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Does the U.S. export inflation? Evidence from the dynamic inflation spillover between the U.S. and EAGLEs

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ABSTRACT

Given the crucial role of inflation as a key economic barometer, our paper investigates the dynamic inflation spillover between the U.S. and the nine emerging and growth-leading economies (EAGLEs) between 1991M1 and 2020M2. Employing the recently developed time-varying parameter vector autoregressions (TVP-VAR)-based connectedness approach, we find evidence of a moderate inflation spillover across the sample countries at normal condition. We further point out that inflation spillover effects with the U.S. are more pronounced for the emerging markets with higher openness, the net oil-importing emerging markets, and the emerging markets following free-float exchange rate regimes. More importantly, the inflation spillover index among the system rises dramatically to over 70% under extremely inflationary conditions, implying that the transmission of spiral inflation is very high. Additionally, the time-varying analysis shows that the role of the U.S. in the inflation shock transmission with emerging countries varies between being a net inflation-exporter and inflation-importer over times. Finally, an investigation of the drivers of the inflation spillovers reveals that the U.S. dollar, emerging markets' economic policy uncertainty, and bilateral trade are key determinants of the inflation shock transmission among the system. Our findings justify central banks' actions in decreasing U.S. dollar reserves to safeguard their domestic currencies.

1. Introduction

Recent global events, including the COVID-19 pandemic, supply chain disruptions, and geopolitical tensions induced by the Russian-Ukrainian war, have led to a worldwide surge in inflation rates. In 2022, inflation reached a multi-decade high of 9.4% in advanced economies,[1] and an average of 9.9% in emerging countries, according to the International Monetary Fund.

Emerging countries are feeling the pinch more acutely due to their lower average household income, a larger portion of household budgets allocated to food and energy consumption, and less flexibility in adjusting their fiscal and monetary policies.[2] This inflationary pressure and the struggle of central banks worldwide to combat hyperinflation rates in 2022 have raised interest in the effect of

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[1] See, Consumer Prices, OECD-Updated: 7 February 2–23.
[2] See, https://www.weforum.org/agenda/2022/02/explainer-how-is-inflation-hitting-low-income-households-in-developing-nations.

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international inflation spillover, particularly between developed and emerging economies. Despite the fact that the emerging markets are more vulnerable to global inflationary pressures,[3] existing literature on inflation spillovers primarily focuses on developed economies (e.g., Elsayed et al., 2021; Jordan, 2016; Pham and Sala, 2022; Tiwari et al., 2019; Wen et al., 2021), overlooking the interactions between developed markets and emerging markets.

Our study aims to fill this gap by investigating the dynamics of inflation shock spillover between the U.S. and the emerging EAGLE group (Brazil, China, India, Indonesia, South Korea, Mexico, Russia, Turkey, and Taiwan).[4] By focusing on the EAGLE countries, our study explores the dynamics of their inflation spillovers with the U.S. and examines how varying degrees of economic openness in these emerging markets influence spillover effects. We primarily focus on the role of emerging markets in global inflation spillovers, due to their distinctive economic characteristics and constraints which makes them more exposed to global inflationary pressures. Edwards (2007) and Gopinath (2015) highlight how emerging economies' structural features, such as reliance on imports for basic goods and heavy borrowing in foreign currencies, enhance their vulnerability to external shocks, including inflationary pressures from developed economies. These unique vulnerability and policy constraints faced by emerging markets magnify the impacts of their economic openness on inflation spillover, prompting our investigation into how varying degree of emerging markets' economic openness influence global inflation spillover dynamics. Principles of open economy macroeconomics suggest that higher degrees of openness to international trade and finance significantly amplify economies' susceptibility to external shocks, including inflationary shocks. For example, Obstfeld and Rogoff (2000) discuss how open economies are more exposed to external shocks, including inflation spillovers, due to significant trade volumes and cross-border investment. Lane and Milesi-Ferretti (2007) find an increasing trend in both trade and financial integration globally and discuss how this increased openness has contributed to the synchronization of business cycles and the spread of inflationary trends across countries. Overall, economic openness facilitates the transmission of inflationary shocks through several mechanisms, including direct impacts on import/export prices via trade and finance channels, the exchange rate pass-through effects (Campa and Goldberg, 2005), and integration into the global supply chain. Our study uniquely contributes to the literature by focusing on the EAGLE economies' role in the global inflation narrative, a perspective significantly underexplored in existing studies. Focusing on the vulnerability of emerging markets to global inflationary pressures would offer critical insights for policymakers to tailor more informed policy responses aimed at enhancing the resilience and stability of these countries.

Given the U.S. dollar's dominance as reverse currency in central banks of emerging countries,[5] and the intricate trade relationships between the U.S. and EAGLE countries,[6] our paper further answers an important question of whether the U.S. acts predominantly as an importer (exporter) of inflation from (to) emerging economies. This is the question left over in the extant literature. We conjecture two channels that determine the role of the U.S. in the inflation spillover effects with emerging economies. First, as a major export destination of emerging markets, U.S. monetary policy changes, such as the Fed's loosening monetary policy, which weakens the U.S. dollar, make the imports from emerging nations to the U.S more expensive. This prompts emerging markets to adjust their currencies to keep their exports' prices competitive, often leading to inflation in emerging countries. This synchronization with the Fed's policy, termed as the "*monetary policy channel*", shows how the U.S. inflation could spill to emerging markets, as evidenced by various studies finding evidence of U.S. monetary policy spillovers to developing countries (e.g., Chen et al., 2014; Anaya et al., 2017; Bräuning and Ivashina, 2020). This channel supports the role of inflation exporter of the U.S. to emerging markets.

In reverse, higher inflation rates in emerging markets could increase the U.S. import prices, directly and indirectly raising U.S. inflation. This helps explain why the U.S. would be an inflation importer from emerging markets (Tootell, 1998). Directly, since many foreign goods prices are included in the calculation of the U.S. Consumer Price Index, higher import prices could increase the U.S domestic inflation. Indirectly, if these imports are key inputs for U.S.-made products, their increased prices can raise production costs, which in turn boost the prices of goods and services made in the U.S. We term this mechanism as the "*consumption channel*", illustrates how the U.S. imports inflation from emerging markets.

To this end, we utilize the time-varying parameter vector autoregressive (TVP-VAR)-based connectedness framework and the quantile-based connectedness method to analyse the inflation spillover effect among sample markets at both the conditional mean and tails of inflation distributions, offering a comprehensive view of inflation spillover dynamics over time and under varying economic conditions. Our study reveals that there is a moderate but growing inflation spillover between the U.S. and the EAGLE group over the sample period, highlighting increased economic and monetary integration between the countries.[7] Our finding is in line with recent evidence reported by Elsayed et al. (2021). Further, the average connectedness results also show that over the sample period, South Korea, India, and Mexico are the key transmitters of inflation shocks, whereas Russia, Indonesia, and Turkey are the most important net inflation shock receivers. Intriguingly, we find that the magnitude of inflation spillover effects between an emerging market with the U.S. depends on country-specific characteristics. Specifically, the inflation spillover effects with the U.S. are more pronounced for the

[3] See Fig. 1 for the display of the higher inflation rates in emerging markets compared to the developed markets.

[4] EAGLE is a group of nine emerging and growth-leading economies, including Brazil, China, India, Indonesia, South Korea, Mexico, Russia, Turkey, and Taiwan.

[5] Data comprised from 149 reporting countries provided by the International Monetary Fund shows that as in the 2nd quarter of 2022, the U.S. dollar accounted for 59% of the central bank reserves. See, https://crsreports.congress.gov/product/pdf/IF/IF11707.

[6] The ratio of imports from EAGLE to the total imports of the U.S. is around 44.82% (See, Fig. 2). The ratio of exports to the U.S. makes up an average of 4.73% of the GDP of EAGLE group in 2020 (See, Fig. 3). Further information of monthly trade balance between the U.S. and EAGLEs can be seen in Appendix A5.

[7] For instance, according to the World Trade Organization (WTO), total merchandise trade values in the world have increased fourfold from above USD 5000 trillion in 2000 to more than USD 22,000 trillion in 2020. Source: https://stats.wto.org/dashboard/merchandise_en.html.

emerging economies with higher openness, the net oil-importing emerging markets, and the emerging markets following free-float exchange rate regimes.

Regarding the role of the U.S. in this inflation relationship, the U.S., on average, emerges as a net inflation importer from the EAGLEs, suggesting the dominant role of the "*consumption channel*" in shaping the inflation transmission between the U.S. and EAGLEs. However, the time-varying analysis shows that the role of the U.S. varies over time between net receiver and net transmitter of inflation shocks. While the U.S. is net importer of inflation shocks from South Korea, India, China, and Indonesia, the country is net exporter of inflation spillover to Taiwan, Turkey, Mexico, Russia, and Brazil.

The results of quantile-based connectedness further uncover that inflation shock transmission is more intense during periods of high market stress and extreme inflationary conditions, with the U.S. more likely to receive shocks from the EAGLEs.

Turning to the drivers of time-varying inflation effect, we investigate the determinants of the spillover effect measured by the TVP-VAR-based connectedness using a comprehensive set of explanatory variables. We find robust evidence that both the inflation spillover from the U.S. to emerging markets and the inflation spillover from emerging markets to the U.S. are positively linked to the strength of the U.S. dollar, the economic policy uncertainty in emerging markets, and the U.S. export or import to and from emerging economies.

Our paper contributes to the extant literature in several ways. First, by focusing on the EAGLE countries, which represent a significant portion of the world GDP, and employing advanced connectedness frameworks, our study offers valuable insights into the dynamics and the determinants of inflation spillover effects between the U.S. and the EAGLE group, an aspect that remains underexplored in the literature. By examining the role of the U.S. as both an importer and exporter of inflation shock and the effect of economic openness on these spillovers, our research makes a significant contribution to the literature on the U.S.'s macroeconomic influence on emerging markets. Our findings timely equip policymakers and investors with crucial information on international inflation spillover during periods of economic instability and stress, particularly emphasizing the critical roles of economic openness in influencing these inflation spillover effects. Second, unlike previous studies that rely on methodologies with inherent limitations,[8] such as loss of data and subjectivity bias in selecting rolling-window length, our work employs a newly developed connectedness framework (TVP-VAR-based connectedness), optimized for analysing low-frequency and short data, such as inflation. This approach not only avoids common issues in traditional methods used to measure connectedness but also enhances the precision and reliability of our findings. Third, our study extends investigation on inflation spillover effects during the highly inflationary environment by applying the quantile-based connectedness approach. This aspect is crucial because while a low to moderate domestic inflation rate is considered pro-economic growth and might not have significant impact on policy and investment decisions, understanding the spillover effects of a high inflation rate is essential for developing more resilient economic strategies.

The remainder of the paper is organized as follows. Section 2 provides a brief review of the related literature. Section 3 presents a description of the models employed in this study. Section 4 presents the data used. Section 5 illustrates and discusses the empirical results. Section 6 conducts robustness checks. Section 7 concludes.

