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Effects of Energy Prices Shocks on Global Inflation: A Panel Structural VAR Approach

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Abstract
Global supply shock suffered massive disruption because of COVID-19 in the last few years. Such a shock is accompanied by an energy price surge caused by the war in Ukraine. We study the effects of energy price shocks (common, idiosyncratic) on inflation due to energy price issues. We set up a panel structural VAR (PSVAR) model to study whether energy price shocks exhibit long memory properties (persistence) having permanent (long-run) effects on global inflation. The model is modelled under Cholesky and Blanchard-Quah restrictions. We calculate medians, averages, and interquartile impulse response functions with confidence interval quantiles following bootstrapping procedure. We see energy shock impact on headline inflation last 2.5 years (slow mean-reversion) reaching pre-crisis level.

Keywords
Energy prices, Inflation, Supply shocks, Panel structural VAR, Impulse response, Persistence

Introduction

It is feasible that the volatility in energy prices could outlast the current supply concerns in the global economy that are tied to COVID-19. Continual uncertainty around the pandemic, interruptions to global supply networks, and shifts in energy consumption as economies recover might all contribute to this. However, it is difficult to forecast the precise timing of these elements and their long-term impact on energy prices.

Dynamics in energy prices always have a significant economic effect on the global economy through the impact on productivity and economic growth. Friedman, the founder of the monetarist school of economic thought, explained inflation from a monetarist perspective by describing it as a monetary phenomenon brought on by an excessive money supply (Friedman, 1968). In addition, academics affiliated with pricing schools place particular emphasis on inflation's effects and describe the phenomenon of inflation as the process of an overall increase in prices through time (Laidler & Parkin, 1977). Despite the difficulty and unpredictability of inflation, academics worldwide have diverse perspectives on the factors that lead to inflation because their fundamental understandings and experiences are distinct. Multiple theories have been developed according to the factors affecting inflation. Some of these theories include the demand-pull theory, the monetary theory, the cost-push theory, the structural theory, the input theory, the expectation theory, and so on. (Argy, 1970; Auerbach, 1976; Gordon & Hall, 1985; Hendershott & Van Horne, 1973; Weber, 1995; Machlup, 1960; Shinkai, 1973; Wang et al., 2022). Many theoretical and empirical studies on inflation expectations, the persistence of inflation, the interaction mechanism of inflation, economic growth, and macroeconomic policies have been conducted by academics worldwide. These studies have been undertaken in addition to the research that has been done on the factors that lead to inflation (Fuhrer, 1995; Johansen & Juselius, 2009; Pivetta & Reis, 2007; Woodford, 2013). There have been a large number of studies that have shown that the formulation of a series of regulation modes, such as monetary policy, fiscal policy, and income distribution policy, is of great significance for stabilizing inflation and maintaining sustained economic growth (Barro, 1974; Liu et al., 2009; Taylor, 1999). In the meantime, the inflation prediction model can be used as a guiding tool for macroeconomic policies (Korobilis, 2017; Marsilli, 2017; Salisu et al., 2019).

Energy price cycles are usually followed by commodity prices resulting in boom/bust inflation episodes. A special role in energy price cycles and associated effects reside in crude oil, gasoline, and natural price dynamics. Energy price shocks result in consumer expenditure pattern change and purchasing power affecting output, inflation, and global macroeconomic conditions. The recent pandemic crisis and inflation resurgence open the issue of new global, permanent inflation (component) the world could face. The questions policymakers and practitioners face today are whether we should look at current price growth as transitory and whether energy price pressures will outlast COVID-19 supply shocks. The Highest volatility (standard deviation = 37) is present for energy commodity prices, with considerably lower volatility for non-energy commodities (standard deviation = 26.9). Within the non-energy commodity price dynamics, we can observe a close pattern and dynamics over the period. Volatility for agricultural commodities in standard deviation equals 26.2, with food price volatility of 27.9. Price volatility for raw materials is 25.9 and fertilizers 39.9. Materials and minerals commodities register a standard deviation of 29.3 in price dynamics.

Moreover, world inflation dynamics have drastically changed since the year 2000. From 1960 to 2000, inflation (price volatility) for energy and non-energy commodities shared close synchronicity. Energy commodity volatility (in standard deviation) was 14.4, while for non-energy items, volatility was 14.6. Both energy and non-energy prices were moving closer together. Since the year 2000, volatility in energy items decoupled from non-energy commodities driving world inflation dynamics. Energy price pressure on world inflation has dominated since January 2000. Permanent movement in energy prices exercised pressure on output and macroeconomic conditions resulting in decoupled inflation dynamics across countries and the world.

Energy price cycles are usually followed by commodity price cycles resulting in boom/bust inflation episodes. A special role in energy price cycles and associated effects reside in crude oil, gasoline, and natural price dynamics. The questions policymakers and practitioners face today are whether we should look at current price growth as transitory and whether energy price pressures will outlast COVID-19 supply shocks. For a 1% increase in the headline inflation index energy price index rise by > 3% on average. We hypothesize that present volatility in energy prices due to global supply chain disruptions caused by COVID-19 could outlast the trigger itself. Headline inflation shows a permanent upper shift in the long run in response to the initial shock in the global supply chain pressure index.

Following and employing the same PSVAR technique as Goes and Cuevas (2016), we construct a model to determine if energy price shocks exhibit long memory qualities with lasting consequences on global inflation.

Although this methodology and procedure permit an imbalanced panel, we chose to employ a balanced panel and confine our sample to observations that suit the sample to eliminate the possibility of estimate bias. To assess inflationary pressures and the duration of the adjustment period, we look for a long memory or persistence in energy price volatility. Could prior and present unfavourable inflation conditions merge energy price shocks and outlast COVID-19 supply issues resurrecting inflation? We develop and estimate a structural Panel VAR to answer this. The panel structural VAR model we develop here allows us to analyze the transmission of energy price shocks (common, idiosyncratic) due to COVID-19 supply issues on inflation.

The rest of the article is structured as follows: After the introduction materials and methods section explains the research sample and methodological framework applied in the study. Next, study results are presented in the result section and discussed in the discussion section. Finally, in the concluding remarks, we explain the practical implication of the research, contribution to the field, originality, limitations of the study, and suggestions for further investigation.

