POLICY RESEARCH WORKING PAPER 9792

Commodity Price Shocks

Order within Chaos?

John Baffes
Alain Kabundi

WORLD BANK GROUP
Prospects Group
October 2021

Policy Research Working Paper 9792

Abstract

The prices of 27 internationally traded commodities are decomposed into transitory and permanent shocks by applying an ideal band-pass filter to monthly data from 1970–2020. The two types of shocks contributed roughly equally to price variations, but with wide heterogeneity. Permanent shocks ac-counted for two-thirds of the variability in agricultural prices but less than 30 percent in energy prices. The transitory shock component revealed three medium-term cycles. The first (from the early 1970s to the mid-1980s) and third (from the early 2000s to 2020 onward) exhibit similar duration and involve almost all commodities, while the second (spanning the 1990s) is mostly applicable to metals, with the notable absence of energy. The permanent shock components differ across commodities, with an up-ward trend for most industrial commodities and downward trend for agriculture. Moreover, the permanent component of commodity prices where investment is irreversible, including energy, metals, and tree crops, exhibits a high degree of nonlinearities, which also coincide with the two post–World War II supercycles. By contrast, the permanent component of annual agricultural prices is linear, reflecting greater flexibility in investment allocation and input use of these commodities. Prices of commodities subjected to widespread policy interventions, such as international commodity agreements, exhibit persistent deviations from linear trends.

This paper is a product of the Prospects Group. It is part of a larger effort by the World Bank to provide open access to its research and make a contribution to development policy discussions around the world. Policy Research Working Papers are also posted on the Web at http://www.worldbank.org/prwp. The authors may be contacted at jbaffes@worldbank.org.

Produced by the Research Support Team

Commodity Price Shocks: Order within Chaos?

John Baffes
jbaffes@worldbank.org

Alain Kabundi
akabundi@worldbank.org

JEL CLASSIFICATION: N05, Q12, O31, Q41

KEY WORDS: Agriculture, commodity shocks, energy, fertilizers, metals, price cycles, price trends, supercycles

---

The authors would like to thank Justin Damien Guenette, Sergiy Kasyanenko, Gene Kindberg-Hanlon, Ayhan Kose, Peter Nagle, Franziska Ohnsorge, Temel Taskin, Hilary Till, as well as participants at two World Bank seminars (August 2020 and June 2021), CEMA conference (June 2021), and JPMCC Research Symposium (August 2021). This research reflects the views of the authors and was partly funded by the Government of Japan through the Policy and Human Resources Development (PHRD) Fund, administered by the World Bank Group.

> Two conclusions stood out most prominently … First, prices of individual commodities were very dissimilar in their movements … [which] emphasizes the desirability of studying the prices of commodities individually. Second, … commodities which were alike in their physical nature, their source of supply, or the uses to which they are put, were pretty generally dissimilar in their price movements during the period [1866-1891] under review.
>
> *Joseph L. Snider (1924)*

1. Introduction

Commodity price movements have significant impacts on emerging markets and developing economies (EMDEs). They can lead to terms of trade shocks, which often account for as much as half of the fluctuations in their economic activity (Mendoza 1995; Kose 2002; Di Pace, Juvenal, and Petrella 2020). In countries where a few commodities represent a significant part of external trade, commodity price movements can exacerbate currency movements. For lower-income commodity importing countries with a large share of consumer expenditure going to food and fuel, price movements can trigger inflationary pressures. Both currency volatility and inflationary pressures pose challenges to monetary policy authorities (Drechsel, McLeay, and Tenreyro 2019). Commodity price increases are often associated with surges in capital inflows, which if not invested wisely, can lead to banking and sovereign default crises when prices collapse—a notable example is the Latin American debt crisis of the 1980s (Kose *et al*. 2021; Eberhardt and Presbitero 2021; Reinhart, Reinhart, and Trebesch 2016). Thus, enhancing our understanding of how (and which) commodity prices respond to various shocks can help policy makers to fine-tune fiscal and monetary policies, ensure financial stability, and undertake poverty-reducing policies in lower income countries.

This paper has two objectives: First, to measure the relative contribution of permanent and transitory shock components to commodity price variability. Second, to examine how similarly (or dissimilarly) individual commodity markets respond to these shocks. Our study complements the literature on commodity price movements and the most recent literature on supercycles in several ways. First, the 27 price series used in the analysis were chosen judiciously from a larger set of prices based on several criteria, including the importance of the respective markets throughout the sample period, the desire to represent all major commodity groups, and the way in which price signals are formed. Second, the decomposition broadens the definition of shocks by accounting for supercycles (part of the permanent shocks in the context of our analysis) and by separating transitory shocks into two types of cycles: (i) the traditional 2 to 8-year cycle associated with the economic activity, which has been studied extensively in the macroeconomic literature and, in the case of commodities, metals markets (Davutyan and Roberts 1994; Labys, Lesourd, and Badillo 1998; Roberts 2009); and (ii) the medium-term cycle with periodicity of 8 to 20 years, which has not been studied in the literature as much but has received attention lately (McGregor, Spinola, and Verspagen 2018; Marañon and Kumral 2019; Ojeda-Joya, Jaulin-Mendez, and Bustos-Pelaez 2019). Third, the beginning of the sample was chosen to ensure that the price formation process reflects the post-Bretton Woods exchange rate arrangements while the choice of the frequency (monthly) enables us to have precise measurement of the high frequency components, especially business cycles and short-term fluctuations.

Numerous findings emerge from the analysis. On average, permanent shocks account for a little less than half of price variability. Of the remainder (transitory shocks), the medium-term and business cycle components account for 33 percent and 17 percent, respectively while only 4 percent is due to short term fluctuations. These shares, however, mask heterogeneity. The permanent shock component dominates agriculture while transitory shocks are more relevant to industrial commodities. Our analysis identifies three medium-term cycles: The first (from the early 1970s to mid-1980s) and third (from the early 2000s to 2020 onwards) exhibit similar duration and involve all commodities. The second, smaller, cycle (spanning the 1990s) is mostly applicable to metals and (less so) agriculture. The permanent shock components differ across commodities as well, with an upward trend for most industrial commodities and downward trend for agriculture. Commodities subjected to widespread policy interventions exhibit persistent price deviations from their respective linear trends. Non-linearities in the permanent component, which coincide with the two post-WWII supercycles, are dominant in commodities where investment is irreversible, such as energy, metals, and tree crops but not annual agricultural crops where there is greater flexibility on investment allocation and input use.

The rest of the paper proceeds as follows. The next section discusses the nature of shocks relevant to commodity markets. Section 3 gives a brief overview of the literature on long term behavior of commodity prices, including the emerging literature on supercycles. Section 4 outlines the ideal band-pass filter used in the analysis while the subsequent three sections discuss the empirical results and highlight findings that are important from policy and research perspectives. The last section concludes. Our analysis is supplemented by two Appendices. The first provides details on the choice and description of commodity price series along with data sources. The second reports detailed results on the medium-term cycles along with graphical representation of the component of each commodity price series.

2. Origins and nature of commodity shocks

Depending on their nature and origin, shocks could have a transitory or permanent impact on a commodity sector; they could also propagate in other commodity sectors. Transitory shocks can originate from several sources, including recessions, such as the 1997 East Asian financial crisis and the 2008 global financial crisis (both of which impacted a wide range of commodities). They can be the outcome of ad hoc policy measures, such as the escalation in tensions between the United States and China in 2018-19 (which impacted metals and soybeans) or bans such as those placed on grain exports during the 2007 and 2011 food price spikes (World Bank 2019). They can also arise from adverse weather conditions, which are common in agriculture, such as the recurring El Niño and La Niña episodes or drought-related production shortfalls (such as grains in 1995 and coffee in 1975 and 1985).[1] Transitory shocks can be associated with accidents (e.g. the 2019 Vale accident in Brazil which disrupted iron ore supplies or the container ship that temporarily obstructed traffic in the Suez Canal in early 2021); conflicts (such as the first Gulf war, when Iraq/Kuwait oil production was halted, or the closure of the Suez Canal in 1956-57 in response to the Suez crisis); and terrorist attacks (e.g., the attacks on Saudi Arabian oil facilities in 2019, which briefly disrupted oil exports).

Other shocks, especially those associated with technology and policies, can exert a more permanent impact on commodity markets—and prices. The development of shale technology in the natural gas and crude oil industries rendered the United States a net energy exporter in 2019 and the world's largest oil producer, for the first time since 1952 (EIA 2020). Advancements in biotechnology during the 1990s increased crop productivity by more than 20 percent (Klümper and Qaim 2014). Policies which encouraged production of biofuels shifted as much as 4 percent of global land from food to biofuel production (Rulli *et al*. 2016). Agricultural policies, including domestic support measures and trade restrictions by members of the Organization of Economic Cooperation and Development (OECD) have exerted downward pressures on global agricultural prices (Aksoy and Beghin 2004). Decisions by the Organization of Petroleum Exporting Countries (OPEC) to manage oil supplies are often associated with changes in the price of crude oil (Kaufmann et al. 2004).

Shocks can also propagate succeeding shocks, particularly those associated with energy markets. The supply-driven oil shocks of 1972 and 1979 induced policies that favored the use of coal, nuclear power, and renewable energy sources in electricity generation as well as fuel-saving technologies in transportation. The oil price boom of the mid-2000s, which was driven mostly by EMDE demand and OPEC supply cuts, pushed up the costs of food production but also triggered the biofuel policies mentioned earlier (Baffes 2013). Following the oil price collapse of 2014, food production costs declined but the diversion of food commodities to biofuel production remained in place.

Lastly, shocks could affect commodity markets in offsetting ways. The strong global economy during the early 1990s, which triggered a boom in metal prices, did not affect oil prices because it was offset by two supply shocks. First, new off-shore

---

[1] Weather shocks could affect energy and metal commodities as well. For example, the oil facilities of the Gulf of Mexico are often disrupted during the hurricane season; extreme temperatures could affect the demand for energy for heating or cooling as it did in mid-2021; for metals, open-pit mines could shut down due to floods (Cashin, Mohaddes, and Raissi 2017).

production capacity in the Gulf of Mexico and the North Sea and, second, additional capacity following the collapse of the Soviet Union. COVID-19, which caused a 9 percent decline in oil consumption during 2020, triggered supply cuts of similar magnitude by the OPEC+ group in April 2020 (World Bank 2020).

3. Literature review on commodity price behavior

The likely paths of commodity prices and their relationship with economic development figured prominently in the early economic literature (Table 1). Malthus (1798) assumed that population growth would outpace production growth of commodities and foresaw shortages; although he did not explicitly mention food prices, the eventual shortages would be expected to exert upward pressure on commodity prices. Based on statistical evidence, Engel (1857, discussed in Stigler 1954) showed that consumers allocate a smaller proportion of their income to total food expenditures as they become wealthier. Engel's conclusion, which was popularized by Kindleberger (1943) and became known as the declining terms-of-trade hypothesis, was later discussed and somewhat confirmed by Prebisch (1950) and Singer (1950).[2] In a related context, Hotelling (1931) demonstrated that the extraction costs of non-renewable resources should rise over time at a rate equal to the interest rate, implying that, for as long as real interest rates are positive, the real prices of non-renewable resources will be trending upwards.

In contrast to these 'monotonic' views, consistent with either upward (Malthus, Hotelling) or downward (Engel, Kindleberger, Prebisch-Singer) price paths, Schumpeter (1939) argued that innovation generates investment booms and busts ("creative destruction") which lead to long-term cycles in the economic activity and, consequently, cycles in commodity prices.[3] Schumpeter's views followed earlier work on cycles by Kondratieff (1926, discussed in Kondratieff and Stolper 1935) and Kuznets (1930). Similar conclusions were reached by others from different perspectives, including Slade (1982) who argued that the combination of low income elasticity of supply and delays caused by investment projects generate cycles with longer duration than the traditional business cycle.

---

[2] The declining Terms-of-trade hypothesis, which served as the intellectual foundation of the post-WWII industrialization policies, was championed by Kindleberger (1943) who wrote (p. 349): "A comparative advantage in natural silk, nitrates, or rubber, or an economy founded on coal and steam may be of fleeting profitability. Inexorably, too, the terms of trade move against agricultural and raw material countries as the world's standard of living increases (except in time of war) and as Engel's law of consumption operates. The elasticity of demand for wheat, cotton, sugar, coffee, and bananas is low with respect to income. If the agricultural and raw material countries of the world want to share the increase in the world's productivity, including that in their own products, they must join the transfer of resources from agricultural, pastoral pursuits, and mining to industry." It is noteworthy to mention that Engel's statistical analysis applied to food commodities while Kindleberger generalized it to all primary commodities.

[3] Jégourel (2018) discusses extensively the relationship between commodity price cycles and business cycles.

Despite extensive theoretical work on cycles, most pre-2000 empirical research on commodity price movements focused mostly on the declining terms-of-trade hypothesis. Results from this, rather extensive, literature have been mixed.[4] Cuddington (1992) examined the long term behavior of 26 annual real commodity prices during 1900-1983 and concluded that nearly two-thirds of the series were trendless while the remainder series were equally split between trending downwards and upwards. This conclusion is remarkably similar to that of Snider (1926) who had established heterogeneity among commodity price movements based on 87 U.S. monthly wholesale prices during 1866-1891. Deaton (1999, p. 27), in assessing the role of commodity prices in Africa's growth prospects, concluded that "[w]hat commodity prices lack in trend, they make up for in variance." Cashin and McDermott (2002), who found a downward price trend in real commodity prices during 1862-1999, also noted that the trend is small compared to price variability and, as such, is of little policy relevance.[5]

In contrast to the above, admittedly mixed, empirical evidence, subsequent research which accounted for the post-2000 commodity price movements and utilized longer price series identified a recurring pattern. During the past one and a half centuries, there have been four (three in the case of energy) commodity price cycles with duration of several decades—they are often referred to as supercycles. The last two of these cycles took place in the past 50 years: The first began in the 1970s and unwound in the early 1990s while the second began in the early 2000s and, for some commodities, is still under way (as of 2021). These supercycles, which span most commodity sectors, are considered to be triggered by demand surges such as the ones triggered by the westward expansion of the United States, the post-WWII reconstruction of Europe, and more recently, China's emergence as the world's industrial production center.[6] The literature on supercycles, which enjoys remarkable agreement among various authors, is summarized in Table 2.

4. Model and data

We begin by decomposing the real price of the commodity, p_t, as follows (Cuddington and Jerrett 2008, Erten and Ocampo 2012, and Ojeda-Joya *et al*. 2019):

---

[4] Baffes and Etienne (2015) reviewed 45 studies which focused exclusively on the Prebisch-Singer hypothesis and concluded that roughly half of them supported the declining terms-of-trade hypothesis. Most of these studies, including some on supercycles reviewed in this paper, used the Grilli-Yang commodity price indices (Grilli and Yang 1988).

[5] There have been other concerns regarding the policy relevance of the declining terms-of-trade hypothesis. Baffes (2007) found that non-energy commodity price movements, especially fertilizers and food commodities, are often driven by energy costs. Likewise, Radetzki *et al* (2008) noted that the post-2000 boom in metal prices was driven, in part, by higher exploration and development costs of new mineral deposits. Tilton (2013), who echoed similar views, concluded that unless the relevant Terms-of-trade accounts for costs, its movements should not be interpreted as worsening or improving positions of commodity exporters.

[6] China's share of global metal consumption increased from 5 percent in 1995 to 55 percent in 2020.

$$p_t \equiv PC_t + TC_t, \tag{1}$$

where PC_t and TC_t represent the permanent and transitory component, respectively. Equation (1), which is a broad representation encompassing several models, has been often approximated by the following regression:

$$p_t = \mu + \beta\tau_t + \varepsilon_t, \tag{2}$$

where τ_t denotes time trend, ε_t is white noise, and μ and β are parameters to be estimated. This model, which often accounts for non-linearities such as a time-squared term (e.g., Slade 1982), has been used extensively in various modeling frameworks.[7] Later attempts to account for cyclicality utilized filters developed by Hodrick and Prescott (1997) (HP filter). However, the HP filter is subjected to some limitations, including its reliance on an *ad hoc* smoothing parameter, which limits the choice of the cycle's duration and is subjected to end-point biases (Phillips and Jin 2015; Hamilton 2018; Phillips and Shi 2019).

To overcome such limitations, we use the frequency domain approach by invoking the following Fourier transform of p_t, denoted as $w_p(\lambda_s)$:

$$w_p(\lambda_s) = \sum_{t=1}^{T} p_t e^{-i\lambda_s t}. \tag{3}$$

T and λ_s represent the number of observations and the fundamental frequencies $\{\lambda_s = (2\pi s/T), s = 0, 1, \dots, T-1, \lambda_s \neq 0\}$. Under non-stationarity of p_t, equation (3) can be written as follows (Corbae, Ouliaris, and Phillips 2002):

$$w_p(\lambda_s) = -\frac{e^{i\lambda_s}}{1 - e^{i\lambda_s}} \frac{[p_T - p_0]}{\sqrt{T}} + \frac{1}{1 - e^{i\lambda_s}} w_v(\lambda_s), \tag{4}$$

where $w_v(\lambda_s)$ is the discrete Fourier transform of v_t ($v_t = p_t - p_{t-1}$). The first term of the right-hand side of equation (4) represents the deterministic trend (i.e., permanent component) in the frequency domain, i.e., the counterpart of τ_t of equation (2). The second term, which represents the transitory component, is obtained as a residual from a regression of p_t on the deterministic trend where $[p_T - p_0]$ is the estimated parameter. Because the detrending is performed in the frequency domain, the common leakage from low frequencies (a key problem of the HP filters) is eliminated. Thus, applying the indicator function for λ_s in a given frequency band to $w_p(\lambda_s)$ yields an unbiased estimate of the

---

[7] Equation (2) has been used often as a filtering process to induce stationarity in price series, most of which are $I(1)$ processes, so-called detrending. A more general class of models associated with equation (2), originally proposed by Nelson and Plosser (1982), assumes that ε_t is stationary with zero mean and a moving average process $A(L)\varepsilon_t = B(L)u_t$, where A(L) and B(L) are lag polynomials with an iid error term, $u_t = N(0, \sigma_u^2)$. This specification has been applied widely in time series modeling, including for commodity prices (e.g., Cuddington and Urzua 1989).

cycle in frequency domain $\widehat{w}_v(\lambda_s)$. The time-domain representation of the cycle is recovered by taking the inverse Fourier transform as follows:

$$TC_t^k = \frac{1}{\sqrt{T}} \sum_{t=1}^{T} \widehat{w}_v(\lambda_s) e^{i\lambda_s t}. \tag{5}$$

Equation (5) enables us to decompose the variability of commodity prices into various components by selecting the appropriate frequencies, k.[8] In the context of the present analysis, we decompose the transitory component into two cycles ($k \in$ [8-20] and [2-8]) and short-term fluctuations ($k \in$ [0-2]). Thus, identity (1) becomes:

$$p_t \equiv PC_t + TC_t^{[8,20]} + TC_t^{[2,8]} + ST_t. \tag{6}$$

PC_t, which represents the permanent component introduced earlier, could be characterized by a linear trend, perhaps subjected to structural breaks, if price behavior is analyzed in the context of declining Terms-of-trade hypothesis (Baffes and Etienne 2016), or it could include non-linearities consistent with supercycles (Cuddington and Jerrett 2008; Fernández, Schmitt-Grohé, and Uribe 2020). The empirical section elaborates further on the nature of PC_t. The second component, $TC_t^{[8,20]}$, denotes the medium-term cycle with a periodicity of 8-20 years as proposed by Blanchard (1997) and popularized by Comin and Gertler (2006). The third component, $TC_t^{[2,8]}$, represents the business cycle with a periodicity of 2-8 years, following traditional definition applied by the National Bureau of Economic Research (Burns and Mitchell 1946). The last component, ST_t captures fluctuations which may reflect short term movements in the economic activity or other macroeconomic variables (such as exchange rates and interest rates) or seasonality and weather patterns (in the case of agriculture). Often these fluctuations are analyzed with Vector Autoregression models (Kilian and Murphy 2014; Baumeister and Hamilton 2019) and GARCH models by utilizing high-frequency data, focusing mostly on volatility (Engle 1982).

Following decomposition, the logarithm of the price was regressed on each component to measure its relative contribution to price variability. For example, the R^2 from the regression of the price on the medium term cycle, $p_t = \mu + \beta TC_t^{[8,20]} + \varepsilon_t$, gives the relative contribution of the medium term cycle to total price variability. Note that the sum of the respective R^2s adds to unity since the sum of the four components adds to the price.

Monthly data for 27 commodity prices covering the period January 1970 to December 2020 (612 observations) were used in the analysis. They come from the World

---

[8] Even after removing the linear trend before detrending, as in equation (4), the cycle still contains a time-varying component, $p_T/\sqrt{T}$, leading to inconsistent results. Corbae and Ouliaris (2006) show that, in addition to consistency, (5) has no finite sampling error, has superior end-point properties, with a much lower mean-squared error compared to popular time-domain filters and other band-pass filters such as Baxter and King (1999) and Christiano and Fitzgerald (2003).

Bank's commodity database ("Pinksheet"), reported in nominal U.S. dollar terms. Prices were deflated by the U.S. Consumer Price Index. The choice of price series was based on a number of criteria in order to ensure that the respective commodities have been important throughout the sample period, they are representing all major commodity groups, and, to the extent possible, price signals have been generated by market-based mechanisms. The prices were grouped into the six categories: energy, base metals, precious metals (Figure 1) and fertilizers, annual agriculture, perennial agriculture (Figure 2). Details on data description and sources are given in Appendix A.

5. Heterogeneity ("chaos")

Decomposition results are summarized in Table 3. The first column reports the share of the price variation accounted by permanent shocks, followed by the contribution of the three transitory components (next three columns).[9] The subsequent two columns give the number of the medium-term and business cycles. The last two columns show results from a trend regression of the permanent shock component—the parameter estimate of the time trend and the Root Mean Square Error (RMSE).

On average across commodities, permanent shocks accounted for 46 percent of price variability while of the remainder, medium-term and business cycles accounted for 33 percent and 17 percent, respectively. These results confirm earlier findings from the macroeconomic literature relevant to EMDEs (Aguiar and Gopinath 2007) as well as the supercycle literature (Erten and Ocampo 2013) which emphasized the larger role of the permanent shock component. The predominance of the medium-term cycle in the transitory component is also in line with Aldasoro *et al*. (2020) and Cao and L'Huillier (2018) who established a greater role of medium-term cycles than business cycles in output fluctuations and domestic financial cycles. Lastly, only four percent of commodity price variability is attributed to shocks that are unwound in less than two years, a result which is consistent across all groups (except the fertilizer group) and most commodities. The lesser importance of the business cycles and short term fluctuations are also consistent with Cashing, McDermott, and Scott (2002) who analyzed the nature of cycles for 36 real commodity prices during 1957-1999 and concluded that (p. 292) "… cycles in economic activity alone do not drive the evolution of commodity prices, and that other factors, particularly supply conditions in individual commodity markets, are likely to be a key determinant of cycles in commodity prices."

The above averages, however, mask heterogeneity. Shocks associated with medium-term frequency accounted for 60 percent and 27 percent of price variability in energy and metals, respectively but only 14 percent in agriculture (Figure 3). These results are consistent with Fernández, Schmitt-Grohé, and Uribe (2020) who find that the

---

[9] The results pertaining to commodity groups have been derived on an individual commodity basis and aggregated to group level by using the weights reported in the first column of Table 3.

permanent component explains 60 percent and 30 percent of the variation in oil and metal prices, respectively.

While medium-term cycles dominated the temporary shock component overall, business cycles accounted for one-quarter of price variability for metals and fertilizers—about twice as much compared to the other four groups. The larger contribution of business cycle component to metal price fluctuations reflects the strong response of metal consumption to industrial activity, a relationship that has been established by numerous authors, including Tilton (1990), Davutyan and Roberts (1994), Labys, Achouch, and Terraza (1999), Roberts (2009), Stuermer (2017), and Marañon and Kumral (2019). Indeed, metals prices, especially copper, are often considered barometers and leading indicators of the global economic activity (Hamilton 2015; Bernanke 2016). This is in sharp contrast to crude oil where the relative contribution of demand and supply shocks is a hotly debated issue (Baumeister, Korobilis, and Lee 2021) and agriculture where supply shocks (primarily driven by weather conditions and policies) dwarf demand shocks.

Shocks had a heterogenous impact across and, in some cases, within groups. Across groups, permanent shocks accounted for two-thirds of price variability in agriculture, less than half in metals (including base and precious), and only 30 percent in energy and fertilizers. Within groups, base and precious metals exhibited the largest degree of heterogeneity (Figure 4).[10] For example, permanent shocks accounted more than two-thirds of the price variability of aluminum, lead, and tin but one-fifth of nickel and zinc. Similarly, while gold prices are driven mostly by permanent shocks, silver prices are driven equally by permanent and transitory shocks, while platinum prices exhibited one of the highest shares of medium-term cyclicality. At the other end of the spectrum, annual agriculture exhibited a high degree of homogeneity, with the permanent component's share of the five food commodities ranging from 62 percent (wheat) to 70 percent (maize).

6. Patterns ("order")

Notwithstanding the heterogeneity, a more detailed look at the size and shape of the transitory and permanent shock components, reveals a number of patterns within and across groups which are relevant from a policy and research perspective.

---

[10] Heterogeneity was based on dispersion, measured as deviation (absolute or standard) around their median share, averaged across the four frequency components. The absolute deviation of the permanent shock component of the base metals is 16.3 percent (based on the six shares reported in first column of the second panel of Table 3) with an 8.5 percent average across the four components. The corresponding 4-component average of annual agriculture is 2.7 percent. These findings are consistent with deviations portrayed by the range between maximum and minimum exhibited in Figure 3.

6.1. Patterns in transitory shocks

The analysis on transitory shocks revealed three medium-term cycles (Figure 5). The first, which involved all commodities, began in the early 1970s, peaked in 1978, and lasted until the mid-1980s. The second, which peaked in 1994, was most pronounced in metals (with duration and amplitude similar to the first cycle) and less so in agriculture. The third, which again involved all commodities, began in the early 2000s, peaked in 2010, and for some commodities is still underway (as of early 2021). The first and third cycles display similar patterns in terms of duration, peaks, and troughs with the two last supercycles documented in the literature (section 7 elaborates further on supercycles).

There are several important observations regarding the second medium-term cycle worth highlighting. In the case of base metals, the second medium-term cycle was as important as the first. It lasted more than 15 years (compared to 14 years of the first cycle) with a trough-to-peak and peak-to-trough amplitudes of 2.22 and 2.86 standard deviations, respectively, compared to 2.24 and 2.36 of the first cycle (Table 4). This cycle coincided with the prolonged expansion of 1990s, associated in part with the Dotcom boom, which ended with the East Asia Financial crisis. The second medium-term cycle for annual agriculture, which was smaller than the first, was associated with a doubling of grain prices during 1994-96 caused, in part, by reduced grain area during the transition of the Former Soviet Union and policy changes in the European Union (McCalla 1999).

In contrast to base metals and agriculture, crude oil and natural gas (whose price is highly correlated with oil) did not exhibit a second medium-term cycle. During the 1990s the oil market was subjected to three offsetting shocks that kept oil prices in check. First, new capacity from unconventional oil sources came into the market (North Sea, Gulf of Mexico, and Alaska). This was a result of innovation and investment in response to the high prices during the 1970s and early 1980s, partly caused by OPEC supply restrictions.[11] Second, considerable spare capacity became available in the global oil market following the collapse of the Soviet Union—prior to its collapse, the Soviet economy featured both inefficient production and energy-intensive consumption (World Bank 2009). Third, the oil price shocks of 1973 and 1979 led to substitution of oil by other energy sources (especially coal and nuclear energy) in electricity generation while policy-mandated efficiency standards in many OECD countries lowered global demand for energy (Baffes, Kabundi, and Nagle 2021).

Some of the commodities with the highest share of transitory shocks (especially the medium-term cycle) are used primarily by the transportation sector. For example, nearly two-thirds of crude oil is used for transportation, three-quarters of natural rubber goes to tire manufacturing, and half of platinum is used in the production of catalytic

---

[11] The three unconventional sources of oil—U.S. shale, Canadian oil sands, and biofuels—are also associated with the third medium-term cycle (Baffes *et al*. 2015). These unconventional sources accounted for approximately one-tenth of global oil supplies at the end of the first and third medium-term cycle.

converters (World Bank 2020b). Not surprisingly, these commodities experienced steep price declines during the first half 2020, following the mobility restrictions (in response to the COVID-19 pandemic.

6.2. Shape of permanent shocks

The analysis of the permanent shock components revealed some important characteristics in terms of trends and variability. The permanent component has trended upwards for energy commodities, downwards for both agricultural groups and fertilizers, and has been nearly trendless for most base metals (Figure 6). The upward trend in energy prices, which is consistent with Hotelling's pricing rule, may reflect resource depletion (Hamilton 2009) while the trendless nature of long-term price movements of some metals could be the outcome of the opposing forces of technological innovation and resource depletion (Marañon and Kumral 2019). Agriculture's downward trend along with the large share of permanent component confirms the declining terms-of-trade hypothesis.

Although the contribution of various shocks differed across- and within-groups, the contribution of permanent shocks to annual agricultural price variability is remarkably similar across the six commodities. This similarity reflects three forces. First, most annual agricultural commodities can be grown with the same inputs, including land, labor force, machinery, and other inputs such as chemicals and fertilizers. Such flexibility allows reallocation among crops from one year to another, in turn preventing sustained price gaps among these commodities. Indeed, despite the large increase of maize and edible oil demand due to biofuels over the past two decades, the prices of these commodities moved in tandem with other grains and oilseeds.[12] Similarly, the impact on soybean prices of the restrictions in soybean imports by China from the United States in 2018 was short-lived due to land reallocation (from soybeans to maize in the U.S. and maize to soybeans in South America). Second, because some annual crops have overlapping uses, substitution in consumption further dampens price disparities. In the case of soybean import restrictions by China, soybean meal was substituted by maize for animal use while soybean oil was substituted by palm oil for human consumption (World Bank 2019).[13] Third, agricultural policy interventions often apply to many commodities and change infrequently. For example, policies in the United States and the European Union, the world's largest players in several agricultural commodity markets, for the most part apply to the same crops. And, when policy reforms are introduced (such as the 1985 Farm

---

[12] Global demand for maize doubled during 2000-20, compared to the 26-28 percent increases in global demand for rice and wheat (in line with the 27 percent world's population growth over this period). The price increases of all three grains, however, moved in a similar manner.

[13] The imposition of tariffs by China on U.S. soybean imports resulted in trade diversion. As China's soybean imports from the U.S. declined and increased from Brazil, the EU began importing more from the U.S. and less from Brazil.

Bill in the U.S. and the 1992 Common Agricultural Policy reform in the EU), they typically apply to all commodities of the respective programs (Baffes and De Gorter 2005).

7. Supercycles

The permanent component of most prices follows a U-shaped pattern which captures the end and the beginning of the two post-WWII supercycles (see Figures B1-B27 of Appendix B). The trough, which occurs in the late 1990s and early 2000s, is consistent with the beginning of the last supercycle triggered by a surge in EMDE demand. To examine the contribution of supercycles to permanent shocks, we extended the analysis by using annual data during the 1900-2020 period.[14] The decomposition was applied to a subset of commodities (15 instead of 27) by using the same criteria applied to the earlier analysis. Hence, we excluded energy (because for most of the pre-1970 period energy prices, especially oil, were negotiated and changed infrequently), fertilizers (because they were not important during the first half of the sample), and precious metals (because for most of the pre-WWI period, their prices did not vary).[15]

Summary statistics from the 1900-2020 decomposition analysis are presented in Table 5. The second column reports the share of the permanent component based on annual frequency during 1970-2020 and compares it with the monthly frequency (shown in the first column of Table 5, which is the same as the share reported in Table 3). The comparison confirms that, while the results from the two frequencies are remarkably similar, changing the data frequency from monthly to annual increases marginally the share of the permanent component at the expense of the business cycle and short term fluctuations, as expected. Results based on the longer sample are reported in the last three columns of Table 5: Permanent component (column III), supercycle (column IV), and long term trend (column V). A summary of the results is also depicted in Figure 7. A number of important findings emerge from the supercycle analysis. First, the decomposition revealed four supercycles, consistent with the literature summarized in Table 2 (also shown in Figure 8). Second, the share of the permanent component based on the 1900-2020 sample was much larger compared to the 1970-2020 sample for all commodities, in some cases considerably so—the average share increased from 60 percent to 80 percent. Third, long-term trends (with frequency of more than 50 years) account for twice as much price variability compared to supercycles (with frequency between 20 and 50 years). Fourth, metals revealed a high degree of heterogeneity while annual agriculture is a highly homogenous group, further confirming results from the earlier analysis. Lastly, while the permanent component of agriculture was dominated by long-term trends, that of metals was

---

[14] The sample based on 1970-2020 data is not long enough to capture supercycles which could last up to 50 years. Thus, the sample extension to 1900-2020.

[15] The annual data used for analysis came from the World Bank's database (since 1960), complemented by Grilli and Yang (1988) during 1900-60.

equally shared by supercycles and long-term trends, albeit with high degree of heterogeneity (supercycles accounted for more than half of price variability in copper, lead, and tin, but only four percent in aluminum). Overall, the results from the 1900-2020 sample are consistent with the Schumpeterian investment booms and busts theory for metals and the declining Terms-of-trade hypothesis for agriculture.

The decomposition based on the longer sample adds an important dimension to our understanding of commodity price movements. The existing literature on supercycles identifies their main causes (mostly attributed to demand factors), calculates their duration (which can go up to 50 years), and counts them (four during the past one and a half century). Our research, which also measures the contribution of supercycles to total price variability, confirms that, of the 15 commodities for which market forces have dominated the price determination process, in only three metals (copper, lead, and tin) supercycles accounted for more than half of price variability. In the case of agriculture, they accounted for only 15 percent. These results imply that the permanent component identified in the shorter sample is dominated by a long-term trends and less so by supercycles.

Our analysis is relevant to the post-pandemic behavior of commodity prices. Following the synchronized commodity price rebound after COVID-19, there has been intense discussion in the financial press whether the price surge marks the beginning of a new supercycle (Terazono 2021). However, as noted by Jerrett (2021) and is also evident in the current analysis, the recent price increases (especially for base metals) could be associated with a business cycle or, at most, the beginning of another investment-driven medium-term cycle, perhaps linked to an investment boom in response to the energy transition (a metal intensive process), rather than a broad-based supercycle. And, while an upcoming supercycle could not be ruled out, it will require 20 years of data to be empirically confirmed.

8. Likely causes of heterogeneity and nonlinearities

Comparing annual agriculture with other groupings reveals some further insights. The behavior of the former can be summarized as follows: Its permanent shock component is linear, homogenous, and it accounts for a large share of price variability. The behavior of the latter can be summarized as follows: Price movements are dominated by transitory shocks (i.e., nonlinearities) while both transitory and permanent shocks are heterogeneous. At least three factors could account for these fundamentally different responses.