2. Literature review

Our paper is related to two strands of literature. The first strand is the literature on the inflation integration (e.g., co-movement and spillover). There are numerous studies that documents that inflation rates across countries tend to converge and co-move. For instance, Kočenda and Papell (1997) and Lopez and Papell (2012) find that inflation converges in the European Union. Similarly, Nusair and Kisswani (2015) document a nonlinear convergence of inflation rates of ASEAN countries to the inflation rates in the US and Japan. Besides, Tiwari et al. (2015) and Tiwari et al. (2016) employ the continuous wavelet approach to investigate the co-movement in inflations in G-7 and European countries, respectively. Both papers document that the inflation correlations are dynamic and vary across different time-frequencies. In an attempt to explore the underlying causes of the inflation convergence or co-movement, Ciccarelli and Mojon (2010) show that inflations of 22 OECD countries co-move and this co-movement is largely explained by common risk factors such as business cycle. In a similar vein, Aastveit et al. (2016) and Hakkio (2010) confirm that common external shocks and international factors contribute significantly to explaining the local inflation rates.

The inflation rates are not only co-move, but could also spill from one country to another through international trade linkage (Auer and Saure, 2013; Bernanke, 2007; Tootell, 1998), commodity prices (Ciccarelli and Mojon, 2010), and synchronization of monetary policies (Tiwari et al., 2015). In this direction, various studies have examined the magnitude and the direction of inflation spillover across countries, with a predominant focus on developed ones. Halka and Szafranek (2016) employ the Diebold and Yilmaz's (2012) connectedness measures to investigate the spillover of several measures of inflation between European Union and small open economies in Europe. They find that the spillover effects vary across different inflation measures and the euro area is the net inflation diffuser in most cases. Tiwari et al. (2019) employ the Diebold and Yilmaz's (2012) and Barunik and Krehlik's (2018) connectedness frameworks to analyse the inflation spillover in Euro-area countries. Other researchers turn to the inflation spillover among G-7 countries and/or the interaction between oil prices and inflation rates (e.g., Elsayed et al., 2021; Istiak et al., 2021; Pham and Sala, 2022; Wen et al., 2021). For instance, Pham and Sala (2022) find a significant level of inflation connectedness among G-7 countries and this connectedness intensifies in periods of common economic turmoil. Elsayed et al. (2021) explore the role of oil inflation in the inflation network of G-7 countries and document that that oil is a net transmitter of inflation shocks. It is noteworthy that in all cited

[8] The previous studies of Halka and Szafranek (2016), Tiwari et al. (2019), Istiak et al. (2021), Wen et al. (2021), Elsayed et al. (2021), Pham and Sala (2022) have used the traditional connectedness methodologies by Diebold and Yilmaz (2012, 2014) and/or Barunik and Krehlík (2018). These methodologies suffer the problems of loss of data and subjectivity bias in choosing the rolling-window length.

studies above, the U.S. acts as a net diffuser of inflation shocks.

Our paper is also related to a strand of literature that explore the impacts of the U.S. macroeconomic factors on the emerging markets. As discussed in the introduction, inflation can spill from the U.S. to emerging markets through the *"monetary policy channel"*. In this channel, an expansionary monetary policy in the US can lead to a loosening monetary policy in emerging markets as the emerging economies aim to keep its exports to the U.S. competitive. Indeed, there are various studies that have confirmed the spillovers from the U.S. monetary policy to the rest of the world, including emerging markets (e.g., Maćkowiak, 2007; Chen et al., 2014; Bowman et al., 2015; Tillmann, 2016; Anaya et al., 2017; Tillmann et al., 2019; Bräuning and Ivashina, 2020; among others). For instance, Chen et al. (2014) find that central banks in emerging economies reacts accordingly to monetary policy shocks from the U.S. Their reactions, however, vary, depending on several factors including the fundamentals of the recipient countries and the unconventional or conventional monetary policy in the U.S. Anaya et al. (2017) examine the impacts of unconventional monetary policy in the U.S. on several macro-economic indicators of emerging markets. They find that in response to an expansionary U.S. shock, both policy (e.g., short-term) interest rates and lending rates in emerging markets decrease. In addition, an expansionary U.S. shock leads to an appreciation of emerging currencies versus the U.S. dollar and higher economic growth in emerging markets. More recently, Bräuning and Ivashina (2020) reveal that U.S. easing monetary policy contributes to increasing the volume of loans from developed countries to emerging economies, hence, playing a significant role in the formation of credit cycles in emerging markets.

Our study extends the literature by investigating the inflation spillover effect between the U.S and EAGLES at both central and tails of inflation distribution. We also contribute to the literature of the U.S. macroeconomic factors' effects on emerging markets by scrutinizing the role of the U.S. in the inflation shock transmission with the emerging markets.

3. Methodologies

Our study examines the international spillover effect of inflation rates between the U.S. and EAGLE countries at both conditional mean and tails of inflation distribution. To explore the dynamic transmission of inflation shocks at the conditional mean, we employ the connectedness measures derived from the time-varying parameter vector autoregressive model (TVP-VAR). Antonakakis et al. (2020) develop the dynamic connectedness framework within the base model TVP-VAR which is introduced by Koop and Korobilis (2014). This approach is selected for its ability to avoid the subjectivity bias caused by window length selection as in traditional rolling-window VAR approach (Diebold and Yilmaz, 2012). The motivation for employing the TVP-VAR-based connectedness method stems from its distinct advantage for analyses of low-frequency datasets. Given the short sample nature of inflation data and the importance of preserving the temporal integrity of our dataset, the TVP-VAR's capacity to circumvent the loss of valuable observation makes it an ideal choice for our analysis. Previous studies have applied the TVP-VAR approach to explore dynamic relationship among macroeconomic variables with data available at low frequency (e.g., Del Negro and Otrok, 2008; Primiceri, 2005), supporting its efficiency and relevance for studies which involve the evolution of economic variables over times.

Then, we measure the spillover of extreme inflation shocks by applying the quantile-based connectedness framework of Ando et al. (2022). So, now we present our two econometric methodologies in subsection 3.1 and 3.2.

3.1. TVP-VAR connectedness

We consider a stationary TVP-VAR(p) of m assets with the optimal lag order p estimated by the Bayesian Information Criterion (BIC) as follows,

$$y_t = \sum_{j=1}^{p} \beta_{j,t} y_{t-j} + \varepsilon_t \quad \varepsilon_t | \mathrm{I}_{t-1} \sim N(0, \boldsymbol{\Sigma}_t) \tag{1}$$

where y_t is the $m \times 1$ vector of monthly inflation rates for m sample countries, and $\beta_{j,t}$ is the jth $m \times m$ time-varying autoregressive coefficient matrices, ε_t is the $m \times 1$ vector residual. We vectorize the time-varying coefficients as $\theta_t \equiv vec\left(\left[\beta_{1,t}, \ldots, \beta_{p,t}\right]'\right)$, with TVP-VAR coefficients evolving following the assumed law of motion which is a random walk as,

$$\theta_t = \theta_{t-1} + \nu_t \quad \nu_t | \mathrm{I}_{t-1} \sim N(0, \xi_t) \tag{2}$$

where the vector error terms $\varepsilon_t \sim N(0, \boldsymbol{\Sigma}_t)$ and $\nu_t \sim N(0, \xi_t)$ in Eq. (1) are not serial correlated; ε_t and ν_t are $m \times 1$ and $m^2 p \times 1$ dimensional vector; the time-varying variance-covariance matrices $\boldsymbol{\Sigma}_t$ and ξ_t are $m \times m$ and $m^2 p \times m^2 p$ dimensional matrices, respectively. I_{t-1} represents all available information at (t-1).

The algorithm for estimation of the time-varying parameters of the TVP-VAR model bases on Kalman filter estimation with forgetting factors following the spirit of Koop and Korobilis (2014). After estimating the time-varying parameters, to drive the connectedness indexes within the underlying TVP-VAR, we transform Eq. (1) into an infinite moving average representation based on the Wold representation theorem as follows,

$$y_t = \sum_{k=0}^{\infty} A_{kt} \varepsilon_{t-k} \tag{3}$$

where A_{kt} is determined as,

$$A_{kt} = \begin{cases} 0 \text{ for } k < 0; \\ I_m \text{ for } k = 0; \\ \beta_{1,t}A_{k-1,t} + \ldots + \beta_{p,t}A_{k-p,t} \text{ for } k > 0 \end{cases}$$

The time-varying coefficients A_{kt} of the vector moving average (VMA) and the time-varying variance-covariance matrices $\boldsymbol{\Sigma}_t$ are used to compute the generalized forecast error variance decomposition (GFEVD) (Koop et al., 1996; Pesaran and Shin, 1998). Then the dynamic connectedness measures of Diebold and Yilmaz (2012) are developed upon the GFEVD, detailed in Appendix A1.

3.2. The quantile connectedness

Our study also employs the quantile connectedness framework, developed by Ando et al. (2022) to measure the dynamic inflation spillover effects between the U.S. and the EAGLE emerging markets at the *upper* tail of the conditional distribution of inflation series. The results of upper quantile connectedness unveil the changes in spillover behavior during the extreme inflationary periods. This quantile-based connectedness framework estimates a VAR system at a given conditional quantile by quantile regression, and then derive the connectedness indices of Diebold and Yilmaz (2012) based on the underlying quantile VAR model.

Consider a VAR system of m assets with the optimal lag order p estimated using the Bayesian Information Criteria (BIC), the VAR model at τth conditional quantile can be estimated by equation-by-equation quantile regression as follows:

$$y_t = \mathscr{B}_{0(\tau)} + \sum_{\ell=1}^{p} \mathscr{B}_{\ell(\tau)} y_{t-\ell} + e_{t(\tau)} \tag{4}$$

where $\tau \in (0,1)$ is a given quantile index, y_t is the $m \times 1$ vector of inflation series for m sample countries, $\mathscr{B}_{0(\tau)}$ is the $m\times 1$ vector of intercepts and $e_{t(\tau)}$ is the $m \times 1$ vector residual at τth quantile. $\mathscr{B}_{\ell(\tau)}$ is the τth $m \times m$ autoregressive parameter matrix at τth quantile.

