets of shocks. They are: the impact of domestic aggregate demand and supply shocks on inflation and inflation expectations and the impact of a global oil price supply shock on these same two variables.

The rest of the paper is organized as follows. In the next section, we provide a brief literature review that concentrates primarily on empirical links between inflation and inflation expectations. In section 3 we provide details about the data set employed and a few stylized facts before proceeding to outline the econometric methodology in section 4. Section 5 discusses the main empirical results while section 6 concludes.

Briefly, we find that inflation expectations respond positively to either domestic aggregate demand or supply shocks, but the effects are generally temporary. This finding holds equally true for the post-crisis period. By contrast, if inflation accelerates due to a pick-up in global oil price inflation, inflation expectations respond significantly positive and effects are long lasting. The impact on inflation is even larger than on inflation expectations. Hence, oil price shocks drive a wedge between inflation and inflation expectations even among professional forecasters. Nevertheless, actual inflation and inflation expectations tend to co-move closely and the pass-through has diminished in the aftermath of the crisis. Therefore, in an era where energy prices are volatile and are subject to large swings, this has implications for when and how aggressively monetary authorities ought to respond to oil price shocks. An additional important implication is that identifying the aggregate supply from aggregate demand components of shocks is critical to understanding the dynamics of both observed and expected inflation.

2. Literature review

Inflation expectations lie at the core of all macroeconomic models (e.g., Woodford, 2003a). Moreover, to the extent that policy is able to influence these expectations, understanding the connection with observed inflation remains an essential ingredient to evaluating the impact of monetary policy.

Especially following the GFC, the debate surrounding the mechanism that best describes how expectations adjust in response to shocks, as well as what are the fundamental drivers of inflation expectations, has been rekindled. The same is true of the companion

[1] A good place to look for speeches by central bankers on all topics is https://www.bis.org/cbspeeches/index.htm?m=7%7C123 where they are collected by the Bank for International Settlements (BIS).

[2] This sub-division is distinct from the question of how expectations are formed which is outside the scope of this paper.

[3] There is insufficient space here to go into the details of the large literature dealing with the various domestic determinants of inflation. The role of technical progress was given impetus by Greenspan (2005), while Juselius and Takats (2015) is a good source on demographic factors and inflation. Murray (2017) outlines the impact of inflation targeting and provides some key references. Boneva, Cloyne, Weale, and Wieladek (2016) is an example of a study that explores the links between quantitative easing and inflation.

literature that explores the dynamics and determinants of observed inflation. An era of ultra-low interest rates, combined with low inflation, has also contributed to reviving the study and debate about links between inflation and inflation expectations.[4]

Rational expectations serve as a convenient benchmark, in part because theoretical models are readily solvable and closed form solutions are typically feasible. However, when confronted with the empirical evidence, considerable differences of opinion emerge about how best to describe the evolution of expectations. For example, an early assessment by the Bank of Japan of its Quantitative and Qualitative Easing program (QQE; Bank of Japan, 2016) finds that the Japanese are prone to adjusting inflation expectations more gradually than in other advanced economies (e.g., the US or the euro area). This is largely due to the backward-looking nature of these expectations. This also resonates somewhat with recent evidence from the US (e.g., Trehan, 2015) and other economies both large and systemically important as well as ones that are small and open (e.g., Bhatnagar et al., 2017).

Of course, there may be several explanations for the sluggish adjustment of inflation expectations. Japan, after two decades or more of very low inflation to low deflation, sets this country apart from the remaining advanced economies which, over the same period, experienced only passing bouts of deflation (early 2000s and in the aftermath of the 2007-8 global financial crisis).[5] Since that time, below 'normal' inflation rates have spread across much of the advanced world. Unsurprisingly, this has attracted the attention and the concern of policy makers. This represents a relatively new element in the story of the dynamics of inflation.[6] It is also notable that, prior to the recent drop in inflation, the main concern was the role of commodity prices, notably oil prices, in generating higher inflation and the extent to which these shocks were seen to have permanent effects or not.[7]

Even if domestic economic slack retains its power to influence inflation, the globalization of trade and finance has introduced a new element into the inflation story, namely the potential role of global slack. Rogoff (2003, 2006) early on drew attention to the link between the phenomenon of globalization and inflation. Alternatively, at almost the high point of the globalization era, studies began to appear that provided empirical support either in favor of a significant global component in inflation, in some of its critical components (e.g., Ciccarelli & Mojon, 2010; Parker, 2017), or via the global influence of China's rapid economic growth (e.g., Pang & Siklos, 2016, and references therein).

Economists, central bankers and policy makers have waxed and waned in their views about the significance of global slack as a source of inflationary pressure. Nevertheless, it is a consideration that needs to be taken seriously and the question remains understudied (e.g., see Borio & Filardo, 2007, Ihrig, Kamin, Lindner, & Marquez, 2010 and Yellen, 2016).[8] More broadly, the notion that a global component is an important driver of domestic inflation rates continues to find empirical support despite of the proliferation of new econometric techniques used to address the question (e.g., Carriero, Corsello, & Marcellino, 2018).[9]

[4] Paralleling this development has been the apparent breakdown of the relationship that defines the Phillips curve. It remains unclear what the source of the breakdown is and whether this is a temporary phenomenon or representative of some fundamental structural shifts in the economy (e.g., see Hooper, Mishkin, & Sufi, 2019; Mavroeidis et al., 2014, and references therein). Not everyone agrees that the Phillips curve deserves to be discarded (e.g., Coibion & Gorodnichenko, 2015; Fischer, 2016). Indeed, those who maintain that the Phillips curve remains a valuable part of the macroeconomist's toolkit focus precisely on the role and behavior or inflation expectations. Others point out that one need to take seriously the amount of economic slack and openness (e.g., Kabukçuoğlu & Martínez-García, 2018 and that the Phillips curve is indeed alive and well (Gordon, 2013) even if its slope may well have changed over time (e.g., Blanchard et al., 2015).

[5] Banerjee and Mehrotra (2018) present some recent international evidence about the determinants of expectations in deflationary environment.

[6] Also, in this connection, see Stock and Watson (2018) who attempt to measure components of inflation that are more cyclically sensitive than others. One strand of the relevant literature considers more carefully the distinction between short and long-run expectations of inflation. The former are considered more volatile, the latter are thought to be more representative of the credibility of the monetary policy regime in place. As Clark and Davig (2016) note, using US data, most studies rely on one or the other type of proxy for expectations but rarely both. Part of the problem is the absence of adequate survey type data beyond a selection of advanced economies. This state of affairs is slowly changing (e.g., see Coibion, Gorodnichenko, & Kamdar, 2018a; Chan et al., 2017). In any case the link between many theoretical models and short-run inflation expectations is inescapable as noted earlier (also see Yellen, 2016).

[7] The precise transmission mechanism between commodity price changes and headline inflation is also one that remains inadequately understood (e.g., Bernanke, 2008; De Gregorio, 2012; Gospodinov & Ng, 2013).

[8] Bianchi and Civelli (2015) conclude that while global slack is a significant determinant of inflation the impact has not been strong enough to generate a structural break in domestic inflation dynamics. Questions, however, have been raised about the robustness of their results (e.g., see Kamber & Wong, 2018).

[9] An important related issue is whether the globalization of inflation phenomenon survives an analysis done using core inflation. Generally, the answer seems to be in the negative (e.g., Béreau, Faubert, & Schmidt, 2018; Carney, 2017; Carriero et al., 2018). Data limitations (see below) prevent us from conducting the analysis below relying on core inflation data. Moreover, other than for some professional forecasts, headline inflation forecast are the most commonly published professional and household forecasts.

Recalling the words of central bankers cited in the introduction there remains much to be learned about the dynamic relationship between observed and expected inflation.[10] The two are inextricably linked, for example, in theory because the anchoring of expectations is thought to be the core requirement of a successful monetary policy strategy that prevents prices (and wages) from drifting away either from a stated objective, as in inflation targeting economies, or an implicit one where the central bank is committed to some form of price stability.[11]

There is, of course, also an ever-expanding literature that examines how well expectations are anchored. This literature focuses mostly on long-run inflation expectations (e.g., see Buono & Formai, 2018; Chan, Clark, & Koop, 2017; Mehrotra & Yetman, 2018; Lyziak & Paloviita, 2016; Strohsal & Winkelmann, 2015, and references therein). A few authors have focused on episodes when inflation is below target (e.g., Ehrmann, 2015), or during mild deflations (Banerjee & Mehrotra, 2018), while IMF (2016), Blanchard (2016), and Blanchard, Cerutti, and Summers (2015), are more general investigations of the issues.[12]

While central bankers and a considerable portion of existing empirical research worries about how changes to inflation expectations influence observed inflation the more recent literature on the anchoring of expectations shifts the emphasis on how inflation shocks can de-anchor these same expectations. Unfortunately, there is as yet no formal definition of 'anchoring'. Indeed, there is still nothing approaching a consensus on the determinants of inflation expectations from various sources (e.g., households, firms, professionals). Factors range from the past history of inflation, knowledge of monetary policy, media portrayals of the inflation process, shopping experience, and the impact of commodity prices, to name some of the most prominent determinants (e.g., see Coibion, Gorodnichenko, Kumar, & Pedemonte, 2018b). Not listed is a role for global factors which is a focus of the present study. Since, as we shall see below, there is a close connection between inflation and expected inflation, and an increasingly well-established link between global and local inflation, there exists an additional unexplored avenue that ties inflation performance on a global scale to local inflation expectations.[13] We contribute to this literature in the sense that we also quantify the effects of inflationary shocks on short-run inflation expectations, which has a bearing on the ability of central banks to anchor inflation in the medium-term.

Beyond the foregoing issues there is also another question that has resonance for central banks especially, namely whose expectations should be examined? While central banks and academics often generate model-based forecasts that are guided by theoretical beliefs (e.g., as in models with a New Keynesian flavor; see Mavroeidis, Plagborg-Møller, & Stock, 2014 for a recent survey) central bankers and professional economists, not to mention academics, often prefer survey-based forecasts. While many survey-type forecasts exist (i.e., households, professional forecasters, firms or enterprises; see Siklos, 2019 for an illustration) very few can be used in a cross-country setting that includes emerging market economies. The reasons have to do with data availability, the manner in which the surveys are carried out, the timing and design of these surveys.

One survey that is generally comparable across countries is the one carried out by Consensus Economics (http://www.consensuseconomics.com/). We mainly rely on these data not only because they are broadly comparable but also because of their global coverage and reliability over time (e.g., see Batchelor, 2001; Loungani, 2001). Nevertheless, another issue stems from reliance on these forecasts: the choice of fixed event versus fixed horizon forecasts. Many forecasts, including ones published by several central banks, are fixed event forecasts as when the inflation or real GDP growth outlooks are evaluated on a calendar year basis. As new information comes in the horizon for such forecasts shrinks over time. In contrast, fixed horizon forecasts come closer to the manner in which models economists use are specified, namely an expectation formed at time t for some future horizon h (i.e., a year or longer). In this case it is the horizon that remains constant.

Ad hoc methods exist to convert fixed event into fixed horizon forecasts (e.g., see Buono & Formai, 2018; Siklos, 2013). Winkelried (2017) adapts the Kozicki and Tinsley (2012) shifting endpoint model to exploit the information content of fixed event forecasts. Of course, we do not know whether or how much new information is absorbed into subsequent forecasts in an environment where the horizon shrinks whether it is because information is sticky or there is sufficient rational inattention that mitigates the effective differences between fixed horizon and fixed event forecasts. Although constructed fixed horizon forecasts are imperfect (e.g., Yetman, 2018) they have the advantage that several papers in the extant literature employ this proxy.

[10] Part of the challenge is what to assume about how expectations are formed, a topic outside the scope of this paper. Theories range from rational expectations noted earlier, rational inattention (Sims, 2006), sticky versus noisy information (Mankiw & Reis, 2002; Woodford, 2003b), to adaptive learning (Sargent, 1999).

[11] The possibility of a persistent gap between observed and expected inflation raises another thorny question, namely the observation that many empirical studies ignore a slowly changing trend in inflation. Cecchetti, Feroli, Hooper, Kashyap, and Schoenholtz (2017) claim the so-called 'local trend' in inflation creates the "illusion" that inflation expectations contain information about future inflation. Hence, taking first differences in inflation expectations (or inflation) destroys potentially useful information. Indeed, Strohsal and Winkelmann (2015) exploit this implication to model expectations using an exponential smooth transition model in the levels. Also, see the survey of Ascari and Sbordone (2014).

[12] Bernanke (2007) suggests a definition that relies on deviations from long-run inflation expectations. However, Levin, Natalucci, and Piger (2004) show that too much sensitivity in short-term inflation expectations is also a sign that expectations are not well anchored.

[13] For a list of the possible theoretical links readers are asked to consult Kabukçuoğlu & Martínez-García, 2018, who motivate this kind of analysis via a New Keynesian Phillips curve adapted to open economies.

Table 1
Data description.

Variable	Description
Dp^e	Inflation expectations (fixed horizon) based on Projections from Consensus Economics for the current and the next year. Updated from Siklos (2013).
gdp	Monthly real GDP estimate using the Chow Lin time disaggregation method and industrial production as a monthly time series.
Dp	Consumer price inflation in y-o-y terms.
ur	Unemployment rate, in %.
stir	Short-term interest rates, 3-months money market rates, in %.
sp	Long-term interest rates, 10-year government bond yields, in %.
eq	Stock price index, in logarithmic transform.
reer	Real effective exchange rate from the BIS data base.
Dp^{oil}	Oil price inflation (in y-o-y terms).
q^{oil}	Global oil production, in logarithmic transform.
Region	**ISO-2 Code**
Advanced	US (United States), CA*(Canada), NO*(Norway), SE*(Sweden), GB*(Great Britain)
Euro area (EA)	AT (Austria), BE (Belgium), DE (Germany), SK (2008; Slovakia), SI (2007; Slovenia), PT (Portugal), GR (2001; Greece), IE (Ireland), IT (Italy), ES (Spain), FI (Finland), FR (France), NL (Netherlands)
CESEE	EE (2011; Estonia), LT (2015; Lithuania), LV (2014; Latvia), BG (Bulgaria), CZ*(Czech R.), HR (Croatia), HU*(Hungary), PL*(Poland), RO*(Romania), RU*(Russia), TR*(Turkey)
Asia	CN (China), JP (Japan), KR*(Korea), MY (Malaysia), PH*(Philippines), SG (Singapore), ID* (Indonesia), IN*(India)
Latin America (LATAM) and South Africa	BR*(Brazil), CL*(Chile), MX*(Mexico), PE*(Peru), ZA*(South Africa)

Notes: * indicates countries that formally target inflation. All countries target inflation since the beginning of the sample, except the following: RO (2005), RU (2014), TR (2006), JP (2013), PH (2002), ID (2005), IN (2016), NO (2001). The years in parenthesis indicate when the countries in question joined the euro area.