- **Investment**. For most energy and metal commodities, bringing discoveries to production is a process that requires investments which are subjected to large upfront costs and are, often, irreversible (Henry 1974; Bernanke 1983; Gilchrist and Williams 2000). Radetzki *et al* (2008), for example, attributed the post-2000 boom in metal prices, in part, to high exploration and development costs of new mineral deposits. Moreover, the time to develop resources could range from a few years to decades, depending on the type of mineral, the size and grade of the deposit, financing conditions, and numerous country-specific factors (World Bank 2016). For example, resource development takes an average of ten years for gold and more than 15 years for base metals such as zinc, lead, copper, and nickel (UNECA 2011). Similarly, tree crops are subject to high upfront costs and long investment cycles as well, in turn leading to asset fixity, an issue that has been addressed in the literature extensively (e.g., Basu and Gallardo 2021).[16] On the contrary, the production cycle of annual agricultural commodities, in addition to being short, it is characterized by a considerable degree of flexibility in input use (as noted earlier a producers can switch from, say, wheat to soybeans from one crop season to the next).

- **Policies**. Widespread and internationally coordinated policy interventions may create large and persistent price deviations from what market forces would dictate (and hence, nonlinearities). Persistent shocks due to the formation or termination of international commodity agreements has been cited by several other studies, including Cashing, Liang and McDermott (2000) as well as Gersovitz and Paxson (1990). To further investigate the role of coordinated policy actions, the last column of Table 3 reports the RMSE of a regression of the permanent component of each price on a time trend, a rough measure of the component's degree of non-linearity. The weighted average of RMSE across all commodities is 6.21. However, the group averages varied widely from 2.46 (base metals) to 14.56 (perennial agriculture), a result that is consistent with the heterogenous behavior discussed earlier. Moreover, the highest degree of nonlinearity is present in commodities which have been subjected to international commodity agreements (cocoa, coffee, crude oil, natural rubber, and tin) or with a history of large policy interventions (cotton)—the RMSE of these seven commodities averaged 11.44 compared to 3.89 for the remaining 20 commodities.[17] These results are consistent with Stuermer (2018) who gives evidence of long run price deviations due to the international tin agreement and Jacks and Stuermer (2020) who provided similar evidence for tin and sugar.
- **Natural endowment**. The distribution of natural endowment is another characteristic that inevitably leads to concentration of production, hence leading to heterogeneity and nonlinearities. Development of metals and energy projects depend on the existence and profitable accessibility of deposits. Similarly, production of perennial

---

[16] Asset fixity was frequently used as an explanation of low food commodity prices in the U.S. during the 1930s (Galbraith and Black 1938). Subsequent research, however, challenged the asset fixity hypothesis for agriculture (Chambers and Vasavada 1983).

[17] Cotton has been subjected to a high degree of government intervention by most major producers, including subsidies by the United States and the EU, taxation of Sub-Saharan cotton producers, and various types of policy interventions by Central Asian producers. Throughout the 1960s and 1970s the cotton market was also subjected to policy distortions by the Soviet Union (Baffes 2011).

agricultural commodities depends on the suitability of agroeconomic conditions. For example, tree crops such coffee and natural rubber are grown in specific regions of the tropics. In contrast, most annual agricultural crops, such as wheat and maize, can be grown under a variety of agroclimatic conditions.

9. Conclusion

One century ago, Snider (1924) concluded that commodity prices behave in a highly heterogenous manner. Subsequent research, including a large body of literature on the declining terms-of-trade hypothesis, did not identify policy-relevant patterns in commodity price movements. Indeed, in assessing the role of commodity prices in the growth prospects of African economies, Deaton (1999) concluded that commodity prices cannot guide policy making because variance dominates trends by a wide margin. This assessment was echoed later by Cashin and McDermott (2002). Subsequent research, however, which accounts for price movements during the past two decades, concludes that the post-2000 commodity price boom and bust is one of the four supercycles (or three, in the case of energy commodities) that have taken place since the late-19th century. Our paper confirms that, while the above assessments are valid, a careful choice of commodities analyzed individually within a frequency-domain framework (which allows separating shocks into transitory and permanent components) could provide some policy insights and guidance for further research.

Our results confirm that, on average across commodities, transitory and permanent shocks (with frequencies of less and more than 20 years, respectively) account for roughly equal shares. At a group-level, however, we find that agricultural prices are dominated by permanent shocks while industrial commodities are influenced mostly by transitory shocks. We also find that the medium-term cycle component of transitory shocks (with frequency of 8-20 years) accounts for twice the variation of the traditional business cycle component (with frequency of 2-8 years), in turn highlighting the importance of the investment activity’s delayed response.

At a more granular level, the paper identified three medium-term cycles, the first and third of which correspond to the latest two supercycles discussed in the literature. While both the first and third medium-term cycles involved all commodities, the latter exhibited higher amplitude and was more synchronized than the first, thus rendering it the largest post-WWII commodity price cycle. The second cycle, which was mostly relevant to metal commodities, did not involve energy at all. We also found that the permanent shock component is trending upwards for most industrial commodities and downwards for agriculture, implying that the former is consistent with Hotelling’s pricing rule while the latter supports the declining terms-of-trade hypothesis. Furthermore, the dominance of medium-term cycles, especially for industrial commodities, corroborates with Schumpeter’s view on investment cycles. The results on longer term trends were also confirmed by analysis on supercycles, which utilized a smaller data set (15 instead of 27 commodities) but for a longer time period (1900-2020 instead of 1970-2020).

A number of policy implications stem from our analysis. Heterogeneity of shocks across commodities implies that policies should be tailored to the terms-of-trade faced by each country by considering the export and import commodity mix rather than applying one-size-fits-all policies. For example, countercyclical macroeconomic policies can help buffer the impact of transitory shocks. Countries that depend on exports of highly "cyclical" commodities that are buffeted by frequent transitory shocks may want to build fiscal buffers during the boom phase and use them during the bust period in order to support economic activity. Policy makers could reduce the duration of the medium-term cycle in mineral commodities by shortening the period between discovery and the production process. In contrast, in countries that rely heavily on commodities that are subject to permanent shocks, structural policies may be needed to facilitate adjustments to new economic environments. For example, low income countries that depend on exports of agriculture as a source of revenue should embark on diversification efforts to limit the effects downward price trends. The procyclicality of policy interventions and commodity agreements is still an important aspect in the oil market where OPEC along with some non-OPEC oil producers engage in supply management. While such management could be beneficial at times and stabilize markets (such as the intervention in the early stages of the pandemic), it is important to be mindful of the fact that such interventions could have long lasting impacts. More broadly, the dominance of medium-term cycles in industrial commodities highlights the importance of investment cycles (and hence investment policies and climate) in commodity price movements.

Our research can be extended in several ways. First, our understanding of the sources of heterogeneity and similarities within and across commodity groups can be enhanced by assessing the degree and the evolution of synchronization in commodity cycles at different frequency domains. Second, although identification of future turning points and the medium-term path of commodity prices is beyond the scope of the current analysis, updating the results regularly with new observations could inform investment- and policy-making decisions. Third, from an econometric perspective, the difference of the permanent component's shares based on the two samples certainly deserves further analysis.

Table 1: Influential writings on the behavior on commodity prices

Author	Contribution
Malthus (1798)	Exponential increase in population combined with linear growth in supply of resources would cause resource shortages and, by implication, high commodity prices. That process, which would gradually lower the standards of living, is known as ***Malthusianism***.
Engel (1857)	Following analysis of budget expenditures of 153 Belgian families in 1853, Engel concluded that poor families spend a larger proportion of their income on food than wealthier families. The finding was later coined ***Engel's Law***.
Mitchell (1908)	Analyzed wholesale prices, wages, and transportation costs for the U.S. economy. Subsequently, Burns and Mitchell (1943), the architects of the business cycles measurement, used commodity prices as leading indicators of the economic activity in order to identify turning points of the U.S. economy.
Snider (1924)	Based on analysis of monthly prices during 1866-91, he concluded that commodity price movements were highly heterogenous and commodities with similar physical characteristics and uses were dissimilar in their price movements.
Kondratieff (1926) and Kuznets (1930)	Kondratieff observed cyclical behavior in economic indicators including commodity prices with duration of 40-60 years (similar to supercycles). Later, Kuznets considered cycles that are triggered by innovation with a duration of 15-20 years (similar to medium-term cycles). These cycles are also known as ***Kondratieff waves*** and ***Kuznets swings***.
Hotelling (1931)	Demonstrated that the extraction costs (and, hence, prices) of non-renewable resources should rise over time at a rate equal to the interest rate. It is known as ***Hoteling's rule***.
Schumpeter (1939)	Argued that innovation creates new industries and destroys old ones. That, in turn, induces booms and busts in investment activity, leading to business cycles and, by consequence, cycles in commodity prices. The process became known as ***Schumpeterian creative destruction***.
Kindleberger (1943)	As a direct consequence of Engel's Law, the terms-of-trade of developing countries (typically commodity-exporting) relative to industrialized economies (generally commodity importing) would be subjected to downward pressures. This is also known as ***Kindleberger's conjecture***.
Prebisch (1950) and Singer (1950)	Based on data from 1870s to WWII, they argued that primary commodity prices decline relative to the prices of manufacturing goods. This is known as the ***declining Terms-of-trade hypothesis*** and the ***Prebisch-Singer hypothesis***.
Deaton (1999)	In assessing the role of commodities in Africa's growth prospects, he noted that "[w]hat commodity prices lack in trend, they make up for in variance."

Notes: The focus of Malthus (1798), Mitchell (1908), Kondratieff (1926), Kuznets (1940), and Schumpeter (1939) was general. The focus of the other authors was commodity-related.

Table 2: Summary of empirical research on supercycles

Author(s)	Data	Main finding
Cuddington and Jerrett (2008)	Six base metals, 1850-2006, deflated by the U.S. CPI and PPI	Four supercycles (the last was ongoing): 1890-1930, 1930-1962, 1962-1998, 1998-
Jerrett and Cuddington (2008)	Three metals, 1850-2006, deflated by the U.S. CPI	Three supercycles: 1850-1925, 1925-1998, 1998-
Cuddington and Zellou (2012)	Crude oil, 1861-2010, deflated by the U.S. CPI and PPI	Three supercycles after WWII which comove with metals: 1861-1884, 1966-1996, 1996-
Erten and Ocampo (2013)	Prices of 24 commodities and indices, 1865-2010, deflated by the U.S. CPI and MUV index	Four supercycles consistent with the Prebisch-Singer hypothesis: 1890-1930, 1930-1965, 1970-1998, 1998-
Rossen (2015)	Prices of 20 metals, 1910-2011, monthly, deflated by the U.S. CPI	Four supercycles: 1910-1930, 1930-1965, 1970-1998, 1998-
Erdem and Ünalmış (2016)	Crude oil, 1861-2014, deflated by the U.S. CPI	Three supercycles: 1861-1882, 1966-1996, 1996-
Buyuksahin, Mo, and Zmitrowicz (2016)	Bank of Canada commodity index, 1899-2015, deflated by the U.S. PPI	Four supercycles: 1899-1932, 1933-1961, 1962-1995, 1996-
McGregor, Spinola, and Verspagen (2018)	Five price indices, 1960-2016, deflated by the MUV	Two supercycles: 1960-1995, 1996-
Ojeda-Joya, Jaulin-Mendez, and Bustos-Pelaez (2019)	Index, 1865-2013 and 24 commodities, 1962-2010, deflated by the MUV index	Supercycles are synchronized and demand-driven: ***Oil***: 1885-1950, 1965-1995, 1996-; ***Metals***: 1877-1920, 1920-1945, 1945-1995, 1995-; ***Non-oil***: 1895-1937, 1937-1996, 1996-
Jacks (2019)	Indices and 40 commodities, 1900-2015, deflated by the U.S. CPI	Three or four medium-term cycles (depending on the commodity) and modestly increasing trend: 1903-1932, 1965-1996, 1996-
Cordano and Zellou (2020)	Natural gas prices, 1922-2015, deflated by the U.S. CPI	Three supercycles, strongly correlated with oil supercycles: 1948-1970, 1970-1994, 1994-2017
Erten and Ocampo (2021)	Four indices as in Erten and Ocampo (2013)	Four supercycles: 1890-1930, 1930-1965, 1970-1998, 1998-
This study	Six metal and nine agricultural prices, 1900-2020, deflated by the U.S. CPI	Four supercycles: 1904-1933, 1933-1966, 1966-1996, 1996-

Notes: All papers (except Rossen 2015) use annual data and are based on the HP filter, except Erdem and Ünalmış (2016) who use BP and HP filters. The MUV index (Manufacturing Unit Value) is a measure of dollar-based global manufacturing inflation monitored by the World Bank.

Table 3: Real commodity price decomposition, 1970-2020

	Share of variance explained by				Number of cycles		PC_t	
	PC_t	$TC_t^{[8-20]}$	$TC_t^{[2-8]}$	ST_t	$TC_t^{[8-20]}$	$TC_t^{[2-8]}$	β	*RMSE*
ENERGY								
Coal [**4.6**]	0.30	0.47	0.21	0.03	3	11	0.43	5.31
Crude oil [**84.6**]	0.24	0.60	0.12	0.04	2	12	1.02	7.65
Natural gas [**10.8**]	0.15	0.72	0.10	0.03	2	11	0.57	2.50
Average	**0.24**	**0.60**	**0.12**	**0.04**	**2**	**11**	**0.95**	**6.99**
BASE METALS								
Aluminum [**312.9**]	0.58	0.19	0.20	0.04	4	10	-0.14	0.64
Copper [**47.4**]	0.47	0.31	0.20	0.03	3	9	-0.80	3.31
Lead [**2.2**]	0.55	0.26	0.16	0.03	3	8	-0.54	4.75
Nickel [**9.9**]	0.18	0.44	0.34	0.05	3	11	-0.78	1.63
Tin [**2.6**]	0.71	0.22	0.06	0.01	3	12	0.05	4.38
Zinc [**5.0**]	0.24	0.24	0.48	0.05	3	8	-0.09	2.08
Average	**0.47**	**0.27**	**0.22**	**0.03**	**3**	**10**	**-0.52**	**2.46**
PRECIOUS METALS								
Gold [**77.8**]	0.62	0.27	0.09	0.02	3	8	1.28	5.38
Platinum [**18.9**]	0.19	0.53	0.24	0.05	3	11	-0.22	1.85
Silver [**3.3**]	0.45	0.39	0.14	0.03	3	11	0.27	13.47
Average	**0.53**	**0.33**	**0.12**	**0.02**	**3**	**10**	**0.96**	**4.98**
FERTILIZERS								
Phosphate [**16.9**]	0.34	0.33	0.26	0.07	3	9	-0.40	6.48
Potassium [**20.1**]	0.33	0.47	0.17	0.03	3	10	-0.46	3.43
TSP [**21.7**]	0.33	0.26	0.35	0.06	4	9	-0.52	3.91
Urea [**41.3**]	0.21	0.43	0.22	0.14	3	12	-0.02	4.44
Average	**0.28**	**0.39**	**0.25**	**0.09**	**3**	**10**	**-0.28**	**4.47**
ANNUAL AGRICULTURE								
Cotton [**8.5**]	0.80	0.07	0.11	0.02	3	13	-0.07	9.00
Maize [**20.5**]	0.70	0.15	0.11	0.04	3	10	-0.50	3.55
Rice [**15.2**]	0.63	0.18	0.14	0.05	3	9	-0.43	3.29
Soybean meal [**29.0**]	0.68	0.11	0.16	0.05	3	10	-0.48	3.48
Soybean oil [**14.3**]	0.66	0.15	0.15	0.03	3	11	-0.72	3.15
Wheat [**12.5**]	0.62	0.17	0.15	0.07	3	9	-0.42	2.60
Average	**0.68**	**0.14**	**0.14**	**0.04**	**3**	**10**	**-0.47**	**3.78**
PERENNIAL AGRICULTURE								
Cocoa [**25.6**]	0.66	0.23	0.10	0.01	3	11	0.03	15.41
Coffee Arabica [**15.7**]	0.60	0.24	0.13	0.03	3	14	0.22	10.38
Coffee Robusta [**15.7**]	0.74	0.18	0.06	0.02	3	13	0.42	15.86
Natural Rubber [**30.6**]	0.29	0.45	0.23	0.03	3	10	-0.36	17.39
Tea [**12.4**]	0.77	0.08	0.12	0.04	3	13	-0.17	9.47
Average	**0.56**	**0.27**	**0.14**	**0.02**	***3***	***12***	**-0.03**	**14.56**
ALL AVERAGE	***0.46***	***0.33***	***0.17***	***0.04***	***3***	***11***	***0.10***	***6.21***

Notes: The numbers in the square brackets of the first column represent weights and add to 100 for each commodity group, subject to rounding errors. PC_t, $TC_t^{[8-20]}$, $TC_t^{[2-8]}$, and ST_t denote the permanent component, medium-term cycle, business cycle, and short-term fluctuations, the shares of which add to 100, subject to rounding. For example, crude oil's shares are: 0.24 + 0.60 + 0.12 + 0.04 = 1. The penultimate column reports the parameter estimate of β from a regressions of $log(PC_t)$ on a time trend. The last column reports the Root Mean Square Error (RMSE) from the same regression. The last row ("ALL AVERAGE") shows the arithmetic average over the five group-weighted averages.

Table 4: Characteristics of the medium-term cycles

		------ *Duration (years)* ------		------ *Amplitude (std)* ------	
	Peak year	*Expansion*	*Contraction*	*Expansion*	*Contraction*
First					
Energy	1980	10.7	11.4	3.20	2.29
Base metals	1978	7.0	6.6	2.24	2.36
Precious metals	1980	11.2	7.5	2.80	1.40
Fertilizers	1978	8.0	9.8	3.30	1.66
Annual agriculture	1977	7.1	10.1	3.04	1.85
Perennial agriculture	1977	7.5	12.9	3.16	2.71
Average	**1978**	**8.6**	**9.7**	**2.96**	**2.04**
Second					
Energy	—	—	—	—	—
Base metals	1991	6.7	8.5	2.22	2.86
Precious metals	1993	4.3	7.7	0.35	1.25
Fertilizers	1992	5.2	6.7	0.71	1.36
Annual agriculture	1995	7.5	8.3	1.64	2.38
Perennial agriculture	1997	6.0	5.9	2.05	2.32
Average	**1994**	**5.0**	**6.2**	**1.16**	**1.71**
Third					
Energy	2008	11.7	10.9	2.38	3.34
Base metals	2009	7.1	5.6	3.58	3.02
Precious metals	2010	10.2	8.1	3.14	3.88
Fertilizers	2009	7.8	6.4	3.13	3.99
Annual agriculture	2011	8.5	8.6	3.33	3.70
Perennial agriculture	2009	6.5	10.5	2.94	3.12
Average	**2010**	**8.6**	**8.4**	**3.08**	**3.51**

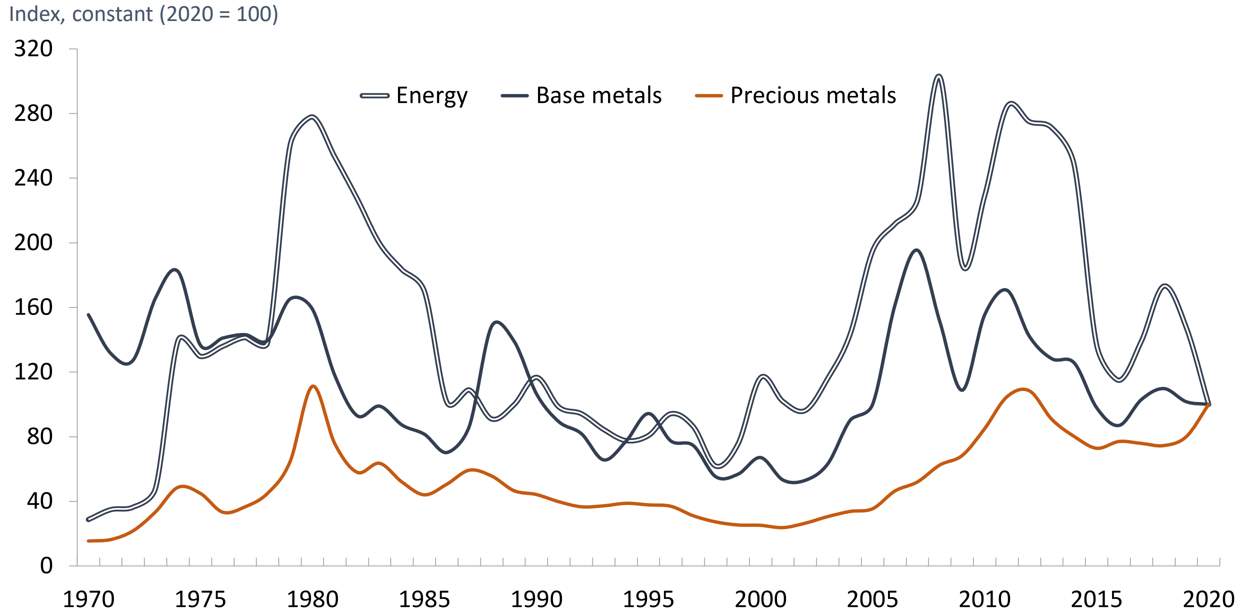
Notes: Commodity-specific statistics are reported in Appendix A (Tables B1-B3). '—' implies that a cycle was not detected. 'std' means standard deviation.

Table 5: Real commodity prices—share of permanent component

	I	*II*	III	*IV*	*V*
	1970-2020		***1900-2020***		
BASE METALS					
Aluminum	0.58	0.62	0.92	0.89	0.04
Copper	0.47	0.50	0.69	0.12	0.57
Lead	0.55	0.58	0.64	0.07	0.57
Nickel	0.18	0.19	0.67	0.35	0.31
Tin	0.71	0.73	0.77	0.12	0.64
Zinc	0.24	0.27	0.45	0.07	0.36
ANNUAL AGRICULTURE					
Cotton	0.80	0.83	0.90	0.77	0.13
Maize	0.70	0.73	0.85	0.72	0.13
Palm oil	0.62	0.66	0.84	0.68	0.16
Rice	0.63	0.66	0.84	0.73	0.12
Wheat	0.62	0.66	0.86	0.72	0.14
PERENNIAL AGRICULTURE					
Cocoa	0.66	0.67	0.84	0.40	0.43
Coffee, composite	0.68	0.70	0.74	0.48	0.25
Natural rubber	0.29	0.31	0.90	0.77	0.13
Tea	0.77	0.80	0.89	0.76	0.13

Notes: Column I shows the share of permanent component reported in Table 3, with two exceptions (in addition to the exclusion of energy, fertilizers, and precious metals). First, soybean oil has been replaced by palm oil (they are close substitutes) and soybean meal has been eliminated due to lack of data. While palm oil is a tree crop, it was included in the annual agriculture group because it is a close substitute with most edible oils, and thus, it behaves as if it is an annual, not tree, crop. other Second, coffee (Arabica) and coffee (Robusta) have been replaced by coffee composite (the average of Arabica and Robusta). Column II reports the share of permanent component for 1970-2020, based on annual frequency. Thus, the difference between columns I and II is the frequency of data. Column III reports the share of the permanent component for the 1900-2020 period (annual frequency). Columns IV and V (which add up to column III, subject to rounding) show the shares of trend component (with frequency above 50 years) and the supercycle component (with frequency between 20 and 50 years) for 1900-2020 period.

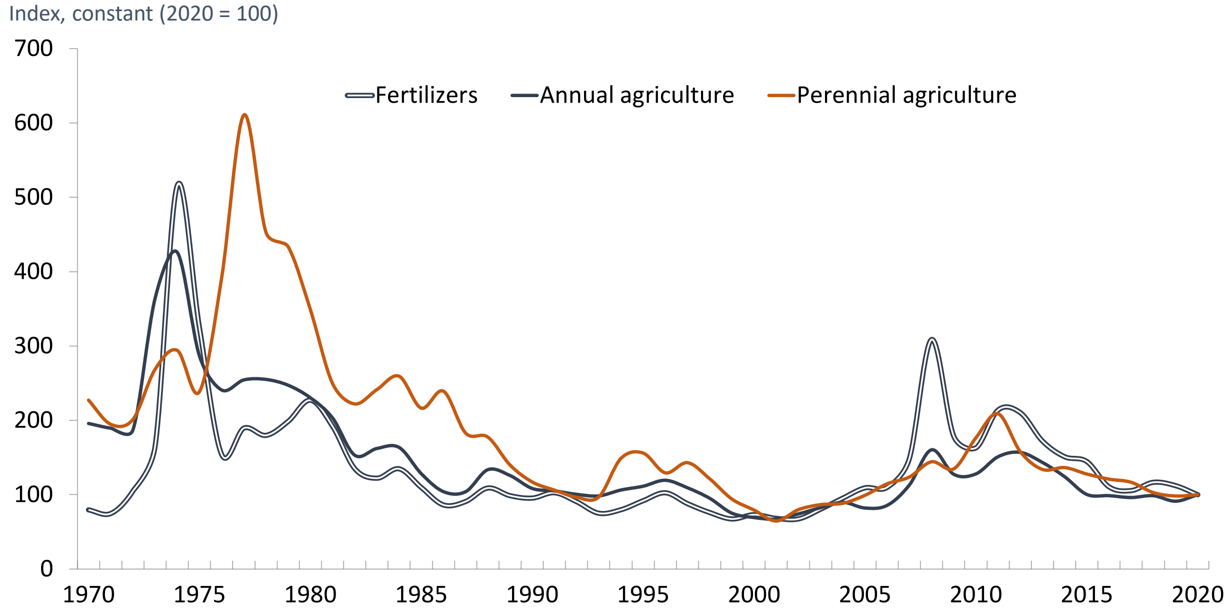
Figure 1: Commodity price indices—energy and metals



Source: World Bank

Notes: The indices (annual averages) have been deflated by the U.S. CPI. Last observation is 2020.

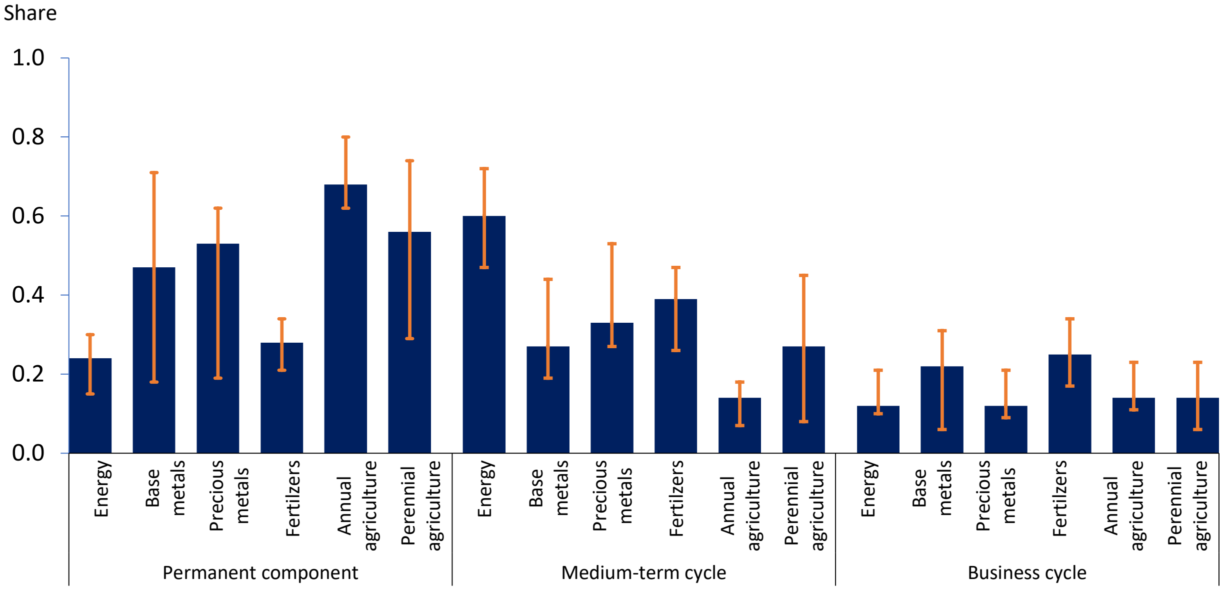
Figure 2: Commodity price indices—fertilizers and agriculture



Source: World Bank

Notes: The indices (annual averages) have been deflated by the U.S. CPI. Last observation is 2020.

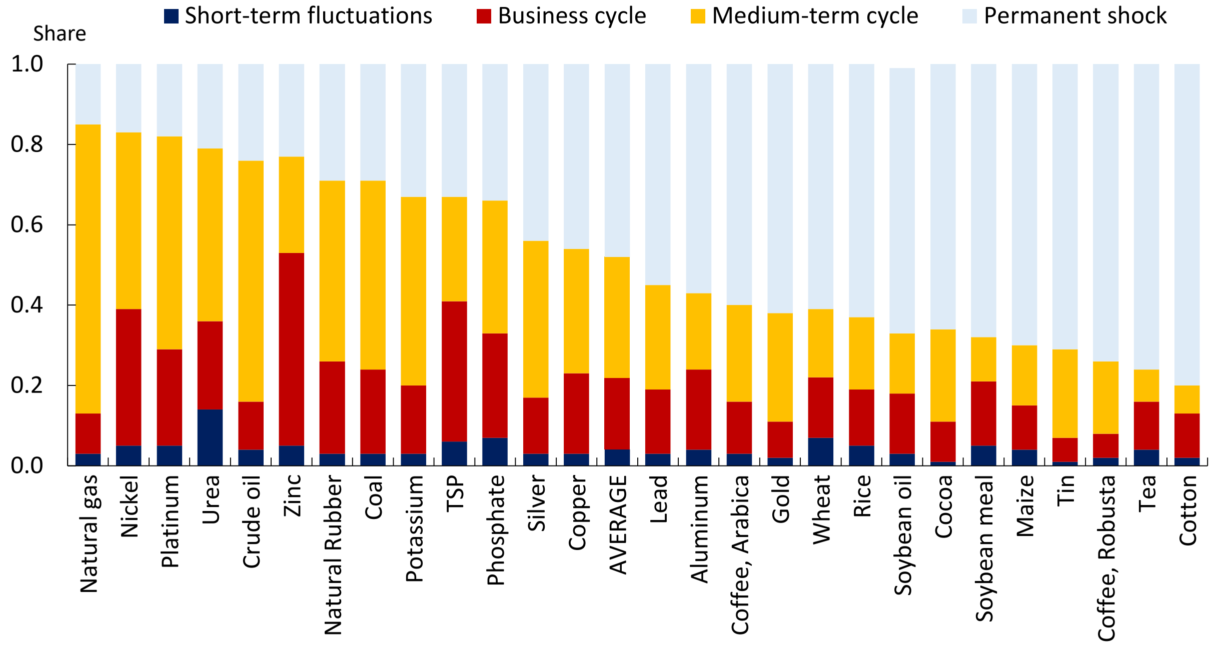
Figure 3: Contribution of shocks, 1970-2020



Source: Authors' calculations

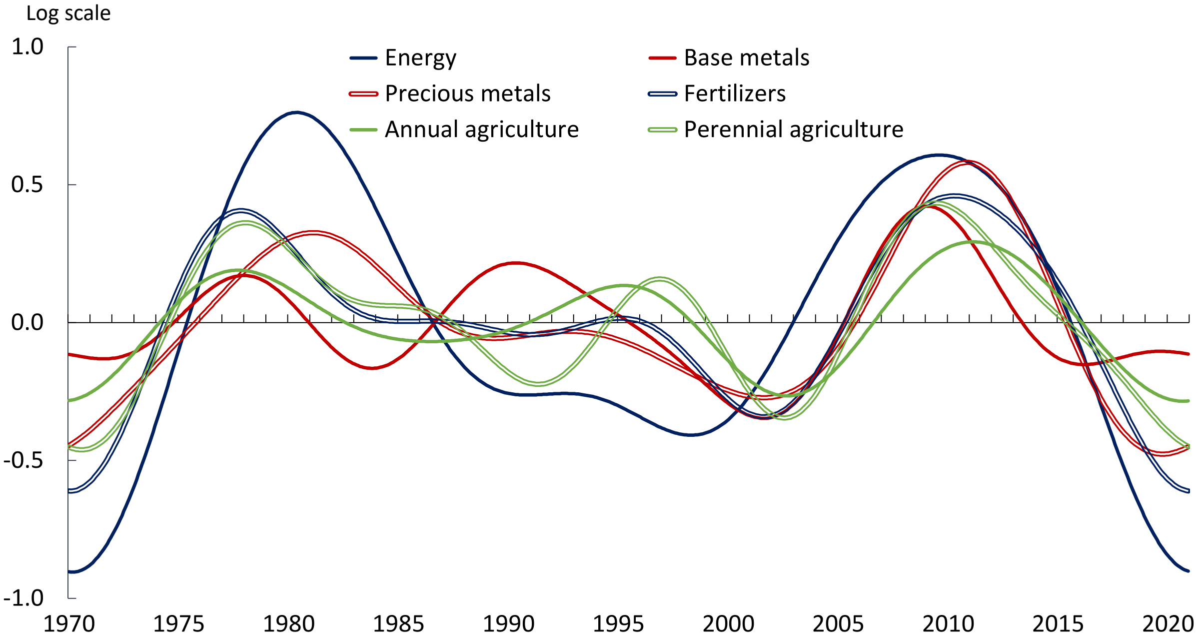
Notes: Blue bars and orange lines denote weighted averages and ranges of each group.