The single equation of (4) estimated by equation-by-equation quantile regression is specified as follows,

$$y_{jt} = \mathscr{B}_{j(\tau)}^{\top} z_t + e_{jt(\tau)} \tag{5}$$

where $j = 1, 2, \ldots, m$ and z_t represents $(mp+1) \times 1$ vector of all regressors including the intercept, $\mathscr{B}_{j(\tau)}$ is the estimated corresponding autoregressive coefficients at τth quantile. Assuming that the residuals adhere to the conditional quantile restriction $Q_\tau(e_{jt(\tau)}|z_t) = 0$, then following Koenker and Xiao (2006), the τth conditional quantile function of y_{jt} can be specified as,

$$Q_\tau\left(y_{jt}\middle|z_t\right) = \mathscr{B}_{j(\tau)}^{\top} z_t \tag{6}$$

Given a value of quantile τ, following the work of Koenker and Hallock (2001), the autoregressive coefficients $\mathscr{B}_{j(\tau)}$ can be estimated by solving the problem,

$$\min_{\mathscr{B}_{j(\tau)}} \sum_{t=1}^{T} \left(\tau - \boldsymbol{I}\left[y_{jt} \le \mathscr{B}_{j(\tau)}{}_{j(\tau)}^{\top} z_t\right]\right)\left(y_{jt} - \mathscr{B}_{j(\tau)}^{\top} z_t\right) \tag{7}$$

where $\boldsymbol{I}[\bullet]$ is the indicative function taking the value of 1 when $y_{jt} \le \mathscr{B}_{j(\tau)}^{\top} z_t$ and 0 otherwise, and T is number of observations in the sample.

To derive the connectedness indices of Diebold and Yilmaz (2012) within the quantile VAR framework, we re-write Eq. (4) as an infinite moving average representation as follows,

$$y_t = \mu_{(\tau)} + \sum_{k=1}^{\infty} A_{k(\tau)} e_{t-k(\tau)} \tag{8}$$

where $\mu(\tau)$ and $A_k(\tau)$ are determined as,

$$\mu_{(\tau)} = \left(I_m - \mathscr{B}_{1(\tau)} - \ldots - \mathscr{B}_{p(\tau)}\right)^{-1} \mathscr{B}_{0(\tau)}$$

$$A_{k(\tau)} = \begin{cases} 0 \text{ for } k < 0; \\ I_m \text{ for } k = 0; \\ \mathscr{B}_{1(\tau)}A_{k-1(\tau)} + \ldots + \mathscr{B}_{p(\tau)}A_{k-p(\tau)} \text{ for } k > 0 \end{cases}$$

We subsequently employ the information of Eq. (8) to derive the dynamic connectedness measures of Diebold and Yilmaz (2012). We present these detail steps in Appendix A2.

4. Data and preliminary analysis

4.1. Sample and data

Our data comprises of two parts. First, we collect the monthly headline consumer price index (CPI) from the World Bank database to proxy for the inflation in the U.S. and EAGLEs. This database is prepared by Ha et al. (2021) and provides a comprehensive set of inflation measures for up to 196 countries over the period of 1970–2022. Our sample data, however, ranges from 1991M1–2022M2 as most data for the selected emerging markets started in 1990. As the inflation data is monthly data, the number of observations in each country's inflation timeseries stands at only 375, which is relatively short compared to other studies on connectedness using daily data. The monthly inflation rate is then calculated as the log difference series of the CPI.

Our paper also uses a wide range of macro-economic variables, international trade data, and uncertainty measures to investigate their roles in driving the inflation spillover effects. The macro-economic variables and international trade data are gathered from the DataStream. Different uncertainty measures are collected from https://www.policyuncertainty.com/.

4.2. Descriptive analysis

Table 1 shows the summary statistics for the monthly inflation rates of the selected countries, highlighting positive average monthly inflation for all countries over the sample period. The number is particularly high for Russia (3.74%), Brazil (3.48%), and Turkey (2.35%) due to early 1990s hyperinflation in these countries. On the contrary, East Asian emerging countries (regions) including Taiwan, South Korea, and China have relatively lower inflation levels. The U.S. has an average monthly inflation rate of 0.20%, which is lower than most of the selected emerging markets. This is not surprising as high inflation rates are more common in emerging markets than in developed countries. Pertaining to the skewness, only the U.S. has a negative number, indicating that deflation is not uncommon in the U.S. Conversely, the positive skewness of all emerging countries suggests that sudden extreme positive inflation shocks are frequent in these countries. The leptokurtic distributions (i.e., kurtosis greater than 3) for most countries (except China and India) indicates the likelihood of extreme low and high inflation rates, underscoring the need to move beyond the mean-based connectedness framework and capture the spillover behaviour at tails of conditional distribution when modelling the inflation spillover effects.

The last three rows of Table 1 present the diagnostic tests of inflation series. First, the Jarque-Bera statistics significantly reject the null hypothesis of normal distribution for all countries. Second, the results of augmented Dickey-Fuller (ADF) tests are statistically significant and reject the null hypothesis of a presence of a unit root in inflation time series, indicating the stationarity in all cases. Finally, the Ljung-Box Q statistics up to 10 lags suggest that there is significant autocorrelation in all inflation series.

Fig. 4 illustrates the pairwise correlation matrix of the inflation series. There are two remarks standing out from here. First, most of the pairwise correlation coefficients (36/45) are positive, which indicates that inflation tends to co-move across the countries in the sample. It is observable that the highest positive correlation coefficient (0.58) belongs to the pair of two large oil-exporting countries, namely, Brazil (BRA) and Russia (RUS). On the contrary, the most negative correlation coefficient (−0.18) is given to the pair of China (CHN) and Indonesia (IDN). Second, the U.S. inflation rate is positively correlated with each of the selected emerging markets, except Indonesia (IDN) and Taiwan (TWN). However, these correlations are relatively low (below 0.12 for all cases). In particular, the inflation rate in the U.S. has the highest correlations with those of China (CHN) (0.12) and Turkey (TUR) (0.1).

5. Empirical results and discussion

We provide the comprehensive understanding of the inflation spillover between the U.S. and EAGLEs in five subsections. In subsection 5.1, we discuss the static inflation spillover results between sample countries at the conditional mean using TVP-VAR-based connectedness approach. Subsection 5.2 reports and discusses the dynamics of the mean-based inflation spillover. Subsection 5.3 examines the heterogeneous inflation spillover effects across countries based on their fundamental characteristics. Subsection 5.4 investigates the changes of inflation spillover behavior in extreme inflationary times by moving to the average connectedness at upper tails (i.e., upper quantile) of the inflation distributions. Lastly, subsection 5.5 analyses the drivers of the inflation spillover measures.

5.1. The average TVP-VAR-based inflation spillover results

We generate the 20-step-ahead generalized forecast error variance decomposition based on the estimated coefficients of the underlying TVP-VAR model as in Eq. (1A). Then, the GFEVD used to compute the connectedness indexes by Diebold and Yilmaz (2012) to measure the inflation spillover effect at the conditional mean between the selected countries, as reported in Table 2. As the results of the TVP-VAR-based connectedness approach are time-varying, each entry reported in the table is the average figure of the connectedness time series over the sample period between 1991M1 and 2022M2. There are several key findings standing out from the table. First, the total spillover index (TSI) of 18.83% implies that on average 18.83% of the forecast error variance of a country's inflation is explained by inflation shocks from all other countries, indicating a moderate level of interconnectedness. This figure is significantly lower than the inflation spillover in G-7 countries, which has been documented to be around 40–50% (e.g., see Istiak et al., 2021; Wen et al., 2021; Elsayed et al., 2021; Pham and Sala, 2022). Thus, the inflation spillover effects between the U.S. and emerging markets are less pronounced than those between developed markets. In other words, emerging markets seem to be quite resilient to external inflation shocks. The "*Spillover from others*" column provides more insights into the resilience of a specific country to external inflation shocks. Specifically, Brazil (9.98), India (12.22), and Taiwan (13.7) are least inflation affected by external shocks, implying these countries (regions)' inflation rates are mostly driven by their domestic factors, rather than impacted by other countries' inflation. On the flip side, Turkey (27.85%), China (25.57%), and the U.S. (25.39%) are most vulnerable to external inflation shocks.

Second, the "*Spillover to others*" row indicates that the South Korea (32.42%) along with China (25.83%), Turkey (25.19%), and the U.S. (25.04%) diffuses most inflation shocks to other countries. As shown in the "KOR" column, the U.S. (11.99%) and China (6.89%)

Table 1
Descriptive statistics.

	USA	BRA	CHN	IND	IDN	KOR	MEX	RUS	TUR	TWN
Mean	0.20	3.48	0.32	0.58	0.68	0.26	0.68	3.74	2.35	0.13
Variance	0.11	76.82	0.79	0.68	1.53	0.20	0.70	200.94	7.58	0.66
Skewness	−0.869	3.068	0.944	0.385	5.033	0.971	3.483	13.747	2.367	0.346
Kurtosis	4.909	8.619	2.036	2.261	34.708	3.290	20.700	226.369	9.649	2.041
JB	422[a]	1,744[a]	120[a]	88.8[a]	20,351[a]	227[a]	7,433[a]	810,316[a]	1,799[a]	72.3[a]
ADF	−138.3[a]	−13.04[a]	−204.2[a]	−167.7[a]	−108.8[a]	−172.3[a]	−40.0[a]	−167.2[a]	−84.3[a]	−435.1[a]
Q(10)	103[a]	1,515[a]	109[a]	72.1[a]	298[a]	76.1[a]	651[a]	83.4[a]	463[a]	22.3[a]

Notes: This table reports the descriptive statistics of monthly inflation of the U.S. and the selected emerging markets between 1991M1 and 2022M2, covering monthly observations. JB statistics indicates the Jarque-Bera test for the normality of sample data. ADF test represents the unit root test. Q (10) represents the Ljung-Box Q-statistics up to the 10th order autocorrelation.

[a] Denotes the cases where the null hypothesis of no autocorrelation (for LB Q test), and normal distribution (for JB test), and a presence of a unit root (for ADF test) is rejected at the 1% significance level.

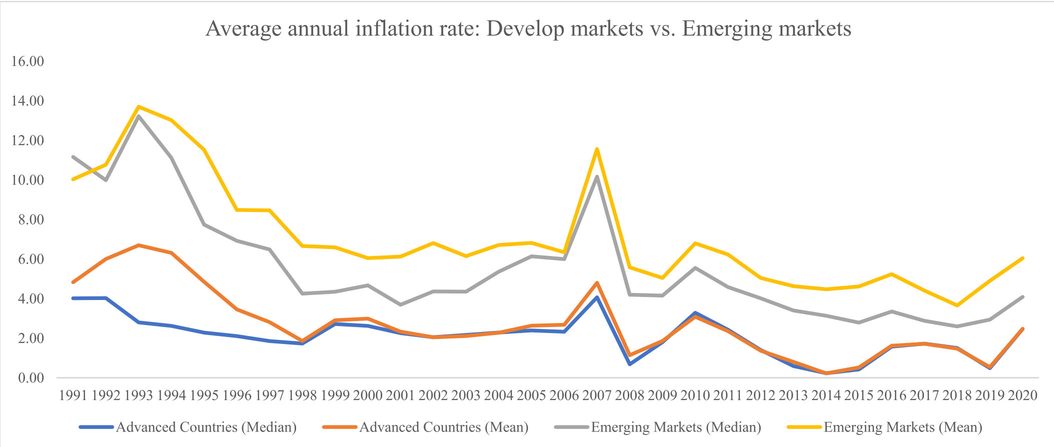

Fig. 1. Average annual inflation rates: Developed markets vs. Emerging markets.
Notes: This figure displays the movement of inflation rates across Developed markets and Emerging Markets between 1991M1 and 2022M2. The data is sourced from World Bank database, prepared by Ha et al. (2021).