Until the recent period of sluggish inflation, the focus of much research fell on accounts that sought to evaluate the success, or lack thereof, of inflation targeting (IT) regimes. The fact that this kind of monetary policy strategy was designed in an era where the challenge was to reduce inflation is not lost on those who ask whether IT regimes are up to the task of maintaining inflation close to the target (e.g., see Ehrmann, 2015 and references therein).[14]

Fuhrer (2017) considers the extent to which expectations of inflation are informative about the dynamics of observed inflation based on empirical work that covers a period of 25 years for the US and Japan. Fuhrer's study is also interested in the extent to which long-term inflation objectives can be modelled via a sequence of short-term forecasts. The answer seems to be in the affirmative but significant departures from the long-term are present in the data. In contrast, our study is not able to determine the strength of any such links due to data limitations, as we shall see. Nevertheless, as suggested above, the degree to which inflation is anchored need not be solely evaluated according to long-term expectations. Short-term deviations can also serve as warning signals.

To our knowledge then, a dynamic model that attempts to evaluate the link between inflation and inflation expectations in economies beyond ones that are advanced, and the role of global factors as well as cross-country interactions, is still missing. The following sections begin to fill the gap.

3. Data and some stylized facts

3.1. Data description

We construct a data set consisting of monthly data. Given the heterogeneity of the countries in our data set we restrict the sample to the 2001m01 to 2016m12 period yielding 192 observations before any transformations (e.g., differencing) are applied.[15] The data we collect are described in Table 1 below.

Our focal variable is inflation expectations (Dp^e) which we measure as fixed horizon inflation forecasts from Consensus Economics. Occasionally, we had to fill some missing values. We did this by relying on data from the World Economic Outlook (http://www.imf.org/en/publications/weo) which also publishes semi-annual current and one calendar year ahead forecasts. Since the current and one year ahead forecasts are calendar year based these were converted to fixed horizon forecasts via the same linear transformation mentioned previously. Effectively, the transformation combines forecast information over a two-year period. Hence, this comes close to the two-year horizon central banks consider it takes for a change in the stance of monetary policy to take effect.

[14] The literature that considers the extent to which inflation expectations are anchored also considers the problem from a couple of other angles not directly considered in this paper. They are: the degree to which inflation and expectations are persistent over time (e.g., see Jain, 2017, and references therein), and whether forecasters disagree about the outlook (e.g., see Siklos, 2019, and references therein).

[15] Although longer samples are clearly feasible for several advanced economies the same is not true of most emerging markets and constraints on obtaining useful expectations data are even more severe again for most of the emerging market economies in our dataset.

Table 2
Descriptive statistics.

	Dp^e				Dp				Correlation (Dp^e, Dp)
	Min.	Median	Max.	SD	Min.	Median	Max.	SD	
Advanced	0.25	1.91	3.34	0.59	−1.1	1.83	4.89	1.09	0.76
EA	0.09	2.02	3.99	0.95	−1.3	2.12	5.43	1.53	0.90
CESEE	0.80	4.20	16.76	3.58	−1.1	4.29	17.88	4.10	0.93
Asia	0.84	2.91	6.35	1.20	−0.4	2.89	9.39	1.99	0.74
LATAM	2.54	4.14	8.29	1.05	−2.4	3.52	11.87	2.77	0.66

Notes: Simple regional averages over country-specific statistics.

The remaining data consist of observed inflation (*Dp*), real GDP (*gdp*), the unemployment rate (*ur*), short-term interest rates (*stir*), the term spread (*sp*), equity prices (*eq*) and the real effective exchange rate (*reer*). These data should capture the most important macroeconomic and financial conditions that could shape inflation expectations. Instead of using industrial production as a measure of output, we converted real GDP into monthly data using the Chow-Lin interpolation procedure (Chow & Lin, 1971). When data were missing we relied on monthly industrial production indices. Consumer prices and oil prices were transformed in year-over-year changes (y-o-y), as were the other series except for the interest rates and unemployment rates which are initially in levels. Data are collected for the 42 countries listed in the bottom panel of Table 1. For the sake of illustration and brevity we grouped them into four regional aggregates, namely advanced economies and the euro area on the one hand and emerging economies from Central East- and South-Eastern Europe (CESEE), Asia and Latin America on the other hand. Note that some CESEE countries adopted the euro during our sample period (Slovenia and Slovakia and the Baltics). We assign Slovenia and Slovakia to the group of euro area countries and the Baltics to the CESEE economies mainly since the latter are comparably more volatile and adopted the euro at a later stage. Also, we assign South Africa to the Latin American countries. This choice does not affect the estimation in the empirical part of the paper – it only affects the arrangement and display of figures and the presentation of the overall results.

Other data were mostly obtained from the International Monetary Fund's International Financial Statistics and national central banks of the economies in our data set. These are easily accessed via the BIS's Central Bank Hub (https://www.bis.org/cbanks.htm?m=2%7C9).

3.2. Stylized facts

A brief data description is provided in Table 2 below.

The data reveal that median inflation expectations are highest in CESEE and Latin American countries. In advanced economies and the euro area, inflation expectations are on average closer to the 2% inflation target pursued in most of the countries in these regions. Inflation expectations are, on average, close to 3% in Asia and thus lie between those of advanced and euro area countries on the one hand and CESEE and Latin American countries on the other hand. In CESEE economies the standard deviation of inflation expectations is rather high, whereas in Latin American countries the small standard deviation indicates that inflation expectations are constantly elevated. A similar picture arises when considering actual inflation provided in the middle panel of Table 2. This is not surprising, given the strong positive correlation of inflation expectations and actual inflation (right panel). Unconditional correlations between observed and expected inflation are highest among European countries (euro area and CESEE above 0.90) and weakest in Latin America (0.66).

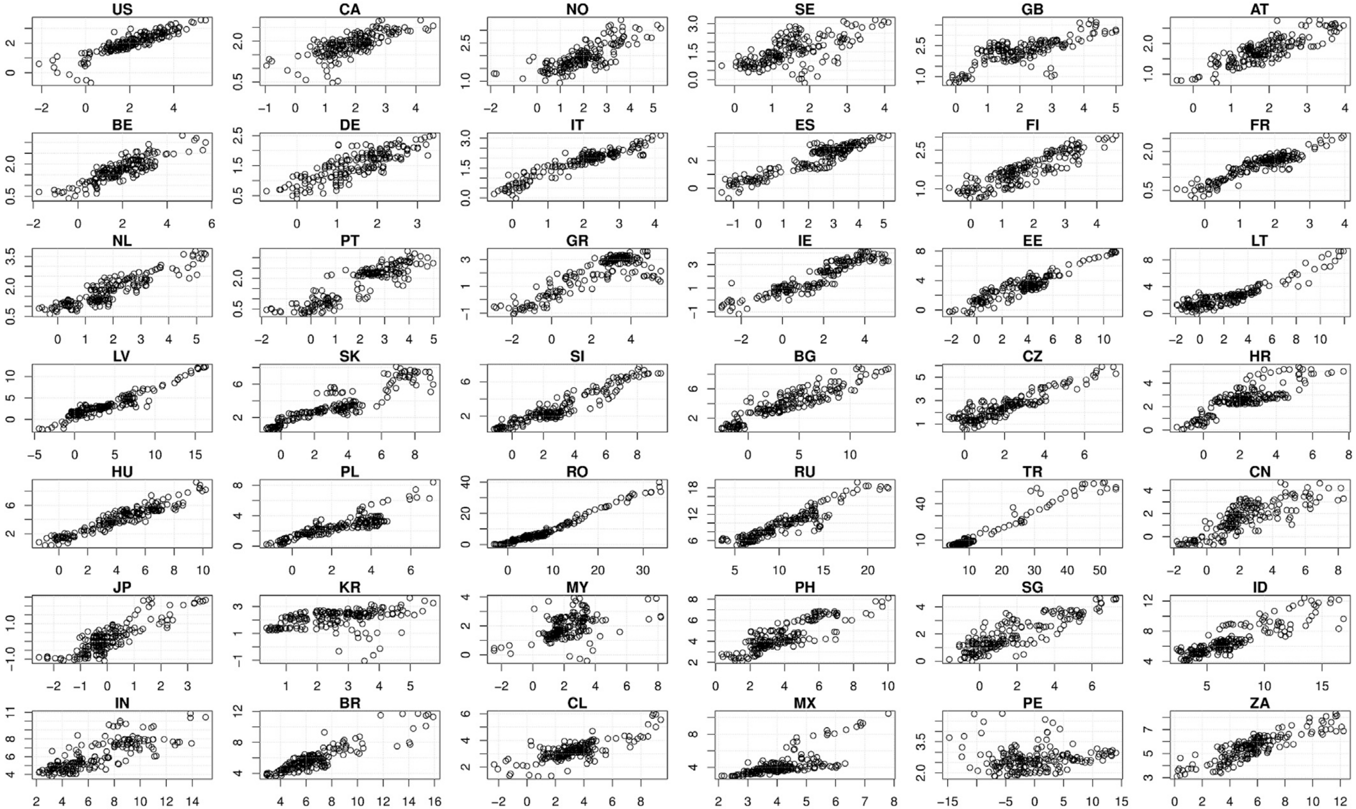
Fig. 1 displays the relationship between inflation and inflation expectations on a country-by-country basis.

The horizontal axis plots observed inflation while the vertical axis shows our measure of inflation expectations. If the two series were perfectly coincident a 45-degree line would describe their relationship. Clearly, this is not the case although a strong positive relationship is visible in several cases, notably including the 10 euro area member economies that have been in the single currency area since the beginning of the sample. Also interesting is that in at least 34 economies there have been instances of deflation albeit of the mild variety.[16] In contrast, there are far fewer instances where inflation expectations are deflationary with only 13 countries recording some temporary evidence of expected deflation[17] Possibly most striking of all is the sheer heterogeneity in the relationship between these two series. Thus, for example, in several cases (i.e., KR, MX, PE, SI, SK) there is much greater variation in observed inflation than in inflation expectations while Malaysia (MY) is the only observable case of variation in expectations exceeding greatly fluctuations in observed inflation. In a few other important instances, the scatter plot suggests a change in the relationship between the two series at low inflation rates (i.e., US, JP). Although non-linearity in inflation performance over time have been noted in the literature (e.g., Ahmad & Civelli, 2016) visual inspection of Fig. 1 does not suggest that a linear approximation would do much injustice in a model that seeks to examine the dynamic relationship between inflation and inflation expectations.

Lastly, we want to examine cross-country links between inflation expectations and actual inflation. To answer this question, we follow Diebold and Yilmaz (2009, 2014) and calculate a spillover index. The Diebold and Yilmaz (2009) spillover index is based on a forecast error variance decomposition and an underlying vector autoregressive (VAR) representation of the data. Hence we estimate two VAR models, one for inflation expectations and one for actual inflation, each featuring 42 endogenous variables, a constant term and 4

[16] Usually these have not exceeded 2% with the highest recorded one-time deflation (annualized rate) reaching only 3%.

[17] Japan is the one exception to this rule where deflationary expectations are relatively more common.



Note: The plot shows on the y-axis inflation expectations (Dp^e) and on the x-axis actual inflation (Dp), country codes are defined in Table 2.

Fig. 1. Observed versus expected inflation, monthly 2001-2016

Note: The plot shows on the y-axis inflation expectations (Dp^e) and on the x-axis actual inflation (Dp), country codes are defined in Table 2.

lags.[18] We calculate the spillover index following the approach of Chan-Lau (2017), utilizing generalized forecast error variances (GFEVD), normalized as in Lanne and Nyberg (2016) so that the shares sum up to unity.[19] More details are provided in Appendix A.1.

The spillover index can be constructed for different horizons (h) of the underlying GFEVD. The index for inflation expectations is about 40% on impact ($h = 0$) and then steadily increases. At six months it is already above 80%. This implies that there exist cross-country dependencies for inflation expectation data. Put differently, domestic inflation expectations are influenced by inflation expectations from abroad. The corresponding figures for actual inflation are a bit smaller in the short-run (30% at $h = 0$) but show a similar degree of connectivity in the medium term (above 80% at $h = 6$).

In Figs. 2 and 3 we provide a regional breakdown of the spillover index. More specifically we show the normalized GFEVD on impact ($h = 0$), after 6 ($h = 6$) and 12 ($h = 12$) months. The colors refer to own contributions (in red), regional contributions (in green) and international contributions (in light gray).

We define regional spillovers as contributions from countries within the same region as shown in Table 1 and international spillovers as those coming from all other economies. A few stylized facts emerge from the analysis. First, and as indicated by the overall spillover index, on impact the domestic component of inflation expectations emerges as an important determinant. For most economies an equal share of forecast error variance can be explained by domestic and global inflation expectation dynamics, whereas at longer forecast horizons the importance of spillovers becomes evident.

Investigating cross-country differences reveals that some countries appear as important drivers of inflation expectations abroad. These include Turkey, which explains the large regional component in inflation expectations in the CESEE region, and to a lesser extent to India, Indonesia and Brazil. Looking at actual inflation, inflation in Peru seems to account for a large share of forecast error variance in other countries' inflation data. To some extent, this could be driven by the nature of the Lanne-Nyberg corrected spillover index, since the normalization appears through the generalized impulse response functions, the size of which depends on the standard error of the underlying reduced form error. To account for the more volatile data in the aforementioned countries, we mean standardize both inflation expectations and actual inflation and re-run the spillover analysis. The results are provided in the appendix, Figures A.2 and A.3. These suggest a less prominent influence for Turkish inflation expectations and actual inflation in Peru, while the remaining results are qualitatively unaffected. Countries like India, Indonesia and Brazil still account for a comparatively higher amount of international forecast error variance decomposition in the remaining economies. Looking at forecast error variance decompositions of actual inflation provided in Fig. 3 leads to very similar results.

