Journal of International Money and Finance 130 (2023) 102771

Contents lists available at ScienceDirect

Journal of International Money and Finance

journal homepage: www.elsevier.com/locate/jimf

Shipping costs and inflation ☆

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ARTICLE INFO

Article history:
Available online 17 November 2022

JEL Classification:
E31
E37
Q43

Keywords:
Price shocks
Shipping cost
Inflation pass-through
Monetary policy

ABSTRACT

The Covid-19 pandemic has disrupted global supply chains, leading to shipment delays and soaring shipping costs. We study the impact of global shipping costs—measured by the Baltic Dry Index (BDI)—on domestic prices for a large panel of countries during the period 1992–2021. We find that spikes in the BDI are followed by sizable and statistically significant increases in import prices, PPI, headline, and core inflation, as well as inflation expectations. The impact is similar in magnitude but more persistent than for shocks to global oil and food prices. The effects are more muted in countries where imports make up a smaller share of domestic consumption, and those with inflation targeting regimes and better-anchored inflation expectations. The results are robust to several checks, including an instrumental variables approach in which changes in shipping costs are instrumented with an indicator of closures of the Suez Canal.

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1. Introduction

Since the second half of 2020, shipping costs have soared. By October 2021, indicators of the cost of shipping containers by maritime freight had increased by over 500 percent from their pre-pandemic levels, while the cost of shipping bulk commodities by sea had tripled (Fig. 1).

Two main factors are responsible for this increase. On the one hand, the strong rise in demand for intermediate inputs on the back of stronger manufacturing activity raised the demand for container shipments. On the other, shipping capacity has been constrained by logistical hurdles and bottlenecks—often related to pandemic disruptions—and shortages in container shipping equipment. Unreliable schedules and port congestion have also led to a surge in surcharges and fees, including demurrage and detention fees.[1]

☆ The authors thank Tobias Adrian, Jihad Azour, Mai Dao, Rupa Duttagupta, Chris Erceg, Andrés Fernández, Gita Gopinath, Pierre Olivier Gourinchas, Petya Koeva-Brooks, Taehoon Kim, Daniel Leigh, Davide Malacrino, Paolo Mauro, Nikhil Patel, Andrea Pescatori, Rafael Portillo, Galen Sher, Cedric Tille, Charles Wyplosz, and seminar participants at the Inter-American Development Bank, the Korea Development Institute, and the Monetary Authority of Singapore for their helpful suggestions. We would like to thank the *JIMF* editor Mark Spiegel and two anonymous referees for excellent comments, which helped to improve the quality of the paper.

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[1] According to Attinasi et al. (2021), the rise in global container shipping costs largely reflects supply constraints for the first quarter of 2020 and stronger demand since the second quarter of 2020.

https://doi.org/10.1016/j.jimonfin.2022.102771
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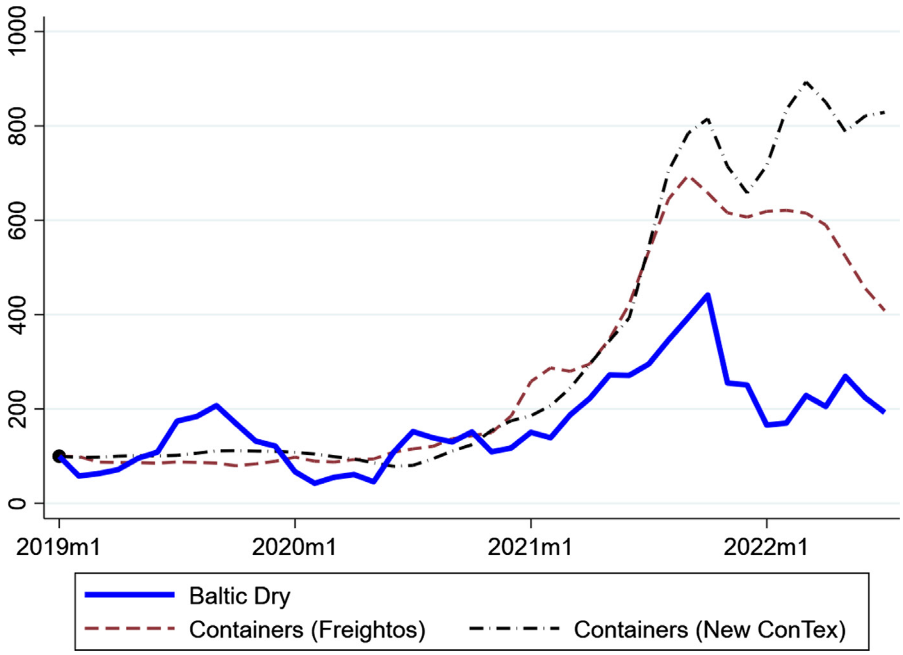


Fig. 1. Indices of shipping costs during the Covid-19 pandemic; January 2019 = 100. Source: Bloomberg. "Freightos" is the Freightos Global Container Index available since October 2016. "New ConTex" is the Container Ship Time Charter Assessment Index published by the Hamburg Shipbrokers' Association available since October 2007.

Increases in shipping costs could generate broad effects on consumer prices. First, they could directly affect import prices, as the local price of imported goods increases proportionately with the cost of shipping. This effect is likely to be nonnegligible, with goods imports amounting to some 38 percent of GDP on average in 2018 and associated freight costs to some 7.5 percent of the value of imported goods (Fig. A1). Freight costs vary greatly across countries—reaching over 15 percent of the value of imported goods in much of Sub-Saharan Africa and among small island states—and are decreasing in the level of GDP per capita and increasing in the country's weighted distance from its trading partners (Fig. A2). Second, an increase in the cost of shipping intermediate inputs generates additional cost pressures for producers, creating pressure to charge higher prices to domestic consumers. Finally, there could be second-round effects on core inflation when, for example, wage bargaining is indexed to past inflation.

Despite the attention to global supply chain disruptions in the media, increasing shipping costs and their role in driving inflation has been overlooked in the academic literature.[2] This stands in contrast to the attention given to studying the inflationary effects of global oil and metal commodity prices, as well as global food prices.

Our paper fills this gap in the literature by providing a systematic analysis of the effects of global shipping costs on domestic inflation in both advanced and developing economies, and examining how countries' structural factors and monetary policy frameworks shape these effects. For this purpose, we examine the response of different measures of domestic inflation—such as import prices, producer price inflation, core inflation, headline inflation and inflation expectations—to changes in the Baltic Dry Index (BDI). We do so using Jordà's (2005) local projection method. The BDI measures the average price paid to transport dry bulk materials (which accounts for about half of world trade according to UNCTAD, 2015) across more than 20 oceanic shipping routes. It has a longer time coverage than other measures of shipping costs, while being strongly correlated to them.

While the index is plausibly uncorrelated to domestic conditions in a small open economy, a possible concern in using changes in the BDI as measure of (exogenous) shocks to shipping costs is that freight rates may increase simply because of higher global demand for materials.[3] Another concern is that freight rates may increase in tandem with oil prices since

[2] See, for instance, "European retailers face goods shortages as shipping costs soar" (*Financial Times*, 31 January 2021), and "Why supply-chain problems aren't going away" (*The Economist*, 29 January 2022).

[3] For example, Jacks and Stuermer (2021) find that shipping demand shocks strongly dominate all others as drivers of real dry bulk freight rates over the long run: the average share of shipping demand shocks in explaining variation in real dry bulk freight rates is 49 percent while the average share of shipping supply shocks is 22 percent and the average share of fuel price shocks is 11 percent. Residual shocks absorb the remaining 18 percent of variation in the real dry bulk index.

the provision of shipping services uses bunker fuel oil as an input. We address these concerns in two ways. In the baseline, we include as a set of controls measures of global and country-specific demand as well as changes in global oil prices.[4] To further buttress a causal interpretation of our findings, we also run an Instrumental Variables (IV) estimation in which we instrument changes to shipping costs using closure events of the Suez Canal (through which approximately thirty percent of global container traffic passes).

The results, based on a sample of 46 countries from February 1992 to December 2021, suggest that increases in global shipping costs have non-negligible, persistent, and statistically significant effect on domestic inflation.[5] A one-standard-deviation (21.8 percentage points) increase in global shipping costs typically increases domestic headline inflation by 0.15 percentage point over 12 months. The effect increases gradually, peaks after 12 months, and reverts six months later. The response is similar for core inflation, but the magnitude of the effect is about one third of the effect on headline inflation. Responses for import and producer prices materialize much faster and are larger in magnitude.

These average effects vary according to country characteristics and monetary policy frameworks. First, as expected, the effect on headline inflation tends to be larger in countries with a higher share of imported final consumption. Second, the medium-term effect on headline and, especially, core inflation is more muted in countries characterized by monetary policy frameworks with track records of delivering low inflation. Reflecting these findings, inflationary impacts tend to be larger in small island and less developed economies.

Our paper relates to two main strands of the literature. The first pertains to the effects of shipping costs on inflation, and is quite limited. Herriford et al. (2016) use a structural vector autoregressive (SVAR) model to estimate the effect of shipping costs on core inflation for the US economy. They find that changes in shipping costs have a modest but statistically significant effect on core PCE inflation. The effect increases over time, peaking after 11 months. UNCTAD (2021) estimates the elasticities between shipping freight rates and CPI, using annual data for a large set of advanced and developing economies, and find that if container freight rates remain at the high levels observed in 2021, global consumer prices will be 1.5 percent higher than without the freight rate surge. OECD (2021) quantifies the impact of rising shipping costs on inflation by examining the pass-through of shipping costs to merchandise import price inflation, and the transmission of import price inflation to consumer price inflation. It finds that a persistent increase in shipping costs of about 50 percent would lead to an increase in CPI inflation of about 0.2 percentage point after four quarters. We build on this literature in several ways: (i) we look at a larger sample of countries; (ii) we rely on monthly data which are better suited to gauge the effect of the volatile shipping cost shocks; (iii) we examine a larger set of measures of inflation to better understand the transmission channels; (iv) we exploit exogenous variation in shipping costs that are orthogonal to demand conditions and to changes in commodity and fuel prices; and (v) we examine the role of countries' structural characteristics and monetary policy framework in shaping the inflation effect of shipping costs.

Our paper also ties into the literature on the effect of global oil and food price shocks on domestic inflation.[6] We complement this literature by comparing the inflationary effect of these shocks with those imparted by shipping costs. While the elasticity of inflation to shipping costs is smaller, shipping costs are much more volatile than oil or food prices. When we standardize the three shocks to one standard deviation, we find that the inflation effects are similar in magnitude but more persistent for shipping costs than those from oil and food price shocks. We also confirm the findings from this literature on the role of strong monetary policy frameworks in reducing second-round effects.

The rest of the paper is organized as follows. Section 2 provides a brief description of the data used in the analysis and presents the empirical methodology. Section 3 presents the main results and robustness checks including the IV results, and studies cross-country differences in the effect of shipping costs. Section 4 concludes.

2. Data and empirical methodology

2.1. Data

We proxy global shipping costs using the Baltic Dry Index (BDI)—see Fig. A3 for the evolution of the index since 1985. This index is created by the London-based Baltic Exchange (founded in 1744), and measures the average price paid to transport dry bulk materials across more than 20 oceanic shipping routes. The reason to use the BDI as our measure of shipping costs is twofold. First, the series offers a long comparable time series starting in January 1985 at daily frequency and covers 100 percent of the bulk dry cargo in transit on the world's oceans. Second, as argued by Jacks and Stuermer (2021), dry bulk markets are decentralized spot markets and dry bulk ship rates are likely to reflect real-time conditions in the supply of and demand for their services. On the other hand, the index does not incorporate information about goods that are shipped in containers

[4] We control for country-specific measures in economic activity, in addition to global output, as the price of dry bulk material is particularly sensitive to economic conditions in specific countries (e.g., China).

[5] Our main sample is an unbalanced panel of 46 countries with jointly available data on headline inflation, core inflation, producer prices and import prices. This allows us to present comparable responses for the four price series, but we show that results are robust when we use a full set of 143 countries with available CPI data over 1985 to 2021.

[6] For previous studies looking at the effect of global oil prices on inflation using a large sample of countries see, for example: LeBlanc and LeBlanc and Chinn (2004), Chen (2009), De Gregorio et al (2007), Habermeier et al. (2009), Caceres et al. (2012), Gelos and Ustyugova (2017), Choi et al. (2018). For previous studies examining the effect of global food prices on domestic inflation see, for example: Loungani and Swagel (2001), Guimaraes et al. (2010), Juvenal and Fawley (2011), Furceri et al. (2016).

or on liquid fuels that are transported by tankers. However, we find that in the period since 2016 for which we have overlapping data on BDI and on a container shipping price index compiled by Freightos, the correlation at a monthly frequency is very high (correlation coefficient of 0.85; see Appendix Table A1).

Our baseline sample contains monthly data since 1992 and covers 46 countries, of which 30 are classified as advanced economies and 16 as emerging economies. We determine the sample based on the joint availability of country-month observations for producer prices, import prices, core prices (excluding food and energy), and headline consumer prices. Doing so allows us to present comparable estimates for the responses of the four price series, but limits our ability to study a more diverse set of lower income countries, which do not tend to produce data on producer and import prices. Still, the cross-section of the data is sufficient to allow us to study cross-country variations in the channels of transmission for global shipping costs.

Table 1 provides summary statistics on the growth rate of domestic headline, core, producer and import prices in our baseline sample, while Table 2 provides summary statistics on the independent variables included in the analysis. Tables A2 and A3 present the list of countries included in the analysis and detailed information about data sources and methodology.

2.2. Empirical methodology

This section outlines the channels through which shipping costs may affect inflation to motivate the estimation strategy. The headline consumer price index, P_t, can be expressed as:

$$P_t = \left(P_t^D\right)^{1-\delta}\left(P_t^I\right)^{\delta}, \tag{1}$$

where I and D superscripts denote imported and domestically-produced goods and services, respectively; and δ is the share of imported goods in the CPI basket. Taking logs and first differences, we get:

$$\pi_t = (1-\delta)\Delta\log P_t^D + \delta\Delta\log P_t^I = (1-\delta)\pi_t^D + \delta\pi_t^I. \tag{2}$$

Shipping costs are thought to affect headline inflation through both arguments in Equation (2). First, there is a direct effect on π_t^I, as the local price of imported goods increases proportionately with the cost of shipping them from the exporter to the importer. This direct effect is a function of the ratio of shipping costs to overall product costs. For instance, the retail price of services would not be directly affected by shipping costs and a semi-conductor may be relatively insensitive to shipping costs, whereas the price of an imported car or refrigerator (expensive but bulky) may be highly sensitive to an increase in shipping costs.

The second, indirect effect is via domestically produced goods and services, whose prices may increase because they are produced using imported intermediate inputs. There could also be second round effects if, for instance, wage bargaining is indexed to past inflation. The indirect effect is affected by the degree to which inflation expectations are well anchored, the credibility of monetary policy, and the markups of firms.[7]

To estimate the impact of changes in shipping costs on inflation, we follow Jordà (2005) and estimate impulse response functions directly from local projections. This approach has been advocated by, among others, Stock and Watson (2007), Auerbach and Gorodnichenko (2013), and Nakamura and Steinsson (2018) as a flexible alternative that does not impose the dynamic restrictions embedded in vector autoregressive (or autoregressive distributed lag) specifications. For small open economies, shipping costs are expected to be exogenous, motivating our focus on reduced form parameters that do not distinguish the structural origin of the shock. For each horizon *k*, the following equation is estimated on monthly data:

$$\pi_{i,t+k} = \alpha_i^k + \sum_{j=1}^{l}\gamma_j^k\pi_{i,t-j} + \sum_{j=0}^{l}\beta_j^k w_{t-j} + \sum_{j=0}^{l}\theta_j^k X_{i,t-j} + \varepsilon_{i,t}^k, \tag{3}$$

with k the response horizon in months, π the year-over-year log change in a price index for country i[8]; w_t is defined as the month-over-month percent change in global shipping costs in month t; α_i^k is a vector of country fixed effects; β_o^k measures the impact of shipping on domestic inflation over the following k periods; and γ_j^k captures the persistence of domestic CPI inflation. X is a set of controls including the global output gap; country i's output gap; the month-over-month growth rate of global oil prices; and the month-over-month growth rate of global food prices. Including these variables in the specification helps to control for global demand affecting shipping costs and allows us to compare the magnitude of the inflationary effects of global shipping costs with those of other variables—such as global oil and food prices.

[7] The heterogeneity of the strength of direct and indirect effects across products is likely to provoke relative price adjustments following a rise in shipping costs. This includes a change in the relative price of goods with respect to services, which played an important role during the pandemic, and would make for an interesting area of future research.

[8] We exclude from all estimations the observations for which the dependent variable π lies below the 1st percentile or above the 99th percentile of the global empirical distribution over 1985 to 2021. Upon inspection, these observations generally belong to episodes of hyperinflation or economic collapse. Baseline results are robust to the use of a dependent variable defined as month-over-month log change (results available upon request).

Table 1
Summary statistics for the baseline sample.

	Headline (%)	Core (%)	Import prices (%)	Producer prices (%)
Full sample				
Mean	2.45	2.17	1.90	2.29
Std. dev.	2.91	2.60	9.53	5.90
N	10,349	10,349	10,348	10,349
Advanced economies				
Mean	1.78	1.59	1.13	1.37
Std. dev.	1.58	1.22	8.82	4.70
N	7,277	7,277	7,277	7,277
Emerging economies				
Mean	4.04	3.55	3.70	4.45
Std. dev.	4.36	4.07	10.84	7.63
N	3,072	3,072	3,071	3,072

Note: Country-month pairs with headline inflation below the first percentile or above the 99th percentile have been excluded.

Table 2
Summary statistics of additional variables in baseline and robustness estimations.