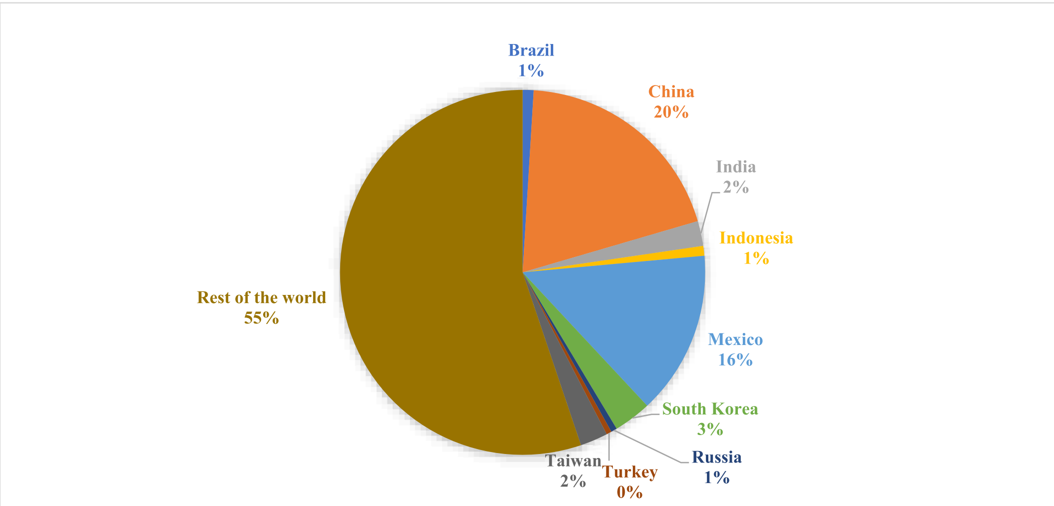

Fig. 2. Contributions of EAGLEs to the US imports in 2020.
Notes: This figure shows the contributions of the selected emerging markets to the total U.S. imports in 2020.

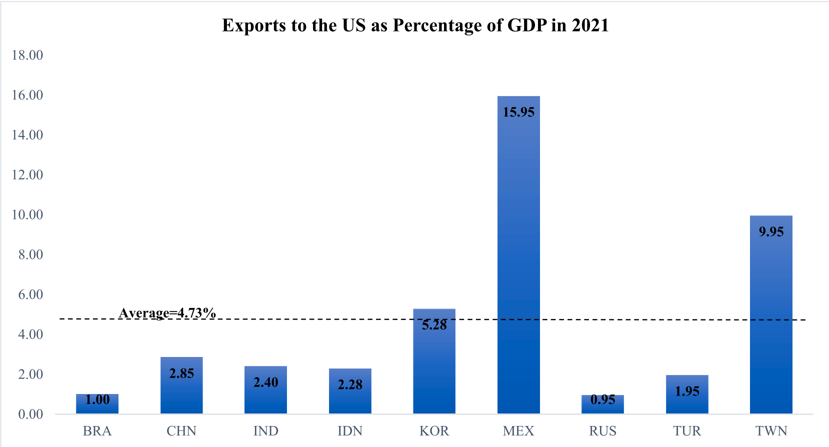

Fig. 3. Exports to the U.S. as percentage of emerging markets' GDP.
Notes: This figure shows the contribution of the exports to the U.S. as percentage of GDP of the selected emerging markets: Brazil (BRA), China (CHN), IND (India), Indonesia (IDN), South Korea (KOR), Mexico (MEX), Russia (RUS), Turkey (TUR), and Taiwan (TWN).

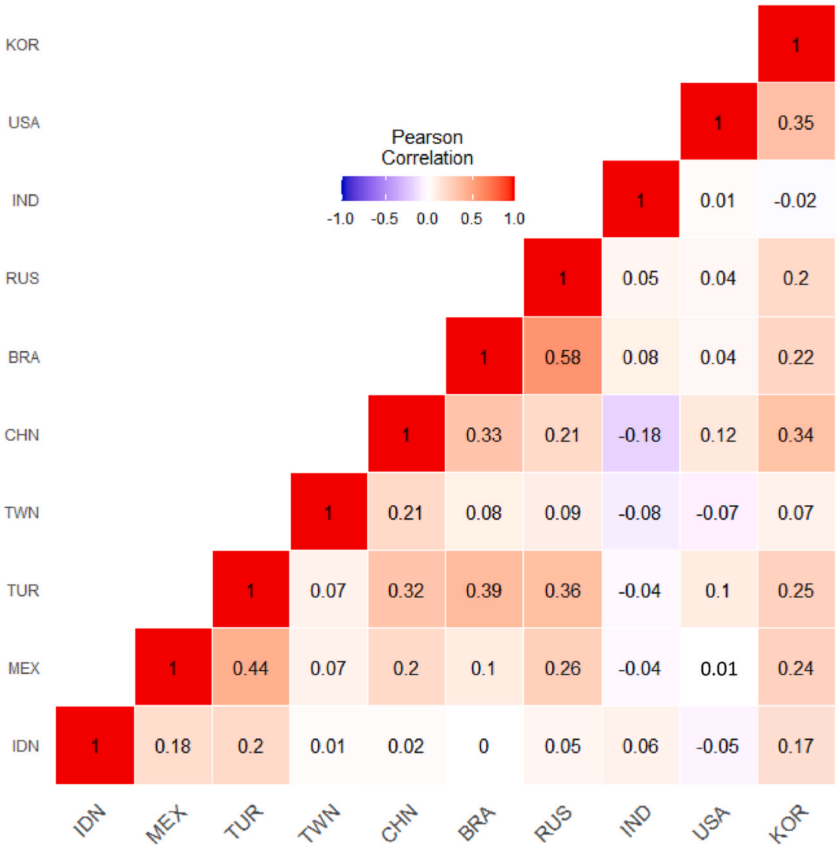

Fig. 4. Inflation correlation matrix between countries.
Notes: This figure shows the pairwise correlation coeffcients of the inflation series among the selected countries.

Table 2
Average TVP-VAR connectedness measures.

	USA	BRA	CHN	IND	IDN	KOR	MEX	RUS	TUR	TWN	*Spillover from others*
USA	74.62	0.07	3.71	5.34	0.37	11.99	0.65	0.32	0.7	2.25	25.39
BRA	0.28	90.02	2.27	0.12	0.02	0.92	0.53	2.29	3.26	0.28	9.98
CHN	3.14	2.28	74.43	4.12	0.49	6.89	2.45	0.19	3.3	2.7	25.57
IND	3.73	0.41	3.27	87.78	0.4	1.56	0.55	0.4	0.51	1.38	12.22
IDN	0.34	0.09	0.95	2.05	85.6	5.75	1.35	0.22	3.52	0.14	14.4
KOR	7.66	0.79	4.38	1.6	2.37	77.73	3.54	0.3	1.1	0.52	22.27
MEX	1.49	0.28	3	0.94	1.14	1.01	79.99	0.77	9.5	1.88	20.01
RUS	1.06	5.55	0.37	1.66	0.12	1.95	3.46	83.04	2.48	0.31	16.96
TUR	2.44	2.9	3.79	1.06	1.44	1.78	11.03	1.53	72.15	1.86	27.85
TWN	4.89	0.3	4.09	1.59	0.54	0.57	0.55	0.35	0.82	86.3	13.7
Spillover to others	25.04	12.67	25.83	18.49	6.9	32.42	24.1	6.37	25.19	11.32	
NSI	−0.35	2.69	0.26	6.27	−7.5	10.15	4.09	−10.59	−2.65	−2.38	
TSI	18.83										

Notes: Results are based on the TVP-VAR-based connectedness framework with lag length of order one (BIC) and a 20-step-ahead generalized forecast error variance decomposition.

are most receivers of shocks from the South Korea. In the "USA" column, it is observable that inflation shocks in the U.S. influence hardly the South Korea (7.66%) and Taiwan (4.89%) while their impacts on Brazil (0.28%) and Indonesia (0.34%) are negligible. The higher inflation spillover effects among the U.S., South Korea, and China can be explained by the fact that these countries are close trading partners. Particularly, the U.S. is the second largest trading partner of the South Korea in terms of both exports and imports.[9] On the other hand, China is the most significant importer from South Korea and the largest exporters to the U.S.[10]

Third, regarding the net spillover index (NSI), South Korea (10.15%), India (6.27%), and Mexico (4.09%) emerge as the primary net transmitters of inflation shocks with the high positive net spillover indexes. In the opposite direction, Russia (−10.59%) and Indonesia (−7.5%) are the largest net receivers of the inflation shocks. Interestingly, we find that the U.S. predominantly acts as a net receiver of inflation shocks from the EAGLEs during the sample period, with its net spillover index being marginally negative at −0.35%. This underscores the influence of the "*consumption channel*" over the "*monetary policy channel*" in shaping the role of the U.S. as the net inflation importer from emerging markets.

To gain more insights into the role of the U.S. in this network inflation connectedness, we report the net pairwise directional spillover index (NPDS) of the U.S. with each emerging country in Table 3. The NDPS of the U.S. with an emerging country is calculated as specified in Eq. (7A). While in general the U.S. is the importer of inflation shocks from the sample emerging markets as a group, the NPDS of the U.S. in Column (3) of Table 3 indicate that the role of the U.S. varies across emerging countries. Specifically, the U.S. mainly receives inflation shocks from South Korea (KOR), India (IND), China (CHN), and Indonesia (IDN) while transmitting shocks to others. Among the net inflation shock diffusers to the U.S., South Korea (KOR) emerges as the most important one as shown by the NPDS of the U.S. with the South Korea ($NPDS_{KOR,USA}$) of −4.33%. The South Korea's inflation shocks contribute 11.99% to the inflation innovations in the U.S. while it receives 7.66% in return. Besides South Korea, India (IDN) and China (CHN) are other important net shock transmitters to the U.S. with the $NPDS_{IDN,USA}$ and $NPDS_{CHN,USA}$ of −1.61% and −0.57%, respectively. The significant roles of these countries in transmitting inflations shocks to the U.S. might be explained by the "*consumption channel*", given the fact that China, India, and South Korea are consistently among the top 15 largest exporting countries[11] to the U.S. and the U.S. usually has trading deficit with these countries.[12] On the opposite direction, Taiwan (TWN), Turkey (TUR), and Mexico (MXN) are the three largest net receivers of inflation spillover from the U.S. with the $NPDS_{TWN,USA}$, $NPDS_{TUR,USA}$, $NPDS_{MXN,USA}$ of 2.64%, 1.74%, and 0.84%, respectively. The strong transmission of inflation shocks from the U.S. to Taiwan and Mexico is understandable because these countries (regions)' GDP are highly dependent on their exporting activities to the U.S.,[13] leading the impact of the U.S. monetary policy more pronounced in these countries. This explanation is supported by several studies that examine the impact of the U.S. monetary policy on emerging markets. For instance, Bowman et al. (2015) reveal that a monetary policy shock that lowers the U.S. 10-year yields by 25 bps could reduce Mexican bond yields up to 30 bps. Chadwick (2019) empirically finds that monetary easing in the U.S. causes the local currency of Taiwan to be depreciated. Moreover, in case of Turkey, since the country's economy is highly dollarized, its macroeconomic variables are substantially vulnerable to outside shocks, including inflation shocks from the U.S. (e.g., Arellano and Heathcote, 2010; Metin-Özcan and Us, 2007; Pınar Ardıç and Selçuk, 2006; Sui et al., 2021).