Summing up, we find that inflation expectations are close to 2% on average in advanced and euro area countries, while they are about 4% for emerging economies from CESEE and Latin America. There also tend to be less deflationary instances than actual inflation data would suggest. The smaller cross-country in Latin America suggests that inflation expectations are generally high for that region, whereas in some CESEE countries expectations might be as low as in advanced economies. Asian economies stand somewhere between these two regional groups. Actual inflation and inflation expectations are generally positively correlated. However, for some countries, this relationship might change when inflation rates are low. Investigating the cross-country dimension further reveals strong connectivity in global inflation expectations. This implies that the expectations formation process is not determined by domestic considerations alone. Instead, international expectations formation plays an important role. Taken at face value this suggests that international linkages should be taken into account when analyzing inflation expectations at the global level. This result confirms, for a much broader set of countries than in the extant literature and for inflation expectations and not only for observed inflation, that there is an element of globalization in inflation expectations.

4. Econometric framework

In this section we investigate how domestic aggregate demand and supply shocks that influence actual inflation also impact inflation expectations. We complement these two domestic shocks by also looking at the effect of a global oil price supply shock. This question is closely related to the literature that examines the anchoring of inflation expectations which frequently employs a regression of inflation expectations on lags of actual inflation (see e.g., Ehrmann, 2015). Nevertheless, inflation expectations and actual inflation are intrinsically related (Lyziak & Paloviita, 2016).

Consequently, we use a global vector autoregressive (GVAR) model to examine the relationship of inflation expectations and inflation. This approach models inflation expectations and inflation jointly and controls for the cross-country linkages evidenced in the previous section. In what follows, we will borrow the GVAR mechanics proposed in Pesaran, Schuermann, and Weiner (2004) and estimate the country models using shrinkage priors and Bayesian estimation techniques. For each country i, we estimate the following vector autoregression, augmented by lags and contemporaneous values of so-called foreign variables, $y^*_{i,t,}$:

[18] Since the model is highly parameterized, we use Normal-Gamma shrinkage priors and Bayesian estimation techniques as in Huber and Feldkircher (2019). The results are based on 500 retained MCMC draws.

[19] A prerequisite to calculate the spillover index is that the shares of forecast error variance sum up to unity. This is the case whenever the (structural) residuals in the VAR are orthogonal. Since we cannot orthogonalize the residuals without the use of further assumptions (such as the timing of shocks as in a Cholesky type of orthogonalization) we rely on the generalized version of the forecast error variance decomposition. The Lanne and Nyberg corrected GFEVD offers the useful property that the shares sum up to unity and has been recently applied in the context of Diebold Yilmaz connectivity in Chan-Lau (2017).

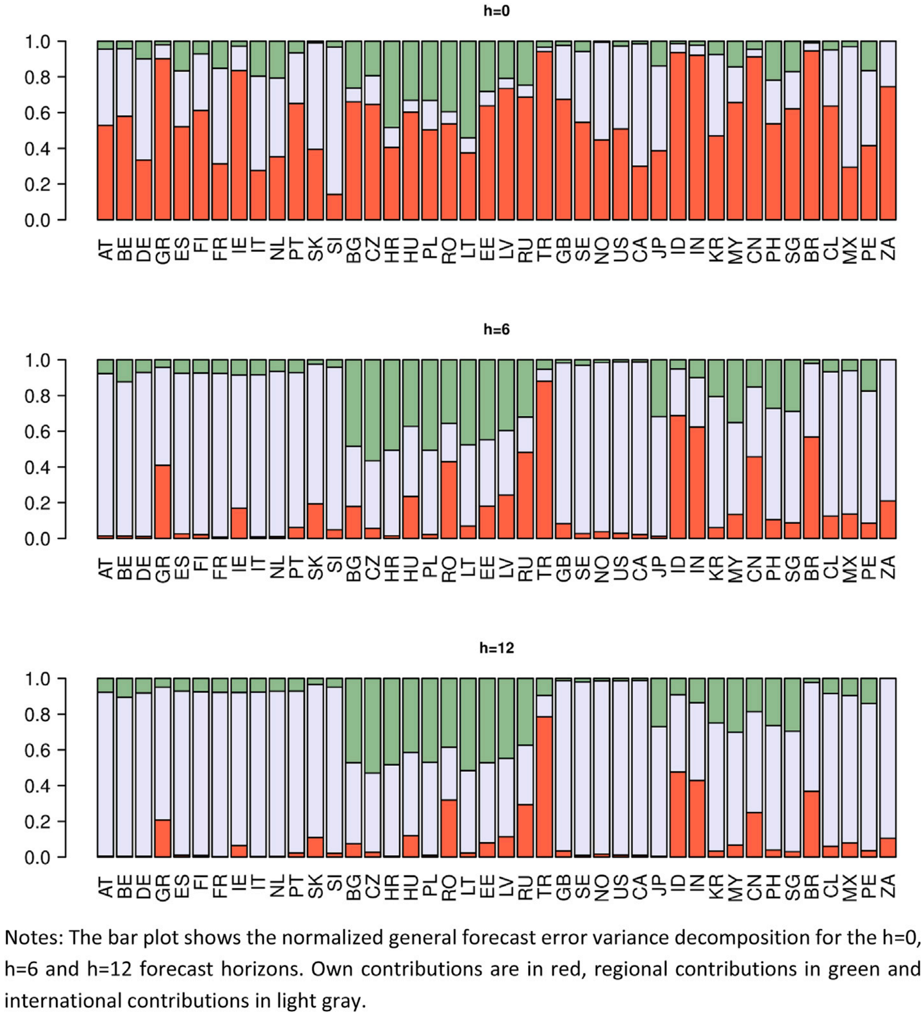


Fig. 2. Regional break down of spillover index: Inflation expectations
Notes: The bar plot shows the normalized general forecast error variance decomposition for the h =
0, h =
6 and h =
12 forecast horizons. Own contributions are in red, regional contributions in green and international contributions in light gray. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

$$y_{i,t} = a_{io} + \sum_{j=1}^{p=2} A_{ij} y_{i,t-j} + \sum_{j=0}^{q=2} B_{ij} y^{*}_{i,t-j} + \varepsilon_{i,t} \quad (1)$$

with $\varepsilon_{i,t}$ being a Gaussian vector white noise process with time-varying variance covariance matrix $\Sigma_{i,t}$, a_{io} a k_i-dimensional vector of intercept terms, A_{ij} for $j = 1, \ldots, 2$ a $k_i \, x \, k_i$ matrix of autoregressive coefficients associated to the jth lag of the endogenous variable and B_{ij} for $j = 0, \ldots, 2$ a $k_i^* \, x \, k_i^*$ coefficient matrices on the k_i^* so-called foreign variables. These are calculated as weighted cross-country averages using weights that account for the interconnectedness between the countries: $y^*_{i,t} = \sum_{z \neq i} w^o_{zj} y_{z,t}$, with $w^o_{zj} \geq 0$; $w^o_{ii} = 0$; $\sum_{i=1}^{N} w^o_{zj} = 1$, for $o = 1, 2, 3$ different weight matrices. Since the focus of our study is inflation and inflation expectations we draw particular attention to the calculation of Dp^* and Dp^{e*}. For that purpose, we utilize the bilateral connectivity indices as discussed previously. More precisely, we use the re-scaled off-diagonal elements of the generalized forecast error variance decompositions ($h = 12$) of inflation expectations ($w^{Dp^e}_{ij}$) to calculate foreign inflation expectations and the one of actual inflation (w^{Dp}_{ij}) to compute foreign inflation. For all other variables we follow the bulk of the GVAR literature and use bilateral trade weights (w^{trade}_{ij})[20]. The use of different weight matrices to

[20] More precisely, we use annual bilateral trade flows from the IMF's DOTS data base, averaged over the period from 2000 to 2012.

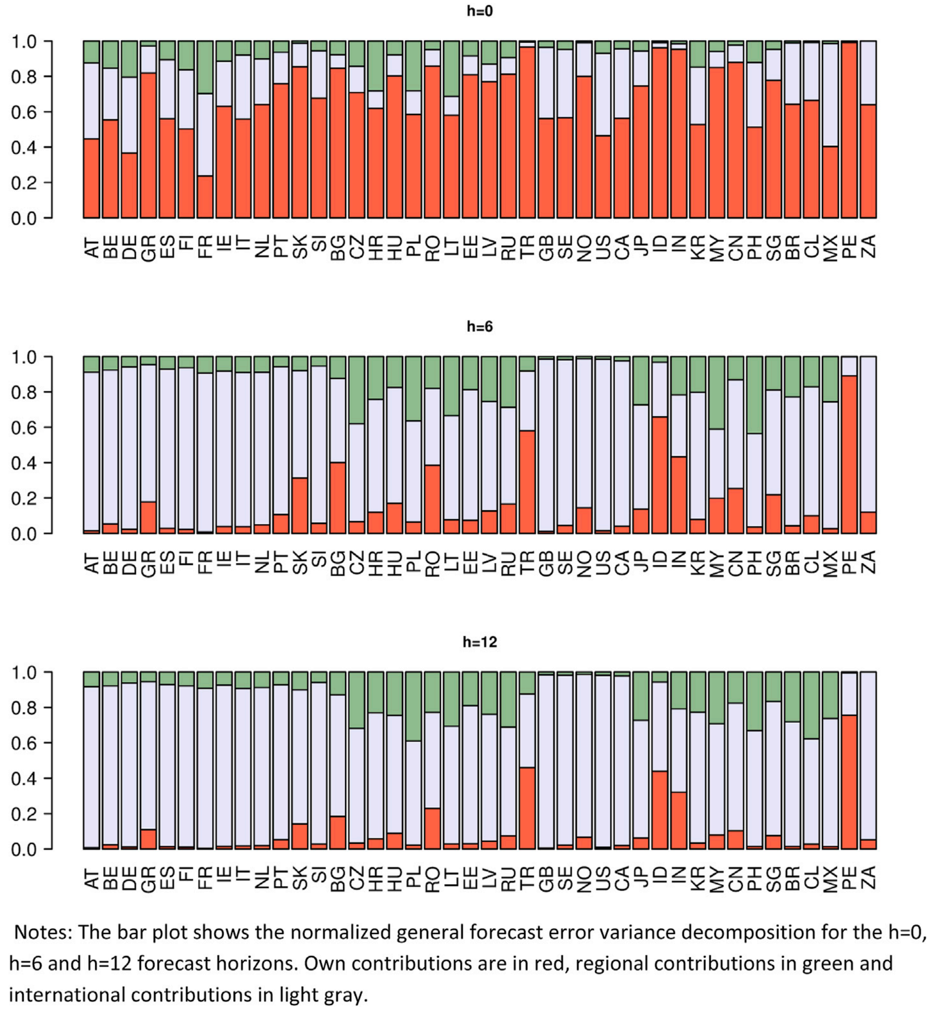


Fig. 3. Regional break down of spillover index: Actual inflation
Notes: The bar plot shows the normalized general forecast error variance decomposition for the h =
0, h =
6 and h =
12 forecast horizons. Own contributions are in red, regional contributions in green and international contributions in light gray. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

compute $y^*_{i,t-j}$ is not uncommon in the GVAR literature (see e.g., Eickmeier & Ng, 2015) but often prohibited by lack of suitable bilateral data. Utilizing the Diebold and Yilmaz (2009) connectivity index offers a valuable and novel alternative to reflect connectivity within the GVAR framework.

The model given in equation (1) features stochastic volatility. We allow the residual variances to vary over time for at least two reasons. First, our sample covers a very volatile time period. Second, to accommodate criticism that the assumption of a homoscedastic variance is at odds with the data for most macroeconomic applications (see e.g., Clark, 2011; Kilian, 1998; Sims & Zha, 2006).

More specifically, we decompose $\Sigma_{i,t}$ into

$$\Sigma_{i,t} = U_i H_{i,t} U'_i, \tag{2}$$

with U_i a k_i-dimensional lower triangular matrix with unit diagonal and off-diagonal elements denoted by $u_{ij,n} (j = 2, \cdots k_i; n = 1, \cdots j-1)$ and $H_{i,t}$ a diagonal matrix with $H_{i,t} = diag(e^{h_{i1,t}}, \cdots e^{h_{ik_i,t}})$. We then assume that the log-volatilities $h_{ij,t}$ follow an AR(1) process:

$$h_{ij,t} = \mu_{ij} + \rho_{ij}(h_{ij,t-1} - \mu_{ij}) + \xi_{ij,t}, \tag{3}$$

with μ_{ij} denoting the (unconditional) mean of the log-volatility, ρ_{ij} the persistence parameter and $\xi_{ij,t}$ a white noise error with variance ϱ^2_{ij}. In the empirical application, impulse responses will be calculated based on the mean volatility over time.

Table 3
Sign restrictions AD and AS shock.

Shock	gdp	Dp	ur	stir	reer	Dp^e
Aggregate demand (AD):	+	+	−	+	+	?
Aggregate supply (AS)	−	+	+	+	+	?

Notes: The restrictions are imposed only on impact, + (−) refers to a positive (negative) impact response of the respective variable.

The general model outlined in equation (2) is completed by including oil price inflation, the quantity of oil produced (i.e., supplied) and euro area interest rates as additional weakly exogenous variables (e.g., as in Kilian & Vega, 2011). The set of variables featured in a typical country model i thus consists of:

$$\begin{aligned} y_{i,t} &= \left(\mathrm{Dp}^e_{i,t}, \mathrm{gdp}_{i,t}, \mathrm{ur}_{i,t}, \mathrm{Dp}_{i,t}, \mathrm{stir}_{i,t}, \mathrm{sp}_{i,t}, \mathrm{reer}_{i,t}, \mathrm{eq}_{i,t}\right)', \\ y^*_{i,t} &= \left(\mathrm{Dp}^{e*}_{i,t}, \mathrm{gdp}^*_{i,t}, \mathrm{ur}^*_{i,t}, \mathrm{Dp}^*_{i,t}, \mathrm{stir}^*_{i,t}, \mathrm{sp}^*_{i,t}, \mathrm{reer}^*_{i,t}, \mathrm{eq}^*_{i,t}, \mathrm{Dp}^{oil*}_t, \mathrm{q}^{oil*}_t, stir^*_{EA,t}\right)'. \end{aligned} \tag{4}$$

Oil price inflation and the quantity of global oil supply are jointly modelled in a separate country model. The weights to calculate Dp^{oil*}, q^{oil*}_t are thus 1 when i equals the index of the oil price model and zero elsewhere. In the oil price model itself, only world GDP, constructed using purchasing power parities, is included as a foreign variable.