Materials and methods

Figure 1 shows us energy and non-energy commodities price volatility since 1960. We can observe an apparent sympathetic movement between world energy and non-energy commodity prices over time. Both commodities' prices moved together, with non-energy price growth dominating energy from 1960 to 2005. After 2005 energy prices rose faster than non-energy until 2014. Then the trend reversed, with non-energy commodity prices retaking the lead. Looking at the correlation between energy and non-energy commodities, we observe a strong (0.93) coefficient. We can also follow a bi-directional Granger link (Hamilton, 1994) between energy and non-energy world commodity prices after running the Granger causality test (F(12, 708) = 2.23, Prob > F = 0.0092 and F(12, 708) = 6.78, Prob > F = 0.0000). Moreover, both strong correlation and bi-directional Granger causality exist between energy and non-energy commodity prices. Volatility in energy commodity prices drives non-energy commodity prices and vice versa (null hypothesis of non-Granger-causality rejected).

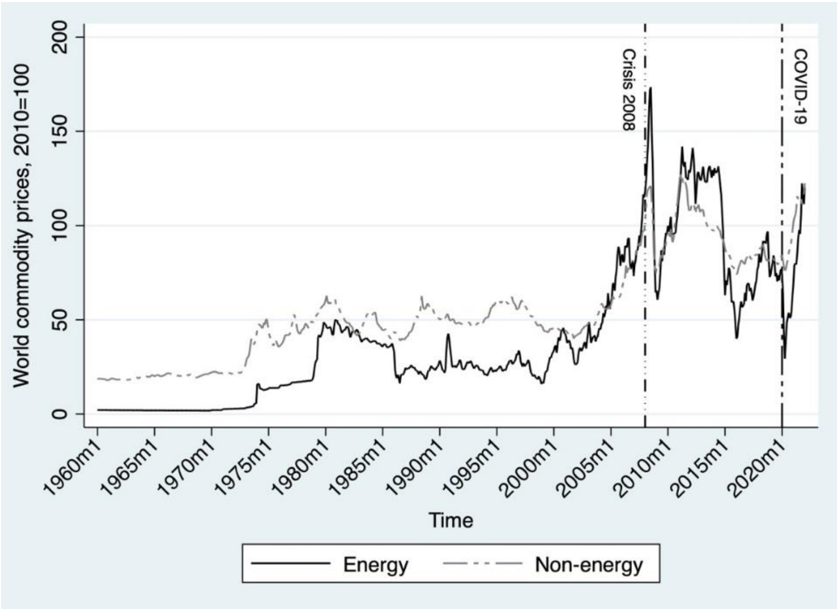

Fig. 1. Energy and non-energy commodity price dynamics 1960-2021

Source: World Bank Commodity Price Data (The Pink Sheet) https://thedocs.worldba nk.org/en/doc/1ad246272dbbc437c74323719506aa0c-0350012021/related/Commodity-p rice-database.zip
Notes: Commodity Price Dynamics January 1960 to January monthly indices based on nominal US dollars, 2010=100, 1960 to present.

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Figure 2 display headline consumer price index inflation since January 2000 for World, Advanced and emerging economies and the U.S. the Highest inflation dynamics is in emerging market economies. Emerging market economies (on average) still strongly depend on fossil fuel resources to support economic growth lagging in the energy transition to advanced economies. In the last ten years, renewable energy prices (correcting for instalment costs) fell considerably (on average 70-90) with no change in coal prices. Advanced economies succeed in developing favourable green financing conditions while emerging economies still struggle. Oil price volatility since 2000 significantly affects price volatility in emerging countries running on fossil fuels growth. The same dynamics and pattern hold for the world economy, with emerging economies and the world economy decoupling from advanced economies and the U.S. Advanced economies and the U.S. managed to get a grip on energy transition resulting in more price stability and less pronounced volatility in time of crisis. Energy transition and green investments keep prices stable and less sensitive to shocks and crises compared to the effects of fossil fuels shocks (coal, crude oil, and natural gas).

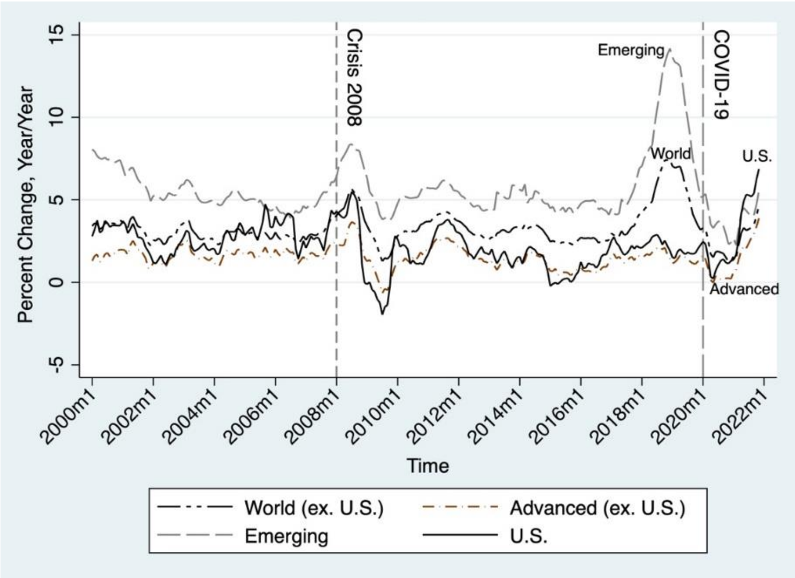

Fig. 2. Headline Consumer Price Index 2000-2022

Source: Database of Global Economic Indicators, Haver Analytics, available at https://www.dallasfed.org/institute/dgei/cpi.aspx
Notes: Headline Consumer Price Index Inflation January 2000 to January 2022 Index 2005=100

Energy price shocks deeply impact inflation, more pronounced than the resulting from other commodity price shocks (non-energy: food, raw materials, fertilizers, metals, and minerals). To understand the effects of shocks on inflation, we must investigate the impact of other global factors like quantitative easing policy, financial cycles, property prices, pandemics, and unemployment (global inflation drivers). The pioneering work of Phillips (1962) suggests we must learn quantitative links that hold between global inflation drivers to understand the inflation nature and dynamics.

We use data from various sources to analyze inflation dynamics and links to energy price volatility, global supply chain disruption due to pandemics, oil shocks, quantitative easing in place from 2008, and unemployment (Philip's law). Data availability, particularly for the energy price index, limits the sample selection across observations and time. The period includes quarterly data from 2005q1 to 2021q1. The total number of countries in the sample is forty-four. See tables one and two for the sample's variable list, definition, and list of countries.