[9] See, e.g., https://wits.worldbank.org/CountrySnapshot/en/KOR.
[10] See, https://wits.worldbank.org/countrysnapshot/en/CHN.
[11] Source: https://wits.worldbank.org/CountryProfile/en/Country/USA/Year/2020/TradeFlow/EXPIMP.
[12] In every year between 1991 and 2021, China and India consistently have had trading surplus with the U.S. (Source: https://www.census.gov/foreign-trade/balance/c5700.html#1991 and https://www.census.gov/foreign-trade/balance/c5330.html). South Korea has had trading surplus with the U.S. in all years since 1991, except three years (1995, 1996, and 1997) (Source: https://www.census.gov/foreign-trade/balance/c5800.html).
[13] Exports to the U.S. account for 9.95% and 15.95% of Taiwan's and Mexico's GDP in 2021, respectively. See, Fig. 3.

Table 3
Net pairwise directional spillover index (NPDS) of the U.S. with each emerging market.

j	Spillover effect from the US to the emerging market j ($\widetilde{\phi}^{g}_{j,USA,t}$)	Spillover effect from the emerging market j to the US ($\widetilde{\phi}^{g}_{USA,j,t}$)	Net pairwise inflation spillover index of the U.S. ($NPDS_{j,USA}$)
	(1)	(2)	(3)=(1)–(2)
BRA	0.28	0.07	0.21
CHN	3.14	3.71	−0.57
IND	3.73	5.34	−1.61
IDN	0.34	0.37	−0.03
KOR	7.66	11.99	−4.33
MEX	1.49	0.65	0.84
RUS	1.06	0.32	0.74
TUR	2.44	0.7	1.74
TWN	4.89	2.25	2.64
Total	25.04	25.39	−0.35

Notes: Results are based on the TVP-VAR-based connectedness framework with lag length of order one (BIC) and a 20-step-ahead generalized forecast error variance decomposition. NPDS is calculated as in Eq. (7A).

5.2. The time-varying TVP-VAR-based inflation spillover results

Given that the inflation spillover effects should be different at some points of time, this subsection explores the time-varying spillover effect measured at the conditional mean of inflation distributions. Fig. 5 presents an overall increase in total spillover index (TSI) from around 17% in 1991 to more than 23% in 2020, suggesting growing economic interdependence, likely due to expanded global trade[14] as well as the amplification of common global factors (Bean, 2006; Borio and Filardo, 2007). Notably, the spillovers intensify during periods of economic turmoil, including the Mexican crisis (1994–1995), the Asian Financial Crisis (1997–1998), the Global Financial Crisis (2008–2009), and the early of the COVID-19 pandemic (early 2020).

Considering the changing role of the U.S. in the dynamic network inflation spillovers, we plot the "*Spillover to others*", "*Spillover from others*", and the "Net Spillover Index" of the U.S. over the sample period in Fig. 6. The blue line indicates the "*Spillover to others*" of the U.S., implying the spillovers from the U.S. to all emerging markets ($DSI_{US\rightarrow EME}$). The orange line denotes the "*Spillover from others*" of the U.S., displaying the spillovers from all emerging markets to the U.S. ($DSI_{EME\rightarrow US}$). The grey line shows the "Net Spillover Index" of the U.S. The blue and orange lines show an increasing trend of the US's role in both transmitting to and receiving from emerging markets, indicating increased inflation interdependence. Despite generally receiving inflation shocks, the Global Financial Crisis (2008–2009) saw the U.S. role switched between net receiver and net transmitter of inflation shocks, as shown by grey line.

To uncover the bilateral spillover effects, we further plot the net pairwise directional spillover index (NPDS) of the U.S. with each emerging country in Fig. 7. Similar to the net spillover index, a reading above (below) 0 of the net pairwise spillover index of the U.S. indicates the country is the net transmitter (receiver) of shocks to (from) the emerging market. First, during most sample period, the U. S. is the net transmitter of inflation shocks to Brazil, Russia, Turkey, and Taiwan, while primarily receiving shocks from South Korea. Second, the increasing trend of the NPDS of the U.S. suggests that Brazil, Mexico, and Russia are more and more vulnerable to inflation shocks from the U.S. while the reverse finding applies for Taiwan. The NPDS index between the U.S. and South Korea became more negative over time, implying the increasing influence of the Asian country's inflation on the U.S.

5.3. Do emerging country's characteristics matter?

This subsection explores whether fundamental characteristics of emerging markets, such as the country's exposure to international trade, the oil-exporting/importing status, and the exchange rate regime, influence inflation spillover effects between the U.S. and emerging markets.

First, international trade creates direct channels for inflation transmission (Tootell, 1998). As such, we expect inflation spillover tends to be more pronounced in emerging countries with significant international trade.

Second, as oil is the global most important commodity, various studies find evidence that a change in oil prices is the key determinant of inflation rates and contributes to the inflation synchronization across countries (e.g., Barsky and Kilian, 2004; Jacquinot et al., 2009; Gómez-Loscos et al., 2011; Elsayed et al., 2021; Wen et al., 2021; among others). More importantly, the inflation of both oil-exporting and oil-importing countries is positively affected by oil prices (e.g., Filis and Chatziantoniou, 2014). On the one hand, it is apparent that oil price increases could cause cost-push inflation in oil-importing markets. On the other hand, oil price increases could lead to demand-side inflationary pressures in oil-exporting countries as their governments tend to increase spending thanks to higher oil-related revenues. As the cause of inflation is diverse, Filis and Chatziantoniou (2014) further show that the positive effect of oil price increases on inflation endures longer in oil-importing countries than in oil-exporting countries. Based on these discussions and given the fact the U.S. is a net oil-importing country, we expect that the inflation spillover between the U.S. and oil-importing countries should be greater than that between the U.S. and oil-exporting countries.

[14] Please see, e.g., https://data.worldbank.org/indicator/NE.TRD.GNFS.ZS.

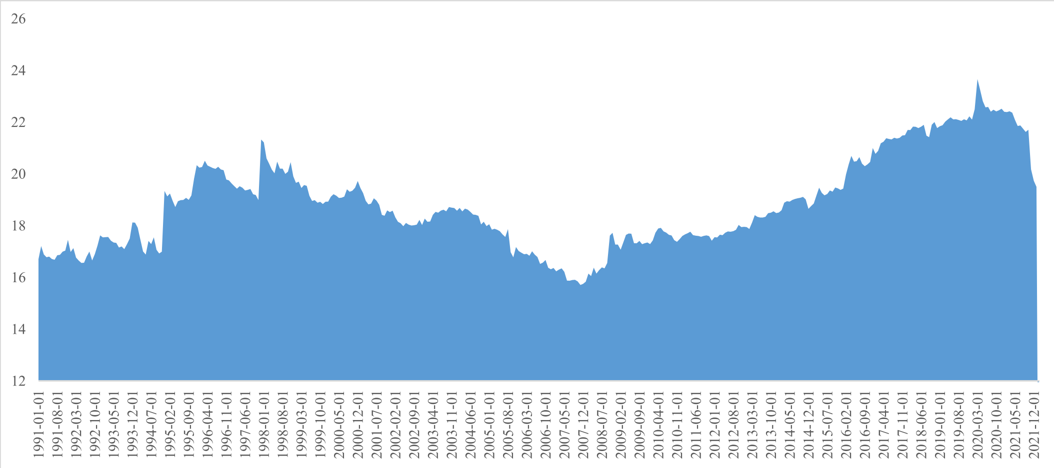

Fig. 5. TVP-VAR dynamic total spillover index.
Notes: Results are based on a TVP-VAR-based connectedness framework with lag length of order one (BIC) and a 20-step-ahead generalized forecast error variance decomposition.

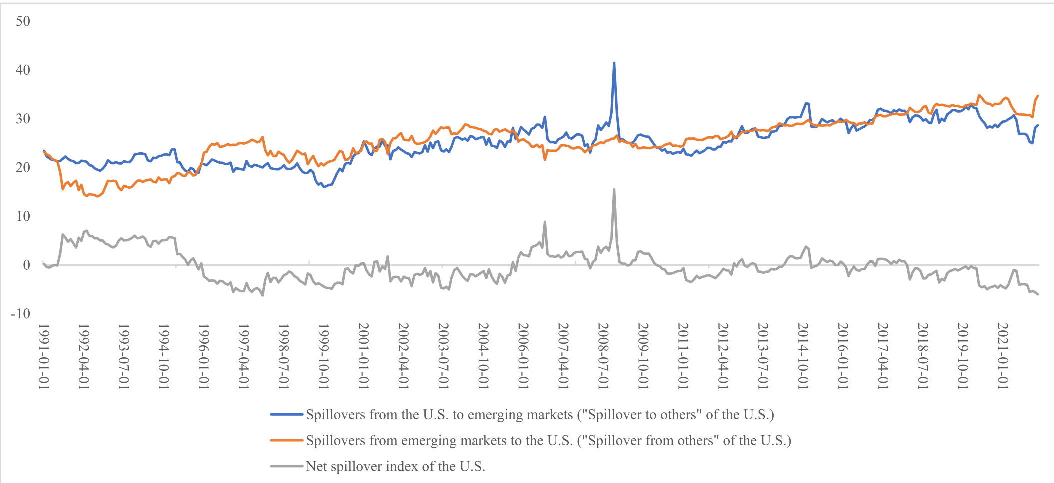

Fig. 6. Inflation spillover measures of the U.S.
Notes: Results are based on the TVP-VAR-based connectedness framework with lag length of order one (BIC) and a 20-step-ahead generalized forecast error variance decomposition.

