Commodity Prices and Production Networks in Small Open Economies*

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Abstract

We study the role of domestic production networks in the transmission of commodity price fluctuations in small open economies. We provide empirical evidence of strong propagation of commodity price changes to quantities produced in domestic sectors that supply intermediate inputs to commodity sectors (*upstream* propagation). Moreover, we document a strong propagation in prices, but null propagation in quantities, to sectors using commodities as intermediate inputs (*downstream* propagation). Our evidence highlights the importance of domestic production networks in shaping the inflationary and the real effects of changes in commodity prices on non-commodity industries.

Keywords: commodity prices, small open economies, production networks

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1 Introduction

Fluctuations in the price of primary commodities are an important source of macroeconomic volatility in small open economies (e.g., Fernández et al., 2018; Di Pace et al., 2020). The main channels in which commodity price fluctuations permeate these economies are the standard *wealth effect* channel and the (input) *cost channel* (e.g., Corden and Neary, 1982a; Allcott and Keniston, 2018; Benguria et al., 2020). In this paper, we make use of disaggregated data on a variety of commodity prices, as well as output and price data for 34 sectors to study the propagation of commodity price changes through domestic production networks in a sample of nine small open economies.

We take advantage of two stylized facts. First, the commodity sectors (mining, agriculture, and food sectors) are central sectors in small open economies, both as suppliers and buyers of intermediate inputs, which gives them a potential role as a source of supply and demand shock propagation. Second, commodity price fluctuations are only mildly correlated across sectors within a country. Therefore, as commodity prices are exogenous to non-commodity sectors in the economies analyzed, we have an ideal scenario to study the propagation of sectoral commodity price changes along the production chain.

We use sectoral data on output and prices, as well as data on domestic production linkages, for a sample of nine commodity exporters from the WIOD. While the WIOD data only spans the period 1995-2009, at an annual frequency, it offers a key advantage compared to other datasets featuring input-output linkages (e.g., OECD input-output data): it provides data on sectoral quantity and price chain indexes. Therefore, we can better trace out the supply-side (cost channel on prices) and the demand-side (quantities) propagation of changes to commodity prices.

We start by documenting that the commodity sectors—this is, agriculture, mining, and food products— are central actors in the domestic production network. For example, among 34 sectors, the mining sector in Australia is the sixth most important supplier of intermediate inputs to domestic sectors (directly and indirectly). In Mexico, for instance, the mining sector is the most important customer (directly and indirectly) of domestic intermediate inputs. On the other hand, the agriculture sector in Denmark and Canada is the 6th most important customer of domestic intermediates.

We then use detailed commodity price data from Fernández et al. (2018) and, for each country, we aggregate it to the sectors in the WIOD data, using trade shares as weights. We show that, as previously documented, commodity prices strongly comove, especially within sectors. For example, the average pairwise correlation among agriculture commodity price growth is 0.85. Nevertheless, we show that within a country, the correlation among sectoral commodity prices is much lower. For instance, the average correlation between agricultural commodities (e.g., wheat and sugar) and food products (soybean meal or palm oil) among countries is 0.16. Hence, we treat the fluctuations in commodity prices as sector and country-specific.

Next, we study the domestic propagation of commodity prices to non-commodity sectors. To this end, we motivate our regressions with a simple small open economy extension of existing production network models in the spirit of Acemoglu et al. (2016). The model shows that commodity prices have a dual propagation. They propagate upstream from commodity firms demanding non-commodity output (demand-channel), and downstream to domestic firms that use commodities as intermediates in production (cost-channel).

In the last part of the paper, we provide empirical evidence of a strong downstream propagation to prices, although not to quantities. While changes in commodity prices pass through to non-commodity prices, non-commodity sectors' production does not diminish significantly. Moreover, we document a strong upstream propagation to quantities: an increase in commodity prices leads to an increase in the production of commodity sectors, leading to an increase in the demand for upstream non-commodity sectors' output. All our regressions consider year fixed-effects (FE), country-sector FE, and/or country-year FE. All in all, our results show that commodity price fluctuations propagate strongly through domestic production linkages. Therefore, future research studying the macroeconomic implications of commodity price fluctuations should consider the details of countries' production network architecture.

Related Literature and Contribution. This paper contributes to two strands of literature. We relate to the now extensive literature on the propagation and macroeconomic effects of commodity price fluctuations (e.g. Corden and Neary, 1982b; Mendoza, 1995; Kose, 2002; Drechsel and Tenreyro, 2018; Benguria et al., 2020; Cao and Dong, 2020; Allcott and Keniston, 2018; Kohn et al., 2021; Romero, 2022; González, 2022; Di Pace et al., 2020). We contribute to this literature by providing empirical evidence on the role of domestic production networks in propagating commodity price changes to other sectors of the economy. The closest papers to ours are Allcott and Keniston (2018) and Benguria et al. (2020), which study the effects of commodity booms on manufacturing industries that locate upstream and downstream of commodities. We contribute to these papers on the following fronts.

First, while these papers define manufacturing industries upstream or downstream to commodities using indicator variables, we consider all direct and indirect production linkages across all producers, including service sectors. Second, we consider a broader set of commodities and countries. Third, we study the effects of short-run fluctuations of commodity prices on non-commodity sectors' prices and production, while their focus is on low-frequency fluctuations in commodity prices (Benguria et al., 2020) and commodity endowments (Allcott and Keniston, 2018). In looking separately at prices and quantities, we can better dissect the transmission mechanisms of commodity prices. Fourth, unlike previous papers that only control for production linkages outside the model, our theoretical model directly speaks and interprets the implications of our empirical results.

We provide a simple model that precisely highlights the mechanisms by which commodity price fluctuations can affect the cross-sectional distribution of gross output and prices with an arbitrary production network structure.

We also contribute to the literature on production networks and business cycles fluctuations (e.g., Horvath, 1998; Foerster et al., 2011; Acemoglu et al., 2012; Atalay, 2017; Baqaee and Farhi, 2019, 2021; Miranda-Pinto, 2021; vom Lehn and Winberry, 2020; Carvalho et al., 2021). We highlight that commodity price changes, besides productivity and financial shocks, have important effects on prices and output quantities and are largely propagated through input-output linkages. As in Carvalho et al. (2021) and Luo (2020) that emphasize the upstream and downstream propagation of productivity shocks and financial shocks, respectively, we show that commodity prices propagate to upstream and downstream sectors.

2 Stylized Facts

In this section, we present two stylized facts regarding commodity sectors. First, commodity sectors are central in the domestic production network. Second, commodity price changes strongly commove across countries but present a very small correlation across sectors within countries.

We first define what we mean by commodity sectors. To do so, we combine data on commodity goods' exports from Fernández et al. (2018) and input-output data from the

WIOD. We use the WIOD data as, unlike the OECD input-output data, it contains sectoral information on production and prices, separately. For more details on data sources and definitions please refer to our Appendix A. We match each commodity good to one of the 34 industries in the World Input-Output Database (WIOD). Table B5 in our Appendix B provides a detailed mapping between goods and sectors in the WIOD data.[1] The three commodity sectors in the WIOD are Agriculture, Forestry, and Fishing; Mining and Quarrying; and Food Products, Beverages, and Tobacco.