The database we use for inflation is from (Ha et al., 2022), with a global database on inflation measures (headline, food, energy, core consumer price inflation, producer price inflation, and gross domestic product deflator). From a total of 196 countries in the database, we select forty-four having quarterly inflation data since 2005q1 to be able to run panel structural vector autoregression. We use quarterly data to capture the volatility of the latest inflation episode. The data selection procedure follows sample and time targeting for a balanced panel required to run structural panel VAR Pedroni (2013).

Tab. 1. Variable and series definition

Variable Name	Indicator Type	Series
HCPI_M	Index	Headline consumer price index, monthly
HCPI_Q	Index	Headline consumer price index, quarterly
HCPI_A	Inflation rates	Headline consumer price inflation, annual
FCPI_M	Index	Food price index, monthly
FCPI_Q	Index	Food price index, quarterly
FCPI_A	Inflation rates	Food price inflation, annual
ECPI_M	Index	Energy price index, monthly
ECPI_Q	Index	Energy price index, quarterly
ECPI_A	Inflation rates	Energy price inflation, annual
CCPI_M	Index	Official core consumer price index, monthly
CCPI_Q	Index	Official core consumer price index, quarterly
CCPI_A	Inflation rates	Official core consumer price inflation, annual
PPI_M	Index	Producer price index, monthly
PPI_Q	Index	Producer price index, quarterly
PPI_A	Inflation rates	Producer price inflation, annual
DEF_Q	Index	GDP deflator index, quarterly
DEF_A	Inflation rates	GDP deflator growth rate, annual
CCPI_Q_E	Inflation rates	Estimated core consumer price inflation, quarterly
CCPI_A_E	Inflation rates	Estimated core consumer price inflation, annual
HCPI_Q_T	Inflation rates	Estimated trend component of headline CPI inflation, quarterly
HCPI_Q_C	Inflation rates	Estimated transitory (cyclical) component of headline CPI inflation, quarterly

Source: Ha, Kose and Ohnsorge, 2021

Table 2 lists the countries in the sample we use for analysis.

Tab. 2. List of countries

Country (44 in the sample)		
Australia	Austria	Belgium
Bulgaria	Canada	Chile
Colombia	Croatia	Cyprus
Czech Republic	Denmark	Finland
France	Germany	Greece
Hungary	India	Italy
Japan	Latvia	Lithuania
Luxembourg	Malaysia	Malta
Mexico	Morocco	The Netherlands
New Zealand	North Macedonia	Norway
Peru	Philippines	Poland
Portugal	Russia	Saudi Arabia
Singapore	Slovakia	Slovenia
Spain	Sweden	Switzerland
United Kingdom	United States	

Source: Ha, Kose and Ohnsorge, 2021

Here we study the effects of energy price pressures on current and future inflation dynamics. We hypothesize that present volatility in energy prices due to global supply chain disruptions caused by COVID-19 could outlast the trigger (global supply shocks) itself. We expect this is a consequence of the quantitative easing policies, strong buybacks at the world financial markets, and systemic shocks persisting since the 2008 financial crisis. World growth engines China, India, and Indonesia still strongly depend on fossil fuels growth. Policymakers in the EU and other countries are becoming increasingly concerned about such a possibility (long memory in energy prices).

Moreover, energy price shocks and global supply issues substantially impact inflation. However, this impact must be decomposed from other international inflation drivers' effects. After introducing inflation targeting during the 1990s, inflation entered a significant moderation period. The financial crisis of 2008 disrupted it shortly, with global inflation closing to 10% in 2008 and settling at about 2% after 2013/14. During the 2008-2014 period, global inflation was un- der pressure from the quantitative easing policy as a worldwide tool for fighting the 2008 crisis. Current global inflation is gaining momentum under conditions significantly different from before the 2008 crisis. A significant share of countries in emerging economies registers inflation > 5% since 2010 (>70%). For advanced economies, we see > 40% of the countries with >5% inflation rate in the same period. Thus, inflationary pressure and inflation expectations are higher than before the 2008 crisis. We develop and estimate a structural Panel VAR to answer this.

Panel structural VARs (PSVAR) allow for full cross-member heterogeneity in the response dynamics (idiosyncratic and common structural shocks) to study the effects of energy price shocks on inflation Góes and Cuevas (2016). We follow and use the same PSVAR procedure as Góes and Cuevas (2016) to set up a model studying whether energy price shocks exhibit long memory properties (persistence) having permanent (long-run) effects on global inflation. Although such methodology and procedure allow using an unbalanced panel, we choose to use a balanced panel restricting our sample (countries and time) to observations fitting the sample to avoid potential estimation bias (if missing values are linked to idiosyncratic errors). We use a M x 1 vector of demeaned panel data to control for fixed effects as in Góes and Cuevas (2016)

$$B_i y^*_{i,t} = A_i(L) y^*_{i,t-1} + e_{i,t} \tag{1}$$

$y^*_{i,t}$ = n-dimensional vector with demeaned stacked endogenous variables,

$$\left(y^*_{i,t} = y_{i,t} - \bar{y}_i, \bar{y}_i \equiv T_i^{-1} \sum_{t=1}^{T_i} y_{i,t} \forall i\right) \tag{2}$$

$y_{i,t}$ = endogeneous variables vector for $t = [1, \ldots, T_i]'$ (country-specific time dimension),
$A_i(L)$ = polynomial of lagged coefficients$\left[A_i(L) \equiv \left(\sum_{j=0}^{J_i} A^i_j L^j\right)\right]$,
J_i = country-specific lag lengths,
A^i_j = coefficient matrix,
$e_{i,t}$ = vector stacked residuals,
B_i = contemporaneous coefficient matrix.