Second, for euro area countries, we have to account for the existence of a single monetary policy. We do this by adding a further country model that determines euro area interest rates. As in Georgiadis (2015) and Feldkircher, Gruber, and Huber (2019), we assume that euro area interest rates follow a Taylor rule. That is, euro area short-term interest rates are set according to euro area actual inflation and output, where we use purchasing power parity weights to aggregate the respective euro area single countries' figures. The euro area short-term interest rate ($stir^*_{EA}$) is then fed as a foreign variable into the other countries' models.[21] Consequently, the euro area countries do not feature own domestic interest rates thereby rendering this region distinct from the other countries as outlined in equation (4).

Note that the specification of the domestic variables given in equation (4) encompasses a lot of models that have previously been estimated in the literature. However, to our knowledge, none model the role of the global components in the manner described above.[22] As noted previously, our interest in the empirical work is motivated primarily by a growing list of studies suggesting that a global component in domestic inflation behavior has become important in recent years.

Using the algebra outlined in appendix A.2 and put forth by Pesaran et al. (2004), we can rewrite the country models in terms of a global model:

$$y_t = \sum_{j=1}^{\max(p,q)=2} F_j y_{t-j} + \mathrm{e}_t. \tag{5}$$

with $\mathrm{y_t} = (\mathrm{y}'_{0,t}, \cdots, \mathrm{y}'_{N,t})'$ denoting the global vector that stacks the data of all countries and F_j stacked coefficient matrices.

To estimate the country models, we use a Normal-Gamma prior on the coefficients and the off-diagonal elements of the variance covariance matrix. This prior has been put forth in Huber and Feldkircher (2019) and applied to the GVAR framework in Huber and Punzi (2017). The exact prior specification is provided in appendix A.2. The country model is then estimated using 30,000 posterior draws after a burn-in phase of 30,000 draws. Due to storage constraints, we use a thinning interval and retain every tenth draw from the 30,000 posterior draws. From these, we reject draws that lead to an unstable GVAR system leaving us with 2620 final draws upon which inference and diagnostic checks are based for the baseline specification.

4.1. *Identification*

We identify two domestic shocks and examine the effects on inflation expectations, namely a domestic aggregate demand and aggregate supply shock. The shocks are identified locally and using sign restrictions (Eickmeier & Ng, 2015). The sign restrictions are summarized in Table 3 below:

The restrictions outlined in Table 3 comply with standard economic theory. As aggregate demand (AD) increases, inflation rises. As in Blanchard and Galí (2010), we assume a negative relationship between output and unemployment, so that the unemployment rate decreases in the face of an AD shock. In line with Peersman (2005), and Huber and Feldkircher, (2019), we assume that the central bank will aim at containing the rise in inflation by increasing interest rates,[23] which in turn causes an appreciation of the real effective exchange rate. The restrictions for an aggregate supply (AS) shock follow a similar reasoning. The only exception and distinguishing

[21] We include euro area short-term interest rates as foreign variable in all countries considered in this study, similar to oil price inflation and oil quantities. A more parsimonious way would be to include them only in euro area country models but we abstain from this a priori assumption and, via the shrinkage priors, to let the data decide about inclusion/exclusion of this variable. Analogous to the oil price model, the weights to calculate $stir^*_{EA}$ are 1 when i equals the index of the euro area monetary policy model and zero elsewhere.

[22] As surveyed in section 2 above, global slack is the global component of choice that enters equation (1).

[23] For the euro area countries, the rise in short-term rates corresponds to a positive innovation in the ECB taylor rule model.

Table 4
Global oil supply shock.

Shock	Dp^{oil}	q^{oil}	$gdp^{importers}$
Oil supply shock:	+	–	–

Notes: The restrictions are imposed only on impact, + (−) refers to a positive (negative) impact response of the respective variable. The restriction on GDP for the oil importing countries ($gdp^{importers}$) has to hold for the majority of oil importing countries.

feature is the fall in output caused by the inward shift of the supply curve. Note that we leave the sign of the variable of interest, inflation expectations, unrestricted. All restrictions are imposed only on impact to ensure that our results are not driven by our assumptions.[24]

We complement the domestic supply and demand shocks by a global oil supply shock, with the restrictions being outlined in Table 4. Commodity price shocks are an important determinant of inflation and their impact on inflation expectations could be potentially different from the domestic demand and supply shocks. While the literature on identifying oil price shocks is large (see e.g., Kilian, 2008, 2009, 2009a; 2009b; Kilian & Lewis, 2011, Kilian and Murphy, 2014), The GVAR framework offers a further convenient way to pin down an oil price shock, namely via the cross-sections. In what follows we will look at a positive innovation to oil price inflation and facilitate identification further by assuming cross-country output restrictions. More specifically, we follow Cashin, Mohaddes, Raissi, and Raissi (2014) and use the subsequent set of restrictions to identify the oil supply shock.

As with the AS shock, the oil supply shock is characterized by an opposite movement of oil prices and quantities. The cross-sectional restrictions on GDP of oil importers ($gdp^{importers}$)[25] further enhance identification of the shock since no other shock moves oil prices, oil production and real output of oil importing countries in opposite directions (Cashin et al., 2014). In contrast to Cashin et al. (2014) we impose the restrictions again only on impact. We do this to be consistent with identification of the domestic demand and supply shocks. We also do not impose the condition that the sum of GDP of oil importing countries has to decline as in Cashin et al. (2014). Instead, the majority of oil importing countries have to experience a fall in output. This restriction ensures that it is not driven by one particularly large country so that identification holds on a more general scale.

5. Empirical results

To get a first impression of the results we provide estimates of impact and peak responses for the three shocks considered in Fig. 4. The domestic aggregate demand and supply shocks are normalized to a +1% increase in actual inflation on impact. The global oil supply shock is calibrated as a +1% increase in oil price inflation.

Comparing impact responses to the three shocks, we see that an aggregate demand shock that drives up domestic inflation has a positive immediate effect on inflation expectations in most of the countries. Impact effects are strongest in Russia and Romania, two countries that witnessed periods of high inflation in the past, and Great Britain. In contrast, the impact effects triggered by an AS shock are mixed, with half of the countries showing positive and the other half negative effects. This might be driven by the contraction in output as the supply curve shifts inward. In emerging economies such as Brazil, Chile, Philippines and Mexico the supply shock triggers an immediate downward revision of inflation expectations. The oil supply shock triggers positive immediate effects in all countries, underscoring the importance of oil price shocks for inflation expectations. Note that the comparably smaller size of the effects is related to the calibration of the shock. With a few exceptions, peak effects on inflation expectations are for all countries positive and in the range of −0.7–1.8%. The number of countries with a strong and positive response (above 0.5%) is largest for the oil price shock corroborating the findings from above.

To investigate the shape and the significance in more detail, we provide the full impulse response functions of inflation expectations and actual inflation in Figs. 5–10. We show the posterior mean (blue solid line) along with 50% and 68% credible intervals. The use of less stringent credible intervals, such as the 50% set, is not uncommon in highly parametrized models, such as the GVAR model (see e.g., Chudik & Fratzscher, 2012 or; Almansour, Aquib, Bluedorn, & Duttagupta, 2015).

We begin by investigating the responses of inflation expectations and actual inflation to a domestic AD shock. We see that for most economies the response of inflation expectations is either flat and hovers around zero or is hump shaped, petering out in the longer term. This finding implies a high degree of anchoring of short-term inflation expectations, which might directly translate into anchoring of long-run inflation expectations. Countries for which inflation expectations converge more slowly comprise advanced and euro area economies (Italy, Ireland, Norway, Portugal and Slovenia), CESEE economies (Bulgaria, Croatia, Russia), Asian economies (China, India and Indonesia) as well as South Africa. In Italy, Norway, South Africa and Slovenia the cooling off phase of inflation expectations takes particularly long. Inflation expectations decrease in India, Indonesia and Chile.

Do inflation expectations and actual inflation always move in the same direction? In Fig. 6 we see that actual inflation responses are not hump shaped – rather in most countries actual inflation gradually declines and dies out after 8–16 months. However, in countries that show a longer adjustment phase, actual inflation responses also take longer to cool off. In countries with negative inflation

[24] In a robustness exercise available upon request, we modify the restrictions to hold for 4 periods for the demand and 7 periods for the supply shock. Our results are qualitatively unchanged by extending the restrictions.

[25] These are the euro area countries, China, Japan, the USA, Brazil, Chile, Peru, Korea, Malaysia, Philippines, Singapore, India, South Africa, Sweden, Turkey, Bulgaria, Czech Republic, Croatia, Hungary, Poland and Romania.

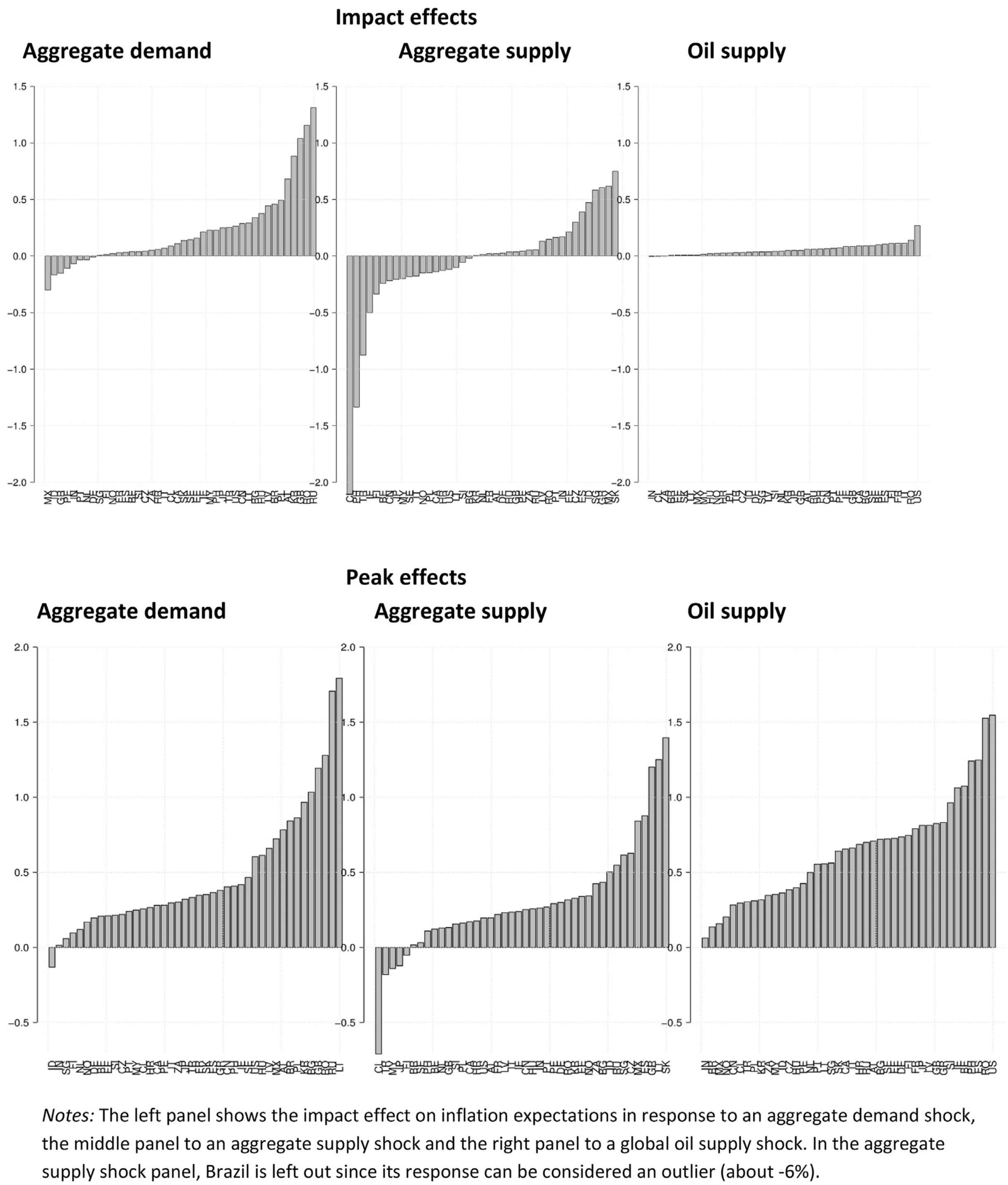


Fig. 4. Impact & peak effects of inflation expectations
Notes: The left panel shows the impact effect on inflation expectations in response to an aggregate demand shock, the middle panel to an aggregate supply shock and the right panel to a global oil supply shock. In the aggregate supply shock panel, Brazil is left out since its response can be considered an outlier (about −6%).