Third, exchange rate regime is also an important determinant of how a country's central bank reacts to inflation shocks and controls inflation (e.g., Bleaney, 2000). Countries with free-floating exchange rate regimes may experience more pronounced inflation spillover effects due to less stringent monetary policies compared to those with fixed or managed regimes (e.g., Bleaney and Francisco, 2007; Giannellis and Koukouritakis, 2013; Husain et al., 2005). Moreover, inflation shocks under floating regimes usually take longer time to die out, which causes inflation to last longer – a phenomenon known as persistent inflation (e.g., Alogoskoufis and Smith, 1991; Dornbusch, 1982; Obstfeld and Rogoff, 1995). In light of these evidence, we conjecture that inflation spillover effects are more pronounced between the U.S. and emerging markets that follow ultimately free-floating exchange rate regimes.

To examine the impacts of these country-specific characteristics on the inflation spillover, we classify the nine emerging markets into two groups based on their exposure to international trade, oil-exporting (importing) status, and exchange rate regime, respectively. First, using the Openness Index in 2018 as proxy for a country's exposure to international trade, we group the emerging countries (regions) into two groups of low openness (including Brazil, China, India, Indonesia, and Russia) and high openness (Korea, Mexico, Turkey, and Taiwan). Second, based on the net oil-importing (exporting) character, the emerging markets are divided into net oil-exporting countries (Brazil, Russia, and Mexico) and net oil-importing economies (China, India, Indonesia, South Korea, Turkey,

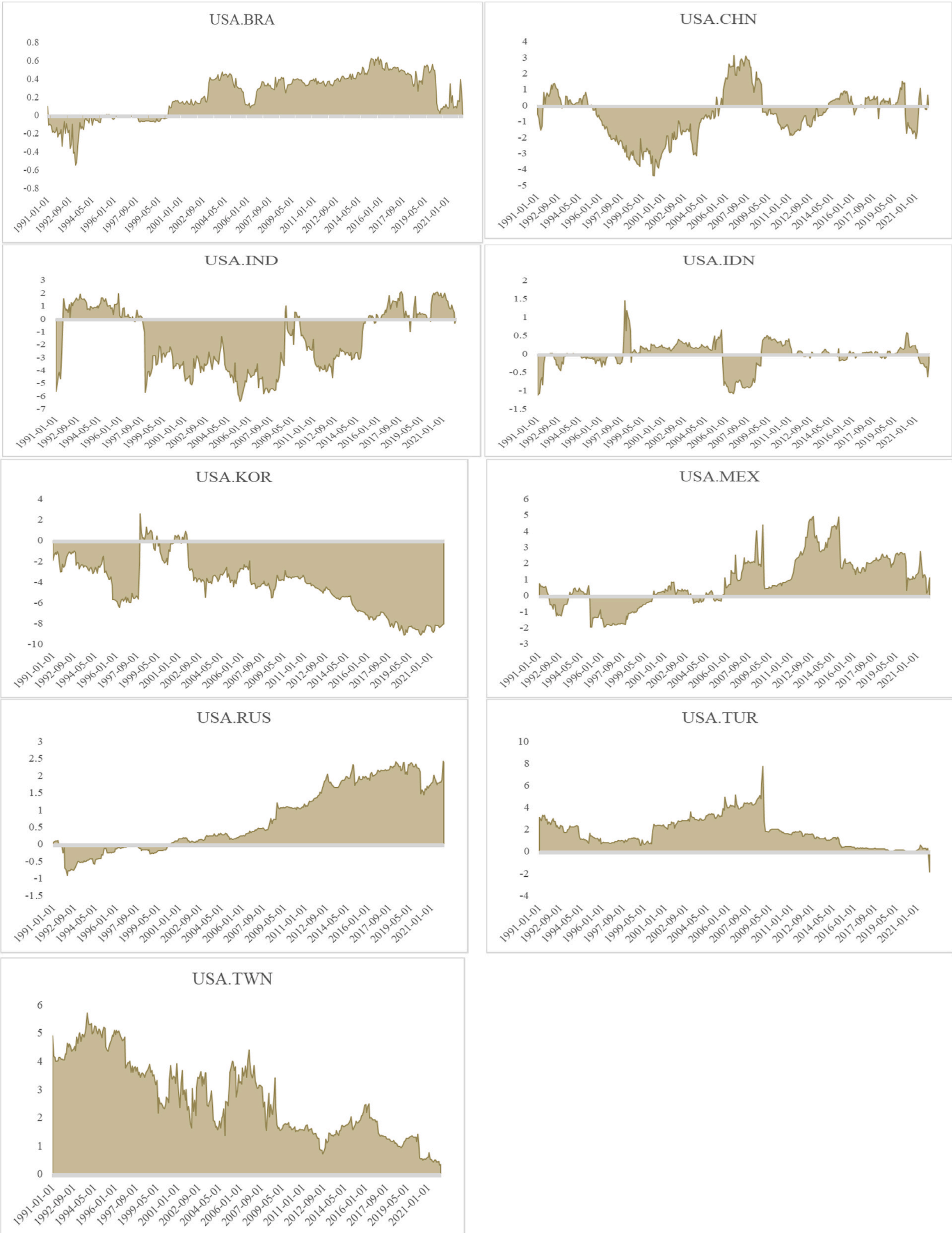

Fig. 7. Time-varying net pairwise directional spillover (NPDS) of the U.S. with each emerging country.
Notes: Results are based on the TVP-VAR-based connectedness framework with lag length of order one (BIC) and a 20-step-ahead generalized forecast error variance decomposition.

and Taiwan). Finally, based on the latest report on exchange rate regime classification from International Monetary Fund (2022),[15] the markets classified as fixed peg or managed floating regimes in the report are divided into low floating regimes (Russia, China, India, and Taiwan), while the currencies defined as floating or free-floating exchange rates are considered high floating systems (South Korea, Brazil, Indonesia, Mexico, and Turkey). The detailed characteristics of each country are provided in Table A3 of Appendix A3.[16]

In order to examine how the inflation spillover effects between the U.S. and emerging market differ depending on the characteristics of emerging markets, we employ the block connectedness technique proposed by Greenwood-Nimmo, Nguyen, & Rafferty (2016) to decompose the total spillover effects among the sample countries in Table 2 into block aggregations of connectedness as reported in Table 4.[17] Panel A Table 4 reports two block aggregations of connectedness: (1) the U.S. and the group of low openness countries; and (2) the U.S. and the group of high openness countries. Each entry in the panel shows the portion of inflation spillover from the column variable to the row variable as percentages of the total inflation spillover effects of the system. High trade openness economies have greater inflation interconnectedness with the U.S. than the other group. In particular, the directional inflation spillover from "High openness" countries to the U.S. stands at 1.559%, whereas, the figure of "Low openness" group is just 0.981%. In a similar vein, directional inflation spillover from the U.S. to "High openness" group is 1.648%, which is nearly twice the number from the U.S. to "Low openness" markets. These figures align with our conjecture that countries, which are exposed more to international trade would have more inflation interdependence with the U.S.

In Table 4 Panel B, two groups of interest are oil-exporting and oil-importing countries. The figures suggest that the inflation interdependence between the U.S. and oil-importing group are much stronger than the inflation transmission between the U.S. and oil-exporting markets. Specifically, the directional spillover index from oil-exporting countries to the U.S. is 0.104%, which is substantially lower than the spillover index from oil-importing group to the U.S. (2.436%). Similarly, oil-exporting economies seem to be more resilient to inflation shocks from the U.S. than oil-importing countries, as evidenced by the directional spillover index from the U.S. to these two groups of 0.283 % and 2.22%, respectively. This finding supports our above prediction.

Finally, in Table 4 Panel C, we consider the role of foreign exchange regime. We find that compared to countries with low floating exchange regime, countries with high floating exchange regime exhibit stronger inflation interconnectedness with the U.S. In details, "Low floating" group both receives and transmits lower portions of inflation shocks from and to the U.S. than "High floating" group. The directional spillover index of "Low floating" group to and from the U.S. are 0.974% and 0.827%, respectively, whereas these figures for "High floating" group are 1.566% and 1.676%, correspondingly. This evidence highlights the role of foreign exchange regime in determining the inflation spillover effects. As emerging markets following managed floating or pegged exchange rate regime are more concerned with inflation and tend to control inflation more closely, their inflation rates are less interrelated with outside inflation shocks from the U.S.

5.4. *Inflation spillover effects during highly inflationary environment (The quantile-based inflation connectedness results)*

This section examines whether the international inflation spillover is more pronounced during the period of high inflationary pressures (e.g., hyperinflation) by using the quantile connectedness,[18] proposed by Ando et al. (2022). Our findings illustrate the inflation spillover effects at the upper tails of the conditional distributions, where the inflation rates are at extremely positive levels.

Table 5 Panel A, B, C, and D present the results of quantile connectedness estimated for four upper quantiles, which are 80%, 85%, 90%, and 95%, respectively. There are three striking findings from here. First, the total spillover index (TSI) markedly increases as the quantile moves further to upper tails, from 47.18% at quantile of 80%–77.15% at quantile of 95%, indicating that inflation shock transmission significantly intensifies during periods of extreme inflation, far exceeding the average TSI of 18.83% at the conditional mean of distributions. Second, consistently across quantiles, the U.S. remains a net importer of inflation shocks, as shown by the consistent negative "Net Spillover Index" of the U.S. in all cases. This lend further supports for the predominance of the *"consumption channel"* in shaping the inflation interdependence between the world's largest economy and emerging countries. Third, under extremely positive inflation environment, some emerging markets turn from net receiver to net transmitter of shocks and vice versa. Specifically, countries (regions) such as Taiwan and Turkey, switch from net shock receivers in normal condition (Table 2), to net shock transmitters in the extreme inflationary conditions (all panels in Table 5). Meanwhile, India shifts from a net shock transmitter to a receiver. Finally, China, South Korea, and Mexico consistently act as net transmitters of inflation shocks in the system while Russia's role maintains its role as net receiver.

5.5. *Drivers of the time-varying inflation spillover effects*

Our previous results in subsection 5.2 show that the inflation spillover between the U.S. and emerging countries exhibits significant variations and highly volatile behaviour, underscoring the importance of investigation of the key drivers of these fluctuations. The comprehensive understanding of the drivers of inflation transmission is of great importance to investors and policymakers when

[15] See, International Monetary Fund. 2022. Annual Report on Exchange Arrangements and Exchange Restrictions 2021.

[16] Note, the countries that have undergone complex changes in their exchange rate policies during our research period are classified based on their exchange rate regimes for the majority of the sample time.

[17] To conserve space, we detail the steps to construct the block connectedness in Appendix A4.

[18] To be consistent with the TVP-VAR connectedness framework's results in subsection 5.1, we employ a 20-step forecast head ($h = 20$) and lag order of 1 ($p = 1$) in the quantile VAR model.

Table 4
The importance of emerging market's specific characteristics.