Based on Pedroni (2013); Góes and Cuevas (2016) methodological procedure on our balanced panel △ $y_{i,t}$ with dimension $i = [1, \ldots, M]'$ (country/members), $t = [1, \ldots, T_i]'$ (time) and $n = [1, \ldots, N]$ (variables) follows (all data as quarterly series):

1. We set up a general model of the form$B_i y^*_{i,t} = A_i(L) y^*_{i,t-1} + e_{i,t}$ with hcpi = headline consumer price index, ecpi = energy price index, ccpi = official core consumer price index, ppi = producer price index, def = GDP deflator, oil = oil crude average price world market ($/bb), pprice = residential property prices selected - (real year-on-year changes, in %), cgap = credit-to-GDP ratio (in % of the GDP), gcpi = global supply chain pressure index, unem = official unemployment rate ILO statistics, rate = official central bank policy rate (% per year) as endogeneous variables.
2. Reduced-form VARs under time effects calculations $\Delta z_t = M_t^{-1} \sum_{i=1}^{M_t} \Delta z_{it}$ takes the form
3.

$$\begin{gathered} B_1 y^*_{1,t} = A_1(L) y^*_{1,t-1} + e_{1,t} \\ \vdots \\ B_M y^*_{M,t} = A_M(L) y^*_{M,t-1} + e_{M,t} \end{gathered} \tag{3}$$

Góes and Cuevas (2016) using the best-fit information criteria selection procedure for lag length selection.

4. Set appropriate identifying restrictions short run (Cholesky) or long run (Blanchard-Quah) for structural shocks estimation $u_{i,t}$ = composite shocks and $\bar{u}_{i,t}$ = common shocks.
5. Calculating diagonal elements of the loading matrices

$$\begin{gathered} u_{1,t} = \Lambda_1 \bar{u}_t + \tilde{u}_{1,t} \\ \vdots \\ u_{M,t} = \Lambda_M \bar{u}_t + \tilde{u}_{M,t} \end{gathered} \tag{4}$$

6. Member-specific impulse responses to unit shocks are calculated following

$$R_1(L) = \Lambda_1 R_1(L) + (I - \Lambda_1 \Lambda_1')R_1(L) \tag{5}$$

Góes and Cuevas (2016) and Lütkepohl (2007).

7. Finally, we calculate medians, averages, and interquartile impulse response functions with confidence interval quantiles following bootstrapping procedure.

For details on the algorithm setup and methodological framework behind the procedure, see Pedroni (2013), Góes and Cuevas (2016), and Luvsannyam (2018).

The panel structural VAR model we develop here allows us to analyze the transmission of energy price shocks (common, idiosyncratic) due to COVID-19 supply issues on inflation. We also search for long memory or persistence in energy prices volatility (mean reversion) to asses inflationary pressures and how long will the adjustment period last.

Following the methodological framework in section four, we set up empirical models as below:

Model (1), $y_{i,t} \equiv [hcpi_{i,t}, ecpi_{i,t}]'$ with $hcpi_{i,t}$ = headline consumer price index and $ecpi_{i,t}$ = energy price index.

Model (2) $y_{i,t} \equiv [hcpi_{i,t}, oil_{i,t}]'$ where $oil_{i,t}$ = oil crude average price world market ($/bb).

For model restriction, we follow the discussion from Lütkepohl et al. (2018) on short-run versus long-run identifying restrictions setting for panel structural VAR impulse response estimation. Discussions on setting reasonable restrictions in structural VAR impulse response analysis point to the long-run restriction issue (long memory) in macroeconomic studies. A study by Lütkepohl et al. (2018) shows it is proper to use long-run (Blanchard-Quah) restrictions Blanchard and Quah (1989) if long-run multipliers are of interest (longer horizon period). In our study, the price series and other series we use show long-run memory properties, so long-run restrictions must be carefully addressed here. To this end, first, we run panel SVAR models as defined above using Cholesky (short-run) restriction and compare it to the results with long-run (BQ) restrictions. Moreover, we can check for the robustness of the results by comparing results running both short-run and long-run restriction estimations.

Results

Following the setting of Pedroni (2013) and Góes and Cuevas (2016) ensures the stability, trend stationary, and full heterogeneous dynamics in our modelling. To account for the shock, both possible temporary and permanent dynamics, we use modelling under Cholesky and Blanchard-Quah restrictions.

We can see the results of running model 1, showing the impact of a shock in energy prices on the headline consumer price index in Figure 3.

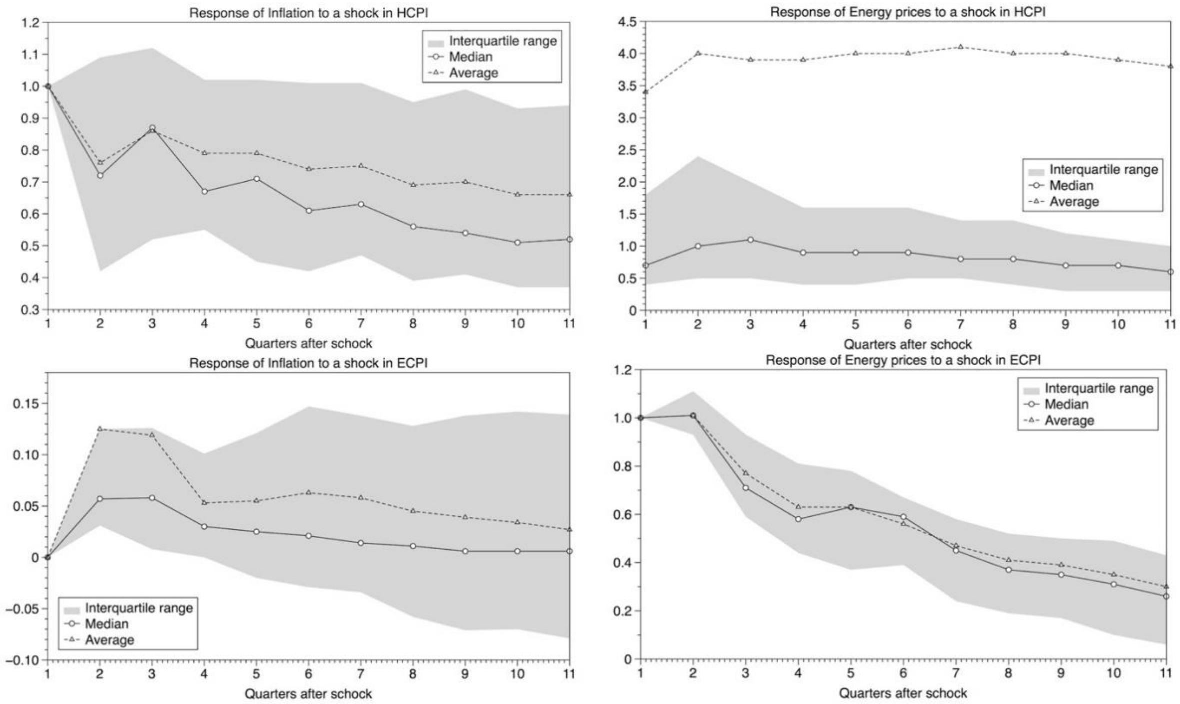

Fig. 3. Composite impulse responses to a shock (model 1)

Source: Authors' research
Notes: Heterogeneous composite impulse responses (sample) median, averages, and interquartile ranges (derived from forty-four impulse response function distributions).