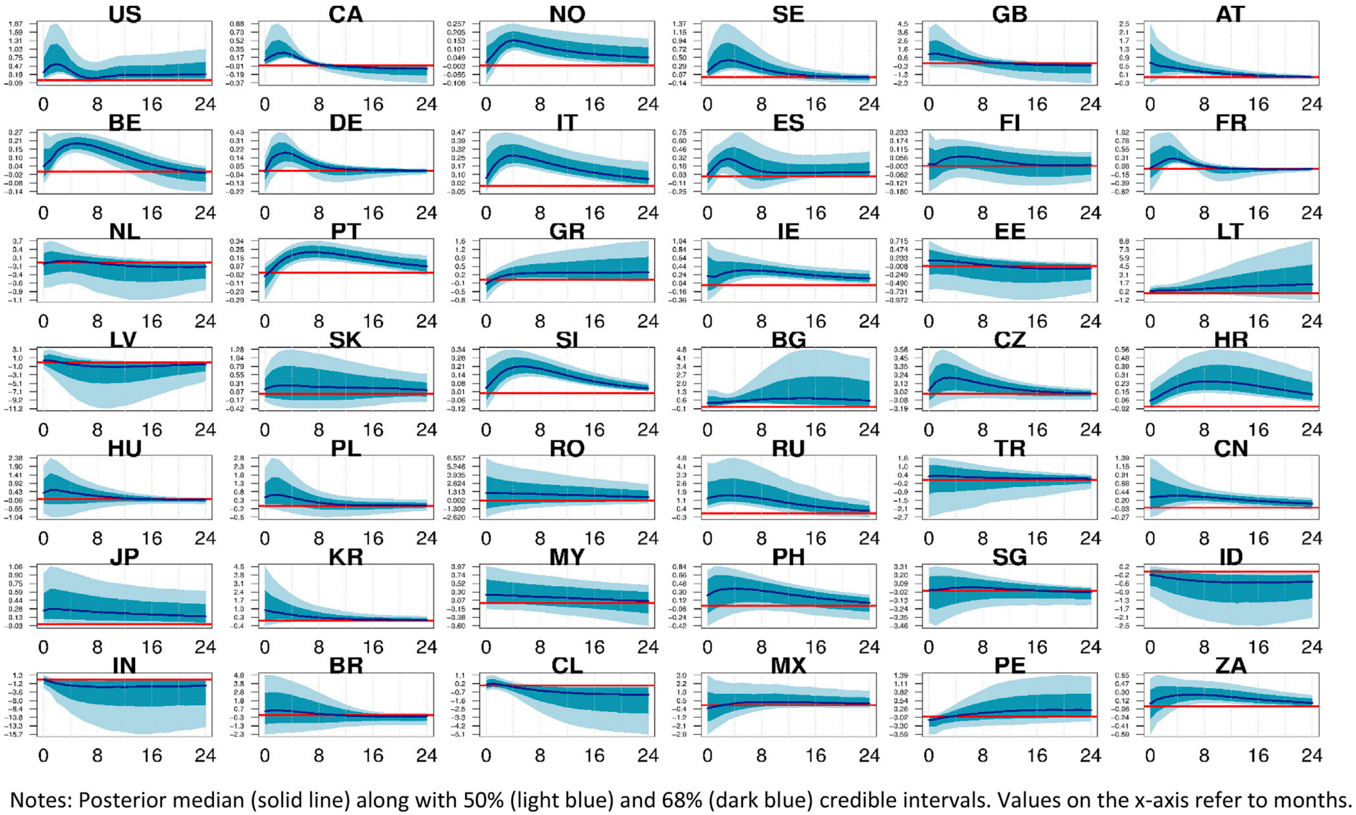
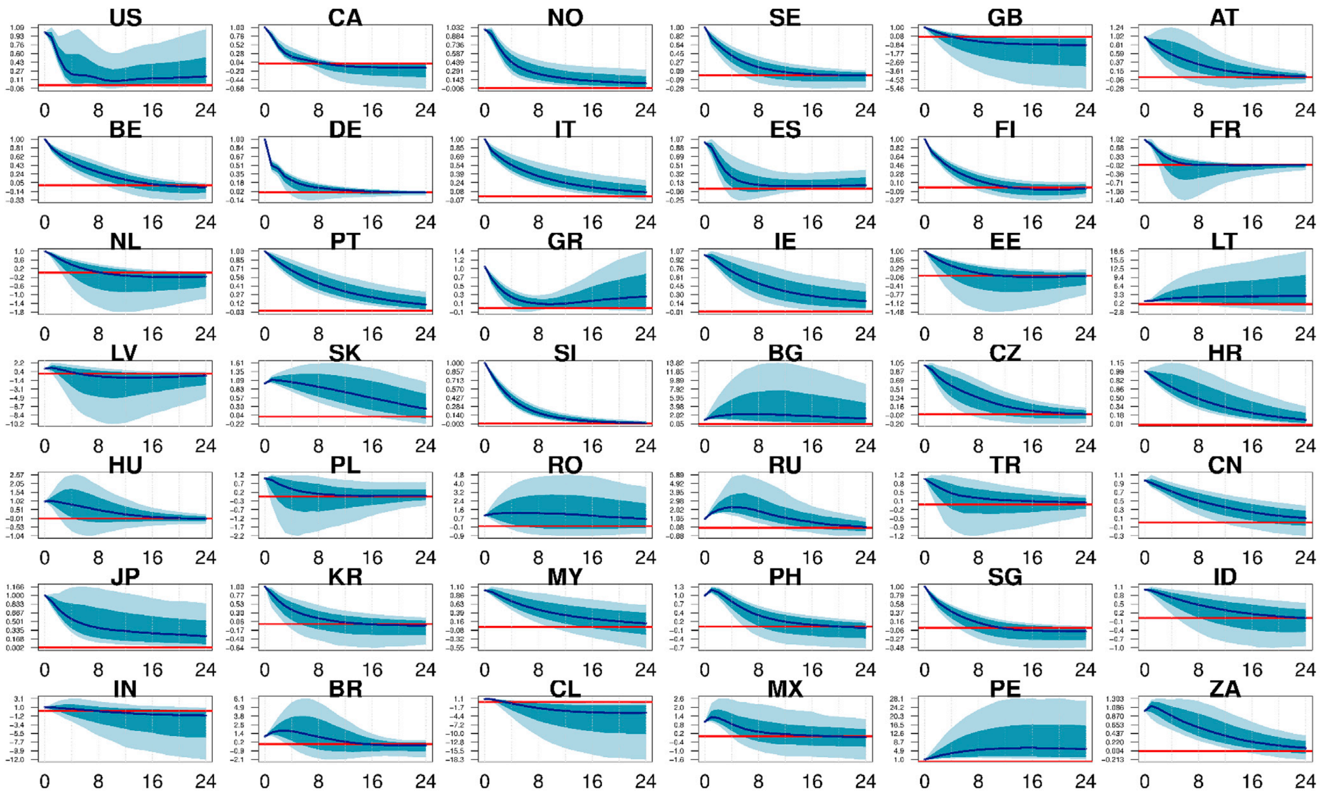
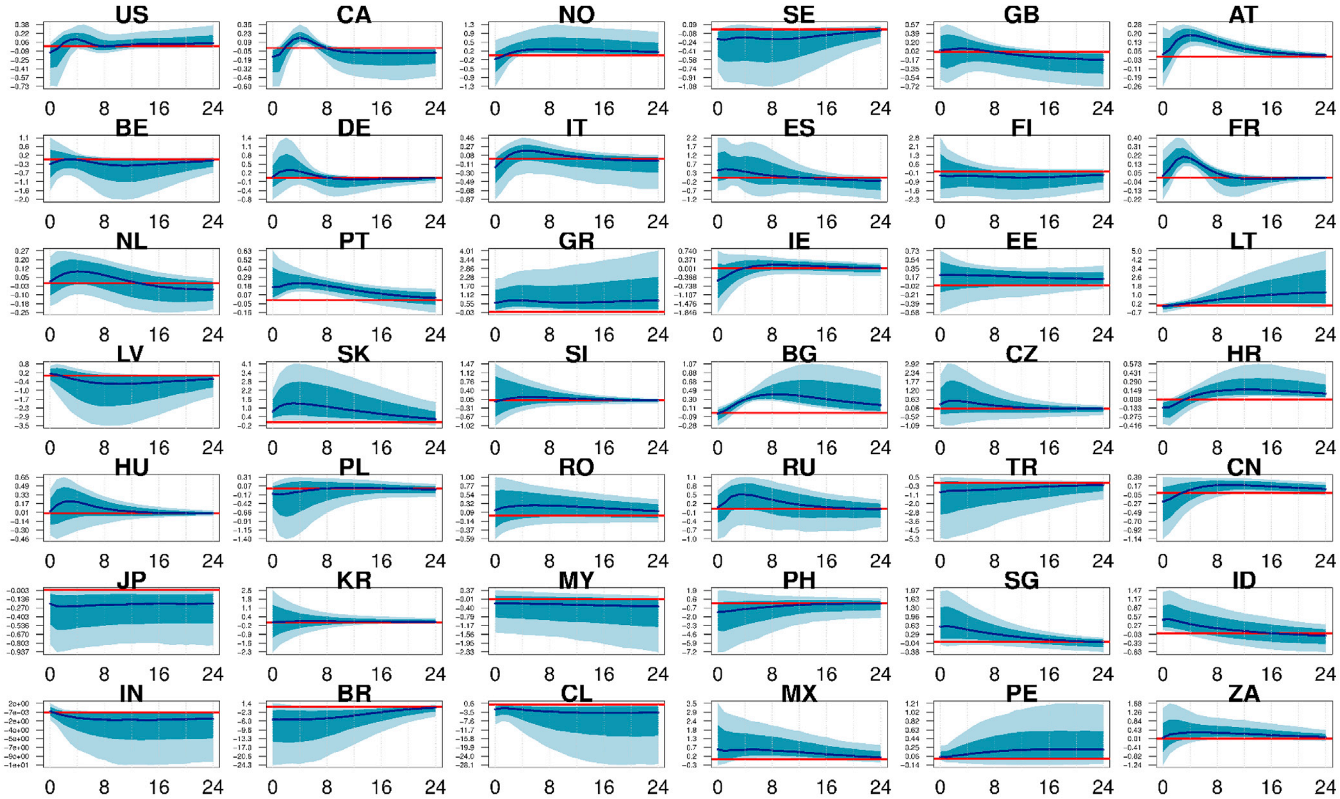


Fig. 5. Response of inflation expectations to an aggregate demand shock (+1 percentage point increase in inflation)
Notes: Posterior median (solid line) along with 50% (light blue) and 68% (dark blue) credible intervals. Values on the x-axis refer to months. . (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)



Notes: Posterior median (solid line) along with 50% (light blue) and 68% (dark blue) credible intervals. Values on the x-axis refer to months.

Fig. 6. Response of actual inflation to an aggregate demand shock (+1 percentage point increase in inflation).
Notes: Posterior median (solid line) along with 50% (light blue) and 68% (dark blue) credible intervals. Values on the x-axis refer to months. . (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)



Notes: Posterior median (solid line) along with 50% (light blue) and 68% (dark blue) credible intervals. Values on the x-axis refer to months.

Fig. 7. Response of inflation expectations to an aggregate supply shock (+1 percentage point increase in inflation)
Notes: Posterior median (solid) along with 50% (light blue) and 68% (dark blue) credible intervals. Values on the x-axis refer to months. . (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

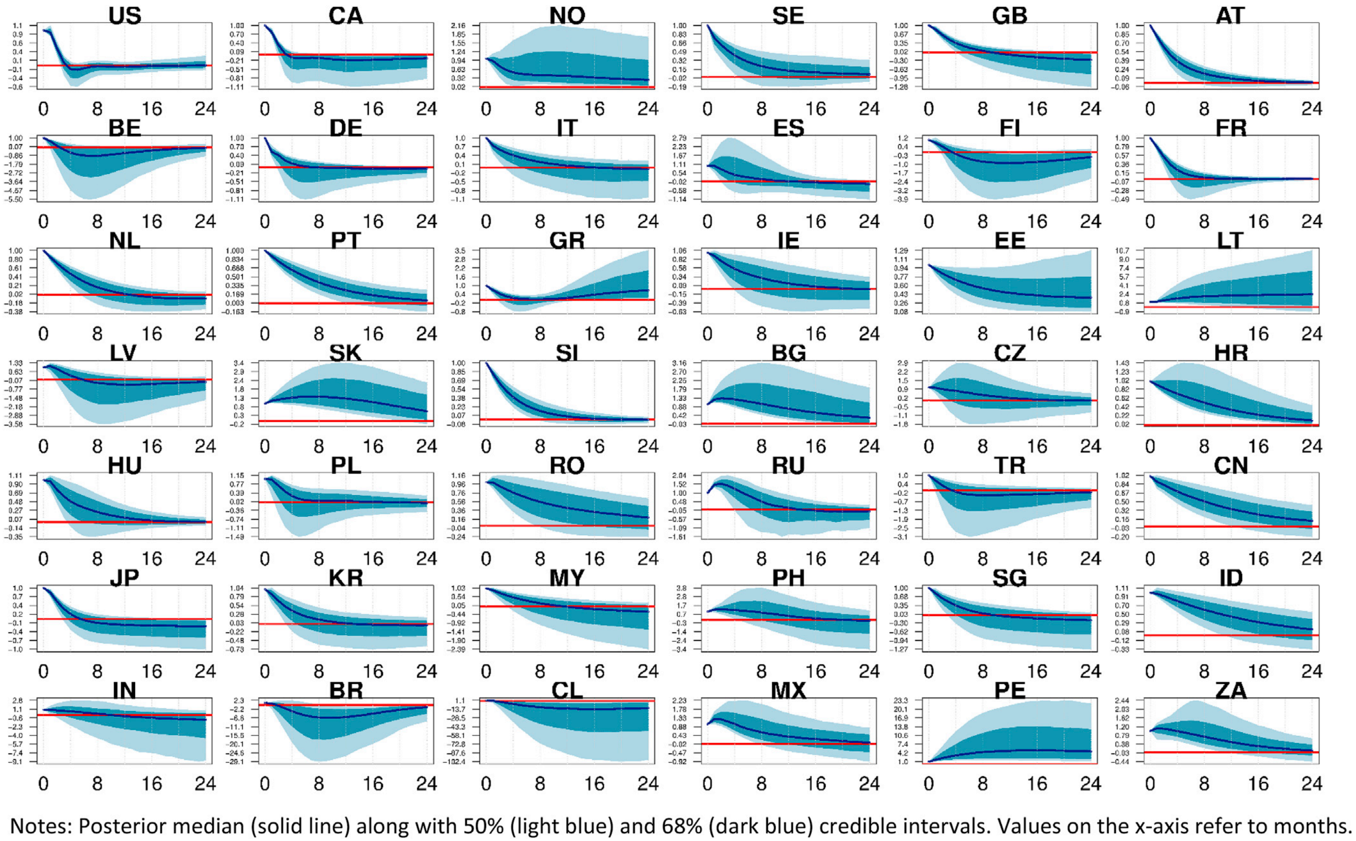


Fig. 8. Response of actual inflation to an aggregate supply shock (+1 percentage point increase in inflation)
Notes: Posterior median (solid line) along with 50% (light blue) and 68% (dark blue) credible intervals. Values on the x-axis refer to months. . (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