	1985–2021			2006–2021		
	N	Mean	Std. Dev.	N	Mean	Std. Dev.
Baltic Dry Index (mom % chg)	10,486	0.36	21.81	7,891	0.24	24.10
Global food price (mom % chg)	10,398	0.24	2.97	7,891	0.26	3.01
Global oil price (mom % chg)	10,486	0.34	10.71	7,891	0.09	11.48
Industrial production (mom % chg)	9,831	0.18	6.07	7,619	0.12	6.53
Inflation expectations (12 m ahead)	9,808	0.03	0.02	7,351	0.02	0.02
Output gap	10,486	−0.06	2.67	7,891	0.01	2.92
World output gap	10,486	−0.07	1.28	7,891	0.01	1.42
IT Dummy	10,486	0.73	0.45	7,891	0.78	0.41
Disagreement about inflation (12 m ahead)	7,876	0.34	0.32	6,201	0.33	0.30
Import share of domestic consumption	5,673	0.21	0.10	3,125	0.24	0.10

Note: All variables described at monthly frequency.

In our baseline specification, the number of lags (l) has been chosen to be equal to twelve, which controls for additive seasonal effects that may exist in the price series. Equation (3) is estimated for each horizon $k = \{0, 1, \ldots, 18\}$ using the ordinary least squares estimator. We estimate heteroskedasticity-robust standard errors clustered at the country level to account for cross-sectional dependence in the error term $\varepsilon_{i,t}^{k}$. The confidence bands are constructed using the standard errors of the β_{o}^{k} coefficients estimated for each horizon k.[9] We display impulse-responses that have been re-scaled for a one-standard-deviation shock to the Baltic Dry Index, and report the associated estimated elasticities in the Appendix.

3. Results

3.1. Baseline results

Table 3 presents the results obtained by estimating the impact of global shipping costs on domestic price indices in a common sample of 46 countries over the period February 1992–December 2021.[10] The results show a positive and statistically significant effect on all four domestic price indices. Fig. 2 illustrates the response of headline inflation following a one-standard deviation increase in the BDI, along with 90 and 95 percent confidence bands (shaded in grey). Global shipping costs have non-negligible, persistent and statistically significant effects on domestic inflation. A one-standard-deviation (21.8 percentage points) increase in global shipping costs typically increases domestic inflation by 0.15 percentage point over 12 months, and reverts in the subsequent six months. The elasticity of domestic inflation to global shipping costs is estimated to be 0.0067 at a horizon of 12 months, which is comparable to freight costs making up on average 0.3 percent of GDP and thus approximately 0.45 percent of household consumption.

Table 3 also reports the coefficients for our main control variables, and Fig. 3 shows the response of headline inflation to a one-standard deviation increase in oil prices (Panel A) and food prices (Panel B). While the elasticity of inflation to shipping

[9] While the presence of a lagged dependent variable and country fixed effects may in principle bias the estimation of the parameters of interests in small samples (Nickell, 1981), the length of the time dimension mitigates this concern. The finite sample bias is in the order of $1/T$, where the average T in the baseline sample is 358.

[10] All coefficients and standard errors have been rescaled for a one standard deviation shock to each independent variable. Fig. A4 shows the impulse-response function without rescaling, and are expressed as elasticities.

Table 3
Baseline estimates.

Headline inflation	*k* = 1	*k* = 3	*k* = 6	*k* = 12	*k* = 18
Shipping costs	0.01705*	0.06409***	0.08632***	0.14667***	0.08627***
	(0.00943)	(0.01646)	(0.01935)	(0.02234)	(0.02218)
Output gap	−0.00133	0.03963	0.17557**	0.19606**	0.11413*
	(0.04282)	(0.07940)	(0.08363)	(0.09711)	(0.06651)
World output gap	−0.00319	0.11551***	0.13096**	0.04840	−0.25255***
	(0.02715)	(0.03472)	(0.04897)	(0.04118)	(0.04761)
World oil price	0.14788***	0.14877***	0.11362***	0.11517***	−0.05282**
	(0.01320)	(0.01883)	(0.02004)	(0.02040)	(0.02138)
World food price	0.04292***	0.10423***	0.18127***	0.15720***	0.08792***
	(0.01276)	(0.02112)	(0.02568)	(0.02169)	(0.01774)
N	10,337	10,275	10,117	9,787	9,460
R^2	0.88	0.75	0.58	0.24	0.17

Note: Coefficients and standard errors have been rescaled to reflect a one-standard-deviation change in each independent variable. Heteroskedasticity-robust standard errors clustered at the country level are reported in parentheses. ***, **, and * denote statistical significance at 99, 95, and 90 percent confidence levels.

Core inflation	*k* = 1	*k* = 3	*k* = 6	*k* = 12	*k* = 18
Shipping costs	0.00571	0.02198**	0.02463*	0.04807***	0.05047***
	(0.00668)	(0.01103)	(0.01366)	(0.01837)	(0.01642)
Output gap	0.03916**	0.08606***	0.18388***	0.24949***	0.13283**
	(0.01659)	(0.02576)	(0.03986)	(0.05688)	(0.05536)
World output gap	−0.00097	0.02784	−0.00487	−0.04051	−0.04357
	(0.01995)	(0.02096)	(0.03064)	(0.03826)	(0.05143)
World oil price	0.01974**	0.02088*	0.00448	−0.01111	−0.03844*
	(0.00791)	(0.01234)	(0.01295)	(0.01708)	(0.02231)
World food price	0.01053	0.03204***	0.06189***	0.07089***	0.04654***
	(0.00711)	(0.01135)	(0.01569)	(0.01722)	(0.01198)
N	10,217	10,134	9,947	9,574	9,209
R^2	0.90	0.79	0.62	0.31	0.21

Note: Coefficients and standard errors have been rescaled to reflect a one-standard-deviation change in each independent variable. Heteroskedasticity-robust standard errors clustered at the country level are reported in parentheses. ***, **, and * denote statistical significance at 99, 95, and 90 percent confidence levels.

Producer price inflation	*k* = 1	*k* = 3	*k* = 6	*k* = 12	*k* = 18
Shipping costs	0.14722***	0.24206***	0.27033***	0.29089***	0.16058***
	(0.03683)	(0.04229)	(0.04436)	(0.04246)	(0.03563)
Output gap	0.01982	0.18944*	0.33437***	0.02219	−0.43803**
	(0.06723)	(0.09550)	(0.11254)	(0.21716)	(0.18627)
World output gap	0.01623	0.35044***	0.32408***	−0.40164***	−1.49166***
	(0.07685)	(0.11318)	(0.11618)	(0.14547)	(0.14000)
World oil price	0.50461***	0.53182***	0.54364***	0.34579***	−0.29007***
	(0.06842)	(0.06854)	(0.06831)	(0.06011)	(0.06821)
World food price	0.06210	0.36099***	0.64567***	0.53841***	0.13766***
	(0.03904)	(0.06596)	(0.09838)	(0.05683)	(0.04866)
N	10,325	10,242	10,081	9,757	9,432
R^2	0.87	0.71	0.49	0.22	0.16

Note: Coefficients and standard errors have been rescaled to reflect a one-standard-deviation change in each independent variable. Heteroskedasticity-robust standard errors clustered at the country level are reported in parentheses. ***, **, and * denote statistical significance at 99, 95, and 90 percent confidence levels.

Import price inflation	*k* = 1	*k* = 3	*k* = 6	*k* = 12	*k* = 18
Shipping costs	0.10454	0.23434**	0.24332**	0.37763***	0.00945
	(0.07454)	(0.09583)	(0.11516)	(0.10038)	(0.06202)
Output gap	−0.11040	0.05798	−0.08649	−0.41123*	−0.62759**
	(0.19205)	(0.17802)	(0.21037)	(0.23713)	(0.28499)
World output gap	−0.10689	0.82070***	0.69861***	0.14652	−1.53151***
	(0.19619)	(0.24593)	(0.22477)	(0.21337)	(0.22983)
World oil price	0.64208***	0.65552***	0.70668***	0.37444***	−0.49572***
	(0.11071)	(0.11587)	(0.10459)	(0.09295)	(0.12483)
World food price	−0.12382	0.20476*	0.46901***	0.63773***	0.17304*
	(0.09154)	(0.12096)	(0.14304)	(0.09867)	(0.09567)
N	10,246	10,069	9,822	9,371	8,956
R^2	0.55	0.42	0.29	0.13	0.10

Note: Coefficients and standard errors have been rescaled to reflect a one-standard-deviation change in each independent variable. Heteroskedasticity-robust standard errors clustered at the country level are reported in parentheses. ***, **, and * denote statistical significance at 99, 95, and 90 percent confidence levels.

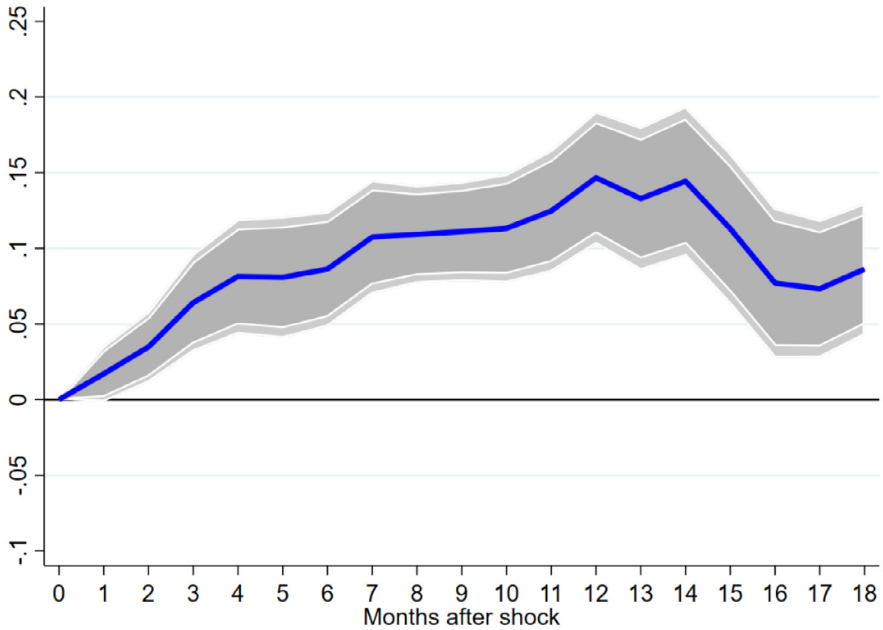


Fig. 2. The impact of shipping costs on measures of national inflation (percentage points). Note: The figure presents the impact of a one standard deviation increase in world shipping costs on domestic headline inflation in the baseline sample of 46 economies. The solid line is the impulse response function (IRF); the dark shaded region indicates the 90 percent confidence band; the light shaded region indicated the 95 percent confidence band. $t = 0$ denotes the year of the shock.

costs is smaller than the elasticity to oil and food prices (Fig. A4), shipping costs are much more volatile, with a standard deviation of 21.8 percentage points versus 10.8 and 3.0 percentage points for oil and food, respectively. The inflationary effects due to variation in global shipping costs are thus quantitatively similar to those generated by variations in global oil and food prices, with the three variables making similar contributions to the overall variation in inflation. The impact on inflation from the BDI is more persistent, however, with inflation rising gradually before reaching its peak after 12 months. In contrast, about 90 percent of the impact on inflation following an oil price shock materializes within four months, while the impact from a food price shock peaks after seven months. One potential explanation is that shipping costs—unlike food and oil—are not sold directly to consumers, but are rather paid by intermediaries who embed their costs into the prices of all traded goods. In standard macroeconomic models with price frictions, such as the staggered price setting assumption proposed by Calvo (1983), pass-through involving the re-adjustment of many prices would take longer to fully materialize than pass-through involving a smaller number of goods.

3.2. Effect on inflation measures

Fig. 4, Panel A reports the response of core inflation to a global shipping cost shock. The response is statistically significant at horizons beyond 6 months, but only a third as large as the impact on headline inflation. The persistence of the response of core inflation is similar to that of headline inflation, and builds gradually until peaking at 14 months.

Fig. 4, Panels B and C report the responses of producer and import prices, which are highly statistically significant at all horizons up to 12 months. The impact of a one-standard-deviation increase in global shipping costs on these prices is stronger, peaking at an impact of 0.3–0.4 percentage point after 12 months. The response materializes much faster than for headline and core inflation, with over 90 percent of the impact in place within four months of the shock.[11]

These results help to understand better the dynamic effects of shipping costs on headline inflation. Following an increase in shipping costs, import prices rise strongly and quickly, and are quickly passed through to producer prices. The response of core inflation—which excludes food and energy—builds more slowly, and peaks 12 months after the shock. The impact on headline prices follows a similar pattern and tapers off after 12 months, when import and producer price inflation return to their pre-shock levels.

[11] Import prices have been converted where necessary to be expressed in local currency. Note that there are certain differences in methodologies used for constructing import price indices across countries. For instance, in the case of the United States, import price indices are based on free-on-board prices and thus do not include ocean freight costs.

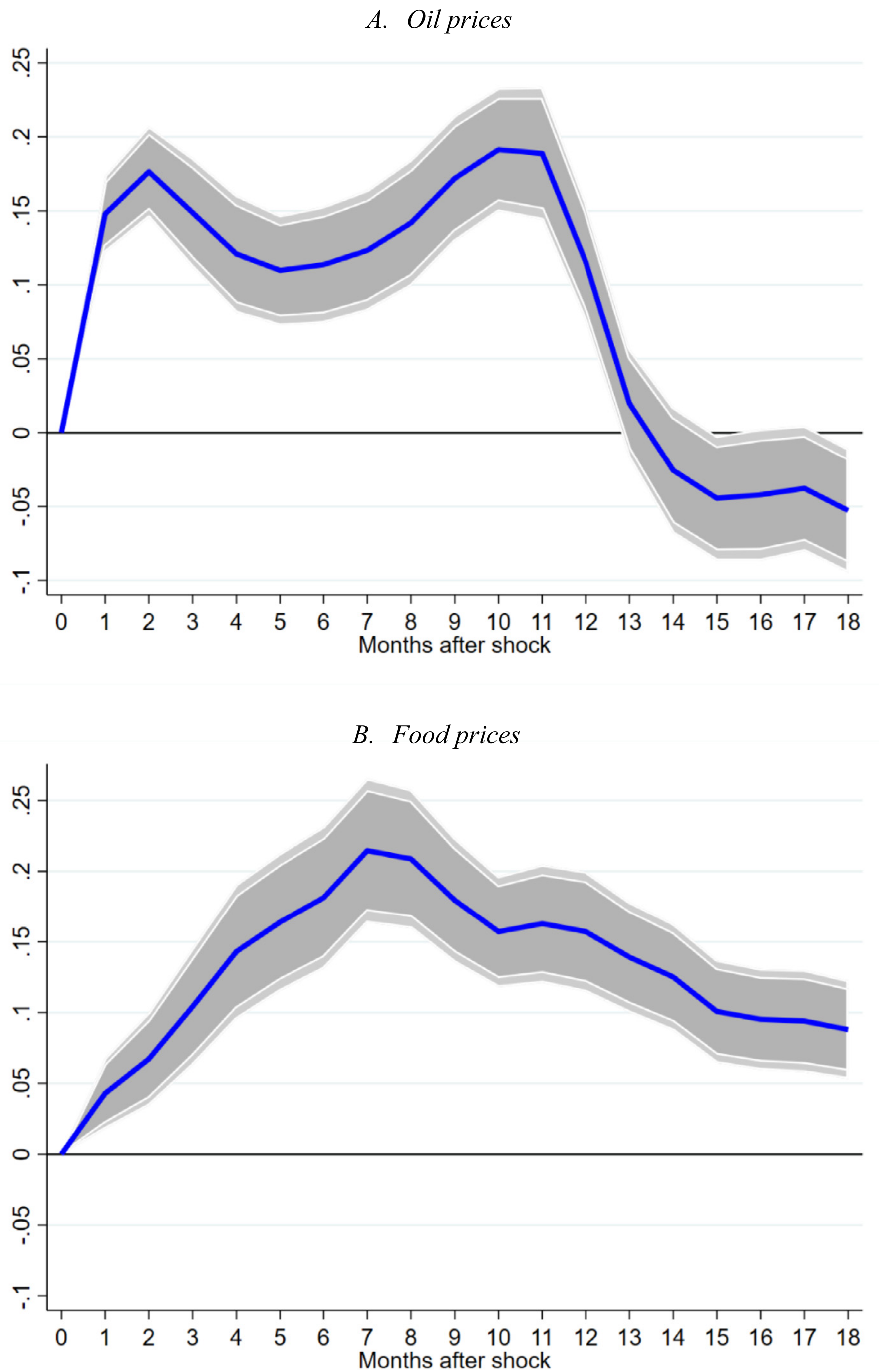


Fig. 3. Impact of global oil and food prices on headline inflation (percentage points). Note: The figures present the impact of one standard deviation increases in each shock on domestic headline inflation in the baseline sample of 46 economies. The solid blue lines are the impulse response functions (IRF); the dark shaded regions indicate the 90 percent confidence bands; the light shaded regions indicate the 95 percent confidence bands. $t = 0$ denotes the year of the shock. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Finally, in Fig. 4, Panel D we look at the effect of shipping costs on inflation expectations at a 12-month horizon. A one-standard-deviation increase in shipping costs is followed by an increase in inflation expectations by about seven basis points, which is highly statistically significant. The response of inflation expectations is also highly persistent, rising until 12 months after the shock and returning to zero after 16 months.