Figure 4: Price decomposition, individual commodities, 1970-2020



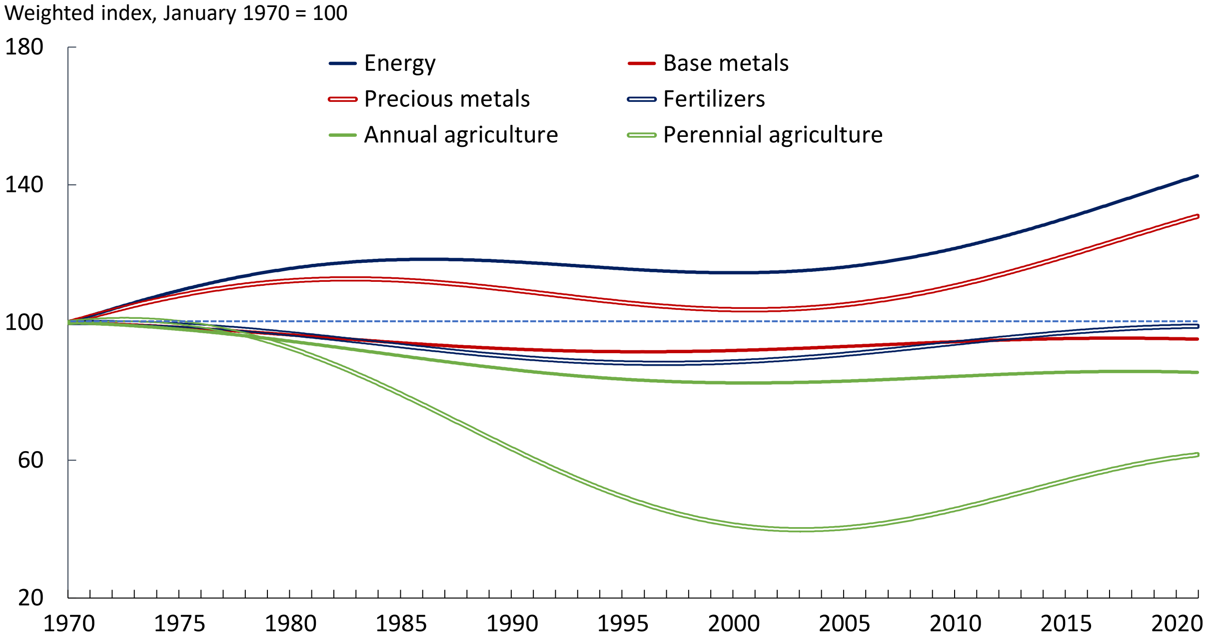
Source: Authors' calculations

Figure 5: Medium-term cycle component



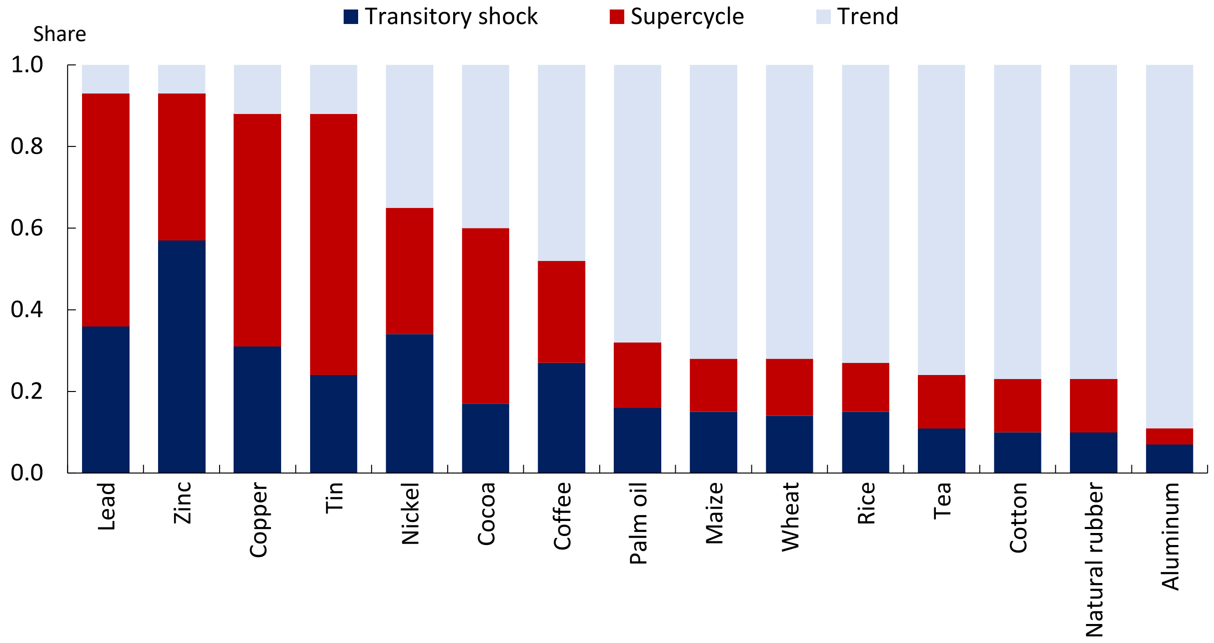
Source: Authors' calculations

Figure 6: Permanent shock component



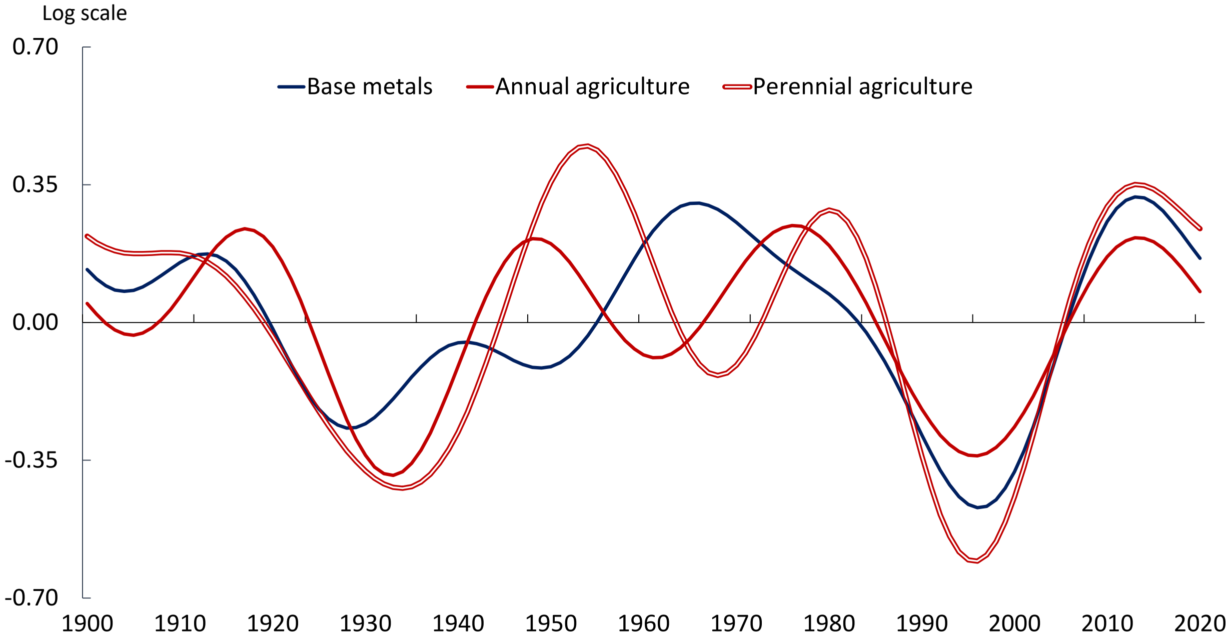
Source: Authors' calculations

Figure 7: Price decomposition, 1900-2020



Source: Authors' calculations

Figure 8: Supercycles, 1900-2020



Source: Authors' calculations

References

Aguiar, M. and G. Gopinath (2007). “Emerging Market Business Cycles: The Cycle Is the Trend.” *Journal of Political Economy* 115(1): 69-102.

Aksoy M.A. and J. Beghin (2004). *Global Agricultural Trade and Developing Co*untries. Washington, DC: World Bank.

Aksoy, M.A and B.M. Hoekman (2010). *Food Prices and Rural Poverty*. Washington, DC: World Bank.

Aldasoro, I., S. Avdjiev, C. Borio, and P. Disyatat (2020). “Global and Domestic Financial Cycles: Variations on a Theme.” BIS Working Paper 864. Basel, Switzerland: Bank of International Settlements.

Baffes, J. (2013). “A Framework for Analyzing the Interplay among Food, Fuels, and Biofuels.” *Global Food Security*, 2(2): 110-116.

Baffes, J. (2011). “Cotton Subsidies, the WTO, and the ‘Cotton Problem’.” *The World Economy*, 34(9): 1534-1665.

Baffes, J. (2007). “Oil Spills on Other Commodities.” *Resources Policy*, 32(3): 126-134.

Baffes, J., A. Kabundi, and P. Nagle (2021). “The Role of Income and Substitution in Commodity Demand.” *Oxford Economic Papers*, forthcoming.

Baffes, J. and X. Etienne (2016). “Analyzing Food Price Trends in the Context of Engel's Law and the Prebisch-Singer Hypothesis.” *Oxford Economics Papers*, 68: 688-713.

Baffes, J., M. A. Kose, F. Ohnsorge, and M. Stocker (2015). “The Great Plunge in Oil Prices: Causes, Consequences, and Policy Responses.” Policy Research Note 1. Washington, DC: World Bank.

Baffes, J. and H. De Gorter (2005). “Experience with Decoupling Agricultural Support.” In *Global Agricultural Trade and Developing Countries*, ed. M.A. Aksoy and J. Beghin. Washington, DC: World Bank.

Basu, R.B. and R.K. Gallardo (2021). “Economic Issues Related to Long-Term Investments in Tree Fruits.” *Choices*, 36(2): 1-7.

Baumeister, C. and J.D. Hamilton (2019). “Structural Interpretation of Vector Autoregressions with Incomplete Identification: Revisiting the Role of Oil Supply and Demand Shocks.” *American Economic Review*, 109(5): 1873-1910.

Baumeister, C., D. Korobilis, and T.K. Lee. (2021). “Energy Markets and Global Economic Conditions.” *Review of Economics and Statistics*, in press.

Baxter, M. and R.G. King (1999). “Measuring Business Cycles: Approximate Band-pass Filters.” *The Review of Economics and Statistics*, 81(4): 575-593.

Bernanke, B. (1983). “Irreversibility, Uncertainty, and Cyclical Investment.” *Quarterly Journal of Economics*, 98(1): 85-106.

Bernanke, B. (2016). "The Relationship Between Stocks and Oil Prices." https://www.brookings.edu/blog/benbernanke/2016/02/19/the-relationship-between-stocks-and-oil-prices/

Blanchard, O. (1997). "The Medium Run." *Brookings Papers on Economic Activity*, 2: 89-158.

Burns, A.F. and W.C. Mitchell (1946). *Measuring Business Cycles*, National Bureau of Economic Research. New York: NBER.

Buyuksahin, B., K. Mo, and K. Zmitrowicz (2016). "Commodity Price Supercycles: What Are They and What Lies Ahead?" *Bank of Canada Review*, Autumn: 35-45.

Cao, D. and J-P. L'Huillier (2018). "Technological Revolutions and the Three Great Slumps: A Medium-run Analysis." *Journal of Monetary Economics*, 96: 93-108.

Cashin, P., K. Mohaddes, and M. Raissi (2017). "Fair Weather or Foul? The Macroeconomic Effects of El Niño." *Journal of International Economics*, 106: 37-54.

Cashin, P. and C.J. McDermott (2002). "The Long-Run Behavior of Commodity Prices: Small Trends and Big Variability." *IMF Staff Papers*, 49(2): 175-199.

Cashing, P., C.J. McDermott, and A. Scott (2002). "Booms and Busts in World Commodity Prices." *Journal of Development Economics*, 69: 277-296.

Cashing, P., H. Liang, and C.J. McDermott (2000). "How Persistent Are Shocks to World Commodity Prices?" *IMF Staff Papers*, 47(2): 177-217.

Chambers, R.G. and U. Vasavada (1983). "Testing Asset Fixity for U.S. Agriculture." *American Journal of Agricultural Economics*, 65(4): 761–769.

Christiano, L. and T. Fitzgerald (2003). "The Band Pass Filter." *International Economic Review*, 44(2): 435–465.

Comin, D. and M. Gertler (2006). "Medium-term Business Cycles." *American Economic Review*, 96(3): 523–551.

Corbae, D., S. Ouliaris, and P.C.B. Phillips (2002). "Band and Spectral Regression with Trending Data." *Econometrica*, 70(3): 1067–1109.

Corbae, D. and S. Ouliaris (2006). "Extracting Cycles from Nonstationary Data." In *Econometric Theory and Practice: Frontiers of Analysis and Applied Research*, ed. by D. Corbae, S. Durlauf, and B. Hansen. New York: Cambridge University Press.

Cordano, A.L.V. and A.M. Zellou (2020). "Super Cycles in Natural Gas Prices and their Impact on Latin American Energy and Environmental Policies." *Resources Policy*, 65: https://doi.org/10.1016/j.resourpol.2019.101513

Cuddington, J.T. (1992). "Long-run Trends in 26 Primary Commodity Prices: A Disaggregated Look at the Prebisch-Singer Hypothesis." *Journal of Development Economics*, 39: 207-227.

Cuddington, J.T. and D. Jerrett (2008). "Super Cycles in Real Metal Prices?" *IMF Staff Papers*, 55 (4): 541-565.

Cuddington, J.T. and C. Urzua (1989). "Trends and Cycles in the Net Barter Terms of Trade: A New Approach." *Economic Journal*, 99: 426–442.

Cuddington, J.T. and A. Zellou (2012). "Is There Evidence of Super-cycles in Crude Oil Prices?" *SPE Economics and Management*, 4(3): 171-181.

Davutyan, N. and M.C. Roberts (1994). "Cyclicality in Metal Prices." *Resources Policy*, 20: 49-57.

Deaton, A. (1999). "Commodity Prices and Growth in Africa." *Journal of Economic Perspectives*, 13: 23-40.

Drechsel, T., M. McLeay, S. Tenreyro (2019). "Monetary Policy for Commodity Booms and Busts." Presented at the Jackson Hole Economic Policy Symposium, Federal Reserve Bank of Kansas City.

Eberhardt, M. and A. Presbitero (2021). "Commodity Prices and Banking Crisis." CEPR Discussion Paper 15959. Center for Economic Policy Research, London.

EIA, Energy Information Administration (2020). *Monthly Energy Review*. April. Washington, DC: U.S. Energy Information Administration.

Engel, E. (1857). "Die productions- und consumtionsverhaltnisse des königreichs sachsen", Zeitschrift des Statistischen Bureaus des Königlich-Sächsischen Ministerium des Inneren, 8/9, 1–54 ["The production and consumption relations of the Kingdom of Saxony", *Journal of the Statistical Office of the Royal Saxon Ministry of the Interior*].

Engle, R.F. (1982). "Autoregressive Conditional Heteroscedasticity with Estimates of Variance of United Kingdom Inflation." *Econometrica*, 50(4): 987–1008.

Erdem, F.P. and I. Ünalmıs (2016). "Revisiting Super-Cycles in Commodity Crises." *Central Bank Review*, 16: 137-142.

Erten, B. and J.A. Ocampo (2021). "The Future of Commodity Prices and the Pandemic-driven Global Recession: Evidence from 150 Years of Data." *World Development*, 137: 105164.

Erten, B. and J.A. Ocampo (2013). "Super Cycles of Commodity Prices since the Mid-nineteenth Century." *World Development*, 44: 14-30.

Fernández, A., A. González, and D. Rodriguez (2018). "Sharing a Ride on the Commodities Roller Coaster: Common Factors in Business Cycles of Emerging Economies." *Journal of International Economics*, 111: 99-121.

Fernández, A., S. Schmitt-Grohé, and M. Uribe (2017). "World Shocks, World Prices, and Business Cycles: An Empirical Investigation." *Journal of International Economics*, 108: S2-S14.

Fernández, A., S. Schmitt-Grohé, and M. Uribe (2020). "Does the Commodity Super Cycle Matter?" NBER Working Paper 27589. Cambridge, MA: National Bureau of Economic Research.

Galbraith, J.K. and J.D. Black (1938). "The Maintenance of Agricultural Production During Depression: The Explanations Reviewed." *Journal of Political Economy*, 46(3): 305–

323.

Gersovitz, M. and C.H. Paxson (1990). "The Economies of Africa and the Prices of Their Exports." *Princeton Studies in International Finance*, No. 68. New Jersey: Princeton University.

Gilchrist, S. and J.C. Williams (2000). "Putty-Clay and Investment: A Business Cycle Analysis." *Journal of Political Economy*, 108(5): 928-960.

Grilli, E.R. and M.C. Yang (1988). "Primary Commodity Prices, Manufactured Goods Prices, and the Terms of Trade of Developing Countries: What Long Run Shows?" *World Bank Economic Review*, 2(1): 1-47.

Hamilton, J. (2015). "What's Driving the Price of Oil Down?" https://econbrowser.com/archives/2015/01/whats-driving-the-price-of-oil-down-2

Hamilton, J. (2018). "Why you Should Never Use the Hodrick-Prescott Filter." *Review of Economics and Statistics*, 100: 831-843.

Henry, C. (1974). "Investment Decisions Under Uncertainty: The 'Irreversibility Effect'." *American Economic Review*, 64: 1006-1012.

Hodrick, R.J. and E.C. Prescott (1997). "Postwar U.S. Business Cycles: An Empirical Investigation." *Journal of Money, Credit and Banking*, 29(1): 1-16.

Hotelling, H. (1931). "The Economics of Exhaustible Resources." *Journal of Political Economy*, 39(2): 137-175.

Jacks, D.S. (2019). "From Boom to Bust: A Typology of Real Commodity Prices in the Long Term." *Cliometrica*, 13: 201-220.

Jacks, D.S. and M. Stuermer (2020). "What Drives Commodity Price Boom and Busts?" *Energy Economics*, 85: 104035.

Jégourel, Y. (2018). "Trends and Cyclicality of Commodity Prices (part 2): Questioning the Commodity Super-Cycle." OCP Policy Center, Policy Brief 18/24.

Jerrett, D. (2021). "How Super is the Commodity Price Cycle?" *Global Commodities Applied Research Digest*, 6(1): 1-6.

Jerrett, D. and J.T. Cuddington (2008). "Broadening the Statistical Search for Metal Price Super Cycles to Steel and Related Metals." *Resources Policy*, 33: 188–195.

Kaufmann, R.K., S. Dees, P. Karadeloglou, and M. Sanchez (2004). "Does OPEC Matter? An Econometric Analysis of Oil Prices." *The Energy Journal*, 25(4): 67-90.

Kilian, L. and D.P. Murphy (2014). "The Role of Inventories and Speculative Trading in the Global Market for Crude Oil." *Journal of Applied Econometrics*, 29 (3): 454-478.

Kindleberger, C.P. (1943). "Planning for Foreign Investment." *American Economic Review*, 33: 347-354.

Klümper, W. and M. Qaim (2014). "A Meta-Analysis of the Impacts of Genetically Modified Crops." Plos One, https://doi.org/10.1371/journal.pone.0111629

Kondratieff, N. (1926). "Die langen Wellen der Konjunktur." *Archiv für Sozialwissenschaft und*

Sozialpolitik, 56(3): 573–609.

Kondratieff, N. and W. Stolper (1935). “The Long Waves in Economic Life.” *The Review of Economics and Statistics*, 17(6): 105-115.

Kose, M.A., P. Nagle, F. Ohnsorge, N. Sugawara (2021). *Global Waves of Debt: Causes and Consequences*. Washington, DC: World Bank.

Kose, M.A. (2002). “Explaining Business Cycles in Small Open Economies: How Much do World Prices Matter?” *Journal of International Economics*, 56(2): 299–327.

Kuznets, S. (1930*). Secular Movements in Production and Prices. Their Nature and their Bearing upon Cyclical Fluctuations*. Boston: Houghton Mifflin.

Labys, W.C., A. Achouch, and M. Terraza (1999). “Metal Prices and the Business Cycle.” *Resources Policy*, 25: 229-238.

Labys, W.C., J.B. Lesourd, and D. Badillo (1998). “The Existence of Metal Price Cycles.” *Resources Policy*, 24(3): 147-155.

Malthus, T.R. (1798). *An Essay on the Principle of Population*. London: J. Johnson.

Marañon, M. and M. Kumral (2019). “Dynamics Behind Cycles and Co-movements in Metal Prices: An Empirical Study Using Band-Pass Filters.” *Natural Resources Research* 29(3): 1487-1519.

McCalla, A.F. (1999). “Prospects for Food Security in the 21st Century with Special Emphasis on Africa.” *Agricultural Economics*, 20: 95-103.

Mendoza, E. (1995). “The Terms of Trade, the Real Exchange Rate, and Economic Fluctuations.” *International Economic Review*, 36: 101-137.

Mitchell, W.C. (1908). *Gold, Prices, and Wages Under the Greenback Standard*. Berkeley, CA: University of California Press.

Nelson, C.R. and C.I. Plosser (1982). “Trends and Random Walks in Macroeconomic Time Series: Some Evidence and Implications.” *Journal of Monetary Economics*, 10: 139-l 62.

Ojeda-Joya, J.N., O. Jaulin-Mendes, and J.C. Bustos-Pelaez (2019). “The Interdependence between Commodity Price and GDP Cycles: A Frequency-domain Approach.” *Atlantic Economic Journal*, 47: 275-292.

Phillips, P.C.B. and S. Jin (2015): “Business Cycles, Trend Elimination, and the HP Filter.” Cowles Foundation Discussion Paper 2005. New Haven, CT: Yale University.

Phillips, P.C.B. and Z. Shi (2019). “Boosting: Why You Can Use the Hodrick-Prescott Filter?” Cowles Foundation Discussion Paper 2192. New Heaven, CT: Yale University.

Prebisch, R. (1950). *The Economic Development of Latin America and its Principal Problems*, New York: United Nations.

Radetzki, M., R.G. Eggert, G. Lagos, M. Lima, and J.E. Tilton (2008). “The Boom in Mineral Markets: How Long Might It Last?” *Resources Policy*, 33: 125-128.

Reinhart, C.M., V. Reinhart, and C. Trebesch (2016). “Global Cycles: Capital Flows, Commodities, and Sovereign Defaults.” *American Economic Review Papers and Proceedings*, 106(5): 574-580.

Roberts, M. (2009). "Duration and Characteristics of Metal Price Cycles." *Resources Policy*, 34: 87-102.

Rossen A. (2015). "What Are Metal Prices Like? Co-movement, Price Cycles, and Long-Run Trends." *Resources Policy*, 45: 255-276.

Rulli, M.C., D. Bellomi, A. Cazzoli, G. De Carolis, and P. D'Odorico (2016). "The Water-Land-Food Nexus of First-generation Biofuels." *Scientific Reports,* 6(22521): 1-10.

Schumpeter J.A. (1939). *Business Cycles: A Theoretical, Historical, And Statistical Analysis of the Capitalist Process*. New York: McGraw-Hill Book Company.

Singer, H.W. (1950). "The Distribution of Gains between Investing and Borrowing Countries." *American Economic Review*, 40: 473–85.

Slade, M. (1982). "Trends in Natural-Resource Commodity Prices: An Analysis of the Price Domain." *Journal of Environmental Economics and Management*, 9: 122-137.

Snider, J.L. (1924). "Wholesale Prices in the United States, 1866-91." *Review of Economics and Statistics*, 6(2): 93-118.

Stigler, G.J. (1954). "The Early History of Empirical Studies on Consumer Behavior." *Journal of Political Economy*, 62: 95–113.

Stuermer, M. (2018). "150 Years of Boom and Bust: What Drives Mineral Commodity Prices?" *Macroeconomic Dynamics*, 22: 702-717.

Terazono, E. (2021). "Top Agricultural Traders Predict a 'Mini Supercycle'." *Financial Times*, June 17.

Tilton, J. (2013). "The Terms of Trade Debate and the Policy Implications for Primary Product Producers." *Resources Policy*, 38: 196-203.

UNECA, United Nations Economic Commission on Africa (2011). "Minerals and Africa's Development: The International Study Groups Report on Africa's Mineral Regimes." Addis Ababa, Ethiopia.

World Bank (1986). *World Development Report: Trade and Pricing Policies in World Agriculture*. Washington, DC: World Bank.

World Bank (2009). *Global Economic Prospects: Commodities at Crossroads.* Washington, DC: World Bank.

World Bank (2016). *Commodities Market Outlook: Resource Development in an Era of Cheap Commodities.* Washington, DC: World Bank.

World Bank (2020). *Commodities Market Outlook: Implications of COVID-19 for Commodities.* Washington, DC: World Bank.

Appendix A: Data description

The price data were taken from the World Bank's world commodity price data system. The sample covers 50 years, January 1970 through December 2020 (612 observations). The prices, which are reported in nominal US dollar terms, were deflated with the U.S. CPI (taken from the St. Louis Fed). Although the World Bank covers more than 70 commodity price series, this paper uses only 27 series. The selection of the commodities was based on the following criteria:

- **Substitutability**. If two commodities are close substitutes only one was included. For example, because the edible oils are close substitutes, only soybean oil is used in the analysis.
- **Importance**. Several commodities that used to be very important in the past are not included in the current study because they have lost their importance during the past few decades, often due to the development of synthetic products. Notable exclusions are wool, hides and skins, sisal.
- **Price determination process**. Prices should be determined by a market-based mechanism such as exchange (or auction in the case of tea). Notable exclusions are iron ore (until recently, its price used to be the outcome of a negotiation process among key players of the steel industry) bananas (its price reflects quotations from a few large trading companies), and sugar (too many policy interventions reduce the significance of the world price indicator).

The prices were grouped into six broad categories, each of which contained at least three but no more than six series in order to maintain a balanced representation. The rest of this Appendix lists the commodities used in the analysis, the groupings, and their main uses. A technical description is also given for each series. More details on sources and description can be found in World Bank (2020, pp. 77-82).

A.1. Energy (3 series)

The energy group includes three series: Coal, crude oil, and natural gas. **Crude oil** is primarily used for transport and, to a lesser degree, petrochemicals while most **coal** and **natural gas** are used for electricity generation and less so for industrial purposes. The prices belonging to the energy group are defined as follows:

- **Coal** (Australia): Thermal, f.o.b. Newcastle, 6,000 kcal/kg, spot price.
- **Crude oil**: Average price of **Brent** (38° API), Dubai Fateh (32° API), and West Texas Intermediate (WTI, 40° API). Equally weighed.
- **Natural gas** (Index): Weights based on five-year consumption volumes for Europe, U.S., and Japan (Liquefied Natural Gas).

A.2. Base metals (6 series)

This group includes aluminum, copper, lead, nickel, tin, and zinc. The metals (aluminum, copper, lead, nickel, tin, and zinc) are widely used in commercial and industrial applications. **Aluminum's** largest uses are in transport, followed by construction, packaging, and electrical grids. **Copper's** main application is in the electrical sector, including power cables, generators and motors, as well as in construction and electronics. **Nickel** is one of the main components of stainless steel, while **zinc** is mostly used as an anti-corrosion agent to galvanize iron and steel while some is alloyed with other metals (e.g., combined with copper to produce brass). **Tin** is heavily used in electronics in the form of solder. **Lead**, which was once used in various chemical applications (most of which have been banned) is still widely used in car batteries, ammunition, and in storage of corrosive liquids. Prices are taken from the London Metal Exchange. As notable exception is iron ore, a key input to steel production. For most of the sample period, iron ore prices were not determined on a competitive basis. The prices, all taken from the London Metal Exchange (LME) are defined as follows:

1. **Aluminum** (LME): Unalloyed primary ingots, standard high grade, physical settlement.
2. **Copper** (LME): Standard grade A, cathodes and wire bar shapes, physical settlement.
3. **Lead** (LME): Refined, standard high grade, physical settlement.
4. **Nickel** (LME): Cathodes, standard high grade, physical settlement.
5. **Tin** (LME): Refined, standard high grade, physical settlement.
6. **Zinc** (LME): Refined, standard special high grade, physical settlement.

A.3. Precious metals (3 series)

Precious metals include gold, platinum, and silver. To various extents, all three precious metals have been used as store of wealth, hedge against uncertainty, jewelry, and industry. Prior to the collapse of Bretton Woods in 1972, **gold** was used as a currency and store of wealth. Then, it was used as a hedge against inflation but more recently it has been used as a hedge against uncertainty. **Silver**, in addition to being considered as precious metal, it also enjoys various industrial uses, including in the electronics industry, jewelry, and silverware. **Platinum** has various industrial uses as well, including the auto industry (as a catalytic converter to reduce exhaust pollution) and various petrochemical applications. The precious metal prices are defined as follows:

1. **Gold** (U.K.): 99.5 percent fine, London afternoon fixing, average of daily rates.
2. **Platinum** (U.K.): 99.9 percent refined, London afternoon fixing.
3. **Silver** (U.K.): 99.9 percent refined, London afternoon fixing.

A.4. Fertilizers (4 series)

The fertilizer group includes, phosphate, potassium, TSP (triple superphosphate), and Urea. Fertilizers are mostly used as inputs to agricultural production. Phosphate is obtained by extraction of minerals. China, the U.S., India and Morocco are the world's top phosphate producers (Morocco accounts for 70 percent of world's phosphate reserves). Phosphate is also a key ingredient of TSP. Urea's key input is nitrogen, which comes either from natural gas or coal. Prices belonging to the fertilizer group are defined as follows:

1. **Phosphate rock**, f.o.b. North Africa.
2. **Potassium chloride** (muriate of potash), spot, f.o.b. Vancouver.
3. **TSP** (triple superphosphate), spot, import U.S. Gulf.
4. **Urea** (Ukraine), f.o.b. Black Sea.

A.5. Annual agriculture (6 series)

Annual agriculture commodities, often termed crop commodities, are produced on an annual basis and as such, land (and other factors of production) can change each crop year, depending on demand and supply conditions. **Cotton**, which accounts for 40 percent of total fiber consumption, is mainly used by the textile industry. China, India, and the U.S. account for more than 60 percent of global production. Cotton is, perhaps, the oldest globally integrated commodity markets—as early as 1886, five exchanges connected by cable were trading cotton futures contracts (Alexandria, Le Havre, Liverpool, New York, and New Orleans). **Maize** is used for both human (white) and animal (yellow) consumption. The U.S., which primarily produces yellow maize, accounts for more than 30 one third of world supplies (one third goes to ethanol production). Maize is traded at the Chicago Mercantile Exchange, the price of which is considered a world indicator. **Rice** is the main food staple in most Asian countries—China and India accounting for more than half of global production. Rice is traded at the Chicago Mercantile Exchange as well, but the futures contract is not used outside the U.S. (it reflects domestic U.S. demand and supply conditions). Instead, Thai prices (and, increasingly Vietnam) are often used as world price indicators (Thailand is the world's second largest exports after India). **Soybeans** is a relatively "new" commodity, primarily grown in the United States and a few South America countries (Argentina, Brazil, and Uruguay). Soybeans is consumed in meal form (animal feedstock, competing with maize) and edible oil form (for human consumption, competing with other edible oils such as palm oil and rapeseed oil). Some edible oils are used as feedstocks for the production of biofuels. Because of the close price correlation among most edible oils, we only used soybean oil in our analysis. Lastly, wheat, more than half of which is produced by the European Union, China, and India, is the most widely consumed grain. Various futures exchanges trade wheat contracts—two the world's most liquid ones are traded by the Chicago Mercantile Exchange.

Prices belonging to the annual agriculture group are defined as follows:

1. **Cotton** (Cotlook "A" index): Middling 1-3/32 inch, traded in Far East, C/F.
2. **Maize** (U.S.): No. 2, yellow, f.o.b. U.S. Gulf ports.
3. **Rice** (Thailand): 5 percent broken, white rice (WR), milled, indicative price based on weekly surveys of export transactions, government standard, f.o.b. Bangkok.
4. **Soybean meal**: Brazilian pellets 48 percent protein, cif Rotterdam.
5. **Soybean oil**: Dutch crude, degummed, f.o.b. NW Europe.
6. **Wheat** (U.S.): No. 1, hard red winter (HRW), ordinary protein, export price delivered at the U.S. Gulf port for prompt or 30 days shipment.

A.6. Perennial agriculture (5 series)

This group contains the following five commodities: Cocoa, coffee Arabica, coffee Robusta, natural rubber, and tea. These commodities are produced by trees, often termed tree crops, and therefore cannot be substituted on an annual basis. Thus, from a production perspective they resemble extractive commodities, such as metals. Coffee, consumed in a form of a beverage, comes in two main varieties, Arabica and Robusta—it is the only commodity in this study that includes more than one price indicator. Arabica, grown at high altitudes in Latin America (including Brazil) and northeastern Africa, accounts for two-thirds of total world output. It has a strong aroma and low level of caffeine. Robusta, with a much stronger taste than arabica, is grown in humid areas at low altitudes in Asia, western and southern Africa, and Brazil. Cocoa, a confectionary product mostly going to chocolate making is produced mostly in Africa—Côte d'Ivoire and Ghana account for nearly two-thirds of global supplies. Cocoa is traded at the Intercontinental Exchange (ICE) and on the London International Financial Futures and Options Exchange (LIFFE). Tea, like coffee, is consumed mostly as a beverage. More than 60 percent of global production comes from China and India, but East Africa tea producing countries, especially Kenya, play an important role in the export market (hence, the choice of Mombasa as the world price barometer). Natural Rubber, two thirds of which is produced by Thailand, Indonesia, and Vietnam is mostly consumed by the tire industry. Natural rubber futures contracts are is traded at Singapore Commodity Exchange (SICOM), Tokyo Commodity Exchange (TOCOM), and the Shanghai Commodity Exchange.

Prices belonging to perennial agriculture group are defined as follows:

1. **Cocoa** (ICCO): International Cocoa Organisation daily price, average of the first three positions on the terminal markets of New York and London, nearest three future trading months.
2. **Coffee Arabica** (ICO): International Coffee Organization indicator price, other mild Arabicas, average New York and Bremen/Hamburg markets, ex-dock.
3. **Coffee Robusta** (ICO): International Coffee Organization indicator price, Robustas, average New York and Le Havre/Marseilles markets, ex-dock.

4. **Tea** (Mombasa/Nairobi): African origin, all tea, arithmetic average of weekly quotes.
5. **Natural Rubber** (Asia): RSS3 grade, Singapore Commodity Exchange Ltd (SICOM) nearby contract.

Appendix B: Price decomposition into trends and cycles

This Appendix includes commodity-specific results on the characteristics of the three medium term cycles (Tables B1, B2, and B3). Figures B1-B27 depict the real price of the commodity in logarithmic terms, the trend component, and the medium- and short-term cycles. Figures B28-B30 depict the trends and the standardized medium-term cycles for individual commodities, presented as groups.

The numbers reported in the last row of each panel in Tables B1, B2, and B3 are the same numbers reported in Table 4. For example, the duration of the expansion and contraction phases of the first medium term cycle for energy (10.7 and 11.4 years, respectively) are the same numbers reported in the first row of Table 4 of the main text. These are weighted averages of the coal, crude oil, and natural gas prices (9.6, 10.4, 12.0 as well as 7.1, 17.6, 9.4, respectively). The weights are the ones reported in Table 2 of the main text.

Figures B1-B27 depict the real price of each commodity (expressed in logarithmic terms) along with the permanent component (upper chart) and transitory component along medium term cycle (lower chart). Figures B28-B30 show the medium term cycles for individual commodities while Figures B31-B33 show the permanent component of individual commodities.