We can see that an exogenous shock in energy prices (ECPI) for 25% of the countries (25th percentile) in the sample results in an inflation (HCPI) increase during the first year (bottom left panel). Aftershock effects turn negative (disinflation impact) after 1.5 years, as we can see from the figure. Long-run effects last 4.5 years after the initial shock in energy prices. Headline inflation average response to energy price shock reaches a peak a half year after the shock. The high inflationary impact of an energy price increase dissipates after three quarters but remains persistent (inflation pressure) in the long run (4.5 years). Energy price shock shows long memory (persistence), resulting in a slow mean-reverting impact on inflation. The effect on inflation is long-lasting with slow mean reversion (return to the level before shock). The median inflation response to energy price shock closely follows the average response at a lower level of inflationary pressure. After reaching a peak in the third quarter, the median response to energy price shock slowly declined but remained slightly above the old inflation level. Countries depending on fossil fuel growth will drive inflation expectations from energy price shocks above the median response to energy price volatility. Under the actual global conditions (war in Ukraine not included in the model), energy price inflationary pressures will not outlast COVID-19 supply shocks. For countries significantly depending on the fossil fuel industry, the energy price shocks (25% of the countries in the sample) will remain permanent, pushing inflationary expectations high and away from reverting to the prior inflation level.

Energy price shocks, such as the one we witness during the time of COVID-19 supply chains and energy supply shocks (natural gas shortage), also exhibit long memory (persistent) behaviour (bottom right panel). An increase in energy prices (initial shock) drives energy price pressure upward for all countries in the sample. The effect is long-lasting, slowly means reverting, at least for 25% of the countries in the sample. Moreover, the time to reversion (due to persistence) is very long, > 4.5 years for 75% of the countries in the sample. Initial energy price shocks slowly die out in the long run, with prices somewhat above the old level. The probability and time to reversion depend on the country's current status of the energy transition, dependence on fossil fuels sources, renewable energy financing conditions (green finance), and history of inflation expectations. To check for the energy price shock spillover effect (common shock) and country-specific (idiosyncratic shock), we decompose median composite responses to initial shock in energy prices (Figure 4).

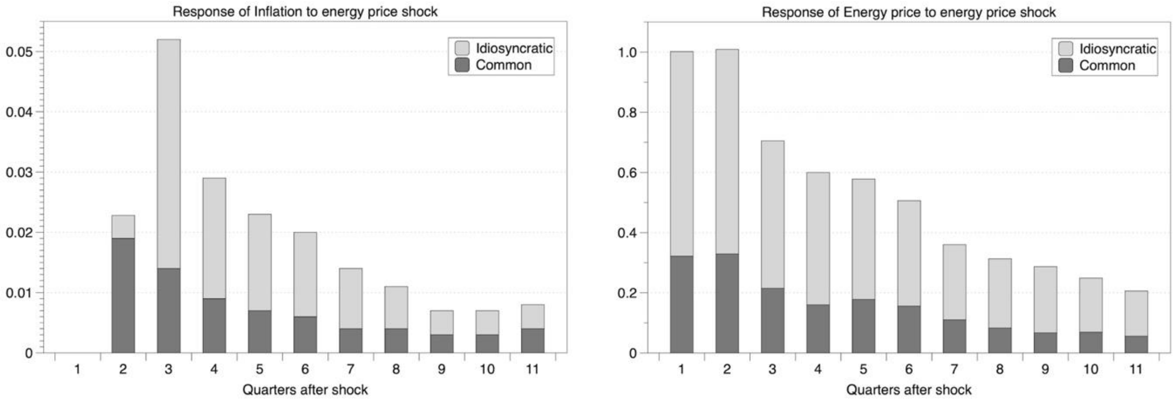

Fig. 4. Decomposition of median composite responses (model 1)
Source: Authors' research
Notes: Median responses to energy price shock decomposed to common (dark grey) and idiosyncratic (light grey) shock over the horizon period.

Figure 4 shows that energy price shock starts as a global event (left panel) with common shock effects dominating over country-specific. International energy price shock spillover is fast (immediate pass-through) and large (globalization effect). After the second quarter, when the energy price shock is already transmitted globally, country-specific inflation shock dominates over common. Global energy price shock is immediately transmitted over the world energy market, soon becoming the country's specific problem (inflationary pressures). Such a condition holds for two years after we observe a balanced impact of common and idiosyncratic shocks on inflation. Governments try to mitigate globally triggered energy shocks by economic package measures. Energy inflation reflects an immediate pass-through of global price shocks' effect on domestic inflation.

Moreover, global energy inflation strongly influences domestic inflation in the long run (after two years). Therefore, we conclude that global energy inflation pressures fastly transmit to domestic inflation. These effects dominate in the first quarter after the shock, quietly dying out in the medium run (two years). An interesting fact is that global energy inflation pressures do not die out (mean revert) but return after two years pushing aside domestic energy inflation pressures once again. In other words, global energy inflation first is a worldwide phenomenon turning to domestic in the medium run. However, energy inflation is still a global issue (common shock domination). That fact has important implications since domestic inflation triggered by global energy inflation shock can be contained (for two years). Still, after global energy inflation, pressures again pick up, driving up the country's headline HICP inflation. Consequently, global energy inflation pressures can not be faced nationally but must be dealt with globally (on a world level).

Initial energy price shock has an immediate pass-through to global and national energy price levels. Energy inflation starts us international turning domestic in the first quarter after the shock. Global energy inflation shock, its spillover effect, after pass-through to the country's energy inflation, remains country-specific (right panel in Figure 4). Once triggered and transmitted worldwide, global energy shock pushes up country-specific energy prices, having a persistent impact (limited but constant in the long run). As for energy inflation, common energy price shocks display high persistence (long memory), having a substantial impact in the first year of the initial shock. Three more quarters after the shock, the initial energy price upward pressure slowly dies out (four years).