Fact 1: Commodity sectors are central sectors in the production network. We describe the network centrality of commodity sectors using standard centrality measures that capture how connected the sectors I am connected to and how connected the sectors that are connected to the sectors that I am connected to, etc. To that end, we analyze commodity sectors' customer and supplier centrality following Acemoglu et al. (2016).[2] We measure the supplier or *downstream* centrality of a given sector i as

$$Supplier_i = \sum_{j=1}^{N} \Psi_{ji}, \tag{1}$$

where Ψ_{ij} is an element of the Leontieff-Inverse matrix defined as

$$\boldsymbol{\Psi} = (\boldsymbol{I} - \boldsymbol{\Omega})^{-1} = \sum_{s=0}^{\infty} \boldsymbol{\Omega}^s$$

[1] In our Appendix A we also provide information on the sample of countries we use from the WIOD and the definition of the variables.

[2] These definitions are slightly different from the notions of downstreamness and upstreamness highlighted in the global value chains literature (see Antras and Chor, 2021). Their measure of upstreamness shows how important other sectors are as buyers to a given sector i. In our case, customer centrality comes from the importance of sector i as a buyer to other sectors. This difference is expected because we focus on how shocks propagate, as in Acemoglu et al. (2016), while Antras and Chor (2021) focuses on the distance of each sector to final demand and primary factors. Our concept is closer to the Katz-Bonacich centrality used in the production networks literature. See Carvalho (2014) for an overview, especially footnote 11.

where $\boldsymbol{I}$ is an identity matrix of size equal to the size of $\boldsymbol{\Omega}$. An element of $\boldsymbol{\Omega}$ is $\Omega_{ji} = P_i M_{ji}/P_j Q_j$. This represents the share of intermediates that sector i supplies to sector j $(P_i M_{ji})$ as a fraction of sector j's sales $(P_j Q_j)$. This shows the direct importance of producer j as a supplier to producer i. An element Ψ_{ji} then records the importance of producer i as a supplier to producer j after considering both direct and indirect linkages. This intuition is precisely highlighted by the last equality in the equation above, where $\boldsymbol{\Psi}$ is an infinite sum of direct and indirect linkages across producers. Therefore, $Supplier_i$ adds across all buyers of good i and measures its importance as a *supplier* to the economy after taking into account direct and indirect linkages.

We then measure the customer or *upstream* centrality of a sector i as

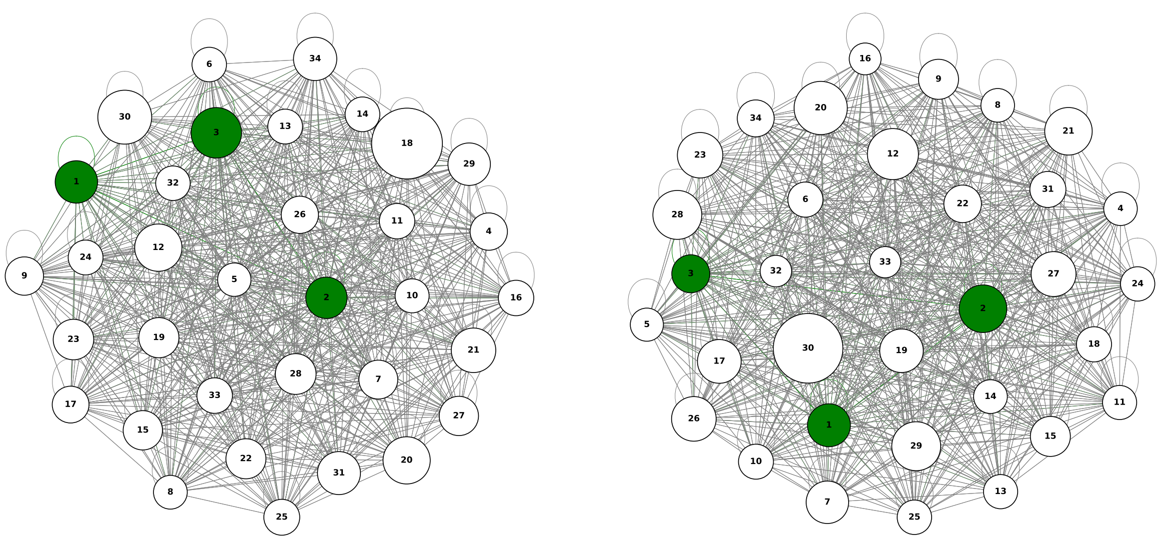
$$Customer_i = \sum_{j=1}^{N} \widetilde{\Psi}_{ij}, \tag{2}$$

where $\widetilde{\Psi}_{ij}$ is an element of the following matrix

$$\widetilde{\boldsymbol{\Psi}} = (\boldsymbol{I} - \boldsymbol{M})^{-1} = \sum_{s=0}^{\infty} \boldsymbol{M}^s$$

where $\boldsymbol{I}$ is an identity matrix of size equal to the size of $\boldsymbol{M}$. An element of $\boldsymbol{M}$ is $m_{ij} = P_j M_{ij}/P_j Q_j$. This represents the share of the sector's j sales that the sector i accounts for. This shows the direct importance of producer i as a buyer to producer j. An element $\widetilde{\Psi}_{ij}$ then records the importance of producer i as a *buyer* to producer j after considering both direct and indirect linkages. $Customer_i$ adds across all suppliers to sector i and measures sector i's importance as a *buyer* to the economy after considering direct and indirect linkages.

Figure 1 plots the domestic network structure of Australia in 1995, using input-output data from the WIOD database. Each node (circle) is a different sector in the economy, and the node's size represents how important that sector is in the network based on the network centralities defined above. Panel (a) shows the network in which each node's size describes the customer centrality of the sector—this is, how much output of other sectors a given sector uses, directly and indirectly—, while in panel (b), the node size is based on each sector's supplier centrality—how much of a given sector output is used as input by other sectors, directly and indirectly.



(a) Customer Centrality (b) Supplier Centrality

Figure 1. Domestic Production Network Australia

Note: This figure shows the domestic production network of Australia (WIOD Input-Output data) for 2011 at the sector level (ISIC rev. 3). An arrow from sector j to sector i represents intermediate inputs flowing from j o i. Each node (circle) is a different sector in the economy, and the size of the node represents how important that sector is as a direct and indirect buyer (panel a) and supplier (panel b) of intermediate inputs. The labels in the nodes are linked to sectors in Table B4 of our Appendix.

We observe in Figure 1 that commodity sectors were central sectors in the domestic production network of Australia in 1995. In particular, panel (a) shows that the food (3) sector is one of the sectors with the largest customer centrality. Panel (b) also shows that mining is one of the most central sectors in its direct and indirect supply of intermediates inputs.

Table 1. Ranking of Network Centrality of Commodity Sectors in 1995

	Customer Centrality			*Supplier Centrality*		
Country	Agric.	Mining	Food	Agric.	Mining	Food
Australia	10	11	3	13	6	17
Bulgaria	2	8	1	2	9	13
Brazil	14	25	2	7	14	10
Canada	6	18	3	4	10	15
Denmark	6	33	1	8	17	11
India	9	25	6	3	9	23
Lithuania	1	33	3	2	34	9
Mexico	10	18	1	7	1	15
Russia	3	6	2	5	3	14
Average	**7**	**20**	**2**	**6**	**11**	**4**

Note: This table presents, for each country and commodity sector, the customer and supplier network centrality. Source: WIOD Input-Output database, 1995.

To describe the relative importance of commodity sectors in the domestic production network of small open economies, we report in Table 1 the ranking of the customer and supplier propagation centrality for the three commodity sectors, with respect to all the other sectors in the economy (a total of 34 in the WIOD data). The main takeaway from Table 1 is that for all the countries in our sample, at least one of the commodity sectors (many times 2 of them) is a central customer and/or a central supplier (top-10) in the domestic production network.