Table B1: Characteristics of the first medium-term cycle

		-------- Expansion phase --------		*------- Contraction phase -------*	
	Peak month	*Duration (years)*	*Amplitude*	*Duration (years)*	*Amplitude*
ENERGY					
Coal	1979:08	9.6	2.82	7.1	1.87
Crude oil	1980:06	10.4	3.57	17.6	2.42
Natural gas	1982:01	12.0	3.22	9.4	2.57
AVERAGE	**1980**	**10.7**	**3.20**	**11.4**	**2.29**
BASE METALS					
Aluminum	1978:06	5.9	3.32	5.6	3.13
Copper	1976:12	6.9	0.50	6.8	1.04
Lead	1978:07	6.4	2.78	6.1	2.88
Nickel	1978:04	6.8	1.86	5.6	1.82
Tin	1980:03	10.2	3.18	9.8	2.20
Zinc	1976:09	5.6	1.77	6.0	3.08
AVERAGE	**1978**	**7.0**	**2.24**	**6.6**	**2.36**
PRECIOUS METALS					
Gold	1981:07	11.5	2.85	7.1	1.26
Platinum	1981:03	11.2	2.35	5.3	0.78
Silver	1980:12	11.0	3.21	10.1	2.15
AVERAGE	**1980**	**11.2**	**2.80**	**7.5**	**1.40**
FERTILIZERS					
Phosphate	1977:07	7.5	3.77	15.8	1.98
Potassium	1980:01	10.0	2.21	6.5	1.14
TSP	1976:09	6.7	3.28	5.4	1.52
Urea	1977:09	7.7	3.94	11.4	1.98
AVERAGE	**1978**	**8.0**	**3.30**	**9.8**	**1.66**
ANNUAL AGRICULTURE					
Cotton	1977:11	7.8	2.95	8.4	2.48
Maize	1976:02	6.1	2.67	12.7	0.54
Rice	1977:12	7.9	2.97	7.1	2.50
Soybean meal	1977:04	7.3	3.33	7.4	1.88
Soybean oil	1977:02	7.1	3.13	12.3	2.05
Wheat	1976:08	6.6	3.19	12.4	1.62
AVERAGE	**1977**	**7.1**	**3.04**	**10.1**	**1.85**
PERENNIAL AGRICULTURE					
Cocoa	1977:11	6.8	4.34	14.0	3.28
Coffee Arabica	1977:08	6.4	3.14	13.8	3.04
Coffee Robusta	1977:06	7.1	2.95	14.1	3.05
Natural rubber	1978:07	8.5	2.52	9.9	1.17
Tea	1979:08	8.6	2.85	12.4	3.01
AVERAGE	**1977**	**7.5**	**3.16**	**12.9**	**2.71**
ALL AVERAGE	***1978***	***8.6***	***2.96***	***9.7***	***2.04***

Notes: Each group average has been calculated based on the weights reported in Table 2 (main text). The average corresponding to the year reflects the median year on which the peak month occurred.

Table B2: Characteristics of the second medium-term cycle

		-------- Expansion phase --------		*------- Contraction phase -------*	
	Peak month	*Duration (years)*	*Amplitude*	*Duration (years)*	*Amplitude*
ENERGY					
Coal	1993:02	6.4	0.65	8.7	1.87
Crude oil	—	—	—	—	—
Natural gas	—	—	—	—	—
AVERAGE	**1993**	**6.4**	**0.65**	**8.7**	**1.87**
BASE METALS					
Aluminum	1989:01	5.0	2.21	5.4	2.03
Copper	1991:10	8.1	2.22	9.9	3.49
Lead	1990:06	5.8	1.87	11.9	2.34
Nickel	1989:12	6.1	2.19	9.9	2.90
Tin	1996:11	6.8	0.68	5.8	0.97
Zinc	1989:01	6.4	3.23	12.7	3.38
AVERAGE	**1991**	**6.7**	**2.22**	**8.5**	**2.86**
PRECIOUS METALS					
Gold	1993:02	4.5	0.38	7.9	1.09
Platinum	1989:07	3.1	0.19	7.3	2.03
Silver	1998:01	7.0	0.54	5.1	0.53
AVERAGE	**1993**	**4.3**	**0.35**	**7.7**	**1.25**
FERTILIZERS					
Phosphate	1998:06	5.2	0.60	5.4	0.82
Potassium	1992:08	6.1	0.88	10.7	1.97
TSP	1986:09	4.6	0.85	5.1	1.02
Urea	1994:04	5.2	0.61	6.1	1.46
AVERAGE	**1992**	**5.2**	**0.71**	**6.7**	**1.36**
ANNUAL AGRICULTURE					
Cotton	1995:09	9.4	2.30	8.1	2.75
Maize	1995:02	6.3	1.63	7.8	2.48
Rice	1995:11	10.8	1.95	7.1	2.76
Soybean meal	1992:04	7.6	1.10	11.2	1.65
Soybean oil	1995:07	6.1	2.11	6.5	3.08
Wheat	1994:09	5.7	1.51	6.6	2.38
AVERAGE	**1995**	**7.5**	**1.64**	**8.3**	**2.38**
PERENNIAL AGRICULTURE					
Cocoa	1997:08	5.7	1.67	4.6	0.91
Coffee Arabica	1997:06	5.8	3.08	5.8	3.15
Coffee Robusta	1997:01	5.8	3.33	5.7	3.48
Natural rubber	1994:08	6.2	0.79	7.0	2.24
Tea	1998:09	6.7	2.98	6.0	2.91
AVERAGE	**1997**	**6.0**	**2.05**	**5.9**	**2.32**
ALL AVERAGE	***1994***	***5.0***	***1.16***	***6.2***	***1.71***

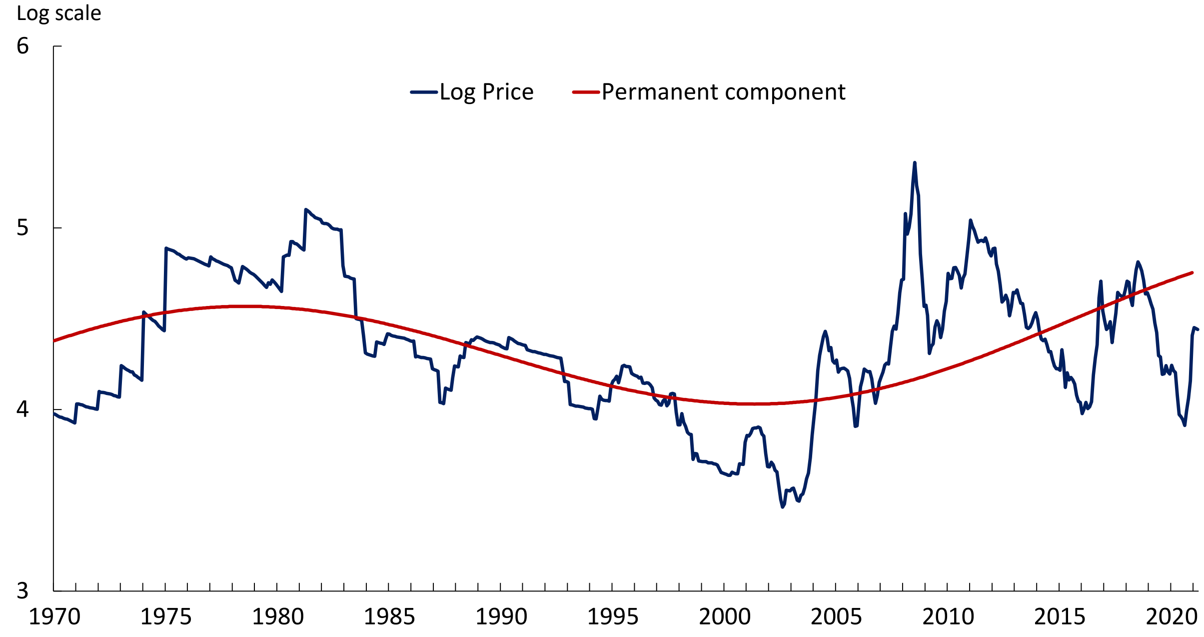
Notes: '—' implies that the corresponding price was subjected to two cycles. In four cases where there were two medium-term cycles, we report statistics for the cycle with the largest duration. For other notes see Table B1.

Table B3: Characteristics of the third medium-term cycle

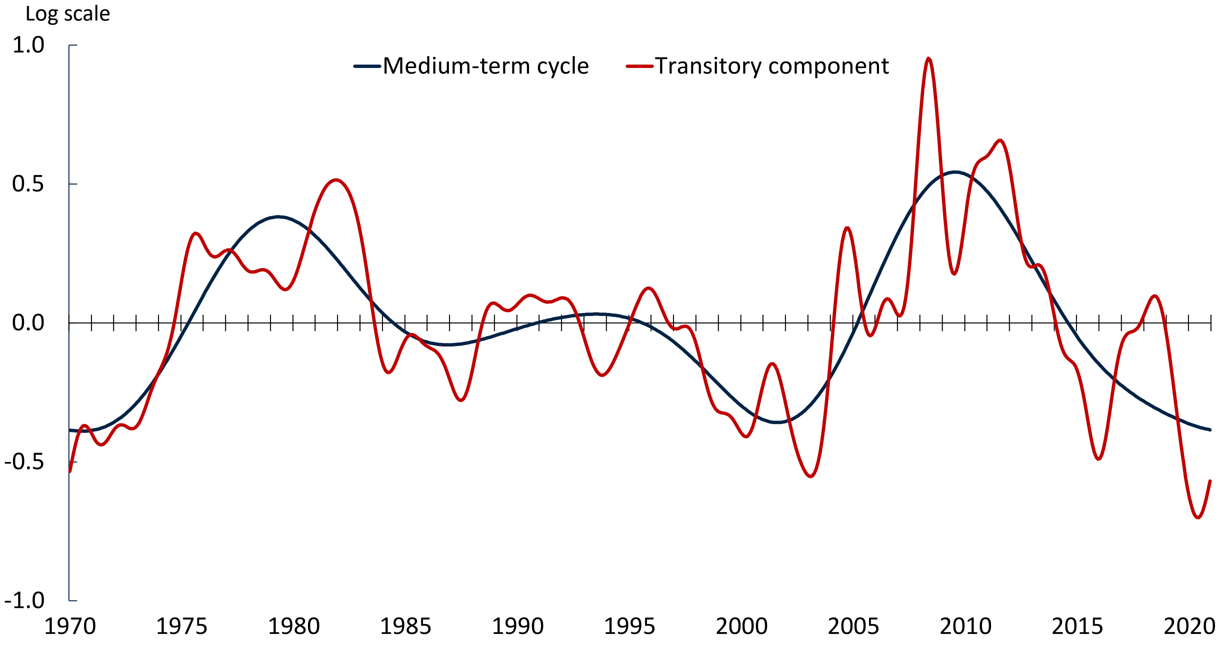
		-------- *Expansion phase* --------		------- *Contraction phase* -------	
	Peak month	*Duration (years)*	*Amplitude*	*Duration (years)*	*Amplitude*
ENERGY					
Coal	2009:07	7.8	2.52	9.7	3.60
Crude oil	2010:02	12.1	2.16	9.8	3.32
Natural gas	2006:10	15.3	2.46	13.2	3.10
AVERAGE	**2008**	**11.7**	**2.38**	**10.9**	**3.34**
BASE METALS					
Aluminum	2008:05	6.0	3.10	6.1	3.34
Copper	2009:05	7.7	4.15	7.2	2.88
Lead	2009:01	6.7	3.86	6.8	3.04
Nickel	2008:06	8.6	3.66	7.7	3.03
Tin	2010:01	7.4	2.95	9.9	3.64
Zinc	2008:03	6.5	3.77	5.9	2.20
AVERAGE	**2009**	**7.1**	**3.58**	**5.6**	**3.02**
PRECIOUS METALS					
Gold	2010:12	9.9	3.17	8.0	4.21
Platinum	2009:12	13.2	3.56	7.8	3.60
Silver	2010:07	7.4	2.70	8.6	3.83
AVERAGE	**2010**	**10.2**	**3.14**	**8.1**	**3.88**
FERTILIZERS					
Phosphate	2011:07	7.7	2.68	8.4	4.25
Potassium	2010:11	7.6	3.93	7.6	4.18
TSP	2010:05	7.9	3.44	9.5	3.95
Urea	2008:05	8.0	2.47	11.6	3.58
AVERAGE	**2009**	**7.8**	**3.13**	**6.4**	**3.99**
ANNUAL AGRICULTURE					
Cotton	2011:09	7.9	3.19	8.3	3.21
Maize	2011:11	9.0	3.57	7.3	4.12
Rice	2010:04	7.3	3.52	9.7	3.19
Soybean meal	2011:08	8.2	3.22	8.3	4.13
Soybean oil	2010:03	8.2	3.24	9.8	3.65
Wheat	2011:09	10.4	3.21	8.3	3.92
AVERAGE	**2011**	**8.5**	**3.33**	**8.6**	**3.70**
PERENNIAL AGRICULTURE					
Cocoa	2008:05	6.3	1.63	10.5	3.21
Coffee Arabica	2009:06	6.1	3.12	11.2	3.06
Coffee Robusta	2008:10	6.2	3.29	11.6	2.91
Natural rubber	2009:08	8.0	3.80	10.3	3.71
Tea	2010:11	6.2	2.84	9.1	2.72
AVERAGE	**2009**	**6.5**	**2.94**	**10.5**	**3.12**
ALL AVERAGE	***2010***	***8.6***	***3.08***	***8.4***	***3.51***

Notes: See notes in Table B1.