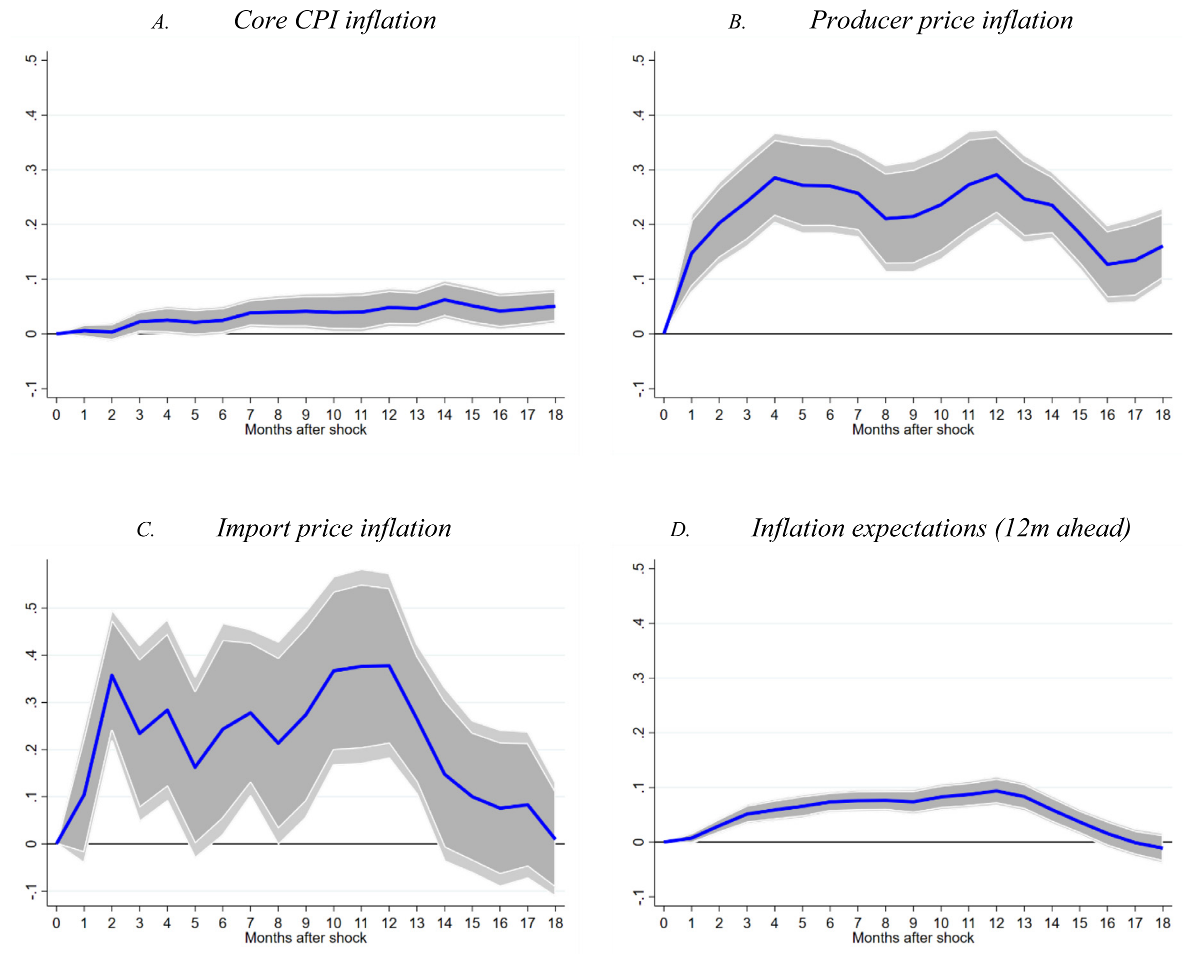


Fig. 4. Impact of shipping costs on measures of national inflation (percentage points). Note: The figures present the impact of one standard deviation increase in shipping costs on measures of domestic price inflation in the baseline sample of 46 economies. The solid blue lines are the impulse response functions (IRF); the dark shaded regions indicate the 90 percent confidence bands; the light shaded regions indicate the 95 percent confidence bands. $t = 0$ denotes the year of the shock. In the case of Panel D, data are available for 43 economies and the sample size is reduced from 10,336 to 9,691 at horizon $h = 1$. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

3.3. Robustness checks

Our baseline sample is an unbalanced panel of 46 countries with jointly available data on headline inflation, core inflation, producer prices and import prices. This allows us to present comparable responses for the four price-series, but we wish to ensure that the sample composition does not drive the results. For this purpose, we re-estimate equation (3) for a full set of 143 countries with available CPI data over 1985–2021. Fig. A5, Panel A, shows that the results based on this larger unbalanced sample are similar to those presented in the baseline, with a one-standard-deviation shock to shipping costs following by an increase in headline inflation of 0.2 percentage points after 12 months. We then estimate equation (3) on a balanced panel of 63 countries that have complete time series for headline inflation from January 1990 to December 2021, reporting the estimated response function in Fig. A5, Panel B. Here again, the results are both qualitatively and quantitatively consistent with the baseline results.

We implement a number of robustness checks to examine the validity of the baseline specification. We begin by estimating variations of equation (3) with different control variables in the vector X. In the first robustness model, we include the growth rate of industrial production for country i—which provides a monthly-frequency measure of domestic activity instead of the quarterly-frequency estimate of the output gap in our baseline model—as well as the growth rate of China's industrial production alongside the world output gap. In the second robustness model, we include the VIX index of equity market volatility as an additional control variable, which has been identified as a driver of the global financial cycle with strong effects on investment in advanced and emerging economies.[12] In the third model, we include the nominal effective

[12] Carrière-Swallow and Céspedes (2013) document how shocks to the VIX lead to large falls in investment in emerging economies, partly because of financial constraints in countries with shallower financial systems.

exchange rate as an additional control variable. In all three models, we also include 12 lags of the additional variables. Fig. A6 displays the responses of headline inflation following a one-standard-deviation shock to shipping costs in each of these three robustness models, and confirms that the baseline results are consistent to these alternative specifications. Finally, we re-estimate the baseline using alternative measures of shipping costs, including the major indices of container shipping prices, and plot the response of headline inflation in Fig. A7. The result that shipping cost increases lead to large and persistent increases in headline inflation is confirmed using all three alternative measures.

In a second exercise, we present an IV estimation, using closures of the Suez Canal to deliver variation in global shipping costs not driven by global demand. Approximately thirty percent of global container traffic transits through the Suez Canal, and alternative sailing routes add weeks to crossing times. Even brief closures cause major disruptions to global trade. We identify-three episodes of traffic disruption during our estimation window: November 2004 when the oil tanker Tropic Brilliance ran aground in the canal, causing a blockage for around three days; February 2006 when a cargo ship drifted at a wrong angle inside the Suez Canal during a sandstorm and blocked transit for a day; and the most recent episode in March 2021 when the canal was blocked for six days after the grounding of the Ever Given container ship. For our baseline, we take into account the severity of the number of days the canal was blocked during each episode, but our results continue to hold if we just treat the month of the blockage as a dummy variable or account for the amount of cargo affected. Since these blockages were a result of exogenous and unexpected accidents, we can be reasonably confident that they are not caused by global demand, thus addressing concerns about reverse causality. The blockages were associated with significant increases in the BDI, highlighting the strength of our instrument.[13]

The instrument is likely to be plausibly exogenous and to satisfy the exclusion restriction criteria. Indeed, we find that adding the instrument as an additional control to the baseline specification (which includes the BDI) does not alter the effect of the BDI on inflation. Similarly, the instrument is not statistically significant when regressed against the residuals from the baseline regression. Both exercises suggest that the instrument is exogenous and does not have a direct influence on inflation beyond its effect on the BDI. The first-stage estimates suggest that this instrument is also "strong". The regression of log changes in the BDI on our measure of Suez Canal blockage yields a t-statistic of over 25. In addition, the Kleibergen-Paap rk Wald F statistic—which is equivalent to the *F-effective* statistic for the non-homoskedastic error in case of one endogenous variable and one instrument (Andrews et al., 2019)—obtained in the panel estimates is much higher than the associated Stock-Yogo critical value for estimation horizon k. The results from the IV estimates in Table 4 confirm our baseline results and show a significant impact on consumer prices that increases over the estimation horizon, with a large impact over the 6- to 18-month horizon. When we use the IV estimation to confirm the results for other domestic prices, we find that core inflation, PPI, and import prices all rise significantly as well.

Our instrument is associated only with increases in shipping costs, but does not capture episodes of exogenous decreases. To allow for asymmetry in the inflationary response according to the sign of the change in shipping costs, we estimate specifications that interact the instrument with the Baltic series that is equal to or less than zero, and another that is greater than zero.[14] We estimate this specification by OLS and by instrumental variables, and report the results in Fig. A8. The OLS specification suggests that falls in shipping costs provoke more persistent impacts at horizons beyond 12 months. However, both specifications confirm the strong and persistent impact of shipping cost increases on headline inflation.

3.4. Heterogeneity across income and regional country samples

We check whether the effect of shipping costs on domestic inflation differs by income groups and across regions. We separately estimate equation (3) for each group of countries, distinguishing advanced, emerging, and low-income economies per the classification presented in the IMF's World Economic Outlook, and regions (Asia, Latin America, and Europe; landlocked countries; and island states in the Caribbean and Pacific). We use all available data from 143 countries starting in 1985 to study regions and groupings that are not represented in our baseline results.[15]

Fig. 5 reports the response of headline inflation across country groups and overlays them against the baseline results discussed above. In Panel A, we show the results when we split the sample according to income group classification for advanced, emerging, and low-income economies. The effect of shipping costs is somewhat smaller in the sample of advanced economies than among emerging and developing countries, which in turn see a smaller effect than the group of low-income countries. This is consistent with the evidence in Fig. A2 that freights costs are decreasing in the level of GDP per capita, as well as with studies from the literature on the inflationary impacts of world oil, food, and exchange rate shocks, which have found lower pass-through in advanced economies in line with stronger monetary policy frameworks (Choi et al., 2018; Furceri et al., 2016; Carrière-Swallow et al., 2021). However, the precision of the estimates does not allow us to reject the null hypothesis that the point estimates for these groups are equal to those in the baseline.

In Panel B, we report the responses across regional groups. There is some evidence that the impact of shipping costs on headline inflation is larger in Latin America and Asia than in European economies, and somewhat larger in landlocked coun-

[13] This result is robust to additional controls in this regression as well as higher lags of the blockage. Similar results are also obtained when using a 0/1 dummy for month of blockage or accounting for amount of cargo affected.

[14] Asymmetry in pass-through from external shocks to domestic inflation are documented in Auer and Mehrotra (2014) and Choi et al. (2018).

[15] As a robustness check, we also estimate these group differences using our baseline sample of 46 countries to ensure that the results are not driven by the difference in the time-series dimension between two groups, reporting results in Fig. A7.

Table 4
Instrumental variable estimation results.

	k = 1	k = 3	k = 6	k = 12	k = 18
Fitted shipping costs	−0.0038	0.0249	0.1072***	0.0991**	0.1315***
	(0.0105)	(0.0173)	(0.0314)	(0.0457)	(0.0366)
Output gap	−0.0138	−0.0165	0.0692	0.0794	0.0503
	(0.0585)	(0.1011)	(0.1610)	(0.1288)	(0.0652)
World output gap	−0.0097	0.0707	−0.1115	−0.2965	−0.7268***
	(0.0356)	(0.0626)	(0.0942)	(0.1934)	(0.1438)
World oil price	0.1393***	0.0837	−0.0523	−0.0771	−0.1602***
	(0.0314)	(0.0839)	(0.1447)	(0.1221)	(0.0362)
World food price	0.0639***	0.1280***	0.1484**	0.1861	−0.0465
	(0.0175)	(0.0371)	(0.0620)	(0.1313)	(0.0482)
N	10,409	10,371	10,247	9,983	9,714
R^2	0.99	0.96	0.85	0.51	0.09
1st stage: F stat	66.5	69.1	74.1	11.6	23.1

Note: Heteroskedasticity-robust standard errors clustered at the country level are reported in parentheses. ***, **, and * denote statistical significance at 99, 95, and 90 percent confidence levels. Coefficients and standard errors have been rescaled to provide the response to a one standard deviation shock to each independent variable.

tries than in those with direct access to ocean ports. By far the largest response of headline inflation is found in our sample of island countries—that is, those with largest distance from trading partners (Fig. A2)—where the maximum impact is more than twice as large as the baseline. We study some of the causes of this heterogeneity across country groups in Section 3.7.

3.5. The effects of global shipping costs on inflation over time

The estimates presented above for the full sample period may mask a change in the response of domestic inflation to changes in global shipping costs over time. To assess this, we re-estimate equation (3) for two successive 15-year sample periods: 1990–2005 and 2006–2021, using the expanded sample of 143 economies. The results presented in Fig. 6 suggest that the impact of shipping costs on headline inflation has remained unchanged over the two periods. While the coefficients for the earlier sample are less precisely estimated—the response is not statistically significant at the 95 percent confidence level—the responses for both periods peak between 10 and 13 months, with the more recent sample showing a peak impact of 0.15. While the earlier period peaks slightly higher, we cannot reject the null hypothesis that these responses are equal in magnitude at all horizons. The consistent strength of the response over time stands in contrast to the literature's findings of significant declines in the pass-through of oil prices (Choi et al., 2018; De Gregorio et al., 2007) and exchange rate changes to domestic inflation (Carrière-Swallow et al., 2021). This may reflect two offsetting factors: while monetary policy frameworks have been strengthened and inflation expectations better anchored, there has been a gradual increase in the trade openness of countries, including the establishment of deeper global supply chains (Fig. A8). We explore this possibility in the next section.

3.6. Non-linearity in the size of shipping cost fluctuations

The literature on exchange rate pass-through has found that larger shocks tend to result in higher rates of pass-through to consumer prices, particularly in emerging market economies (Caselli and Roitman 2019). We investigate whether shipping costs also have non-linear effects on consumer prices by augmenting equation (3) by introducing a quadratic term:

$$\pi_{i,t+k} = \alpha_i^k + \sum_{j=1}^{l} \gamma_j^k \pi_{i,t-j} + \sum_{j=0}^{l} \beta_j^k w_{t-j} + \varphi^k Sign(w_t) \cdot w_t^2 + \sum_{j=0}^{l} \theta_j^k X_{i,t-j} + \varepsilon_{i,t}^k, \tag{4}$$

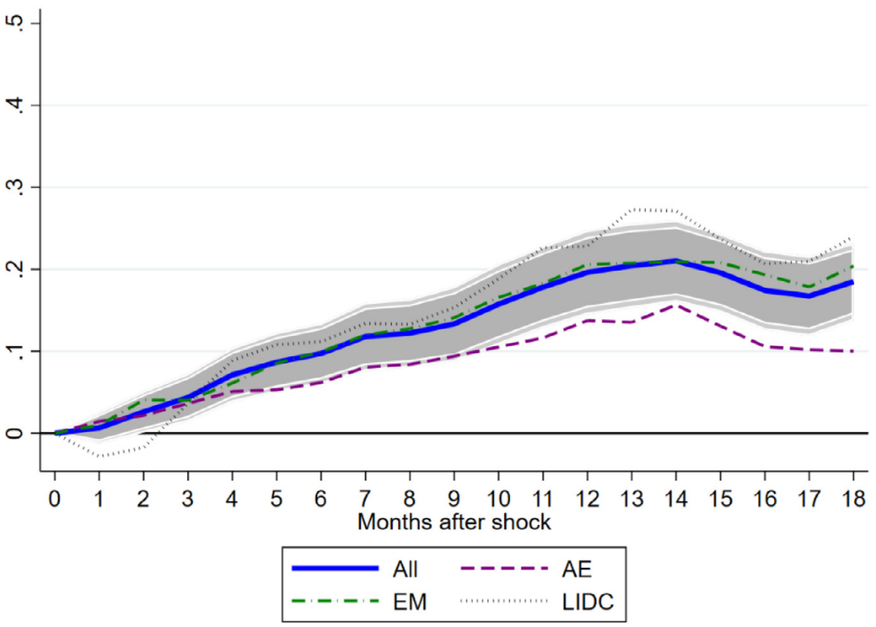
where the coefficient φ^k captures possible non-linear effects from large fluctuations in global shipping costs. We report the results from this estimation in Table 5, and as above the coefficients and standard errors have been re-scaled to reflect responses to one standard deviation changes.

We find that non-linearities are significant only in the first five months following an increase in global shipping costs. Larger increases in shipping costs lead to faster pass-through to headline inflation. However, for horizons of six to 15 months, the quadratic term is no longer significant, such that larger fluctuations have the same elasticity as smaller ones. At the longer horizon of 18 months, the quadratic term's sign is inverted and the coefficient is highly significant, such that larger fluctuations have smaller impact on inflation.