Fact 2: Sectoral commodity price changes are only mildly correlated across sectors, within a country. We first describe the process of constructing sectoral indexes of commodity prices.

(i) We use the commodity prices and exports data in Fernández et al. (2018).[3] For each country, we calculate the share of each commodity good in its sectoral group, be it agriculture, mining, or food sectors. Then, we multiply each sector-country weight by the monthly commodity price. The details on the commodities we use and the mapping to WIOD industries are in Table B5.

(ii) The outcome from step (i) is a matrix of country-specific monthly commodity price index that we deflate using the US Consumer Price Index (CPI).

(iii) We take the average across months within each quarter by year.

We now investigate the correlation between sectoral commodity price growth within countries. As highlighted in Fernández et al. (2018), commodity fluctuations strongly commove across countries. Indeed, the cross-country correlation between commodity price changes in Agriculture and Forestry, Mining and Quarrying, and Foods Products and Beverage sectors are 0.85, 0.65, and 0.5, respectively. However, as shown in Table 2, the growth rate of commodity prices present a small correlation across sectors within countries. The average cross-country correlation between agriculture and mining commodity price growth is 0.57; the average cross-country correlation between agriculture and food commodity prices is 0.16; and the average cross-country correlation between mining and foods commodity prices is -0.13.[4] Therefore, instead of aggregating commodity sectors to one, our empirical analysis considers each commodity sector, within a country, separately.

[3] The authors use commodity price data from the IMF primary commodity price system and COMTRADE

Table 2. Average Pairwise Correlation across Commodity Prices

	Correlation
Agriculture/Mining	0.57
Agriculture/Food	0.16
Mining/Food	-0.13

Note: This table presents the cross-country average of the within-country pairwise correlations among the log change of sectoral commodity prices.

3 Commodity prices via production networks

As pointed out in Acemoglu et al. (2016), the production networks literature is usually ambiguous about what upstream or downstream means. In this paper, we strictly follow their approach in that upstream or downstream refers to how shocks are propagated throughout the network structure and not by the sectors' position. A graphical representation of this idea is in Figure 2 below, where we plot two sectors k and i where sector k supplies to sector i. Here, the shock to sector k (the supplier) propagates *downstream*, while a shock to sector i (the buyer) propagates *upstream*.

3.1 A simple model

We build a simple economic environment to describe the network spillovers implied by commodity price changes. Our model features a representative consumer that consumes $N+1$ goods in a static setting. Each $N+1$ sectors produce using a constant returns to scale production function. Sectors up to sector N produce using labor and intermediate inputs.

data on trade weights.

[4] Figure B3 to Figure B5 in our Appendix depict sectoral commodity price growth for countries in our sample. Besides confirming Fact 2 (low within-country correlation across commodity prices), these figures show substantial volatility of commodity prices over time.

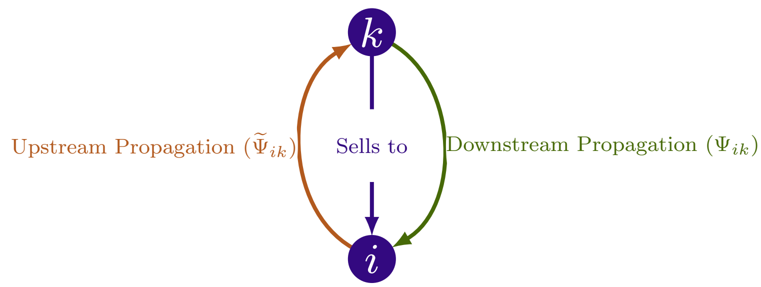


Figure 2. Upstream and Downstream Propagation

Note: This figure shows the propagation of shocks along the production network where we remove all other nodes and focus on total propagation (both direct and indirect). Downstream propagation from seller k to buyer i (Ψ_{ik}) and upstream propagation from buyer i to seller k ($\tilde{\Psi}_{ik}$). This illustrates the construction of measures in equations (6) and (7).

Sector $N+1$ produces using labor, intermediate inputs and capital. Importantly, sector $N+1$ good price is *exogenously* given. All factors payments are rebated back to the household. For mathematical simplicity we study all our prices relative to the wage. We also abstract from changes in the nominal exchange rate. In effect, we are normalizing the exchange rate to one.[5] Please refer to Appendix C for more details on the model.

Proposition 1 (Price Responses to a Commodity Price Change)**.** Consider a perturbation of the commodity price, $d\log P_{N+1}$. Up to a first-order approximation, changes in good prices satisfy

$$\frac{d\log P_i}{d\log P_{N+1}} = \underbrace{\frac{\Psi_{i,N+1}}{\Psi_{N+1,N+1}}}_{\text{Cost Push}}, \tag{3}$$

where $\Psi_{i,N+1}$ represents how important is the commodity sector $N+1$ as supplier, both directly and indirectly, to sector i. The term $\Psi_{N+1,N+1}$ is the own supply intensity of the

[5] We can solve a more general version of our model in which all prices are expressed relative to the imported goods price, which is exogenously determined in international markets. In this case, we don't need to worry about the nominal exchange rate, as we study the relative price of two international prices. The mathematical results in this case are more involved, and the network spillovers are more general. The results are qualitative the same.

commodity sector. When $\Psi_{N+1,N+1}$ is large, commodity sectors are more isolated and less connected to other sectors in the network. In this case, the cost-push channel is mitigated uniformly acrosss sectors.

Proof. See proof in Appendix C ■

Proposition 2 (Changes in Gross Output, $d\log Q_i$)**.** Up to a first-order approximation, and assuming Cobb-Douglas production technologies, changes in gross output following a commodity price change, $\mathrm{d}\log P_{N+1}$, satisfy

$$\frac{\mathrm{d}\log Q_i}{\mathrm{d}\log P_{N+1}} = \underbrace{\frac{\Psi_{N+1,i}}{\lambda_i}\frac{\bar{Y}}{GDP}\phi}_{\text{Foreign Demand}} + \underbrace{\sum_{k=1}^{N+1}\frac{\Psi_{ki}}{\lambda_i}b_k DD}_{\text{Domestic Demand}} - \underbrace{\frac{\Psi_{i,N+1}}{\Psi_{N+1,N+1}}}_{\text{Cost Push}}, \tag{4}$$

where $\bar{Y}/GDP$ represents the export share of commodities on overall production, ϕ is elasticity of exports ($\bar{Y}$) relative to the commodity price and DD is a domestic demand component.

Proof. See proof in Appendix C ■

Proposition 2 emphasizes three channels of propagation on quantities. The first channel, the foreign demand (for commodities) channel, depends on the specific linkages (direct and indirect) between sector i and the commodity sector. In this case, what matters is the importance of the commodity sector as a buyer, which is why $\Psi_{N+1,i}$ rather than $\Psi_{i,N+1}$ is involved. The second term, which we denominate domestic demand channel does not depend on commodity-specific linkages but it reflects how the sector is exposed to domestic aggregate demand. The last term is the cost-push which also appeared in the price equation and it is a function of sector i's commodity-specific linkages.

3.2 Empirical specification

Motivated by Propositions 1 and 2 we estimate the network spillovers of commodity price changes using the following specification[6]

$$y_{ict} = \delta_t + \alpha_{i,c} + \delta_{c,t} + \phi_1 Upstream_{ict} + \phi_2 Downstream_{ict} + \boldsymbol{\nu}'\boldsymbol{X}_{ict-1} + \epsilon_{ict}, \tag{5}$$

where y_{ict} is sector i's output or prices in country c at time t, sourced from the WOID data. δ_t represent year fixed effects, $\alpha_{i,c}$ are country-sector fixed-effects, and $\delta_{c,t}$ are a full set of country-time fixed effects. These fixed effects aim to control for other macroeconomic disturbances (be country-specific or global) as well as sector-specific dynamics in y_{ict}. For instance, these controls can account for the Domestic Demand channel in Proposition 2 or for fluctuations in exchange rates, which we abstract from in our stylized model.