Moreover, energy's overall impact and relevance are common to idiosyncratic shock in- crease in the long run. Country-specific energy shocks dominate over common (global) in the short and medium run. In the long run, global energy price volatility exercises significant energy inflation pressure on a country's energy price and inflation. These findings corroborate the above results on the energy price shock and headline inflation link. Headline inflation is driven by energy price shock (oil and natural gas prices) in the short run. In the long-run country-specific inflation determinants (food and housing prices, macroeconomic conditions, consumer expenditure pattern) are the most prominent factors driving a country's headline inflation. Common and country-specific energy shocks are the short-term energy inflation drivers. In the medium run, country-specific energy conditions cause country-specific energy inflation, but in the long run, energy inflation is more sensitive to global oil and gas price shocks.

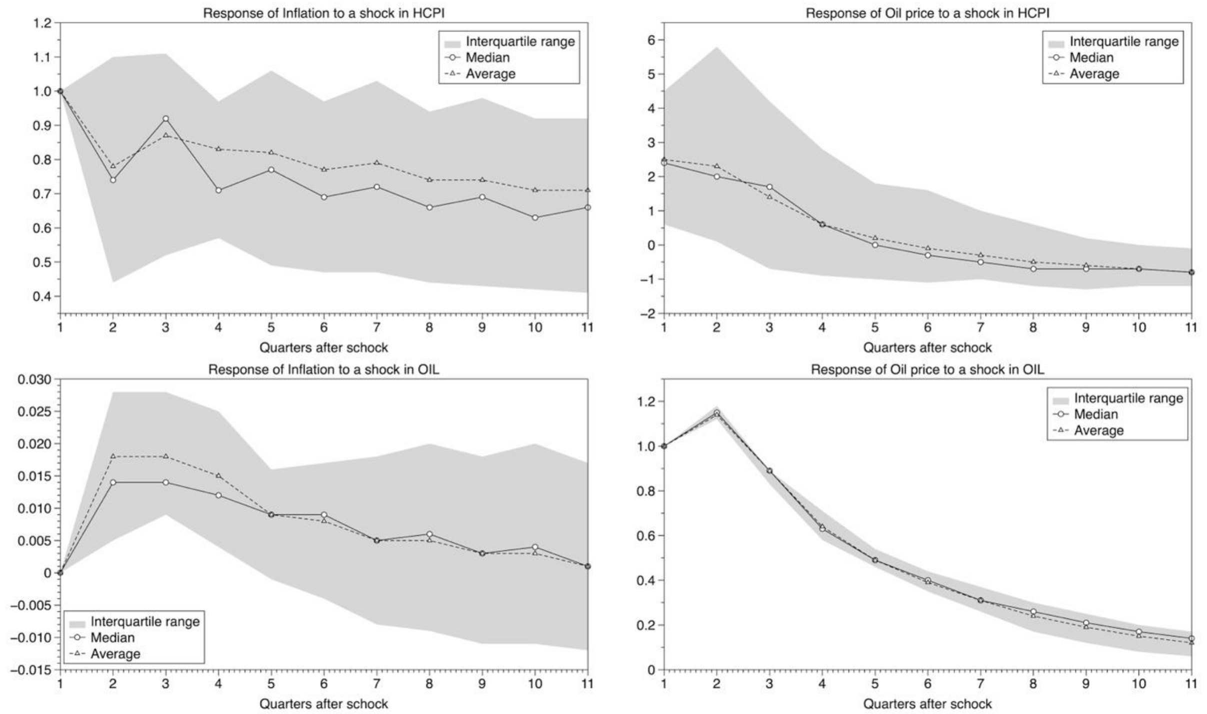

Fig. 5. Composite impulse responses to a shock (model 2)

Source: Authors' research
Notes: Heterogeneous composite impulse responses (sample) median, averages, and interquartile ranges (derived from forty-four impulse response function distributions).

The highly dominant factor driving energy inflation is usually the price of oil. The results of running model 2 show that headline inflation is sensitive to short- and medium-run oil price volatility (Figure 5). Energy inflation accelerated in early 2021 due to changes in oil prices and tax and other fee increases (Rubene and Koester, 2021). We estimate a panel SVAR model to asses oil price changes' impact on the energy price index (results not presented here). Oil price shocks drive energy prices up for 75% of the countries in the sample. The impact is more substantial three quarters after the shock slowly dying out but with no mean reversion in energy prices. Oil price shocks push energy prices up, and the effect is permanent; the energy price index does not revert to the level before the shock. Same effect hold for the oil price dynamics. A shock in the oil price drives oil prices up, having a permanent (no mean reversion) effect on future oil prices (bottom right panel). Oil price change pressure on energy inflation diminishes after two quarters and decreases in the future. However, a shock in the oil prices causes a jump in the energy price series (permanent change). We observe that a jump process (positive oil price shock) also holds for the energy price (energy inflation). Positive volatility in oil prices causes upward pressure on energy prices, having a permanent effect. In the short run, the effects of a jump in the oil price are elastic, turning inelastic in the medium term, holding at 0.6 elasticity over the long run.

Oil price jumps directly impact headline inflation in the short-run (bottom left panel in Figure 5), slowly decaying after. In the long run, the effects of the oil shocks on headline inflation follow a downward pressure (mean reversion after four years). However, a shock in the oil prices causes an uncertainty effect (inflation expectation) caused by a change in consumer expenditures pattern. Oil price shocks are not a dominant factor for inflation; however, the initial jump in oil price transmits (pass-through) directly to energy inflation and indirectly to the food and housing prices, inflation expectation). Such an effect (top left panel) remains permanent and significant, with headline inflation displaying no mean reversion in the long run. Direct transmission (impact) of oil price shock on headline inflation is weak but permanent. Still, the indirect effect on inflation (through other commodity prices) is significant and permanent.

Here we present median composite responses to oil price shocks decomposed into common and idiosyncratic oil shocks (Figure 6).