Panel A. Low-openness vs. high-openness			
	USA	Low openness	High openness
USA	7.462	0.981	1.559
Low openness	0.855	44.814	4.329
High openness	1.648	3.316	35.033
Panel B. Oil-exporting vs. oil-importing			
	USA	Oil-exporting	Oil-importing
USA	7.462	0.104	2.436
Oil-exporting	0.283	26.593	3.123
Oil-importing	2.22	2.923	54.853
Panel C. Foreign exchange regime (Low floating vs. high floating)			
	USA	Low floating	High floating
USA	7.462	0.974	1.566
Low floating	0.827	34.509	4.663
High floating	1.676	3.359	44.961

Notes: Results are initially based on the TVP-VAR-based connectedness framework with lag length of order one (BIC) and a 20-step-ahead generalized forecast error variance decomposition. Then, the block connectedness framework of Greenwood-Nimmo et al. (2016) is applied to compute the inflation spillover measures between groups.

considering their portfolio allocation and forecasting inflation to propose efficient and timely macroeconomic policies. We examine the determinants of the inflation spillover effects between the U.S. and emerging markets by estimating the following models,

$$DSI_{US\rightarrow EME,t} = \beta_0 + \beta_1 USMPU_t + \beta_2 USTPU_t + \beta_3 DXY_t + \beta_4 VIX_t + \beta_5 FFR_t + \beta_6 WTI_t + \beta_7 OVX_t + \beta_8 EMEPU_t + \beta_9 US\_EXP_t + \varepsilon_t \tag{15}$$

and

$$DSI_{EME\rightarrow US,t} = \gamma_0 + \gamma_1 USMPU_t + \gamma_2 USTPU_t + \gamma_3 DXY_t + \gamma_4 VIX_t + \gamma_5 FFR_t + \gamma_6 WTI_t + \gamma_7 OVX_t + \gamma_8 EMEPU_t + \gamma_9 US\_IMP_t + \epsilon_t \tag{16}$$

where $DSI_{US\rightarrow EME}$ *and* $DSI_{EME\rightarrow US}$ denote the directional spillover index from the U.S. to emerging markets, and the directional spillover index from emerging markets to the U.S., respectively; β_0 and γ_0 are intercepts; $\beta_i, \gamma_i | i = 1, \ldots, 9$ are the sets of estimated coefficients; ε_t is the residual term.

There are nine selected explanatory variables including: (1) *USMPU* is the natural logarithm of the monetary policy uncertainty index in the U.S. introduced by Husted et al. (2020); (2) *USTPU* is the natural logarithm of the U.S. trade policy uncertainty index from Baker et al. (2016); (3) *DXY* is natural logarithm of the U.S. dollar index; (4) *VIX* is the CBOE implied volatility index of the S&P 500 index; (5) *FFR* is the Fed's fund rate; (6) *WTI* is the natural logarithm of WTI crude oil spot price; (7) *OVX* is the volatility of WTI crude oil measured by its standard deviation of returns during one month; (8) *EMEPU* is the average economic policy uncertainty index of six emerging markets in the sample[19]; (9) *US_EXP* is the natural logarithm of the U.S. exports (in USD billion) to the emerging markets used as a regressor in Eq. (15) while *US_IMP* is the natural logarithm of the U.S. imports (in USD billion) from the emerging markets included as an explanatory variable in Eq. (16).

The first seven explanatory variables in Eqs. (15) and (16) reflect several factors that possibly affect the inflation shock transmission between the U.S. and emerging markets. First, we include four important variables to account for the change in macro-economic conditions in the U.S. including *USMPU*, *USTPU*, *DXY*, and *FFR*. The U.S. monetary policy uncertainty (*USMPU*) and trade policy uncertainty (*USTPU*) represent key policy uncertainties in the U.S, encompassing the risks of changes in monetary and trade policies of the U.S.,[20] which are well regarded as important drivers of inflation integration between the U.S. and other countries. Policy uncertainties are documented to be an important driver of inflation (Balcilar et al., 2017; Istrefi and Piloiu, 2014). For instance, Istrefi and Piloiu (2014) find that both long- and short-term inflation expectations are vulnerable to policy-related uncertainty shocks. In addition, the US dollar index (*DXY*) is included in the equations as it also matters to the U.S. inflation and trade balance. According to Cecchetti et al. (2000), the U.S. dollar index can be used to predict the U.S. inflation rates, however, its credibility might vary depending on certain macroeconomic conditions. Concerning to the impact of the U.S. dollar index on the U.S. trade balance, various studies such as Cushman (1987), Yousefi and Wirjanto (2003), and Hunt and Rebucci (2005) indicate the U.S. dollar appreciation

[19] These countries are Brazil, China, India, South Korea, Russia, and Mexico. The data on the economic policy uncertainty index is unavailable for Turkey, Taiwan, and Indonesia.

[20] The construction of the U.S. economic policy uncertainty index includes the uncertainty relating to trade policies as a component. See, Baker et al. (2016).

Table 5
Spillover inflation effects across various upper quantiles.

Panel A. At quantile = 80%

	USA	BRA	CHN	IND	IDN	KOR	MEX	RUS	TUR	TWN	*Spillover from others*
USA	45.96	1.18	7.78	8.59	3.14	16.08	6.2	0.14	5.27	5.67	54.04
BRA	1.55	77.14	6.79	2.58	0.57	1.47	2.02	1.1	3.74	3.03	22.86
CHN	5.43	7.9	34.1	5.02	4.61	13.1	9.44	1.2	10.32	8.89	65.9
IND	10.28	1.95	4.02	53.73	6.8	7.99	5.23	0.63	3.61	5.75	46.27
IDN	2.75	0.57	3.53	4.66	54.59	7.06	9.2	0.3	13.23	4.12	45.41
KOR	12.12	1.21	12.52	5.18	8.64	40.21	9.67	0.04	4.53	5.88	59.79
MEX	4.44	0.66	9.46	3.14	5.99	6.81	45.38	2.26	14.58	7.27	54.62
RUS	0.19	6.46	1.32	0.53	0.83	0.31	1.99	84.42	3.32	0.61	15.58
TUR	3.66	6.04	12.6	3.77	4.39	7.43	14.24	0.4	39.89	7.58	60.11
TWN	6.32	2.08	11.18	4.91	4.04	7.21	5.2	0.14	6.15	52.77	47.23
Spillover to others	46.75	28.06	69.2	38.37	39	67.46	63.19	6.21	64.76	48.8	
NSI	−7.3	5.2	3.3	−7.9	−6.4	7.66	8.57	−9.36	4.65	1.57	
TSI	47.18										

Panel B. At quantile = 85%

	USA	BRA	CHN	IND	IDN	KOR	MEX	RUS	TUR	TWN	*Spillover from others*
USA	37.27	2.03	8.33	10.16	4.77	16.14	7.6	0.31	5.65	7.74	62.73
BRA	2.35	65.02	10.51	3.87	1.24	2.39	2.89	0.45	6.06	5.22	34.98
CHN	5.77	8.26	26.47	7.03	5.17	12	10.27	1.89	13.14	10	73.53
IND	10.9	2.26	5.75	44.43	8.2	9.22	6.4	0.7	4.66	7.49	55.57
IDN	4.73	0.99	6.21	6.11	42.63	10.47	11.12	0.42	11.78	5.55	57.37
KOR	12.81	1.48	12.32	7.48	8.8	33.55	10.03	0.11	6.09	7.34	66.45
MEX	6.02	1.14	11.61	5.97	6.92	9.49	33.66	1.66	14.6	8.92	66.34
RUS	0.62	5.4	2.17	1.2	2.14	0.97	2.86	78.66	3.87	2.11	21.34
TUR	5.06	5.17	14.05	6.09	5.03	8.32	15.22	0.44	31.51	9.1	68.49
TWN	8.46	2.97	12.44	6.83	4.89	8.75	6.28	0.75	6.91	41.72	58.28
Spillover to others	56.71	29.72	83.38	54.73	47.16	77.74	72.67	6.74	72.76	63.47	
NSI	−6.01	−5.26	9.85	−0.84	−10.21	11.29	6.33	−14.61	4.27	5.19	
TSI	56.51										

Panel C. At quantile = 90%

	USA	BRA	CHN	IND	IDN	KOR	MEX	RUS	TUR	TWN	*Spillover from others*
USA	28.07	1.68	8.81	11.23	8.19	15.12	10.08	0.43	7.52	8.87	71.93
BRA	4.42	50.67	10.85	6.16	3.32	4.33	5.37	0.36	8.41	6.1	49.33
CHN	7.68	6.48	20.05	6.84	8.62	12.44	11.76	0.22	16.04	9.87	79.95
IND	10.88	2.48	6.22	34.38	10.16	9.6	9.71	1	6.44	9.14	65.62
IDN	7.33	1.25	8.27	9.24	24.26	12.58	14.53	0.38	14.31	7.85	75.74
KOR	11.43	2.11	12.63	7.41	8.97	24.39	11.68	3.07	9.59	8.73	75.61
MEX	5.83	1.03	7.88	7.44	10.36	9.93	25.18	11.23	12.77	8.34	74.82
RUS	2.56	4.49	5.07	5.08	6.55	5.13	9.46	50.05	6.76	4.87	49.95
TUR	6.52	3.64	13.06	5.47	9.78	11.09	15.39	0.51	25.29	9.25	74.71
TWN	9.99	2.62	10.46	8.71	7.79	10.22	9.92	1.95	8.37	29.97	70.03
Spillover to others	66.63	25.77	83.25	67.58	73.73	90.44	97.91	19.15	90.22	73.02	
NSI	−5.3	−23.56	3.29	1.96	−2.02	14.83	23.08	−30.8	15.51	2.99	
TSI	68.77										

Panel D. At quantile = 95%

	USA	BRA	CHN	IND	IDN	KOR	MEX	RUS	TUR	TWN	*Spillover from others*
USA	16.1	2.86	9.59	11.69	11.86	12.08	13.29	1.71	11.81	9.01	83.9
BRA	4.7	36.87	12.31	6.36	4.01	5.69	6.63	3.47	11.35	8.6	63.13
CHN	6.25	7.07	15.54	8.13	8.19	10.44	12.38	5.77	14.96	11.27	84.46
IND	9.87	3.25	8.17	25.17	12.05	9.28	9.49	6.4	6.07	10.25	74.83
IDN	7.99	1.38	8.68	8.44	23.92	12.71	14.32	0.26	15.27	7.01	76.08
KOR	10.24	3.61	13.14	8.23	9.44	19.35	11.23	3.95	11.01	9.81	80.65
MEX	6.61	1.39	10.06	5.48	8.75	9.69	25	2.7	20.66	9.68	75
RUS	4.3	10.53	12.04	7.69	7.35	6.82	9.45	19.62	10.82	11.37	80.38
TUR	6.2	3.57	12.65	3.05	8.35	11.42	18.66	0.36	27.99	7.76	72.01
TWN	6.83	5.65	12.47	8.44	7.57	8.95	10.39	10.84	9.94	18.91	81.09
Spillover to others	62.99	39.31	99.11	67.54	77.56	87.07	105.84	35.48	111.88	84.75	
NSI	−20.91	−23.82	14.65	−7.29	1.49	6.42	30.83	−44.9	39.87	3.67	
TSI	77.15										

Notes: Results are based on the quantile VAR-based connectedness approach with lag length of order one (BIC) and a 20-step-ahead generalized forecast error variance decomposition.

deteriorates the U.S. trade balance and vice versa.[21] Besides these roles, the U.S. dollar is also considered a safe haven for emerging stock markets (Wen and Cheng, 2018) and a high level of the U.S. dollar might intensify the spillover effects across financial markets (Batten et al., 2019; Bouri et al., 2021; Saeed et al., 2021). The last U.S. variable included in these equations is the Fed's fund rate (*FFR*), which accounts for the short-term interest rates and the Fed's monetary policy stance. Because the U.S. monetary policy can spillover to emerging markets (e.g., Maćkowiak, 2007; Chen et al., 2014; Bowman et al., 2015; Anaya et al., 2017; Bräuning and Ivashina, 2020; among others), inflationary pressures caused by loosening monetary policy in the U.S. can transmit to the emerging markets as well.