Our network spillover measures, based on our previous propositions, are $Upstream_{ict}$ and $Downstream_{ict}$. These network measures vary at the sector-country-year level. $\boldsymbol{X}_{ict-1}$ is a $H \times 1$ vector of lagged controls, including the dependent variable and our network spillover measures. Finally, ϵ_{ict} is an error term. Our identification assumption is that commodity prices determined in international markets are exogenous to non-commodity sectors in these small open economies.

Our model assumes one commodity sector but in the data we observe three. Hence, to measure the network spillovers we denote a commodity sector by $k \in \mathcal{K}$ where $\mathcal{K}$ is the set of commodity sectors. We denote non-commodity sectors by either i or j, where $i, j = 1, ..., N$

[6]While there is an important literature emphasizing the different effects of demand-side vs. supply-side shocks to commodity prices (e.g., Kilian, 2009; Aastveit et al., 2023), our goal is to study the propagation mechanisms of changes in commodity prices, regardless of the source of shock. Nevertheless, our results will speak to the potential sources of commodity prices. In particular, demand-side shocks to commodity prices propagate more strongly to sectors upstream to commodities, while supply-side shocks to commodity prices propagate more strongly to sectors downstream to commodities.

with N the total number of non-commodity sectors.

The downstream effect of commodity price fluctuations that is to those *buying* from the commodity sector either directly or indirectly through input-output linkages, in sector i in the country c at time t is

$$Downstream_{ict} = \sum_{k \in \mathcal{K}} \left(\Psi_{ikc} - \mathbf{1}_{i=k} \right) \cdot \tilde{p}_{kct}, \tag{6}$$

where Ψ_{ikc} stands for the importance of the commodity sector k in supplying intermediate inputs to sector i, as defined in Proposition 1. $\mathbf{1}_{i=k}$ is an indicator variable that takes the value of 1 when $i = k$ and zero otherwise. $\tilde{p}_{kct}$ corresponds to commodity price growth for commodity sector k in the country c at time t.

The upstream effect of commodity price fluctuations, that is from the commodity sectors to that *selling* to it, from sector k to sector i in the country c at time t is measured as

$$Upstream_{ict} = \sum_{k \in \mathcal{K}} \left(\tilde{\Psi}_{kic} - \mathbf{1}_{i=k} \right) \cdot \tilde{p}_{kct}, \tag{7}$$

where $\tilde{\Psi}_{kic}$ stands for the direct and indirect importance of commodity sector k as a buyer to sector i. In particular, $\tilde{\Psi}_{kic} = \frac{\Psi_{kic}}{\lambda_i}$ in Proposition 2's foreign demand channel.

3.3 Results

We now present empirical evidence on the transmission mechanism of commodity price fluctuations via production networks. Table 3 presents the results of estimating Equation (5) using quantity and price indexes for gross output. All regressions include one lag of the dependent variable. To ease the interpretation of our coefficients, we standardized our Upstream and Downstream measures to have a unit standard deviation.

We first focus on the effects on sectors selling to the commodity sector ($Upstream_{ict}$). Columns (1) to (3) show that real commodity price fluctuations positively affect the gross output of non-commodity sectors. In particular, in column (3)—where we control for a year, country-sector, and country-year fixed effects—a one standard deviation increase in commodity prices generates a 0.72 percent (1.3 percent) increase in the sectoral gross output quantity index, on impact (cumulative). We find no evidence of downstream ($Downstream_{ict}$) effects on quantities of commodity price changes. Columns (4) to (6) show that, despite the muted downstream effect on quantities, we observe a strong downstream propagation of commodity prices to the price of non-commodity sectors, with no upstream propagation. A one standard deviation increase in commodity prices generates a 0.82 percent impact increase in the sectoral gross output price index (1.97 percent cumulative) of non-commodity sectors downstream to commodities.[7]

3.4 Discussion

Our empirical results support the predictions of our simple production network small open economy model. This is, non-commodity sectors are significantly affected by fluctuations in commodity prices in small open commodity exporting countries. These spillovers, which we estimate using economic theory and observed production linkages, help us microfounding the transmission channels of commodity price fluctuations from a granural perspective. The literature has mainly focused on the aggregate effects or cross-country spillovers of commodity prices. However, understanding how commodity prices propagate to other industries in small open economies is crucial to better assess the need for macroeconomic stabilization policies, which in this case could be implemented through sectoral stabilization policies. Moreover,

[7] In our Appendix, Table B6, we show that the same results hold when we exclude Russia, one of the main oil producers in the world, from our sample.

Table 3. Network Effects of Commodity Price Changes on Non-Commodity Sectors

	Panel (a): Quantity			Panel (b): Prices		
	(1)	(2)	(3)	(4)	(5)	(6)
Upstream_{ict}	0.0067**	0.0080**	0.0072***	0.0004	0.0067	0.0019
	(0.0031)	(0.0031)	(0.0022)	(0.0067)	(0.0075)	(0.0024)
Upstream_{ict-1}	0.0027	0.0055	0.0058***	-0.0171	-0.0008	-0.0003
	(0.0035)	(0.0037)	(0.0020)	(0.0137)	(0.0070)	(0.0018)
Downstream_{ict}	0.0022	0.0018	-0.0007	0.0104*	0.0099**	0.0082***
	(0.0017)	(0.0016)	(0.0012)	(0.0054)	(0.0049)	(0.0026)
$\text{Downstream}_{ict-1}$	-0.0020	-0.0020	-0.0024**	0.0074	0.0090**	0.0115***
	(0.0015)	(0.0015)	(0.0011)	(0.0058)	(0.0039)	(0.0023)
Accumulated Upstream	0.0094**	0.0135***	0.0130***	-0.0167	0.0058	0.0016
	(0.0044)	(0.0047)	(0.0032)	(0.0159)	(0.0092)	(0.0035)
Accumulated Downstream	0.0002	-0.0001	-0.0031	0.0178***	0.0189***	0.0197***
	(0.0023)	(0.0024)	(0.0019)	(0.0097)	(0.0073)	(0.0036)
Observations	3906	3906	3906	3906	3906	3906
Within R^2	0.924	0.777	0.766	0.959	0.737	0.694
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Country × Sector F.E.		Yes	Yes		Yes	Yes
Country × Year F.E.			Yes			Yes

Note: This table presents OLS regressions using sectoral log quantity (columns 1 to 3) and log price index (columns 4 to 6) as the dependent variable. The independent variables also include one lag of the dependent variable. Double clustered country-year standard errors in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

our results also can speak to the literature investigating the Dutch disease hypothesis (e.g., Corden and Neary, 1982a; Allcott and Keniston, 2018). In this regard, our results point to positive spillovers to upstream sectors' production and limited negative real effects on sectors downstream to commodities. Hence, while we do find evidence on the cost channel, the positive spillovers to non-commodity sectors appear to compensate for higher production costs, rendering the output of sectors downstream to commodities unaffected.

