CHAPTER 7

Primary Commodity Price Series: Lessons for Policymakers in Resource-Rich Countries

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INTRODUCTION

This chapter investigates the challenges faced by policymakers when conducting a fiscal policy in resource-rich countries. These challenges become more acute in resource-rich countries in Africa, because in many of them revenues from exporting primary commodities still account for the bulk of export earnings. We shall mainly consider three challenges: (i) the possible secular decline of real commodity prices, the so-called Prebish–Singer hypothesis, (ii) the long cycles that characterize real commodity prices, (iii) the exceeding volatility of real commodity prices and the fact that this volatility is time varying.

A fourth challenge is that many of these primary commodities are exhaustible, which raises the question of equity across generations and the necessity to invest the rents from natural-resource extraction into reproducible capital in order to enjoy a constant stream of consumption, following the so-called Hartwick rule (see Hartwick, 1977; and Atkinson and Hamilton, 2003). We will not deal directly with this fourth challenge in this chapter, because an analysis of commodity prices is of little help in tackling this challenge.

We recall that the Prebish–Singer hypothesis states that real commodity prices follow a downward secular trend. Prebish (1950) and Singer (1950) claimed that there had been a downward long-term trend in these prices and that this decline was likely to carry on. The main theoretical explanations given for this adverse long-term trend are: (i) income elasticities of demand for primary commodities

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being lower than those for manufactures; (ii) absence of differentiation among commodity producers leading to highly competitive markets; (iii) productivity differentials between North and South; (iv) asymmetric market structures (oligopolistic rents for the North and zero economic profit for competitive commodity producers in the South; (v) the inability of wages to grow in the presence of an "unlimited" supply of labor at the subsistence wage in primary commodity producing countries (Lewis, 1954), which implies a zero trend, and (vi) a decline in demand from industrial countries.

The consequences of the Prebish–Singer hypothesis are very important for developing countries, because many of them depend on only a few primary commodities to generate most of their export earnings. For instance, it is estimated that around 60 percent of their export earnings are obtained from primary commodities. For approximately 40 such countries, export earnings depend on the production of three or fewer commodities. This overwhelming commodity reliance has serious policy consequences. In case of an actual long-run downward trend of the exported commodities, the concerned country might have to explore diversifying its export portfolio to include manufactures and services.

The first empirical studies revealing a downward real price assumed that y_t, the logarithm of the real commodity price, is generated by a stationary process around a time trend ($I(0)$):

$$y_t = \beta_0 + \beta_1 t + \varepsilon_t,\ t = 1,\ldots,T, \tag{1}$$

where t is a linear trend and the random variable ε_t is stationary with mean 0 and variance σ^2_ε. The parameter of interest is the slope β_1, which is predicted to be negative under the Prebish–Singer hypothesis. Grilli and Yang (1988), among others, employing a data set of 24 annual commodity prices found that a weighted aggregate index dropped by 0.6 percent per year. Other researchers assumed that commodity prices were generated by a so-called difference-stationary (DS or $I(1)$) model, implying that y_t is nonstationary:

$$\Delta y_t = \beta_1 + \nu_t,\ t = 1,\ldots,T, \tag{2}$$

where ν_t is stationary and invertible. Some empirical studies employing equation (2) show evidence against the hypothesis. In particular, Kim and others (2003) found that relative commodity prices behave like unit root processes (nonstationary process), and only five commodity prices among the 25 commodity prices included in the Grilli–Wang index exhibit the negative trend predicted by the hypothesis. It is well known, now, that if y_t is a DS process, then using equation (1) to test the null hypothesis: $\beta_1 = 0$ will result in acute size distortions, leading to a wrong rejection of the null when no trend is present, even asymptotically.

Alternatively, if the true generating process is given by equation (1) and we base our test on equation (2), our test becomes inefficient and less powerful than the one based on the correct equation. Therefore, when testing the Prebish–Singer hypothesis we must first test the order of integration of our relative commodity prices in

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order to use the right equation. The problem might be compounded by the presence of structural breaks in equation (1) or (2). In that case, the true generating process may be a trend-stationary process with breaks:

$$y_t = \beta_0 + \beta_1 t + \delta DU_t(\omega^*) + \gamma DT_t(\omega^*) + \varepsilon_t, \quad t = 1,\ldots,T, \tag{3}$$

or, alternatively, a difference stationary with breaks:

$$\Delta y_t = \beta_1 t + \delta D_t(\omega^*) + \gamma DT_t(\omega^*) + \Delta\varepsilon_t, \quad t = 2,\ldots,T, \tag{4}$$

where $DT_t(\omega^*) = t - T^*$ when $t > T^*$ and 0 otherwise, $DU_t(\omega^*) = 1$ if $t > T^*$ and 0 otherwise $D_t(\omega^*) = 1$ when $t = T^* + 1$ and 0 otherwise, with $T^* = [\omega^* T]$ the break date with the associated break fraction $\omega^* \in (0,1)$ and [.] denotes the integer part of the argument. As shown by Perron (1989), the properties of tests for the presence of a break in trend are also highly dependent on the order of integration of the series concerned.