3.7. Factors affecting the pass-through of shipping costs to inflation

The results presented so far have revealed some heterogeneity in the inflationary effect of shipping costs across countries and over time. In this section, we investigate the role of two characteristics that we expect to determine the effect on head-

Panel A. By income group



Panel B. By geographic region

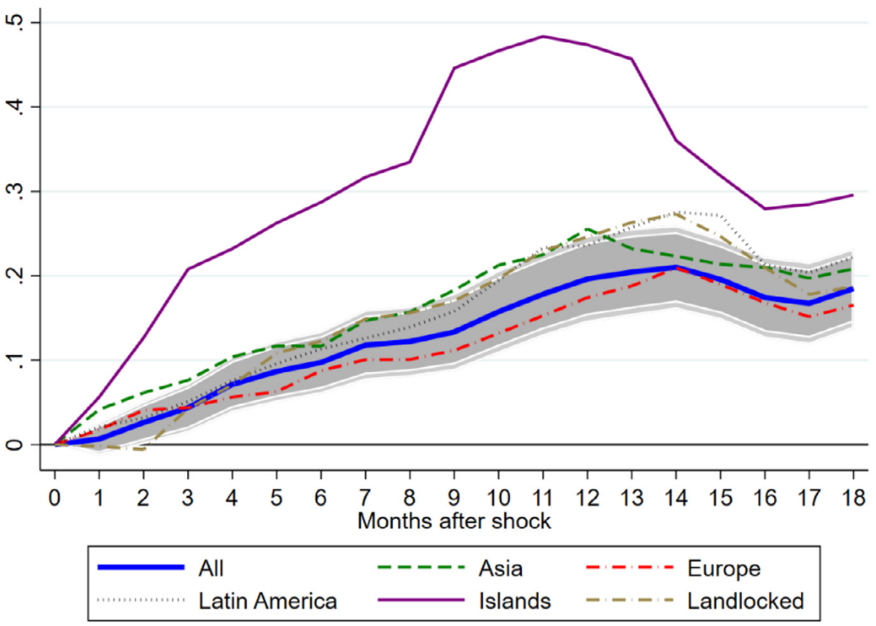


Fig. 5. Impact of shipping costs on headline inflation; by country groups (percentage points). Note: The figures present the impact of one standard deviation increase in shipping costs on domestic headline inflation in an augmented sample of 143 economies. The solid blue lines are the impulse response function (IRF) for the full sample; the dark shaded regions indicate the 90 percent confidence bands; the light shaded regions indicate the 95 percent confidence bands. The dotted lines are the IRFs for sub-samples, with countries grouped by income (Panel A) and geographic region (Panel B). $t = 0$ denotes the year of the shock. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

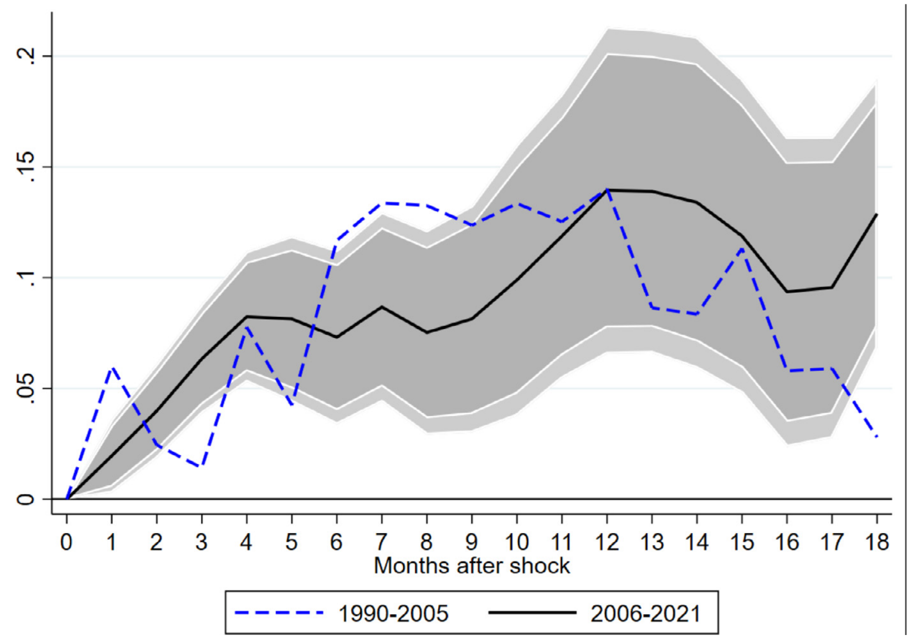


Fig. 6. Impact of shipping costs on headline inflation; by change over time (percentage points). Note: The figure presents the impact of one standard deviation increase in shipping costs on domestic headline inflation. The dashed blue line shows the response for the augmented sample of 143 economies in the early period and the solid black line shows the same for the later period; the dark shaded region indicates the 90 percent confidence band for the later period; the light shaded region indicated the 95 percent confidence band for the later period. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 5
Non-linear effects of shipping costs.

	k = 1	k = 3	k = 6	k = 12	k = 18
Shipping costs (linear)	−0.0271*	−0.0198	0.0619**	0.1301***	0.1681***
	(0.0140)	(0.0218)	(0.0272)	(0.0287)	(0.0362)
Shipping costs (quadratic)	0.0540***	0.1028***	0.0300	0.0203	−0.0993***
	(0.0191)	(0.0255)	(0.0325)	(0.0333)	(0.0355)
Output gap	−0.0042	0.0339	0.1740**	0.1950**	0.1224*
	(0.0425)	(0.0780)	(0.0832)	(0.0973)	(0.0661)
World output gap	−0.0141	0.0953***	0.1248**	0.0441	−0.2360***
	(0.0267)	(0.0337)	(0.0496)	(0.0418)	(0.0481)
World oil price	0.1466***	0.1461***	0.1128***	0.1150***	−0.0519**
	(0.0132)	(0.0186)	(0.0196)	(0.0204)	(0.0213)
World food price	0.0403***	0.0991***	0.1798***	0.1559***	0.0932***
	(0.0128)	(0.0212)	(0.0257)	(0.0227)	(0.0187)
N	10,337	10,275	10,117	9,787	9,460
R^2	0.88	0.75	0.58	0.24	0.17

Note: Results from estimation of equation (4). Heteroskedasticity-robust standard errors clustered at the country level are reported in parentheses. ***, **, and * denote statistical significance at 99, 95, and 90 percent confidence levels. Coefficients and standard errors have been rescaled to provide the response to a one standard deviation shock to each independent variable.

line inflation: the importance of imports in the domestic economy; the degree of integration into global supply chains; and the strength of the monetary policy framework. To test for these factors, we estimate an augmented version of equation (3):

$$\pi_{i,t+k} = \alpha_i^k + \sum_{j=1}^{l} \gamma_j^k \pi_{i,t-j} + \sum_{j=0}^{l} \sum_{b} I_b(Y) \beta_j^k w_{t-j} + \sum_{j=0}^{l} \theta_j^k X_{i,t-j} + \varepsilon_{i,t}^k. \tag{5}$$

The dummy variables $I_b(Y)$ denote bins of data defined over the empirical distribution of each state variable Y. These are interacted with the Baltic Dry Index variable to estimate how its impact on π changes for different values of Y.

We start estimating equation (5) for the *Share of domestic final consumption that is imported*. The inflationary impact of changes in global shipping costs are expected to depend on the share of imported goods in final domestic consumption. We measure this variable using the EORA global input–output table. For each country, we use the average value of the ratio for each country over the available data period of 1990–2014. We then define three bins of data: (i) countries in the first quartile; (ii) countries in the second and third quartiles; and (iii) countries in the fourth quartile. Fig. 7 shows the response of headline inflation (Panel A) and core inflation (Panel B) to a one-standard-deviation shock to shipping costs for the first and third bins. We find that the impact of an increase in shipping costs is larger in countries with a high import share of domestic consumption (over 24.6 percent). For the response of core inflation, the difference between the coefficients for these two bins is statistically significant at horizons between 13 and 16 months.[16]

We then explore the role of a country's integration into global supply chains, introducing an interaction term for the *Degree of backward integration into supply chains as a share of total imports*. This is measured using the EORA global input–output table, and is defined as the share of foreign value added that is used as inputs for producing exports. We define two bins of data with the sample cut at the median. Fig. 8 shows the response of headline inflation (Panel A) and core inflation (Panel B) to a one-standard-deviation shock to shipping costs for low and high degrees of integration. We find that the responses of headline and core inflation are significantly larger for countries with greater backward integration. In fact, countries with low integration see no statistically significant response of core inflation following fluctuations to shipping costs.

We then look at monetary policy frameworks. A very simple proxy for the strength of monetary policy regimes is a summary measure of the central bank's track record at delivering price stability. Countries with a recent history of above-target (or high) inflation are likely to have less anchored inflation expectations, in part because they may perceive exogenous shocks as being more persistent. For example, firms in a high inflationary environment tend to perceive global oil price shocks as being more persistent than firms in a low inflationary environment (Taylor, 2000). We use the average inflation rate in the 1990s to split the sample at the median into "high" and "low past inflation" bins. Fig. 9 presents results from this interaction with high and low bins for the response of four measures of domestic prices. It shows that countries that experienced low inflation during the 1990s have similar levels of pass-through to headline, producer price, and import price inflation. However, there is a statistically significant difference between the responses of core inflation for these two groups (Panel B). Whereas economies with high past inflation see a substantial increase in core inflation of about 0.08 after 14 months, those with low past inflation see virtually no pass-through to core inflation (0.025 after 14 months). We interpret this result as signaling the importance of sound monetary policy for mitigating the pass-through of shipping costs to domestic prices through indirect channels, including second-round effects, but also its relative inability to affect pass-through through direct channels.

To test the robustness of this result, we estimate interactions using three alternative—and arguably more precise—proxies for strong monetary policy frameworks:

Inflation targeting regime: when a central bank strives to hold inflation at some numerically specified level, it helps anchor inflation expectations, thereby reducing the impact of global shocks on domestic inflation. IMF (2015) and Furceri et al. (2016) find that a country with inflation targeting tends to have a lower impact of inflation surprises on inflation expectations. Fig. 10 shows the response of headline inflation (Panel A) and core inflation (Panel B) interacted by an inflation targeting dummy. The impact of an increase in shipping costs is larger in countries without inflation targeting regimes than in those with an inflation targeting regime. For the response of headline and core inflation, the differences between the coefficients for these two bins are statistically significant.

Estimated anchoring of inflation expectation: For a similar reason, inflation of a country with well-anchored inflation expectations (a smaller response of inflation expectations to inflation surprises) is likely to be less affected by changes in global oil prices. We use an estimate for the degree of anchoring of inflation expectations provided by Choi et al. (2022). Their methodology relies on the inverse of the initial response of inflation expectations to inflation surprises using private sector inflation survey data between 1990 and 2014. We split the sample at the median of the empirical distribution to construct two bins. Fig. 11 presents results from this interaction with high and low estimated anchoring of inflation expectations, showing that again the response of headline inflation is similar across these two groups, but that the response of core inflation is much stronger where inflation expectations are poorly anchored. The difference between the coefficients for these two bins is statistically significant.

Disagreement about future inflation among professional forecasters: Several papers in the literature have proposed that the disagreement among professional forecasters provides a proxy for the anchoring of inflation expectations (e.g. Capistrán and Ramos-Francia, 2010; Dovern, Fritsche and Slacalek, 2012; Brito et al., 2018). We split the sample at the median to construct two bins. Fig. 12 presents the results for the interactions with low and high disagreement. It shows that there is modestly lower pass-through of shipping costs to headline and core inflation among those countries who have lower disagreement, indicating that inflation expectations are better anchored. The difference between the coefficients for these two bins is statistically significant.

To further check the role of strong monetary policy frameworks in reducing second-round inflationary effects, we estimate the response of wages to shipping costs. We do so using a similar specification as equation (3) for headline inflation, applied to a sample of 18 countries with annual data for the period 1985–2021—we use annual data as monthly or quarterly data on wages are not widely available.[17] The results show that while there is evidence of second-round effects for the sample—with wages rising for one year following an increase in shipping costs (Fig. A9, Panel A)—these effects are larger in countries where inflation expectations are less anchored (Fig. A9, Panel B).

[16] Motivated by the positive correlation between remoteness and freight costs shown in Fig. A2 and results for island countries, we also estimated an interaction with the weighted distance from a country's trading partners. However, we found that this did not lead to statistically significant differences in the responses of prices to shipping costs, especially when removing island countries. Results are available upon request.

[17] The 18 countries are: Austria, Belgium, Czech Republic, Finland, France, Germany, Greece, Italy, Japan, Norway, Poland, Portugal, Serbia, Slovenia, South Korea, Spain, United Kingdom, and United States. The variable used is total labor compensation from the IMF's World Economic Outlook.

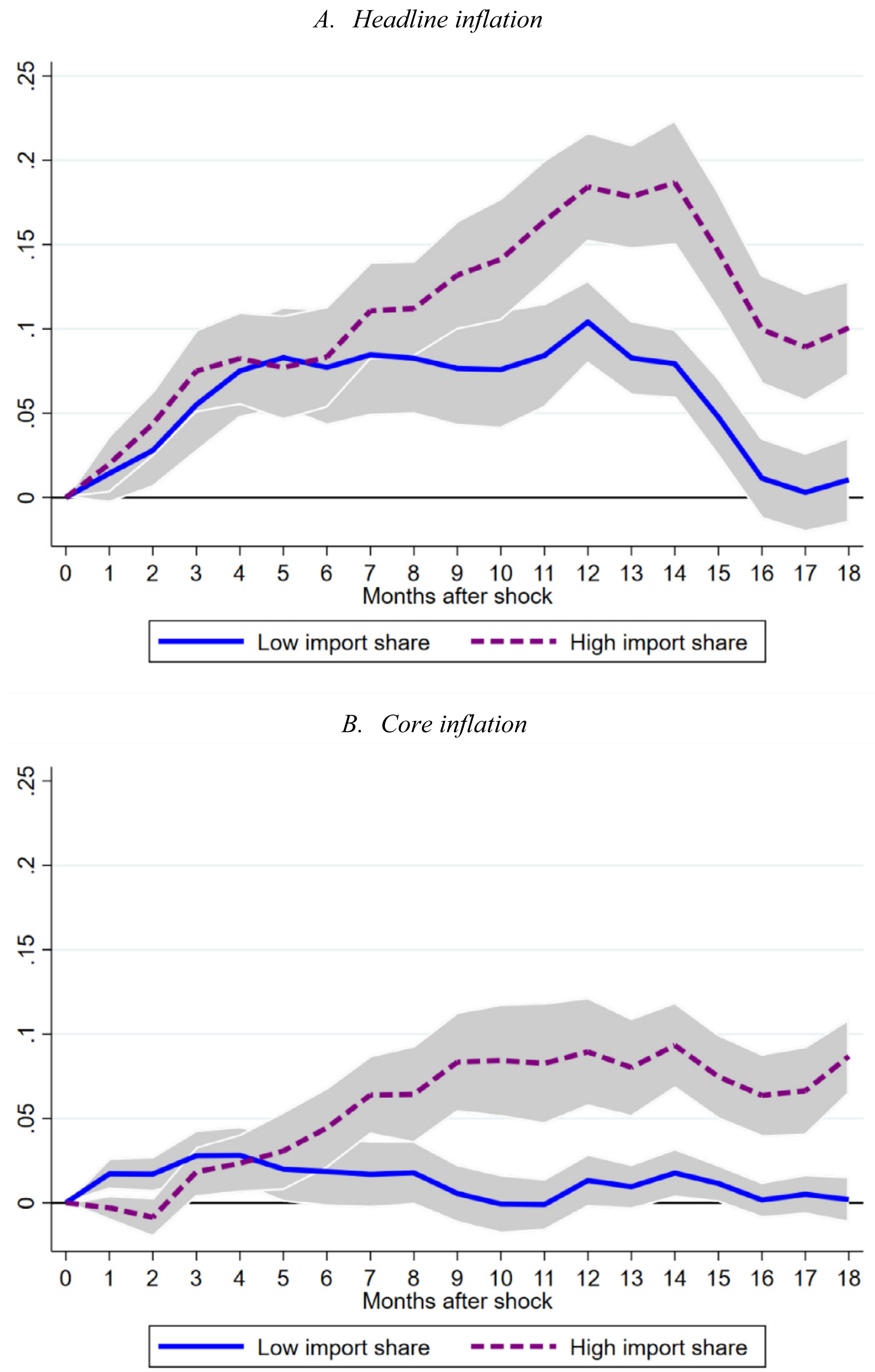
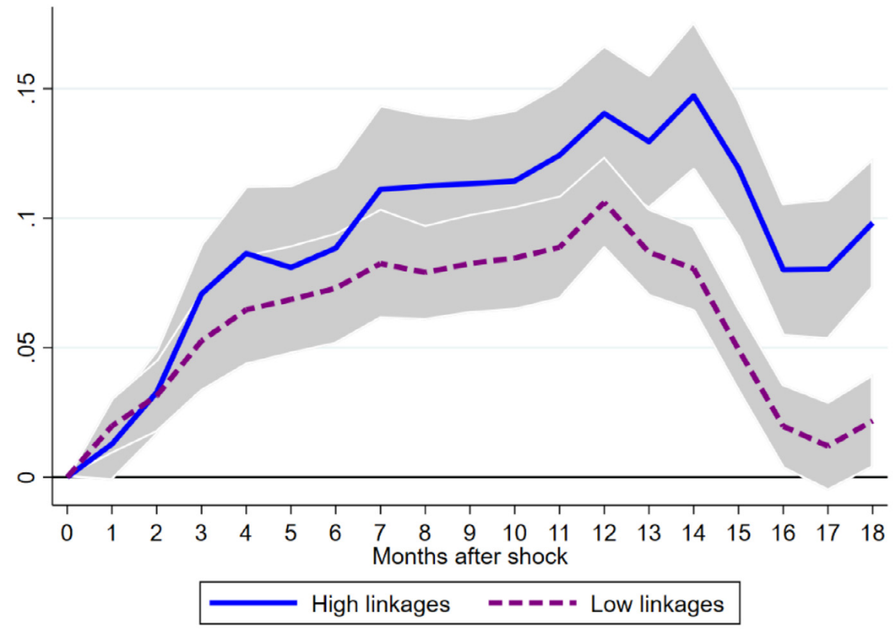


Fig. 7. Response of domestic prices; interaction with import content. Note: The figures present the impact of one standard deviation increase in shipping costs on measures of domestic price inflation in the baseline sample of 46 economies, where the shipping costs variable has been interacted with a dummy variable indicating bins of data over the import share of domestic consumption. The dashed purple lines are the impulse response functions (IRF) for countries with an import share in the fourth quartile; the solid blue lines are the IRFs for countries with an import share in the first quartile. The shaded regions indicate one standard error bands. $t = 0$ denotes the year of the shock. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

As a robustness check, we estimate all interaction specifications using time fixed effects instead of the global control variables. We then multiply the Baltic Dry shock with a dummy variable for one of the bins of data to estimate each interacted effect. Table A4 reports the estimated coefficients on the interaction terms, considered one at a time (Panel A). All interaction

A. Headline inflation



B. Core inflation

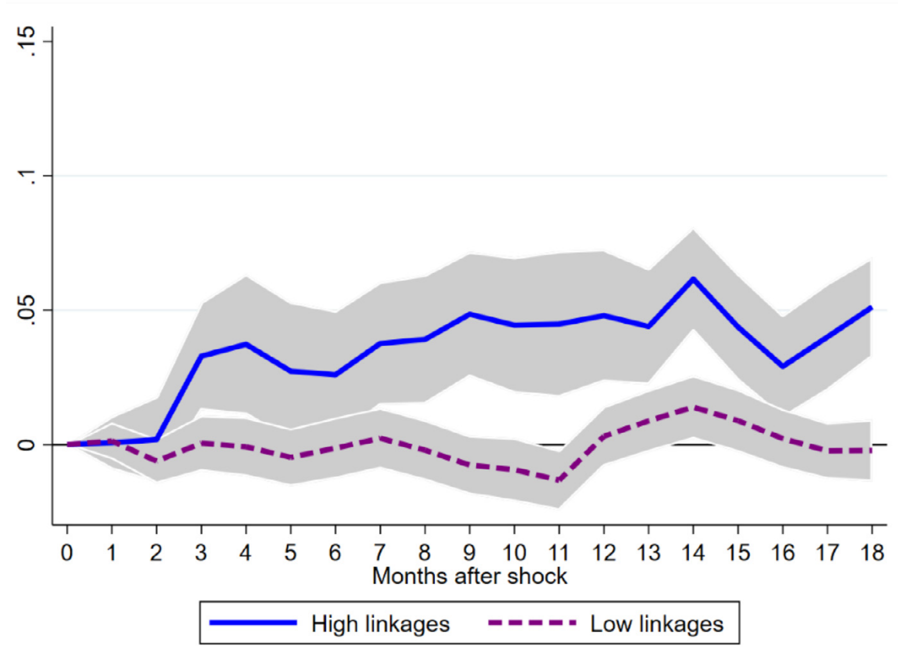


Fig. 8. Response of domestic prices; interaction with backward GVC linkages. Note: The figures present the impact of one standard deviation increase in shipping costs on measures of domestic price inflation in the baseline sample of 46 economies, where the shipping costs variable has been interacted with bins of data over the degree of backward linkages in global value chains as a share of total imports. The solid blue lines are the impulse response functions (IRF) for countries with above-median linkages; the dashed purple lines are the IRFs for countries with below-median linkages. The shaded regions indicate one standard error bands. $t = 0$ denotes the year of the shock. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