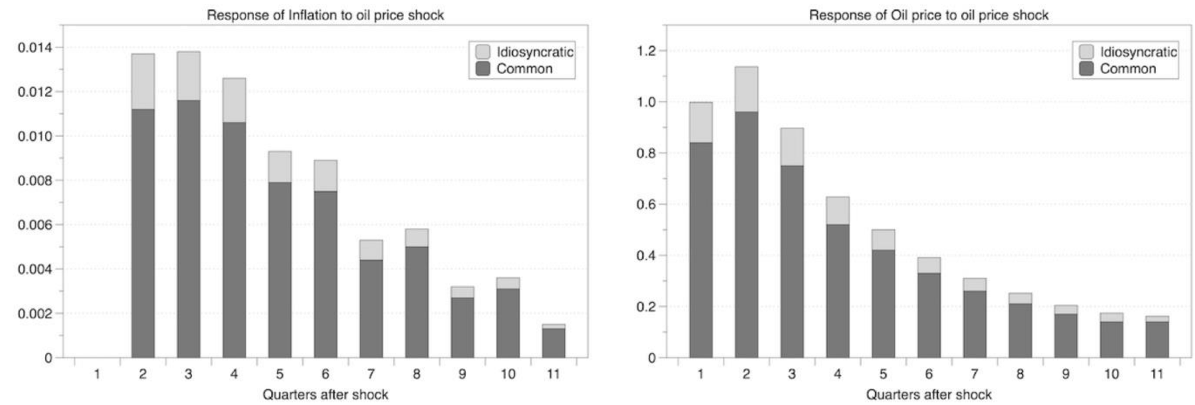

Fig. 6. Decomposition of median composite responses (model 2)

Source: Authors' research
Notes: Median responses to energy price shock decomposed to common (dark grey) and idiosyncratic (light grey) shock over the horizon period.

As expected, oil price shocks are globally dominating country-specific oil shocks from the short to the long run. Headline inflation shows an immediate positive response to a positive shock in oil prices. The effects of the shock usually last for eleven quarters, slowly mean reverting to zero after three years. Global oil price shocks cause energy inflation pressure (pass-through) with a spike after two quarters. After the second quarter, the energy inflation pressure caused by a sudden change in oil prices shows mean reversion dynamics. Fast mean-reversion occurs from the 2-7 quarter switching after to slow mean-reversion path. Oil prices after the shock tend to stay above the pre-shock levels. The pass-through mechanism of oil shock is fully global, with limited country-specific effects ranging from 5 (minimum) to 20% (maximum).

Robustness testing

We run several different model specifications to check the result's robustness. First, modifying models 1 - 4, substituting headline inflation endogenous variable with core consumer price index and adding additional endogenous variable (central bank policy rate - BIS data and official central bank sources), we compare with baseline impulse-response shock. For models 1 and 2, we also run Blanchard-Quah decomposition (long-run restriction) when applicable.

Modifying model (1), we get $y_{i,t} \equiv [ccpi_{i,t}, ecpi_{i,t}]'$ running PSVAR to get an impulse response to energy inflation shock (Figure 7).

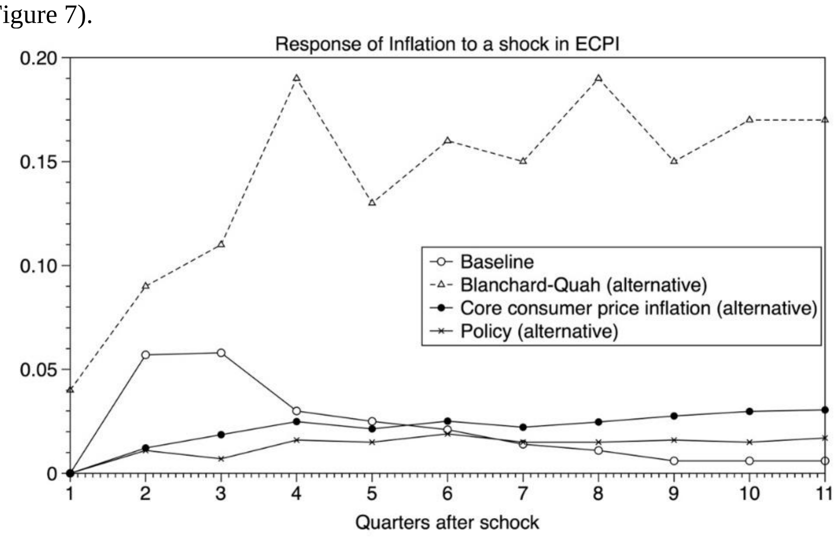

Fig. 7. Re-estimation of a model (1) – median composite response

Source: Authors' research

First, we substitute (HCPI) with (CCPI) for robustness check (baseline comparison) to model 1. In the graph above, we see that the results (Core response of inflation to a shock in ECPI) are similar to the baseline (HCPI).

Substituting (CCPI) for (HCPI) does not affect the baseline results proving robustness results. Another robustness test expands model (1) by adding endogenous policy variables (central bank policy rate - Policy in Figure 7). We see that the median response of inflation to energy shock after model (1) expansion remains close to the baseline scenario. To check for possible bias between short and long-run restrictions modelling, we also run a Blanchard-Quah restriction on model 1 (Blanchard-Quah). We see that the response is more significant (inflation on a higher level due to a shock in energy), but the dynamics are similar to the baseline model. Overall, the baseline scenario of model 1 is robust to different model alternations.

We apply similar model alternations to model (2) and compare the results with baseline inflation results (Figure 8) to oil price shock.

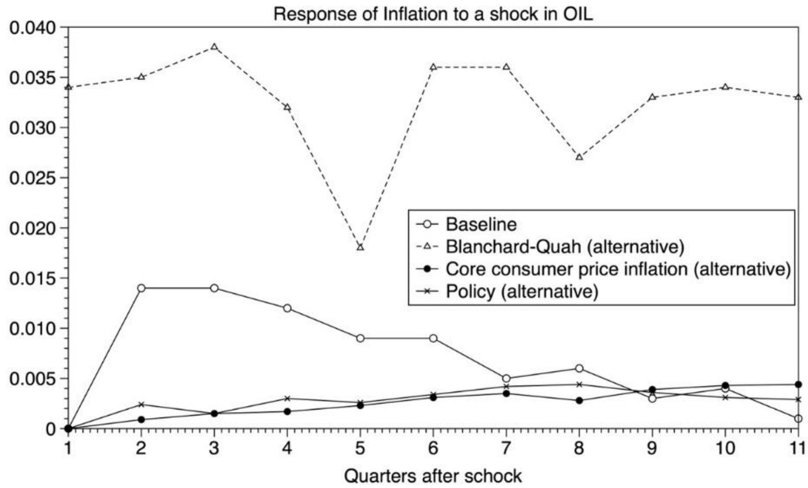

Fig. 8. Re-estimation of a model (2) – median composite response

Source: Authors' research

Discussion

Energy expenses are a substantial component of the total price of products and services. Therefore, energy prices and inflation are closely related. Other products and services may also rise when energy prices rise, resulting in higher inflation.