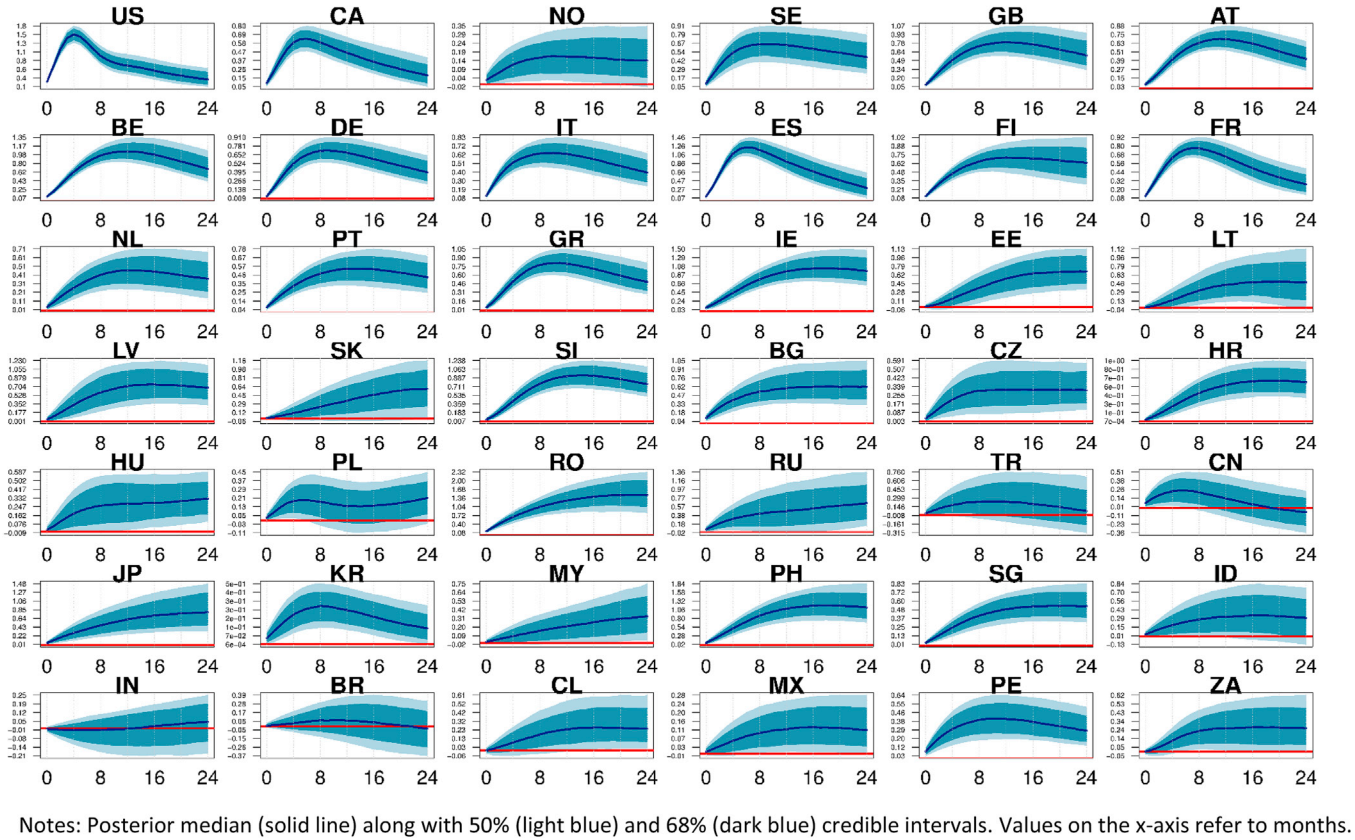
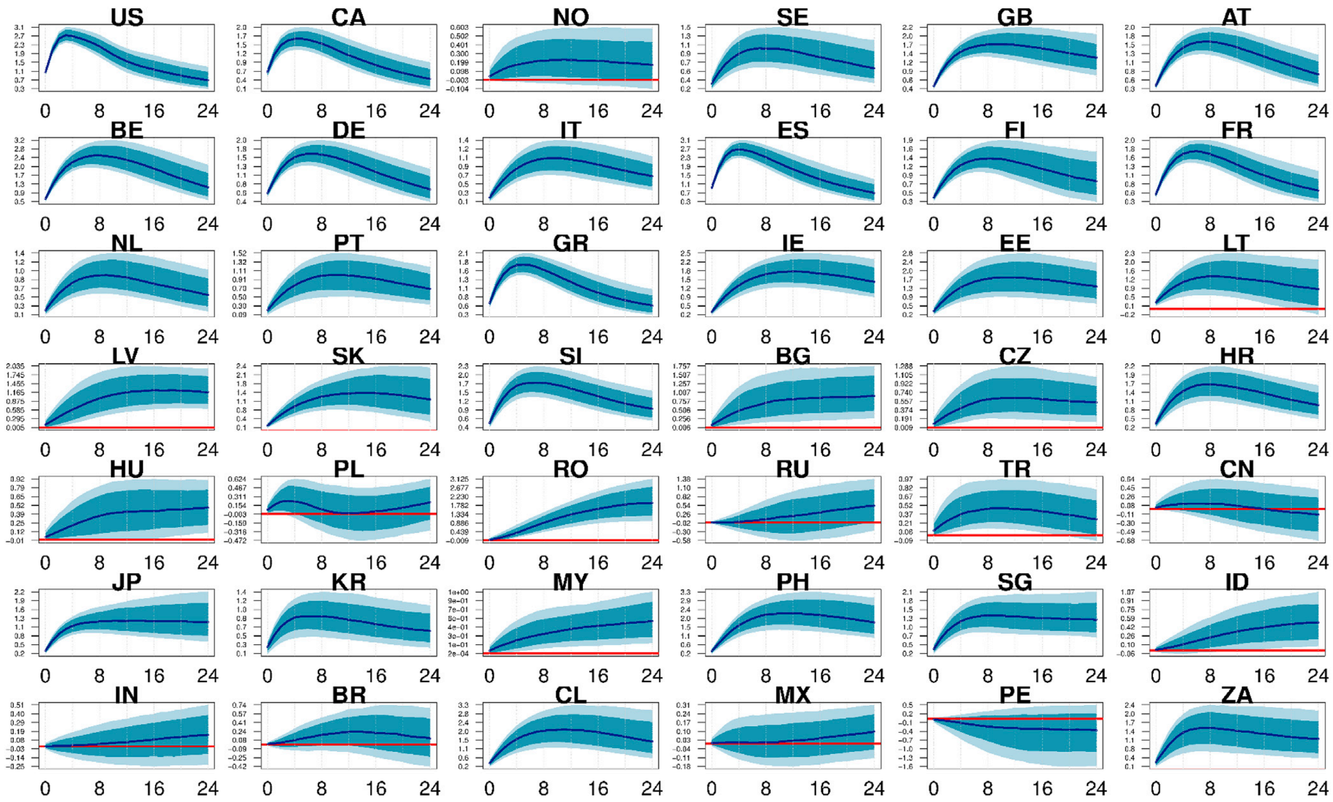


Fig. 9. Response of inflation expectations to an oil supply shock (+1 percentage point increase in oil price inflation)
Notes: Posterior median (solid line) along with 50% (light blue) and 68% (dark blue) credible intervals. Values on the x-axis refer to months. . (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)



Notes: Posterior median (solid line) along with 50% (light blue) and 68% (dark blue) credible intervals. Values on the x-axis refer to months.

Fig. 10. Response of actual inflation to an oil supply shock (+1 percentage point increase in oil price inflation)
Notes: Posterior median (solid line) along with 50% (light blue) and 68% (dark blue) credible intervals. Values on the x-axis refer to months. . (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

expectation responses actual inflation tends to be negative over the impulse response horizon such as in the cases of India and Chile. In Indonesia, by contrast, actual inflation is positive up until 20 months revealing a negative relationship between inflation expectations and inflation, which, however, is not statistically significant since credible intervals of both responses overlap.[26] A significantly larger long-run effect of inflation compared to inflation expectations can be found in Peru, though.

Next, we investigate the impact of domestic AS shocks on inflation expectations. Here, we also find that inflation expectations tend to adjust rather quickly for almost all countries. Shapes of actual inflation responses tend to differ from those for inflation expectations indicating that there is no direct one-to-one relationship between the two series. Exceptions to this result are obtained in countries that either show a positive and significant response of inflation expectations in the long-run (Bulgaria and Croatia) or a negative response (India, Brazil and Chile). In these countries, inflation expectations tend to follow closely actual inflation responses implying that there is no divergence between responses of inflation expectations and actual inflation. Only in two countries are differences in long-run responses of inflation expectations and inflation statistically significant. More specifically, in Chile, responses of inflation expectations are significantly more pronounced than responses of actual inflation, whereas the opposite is the case in Peru.

Finally, we look at the effects of a supply side driven acceleration of oil price inflation. Here, we see that most of the effects are positive and long-lasting. Also, the effects are sometimes rather sizable even in the long-run. In Figure A4. the bottom panel shows differences in inflation expectations and inflation responses along with 68% credible intervals. The figure indicates that even after 25 months, effects on actual inflation are sizable and for some countries significantly larger than those on inflation expectations. Regressing the posterior median of these differences on the sum of exports and imports in % of GDP, averaged over the sample period, shows that countries with a higher degree of trade openness show larger differences in responses (see Table, A.2 in the appendix). The implication is that for more open economies the effect of oil price changes on domestic inflation is larger, thereby driving a wedge between expectations and actual inflation. That the effect of global shocks on domestic inflation is larger for more open economies is consistent with the findings provided in Ahmad and Civelli (2016). Having said that, responses of inflation expectations in absolute terms also tend to be sizeable. Indeed, in 23 of 42 countries, long run-effects on inflation expectations are above 0.4. This implies that nearly half of the acceleration in oil prices directly translates into upward movements of inflation expectations. In contrast to the domestic demand and supply shocks, there are no significantly negative responses for the countries covered in this study. Finally, comparing the shapes of impulse responses, we find a strong relationship between actual inflation and inflation expectation responses.

Summing up, inflation expectations increase in the short-run if inflationary pressure stems from either domestic supply or demand shocks. However, no permanent effects are found. This result changes when a global acceleration of oil price inflation is considered. Here, we find positive long-run effects on inflation expectations for a range of countries. Also, there is a close link between actual inflation and inflation expectations indicating that there is a direct pass-through, to a different extent, from oil prices to domestic inflation to inflation expectations.

5.1. Did the global financial crisis affect the pass-through from inflation to inflation expectations?

In this section we examine whether the link between inflation and inflation expectations has been affected by the period after the global financial crisis. The aftermath of the global financial crisis was characterized by low inflation rates in advanced economies (Ehrmann, 2015) as well as ultra-low interest rates and unconventional monetary policy. Doh and Oksol (2018) argue that the launch of large-scale asset purchase programs helped stabilizing inflation expectations in the US. Whether this claim can be supported on a global scale has not been examined so far.

We first run a sub-sample analysis to broadly examine parameter changes over time and second, draw particular attention to one facet of the aftermath of the crisis, namely monetary policy and the zero lower bound. For the sub-sample analysis, we re-estimate the GVAR model for the post-crisis period, which we define from 2009m12–2016m12. We use a later cut-off date that marks the aftermath of the GFC since we use a global sample and some countries (e.g., in CESEE) have been affected with a delay (see e.g., the discussion in Feldkircher, 2014).[27]

To gauge in a more systematic way whether the effects change over time we calculate the differences in impulse responses from the full and post-crisis period. Using Monte Carlo integration, we compute the median difference along with its 68% credible interval.[28] In case both responses are similar, the median should be close to zero or, since estimation and structural uncertainty precludes any precise statement, the bounds large. The results are reported in Table 5, which shows the median of the difference in cumulative impulses responses as well as for its peak value. Significant values according to the 68% bounds are in bold.

Looking at the table reveals that the differences in cumulative inflation expectation responses to an inflationary AD or AS shock are in general rather small. This indicates that the link between inflation and inflation expectations tends not to be different in the post-crisis period for most of the countries. However, in some countries, we find significant deviations post-crisis. For example, for France,

[26] Indonesia adopted an inflation targeting regime in 2000. One way of rationalizing the result reported above is by arguing that, in the presence of a positive inflation shock, the central bank will tighten policy to maintain its credibility. Assuming this is the case inflation expectations should fall subsequently. Inflation targeting, however, may be a necessary but not sufficient condition to obtain such as result. All that is needed is a credible central bank which is expected to control inflation.

[27] We have also re-estimated the GVAR model over the pre-crisis period, but the model was less stable, which prohibits a direct comparison of pre- and post-crisis periods.

[28] More precisely, we have a different number of MCMC draws for which a rotation matrix has been found for the two sample periods. We randomly match the number of MCMC draws for both periods 500 times and calculate the statistic of interest (the difference in responses).

Table 5
Sub-sample analysis of long-run and peak effects.

	Long-run (h = 25)			Peak		
	AD	AS	Oil	AD	AS	Oil
US	0.07	0.19	−0.03	−0.17	0.21	**0.55**
CA	−0.07	**−0.08**	0.11	−0.02	0.06	**0.45**
NO	0.06	0.16	**0.31**	0.08	−0.47	**0.17**
SE	−0.08	−0.04	0.26	0.11	−0.18	0.41
GB	−0.46	−0.20	0.12	0.76	−0.15	0.22
AT	0.00	0.00	0.20	0.19	0.02	**0.40**
BE	−0.08	−0.11	**0.54**	−0.20	−0.05	**0.86**
DE	0.01	0.00	0.12	−0.11	−0.09	0.21
IT	−0.18	0.39	**0.39**	−0.17	0.16	**0.43**
ES	0.05	−0.20	0.25	0.06	0.22	**1.02**
FI	0.00	−0.01	0.41	−0.12	−0.41	**0.49**
FR	**−0.30**	−0.02	0.34	−0.32	−0.07	**0.45**
NL	−0.16	0.04	0.05	−0.26	0.00	0.17
PT	0.03	0.15	**0.36**	−0.09	−0.18	**0.40**
GR	0.06	0.31	**0.59**	0.04	−0.36	**0.66**
IE	0.14	−0.02	**0.94**	0.03	−0.24	**0.89**
EE	0.03	−0.06	**0.54**	−0.05	−0.17	0.44
LT	1.54	1.10	0.25	1.24	0.90	0.11
LV	−0.39	−0.34	0.42	0.29	−0.17	0.37
SK	−0.02	0.22	0.05	0.01	0.67	0.03
SI	−0.01	−0.02	**0.55**	0.00	−0.09	**0.64**
BG	0.39	0.13	**0.62**	0.52	0.07	**0.50**
CZ	−0.09	0.10	0.08	−0.18	0.49	−0.09
HR	0.04	0.02	0.36	−0.03	−0.09	0.32
HU	−0.40	−0.10	0.23	−0.16	−0.08	0.13
PL	0.13	0.07	**−0.71**	0.29	−0.01	**−0.68**
RO	0.33	−0.07	**0.97**	−0.74	0.00	0.79
RU	0.02	−0.17	0.44	0.87	0.10	0.38
TR	0.06	−0.20	0.19	−0.13	−0.43	0.03
CN	0.06	0.03	−0.25	−0.20	−0.24	−0.08
JP	0.07	0.05	0.29	0.07	−0.01	0.24
KR	−0.03	0.01	0.04	0.12	0.19	0.11
MY	−0.63	−0.40	−0.31	−0.51	−0.22	−0.30
PH	0.07	−0.04	**0.80**	0.14	−0.21	**0.73**
SG	−0.08	−0.10	0.05	−0.11	0.20	−0.07
ID	**−0.66**	−0.26	0.31	−0.46	0.12	0.22
IN	−1.45	−1.64	0.03	0.24	−0.30	−0.03
BR	0.28	0.34	−0.32	1.16	−0.47	−0.10
CL	−0.71	−1.96	**0.35**	0.12	−0.94	**0.32**
MX	0.09	0.11	0.08	−0.07	0.58	0.03
PE	**0.84**	**0.70**	0.22	0.31	**0.28**	**0.28**
ZA	0.10	0.07	0.32	0.24	−1.40	0.24

Notes: The table shows the differences of inflation expectations impulse responses estimated over the full sample period and the post-crisis sample period (2009m12 to 2016m12). The figures constitute median differences over 500 randomly permutated draws, figures in bold indicate statistically different values according to 68% credible intervals.