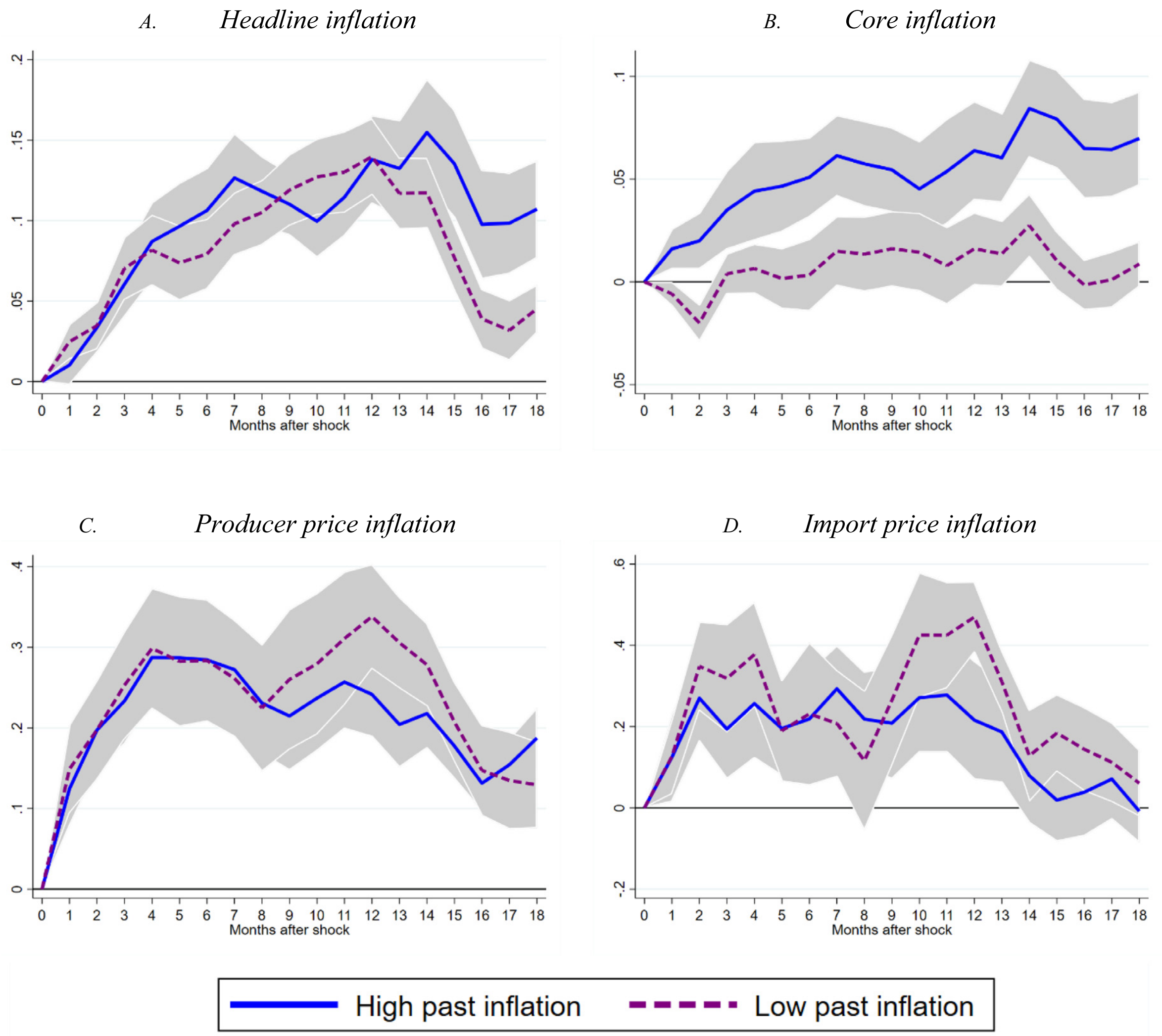


Fig. 9. Response of domestic prices; interaction with average inflation in 1990s. Note: The figures present the impact of one standard deviation increase in shipping costs on measures of domestic price inflation in the baseline sample of 46 economies, where the shipping costs variable has been interacted with a dummy variable indicating bins of data over the average inflation rate in the 1990s. The dashed purple lines are the impulse response functions (IRF) for economies with past inflation below the median; the solid blue lines are the IRFs for economies with past inflation above the median. The shaded regions indicate one standard error bands. $t = 0$ denotes the year of the shock. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

terms have statistically significant positive coefficients at some horizon, usually between 9 and 18 months. As an additional robustness check, we estimate a specification that contains time fixed effects and all the interaction terms together (Panel B). The interaction terms for the import share of consumption and average past inflation are both highly significant determinants of the responses of headline and core inflation, but the interaction terms on the alternative proxies of monetary policy are generally not significant, due to high collinearity.

Our final robustness check is a more stringent exercise to test whether the impact of the monetary policy regime matters independently of the level of underlying inflation. The three proxies for strong monetary policy frameworks considered above are correlated, and may be endogenous to the inflation regime—for instance, inflation targeting may emerge where inflation has tended to be low already. We follow Colombo et al. (2022) in estimating a set of specifications with a triple interaction between shipping costs, the long-term level of inflation, and either the dummy for an inflation targeting regime or the level of disagreement among professional forecasters of inflation (Fig. A12). The long-term level of inflation in this exercise corresponds to the average level of inflation for each country within our estimation period (1992–2021), and we split the sample at the median. For countries with high average inflation levels, the adoption of inflation targeting reduces the pass-through of shipping costs to headline inflation at horizons between 11 and 18 months. And for countries with low

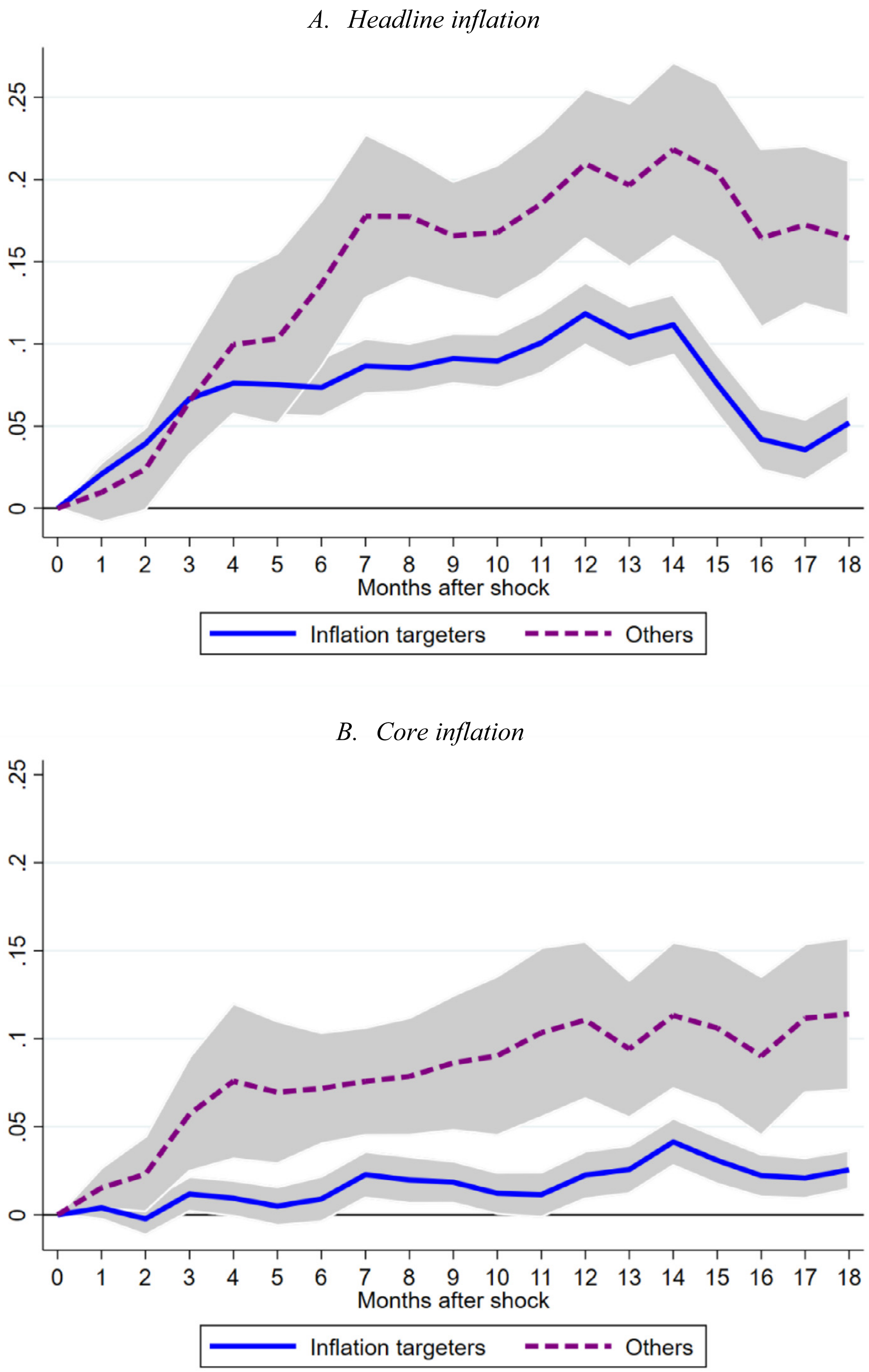


Fig. 10. Response of domestic prices; interaction with inflation targeting regime dummy. Note: The figures present the impact of one standard deviation increase in shipping costs on measures of domestic price inflation in the baseline sample of 46 economies, where the shipping costs variable has been interacted with a dummy variable indicating an inflation targeting regime. The solid blue lines are the impulse response functions (IRF) for countries with inflation targeting regimes; the dashed purple lines are the IRFs for countries with other monetary policy frameworks. The shaded regions indicate one standard error bands. $t = 0$ denotes the year of the shock. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

average inflation levels, greater disagreement increases the pass-through of shipping costs to headline inflation at horizons of 6–18 months. These results confirm the important and independent role of monetary policy frameworks, even when conditioning for the inflation regime.

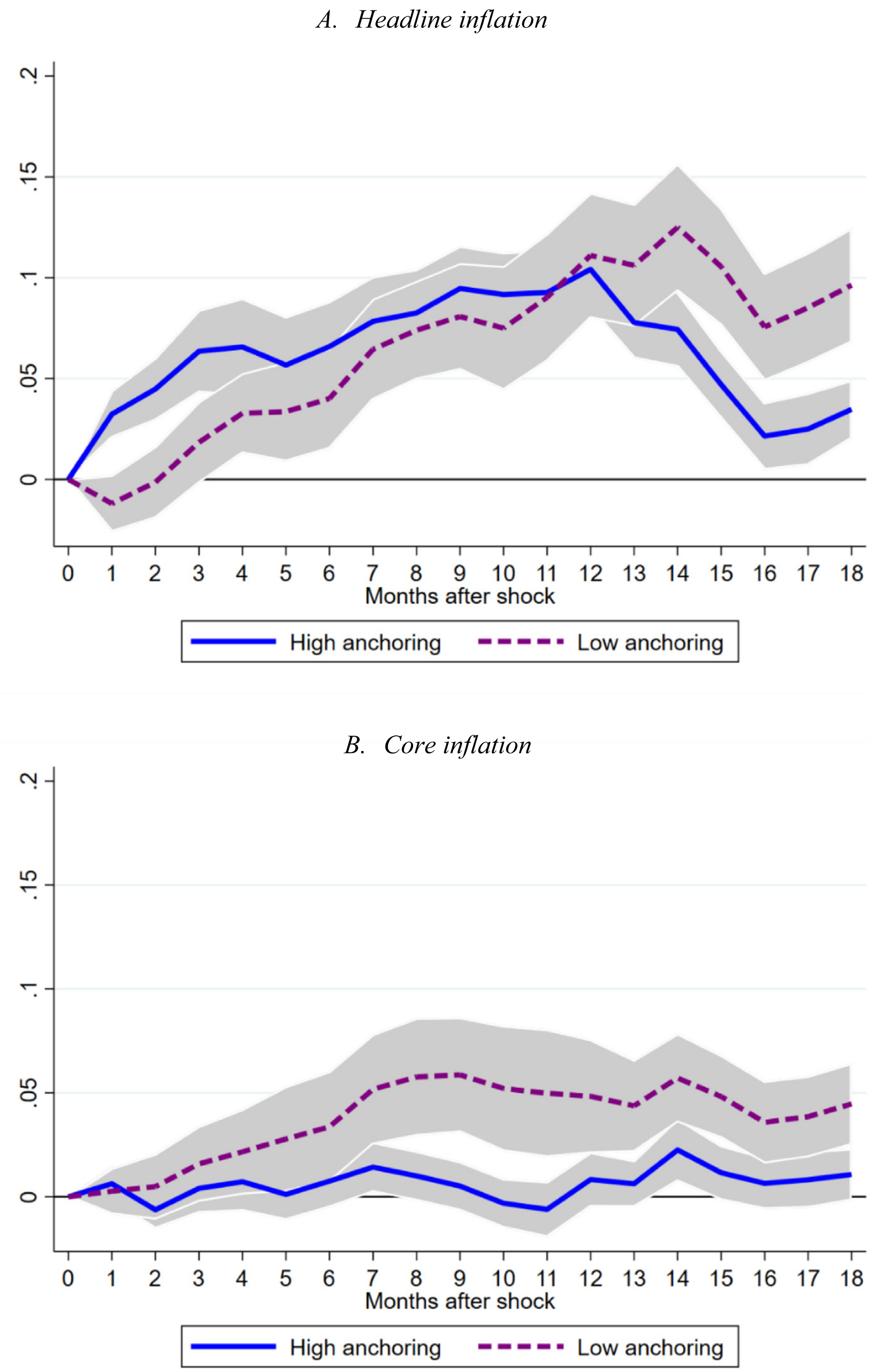


Fig. 11. Response of domestic prices; interaction with estimated anchoring of inflation expectations. Note: The figures present the impact of one standard deviation increase in shipping costs on measures of domestic price inflation in the baseline sample of 46 economies, where the shipping costs variable has been interacted with a dummy variable indicating bins of data over an estimate for the degree of inflation anchoring from Choi et al. (2022). The dashed purple lines are the impulse response functions (IRF) for countries with anchoring below the median; the solid blue lines are the IRFs for countries with anchoring above the median. The shaded regions indicate one standard error bands. $t = 0$ denotes the year of the shock. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

4. Conclusions

This paper investigates the impact of global shipping cost movements on domestic inflation since 1992. We have described the strength and sequence of the transmission of these fluctuations through import prices, producer prices, and

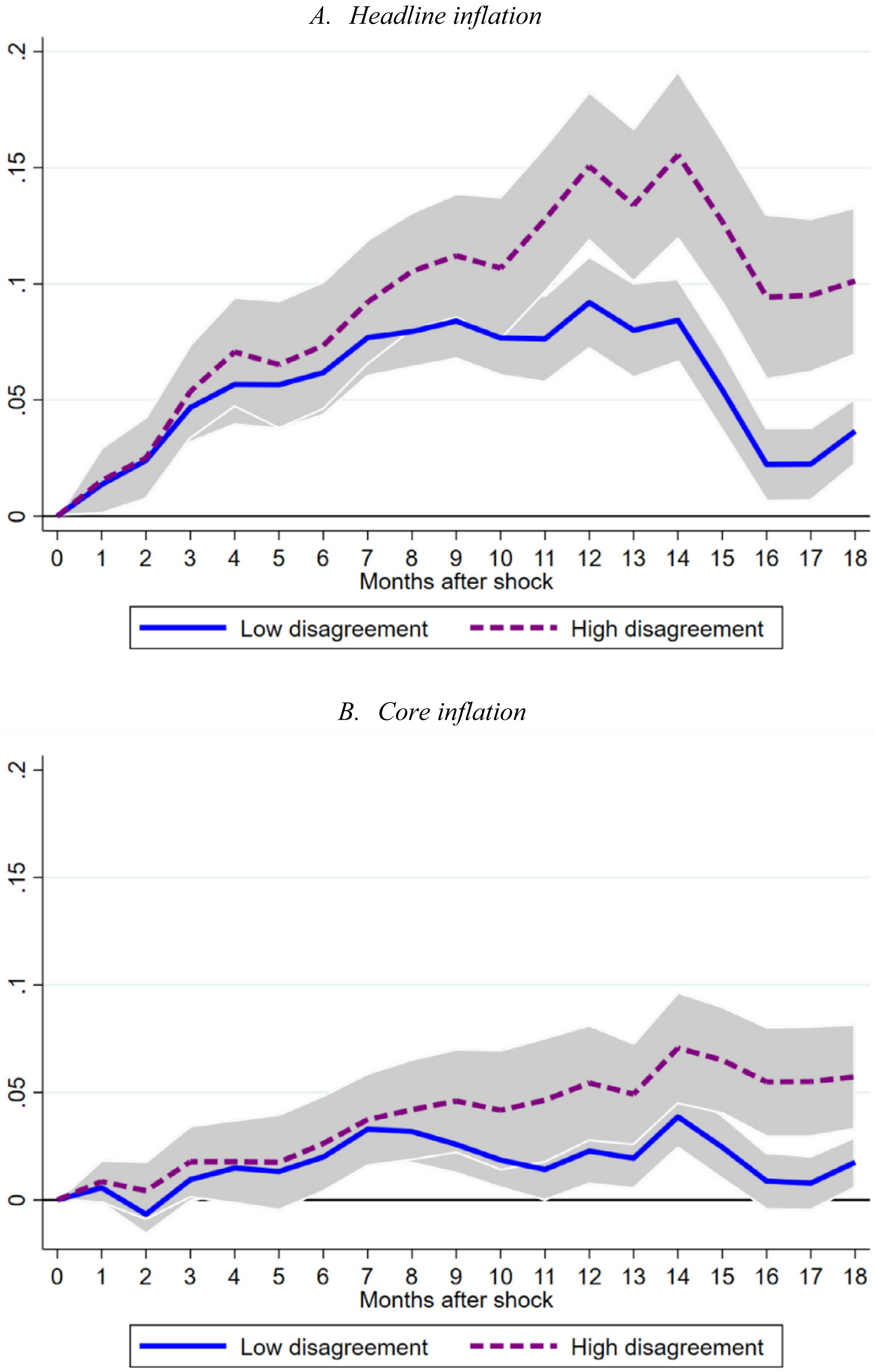


Fig. 12. Response of domestic prices; interaction with disagreement among professional forecasters of inflation. Note: The figures present the impact of one standard deviation increase in shipping costs on measures of domestic price inflation in the baseline sample of 46 economies, where the shipping costs variable has been interacted with a dummy variable indicating bins of data over the disagreement among professional forecasts of inflation reported by Consensus Economics. The dashed purple lines are the impulse response functions (IRF) for countries with disagreement above the median; the solid blue lines are the IRFs for countries with past inflation below the median. The shaded regions indicate one standard error bands. $t = 0$ denotes the year of the shock. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

into core and headline inflation. We have also explored how the pass-through has changed over time, how it varies across countries, and which factors may influence such differences.