Figure B1: Coal

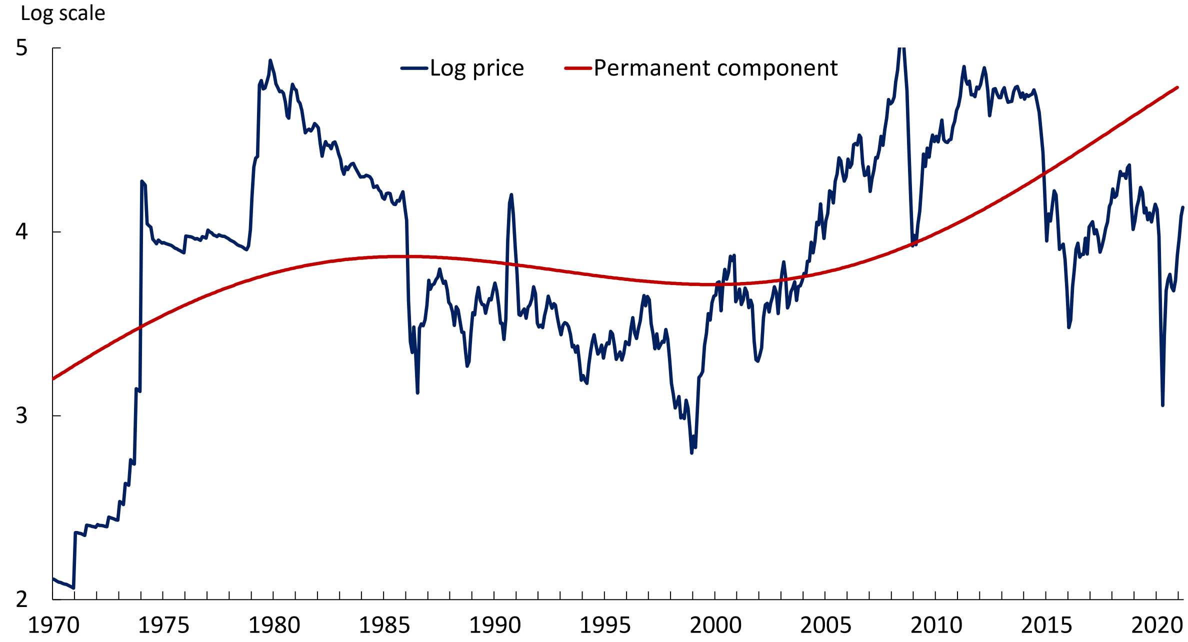


Source: Authors' calculations

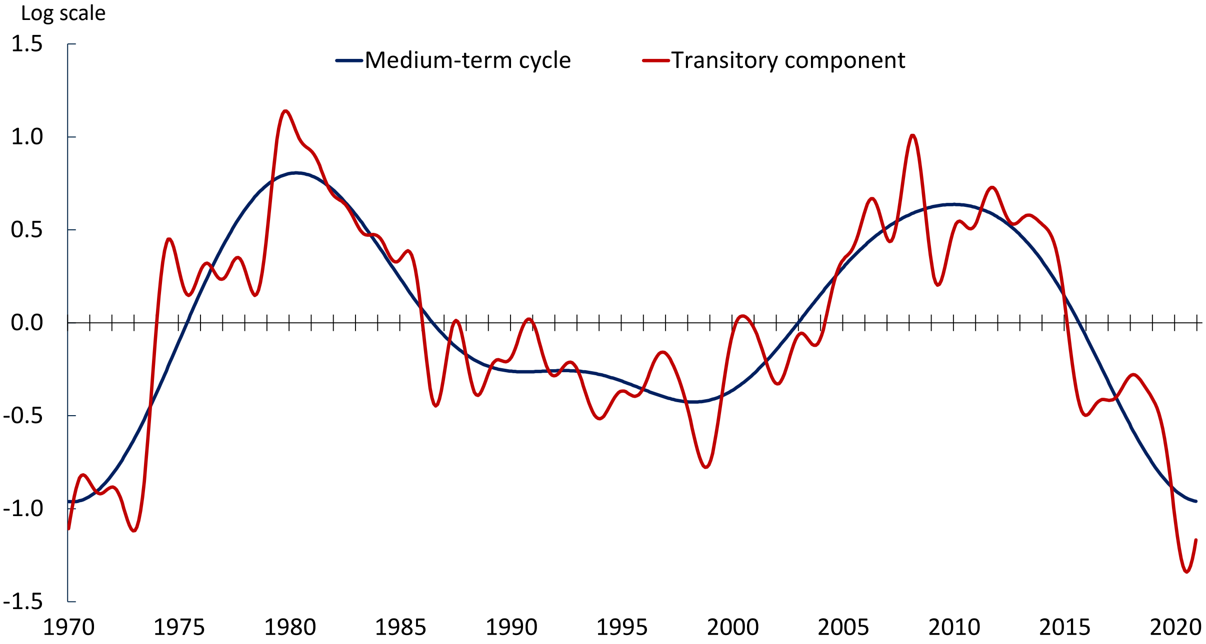


Source: Authors' calculations

Figure B2: Crude oil

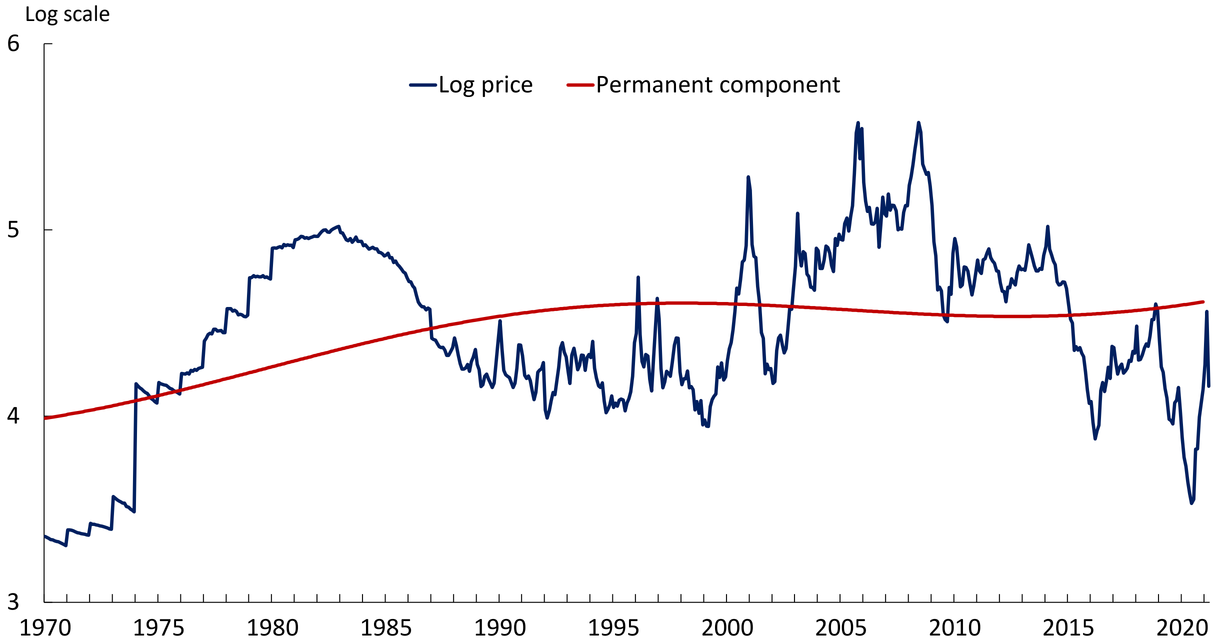


Source: Authors’ calculations

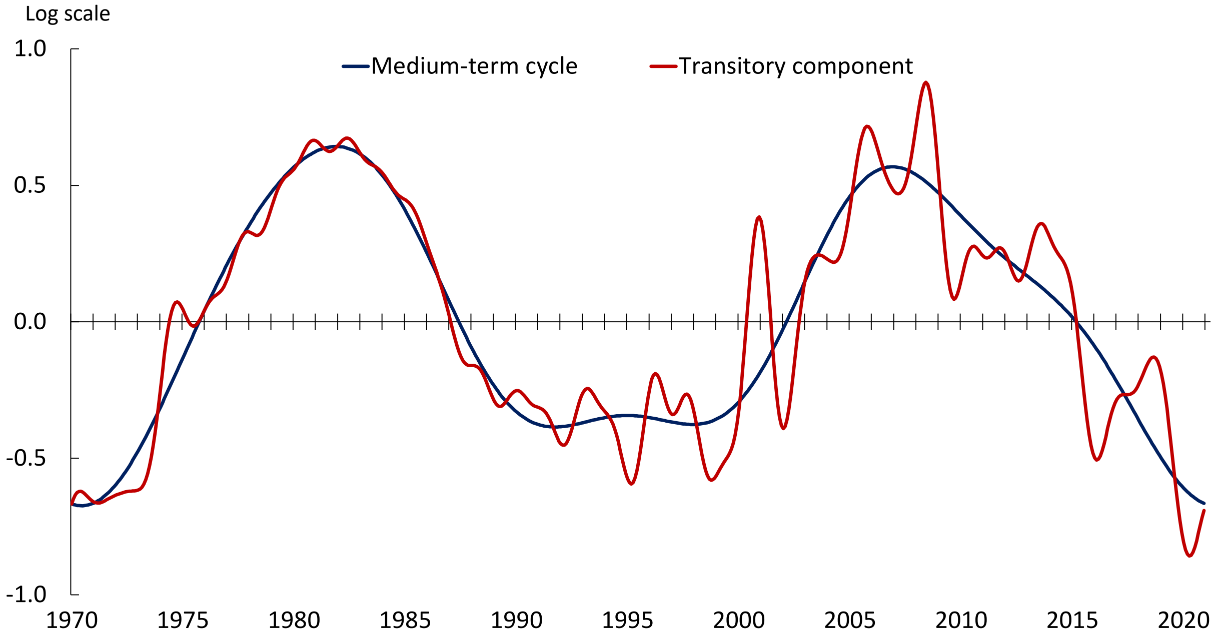


Source: Authors’ calculations

Figure B3: Natural gas

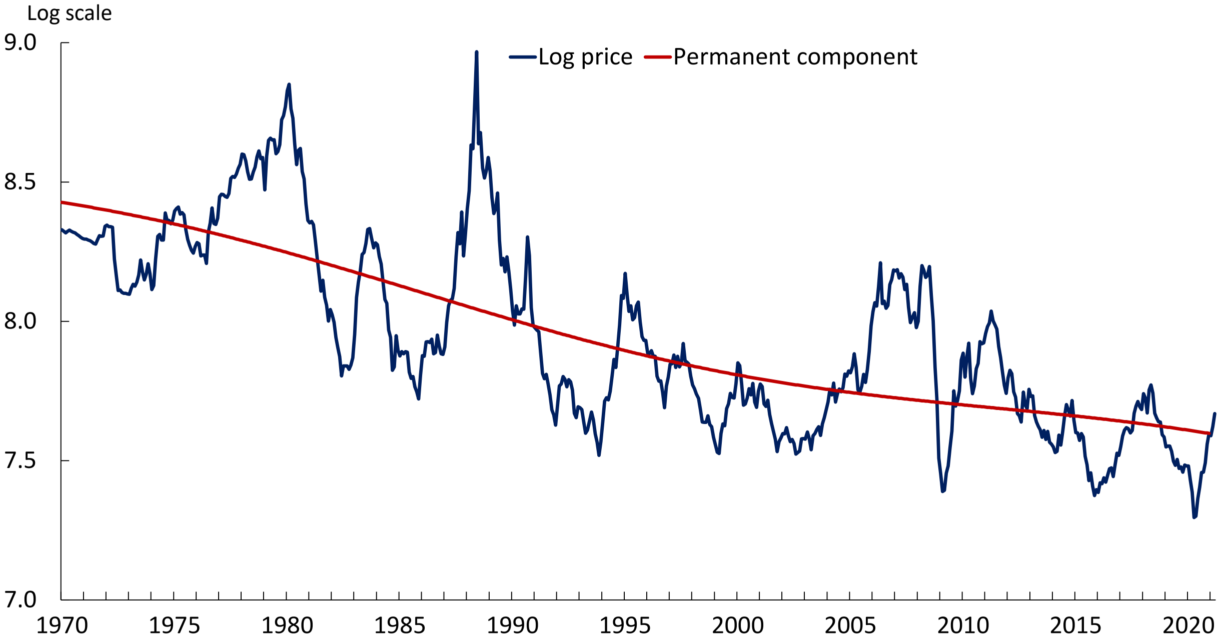


Source: Authors' calculations

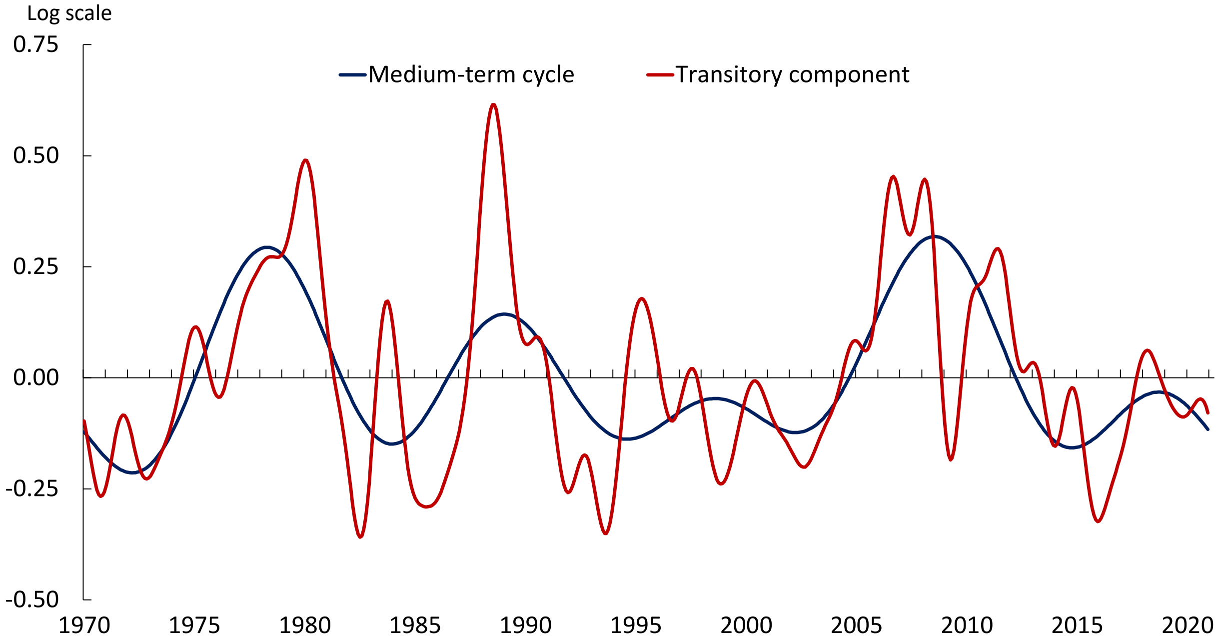


Source: Authors' calculations

Figure B4: Aluminum

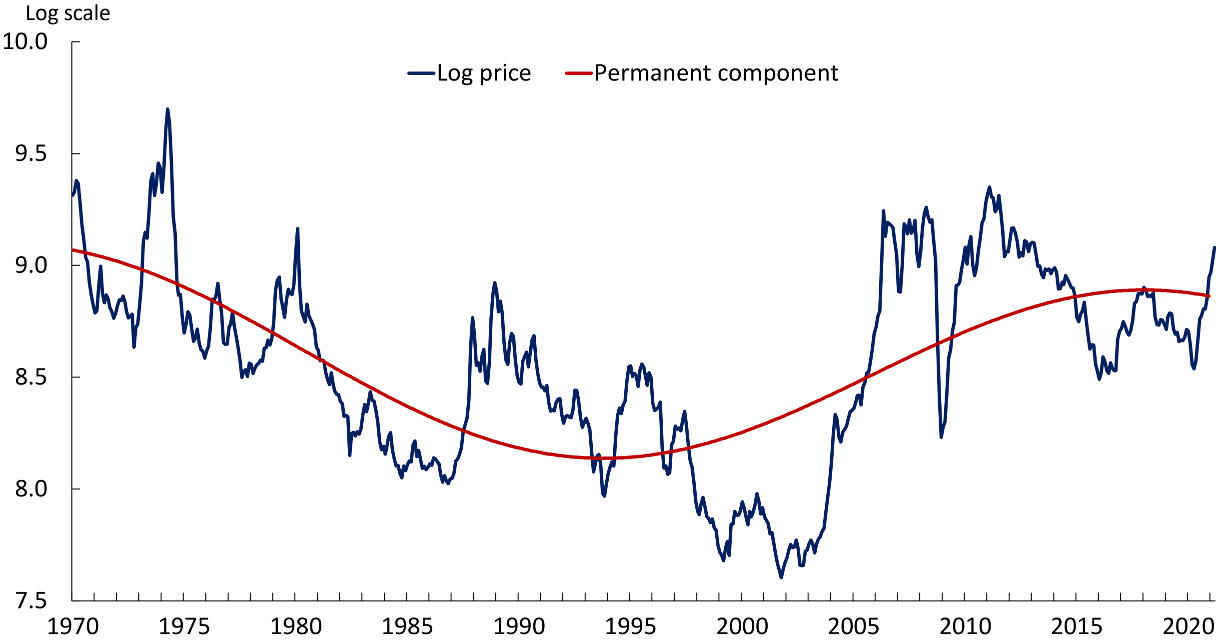


Source: Authors' calculations

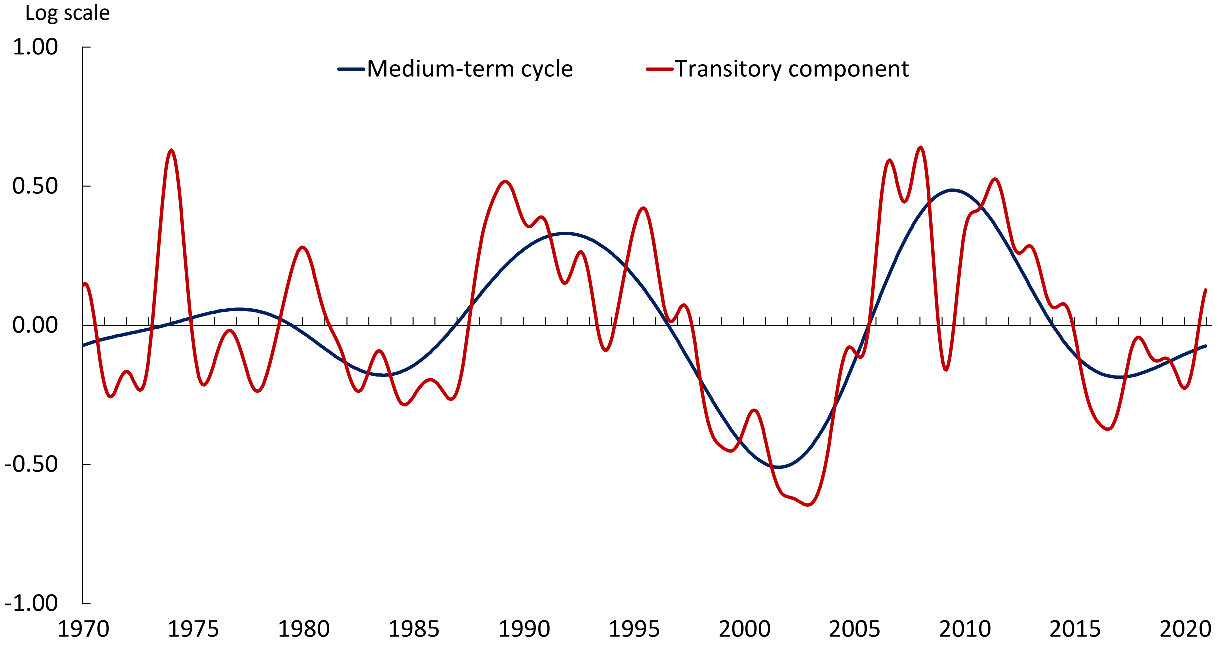


Source: Authors' calculations

Figure B5: Copper

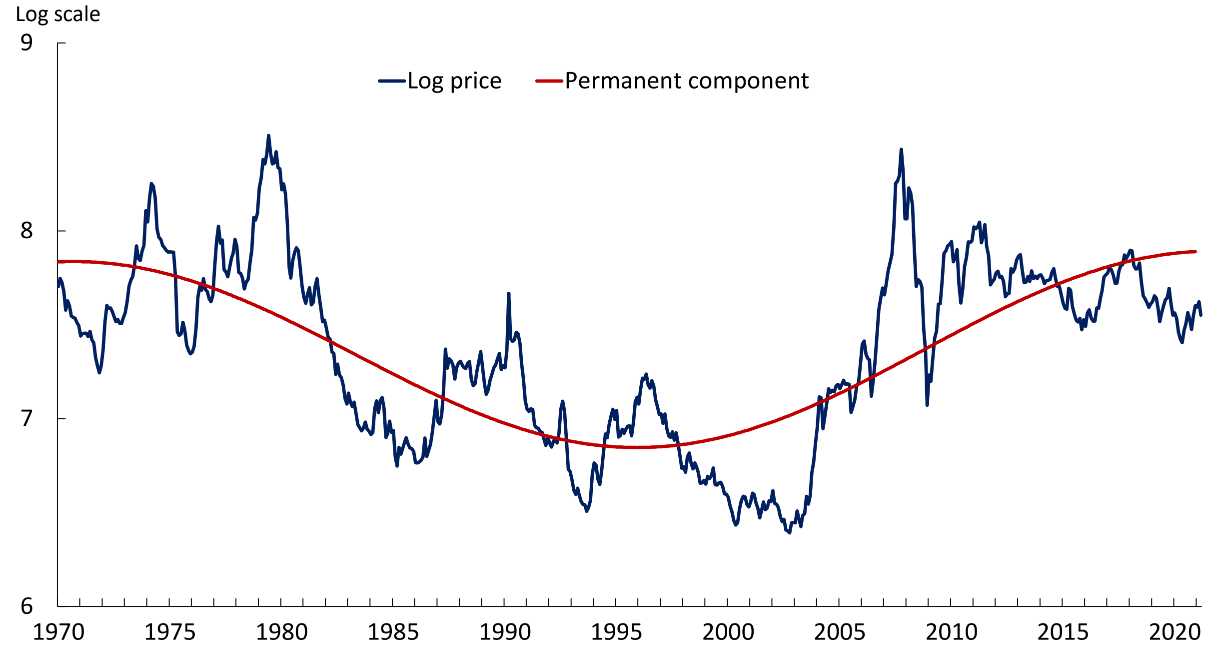


Source: Authors' calculations

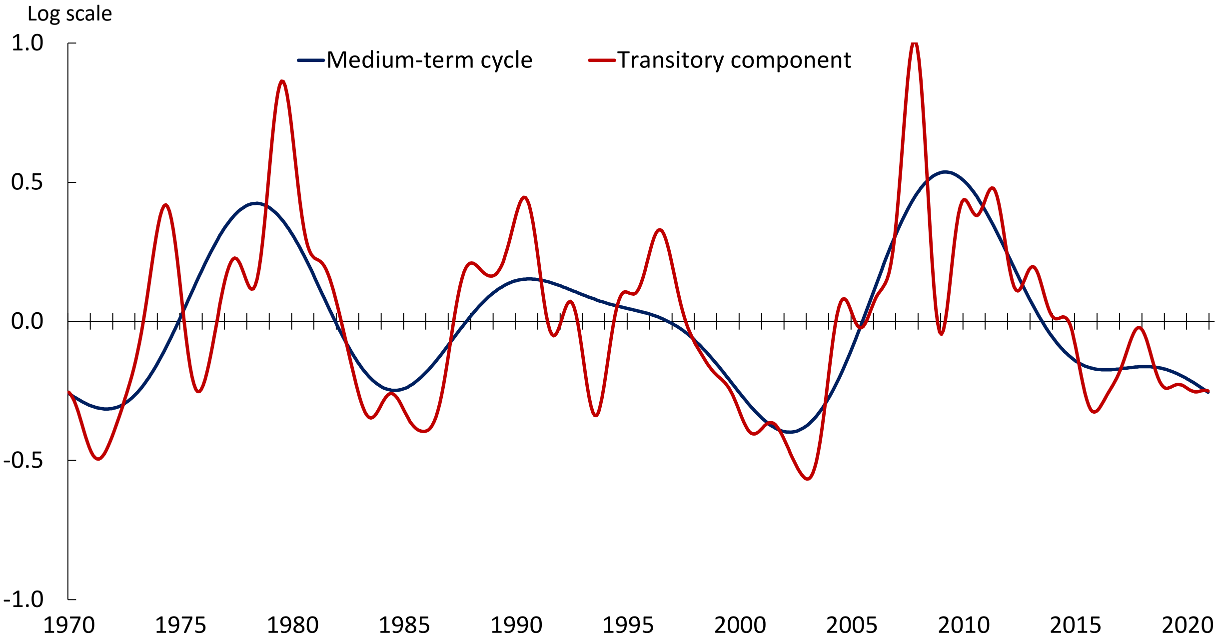


Source: Authors' calculations

Figure B6: Lead

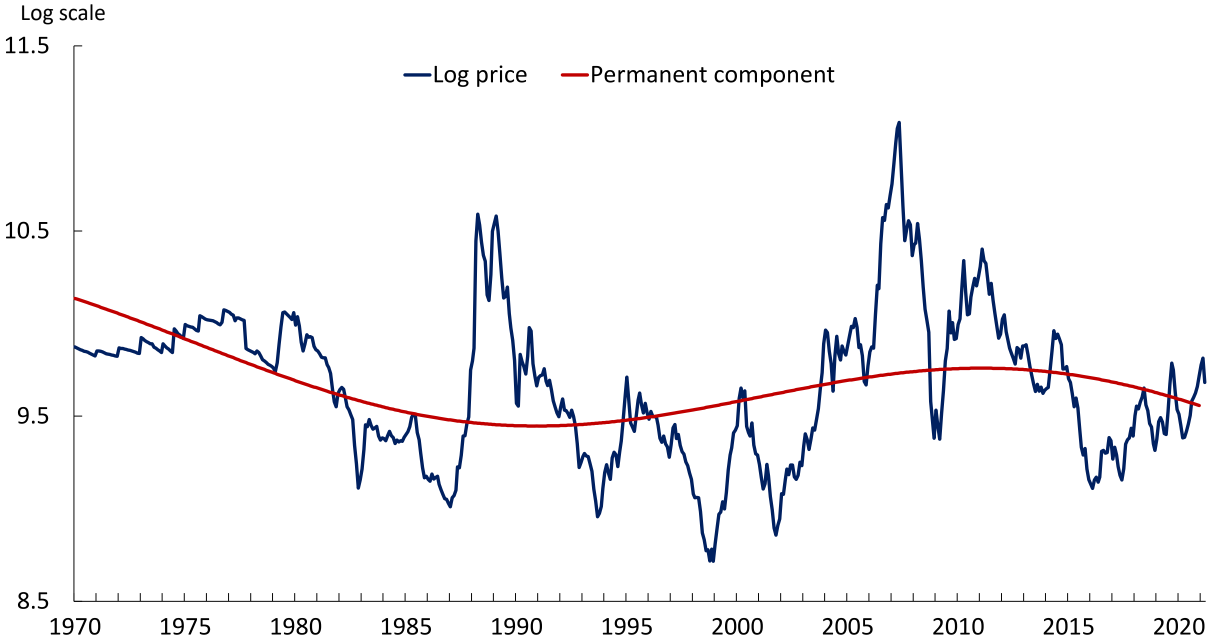


Source: Authors' calculations

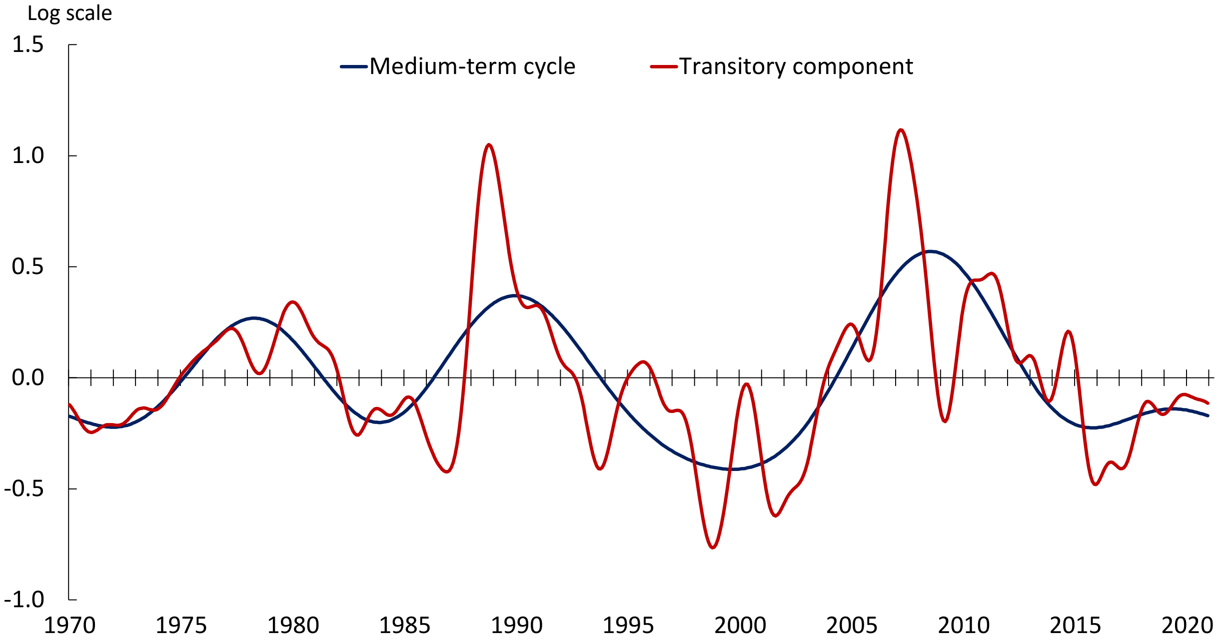


Source: Authors' calculations

Figure B7: Nickel

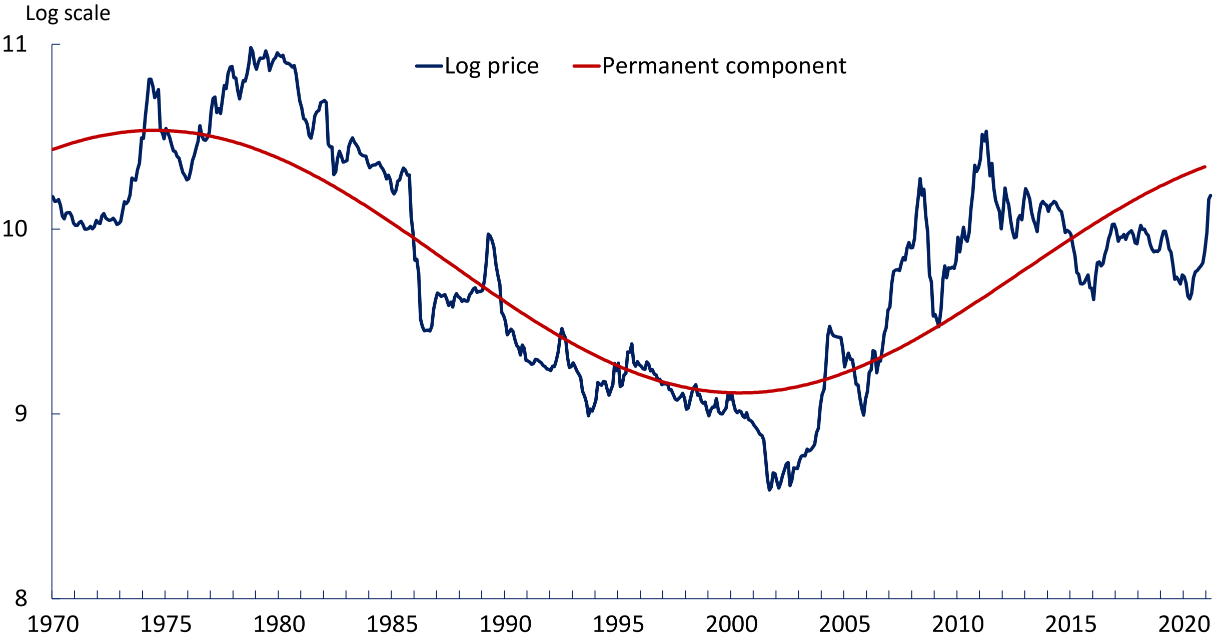


Source: Authors' calculations

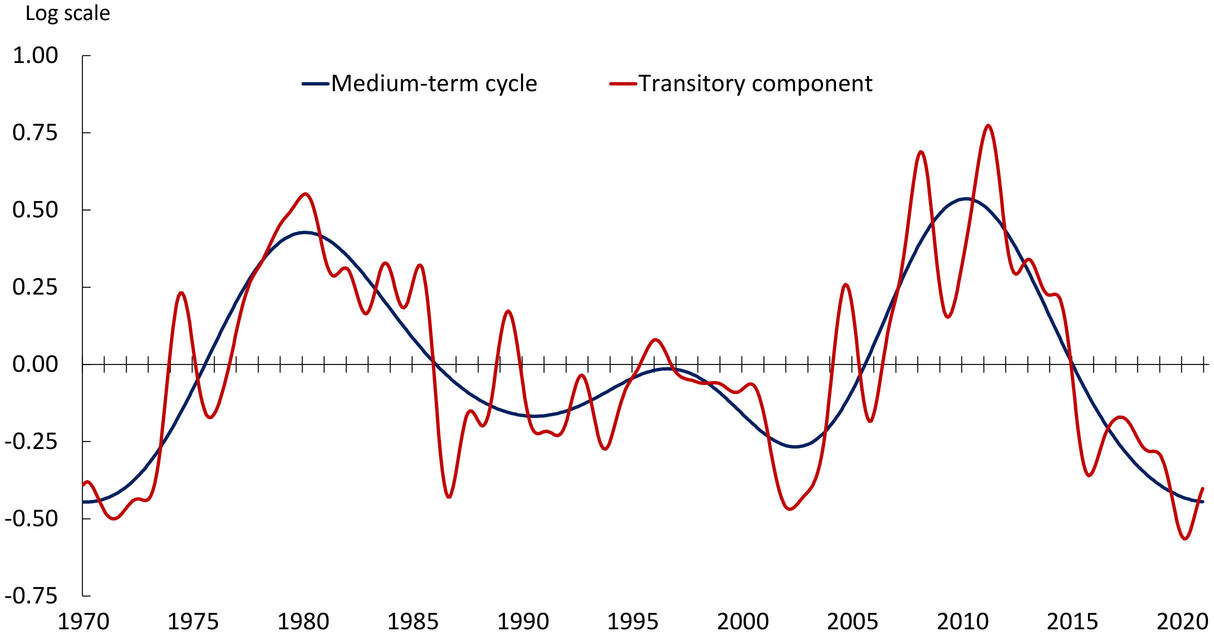


Source: Authors' calculations

Figure B8: Tin

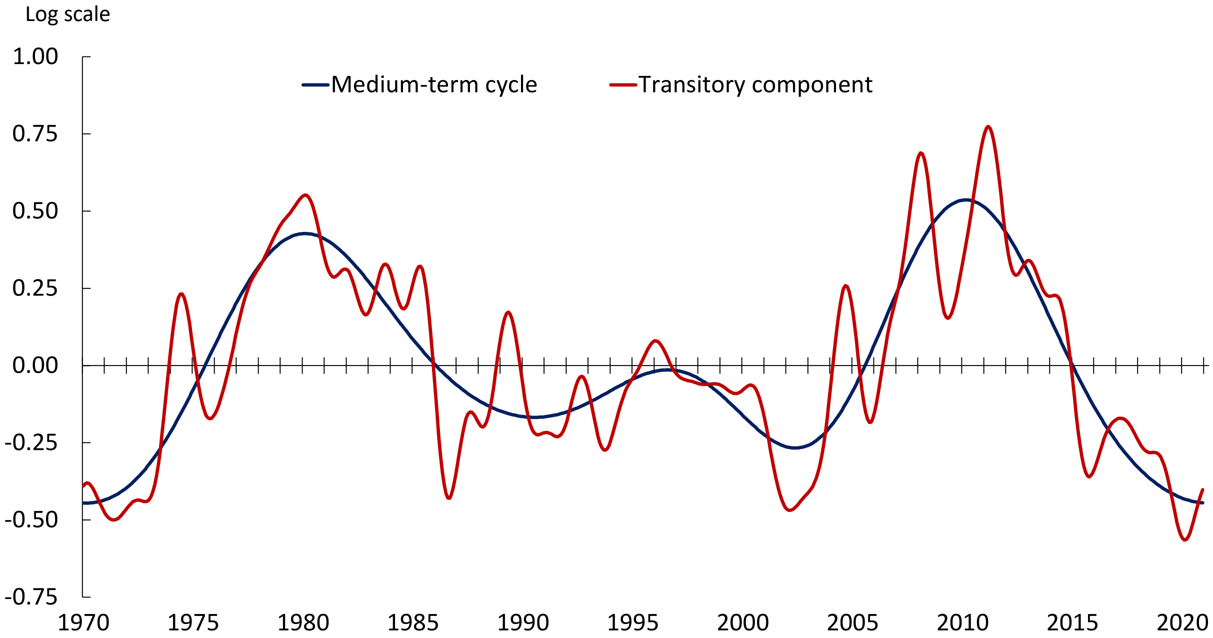


Source: Authors' calculations

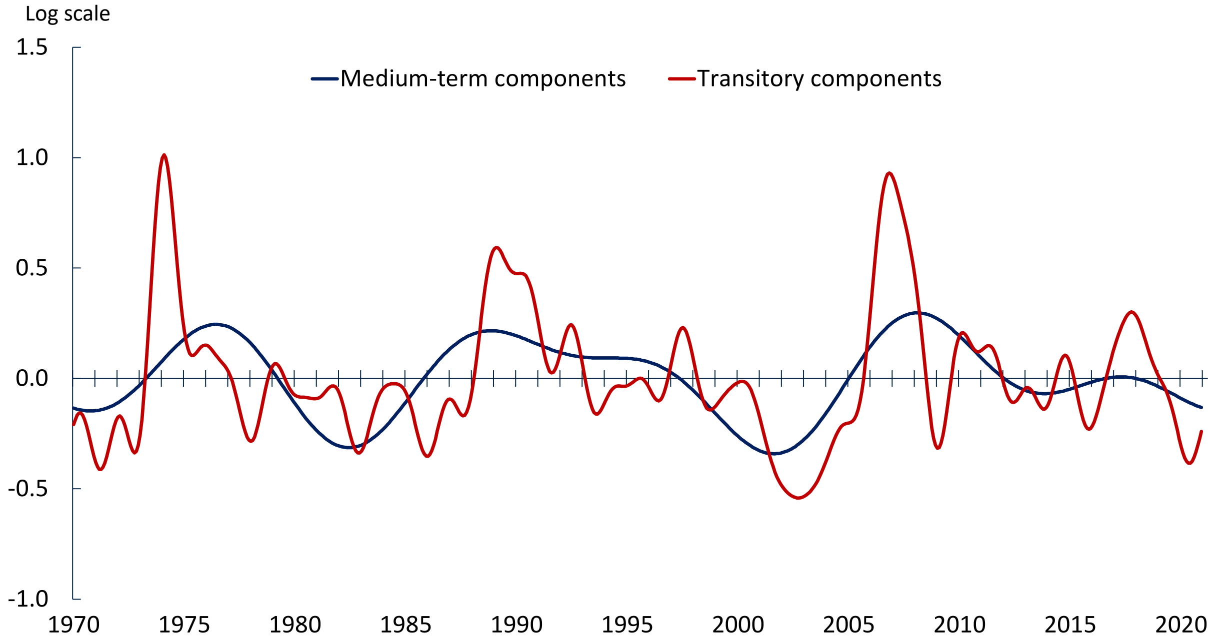


Source: Authors' calculations

Figure B9: Zinc

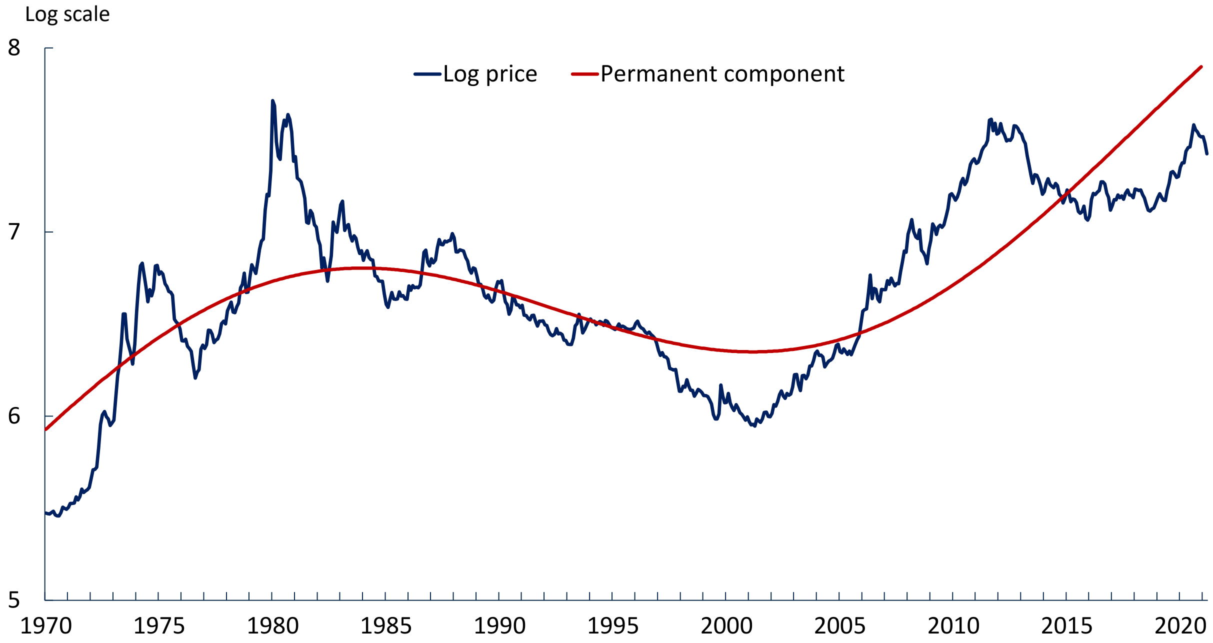


Source: Authors' calculations