Indonesia and Canada we find stronger (positive) responses of inflation expectations in the post-crisis period. The opposite is found in the case of Peru, with inflation expectations reacting less in the post-crisis period compared to the full sample period. The differences in inflation expectation responses to the oil price shock are positive for most countries and significantly so for nearly a third of them. This implies that inflation expectations in the aftermath of the crisis would react less strongly to an oil price shock that drives up inflation.[29] Poland is an exception since it exhibits a comparably higher sensitivity of inflation expectations to an increase in oil prices in the aftermath of the crisis. Looking at peak effects tells a similar story.

We then proceed to investigate whether the transmission of the shocks is altered by the zero lower bound constraint. We do this by using so-called shadow interest rates, which are derived from term structure models. The shadow rate mirrors actual rates during normal times and becomes negative during periods when the zero lower bound is binding. We substitute the shadow rates for short-term interest rates in the countries that experienced periods of zero short-term interest rates, namely the country model for the ECB, Japan, the UK

[29] Also notable are large variations in oil prices since the GFC. Of course, there continues to be a lively debate about whether the pass-through effects in oil prices has changed over time. See, for example, Clark and Terry (2010) and Baumeister and Kilian (2016) for the US and Holm-Hadulla and Hubrich (2017) for the euro area.

and the US. The shadow rates we use are from Krippner (2013) and are publicly available from the webpage of the Reserve Bank of New Zealand. We then re-estimate the model and calculate impulse responses to the three shocks as above. The correlation of inflation expectations posterior median impact responses with and without shadow rates is above 0.9 for both the local demand and local supply shocks. For the oil supply shock, the correlation is close to 1. This indicates that accounting for monetary policy during the zero lower bound period does not alter our baseline results. To investigate this further we carry out the same exercise as with the sub-sample analysis above, namely calculating differences of impulse responses for the two settings and gauging their statistical significance. The results are provided in Table A1.

Summing up, for most countries, we do not find a systematically different effect of domestic demand and supply shocks on inflation expectations in the aftermath of the crisis. This holds also true for advanced countries that used unconventional monetary policy to drive up inflation during that period and when using shadow rates instead of actual short-term interest rates for countries that hit the zero lower bound. When inflation picks up due to a shortage in oil supply, however, inflation expectations in a range of countries respond less in the aftermath of the crisis.

5.2. *What drives inflation expectations?*

We assess the drivers of inflation expectations by looking at a forecast error variance decomposition. Since we are interested more generally in the drivers of inflation expectations, we use the Lanne-Nyberg corrected generalized forecast error variance decomposition as in section 4.[30] The posterior mean of the variance decompositions after 12 months are provided in Table 5.

The first column shows the variables that explain more than 50% of the total forecast error variance of inflation expectations in a particular country for the model estimated over the full sample period. For example, more of half of the total forecast error variance of inflation expectations in the US can be accounted for by shocks to oil price inflation. More generally, oil price inflation turns out to be a major determinant of inflation expectations in advanced and euro area countries corroborating the results of Galesi and Lombardi (2013). By contrast, in emerging economies, domestic inflation expectations account for the bulk of the forecast error variance. For some countries, additional foreign macro variables account for a significant share of forecast error variance. These include an effect from Turkey and India, two large emerging markets. Shocks to actual inflation dynamics appear less frequently. The right column of Table 6 provides the forecast error variance decompositions for the post-crisis period. In general, oil inflation shocks appear less frequently as determinants of forecast error variance. Also, for most countries forecast error variance is accounted for by more factors compared to considering the full sample. In some countries additional domestic variables show up as important determinants (e.g., in Hungary or Spain), while in others international factors account for forecast error variance (e.g., Russia in Croatia and Poland). There is surprisingly little change in the composition of forecast error variance explanatory factors regarding Latin American countries.

Overall, we conclude that domestic inflation expectations and oil price inflation are important determinants of inflation expectations. To a lesser extent this holds true for domestic actual inflation an indication that energy prices drive a wedge between observed and expected inflation. International variables from important emerging markets such as India and Turkey or Russia for some CESEE economies also explain a significant share of forecast error variance in inflation expectations.

6. Conclusions

In this paper we investigate the dynamics of global inflation and short-run inflation expectations. We first demonstrate the existence of substantial interdependence between global and domestic inflation and inflation expectations. This implies that inflation expectations are not only driven by changes in domestic macroeconomic conditions but also by inflation expectations of other countries. The same holds true for observed inflation.

We then proceed to investigate the drivers of inflation expectations controlling for global linkages in the data. We rely on a global vector autoregressive (GVAR) model estimated using Bayesian shrinkage priors. Our model nests a broad range of specifications for inflation and inflation expectations including variables that measure global slack. We then identify three shocks that can lead to inflationary pressure, namely a domestic aggregate demand shock, a domestic aggregate supply shock and a global acceleration of oil price inflation. The shocks are identified using sign restrictions and the oil supply shock makes use of the cross-sectional dimension of the data (Cashin et al., 2014, Mohaddes and Pesaran, 2016).

Our main findings are as follows: First, we find that inflation expectations respond positively to domestic shocks that drive up actual inflation. This is true for aggregate demand shocks that drive up both actual inflation and output as well as for aggregate supply shocks which are characterized by an acceleration of inflation but a contraction in output. Peak effects of inflation expectations tend to be positive, but overall effects are rather short-lived. The most direct pass-through from actual inflation to inflation expectations, however, is observed when inflation increases due to a global acceleration of (supply-driven) oil price inflation. Here, both actual inflation and inflation expectations respond positively and effects are sizeable. This implies that for a policy maker interested in the anchoring of long-run inflation expectations, oil price shocks should be closely watched since the high pass-through to short-run inflation expectations can limit the room for long-run inflation expectation anchoring. This is not the case for domestic demand and supply shocks that only show short-lived effects on short-run inflation expectations.

Second, we examine whether the pass-through of inflation to short-run inflation expectations has changed during the aftermath of

[30] An alternative would be to assess error variances based on the structural model. This would allow us to quantify the shares of variance explained by either demand or supply shocks. This, however, is computationally demanding for shocks which are identified via sign restrictions.

Table 6
Generalized forecast error variance decomposition.

Country	Full sample period	Post-crisis period
US	Dpoil	Dpoil, US.Dp^e
CA	TR.stir, Dpoil, CA.Dp^e	CA.Dpe, CA.Dp, CA.gdp.m
NO	NO.Dp^e, NO.Dp, NO.stir	NO.Dp^e, NO.Dp, EA.stir
SE	SE.Dp^e, Dpoil, EA.stir	SE.Dp^e, SE.Dp
GB	GB.Dp^e, Dpoil	GB.Dp^e, TR.stir, Dpoil
AT	Dpoil, AT.Dp^e	AT.Dp^e, AT.Dp
BE	Dpoil	BE.Dp, BE.Dp^e
DE	Dpoil, DE.Dp^e, IN.sp	Dpoil, DE.Dp^e, DE.Dp
IT	Dpoil, IT.Dp, IT.Dp^e	IT.Dp, IT.Dp^e
ES	Dpoil	ES.Dp, ES.Dp^e, ES.sp
FI	Dpoil, FI.Dpe	FI.Dp^e, FI.Dp
FR	Dpoil	FR.Dp^e, Dpoil, FR.Dp
NL	NL.Dp^e, Dpoil	NL.Dp^e, NL.Dp
PT	PT.Dp^e, PT.Dp	PT.Dp, PT.Dp^e
GR	GR.Dp^e	GR.Dp^e
IE	IE.Dp^e, Dpoil	IE.Dp^e
SK	SK.Dp^e	SK.Dp, SK.Dp^e, RU.sp, RU.stir
SI	SI.Dp^e, Dpoil	SI.Dp, SI.Dp^e
EE	EE.Dp^e, EE.Dp	EE.Dp, EE.Dp^e
LT	LT.sp, LT.Dp^e	LT.Dp, LT.Dp^e, EA.stir
LV	LV.Dp^e	LV.Dp, LV.stir, LV.sp
BG	BG.Dp, TR.stir, BG.Dp^e, BG.sp	BG.Dp
CZ	CZ.Dp^e, EA.stir	CZ.Dp, CZ.Dp^e, Dpoil, CZ.ur
HR	HR.Dp^e, IN.sp, IN.stir	HR.Dp, HR.Dp^e, RU.sp, RU.stir
HU	HU.Dp^e, IN.sp	HU.Dp, HU.Dp^e, HU.stir
PL	PL.Dp^e, IN.sp, IN.stir	PL.Dp^e, RU.sp, RU.stir, PL.sp, PL.Dp, ID.Dp
RO	RO.Dp^e	RO.Dp, RO.Dp^e
RU	RU.Dp^e	RU.Dp^e
TR	TR.Dp^e	TR.Dp^e, TR.Dp
CN	CN.Dp^e	CN.Dp^e, CN.Dp
JP	JP.Dp^e, TR.stir	JP.Dp^e
KR	KR.Dp^e	KR.Dp^e
MY	MY.Dp^e	MY.Dp^e
PH	PH.Dp^e	PH.Dp, PH.Dp^e, Dpoil
SG	SG.Dp^e	SG.Dp^e, SG.Dp
ID	ID.Dp^e	ID.Dp
IN	IN.Dp^e	IN.Dp^e
BR	BR.Dp^e	BR.Dp^e
CL	CL.Dp^e	CL.Dp^e
MX	MX.Dp^e	MX.Dp^e
PE	PE.Dp^e	PE.Dp^e, PE.stir
ZA	ZA.Dp^e, TR.stir	ZA.Dp^e

the global financial crisis – a period that was characterized by low inflation in advanced economies and the introduction of unconventional monetary policies by several major central banks to stimulate inflation. We find that the transmission between inflation and inflation expectations was largely unaffected in response to domestic demand and supply shocks. For the oil supply shock, our findings indicate a smaller impact on inflation expectations post-crisis. This implies a greater likelihood of a successful anchoring of long-run inflation expectations in the aftermath of the crisis compared to the full sample period. Lastly, we examine more generally the drivers of inflation expectations. Here we find that domestic inflation expectations, oil prices and variables from large emerging economies such as India and Turkey are important drivers of inflation expectations. For some CESEE economies, Russian macroeconomic conditions also shape inflation expectations.

Some (e.g., Coibion, Gorodnichenko, Kumar, et al., 2018b) have drawn attention to differences between household and the professional forecasts used in the present study as critical to determining whether expectations are anchored. Clearly, this is a potential area where additional work is necessary. However, unlike household expectations, whose availability is episodic and where the manner in which surveys are structured and information about inflation expectations are solicited, our data set consists of comparable data and is on a global scale. Moreover, paralleling some of the results based on household surveys, professional forecasts are potentially just as sensitive to energy prices movements. Policy makers will have to bear this in mind when associating a tightening or loosening of monetary policy to changes in oil prices.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.iref.2019.06.004.

Notes: The table shows the variables (.*) that explain more than 50% of variance of inflation expectations in a given country (ISO code) at the $h = 12$ months forecast horizon. Posterior mean based on the full set of MCMC draws of the Lanne and Nyberg (2016) corrected generalized forecast error variance decompositions shown. The variables are defined in the text.

References

Ahmad, S., & Civelli, A. (2016). Globalization and inflation: A threshold investigation. *Journal of Macroeconomics, 48*(C), 283–304.

Almansour, A., Aquib, A., Bluedorn, J., & Duttagupta, R. (2015). How vulnerable are emerging markets to external shocks? *Journal of Policy Modeling, 37*(3), 460–483.

Ascari, G., & Sbordone, A. (2014). The macroeconomics of trend inflation. *Journal of Economic Literature, 52*(3), 679–739.

Auer, R., Borio, C., & Filardo, A. (2017). *The globalization of inflation: The growing importance of global value chains*. BIS working paper 602, January.

Banerjee, R., & Mehrotra, A. (2018). *Deflation expectations*. BIS working paper 699, February.

Bank of Japan. (2016). Developments in inflation expectations over the three years since the introduction of quantitative and qualitative monetary easing (QQE). 14 October, available from https://www.boj.or.jp/en/mopo/outline/qqe.htm/.

Batchelor, R. (2001). How useful are the forecasts from intergovernmental agencies? The IMF and the OECD versus the consensus. *Applied Economics, 33*(2), 225–235.

Baumeister, C., & Kilian, L. (2016). Lower oil prices and the U.S. Economy: Is this time different? *Brookings Papers on Economic Activity*, 287–343.

Béreau, S., Faubert, V., & Schmidt, K. (2018). *Explaining and forecasting euro area inflation: The role of domestic and global factors*. Banque de France Working Paper Nr. 663.

Bernanke, B. (2007). Inflation expectations and inflation forecasting. In *Speech to the monetary economics workshop of the NBER summer institute, cambridge, Massachusetts, 10 july*.

Bernanke, B. S. (2008). Outstanding issues in the analysis of inflation. In *At the federal Reserve Bank of boston's 53rd annual conference, 9 june*.

Bhatnagar, S., Cormier, A.-K., Hess, K., de Leon-Manlagnit, P., Martin, E., Rai, V., et al. (2017). *Low inflation in advanced economies: Facts and drivers*. Bank of Canada Staff Analytical Note 2017-16.

Bianchi, F., & Civelli, A. (2015). Globalization and inflation: Evidence from a time-varying VAR. *Review of Economic Dynamics, 18*(2), 406–453.