4 Conclusion

We study how sectoral commodity price fluctuations propagate through domestic production networks in small open economies. We provide empirical evidence and a simple theoretical model that highlight the supply-driven and the demand-driven components in the propagation of commodity prices to other sectors. We show that commodity sectors are central sectors, both as sellers and buyers, in the domestic production network of small open economies. We then show, empirically and theoretically, that the propagation of sectoral commodity price fluctuations to non-commodity sectors' output has an important production network component. We find that the gross output of non-commodity upstream sectors, those sectors supplying intermediate inputs to commodity sectors, largely respond to commodity price shocks. In contrast, we find evidence of muted downstream propagation on quantities, to those buying intermediate inputs from commodity sectors. Our results also show strong downstream propagation to non-commodity sector prices, consistent with changes in the cost of intermediate inputs transmitted through the network.

All in all, our results highlight the importance of the production network in propagating commodity price fluctuations throughout the economy.

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ONLINE APPENDIX

A Data sources and Definitions

Macroeconomic Aggregates

The data for the estimation of commodity price changes are obtained from the following sources: Fernández et al. (2018) is used for the sectoral commodity price index.

Input-Output Table Database

WIOD Data. Our main database is the World Input-Output database (Timmer et al., 2015), release 2013. It provides information on intersectoral and cross-country final and intermediate flows for 40 countries and 35 sectors classified according to the International Standard Industrial Classification Revision 3 (ISIC Rev. 3). These tables match the 1993 version of the SNA. We use the sectoral data on quantities (gross output, value-added, number of employees, and capital) and price indexes for the period 1995-2011(2009) in the National IO tables. The sample of small open economies with data on commodity prices and WIOD input-output data includes the following countries: Australia, Bulgaria, Brazil, Canada, Denmark, India, Lithuania, Mexico, and Russia.

This dataset is freely available here https://www.rug.nl/ggdc/valuechain/wiod/wiod-2013-release.

Commodity Data

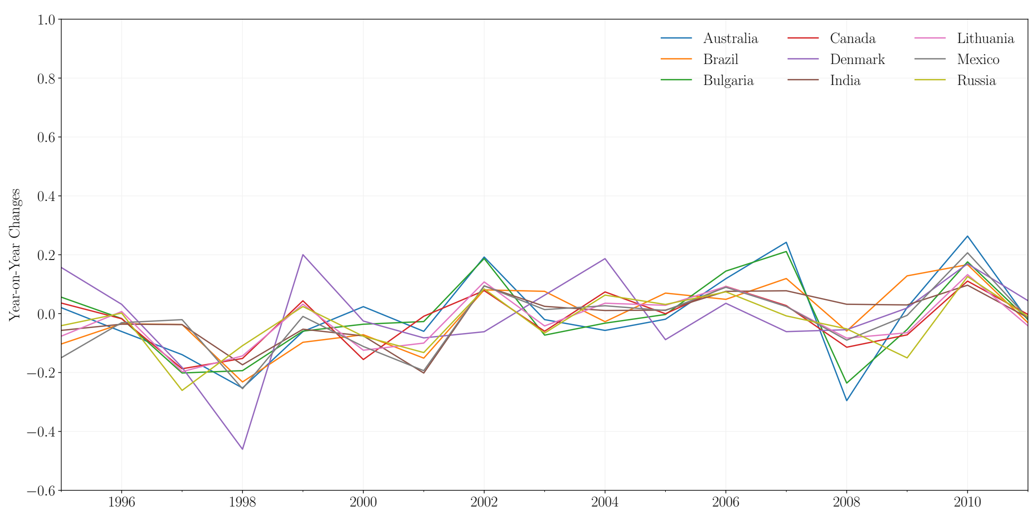
To measure sectoral linkages to the *commodity sector* we use detailed information on each country's commodity bundle composition from Fernández et al. (2018). There is a total of 44 commodities classified according to the Harmonized System (HS) 1992 – 4 digits. We separate commodities into 3 groups: Agriculture, Hunting, Forestry, and Fishing; Mining and Quarrying; and Food Products, Beverages, and Tobacco.

B Additional Tables and Figures

B.1 Tables

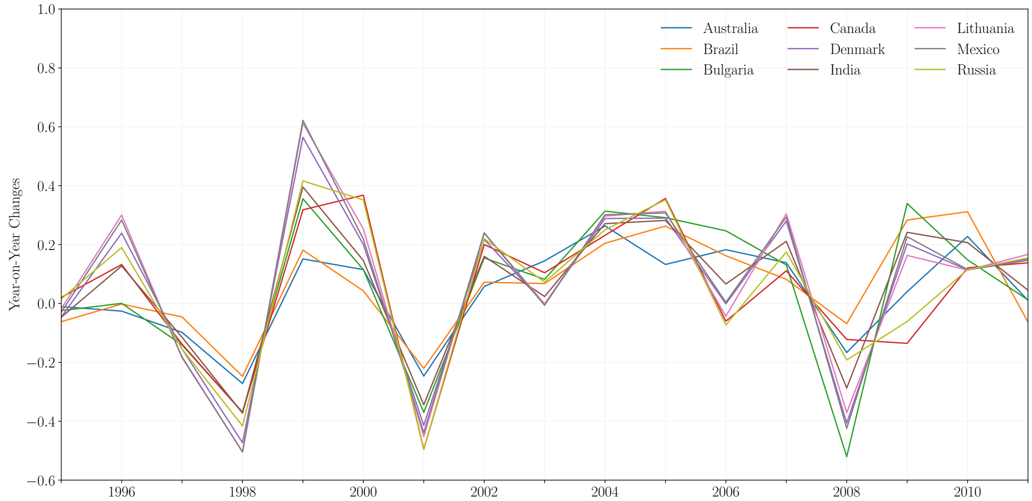
B.2 Extra Figures

Figure B3. Commodity Price Changes: Agriculture and Forestry



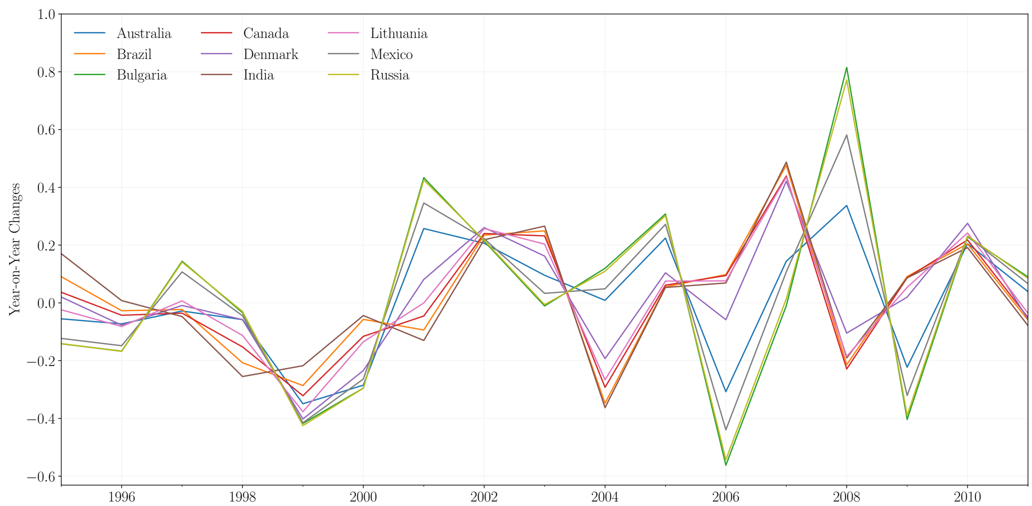
Note: This figure plots commodity price year-on-year changes for the agriculture and forestry sector in our sample of 9 countries in the WIOD database.

Figure B4. Commodity Price Changes: Mining and Quarrying



Note: This figure plots commodity price year-on-year changes for the mining and quarrying sector in our sample of 9 countries in the WIOD database.