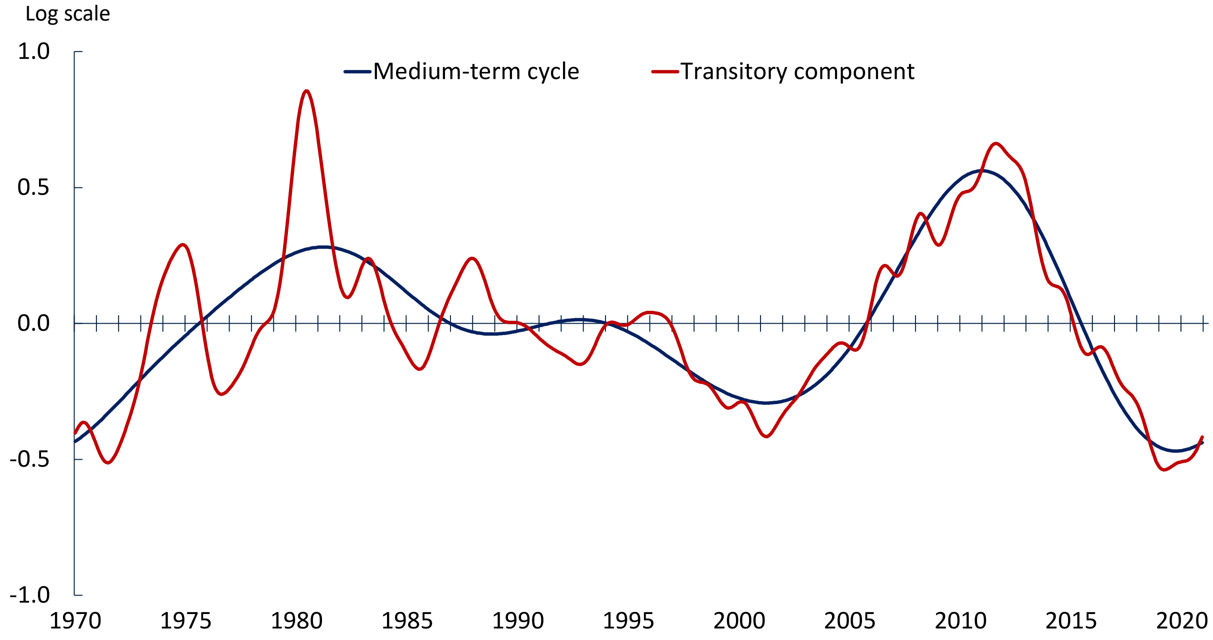


Source: Authors' calculations

Figure B10: Gold

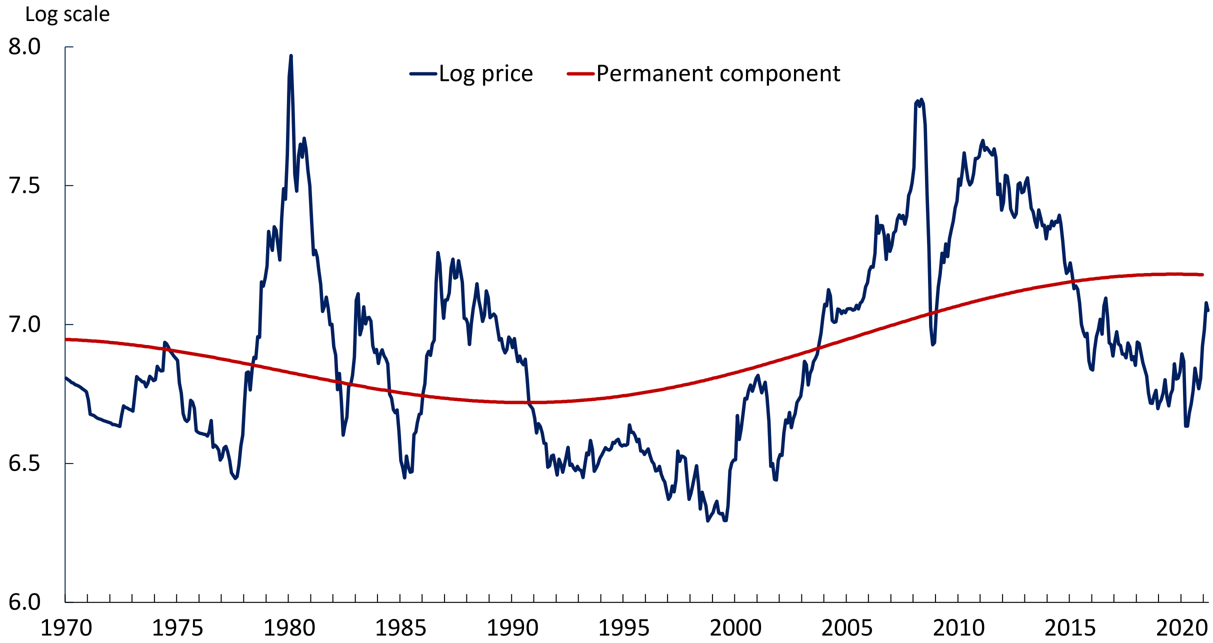


Source: Authors' calculations

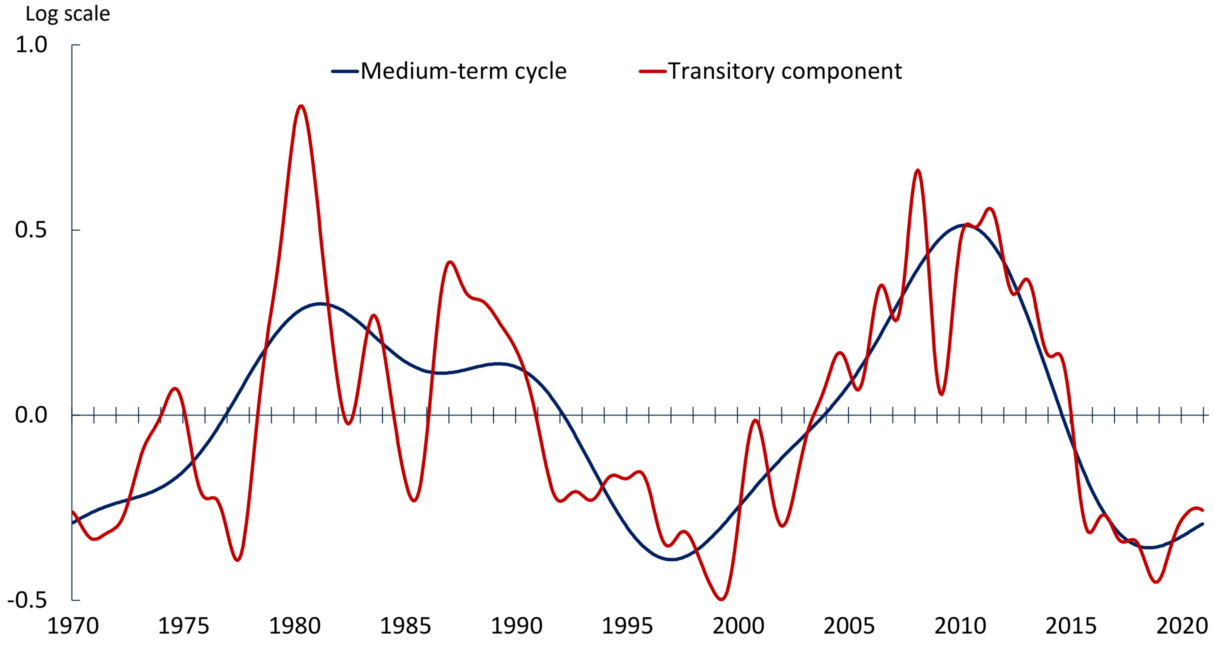


Source: Authors' calculations

Figure B11: Platinum

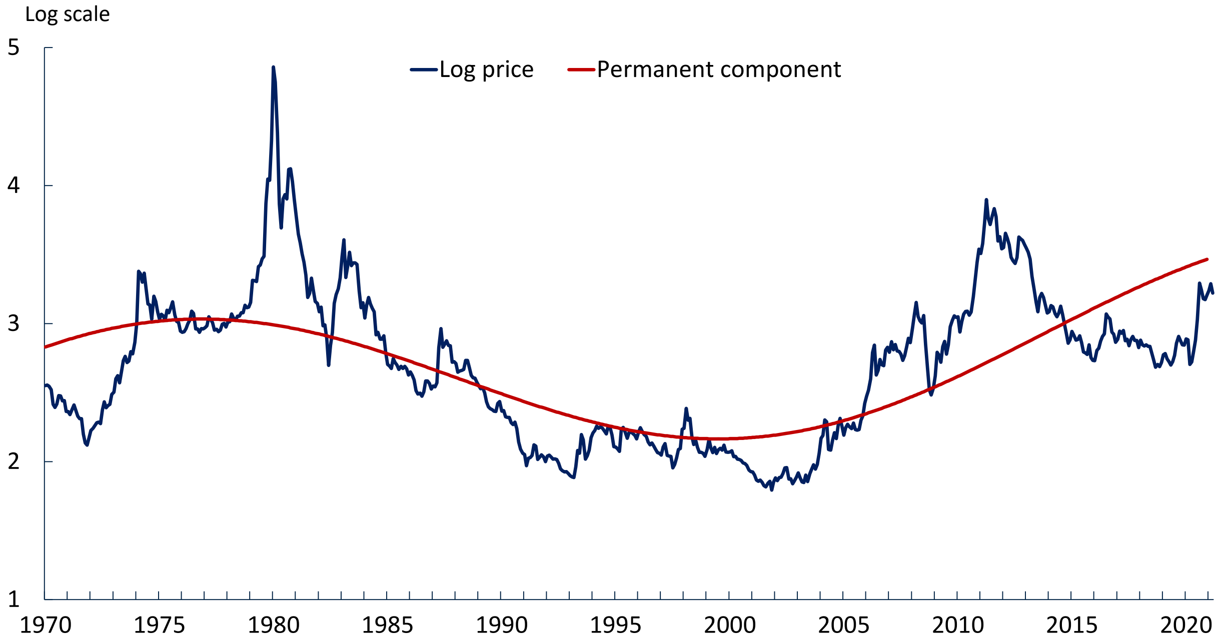


Source: Authors' calculations

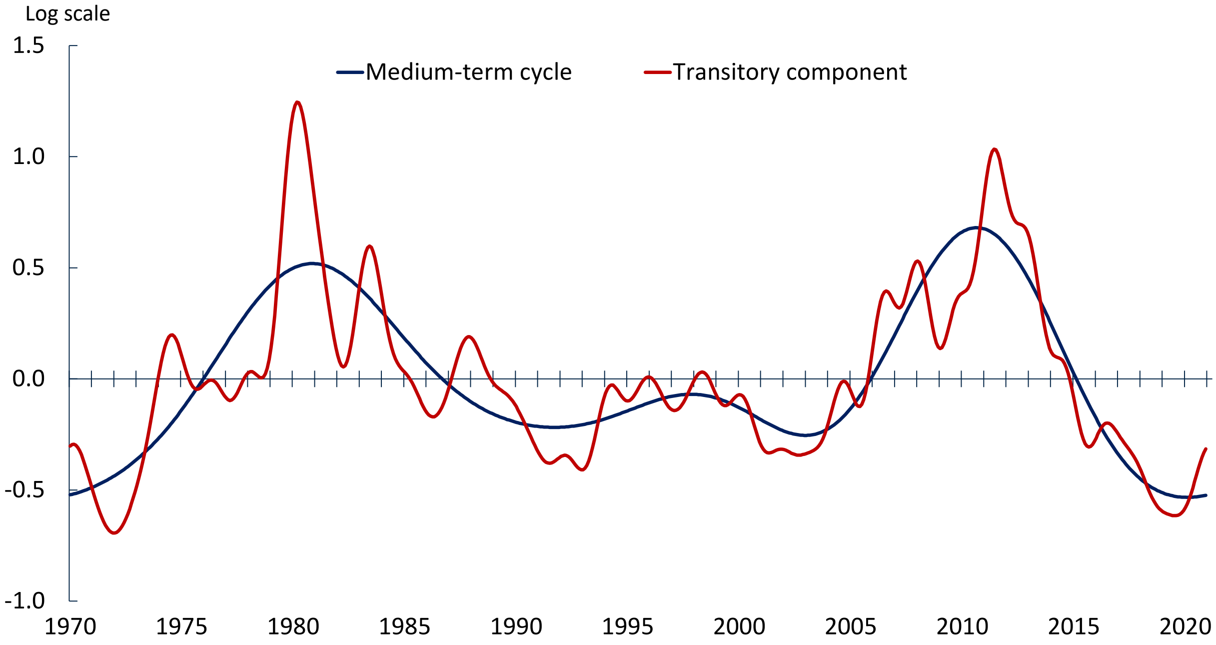


Source: Authors' calculations

Figure B12: Silver

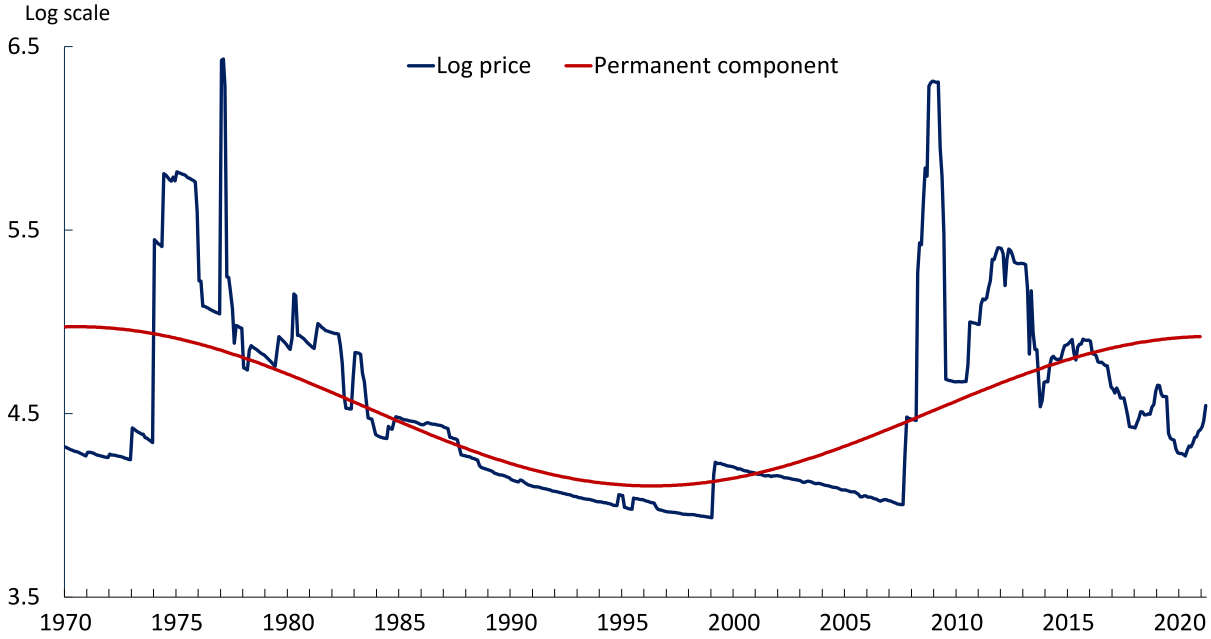


Source: Authors' calculations

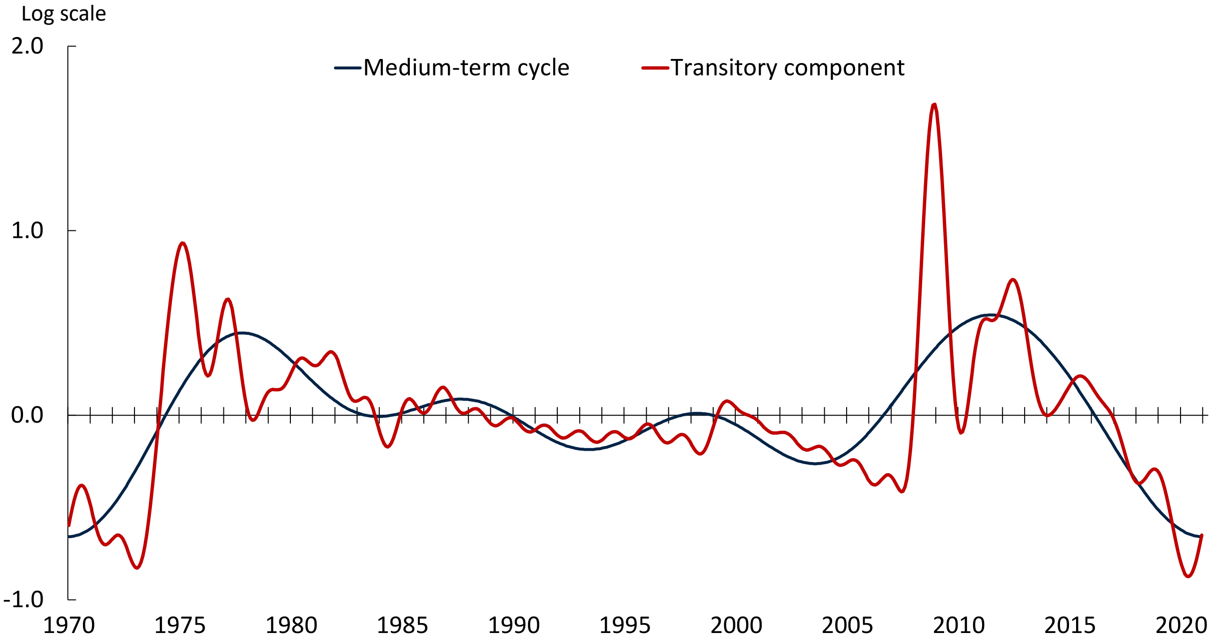


Source: Authors' calculations

Figure B13: Phosphate

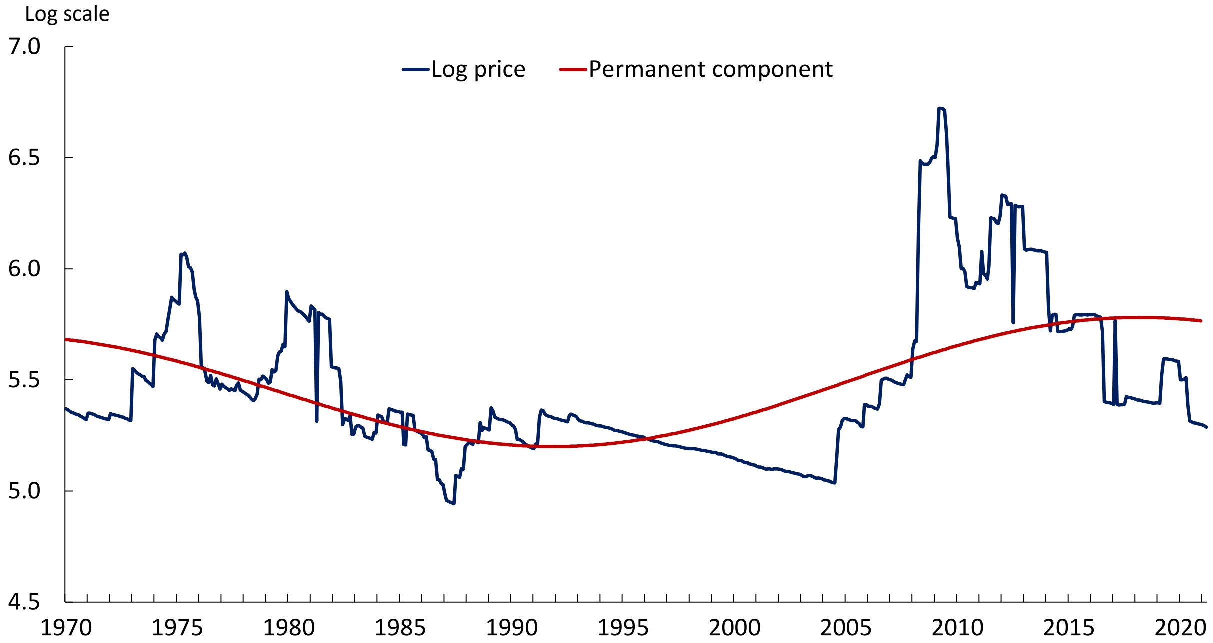


Source: Authors' calculations

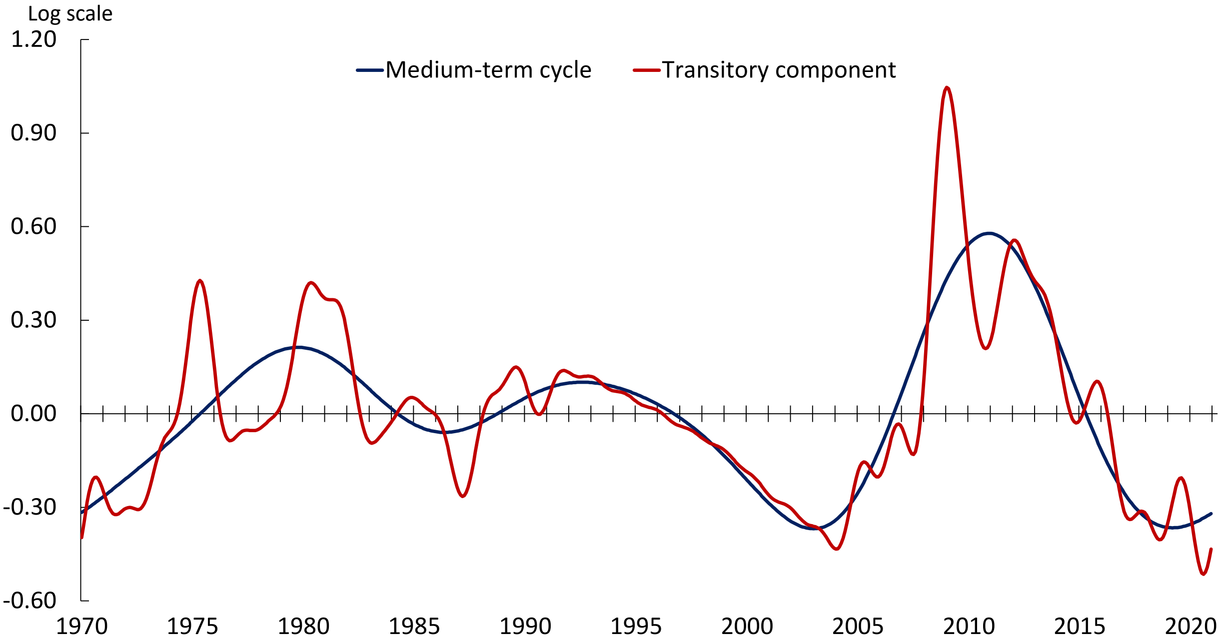


Source: Authors' calculations

Figure B14: Potassium

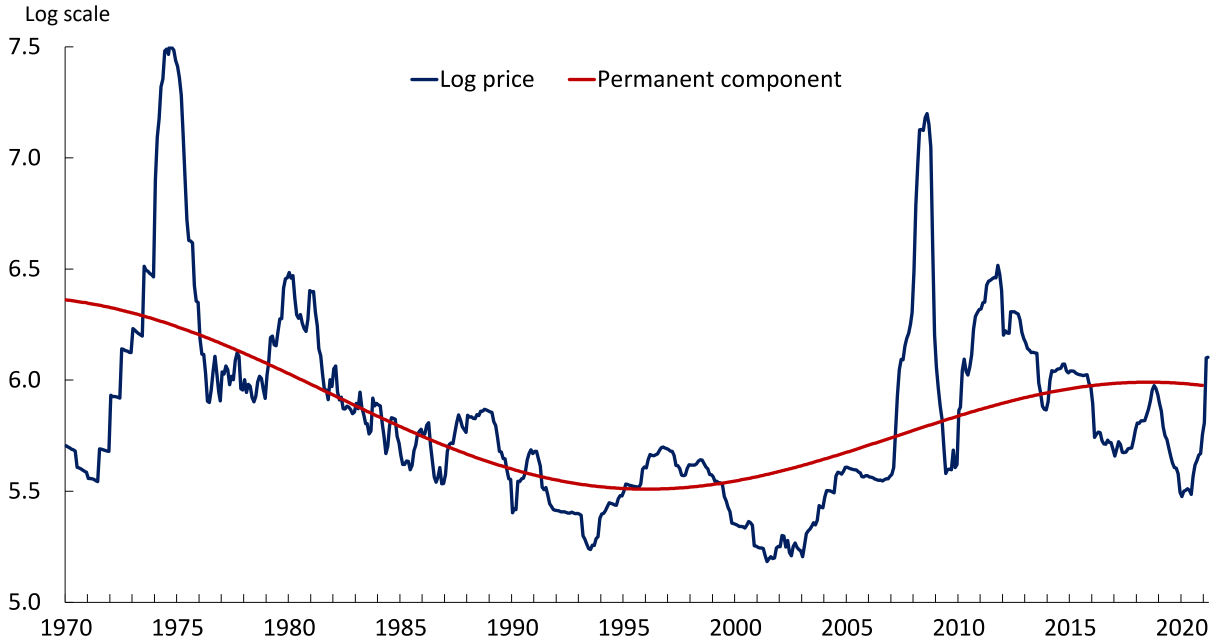


Source: Authors' calculations

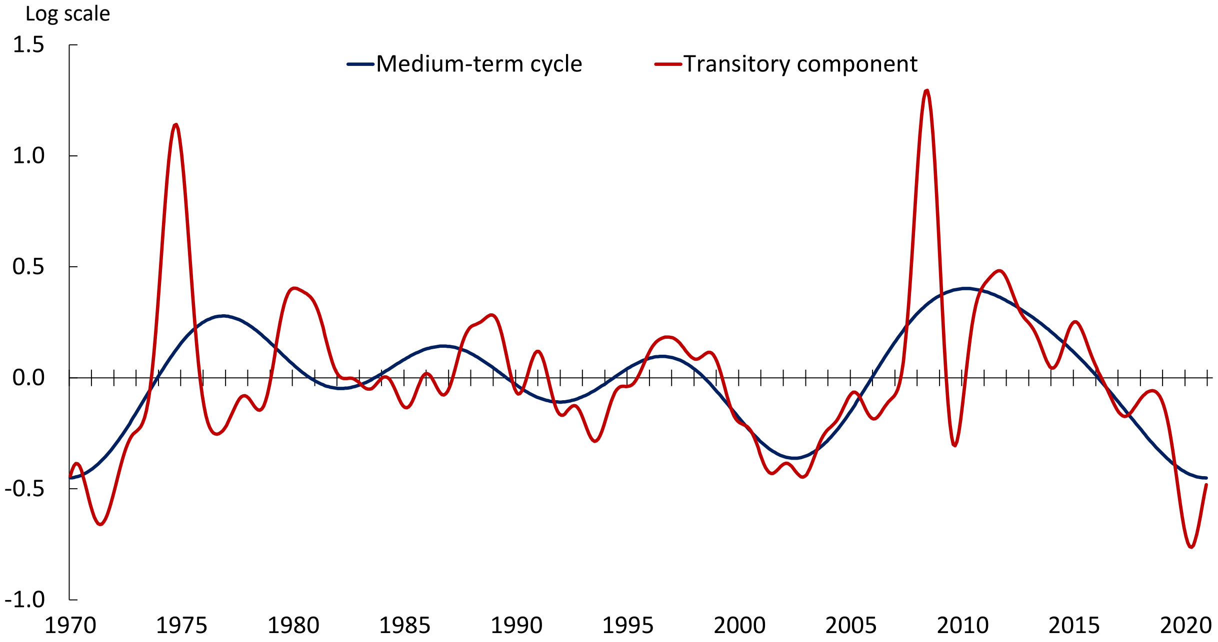


Source: Authors' calculations

Figure B15: TSP

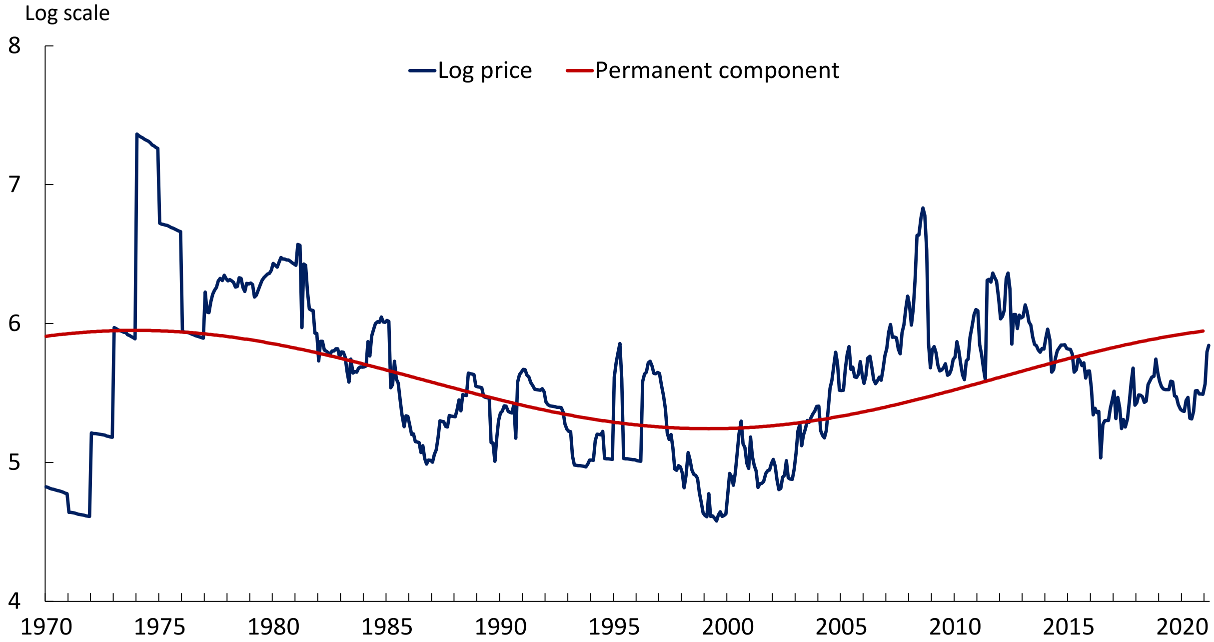


Source: Authors' calculations

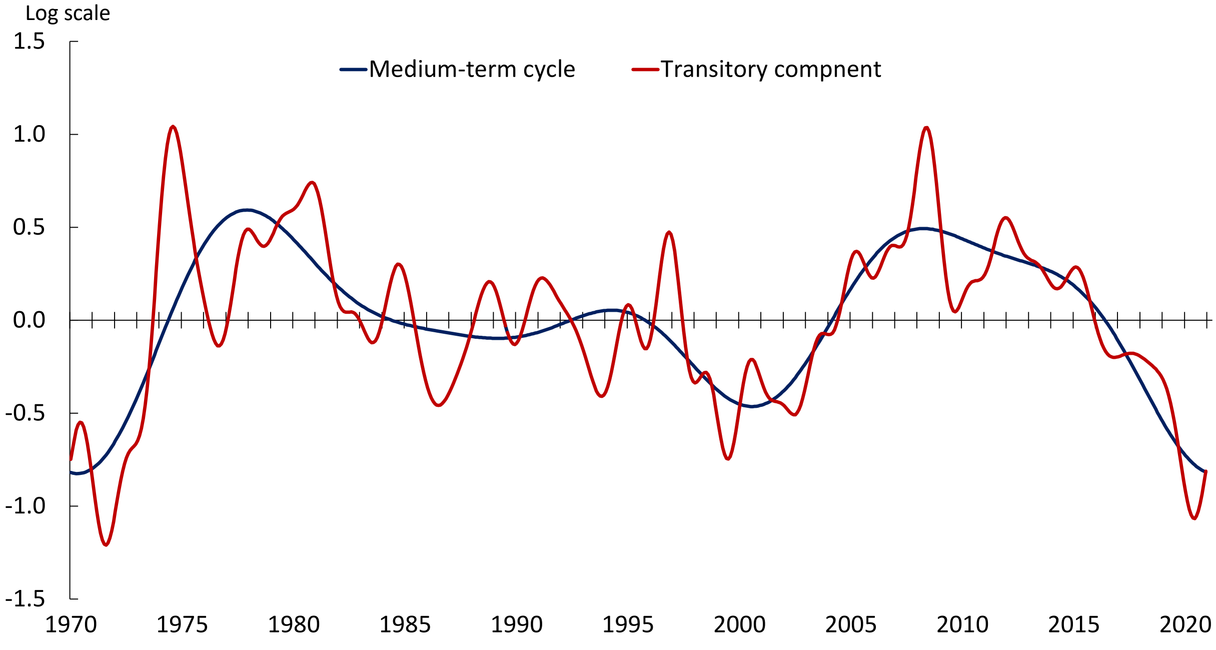


Source: Authors' calculations

Figure B16: Urea

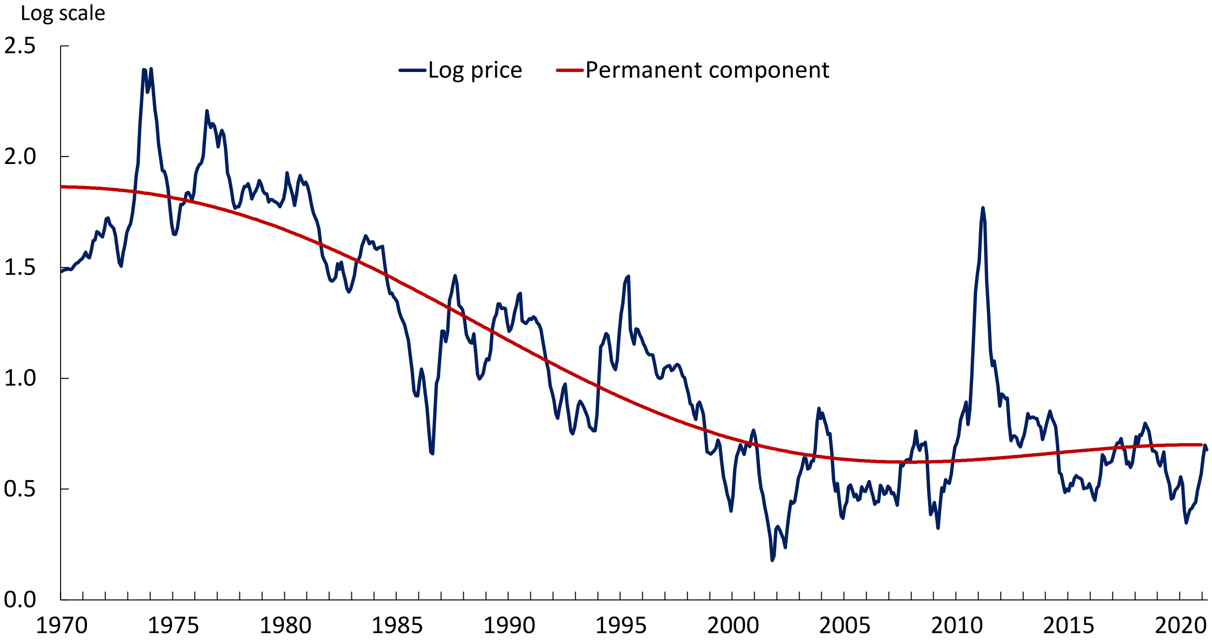


Source: Authors' calculations

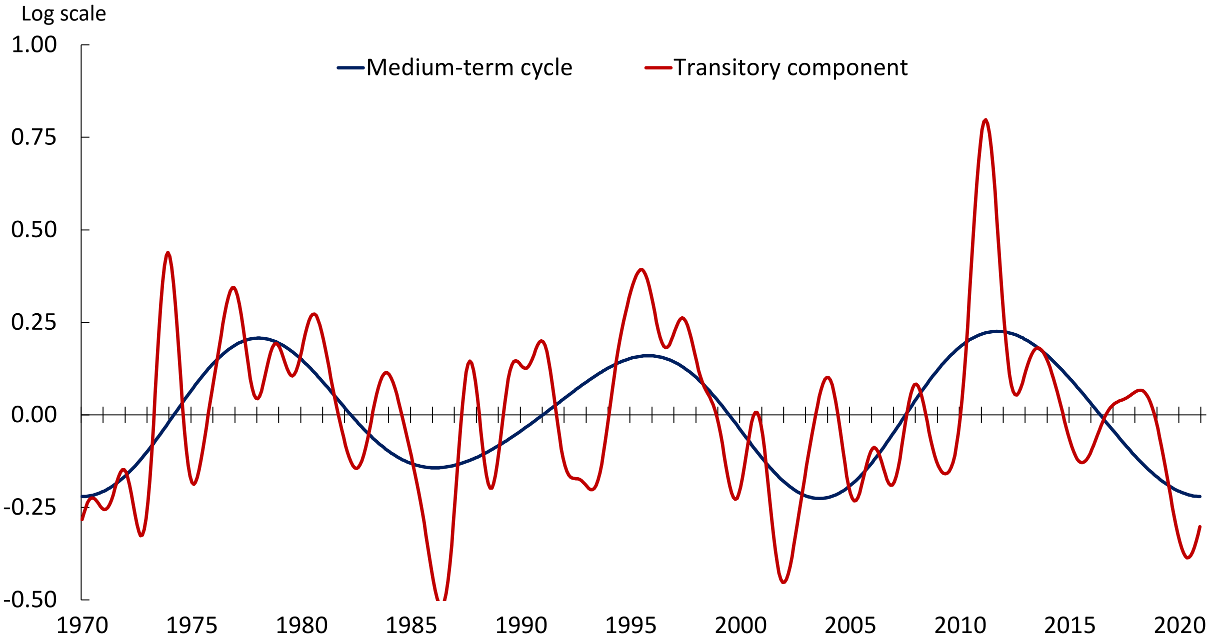


Source: Author's calculations

Figure B17: Cotton

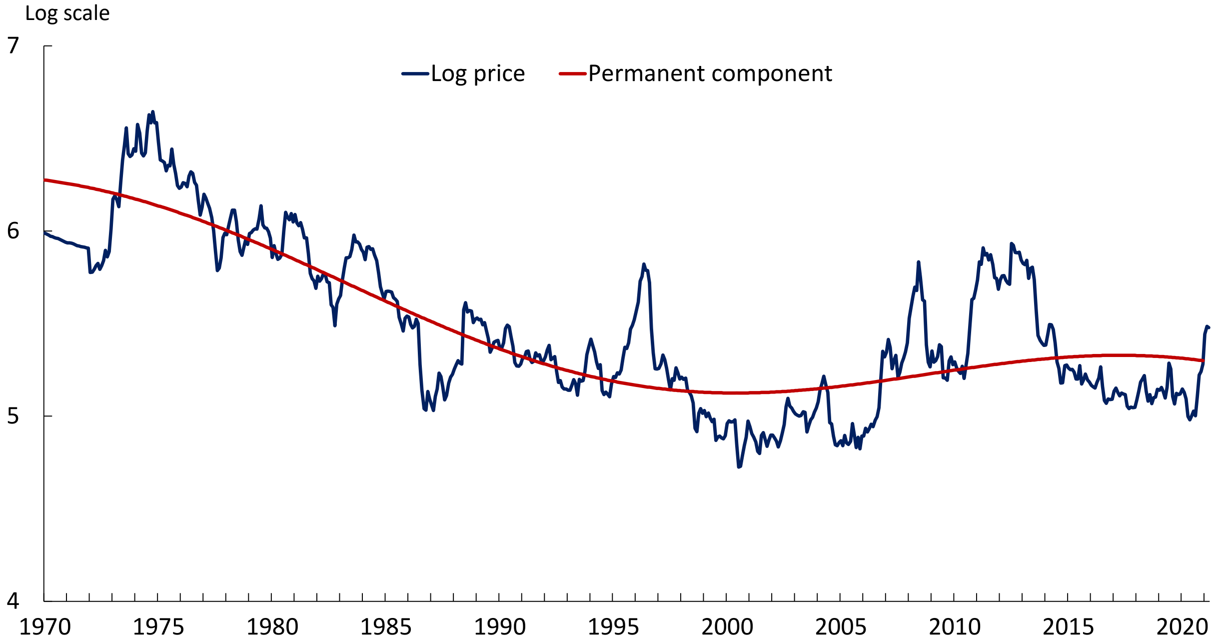


Source: Authors' calculations

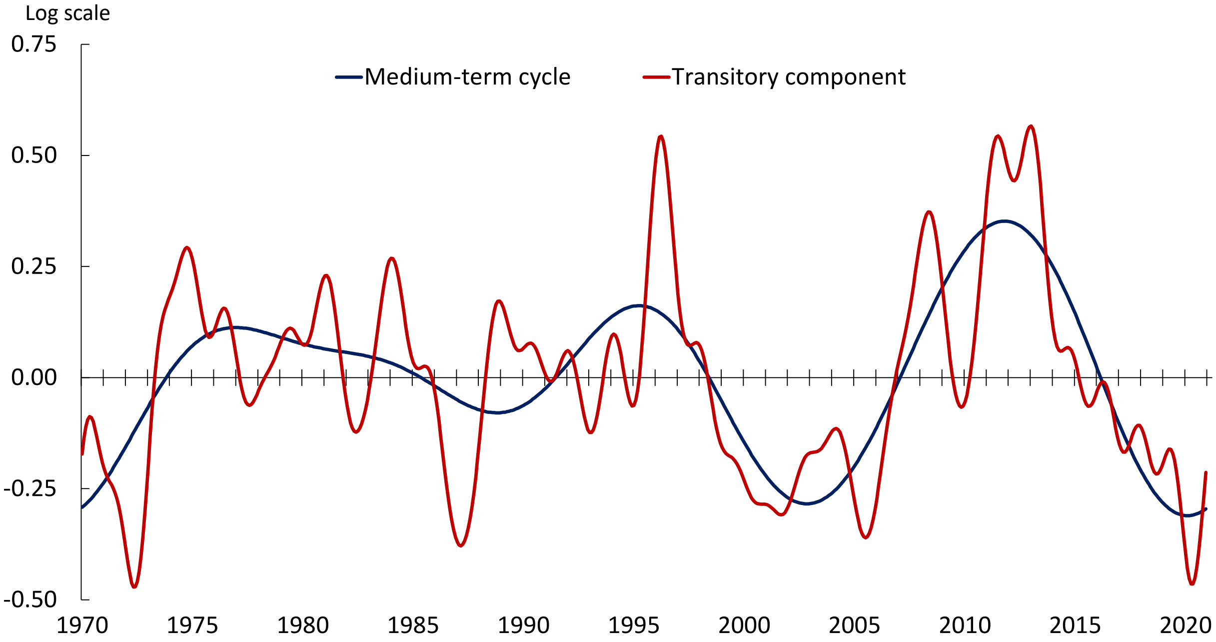


Source: Authors' calculations