Blanchard, O. (2016). The Phillips curve: Back to the '60s? *American Economic Review, 106*(5), 31–34.

Blanchard, O., Cerutti, E., & Summers, L. (2015). *Inflation and activity: Two explorations and their monetary policy implications*. IMF working paper 15/230.

Blanchard, O., & Galí, J. (2010). Labor markets and monetary policy: A new keynesian model with unemployment. *American Economic Journal: Macroeconomics, 2*(2), 1–30.

Boneva, L., Cloyne, J., Weale, M., & Wieladek, T. (2016). The effect of unconventional monetary policy on inflation expectations: Evidence from firms in the United Kingdom. *International Journal of Central Banking*, (September), 161–195.

Borio, C., & Filardo, A. (2007). *Globalization and inflation: New cross-country evidence on the global determinants of domestic inflation*. BIS working paper 227, May.

Buono, I., & Formai, S. (2018). New evidence on the evolution of the anchoring of inflation expectations. *Journal of Macroeconomics, 57*, 39–54.

Carney, M. (2017). *Globalisation and inflation*, 2017 IMF Michel Camdessus Central Banking Lecture.

Carriero, A., Corsello, F., & Marcellino, M. (2018). *The global component of inflation volatility*. working paper 1170, Bank of Italy, April.

Cashin, P., Mohaddes, K., Raissi, M., & Raissi, M. (2014). The differential effects of oil demand and supply shocks on the global economy. *Energy Economics, 44*, 113–134.

Cecchetti, S., Feroli, M., Hooper, P., Kashyap, A., & Schoenholtz, K. (2017). *"Deflating inflation expectations: The implications of inflation's Simple dynamics", prepared for the 2017*. New York, N.Y.): U.S. Monetary Policy Forum.

Chan-Lau, J. (2017). *Variance decomposition networks: Potential pitfalls and a Simple solution*. IMF working paper, WP/17/107.

Chan, J., Clark, T., & Koop, G. (2017). *A new model of inflation, trend inflation, and long-run inflation expectations*. working paper, University of Technology Sydney, May).

Chow, G. C., & Lin, A-l (1971). Best linear unbiased interpolation, distribution, and extrapolation of time series by related series. *Review of Economics and Statistics, 53*(November), 372–375.

Chudik, A., & Fratzscher, M. (2012). *Liquidity risk and the global transmission of the 2007-08 financial crisis and the 2010-11 sovereign debt crisis*. Globalization and Monetary Policy Institute Working Paper 107.

Ciccarelli, M., & Mojon, B. (2010). Global inflation. *Review of Economics and Statistics, 92*(August), 524–535.

Clark, T. (2011). Real-time density forecasts from bayesian vector autoregressions with stochastic volatility. *Journal of Business & Economic Statistics, 29*(3), 327–341.

Clark, T., & Davig, T. (2016). *The relationship between inflation and inflation expectations*. originally prepared in 2009 for the FOMC Secretariat, released April 2016.

Clark, T., & Terry, S. (2010). Time variation in inflation passthrough of energy prices. *Journal of Money, Credit, and Banking, 42*(October), 1420–1433.

Coibion, O., & Gorodnichenko, Y. (2015). Is the Phillips curve alive and well After all? Inflation expectations and the missing disinflation. *American Economic Journal: Macroeconomics, 7*(January), 197–232.

Coibion, O., Gorodnichenko, Y., & Kamdar, R. (2018a). the formation of expectations, inflation and the Phillips curve. *Journal of Economic Literature, 56*(4), 1447–1496.

Coibion, O., Gorodnichenko, Y., Kumar, S., & Pedemonte, M. (2018b). "Inflation expectations – a policy tool?". In *Paper presents at the 2018 ECB forum on central banking, sintra, Portugal, june*.

De Gregorio, J. (2012). Commodity prices, monetary policy, and inflation. *IMF Economic Review, 60*(December), 600–633.

Diebold, F., & Yilmaz, K. (2009). Measuring financial asset return and volatility spillovers, with application to global equity markets. *Economic Journal, 119*, 158–171.

Diebold, F., & Yilmaz, K. (2014). On the network topology of variance decompositions: Measuring the connectedness of financial firms. *Journal of Econometrics, 182*(2), 119–134.

Doh, T., & Oksol, A. (2018). *Has the anchoring of inflation expectations changed in the United States during the past decade?* (pp. 31–58) Economic Review, Federal Reserve Bank of Kansas City.

Ehrmann, M. (2015). Targeting inflation from below: How do inflation expectations behave? *International Journal of Central Banking, 11*(September), 213–249.

Eickmeier, S., & Ng, T. (2015). How do US credit supply shocks propagate internationally? A GVAR approach. *European Economic Review, 74*(C), 127–145.

Feldkircher, M. (2014). The determinants of vulnerability to the global financial crisis 2008 to 2009: Credit growth and other sources of risk. *Journal of International Money and Finance, 43*, 19–49.

Feldkircher, M., Gruber, T., & Huber, F. (2019). International effects of a compression of euro area yield curves. *Journal of Banking & Finance*. forthcoming.

Fischer, S. (2016). Reflections on macroeconomics then and now. In *At 32nd annual national association for business economics economic policy conference 'policy challenges in an interconnected world', 7 march*.

Friedman, M. (1968). The role of monetary policy. *American Economic Review, 58*, 1–17.

Fuhrer, J. (2017). *Japanese and U.S. Inflation dynamics in the 21st century*. IMES Discussion Paper No. 2017-E-5.

Galesi, A., & Lombardi, M. J. (2013). *"External shocks and international inflation linkages," the GVAR handbook: Structure and applications of a macro model of the global economy for policy analysis* (pp. 255–270). Oxford University Press, 2013.

Georgiadis, G. (2015). Examining asymmetries in the transmission of monetary policy in the euro area: Evidence from a mixed cross-section global VAR model. *European Economic Review, 75*(C), 195–217.

Gordon, R. (2013). *The Phillips curve is alive and well*. NBER working paper 19390, August.

Gospodinov, N., & Ng, S. (2013). Commodity prices, convenience yields and inflation. *Review of Economics and Statistics, 95*(March), 206–219.

Greenspan, A. (2005). *Economic outlook*. nov. 3, 2005, available from www.federalreserve.gov/boarddocs/testimony/2005/20051103/default.htm.

Holm-Hadulla, F., & Hubrich, K. (2017). *Macroeconomic implications of oil price fluctuations: A regime-switching framework for the euro area", finance and economics discussion series*. Federal Reserve Board, working paper 2017—63, May.

Hooper, P., Mishkin, F., & Sufi, A. (2019). *Prospects for inflation in a high pressure economy: Is the Phillips curve dead or is it just hibernating?*, 2019 US Monetary Policy Forum, February.
Huber, F., & Feldkircher, M. (2019). Adaptive shrinkage in bayesian vector autoregressive models. *Journal of Business & Economic Statistics, 37*(issue 1), 27–39.
Huber, F., & Punzi, M. (2017). The shortage of safe assets in the US investment portfolio: Some international evidence. *Journal of International Money and Finance, 74*, 318–336.
Ihrig, J., Kamin, S. B., Lindner, D., & Marquez, J. (2010). Some Simple tests of the globalization and inflation hypothesis. *International Finance, 13*(Winter), 343–375.
Jain, M. (2017). Perceived inflation persistence. *Journal of Business & Economic Statistics, 37*(1), 110–120. https://doi.org/10.1080/07350015.2017.1281814.
Juselius, M., & Takats, E. (2015). *Can demography affect inflation and monetary policy?*. BIS working paper 485.
Kabukçuoğlu, A., & Martínez-García, E. (2018). "Inflation as a global phenomenon – some implications for inflation modeling and forecasting". *Journal of Economic Dynamics and Control, 87*(C), 46–73.
Kamber, G., & Wong, B. (2018). *Global factors and trend inflation*. BIS working paper 688, January.
Kilian, L. (1998). Confidence intervals for impulse responses under departures from normality. *Econometric Reviews, 17*(1), 1–29.
Kilian, L. (2008). A comparison of the effects of exogeneous oil supply shocks on output and inflation in the G7 countries. *Journal of the European Economic Association, 6*, 78–121.
Kilian, L. (2009). Not all oil price shocks are alike: Disentangling demand and supply shocks in the crude oil market. *American Economic Review, 99*(June), 1053–1069.
Kilian, L. (2009a). Causes and consequences of the oil shock of 2007-08: Comment. *Brookings Papers on Economic Activity, 1*, 267–278.
Kilian, L. (2009b). Not all oil price shocks are alike: Disentangling demand and supply shocks in the crude oil market. *American Economic Review, 99*(3), 1053–1069.
Kilian, L., & Lewis, L. (2011). Does the fed respond to oil price shocks? *Economic Journal, 121*(September), 1047–1072.
Kilian, L., & Murphy, D. (2014). The role of inventories and speculative trading in the global market for crude oil. *Journal of Applied Econometrics, 29*(April), 454–478.
Kilian, L., & Vega, C. (2011). Do energy prices respond to US macroeconomic news? A test of the hypothesis of predetermined energy prices. *Review of Economics and Statistics, 93*(May), 660–671.
Kozicki, S., & Tinsley, P. (2012). Effective use of survey information in estimating the evolution of inflation expectations. *Journal of Money, Credit, and Banking, 44*(1), 145–169.
Krippner, L. (2013). Measuring the stance of monetary policy in zero lower bound environments. *Economics Letters, 118*(1), 135–138.
Lanne, M., & Nyberg, H. (2016). Generalized forecast error variance decomposition for linear and nonlinear multivariate models. *Oxford Bulletin of Economics & Statistics, 78*(4), 595–603.
Levin, A., Natalucci, F., & Piger, J. (2004). The macroeconomic effects of inflation targeting. *Federal Reserve Bank of St. Louis Review, 86*(4), 51–80.
Loungani, P. (2001). How accurate are private sector forecasts? Cross-country evidence from consensus forecasts of output growth. *International Journal of Forecasting, 17*(July-September), 419–432.
Lyziak, T., & Paloviita, M. (2016). *Anchoring of inflation expectations in the euroa rea: Recent evidence based on survey data*. ECB Working paper series, No. 1945/2016.
Mankiw, G., & Reis, R. (2002). Sticky information versus sticky prices: A proposal to replace the new keynesian Phillips curve. *Quarterly Journal of Economics, 117*, 1295–1328.
Mavroeidis, S., Plagborg-Møller, M., & Stock, J. H. (2014). Empirical evidence on inflation expectations and the new keynesian Phillips curve. *Journal of Economic Literature, 52*(March), 124–188.
Mehrotra, A., & Yetman, J. (2018). Decaying expectations: What inflation forecasts tell US about the anchoring of inflation expectations. *International Journal of Central Banking, forthcoming, 14*(5), 55–101.
Mohaddes, K., & Pesaran, M. H. (2016). Country-specific oil supply shocks and the global economy: A counterfactual analysis. *Energy Economics, 59*, 382–399.
Murray, J. (2017). Inflation targeting after 28 Years: What have we learned?. available from www.regjeringen.no/contentassets/adcde72c116c4804b50e8e44b851569e/1_murray.pdf.
Pang, K., & Siklos, P. L. (2016). Macroeconomic consequences of the real-financial nexus: Imbalances and spillovers between China and the US. *Journal of International Money and Finance, 65*(July), 195–212.
Parker, M. (2017). *Global inflation: The role of food, housing, and energy prices*. ECB working paper No. 2024, February.
Peersman, G. (2005). What caused the early millennium slowdown? Evidence based on vectorautoregressions. *Journal of Applied Econometrics, 20*(2), 185–207.
Pesaran, H., & Chudik, A. (2016). Theory and practice of GVAR modeling. *Journal of Economic Surveys, 30*(February), 165–197.
Pesaran, H., Schuermann, T., & Weiner, S. (2004). Modeling regional interdependencies using a global error-correcting macroeconometric model. *Journal of Business & Economic Statistics, 22*, 129–162.
Rogoff, K. (2003). Globalization and global disinflation. In *Monetary policy and uncertainty: Adapting to a changing economy* (Vol 88, p. 45). Federal Reserve Bank of Kansas City.
Rogoff, K. (2006). Impact of globalization on monetary policy. In *The new economic geography: Effects and policy implications* (pp. 24–26). Jackson Hole, Wyoming.
Sargent, T. (1999). *The conquest of American inflation*. Princeton, NJ: Princeton University Press.
Siklos, P. L. (2013). Sources of disagreement in inflation forecasts: An international empirical investigation. *Journal of International Economics, 90*(May), 218–231.
Siklos, P. L. (2019). What has publishing inflation forecasts accomplished?", in central banks and their competitors. In D. Mayes, P. L. Siklos, & J.-E. Sturm (Eds.), *Handbook of the economics of central banking* (pp. 737–777). Oxford: Oxford University Press.
Sims, C. (2006). Rational inattention: Beyond the linear-quadratic case. *American Economic Review, 96*(2), 158–163.
Sims, C., & Zha, T. (2006). Were there regime switches in US monetary policy? *American Economic Review, 96*(1), 54–81.
Stock, J., & Watson, M. (2018). Slack an cyclically sensitive inflation. In *Paper presented at the 2018 european central bank forum on Central Banking, sintra, june*.
Strohsal, T., & Winkelmann, L. (2015). Assessing the anchoring of inflation expectations. *Journal of International Money and Finance, 50*, 33–48.
Trehan, B. (2015). Survey measures of expected inflation and the inflation process. *Journal of Money, Credit, and Banking, 47*(February), 207–222.
Winkelried, D. (2017). Inferring inflation expectations from fixed-events forecasts. *International Journal of Central Banking, 13*(June), 1–31.
Woodford, M. (2003a). *Interest and prices*. Princeton, N.J.: Princeton University Press.
Woodford, M. (2003b). Imperfect common knowledge and the effects of monetary policy. In P. Aghion, R. Frydman, J. Stiglitz, & M. Woodford (Eds.), *Knowledge, information, and expectations in modern macroeconomics: In honor of edmund phelps*. Princeton, NJ: Princeton University Press.
Yellen, J. (2016). Macroeconomic research after the crisis. In *At 60th annual conference of the federal Reserve Bank of boston 'the elusive "Great" recovery: Causes and implications for future business cycle dynamics', 14 october*.
Yetman, J. (2018). *The perils of approximating fixed-horizon inflation forecasts with fixed-events forecasts*. BIS working paper 700, February.