Figure B5. Commodity Price Changes: Food Products and Beverages



Note: This figure plots commodity price year-on-year changes for the food and beverages sector in our sample of 9 countries in the WIOD database.

C Theory Proofs

Setup. The model is static. The representative consumer consumes $N + 1$ goods and exhibits Cobb-Douglas preferences over these goods. Each $N + 1$ sector produces using a Cobb-Douglas production function. Sectors up to sector N produce using labor and intermediate inputs. Sector $N+1$ produces using labor, intermediate inputs, and capital. Importantly, sector $N+1$ good price is *exogenously* given. All factor payments are rebated back to the household. Both factors and good markets are perfectly competitive. Since goods market are competitive prices equal the marginal costs.

Notation and Definitions. We use **bold** to denote vectors and matrices. For any matrix $\boldsymbol{X}$, we use $\boldsymbol{X}^T$ for its transpose.

We let $\mathbf{\Omega}$ to be the *input-output matrix* of this economy, with typical element

$$\mathbf{\Omega} = \{\Omega_{ij}\} = \frac{P_j M_{ij}}{P_i Q_i} \quad \text{for all } i, j = 1, ..., N+1.$$

This typical element states how much producer i spend on good j, $P_j M_{ij}$, as a fraction of i's sales, $P_i Q_i$. Here P_i is the price of good i, Q_i is the quantity sold of good i, and M_{ij} is how much producer i buys of the quantity of good j.

With some abuse of notation, we also define producer's i expenditure on factor $f = \{L, K\}$ i.e. expenditure on labor and capital, respectively as

$$\Omega_{iL} = \frac{WL_i}{P_i Q_i}; \qquad \Omega_{iK} = \frac{RK_i}{P_i Q_i}.$$

We define $\mathbf{\Psi}$ as the *Leontieff-Inverse matrix* that satisfy

$$\mathbf{\Psi} = (\boldsymbol{I} - \mathbf{\Omega})^{-1} = \sum_{s=0}^{\infty} \mathbf{\Omega}^s \text{ with typical element } \{\Psi_{ij}\}.$$

Notice that this is defined over the $N+1$ goods and does not incorporate spending on factors. This matrix captures both the direct and indirect linkages across producers. For instance, Ψ_{ij} denotes how important producer j as a *direct and indirect* supplier to producer i.[8]

[8] There are some regularity conditions that $\mathbf{\Omega}$ must satisfy to be able to write in this way. We note, however that they are seldom satisfied since $\sum_{j=1}^{N+1} \Omega_{ij} < 1$, and so is a sub-stochastic matrix. This implies its spectral radii is less than one. Then by the *Neumann Series Lemma*, the result follows. See Sargent and Stachurski (2022), pp 12-16, for a more formal discussion on these issues.

On the consumption side, we define $\boldsymbol{b}$ as follows

$$\boldsymbol{b} = \{b_i\} = \frac{P_i C_i}{GDP},$$

where C_i represents home consumption of good i.

Since there are two factors of production, capital and labor, we define their shares on *Nominal Gross Domestic Product* (GDP) as

$$\Lambda_L = \frac{WL}{GDP}; \quad \Lambda_K = \frac{RK}{GDP}; \quad \Lambda_L + \Lambda_K = 1.$$

where W and R are the wage rate (labor price) and the rental rate (capital price), L is the equilibrium labor quantity, and K is the capital equilibrium quantity. The last result above follows from the fact that everything in this economy is produced out of factors, and therefore total value added (GDP) should equal factor payments.

Finally, we let λ_i to denote the *Domar weight* of producer i on total value added i.e.

$$\lambda_i = \frac{P_i Q_i}{GDP}.$$

In the presence of intermediate goods in production, this is the relevant size statistic of each producer on total value added.

D Proofs

Proof of Proposition 1. Starting from price changes, we have

$$d\log P_i = \Omega_{iL} d\log W + \sum_{j=1}^{N+1} \Omega_{ij} d\log P_j \quad \text{for all } i = 1, 2, ..., N$$

$$d\log P_{N+1} = \Omega_{N+1,L} d\log W + \Omega_{N+1,K} d\log R + \sum_{j=1}^{N+1} \Omega_{N+1,j} d\log P_j$$

where we define $\mathbf{\Omega}_K = (0, 0, ..., \Omega_{N+1,K})$ is a $(N+1) \times 1$ vector where its first N elements are 0 because non-tradable sectors do not use capital directly.

Using the wage as the numeraire, $d\log W = 0$, and stacking the system into matrix/vector form, we have

$$d\log \boldsymbol{P} = \mathbf{\Omega} d\log \boldsymbol{P} + \mathbf{\Omega}_K d\log R$$

Inverting the system we arrive

$$d\log \boldsymbol{P} = \mathbf{\Psi}\mathbf{\Omega}_K d\log R \Longrightarrow d\log P_i = \Psi_{i,N+1}\Omega_{N+1,K} d\log R \text{ for all } i = 1, 2, ..., N+1 \tag{D.1}$$

Note that we can write the above expression as

$$d\log \boldsymbol{P} = \widetilde{\mathbf{\Omega}}_K d\log R$$

where we define the typical element of $\widetilde{\mathbf{\Omega}}_K = \{\widetilde{\Omega}_{iK}\} = \{\Psi_{i,N+1}\Omega_{N+1,K}\}$, that represents the *network-adjusted* capital share of producer i.

We now make use of the fact that $d\log P_{N+1}$ is exogenously given to express changes in the rental rate, $d\log R$, as an explicit function of it since

$$d\log P_{N+1} = \widetilde{\Omega}_{N+1,K} d\log R \Longrightarrow d\log R = \frac{1}{\widetilde{\Omega}_{N+1,K}} d\log P_{N+1}$$

Replacing this expression into Equation (D.1), we get

$$d\log P_i = \frac{\widetilde{\Omega}_{i,K}}{\widetilde{\Omega}_{N+1,K}} d\log P_{N+1} = \frac{\Psi_{i,N+1}}{\Psi_{N+1,N+1}} d\log P_{N+1} \tag{D.2}$$

which completes the proof. ■

Before the proof of Proposition 2, we solve for sectoral Domar weights. Start from the market clearing condition and aggregate resource constraints in terms of Domar weights and matrix form

$$\boldsymbol{\lambda} = \boldsymbol{\Psi}^T \left(\boldsymbol{b} + \boldsymbol{e}_{N+1} \frac{\bar{Y}}{GDP} \right) \tag{D.3}$$

Totally differentiating this expression

$$d\boldsymbol{\lambda} = \underbrace{d\boldsymbol{\Psi}^T \left(\boldsymbol{b} + \boldsymbol{e}_{N+1} \frac{\bar{Y}}{GDP} \right)}_{\text{Changes in IO matrix given Demand Shares}} + \underbrace{\boldsymbol{\Psi}^T \left(d\boldsymbol{b} + \boldsymbol{e}_{N+1} d \left(\frac{\bar{Y}}{GDP} \right) \right)}_{\text{Changes in Demand Shares given IO linkages}} \tag{D.4}$$