Figure B18: Maize

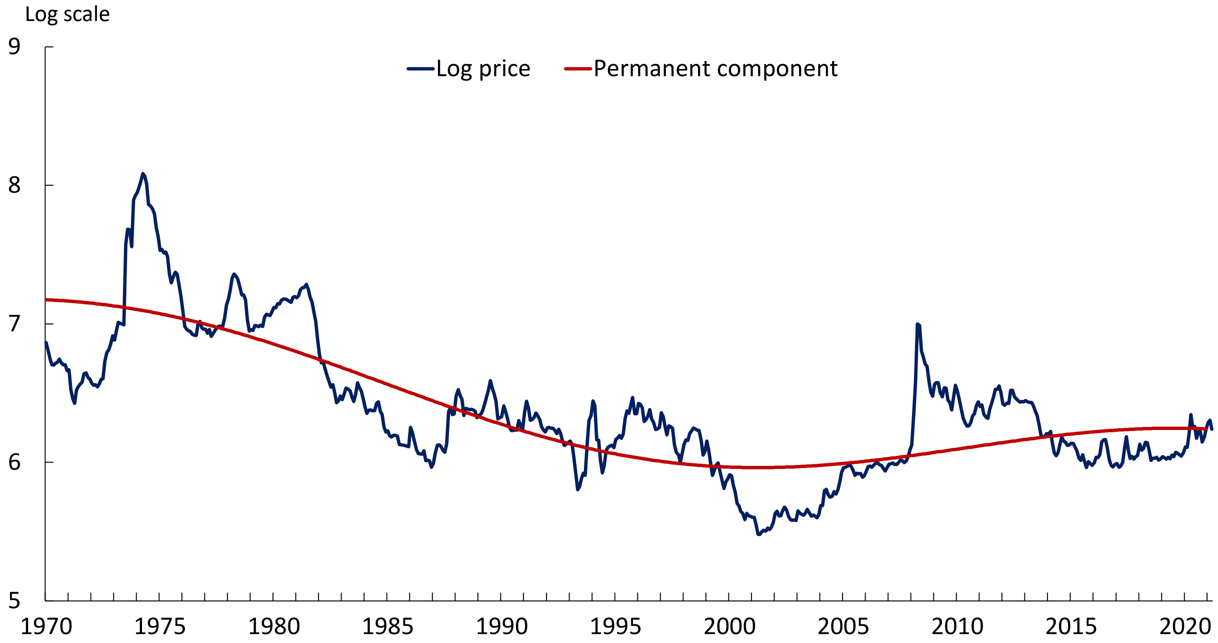


Source: Authors' calculations

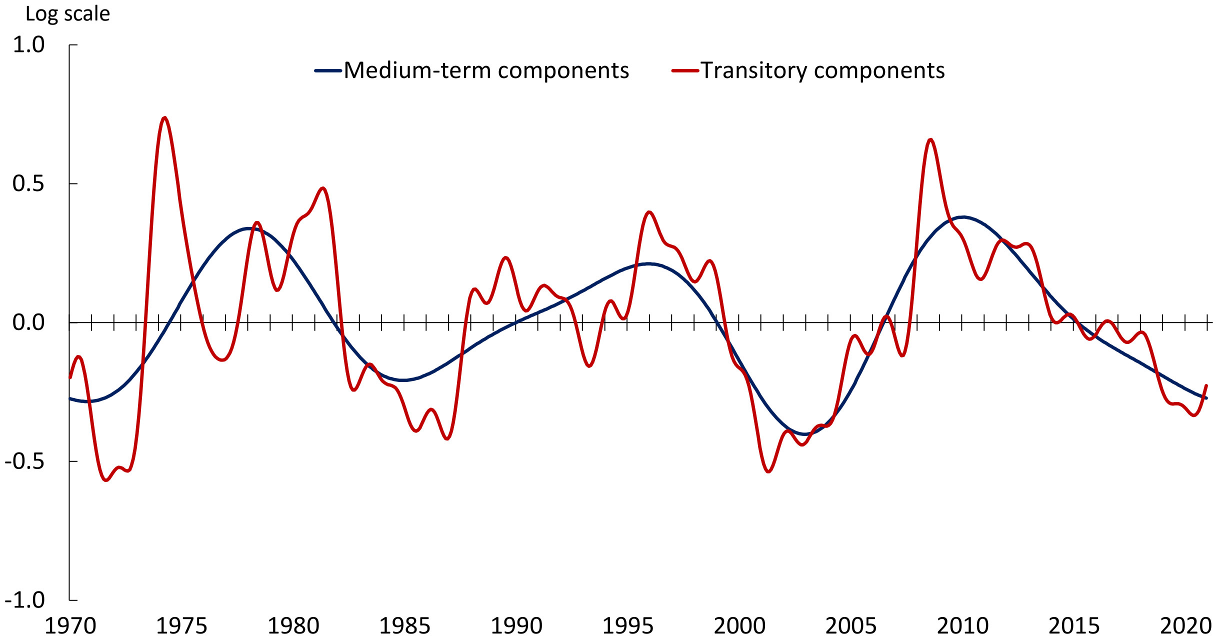


Source: Authors' calculations

Figure B19: Rice

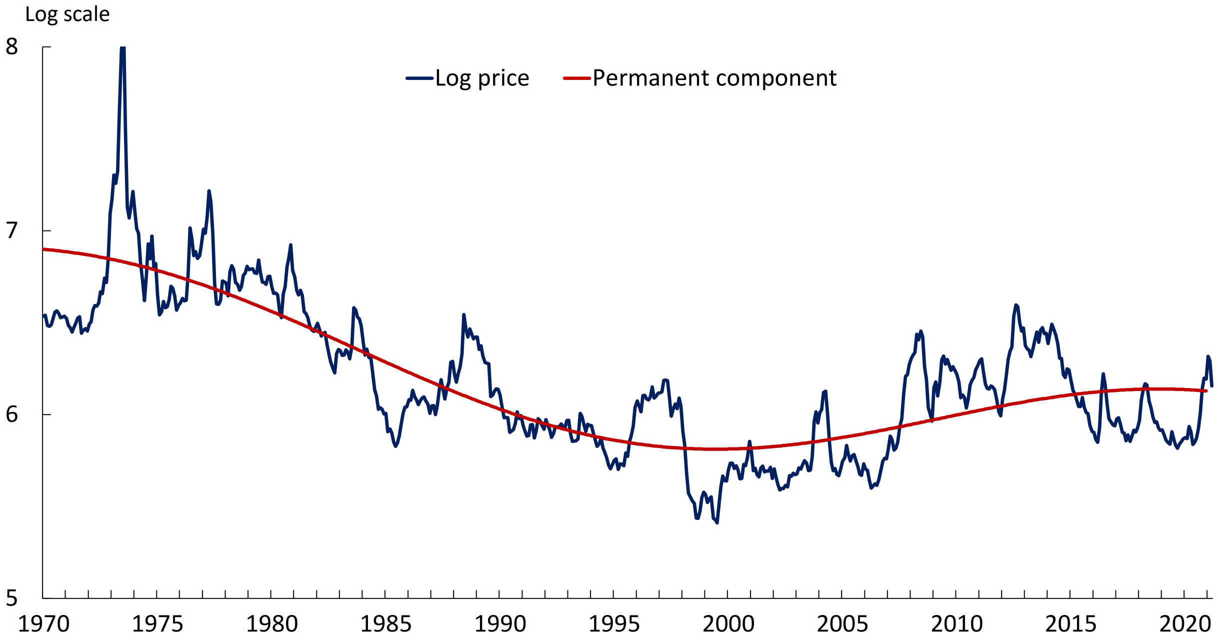


Source: Authors' calculations

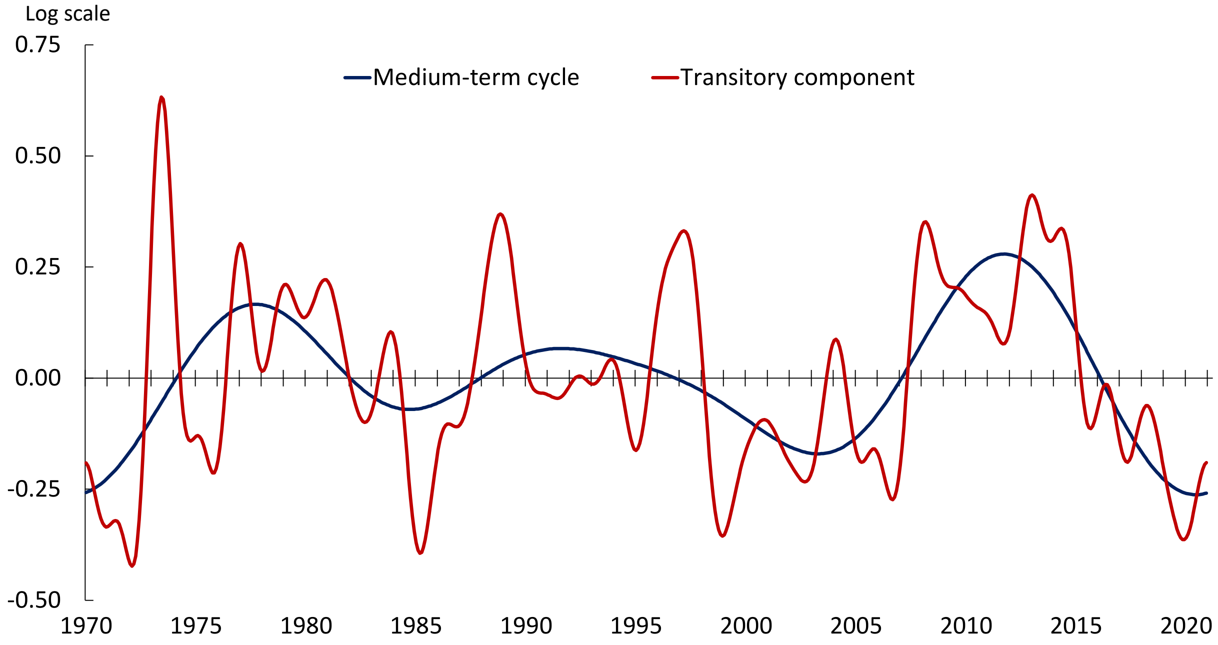


Source: Authors' calculations

Figure B20: Soybean meal

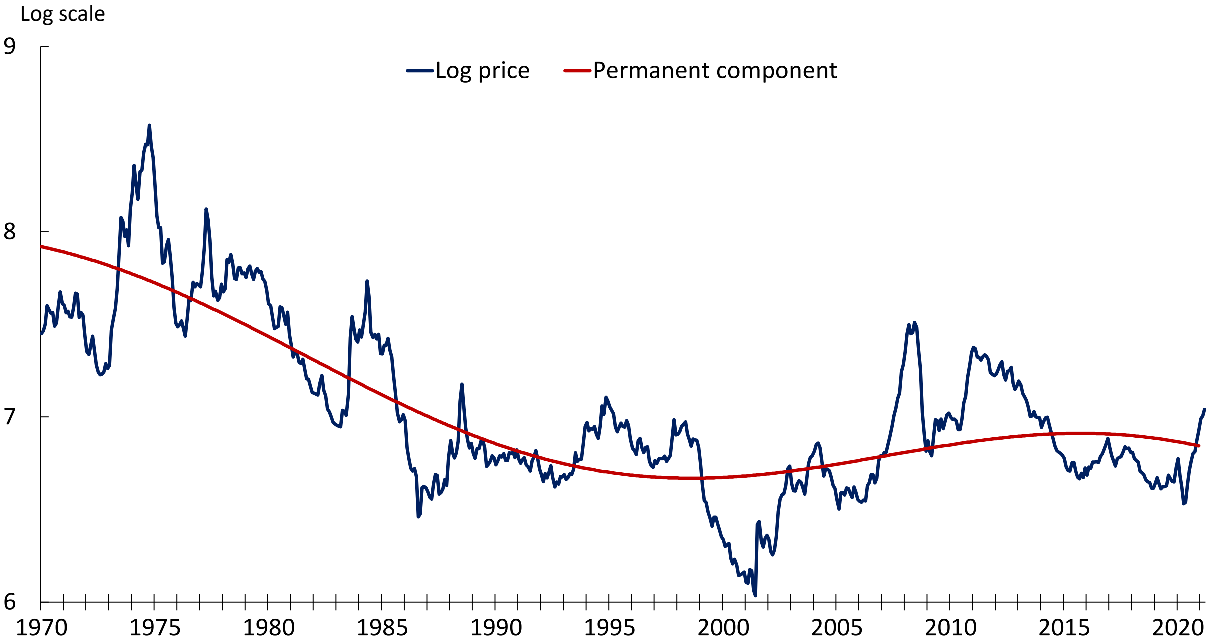


Source: Authors' calculations

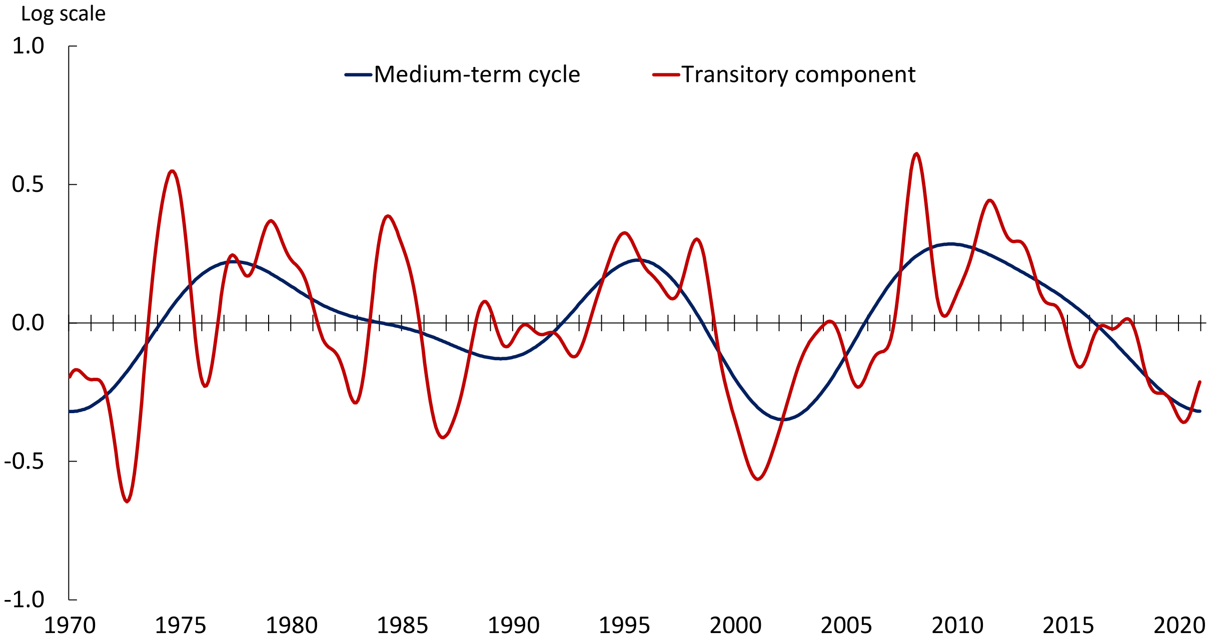


Source: Authors' calculations

Figure B21: Soybean oil

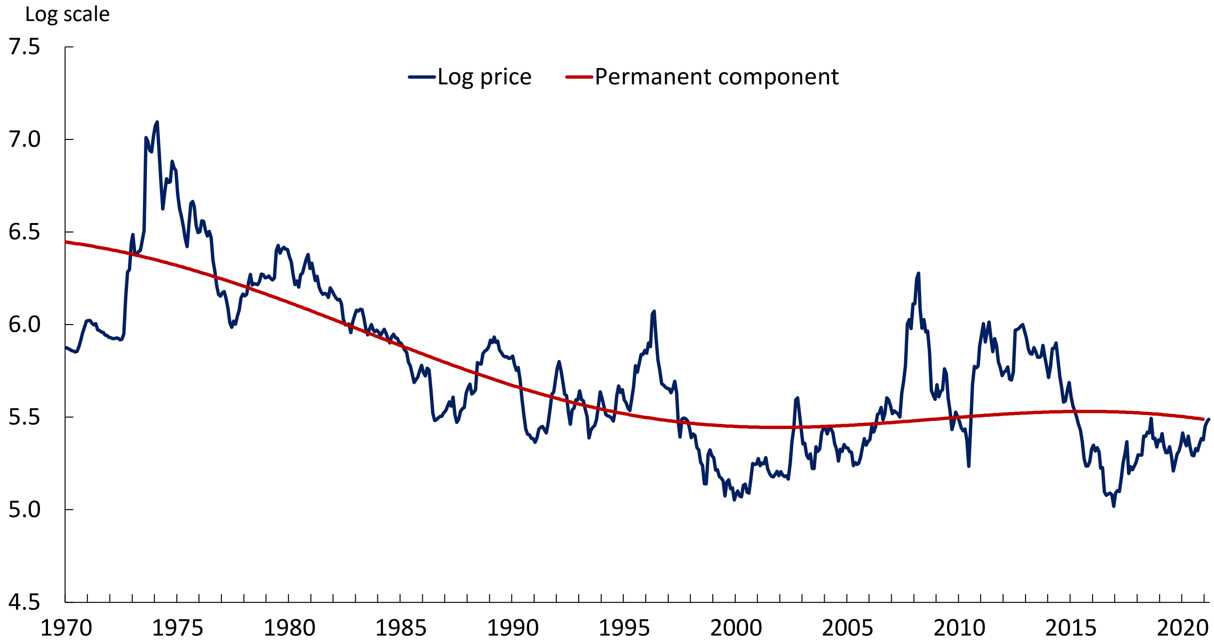


Source: Authors' calculations

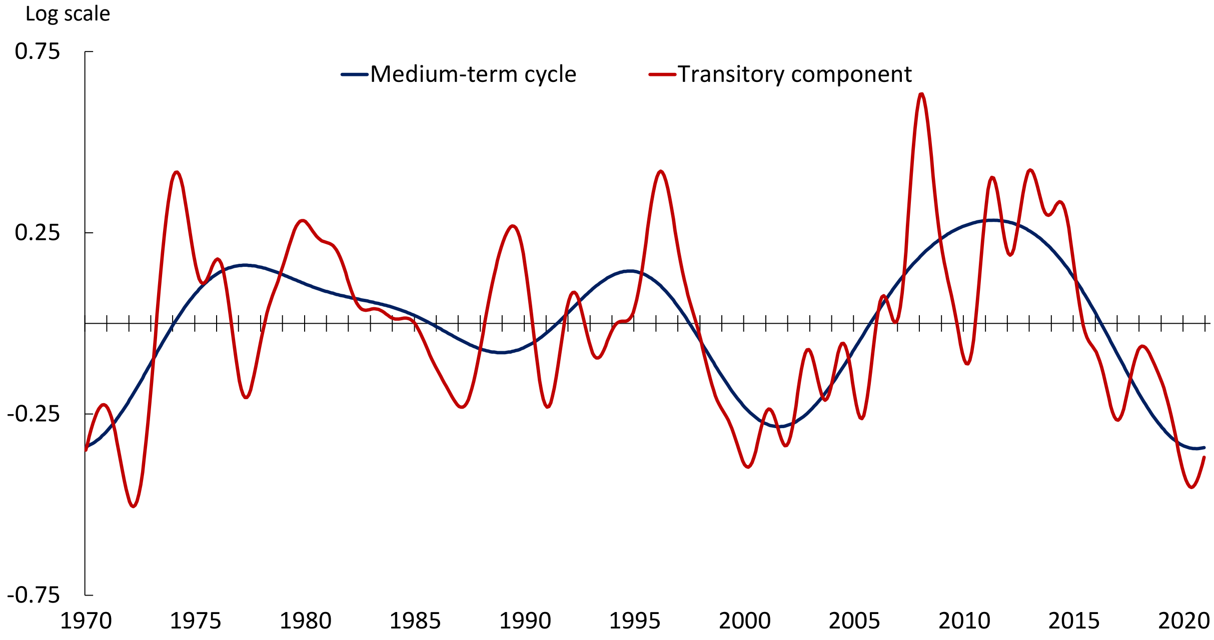


Source: Authors' calculations

Figure B22: Wheat

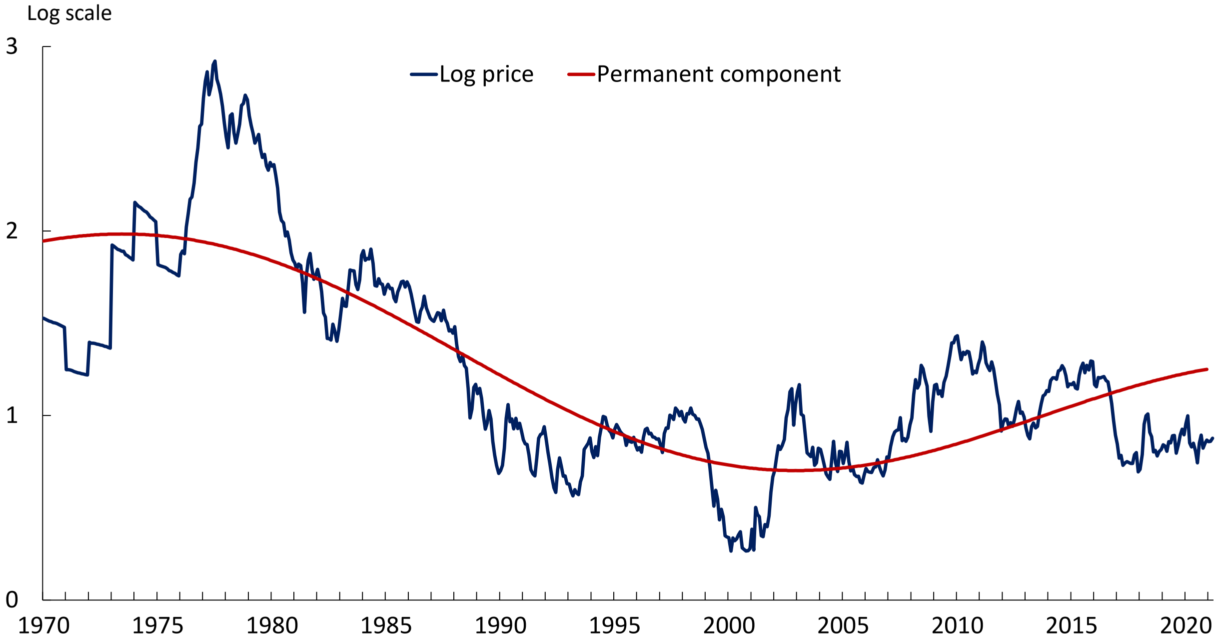


Source: Authors' calculations

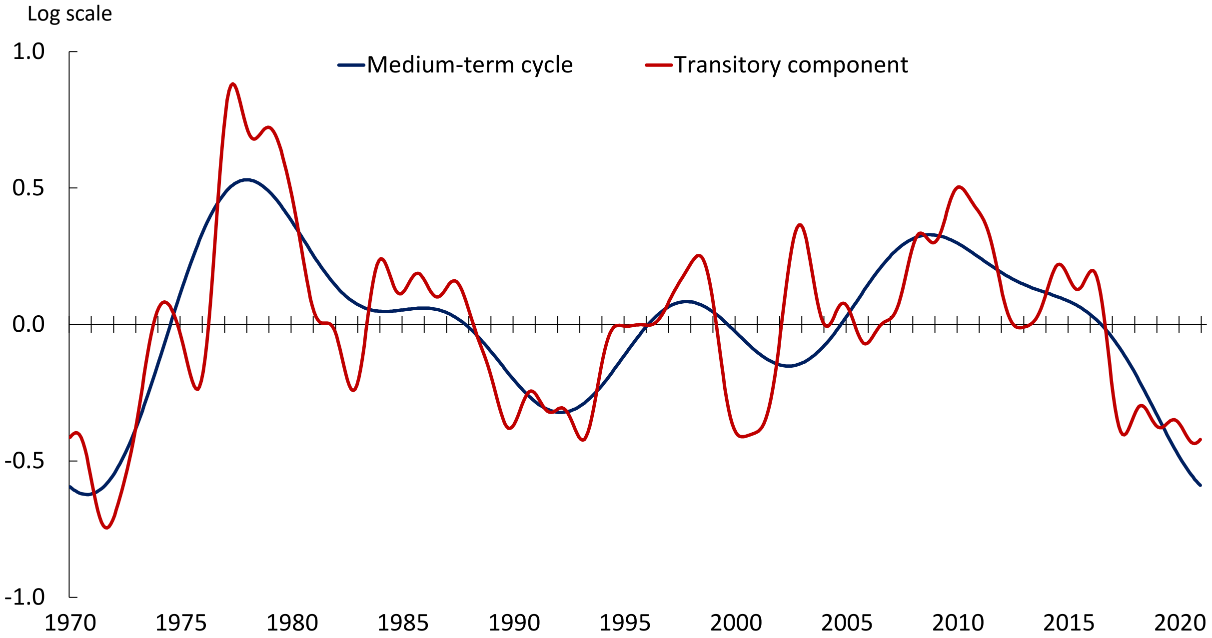


Source: Authors' calculations

Figure B23: Cocoa

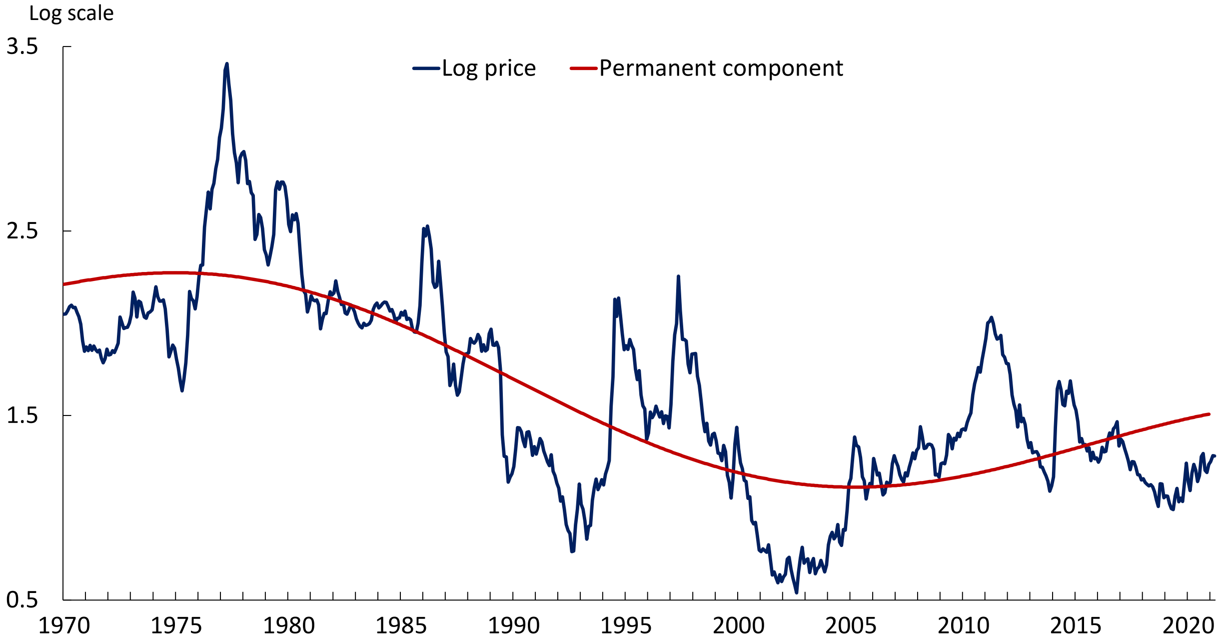


Source: Authors' calculations

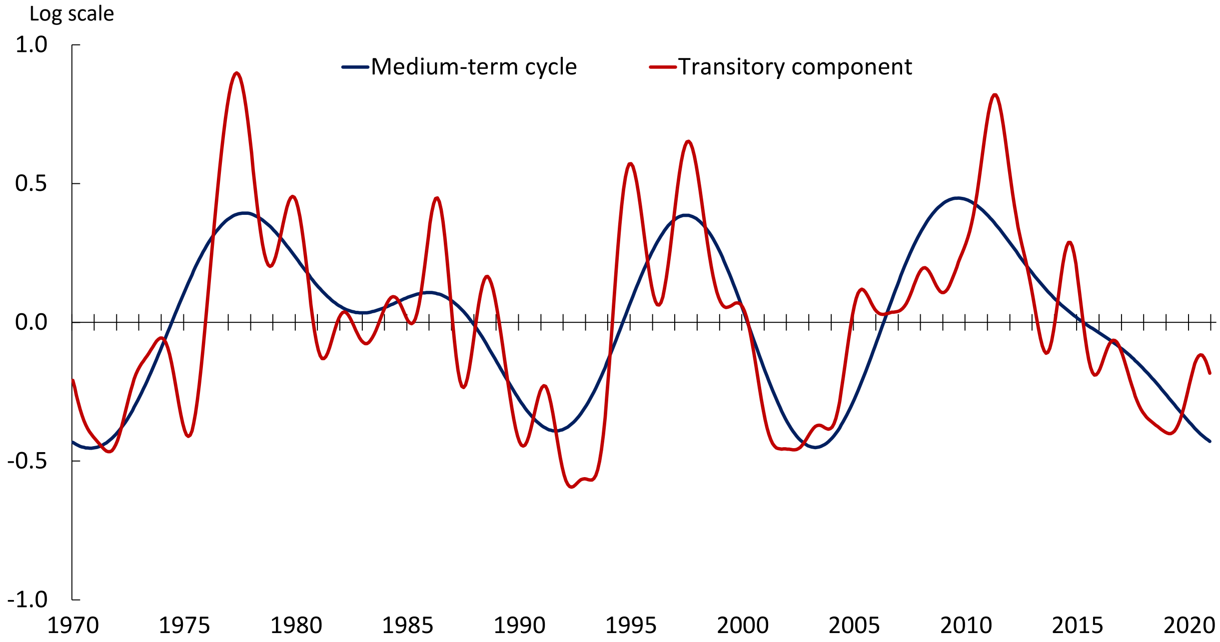


Source: Authors' calculations

Figure B24: Coffee, Arabica

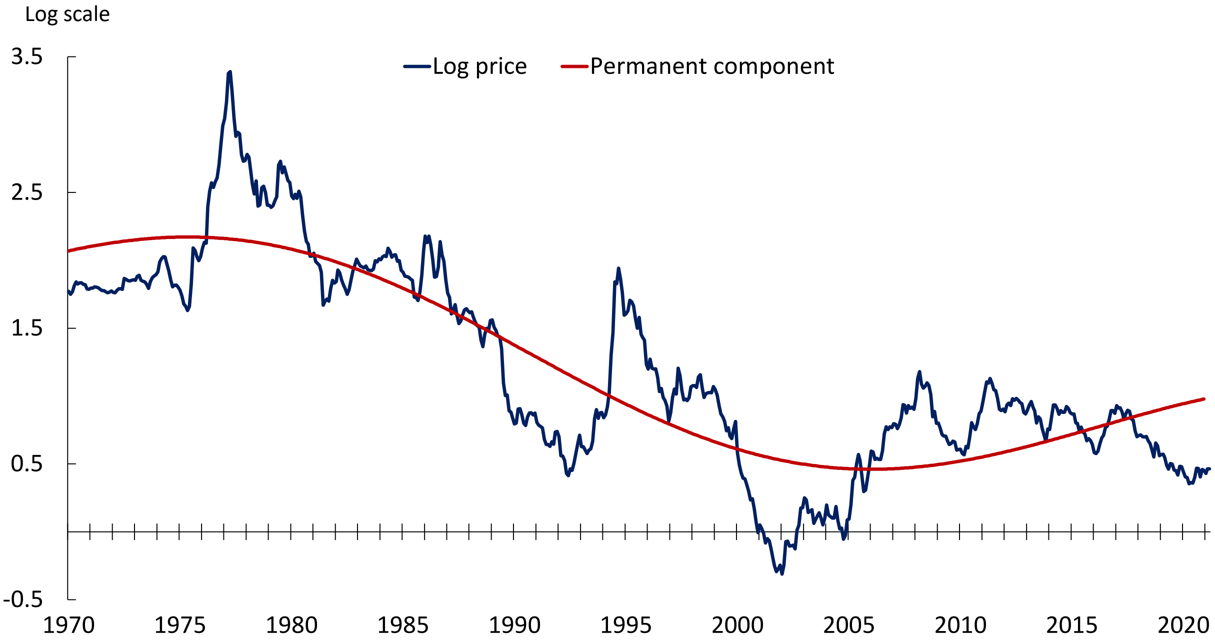


Source: Authors' calculations

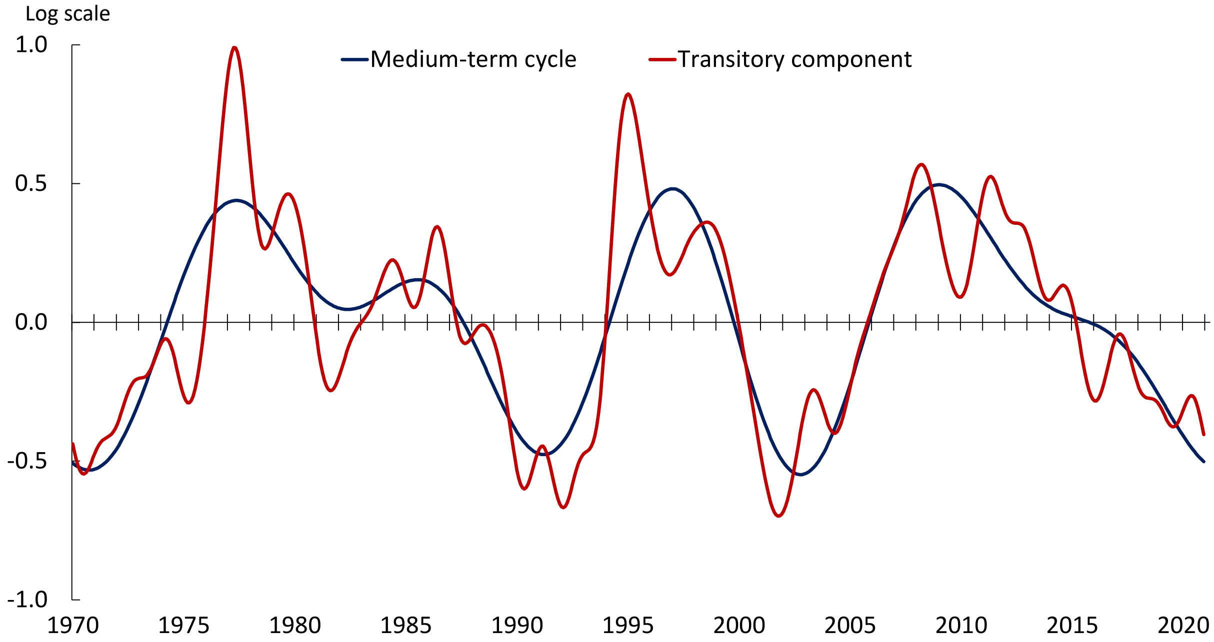


Source: Authors' calculations

Figure B25: Coffee, Robusta

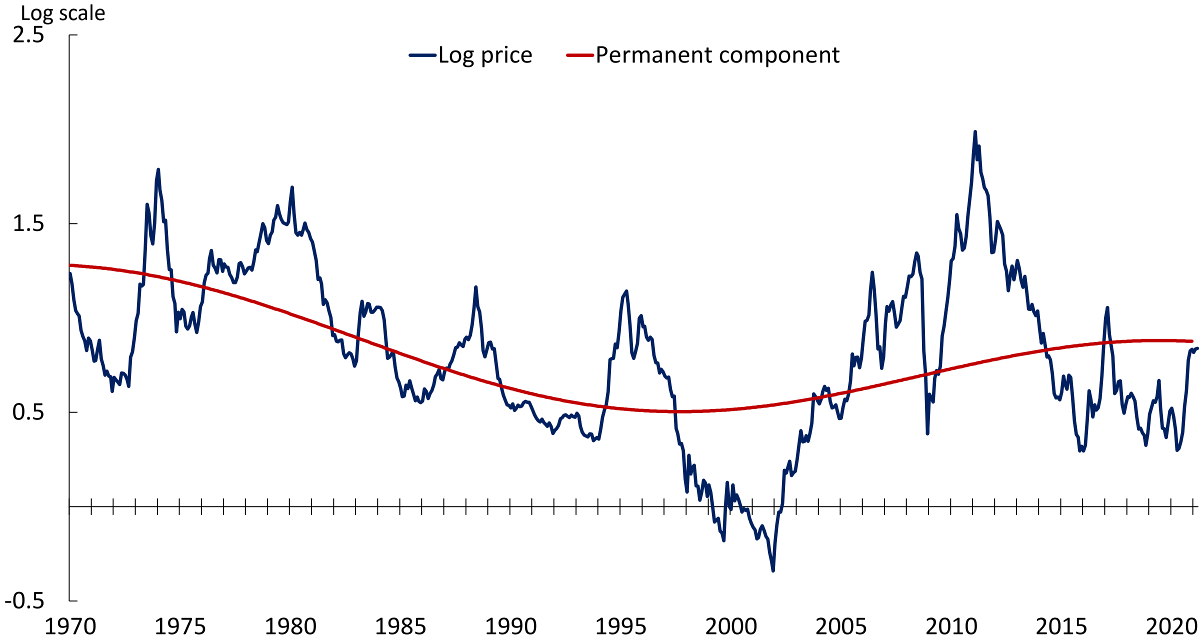


Source: Authors’ calculations

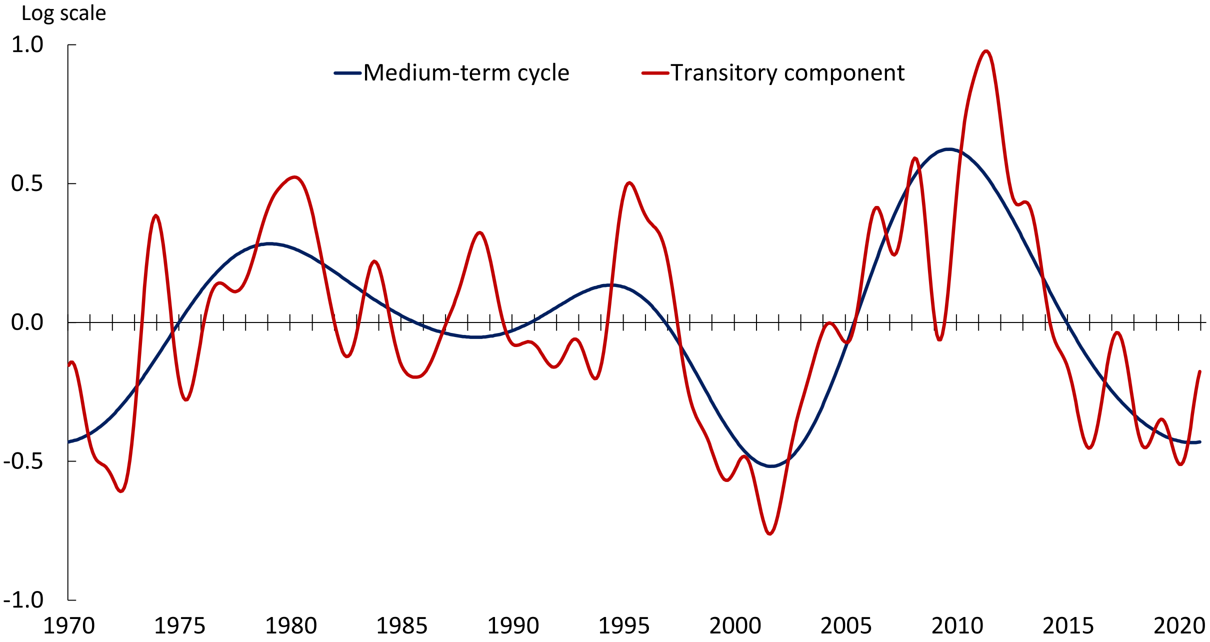


Source: Authors’ calculations

Figure B26: Natural rubber

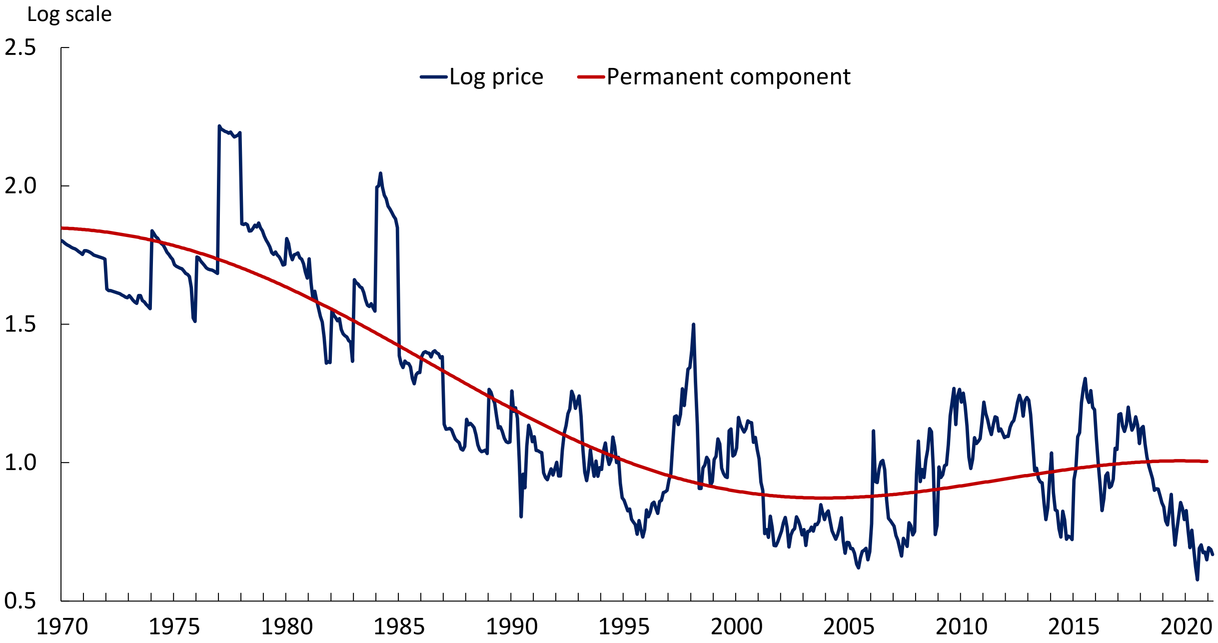