Our main finding is that a one-standard-deviation increase in global shipping costs increases domestic headline inflation by about 0.15 percentage point, with the effect building up over the course of 12 months. Unlike many other pass-throughs that have been studied in the literature, this effect appears to have remained strong over time, perhaps reflecting the increased openness of countries to international trade.

We find that the strength of the pass-through from shipping costs to domestic inflation depends crucially on the import share of domestic consumption; the degree of integration into global supply chains; and on the strength of the monetary framework. This is consistent with observed heterogeneity across countries groups, with larger impacts in emerging-market and low-income countries that tend to have weaker monetary frameworks, and highest impact of all among small-island countries which rely heavily on imported goods.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix

See Figs. A1–A12 and Tables A1–A5.

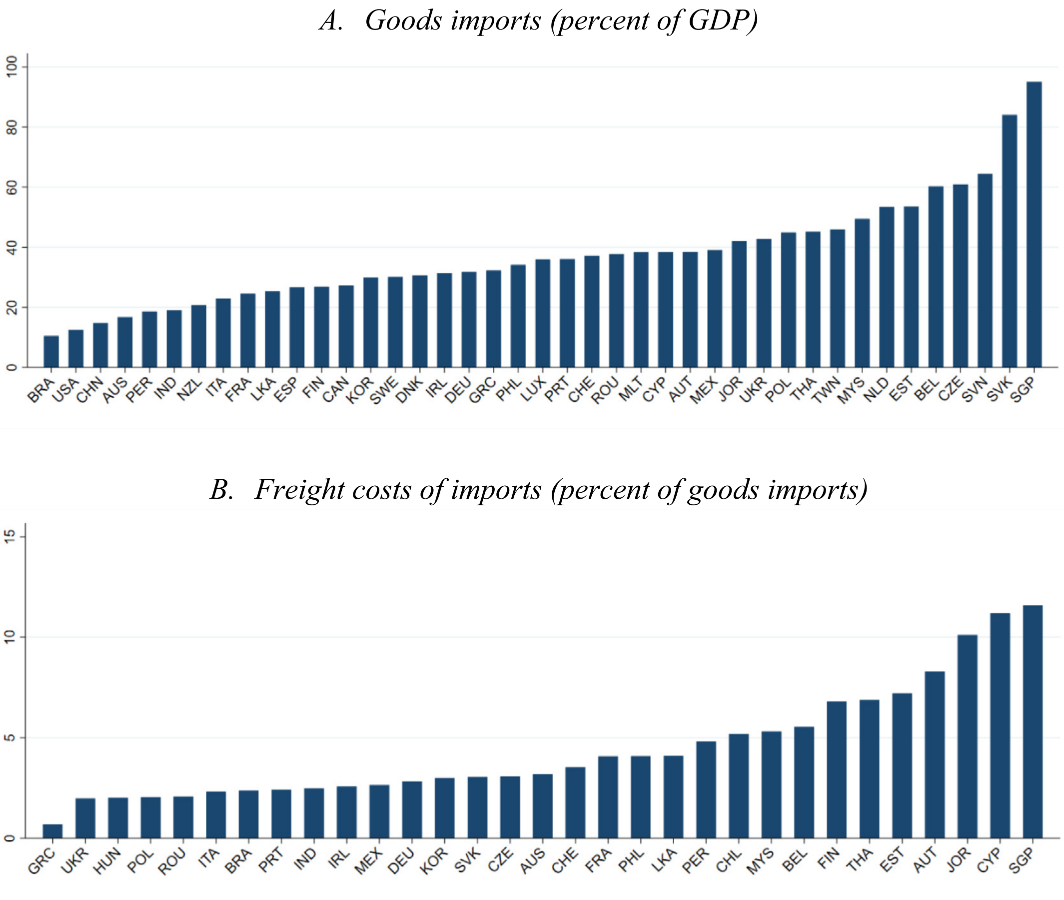


Fig. A1. Import intensity and spending on freight; 2018. Source: IMF World Economic Outlook and Balance of Payments Statistics. Note: Displaying non-missing values in 2018 for the 46 countries in our baseline sample.

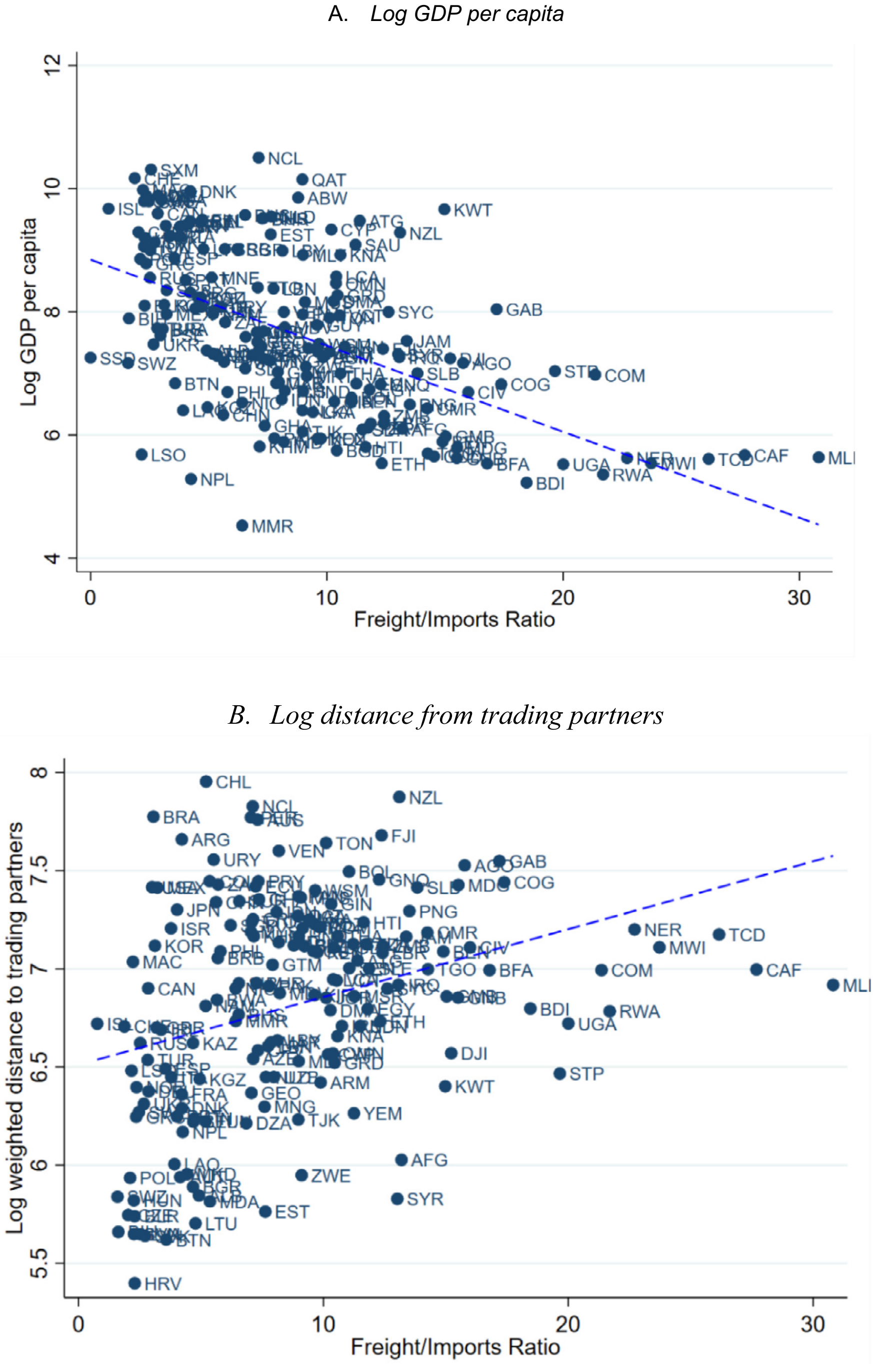


Fig. A2. Correlates of freight costs; 2005–18 average. Source: IMF World Economic Outlook and Balance of Payments Statistics. Note: Values for freight costs and for GDP per capita are period averages over 2005–18. Trade-weighted distance is constructed using bilateral distances from Mayer and Zignago (2011) and weighted by total bilateral goods trade in 2019. The dashed blue lines correspond to the fitted values from linear models with a constant term. For panel A, the slope coefficient is −0.14 and the R^2 is 0.31. For panel B, the slope coefficient is 0.035 and the R^2 is 0.11. In both cases, the null hypothesis that the slope coefficient is equal to zero can be rejected with a p-value smaller than 0.001.

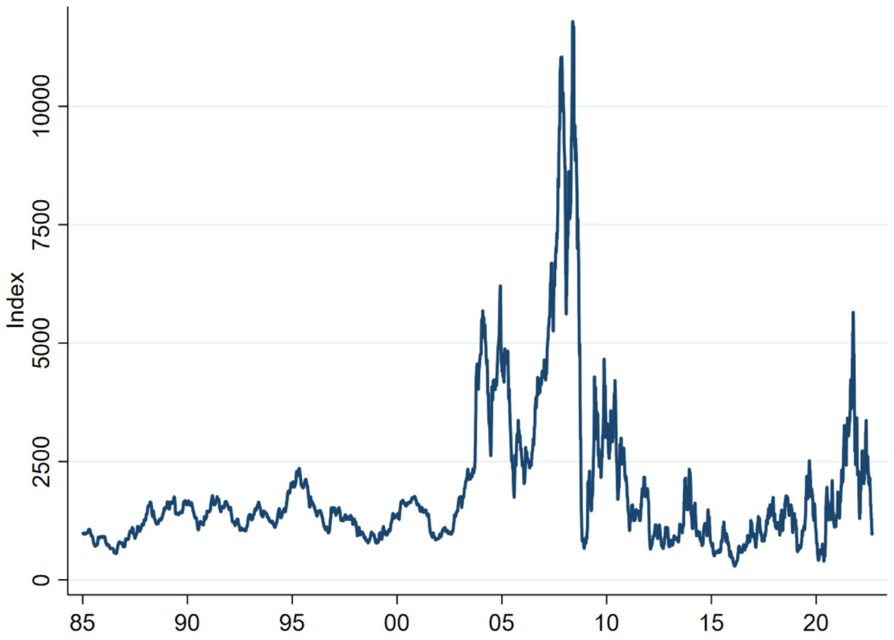


Fig. A3. Baltic Dry Index, January 1985–September 2022. Source: Bloomberg.

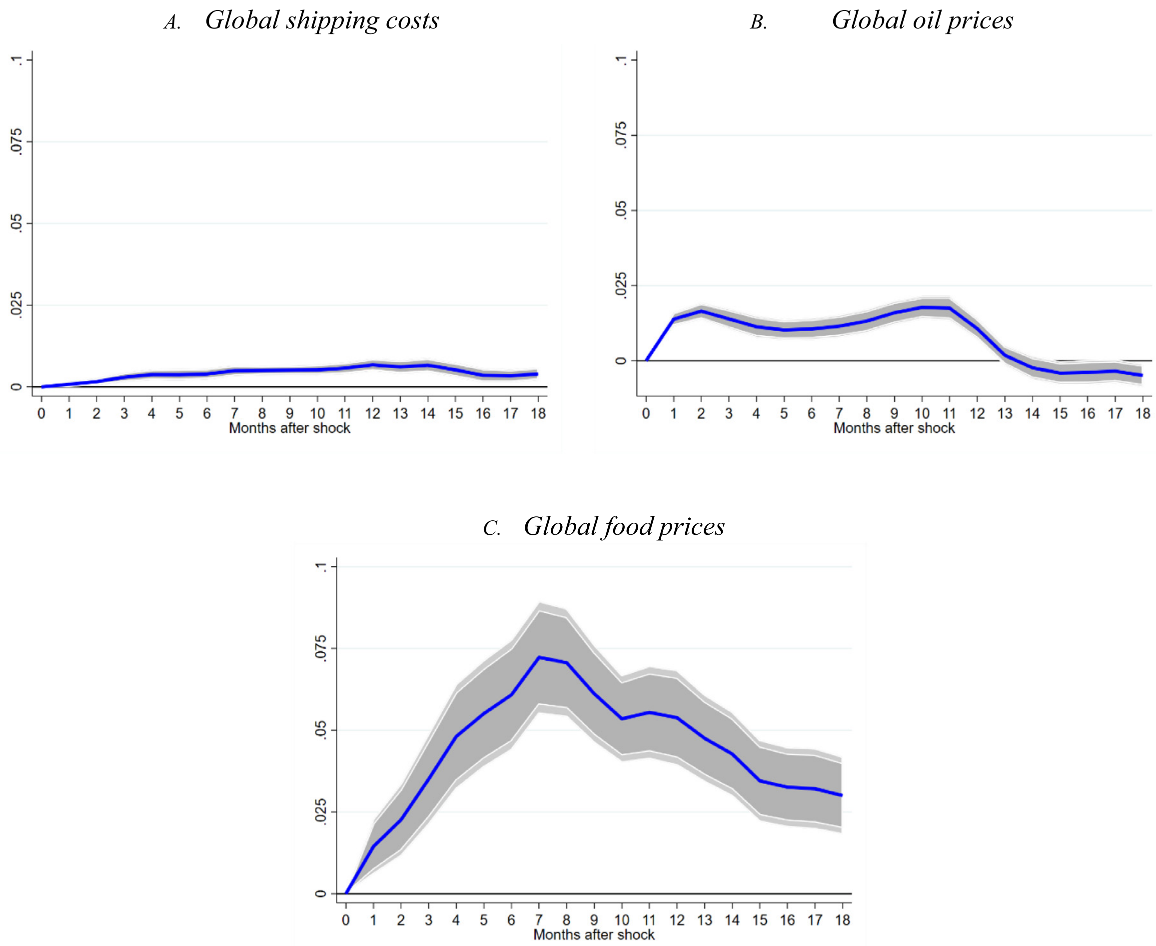
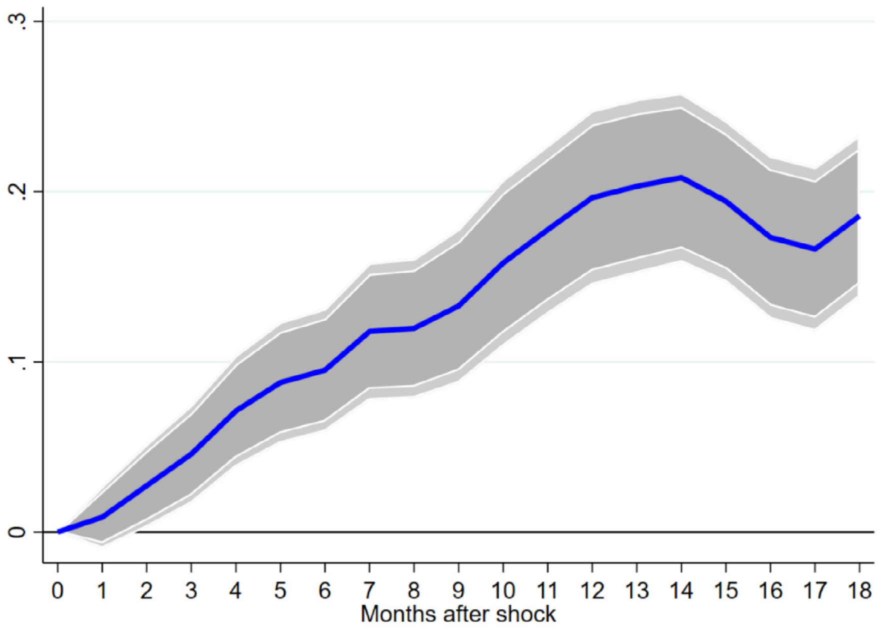


Fig. A4. Elasticity of headline inflation to global variables (percentage points). Note: The figures present the impact of a one percentage point increase in each global variable on headline price inflation in the baseline sample of 46 economies. The solid line is the impulse response function (IRF); the dark shaded region indicates the 90 percent confidence band; the light shaded region indicated the 95 percent confidence band. $t = 0$ denotes the year of the shock.