In addition to the five U.S. market indicators, we include the WTI crude oil price (*WTI*) and the oil volatility index (*OVX*) to proxy for the general price level and uncertainty in global commodity markets. A high level of global commodity prices might be an explanation for global inflation integration as it directly affects the aggregate supply by raising production costs (e.g., inflation triggered from supply side). Further, as the world's most crucial commodity, numerous studies have shown that oil prices affected inflation rates in both developed and emerging markets (Cuñado and de Gracia, 2003; Farzanegan and Markwardt, 2009; Zhao et al., 2016; among others). Finally, we take in the policy uncertainty in emerging markets by adding the average economic policy uncertainty index (*EMEPU*) of six emerging markets including Brazil, China, India, South Korea, Russia, and Mexico. The last variable in Eq. (15) is the exports from the U.S. to emerging markets (*US_EXP*) accounting for the critical role of international trade on the inflation spillover effects. In Eq. (16), the U.S. imports from emerging economies (*US_IMP*) is the last regressor accounting for the effect of international trade on inflation shock transmission.

We estimate Eqs. (15) and (16) using the feasible generalized least square (FGLS). Our motivation of using FGLS for the regression analysis of the drivers of inflation connectedness hinges on its robustness in handling issues of heteroskedasticity and autocorrelation. These issues are common when the regression model's dependent variable is derived from estimates (Lewis and Linzer, 2005). This method, as demonstrated in study of Pham et al. (2022), which investigates the determinants of connectedness between energy and cryptocurrency markets, enables a precise investigation of underlying factors of a network connectedness. The estimated coefficients and their corresponding standard errors are reported in Table 6. The regression results yield several remarkable findings. First, the adjusted R-squared of both models are relatively of 63.4% and 79.6%, respectively, suggesting that both models have ability to explain the variation of the spillover measures. The statistical significance of the F-statistics further corroborates this conclusion.

Pertaining to the inflation spillover from the U.S. to emerging markets, we find that the $DSI_{US \rightarrow EME}$ is positively correlated with the *USTPU* (1.029) and the *DXY* (4.962) while insignificantly affected by the *USMPU*. These figures indicate that transmission of inflation shocks from the U.S. to emerging economies is higher during times of trade policy uncertainty and dollar appreciation. Interestingly, the U.S. monetary policy uncertainty does not significantly affect the inflation spillover of the U.S to other countries. In addition, inflation spillover effects from the U.S. tend to be more pronounced when the Fed expands its monetary policy as evidenced by the negative and statistically significant coefficient of *FFR* (−0.282). Regarding the impact of global commodity market, higher oil prices and volatility increase inflation spillover, as shown by significant positive coefficient of WTI (5.078). Finally, the coefficients of *EMEPU* and *US_EXP* are both positive and statistically significant, standing at 0.007 and 5.973, respectively. These numbers suggest that emerging markets receives more inflation shocks from the U.S. when their policy-related uncertainty are high and when they import more from the U.S. Notably, a 1 percent increase in the U.S. export to emerging markets causes a 5.973% increase in the $DSI_{US \rightarrow EME}$.

Concerning the directional inflation spillover effects from emerging markets to the U.S., we reveal that only four out of nine selected explanatory variables statistically and significantly explain the variation of $DSI_{EME \rightarrow US}$, including the dollar index (DXY), the WTI, the EMEPU and the US_IMP. In particular, the U.S. dollar's value significantly strengthens inflation spillover from emerging markets to the U.S. This positive relationship is consistent with our conjecture about the role of a strong US dollar as a booster of the U.S. imports from emerging markets. It is also in line with recent evidence from Batten et al. (2019), Saeed et al. (2021), and Bouri et al. (2021) that the strengthening of the U.S. dollar is associated with more interconnectedness of global financial markets. Contrary to our expectation, the coefficient of WTI is negative and statistically significant (−2.46), implying that the increasing oil prices exert an attenuating impact on the inflation spillover from emerging markets to the U.S. Besides, the impacts of the emerging markets' economic policy uncertainty (*EMEPU*) and the U.S. imports from emerging markets (*US_IMP*) are consistent with our expectations. The coefficient of *EME_EPU* is 0.015, implying that an 1% increase in the *EMEPU* leads to an 0.015% increase in the $DSI_{EME \rightarrow US}$. In a similar vein, the coefficient of *US_IMP* (13.143) suggests that an 1% increase in the U.S. imports from emerging markets induces an 13.143% increase in the $DSI_{EME \rightarrow US}$.

6. Robustness checks

One concern might be that our results are driven by the choice of the number of *h*-step forecast ahead used to calculate the time-varying inflation spillover measures. To address this concern, we re-estimate the inflation spillover measures in this study using *10*-step and *30*-step forecast ahead as robustness checks for our key empirical findings. We first report the average spillover measures in Table A6 of Appendix A6. As shown in both panels of the appendix, the U.S. remains the net receiver of inflation shocks from the EAGLES with the net spillover index (NSI) of the U.S. in Panels A and B being −1.5% and −0.82%, respectively. In addition, the role of other countries as net exporter or net importer of inflation spillover effects in the network is consistent with our base results in Table 2. We further plot the time-varying TSI using various *h*-step forecast ahead in Fig. A7 of Appendix A7. It is observable that the evolvements of these connectedness indices are very close to those of our main analysis in Fig. 5. Overall, these results of the robustness

[21] These findings are consistent with the traditional external trade channel which implies that when the U.S. dollar appreciates against another country's currency, the products of that country become more competitive relative to U.S. products, thereby fostering its exports and output.

Table 6
Drivers of directional inflation spillover effects.

	$DSI_{US \rightarrow EME}$ (1)	$DSI_{EME \rightarrow US}$ (2)
USMPU	0.204 [0.288]	−0.337 [0.249]
USTPU	1.029*** [0.342]	0.096 [0.299]
DXY	4.962*** [1.751]	7.12*** [1.547]
FFR	−0.282*** [0.082]	−0.011 [0.072]
WTI	5.078*** [1.318]	−2.46** [1.183]
OVX	0.004* [0.002]	−0.0001 [0.002]
EMEPU	0.007** [0.004]	0.015*** [0.003]
US_EXP	5.973*** [1.431]	
US_IMP		13.143*** [0.966]
Constant	−34.072*** [7.295]	−63.81*** [6.389]
Adjusted-R^2	0.634	0.796
N. Obs.	363	363
F-statistics	80.53***	180.45***

Notes: This table presents the estimated coefficients and their standard errors (in bracket) of Eqs. (15) and (16) using the Generalized Feasible Least Square (GFLS), where *DSI* is based on a TVP-VAR-based connectedness with a 20-step forecast ahead. The *DSI* is defined in Eqs. (4A) and (5A). ***, ** and * indicate statistical significance at the 1%, 5%, and 10% significance levels, respectively.

tests add more credence to our key empirical findings in this paper.

7. Conclusion

Rising inflation has been a major concern in global economic policy over the last one to two years. Our study's insights into inflation spillover effects between the U.S. and EAGLE countries and their determinants offer valuable guidance for formulating more comprehensive economic response policies, conducting further academic research and making informed investment decisions. Our findings underscore the intricate network of international inflation dynamics and its profound impact on domestic economic conditions, thereby necessitating a broader perspective on inflation management that are resilient to both domestic and international shocks.

Given the considerable inflation spillover effects observed, especially during extreme inflationary conditions where the total spillover of the sample markets can reach to 70%, it is critical for government authorities to adopt an integrated policy framework. This framework should account for both domestic inflation metrics and the potential impact of global inflation dynamics. This approach would enable the design of more resilient economic policies capable of withstanding global inflationary pressures. Integrated policies for effectively managing inflation spillovers also necessitate enhanced cooperation and communication among central banks and financial regulators across different countries. By sharing insights and data on inflation trends and policy responses, countries can better anticipate and mitigate the effects of inflation spillover. This collaborative approach can lead to a more synchronized response to global inflationary pressures, reducing the likelihood of adverse impacts on domestic economies.

Our findings underscore the importance of the U.S. dollar's role, bilateral trade and the emerging markets' economic policy uncertainty in influencing inflation spillover. Policymakers should closely monitor these factors and consider them in their inflation forecasts and policy adjustments, particularly for countries that are major trading partners with the U.S., where bilateral trade imbalances may exacerbate inflation spillover effects.

Regarding national reserve management, the critical role of the U.S. dollar as a driver of inflation shock transmission underscores the need for strategic management of national reserves. Central banks of emerging markets may need to reassess their reserve compositions to mitigate vulnerabilities related to U.S. dollar fluctuations. Diversifying reserves could be prudent strategy to protect domestic currencies and manage inflation more effectively.[22]

For investors, understanding the role of the U.S. and EAGLE countries in global inflation dynamics can help design informed investment strategies, especially in times of economic instability. By considering the international inflation spillover effects, investors can better assess the risks associated with investments in different regions/countries. Our findings suggest that investors should consider the inflationary trends and monetary policies of the U.S. and EAGLE countries when diversifying their portfolios to mitigate risks associated with inflation spillovers.

Our findings open avenues for further research into the determinants of inflation spillover and its mechanisms. Researchers could explore the long-term impacts of varying monetary and fiscal policies on international inflation dynamics, focusing on the role of major economies like the U.S. in shaping global inflation trends. The significant spillover during extreme inflationary conditions suggests a need for adopting advanced quantitative models that can predict such dynamics under various economic conditions.

[22] See, https://www.nytimes.com/2022/10/27/business/strong-dollar-global-economy.html.

Declaration of competing interest

On behalf of all authors included in the manuscript "Does the U.S. export inflation? Evidence from the dynamic inflation spillover between the U.S. and EAGLEs", I, Hung Do, declare that there is no financial/personal interest relating to this research project.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.iref.2024.103427.

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