The impact of energy prices on manufacturing costs is one way to influence inflation (Marin and Vona, 2021, Steinbuks and Neuhoff, 2014). Manufacturing goods and services could increase when energy costs rise, resulting in higher customer pricing. For instance, a rise in oil prices could lead to more significant transportation expenses and higher pricing for items transported by truck or ship (Bijnens et al., 2021).

The influence of energy costs on consumer expenditure is a second method in which energy prices can affect inflation. When energy prices increase, customers have less discretionary income to spend on other products and services, which can lead to a fall in demand and, perhaps, lower prices. Nevertheless, a substantial increase in energy prices could lead to decreased economic activity and job losses, which can diminish consumer spending and demand for products and services (He et al., 2016).

Energy price shocks, such as unexpected spikes in oil prices, can significantly impact inflation (Živkov et al., 2019). This is because they can lead to substantial and abrupt fluctuations in the prices of products and services and increased economic uncertainty and volatility (Cross and Nguyen, 2018; Punzi, 2019).

The impact on inflation will depend on the magnitude of the price shock and the economy's sensitivity to energy prices. For instance, an economy that depends significantly on oil imports will be more susceptible to changes in oil prices than one that produces its oil. In addition, inflation-targeting central banks may increase interest rates to counteract inflationary pressure on rising energy prices. Energy prices play a crucial role in determining inflation, and fluctuations in energy prices can affect both production costs and consumer expenditure, hence influencing inflation. In addition, the economy's sensitivity to energy costs and the Central Bank's response to inflationary pressure can also play a role in determining the overall effect of inflation.

Energy shock transmission channels refer to how fluctuations in energy prices might impact the economy. There are many potential transmission mechanisms by which an energy shock can spread. First, rising energy prices can increase production costs for firms, leading to higher pricing for goods and services (cost-push inflation). Second, rising energy prices could lead to higher household costs, decreased disposable income, and reduced consumer spending (Onour, 2021). Third, higher energy prices could lead to poorer earnings for energy-intensive enterprises, reducing investment in these sectors. Fourth, higher energy prices can reduce the

competitiveness of domestic goods on the global market, resulting in a decline in exports and an increase in imports (Rizvi and Itani, 2022).
Central banks may increase interest rates to offset inflationary pressures induced by rising energy prices, resulting in tighter credit conditions and a sluggish economy (monetary policy), see (Ma et al., 2022).

A rise in energy prices can cause an increase in market volatility, which can discourage investment and generate uncertainty in financial markets (Yousaf et al., 2022; Su et al., 2023; Su, 2022). These transmission channels can significantly affect the economy and amplify the consequences of energy price shocks. However, the precise impact of an energy shock on an economy may differ based on country-specific characteristics, such as energy independence, energy use, and economic structure.

This research helps understand the implications of energy inflation and disruptions to the supply chain on headline inflation (Medina-Serrano et al., 2022). It was discovered that although a unit shock in energy costs had an initial favourable impact, it persisted for only 2.5 years before reverting to pre-crisis levels (for most countries).

Energy inflation reflects the immediate impact of global price shocks on domestic inflation. The global shock in energy prices is immediately transmitted over the global energy market and will soon become the country's specific problem (inflationary pressure). This condition persists for two years after we observe a balanced effect of common and idiosyncratic shocks on inflation. We conclude that global energy inflation is rapidly transferring to domestic inflation. The initial shock in energy prices immediately impacts international and national energy prices.

Energy inflation is causing us to turn domestically in the first quarter after the shock. Global energy inflation pressure cannot be met nationally but globally (at the world level). Country-specific energy shocks dominate common (international) in the short and medium run. Energy inflation accelerated at the beginning of 2021 due to changes in oil prices, taxes, and other fee increases (Rubene and Koester, 2021). A shock in the oil price drives up energy prices for 75% of the countries in the sample. The impact is more substantial three quarters after the shock is slowly dying out but without a mean reversal of energy prices. A positive shock in the oil price leads to a rise in the energy price (energy inflation). In the short term, the effects of an increase in oil prices are elastic, inelastic, and in the long term, at 0.6 elasticity.

Oil price shocks are not a dominant factor in inflation. However, the initial jump directly transmits (through) energy inflation, indirectly to food and housing prices and inflation expectations. The effect remains permanent and significant, with headline inflation indicating no mean reversal.

Conclusions

This article suggests that energy price shocks had a limited effect on headline inflation, lasting approximately two and a half years before reverting to pre-crisis levels in most nations investigated. However, supply chain disruptions induced by pandemics are significantly more severe. They can have persistent effects on inflation in 75% of the sampled countries, suggesting that inflation will not return to its pre-crisis level for at least five years.

Here we accurately measure the effect of energy inflation and supply chain disruption shocks on headline inflation. It was discovered that although a unit shock in energy costs had a favourable initial impact, it persisted for only 2.5 years before returning to pre-crisis levels (for most countries).

The practical implications of this paper are that policymakers should be aware of the different effects energy inflation and supply chain disruption shocks have on headline inflation. Energy price shocks can cause an immediate positive effect, but they are only temporary - lasting for around 2.5 years before reverting to pre-crisis levels in most studied countries. This suggests that policymakers need to consider these long-term impacts when deciding how best to manage economic recovery from global crises like the one we could face in 2023. The question facing policymakers and practitioners today is whether the current price growth should be viewed as temporary and whether energy price pressures will outlast COVID-19 supply disruptions. We investigate the effects of energy price pressures on inflation's current and future dynamics.

Limitations of the study rest in the sample selection across observations and time is restricted due to the limited availability of data, particularly for the energy price index. The range of data comprises every first quarter from 2005q1 to 2021q1 inclusively. There are a total of forty-four different countries represented in this sample. Future studies should attempt to use a balanced and larger sample (database) with more time series data. Also, a more robust theoretical background and causality framework between energy prices and dynamics should be explored in future studies. However, study limitations do not devalue the contributions of this study in the field of energy prices and inflation relationship and causality.

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