A. All available CPI data; 1985–2021 (143 economies)



B. Balanced CPI panel; 1990–2021 (62 economies)

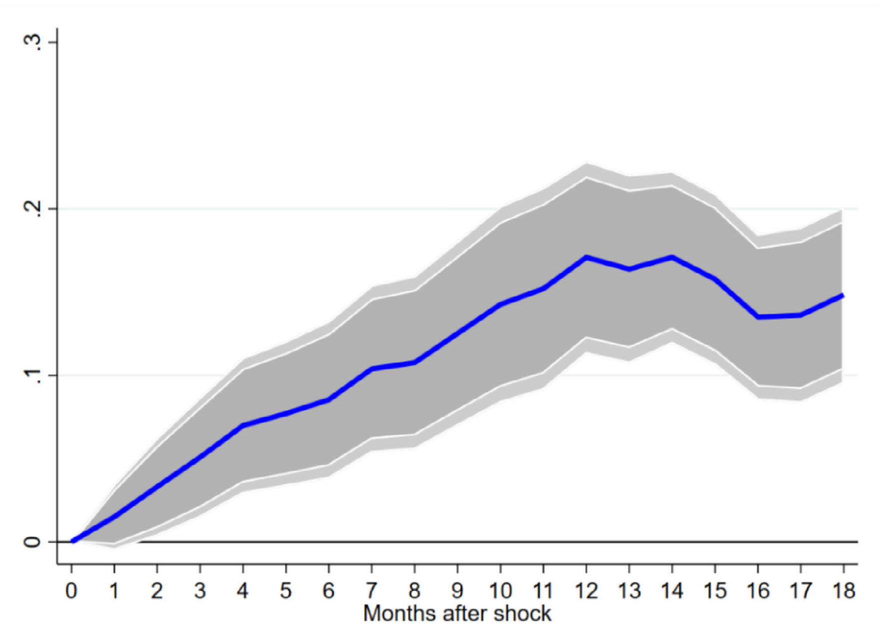


Fig. A5. The impact of global shipping costs on headline inflation in alternative samples. Note: The figure presents the impact of a one standard deviation increase in global shipping costs on domestic headline inflation. The solid line is the impulse response function (IRF), and the shaded regions indicate 90 percent confidence bands (dark grey) and 95 percent confidence bands (light grey). t = 0 denotes the year of the shock.

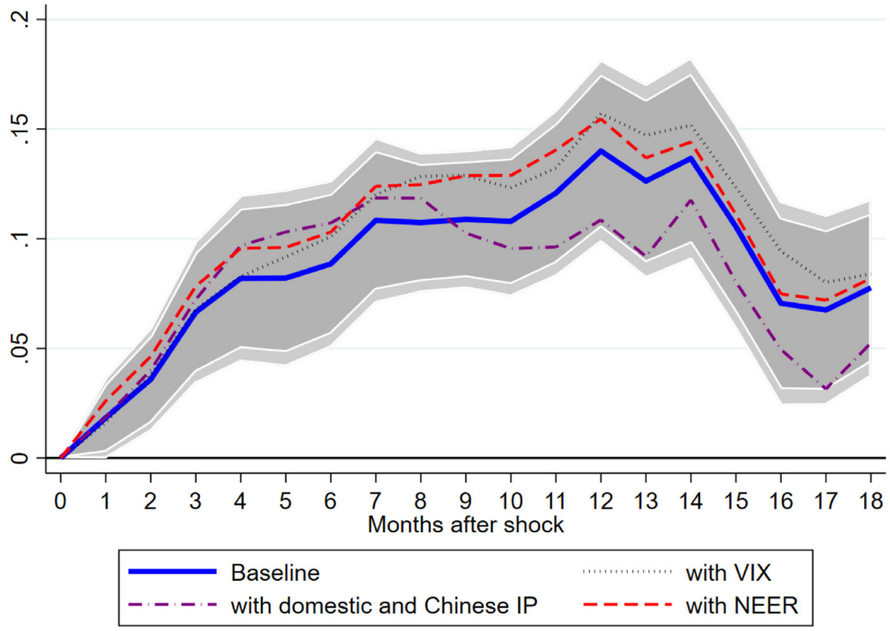
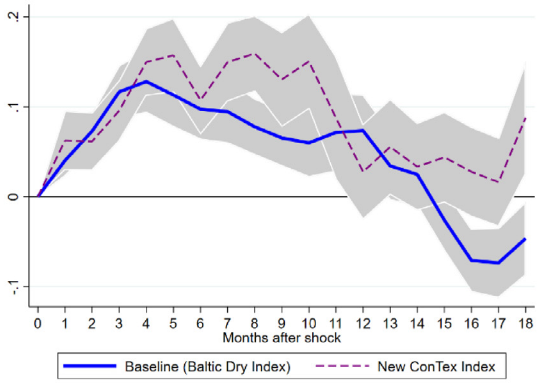
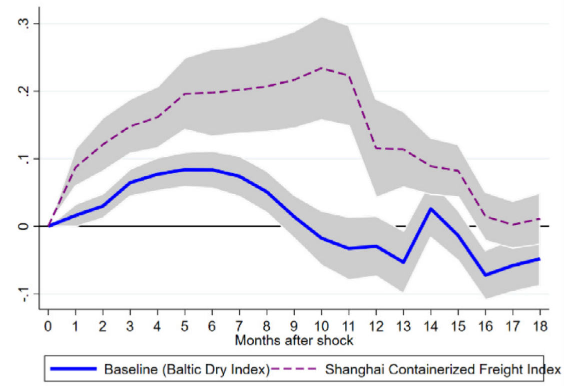


Fig. A6. Impact of shipping costs on headline inflation; robustness models. Note: The figure presents the impact of one standard deviation increase in shipping costs on domestic headline inflation in our baseline sample of 46 economies. The solid blue line is the impulse response function (IRF) for the baseline model; the dark shaded region indicates the 90 percent confidence band; the light shaded region indicated the 95 percent confidence band. The dotted lines are the IRFs for the four robustness models that include: (i) contemporaneous and 12 lags of the change in the VIX index (black dots); (ii) contemporaneous and 12 lags of the change in the nominal effective exchange rate (red dashed); (iii) contemporaneous and 12 lags of the change in domestic and Chinese industrial production (purple dot-dashed). t=0 denotes the year of the shock.

A. *New ConTex Index*



B. *Shanghai Containerized Freight Index*



C. *Drewry Composite Container Index*

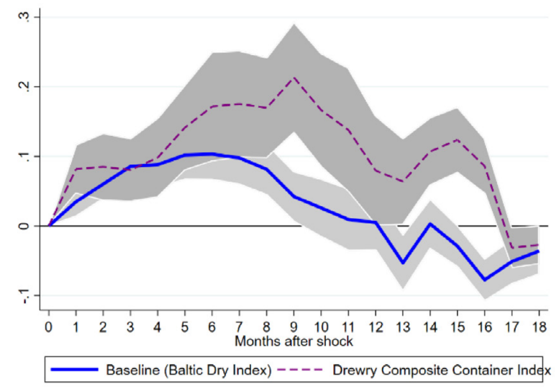


Fig. A7. Impact of shipping costs on headline inflation; alternative measures of shipping costs. Note: The figure presents the impact of one standard deviation increase in shipping costs on domestic headline inflation in our baseline sample of 46 economies, using the Baltic Dry Index (blue solid lines) and alternative measures of shipping costs (dashed purple lines). The shaded regions indicate the 90 percent confidence bands. In each panel, an overlapping sample has been used according to the joint availability of the shipping cost indices (Panel A: October 2007–December 2021; Panel B: November 2010–December 2021; Panel C: June 2011–December 2021).

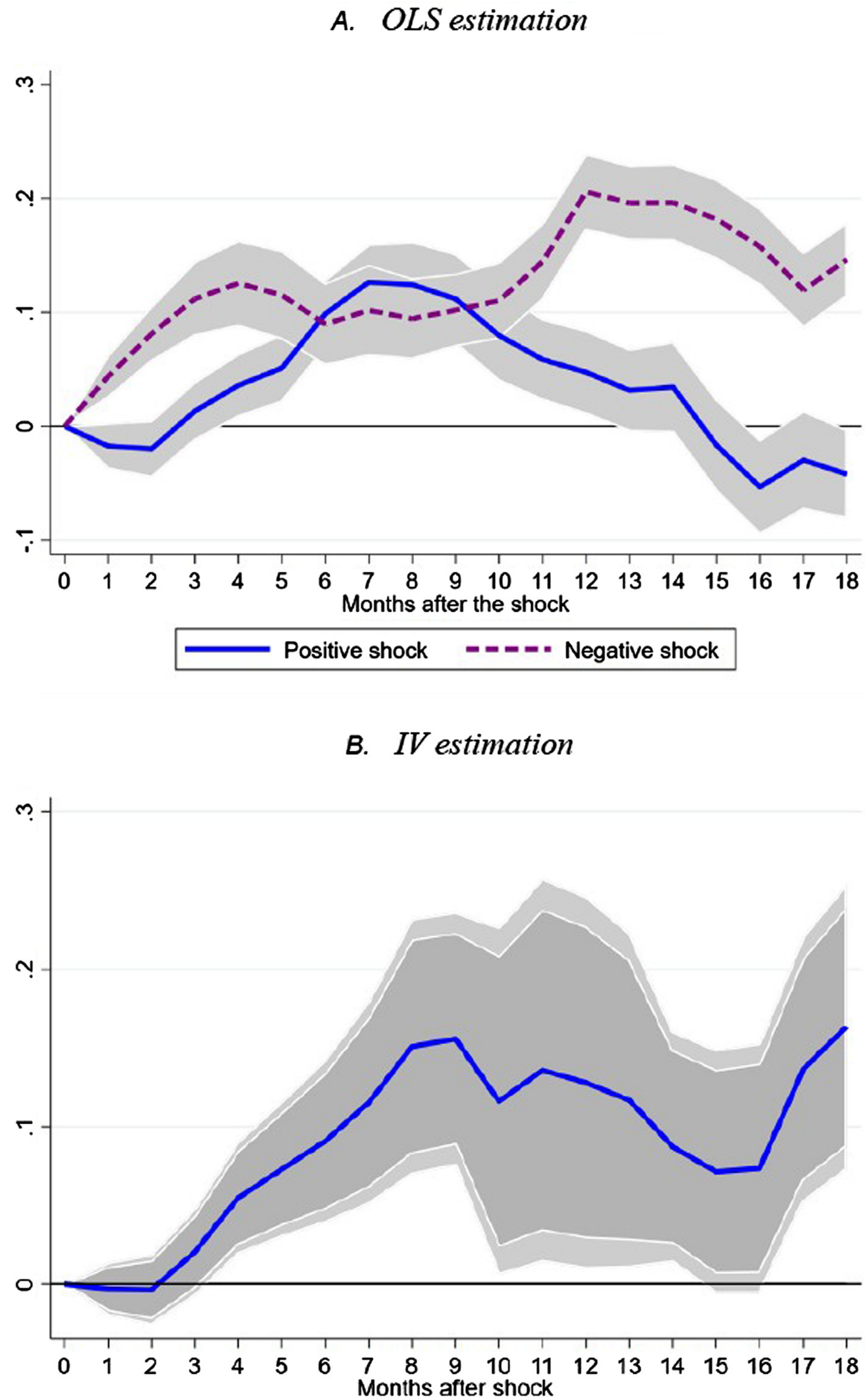


Fig. A8. Impact of shipping costs on headline inflation; asymmetric responses. Note: The figure presents the impact of one standard deviation increase in shipping costs on domestic headline inflation in our baseline sample of 46 economies. Panel A estimates a specification that includes interactions of the Baltic Index with indicator variables for positive and negative changes, in which the solid blue line is the response to a rise in shipping costs and the dashed purple line is the (negative) response to a fall in shipping costs. Panel B estimates the instrumental variables specification interacted by positive changes in the Baltic Index.

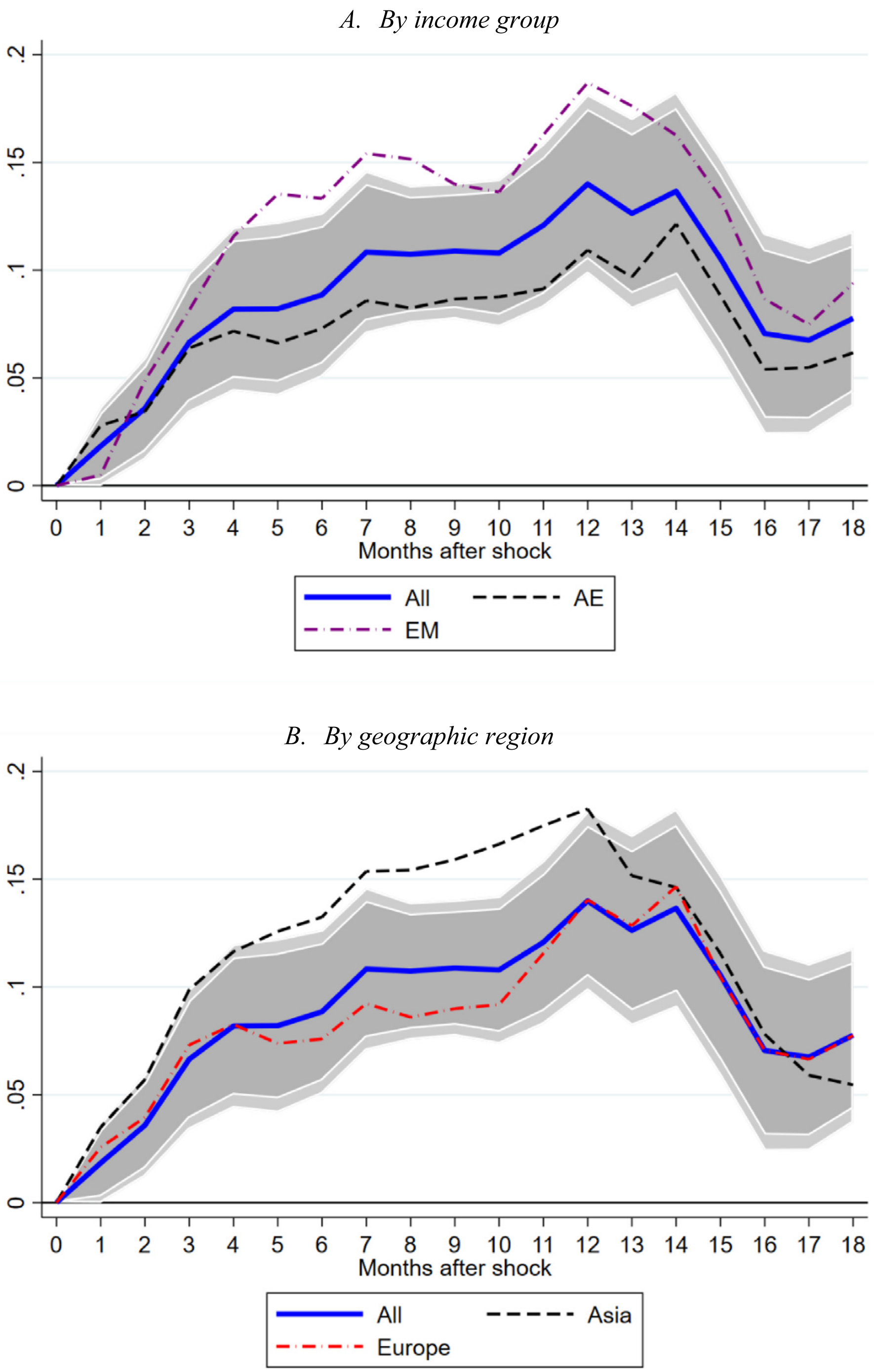


Fig. A9. Impact of shipping costs on headline inflation; baseline sample. Note: The figures present the impact of one standard deviation increase in shipping costs on domestic headline inflation in the baseline sample of 46 economies. The solid line is the impulse response function (IRF) for the full sample; the dark shaded region indicates the 90 percent confidence band; the light shaded region indicated the 95 percent confidence band. The dotted lines are the IRFs for sub-samples, with countries grouped by income (Panel A) and geographic region (Panel B). $t = 0$ denotes the year of the shock.

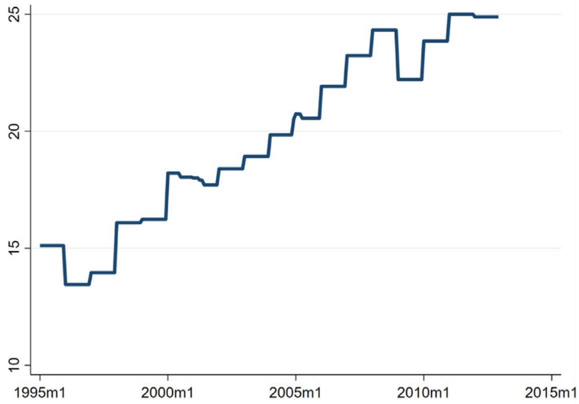
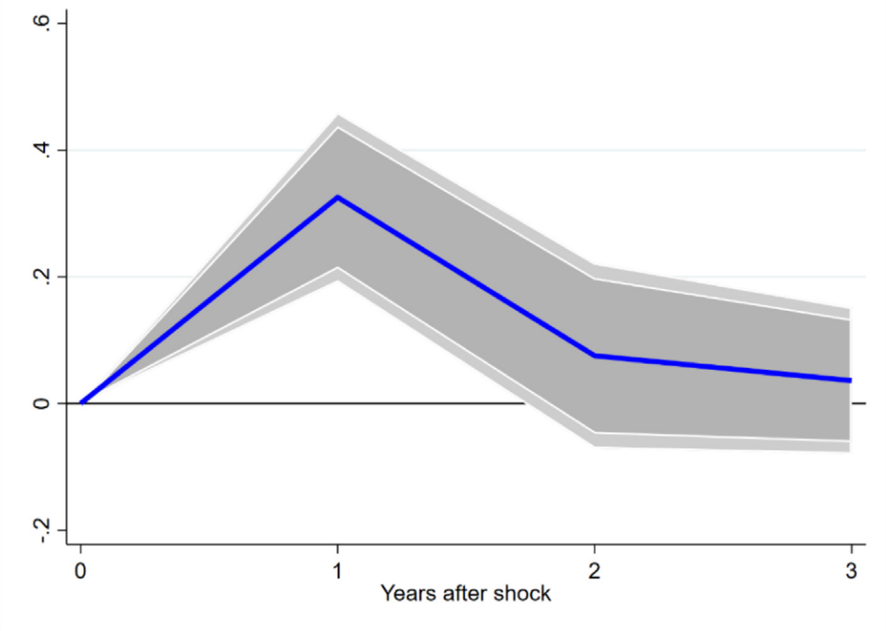


Fig. A10. Average import share of domestic consumption (percentage of domestic consumption). Source: EORA import-output table. Note: Figure shows the average import share of domestic consumption for the 46 economies in our baseline sample.