Source: Authors' calculations

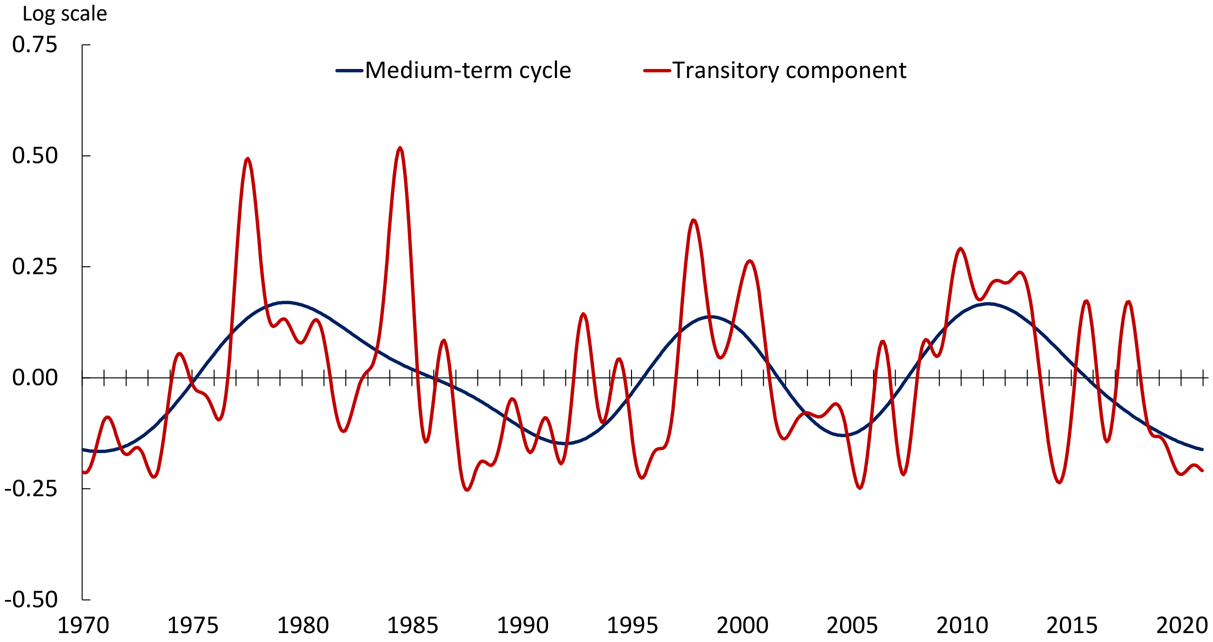


Source: Authors' calculations

Figure B27: Tea

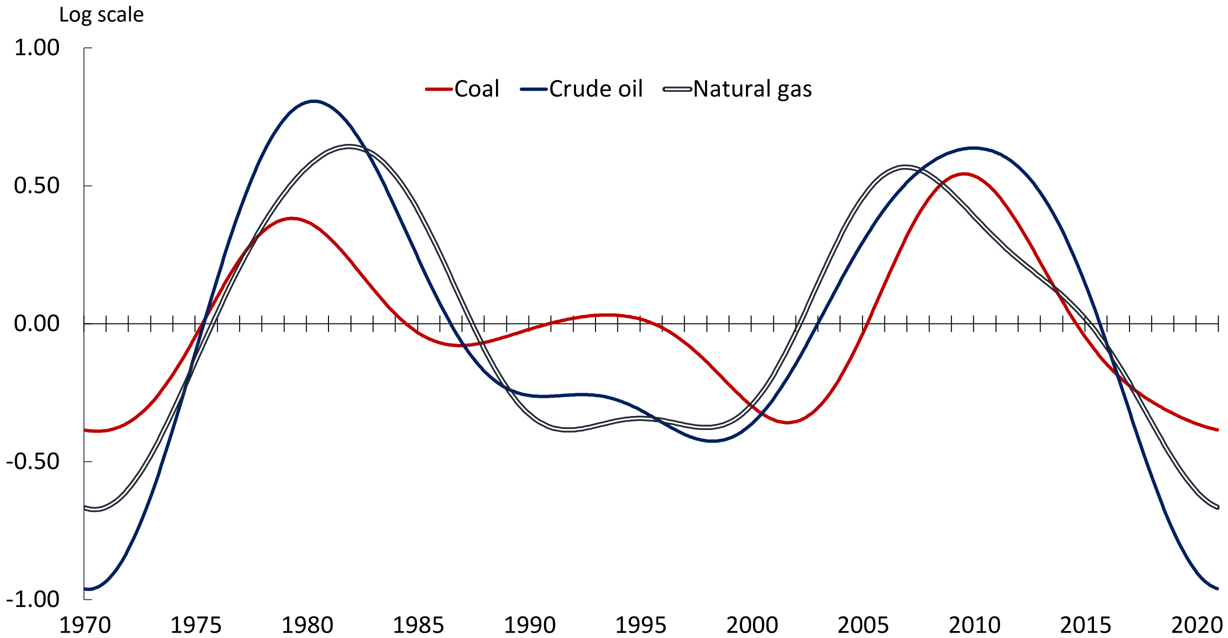


Source: Authors’ calculations

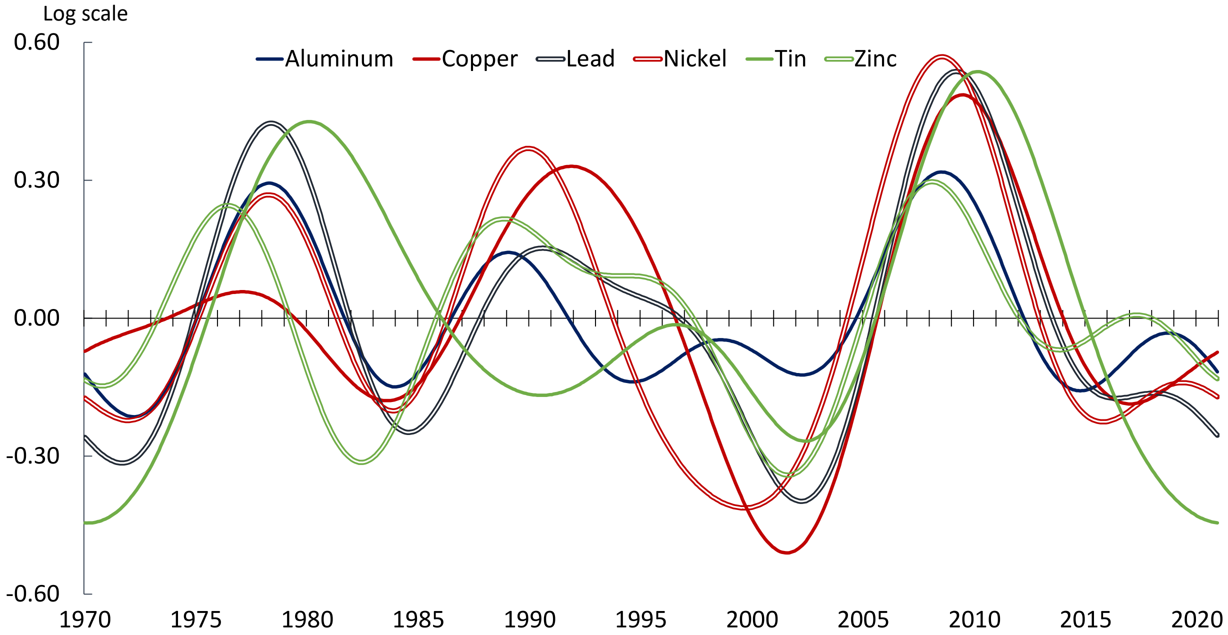


Source: Authors’ calculations

Figure B28: Medium-term cycles—Energy and base metals

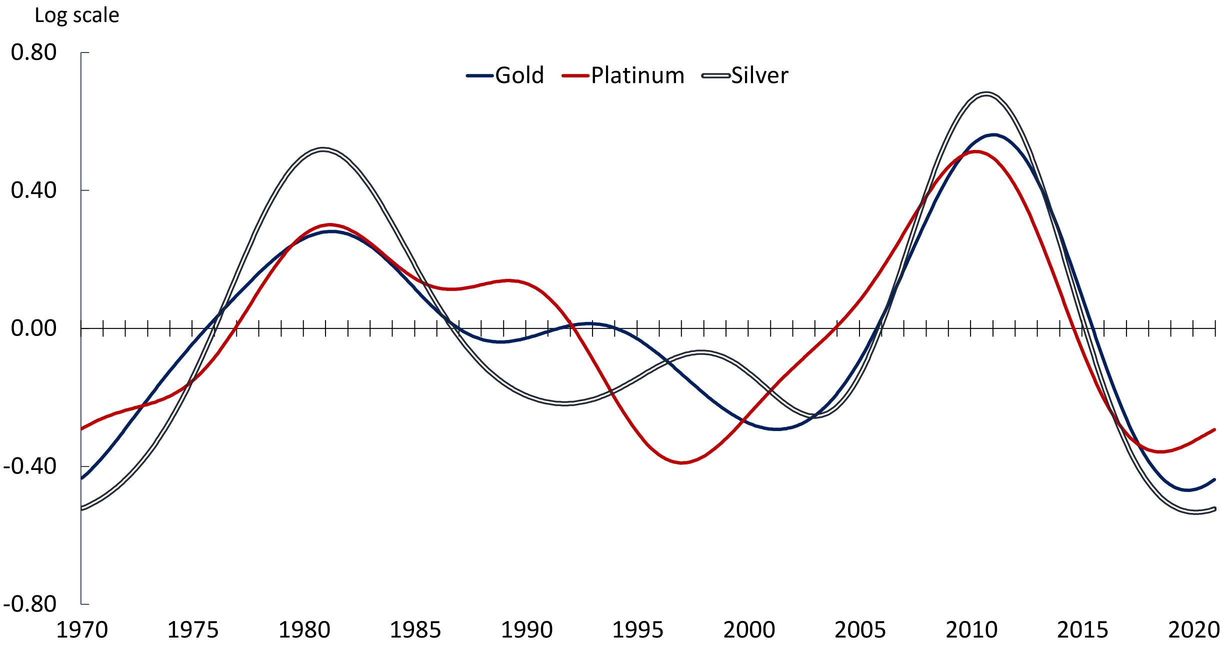


Source: Authors' calculations

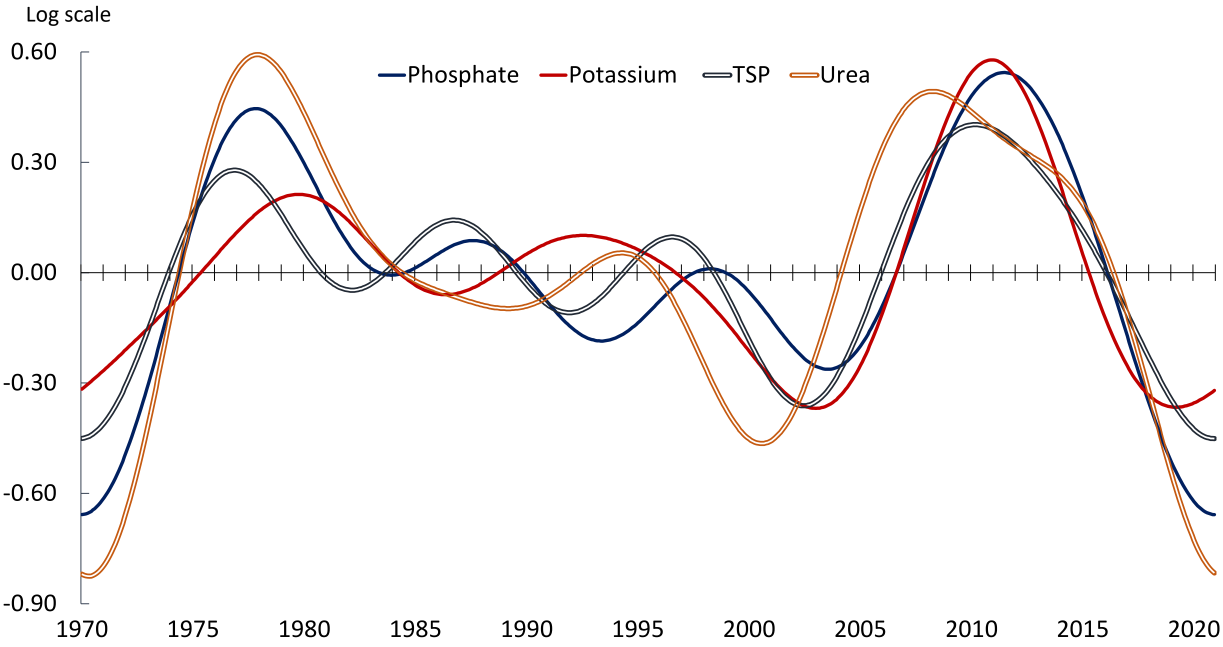


Source: Authors' calculations

Figure B29: Medium-term cycles—Precious metals and fertilizers

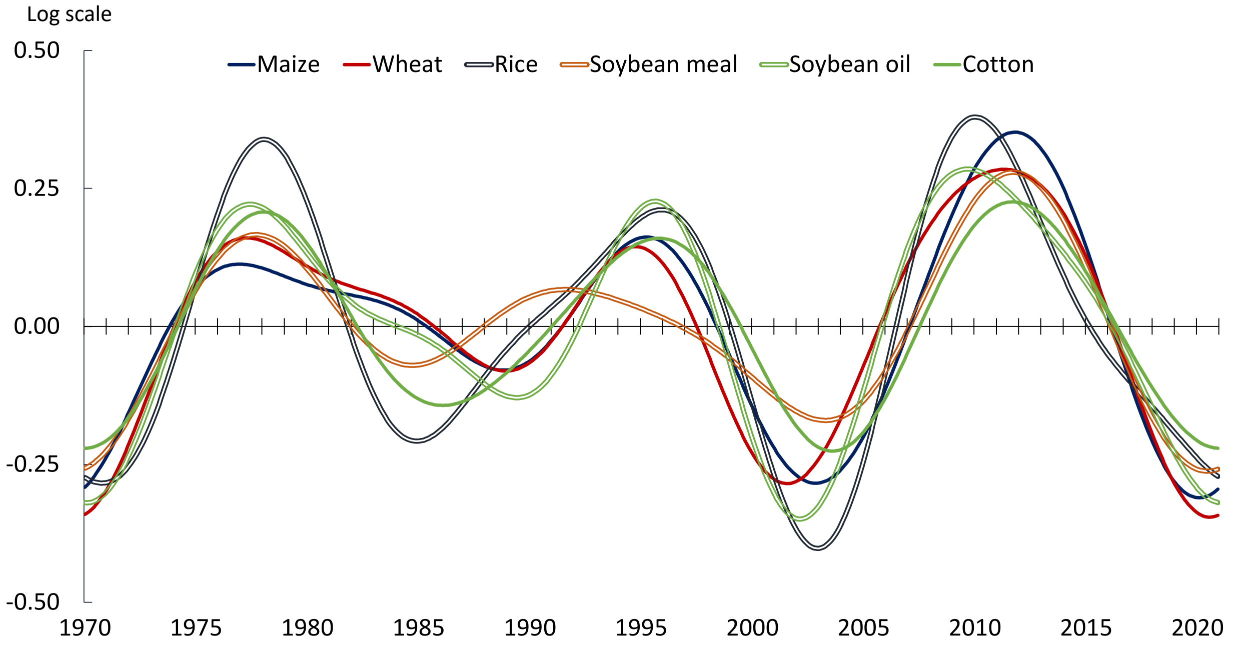


Source: Authors' calculations

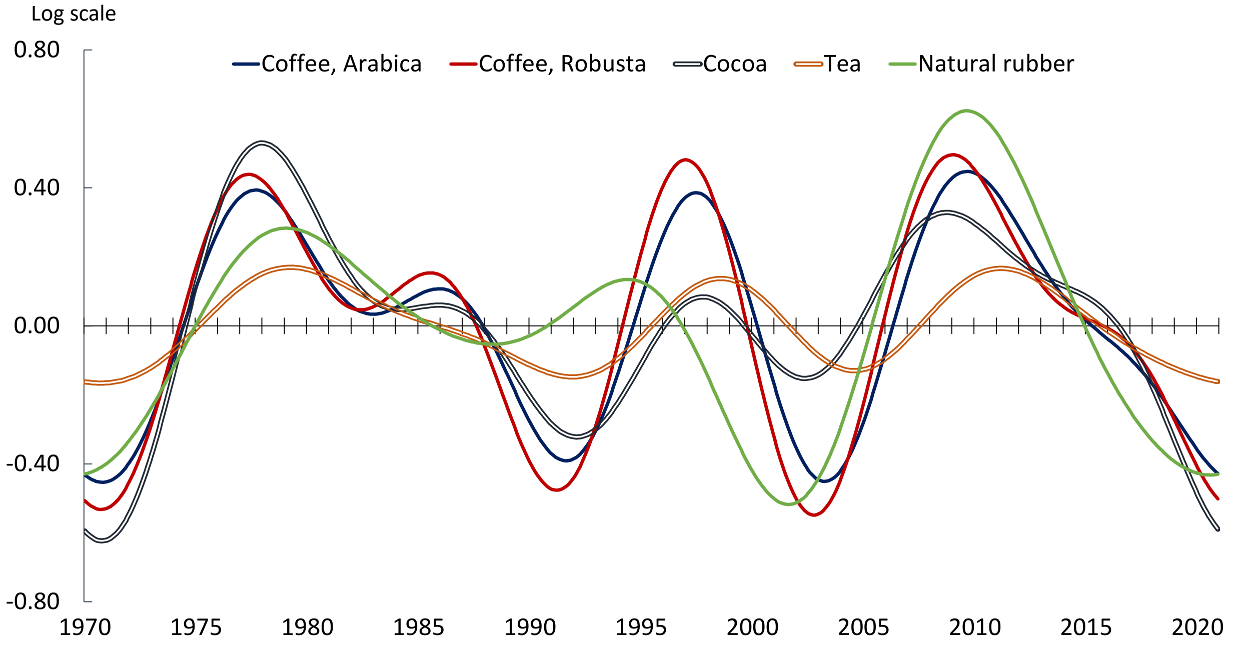


Source: Authors' calculations

Figure B30: Medium-term cycles—Agriculture

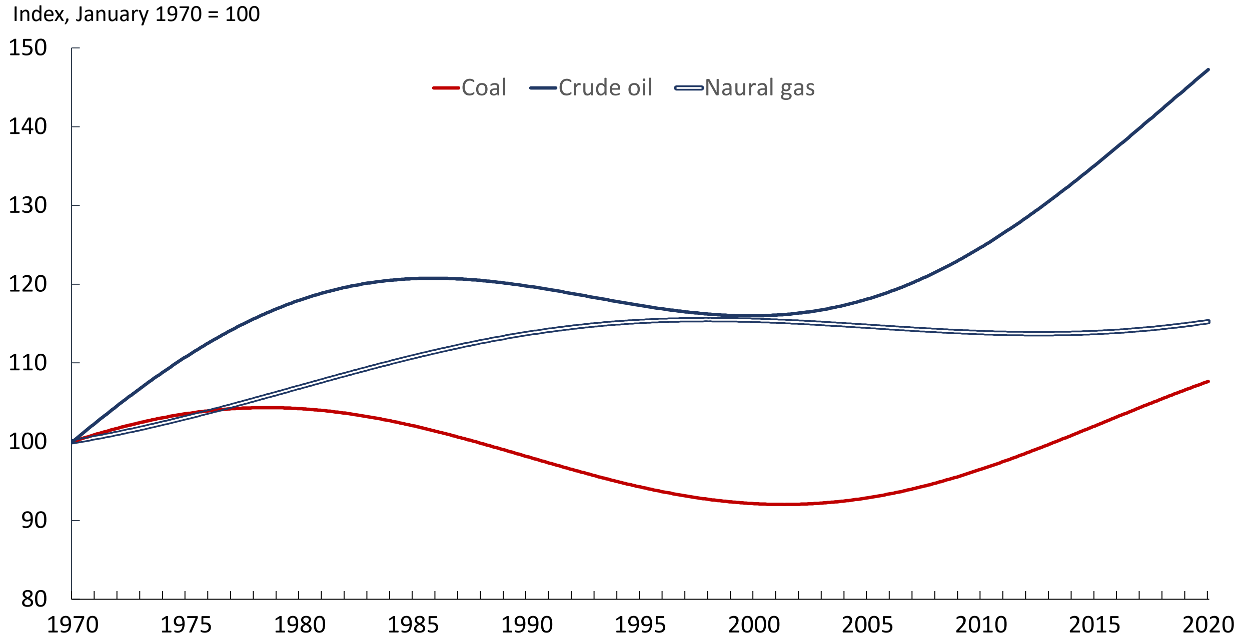


Source: Authors' calculations

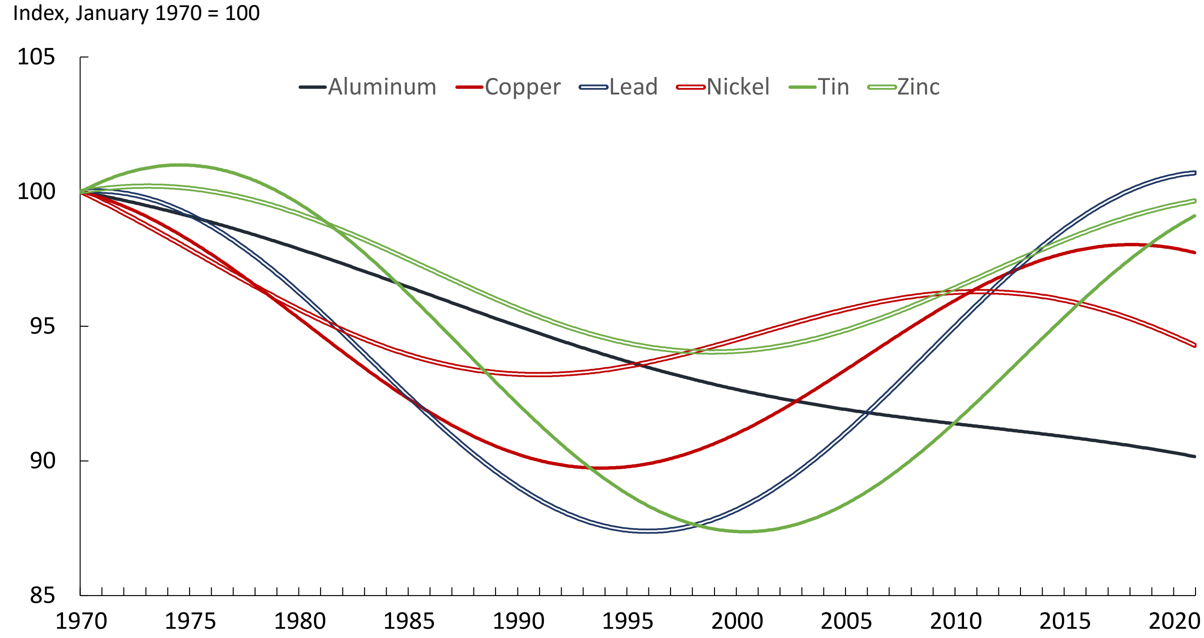


Source: Authors' calculations

Figure B31: Permanent component—Energy and base metals

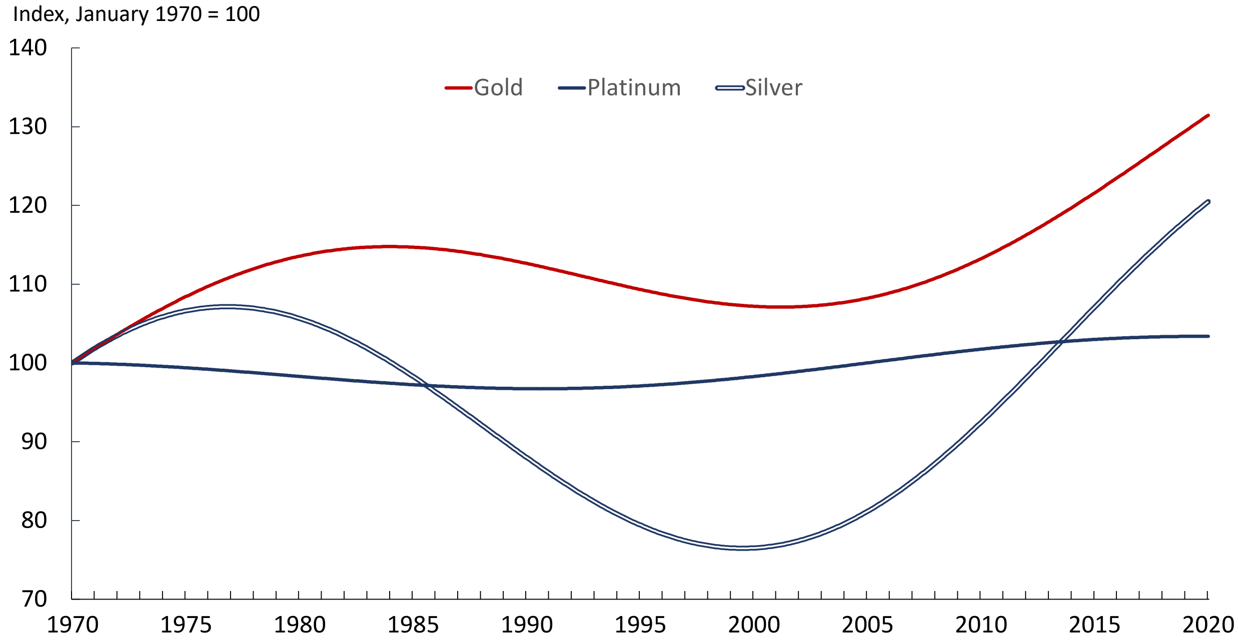


Source: Authors' calculations

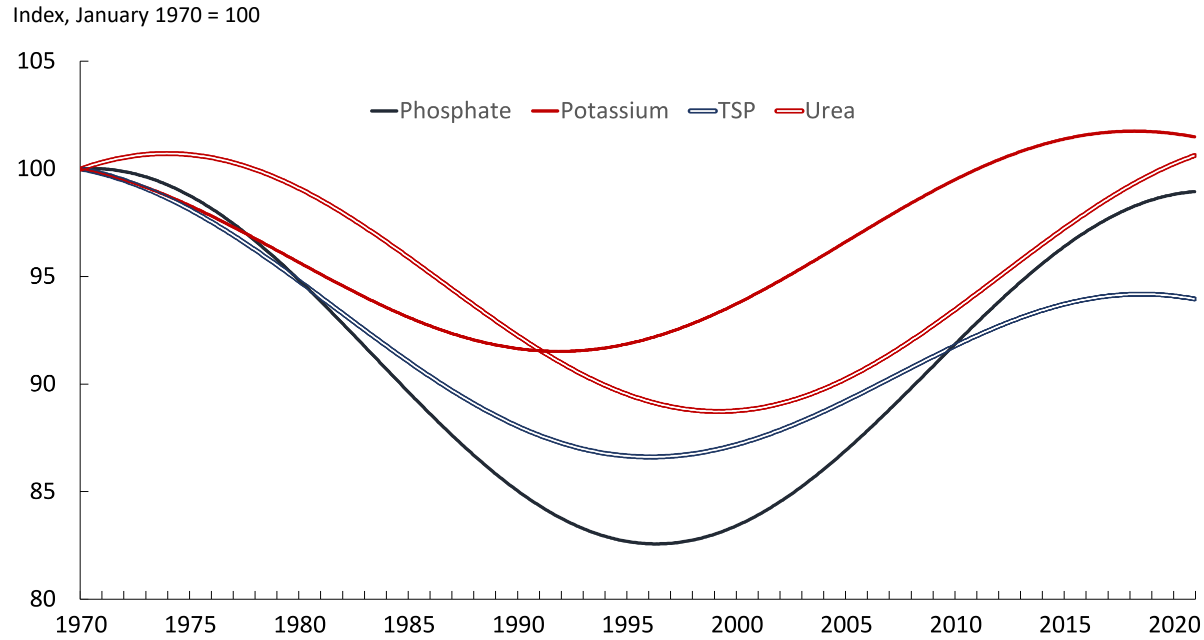


Source: Authors' calculations

Figure B32: Permanent component—Precious metals and fertilizers

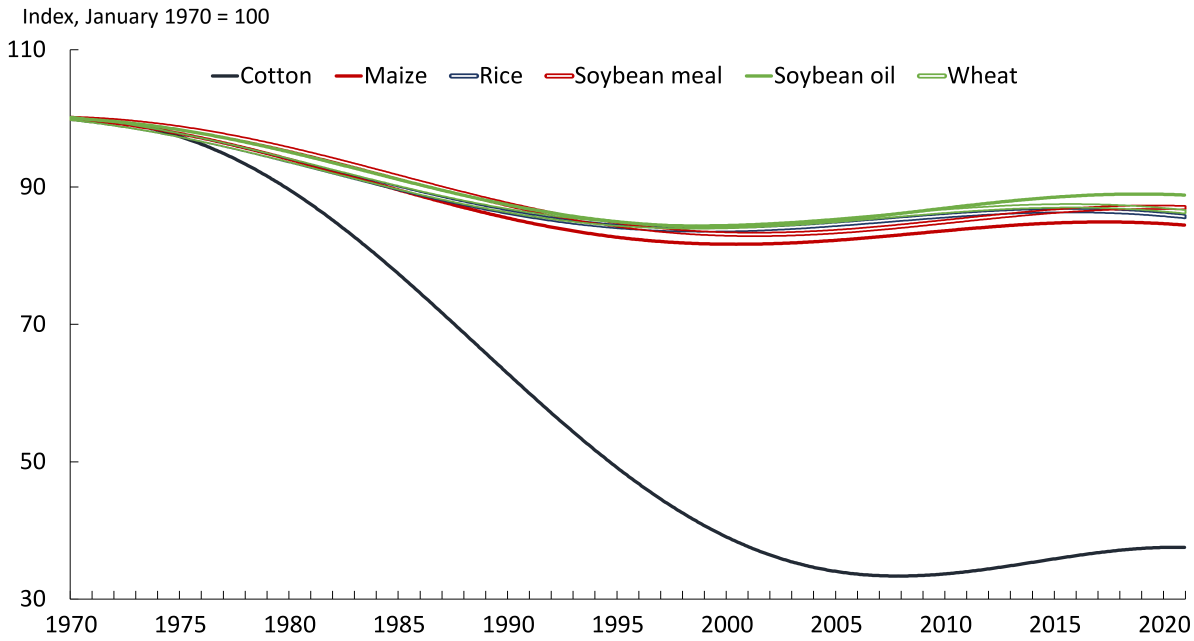


Source: Authors' calculations

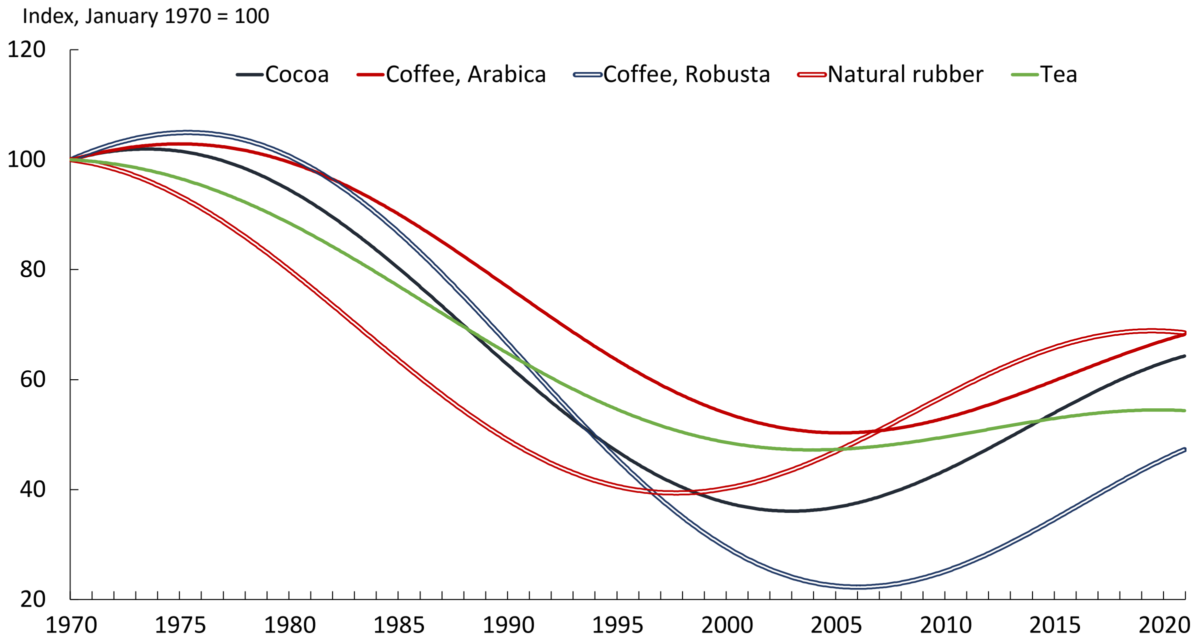


Source: Authors' calculations

Figure B33: Permanent component—Agriculture



Source: Authors' calculations



Source: Authors' calculations