We now totally differentiate the definition of the Leontieff-Inverse, $\boldsymbol{\Psi}$, to map its changes to changes in the IO matrix, $\boldsymbol{\Omega}$

$$\begin{aligned}
\boldsymbol{\Psi}^T &= (\boldsymbol{I} - \boldsymbol{\Omega}^T)^{-1} \\
\boldsymbol{\Psi}^T (\boldsymbol{I} - \boldsymbol{\Omega}^T) &= \boldsymbol{I} \\
\boldsymbol{\Psi}^T - \boldsymbol{\Psi}^T \boldsymbol{\Omega}^T &= \boldsymbol{I} \\
d\boldsymbol{\Psi}^T - d\boldsymbol{\Psi}^T \boldsymbol{\Omega}^T - \boldsymbol{\Psi}^T d\boldsymbol{\Omega}^T &= \boldsymbol{0} \\
d\boldsymbol{\Psi}^T (\boldsymbol{I} - \boldsymbol{\Omega}^T) &= \boldsymbol{\Psi}^T d\boldsymbol{\Omega}^T \\
d\boldsymbol{\Psi}^T &= \boldsymbol{\Psi}^T d\boldsymbol{\Omega}^T \boldsymbol{\Psi}^T \\
d\boldsymbol{\Psi}^T (\boldsymbol{b} + \boldsymbol{b}^*) &= \boldsymbol{\Psi}^T d\boldsymbol{\Omega}' \underbrace{\boldsymbol{\Psi}^T (\boldsymbol{b} + \boldsymbol{b}^*)}_{= \boldsymbol{\lambda}} \\
d\boldsymbol{\Psi}^T (\boldsymbol{b} + \boldsymbol{b}^*) &= \boldsymbol{\Psi}^T d\boldsymbol{\Omega}^T \boldsymbol{\lambda}
\end{aligned}$$

Using this expression into Equation (D.4)

$$d\boldsymbol{\lambda} = \boldsymbol{\Psi}^T d\boldsymbol{\Omega}^T \boldsymbol{\lambda} + \boldsymbol{\Psi}^T \left(d\boldsymbol{b} + \boldsymbol{e}_{N+1} d \left(\frac{\bar{Y}}{nGDP} \right) \right). \tag{D.5}$$

Since all production functions are of the Cobb-Douglas type, $\boldsymbol{\Omega} = \boldsymbol{0}_{(N+1)\times(N+1)}$ and thus

$\mathbf{\Psi}^T d\mathbf{\Omega}^T \boldsymbol{\lambda} = \mathbf{0}_{(N+1)\times 1}$. Therefore, for a given producer i, we have

$$d\lambda_i = \sum_{k=1}^{N+1} \Psi_{ki} \left(b_k d \log b_k + \delta_{k,N+1} \frac{\bar{Y}}{GDP} (\mathrm{d} \log \bar{Y} - \mathrm{d} \log GDP) \right), \tag{D.6}$$

where δ_{ki} is the kronecker delta and equals 1 if $k = i$ and it is zero otherwise.

We now focus on the first term on the right-hand side of the above equation. To simplify, we assume that the home consumer has Cobb-Douglas preferences over goods. This means that consumption of each good k as a share of *total expenditure* is constant and independent of quantities and prices. Note, however, that b_k is a ratio with respect to the nominal GDP of the home country. As a result, they may respond to changes in both expenditure and GDP. The Cobb-Douglas preferences do not imply that these ratios are constant. To be more transparent, write

$$b_k = \frac{P_k C_k}{GDP} = \frac{P_k C_k}{E} \frac{E}{GDP}$$

where E represents total expenditure at home.

Log-differentiating the above expression

$$\mathrm{d} \log b_k = \underbrace{d \log \frac{P_k C_k}{E}}_{=0 \text{ due to Cobb-Douglas Preferences}} + \mathrm{d} \log \frac{E}{GDP} = \mathrm{d} \log E - \mathrm{d} \log GDP$$

Therefore, b_k will change, provided that there is a difference between changes in expenditure and changes in nominal GDP. Intuitively, under Cobb-Douglas preferences, expenditure in good k raises proportionally to changes in total expenditure. This raises the numerator in $d \log E$ for all good k, while the denominator raises as changes in nominal GDP $d \log GDP$. Therefore, if expenditure raises more than nominal GDP, the expenditure share on good k as a fraction of nominal GDP, $d \log b_k$, will raise.

Using these results into Equation (D.6), we get

$$d\lambda_i = \sum_{k=1}^{N+1} \Psi_{ki}(b_k d\log b_k + \delta_{k,N+1}\frac{\bar{Y}}{GDP}(d\log\bar{Y} - d\log GDP))$$

$$d\lambda_i = \sum_{k=1}^{N+1} \Psi_{ki}\left(b_k(d\log E - d\log GDP) + \delta_{k,N+1}\frac{\bar{Y}}{GDP}(d\log\bar{Y} - d\log GDP)\right)$$

$$d\lambda_i = \sum_{k=1}^{N+1} \Psi_{ki}(b_k d\log E + \delta_{k,N+1}\frac{\bar{Y}}{GDP}d\log\bar{Y}) - \underbrace{\sum_{k=1}^{N+1} \Psi_{ki}\left(b_k + \delta_{k,N+1}\frac{\bar{Y}}{GDP}\right)}_{=\lambda_i} d\log GDP$$

$$d\lambda_i = \sum_{k=1}^{N+1} \Psi_{ki}\left(b_k d\log E + \delta_{k,N+1}\frac{\bar{Y}}{GDP}d\log\bar{Y}\right) - \lambda_i d\log GDP$$

Upon rearranging

$$d\log\lambda_i = \frac{1}{\lambda_i}\left(\sum_{k=1}^{N+1} \Psi_{ki}(b_k d\log E + \delta_{k,N+1}\frac{\bar{Y}}{GDP}d\log\bar{Y})\right) - d\log GDP \tag{D.7}$$

Therefore, changes in the Domar weights can be written as

$$d\log\lambda_i = \frac{1}{\lambda_i}\left(\sum_{k=1}^{N+1} \Psi_{ki}\left(b_k d\log E + \delta_{k,N+1}\frac{\bar{Y}}{GDP}d\log\bar{Y}\right)\right) - d\log GDP. \tag{D.8}$$

Proof of Proposition 2. To prove this result, we use the fact that

$$\begin{aligned} d\log Q_i &= d\log\lambda_i + d\log GDP - d\log P_i \\ &= \frac{1}{\lambda_i}\left(\sum_{k=1}^{N+1} \Psi_{ki}\left(b_k d\log E + \delta_{k,N+1}\frac{\bar{Y}}{GDP}d\log\bar{Y}\right)\right) - d\log P_i \end{aligned}$$

Using Proposition 1, we can rewrite this as

$$d\log Q_i = \sum_{k=1}^{N+1} \frac{\Psi_{ki}}{\lambda_i} b_k \mathrm{d}\log E + \sum_{k=1}^{N+1} \frac{\Psi_{ki}}{\lambda_i}\frac{\bar{Y}}{GDP}\delta_{k,N+1} d\log\bar{Y} - \frac{\widetilde{\Omega}_{i,K}}{\widetilde{\Omega}_{N+1,K}}\mathrm{d}\log P_{N+1}$$

We are left to link $\mathrm{d}\log E$ and $d\log\bar{Y}$ to $\mathrm{d}\log P_{N+1}$. We assume that $d\log\bar{Y}$ is an increasing function of the commodity price $d\log P_{N+1}$, in particular

$$\log \bar{Y} = \phi \log P_{N+1}$$

For total expenditure, recall the following two equations

$$\mathrm{d}\log GDP = \frac{\Lambda_K}{\widetilde{\Omega}_{N+1,K}} \mathrm{d}\log P_{N+1},$$
$$E = GDP - \bar{Y}.$$