A. Linear model



B. Interaction with estimated anchoring of inflation expectations

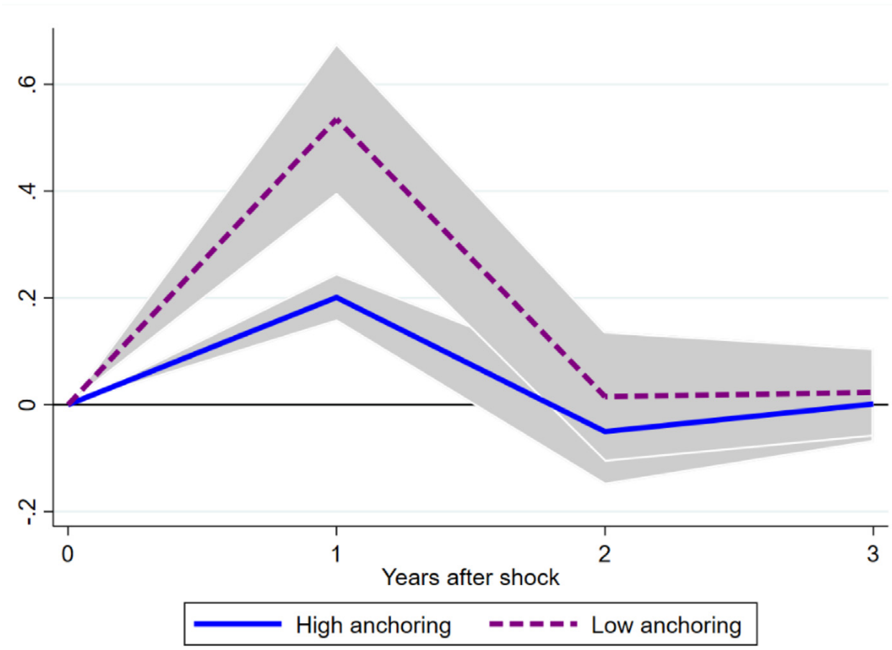
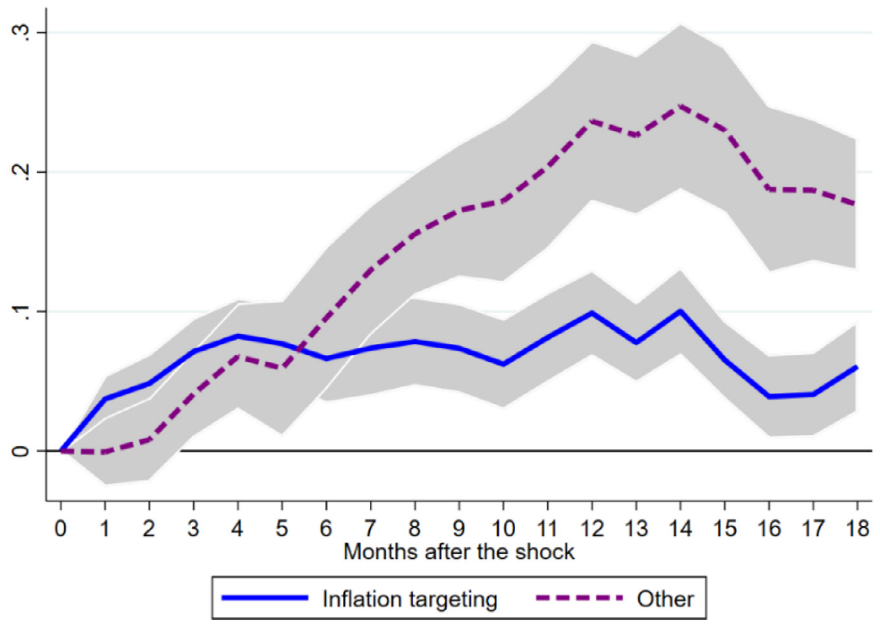


Fig. A11. Impact of shipping costs on wages (percentage points). Note: The figures present the impact of a one standard deviation increase in shipping costs (21.8 percentage points based on monthly frequency to ensure comparability to the baseline results) on wages in a sample of 18 economies. $t = 0$ denotes the year of the shock. For Panel A, the solid line is the impulse response function (IRF); the dark shaded region indicates the 90 percent confidence band; the light shaded region indicated the 95 percent confidence band. For Panel B, the shipping costs variable has been interacted with a dummy variable indicating bins of data over an estimate for the degree of inflation anchoring from Choi et al. (2022). The purple line is the IRF for economies with below median anchoring; the blue line is the IRF for economies with above median anchoring; the shaded regions are one standard error bands.

A. High-inflation regime



B. Low-inflation regime

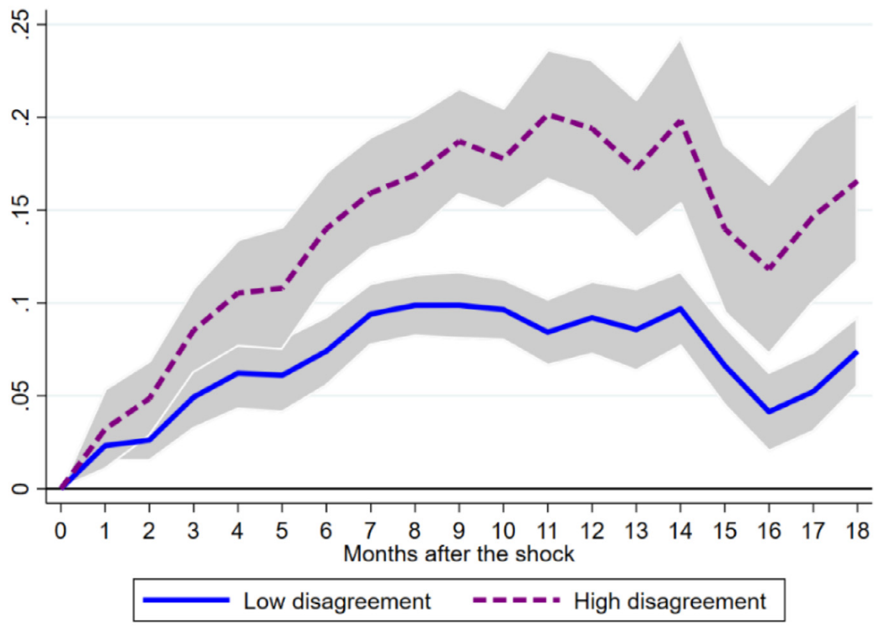


Fig. A12. Impact of shipping costs on headline inflation (percentage points). Note: The figures present the impact of a one standard deviation increase in shipping costs on headline inflation in a sample of 46 economies. *t* = 0 denotes the year of the shock. Panel A shows triple interactions for the high-inflation regime, with the solid blue line the impulse response function (IRF) interacted with the inflation targeting regime dummy; the dashed purple line the IRF interacted with the not inflation targeting dummy; the shaded regions indicate the one standard error bands. For Panel B shows the triple interactions for the low-inflation regime, with the solid blue line the IRF interacted with the dummy denoting low disagreement among professional forecasters of inflation; the dashed purple line the IRF interacted with the dummy denoting high disagreement among professional forecasters of inflation; the shaded regions are one standard error bands.

Table A1
Correlation across alternative measures of shipping costs.

	Baltic Dry	CTS	Freightos	New ConTex	Shanghai	Drewry
Baltic Dry	1.00					
CTS	0.61	1.00				
Freightos	0.84	0.98	1.00			
New ConTex	0.37	0.78	0.98	1.00		
Shanghai	0.73	0.88	0.99	0.94	1.00	
Drewry	0.77	0.82	0.99	0.95	0.99	1.00

Note: Pairwise correlation coefficients calculated in overlapping samples at monthly frequency: Baltic Dry Index (1985 m1-2022 m1); CTS global container (2011 m2-2021 m11); Freightos global container index (2016 m10-2022 m1); New ConTex is the Container Ship Time Charter Assessment Index published by the Hamburg Shipbrokers' Association (2007 m10-2022 m1); Shanghai Containerized Freight Index (2010 m11-2022 m1); Drewry Composite Containerized Index (2011 m6-2021 m1).

Table A2
Baseline sample.

Economy	N	Start	End	Economy (continued)	N	Start	End
Australia	279	Jul-98	Sep-21	Sri Lanka	94	Jan-14	Oct-21
Austria	262	Jan-00	Oct-21	Lithuania	191	Jan-06	Nov-21
Belgium	250	Jan-01	Oct-21	Luxembourg	262	Jan-00	Oct-21
Bulgaria	262	Jan-00	Oct-21	Latvia	131	Jan-11	Nov-21
Brazil	359	Jan-92	Nov-21	Mexico	335	Jan-94	Nov-21
Canada	299	Jan-97	Nov-21	Malta	227	Dec-02	Oct-21
Switzerland	204	Jan-05	Dec-21	Malaysia	203	Jan-05	Nov-21
Chile	222	Apr-03	Sep-21	Netherlands	311	Jan-96	Nov-21
China	201	Jan-05	Nov-21	New Zealand	270	Apr-99	Sep-21
Cyprus	262	Jan-00	Oct-21	Peru	331	Jan-94	Jul-21
Czech Republic	287	Jan-98	Nov-21	Philippines	124	Jun-11	Sep-21
Germany	311	Jan-96	Nov-21	Poland	268	Jun-99	Sep-21
Denmark	179	Jan-07	Nov-21	Portugal	202	Jan-05	Oct-21
Spain	262	Jan-00	Oct-21	Romania	185	Jun-06	Oct-21
Estonia	288	Jan-98	Dec-21	Singapore	359	Jan-92	Nov-21
Finland	323	Jan-95	Nov-21	Slovak Republic	153	Jan-09	Sep-21
France	275	Jan-99	Nov-21	Slovenia	191	Jan-06	Nov-21
Greece	263	Jan-00	Nov-21	Sweden	311	Jan-96	Nov-21
Hungary	225	Feb-03	Oct-21	Thailand	323	Jan-95	Nov-21
India	96	Jan-13	Dec-20	Taiwan Province of China	360	Jan-92	Dec-21
Ireland	311	Jan-96	Nov-21	Ukraine	107	Jan-13	Nov-21
Italy	263	Jan-00	Nov-21	United States	360	Jan-92	Dec-21
Jordan	189	Jan-06	Sep-21				
Korea	360	Jan-92	Dec-21	TOTAL (46)	11,530	Jan-92	Dec-21

Source: Authors.

Table A3
Sources and definitions of variables.

Definition	Source	Note
Consumer Price Index	Haver Analytics	
Core CPI	Haver Analytics	Chile: spliced using historical variation in IPCX1 for 2003–2011.
Producer Price Index	Haver Analytics	
Import price index	Haver Analytics	China and Philippines: quarterly frequency. India: annual frequency. Brazil, Malaysia, Mexico, Peru, Switzerland, and Turkey: original series denominated in US dollars have been multiplied by the nominal exchange rate to express in local currency units.
Industrial production index	Haver Analytics	China: spliced backwards using variation in quarterly real GDP for 1991–1997.
Baltic Dry Index	Bloomberg	Daily frequency data; monthly average
Freightos global container index	Bloomberg	Weekly frequency; monthly average
CTS global container index	Bloomberg	Monthly frequency
Container Ship Time Charter Assessment Index	Bloomberg and Hamburg Shipbrokers' Association	Monthly frequency
World oil price	Bloomberg	West Texas Intermediate Crude Oil Prices
World food price index	IMF Primary Commodity Prices	Monthly since January 1992. Includes Cereal, Vegetable Oils, Meat, Seafood, Sugar, and other food.
Output gap	IMF World Economic Outlook	Detrended quarterly real GDP; HP filter with lambda = 1,600.
World output gap	IMF World Economic Outlook	Annual data
Wages (total labor compensation)	IMF World Economic Outlook	Annual data
Nominal effective exchange rate	IMF Information Notice System	Local currency units/USD
VIX index	Bloomberg	Equity price volatility index from Chicago Board Options Exchange
Import share of domestic consumption	EORA Global Input-Output table	Annual frequency 1990–2014
Backward integration into global supply chains	EORA Global Input-Output table	Annual frequency 1990–2014. Share of foreign value added that is used as inputs for producing exports
Inflation expectations	Consensus Economics	Synthetic 12-months-ahead using weighted average of current and next year fixed-event forecasts
Disagreement about future inflation	Consensus Economics	Standard deviation across individual forecasts
Distance from trade partners	CEPII GeoDist Database (distances) and UN COMTRADE (trade flows)	Weights constructed using total trade in 2019.
Landlocked country dummy	CEPII GeoDist Database	
Inflation targeting dummy		1 if inflation targeting, 0 otherwise
Advanced/developing dummy	IMF World Economic Outlook	1 if advanced, 0 if developing

Source: Authors.

Table A4
Instrumental variable estimation results (asymmetric).

	k = 1	k = 3	k = 6	k = 12	k = 18
Fitted shipping costs (positive only)	−0.00255	0.0168	0.0748***	0.112**	0.135***
	(0.00709)	(0.0117)	(0.0218)	(0.0512)	(0.0381)
Output gap	−5.26e-05	−5.22e-05	0.000298	0.000305	0.000511**
	(0.000215)	(0.000374)	(0.000572)	(0.000471)	(0.000210)
World output gap	−0.000154	0.00107*	0.00142	7.23e-05	−0.00316***
	(0.000283)	(0.000593)	(0.00105)	(0.000715)	(0.000553)
World oil price	0.0126***	0.00950	0.00232	0.000156	−0.00549*
	(0.00250)	(0.00681)	(0.0115)	(0.0118)	(0.00288)
World food price	0.0199***	0.0534***	0.0962***	0.112***	0.0394***
	(0.00597)	(0.0164)	(0.0306)	(0.0346)	(0.00916)
N	10,409	10,371	10,247	9,983	9,714
R^2	0.99	0.96	0.85	0.51	0.11
1st-stage: F stat	156.6	164.1	165.8	13.2	29.4

Note: Heteroskedasticity-robust standard errors clustered at the country level are reported in parentheses. ***, **, and * denote statistical significance at 99, 95, and 90 percent confidence levels. Coefficients and standard errors for have been rescaled to provide theresponse to a one standard deviation shock to each independent variable.

Table A5
Robustness specifications for interactions with time fixed effects.

Single interaction models	k = 1	k = 3	k = 6	k = 9	k = 12	k = 13	k = 15	k = 18
Headline inflation								
Import share (high)	0.0015	0.0042	−0.0101	0.0264	0.0498	0.0618**	0.0499	0.0359
	(0.0164)	(0.0234)	(0.0343)	(0.0332)	(0.0313)	(0.0296)	(0.0369)	(0.0322)
Past inflation (high)	−0.0196	−0.0186	0.0257	0.0035	0.0231	0.0426	0.0833***	0.0755***
	(0.0151)	(0.0223)	(0.0311)	(0.0262)	(0.0268)	(0.0283)	(0.0319)	(0.0292)
No IT regime	−0.0127	−0.0042	0.0669	0.0762**	0.0807*	0.0757*	0.1112**	0.0981**
	(0.0191)	(0.0310)	(0.0540)	(0.0351)	(0.0433)	(0.0457)	(0.0512)	(0.0455)
Anchoring (low)	−0.0470**	−0.0597**	−0.0539	−0.0165	0.0005	0.0166	0.0442	0.0591*
	(0.0197)	(0.0266)	(0.0346)	(0.0294)	(0.0307)	(0.0322)	(0.0360)	(0.0337)
Disagreement (high)	−0.0040	0.0106	0.0321	0.0354	0.0503**	0.0502**	0.0685***	0.0534**
	(0.0133)	(0.0147)	(0.0227)	(0.0216)	(0.0238)	(0.0243)	(0.0245)	(0.0228)
N	10,473	10,411	10,253	10,088	9,923	9,869	9,759	9,596
R^2	0.89	0.79	0.65	0.55	0.46	0.46	0.46	0.45
Core inflation								
Import share (high)	−0.0116	−0.0082	0.0202	0.0519	0.0556*	0.0478*	0.0377	0.0599**
	(0.0098)	(0.0210)	(0.0286)	(0.0336)	(0.0327)	(0.0284)	(0.0273)	(0.0253)
Past inflation (high)	0.0148	0.0203	0.0532**	0.0534*	0.0569**	0.0531**	0.0737***	0.0588**
	(0.0110)	(0.0207)	(0.0242)	(0.0284)	(0.0260)	(0.0228)	(0.0234)	(0.0235)
No IT regime	0.0140	0.0495	0.0583*	0.0577	0.0803*	0.0575	0.0655	0.0876**
	(0.0128)	(0.0343)	(0.0354)	(0.0403)	(0.0430)	(0.0368)	(0.0421)	(0.0418)
Anchoring (low)	−0.0089	−0.0067	0.0218	0.0583*	0.0297	0.0238	0.0229	0.0218
	(0.0126)	(0.0220)	(0.0288)	(0.0330)	(0.0294)	(0.0248)	(0.0256)	(0.0261)
Disagreement (high)	0.0010	0.0132	0.0087	0.0262	0.0295	0.0270	0.0345	0.0368*
	(0.0098)	(0.0135)	(0.0206)	(0.0200)	(0.0205)	(0.0187)	(0.0211)	(0.0201)
N	10,353	10,270	10,083	9,896	9,710	9,649	9,525	9,345
R^2	0.91	0.81	0.66	0.52	0.41	0.39	0.36	0.33

Note: Responses of headline and core inflation following a one standard deviation shock to the Baltic Dry Index; differential impact for countries in the indicated bin versus others. Table reports estimates for specifications that include time fixed effects instead of global control variables, and are estimated on the baseline sample of 46 economies over 1992–2021. Each row corresponds to estimates from a separate model. Heteroskedasticity-robust standard errors clustered at the country level are reported in parentheses. ***, **, and * denote statistical significance at 99, 95, and 90 percent confidence levels.

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