Log-differentiating the expression for expenditure and using the above relationships, we get

$$\mathrm{d}\log E = \frac{GDP}{E}\mathrm{d}\log GDP - \frac{\bar{Y}}{E}\mathrm{d}\log \bar{Y} = \left(\frac{GDP}{E} \frac{\Lambda_K}{\widetilde{\Omega}_{N+1,K}} - \frac{\bar{Y}}{E}\phi \right) \mathrm{d}\log P_{N+1}$$

Replacing the expression for domestic expenditure and net transfers to the rest of the world as a function of the commodity price shock, we arrive at

$$\frac{\mathrm{d}\log Q_i}{\mathrm{d}\log P_{N+1}} = \underbrace{\frac{\tilde{b}_i}{\lambda_i} \left(\frac{GDP}{E} \frac{\Lambda_K}{\widetilde{\Omega}_{N+1,K}} - \frac{\bar{Y}}{E}\phi \right)}_{\text{Domestic Demand}} + \underbrace{\frac{\Psi_{N+1,i}}{\lambda_i} \frac{\bar{Y}}{GDP}\phi}_{\text{Foreign Demand}} - \underbrace{\frac{\widetilde{\Omega}_{i,K}}{\widetilde{\Omega}_{N+1,K}}}_{\text{Cost Push}} \tag{D.9}$$

where

$$\tilde{b}_i = \sum_{k=1}^{N+1} \Psi_{ki} b_k,$$
$$\tilde{b}_i + \Psi_{N+1,i} \frac{\bar{Y}}{GDP} = \lambda_i, \quad \text{for all } i = 1, 2, ..., N+1$$

Setting $DD = \left(\frac{GDP}{E} \frac{\Lambda_K}{\widetilde{\Omega}_{N+1,K}} - \frac{\bar{Y}}{E}\phi \right)$, completes the proof. ■

Table B4. Sectors in WIOD Database

Sector Number	Sector Name
1	Agriculture, Hunting, Forestry and Fishing
2	Mining and Quarrying
3	Food, Beverages, and Tobacco
4	Textiles and Textile Products
5	Leather, Leather, and Footwear
6	Wood and Products of Wood and Cork
7	Pulp, Paper, Paper, Printing, and Publishing
8	Coke, Refined Petroleum and Nuclear Fuel
9	Chemicals and Chemical Products
10	Rubber and Plastics
11	Other Non-Metallic Mineral
12	Basic Metals and Fabricated Metal
13	Machinery, Nec
14	Electrical and Optical Equipment
15	Transport Equipment
16	Manufacturing, Nec; Recycling
17	Electricity, Gas and Water Supply
18	Construction
19	Sale, Maintenance and Repair of Motor Vehicles and Motorcycles
20	Wholesale Trade and Commission Trade
21	Retail Trade
22	Hotels and Restaurants
23	Inland Transport
24	Water Transport
25	Air Transport
26	Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies
27	Post and Telecommunications
28	Financial Intermediation
29	Real Estate Activities
30	Renting of M&Eq and Other Business Activities
31	Public Admin and Defence; Compulsory Social Security
32	Education
33	Health and Social Work
34	Other Community, Social and Personal Services

Table B5. Commodities and WIOD Industries.

Commodity	HS Code	Industry
Beef	201	Agriculture, hunting, forestry and fishing
Pork	203	Agriculture, hunting, forestry and fishing
Lamb	204	Agriculture, hunting, forestry and fishing
Chicken	207	Agriculture, hunting, forestry and fishing
Fish	301	Agriculture, hunting, forestry and fishing
Fish Meal	304	Agriculture, hunting, forestry and fishing
Shrimp	306	Agriculture, hunting, forestry and fishing
Bananas	803	Agriculture, hunting, forestry and fishing
Coffee	901	Agriculture, hunting, forestry and fishing
Tea	902	Agriculture, hunting, forestry and fishing
Wheat	1001	Agriculture, hunting, forestry and fishing
Barley	1003	Agriculture, hunting, forestry and fishing
Corn	1005	Agriculture, hunting, forestry and fishing
Rice	1006	Agriculture, hunting, forestry and fishing
Soybeans	1201	Agriculture, hunting, forestry and fishing
Groundnuts	1202	Agriculture, hunting, forestry and fishing
Wool	1505	Agriculture, hunting, forestry, and fishing
Sugar	1701	Agriculture, hunting, forestry and fishing
Cocoa	1801	Agriculture, hunting, forestry and fishing
Natural Rubber	4001	Agriculture, hunting, forestry, and fishing
Hides	4101	Agriculture, hunting, forestry and fishing
Hard Log	4401	Agriculture, hunting, forestry and fishing
Soft Log	4403	Agriculture, hunting, forestry and fishing
Hard Swan	4407	Agriculture, hunting, forestry and fishing
Soft Swan	4408	Agriculture, hunting, forestry and fishing
Cotton	5201	Agriculture, hunting, forestry and fishing
Iron	2601	Mining and quarrying
Copper	2603	Mining and quarrying
Nickel	2604	Mining and quarrying
Aluminum	2606	Mining and quarrying
Lead	2607	Mining and quarrying
Zinc	2608	Mining and quarrying
Tin	2609	Mining and quarrying
Coal	2701	Mining and quarrying
Crude Oil	2709	Mining and quarrying
NatGas	2711	Mining and quarrying
Uranium	2844	Mining and quarrying
Gold	7108	Mining and quarrying
Soybean Meal	1208	Food products, beverages and tobacco
Soy Oil	1507	Food products, beverages and tobacco
Olive Oil	1509	Food products, beverages and tobacco
Palm Oil	1511	Food products, beverages and tobacco
Sun Oil	1512	Food products, beverages and tobacco
Coconut Oil	1513	Food products, beverages and tobacco

Table B6. Network Effects of Commodity Price Changes on Non-Commodity Sectors Without Russia

	Panel (a): Quantity			Panel (b): Prices		
	(1)	(2)	(3)	(4)	(5)	(6)
Upstream_{ict}	0.0055	0.0071**	0.0081***	-0.0060	0.0062	0.0026
	(0.0034)	(0.0033)	(0.0024)	(0.0067)	(0.0060)	(0.0022)
Upstream_{ict-1}	0.0043	0.0071*	0.0054**	-0.0210	-0.0034	-0.0008
	(0.0038)	(0.0040)	(0.0022)	(0.0153)	(0.0055)	(0.0018)
Downstream_{ict}	0.0019	0.0015	-0.0005	0.0034	0.0071**	0.0070***
	(0.0016)	(0.0015)	(0.0013)	(0.0052)	(0.0036)	(0.0025)
$\text{Downstream}_{ict-1}$	-0.0014	-0.0015	-0.0023**	0.0042	0.0073**	0.0107***
	(0.0015)	(0.0014)	(0.0012)	(0.0056)	(0.0033)	(0.0023)
Accumulated Upstream	0.0098	0.0142**	0.0135***	-0.0269	0.0028	0.0018
	(0.0052)	(0.0053)	(0.0036)	(0.0185)	(0.0060)	(0.0032)
Accumulated Downstream	0.0005	0.0001	-0.0028	0.0075	0.0144**	0.0177***
	(0.0023)	(0.0024)	(0.0020)	(0.0102)	(0.0049)	(0.0036)
Observations	3472	3472	3472	3472	3472	3472
Within R^2	0.932	0.800	0.789	0.958	0.702	0.720
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Country × Sector F.E.		Yes	Yes		Yes	Yes
Country × Year F.E.			Yes			Yes

Note: This table presents OLS regressions using sectoral log quantity (columns 1 to 3) and log price index (columns 4 to 6) as the dependent variable. The independent variables also include one lag of the dependent variable. Double clustered country-year standard errors in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.