To increase the power of these tests we may use panel unit-root and/or stationarity tests, which are well known to be more powerful than their single-time series counter-part. However, in order to avoid the pretesting problem, we will also use the tests for the presence of linear trend and the tests for a broken trend, proposed by Harvey, Leybourne, and Taylor (2007 and 2009, respectively) which are both robust to whether shocks are generated by $I(0)$ or $I(1)$ processes. However, the knowledge that commodity prices are stationary (mean reverting) or nonstationary is crucial for conducting an appropriate fiscal policy. In the case where commodity prices are mean reverting, any shock will have only a transitory effect, whereas if commodity prices are nonstationary, shocks imprint a permanent effect on those prices.

The second aspect of real primary commodity prices that we will explore is the identification of cycles. The presence of cycles, particularly long cycles, creates booms and busts in income and unemployment, necessitating the construction of stable and sustainable budgets, that is, countercyclical budgets, also called structural budgets. The main explanations given for the presence of long-term cycles are these:

(i) Elasticities of supply and demand relative to price are low in the short term but increase with time. Therefore, prices come back to the long-run equilibrium after a peak.

(ii) For nonrenewable resources, the answer to the question, *Should we leave resources in the ground or extract them?* will depend on an arbitrage condition between the interest rate and the expected future of price increase (Hotelling, 1931). This leads to an inverse relationship between real interest rates and real commodity prices.

(iii) Speculative bubbles may drive commodity prices away from their fundamentals until they burst, pushing commodity prices back to their equilibrium (e.g., oil speculation during the recent peak).

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Finally, the last challenge when trying to conduct a successful fiscal policy in resource-rich countries is that most commodity prices are found to be volatile, and this volatility is time varying (UNCTAD, 2008; Mintz, 1967). The possible causes of price volatility are these:

- Supply shocks: wars, epidemics, weather, political unrest lead to shortfalls in production and to large price variances.
- The switch to floating exchange rate regimes has increased the volatility of commodity prices (Reinhart and Wickham, 1994).

In the next section, we present the data and examine the empirical evidence of these three challenges. After that we review the possible solutions suggested in the literature to tackle these three challenges, followed by some concluding remarks.

EMPIRICAL EVIDENCE

Data

The annual data set used in this study covers the period 1960–2007 for nine primary commodities: zinc, tin, oil, wool, iron, aluminum, beef, coffee, and cocoa. Figure 7.1 plots the natural logarithm of the nine commodity prices relative to the U.S. Commodity Price Index for 2005. Looking only at these graphs, it is difficult to say whether the series are stationary (mean reverting) or nonstationary. It is also very hard to say whether they present a deterministic downward trend. We have to use appropriate tests to settle these two questions. We also present in Figure 7.2 the distributions of the nine commodity prices. It is clear that these distributions are very different from the normal distribution. They have at least two modes, which might indicate clustering of prices at different levels due to persistent cycles. Most of these distributions, if not all of them, have fatter tails than the normal distribution, suggesting the possibility of extreme values.

Testing Whether the Series Are Mean Reverting Using Panel Data Stationarity Tests

It is well known that univariate time series tests for unit root and stationarity have very low power. It has been shown through simulations that panel data tests for unit root and stationarity are far more powerful than their univariate counterpart (see Breitung and Pesaran, 2008, for a review of this literature). In this chapter, we use the recent panel stationarity test proposed by Hadri and Rao (2008). This test allows for a break in the intercept or the trend or in both. The selection of the appropriate break model for each price series, among the four possible ones, is data driven. Any serial correlation is mopped out. It also corrects for the very likely presence of cross-sectional dependence of unknown form via the bootstrapping method.

Table 7.1 shows the pairwise correlation coefficients across prices. There are positive and significant correlations between real commodity prices, except for the oil price series where the coefficients are relatively small and some are negative (but all are insignificant at the 5 percent significance level). Pindyck

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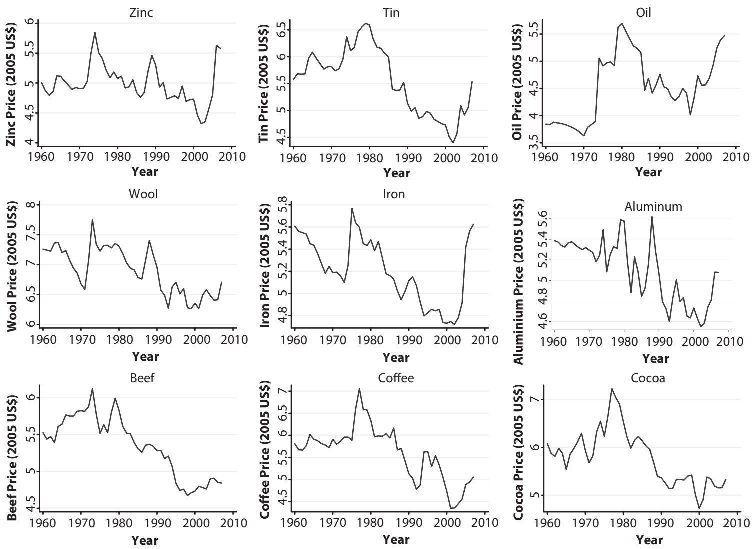
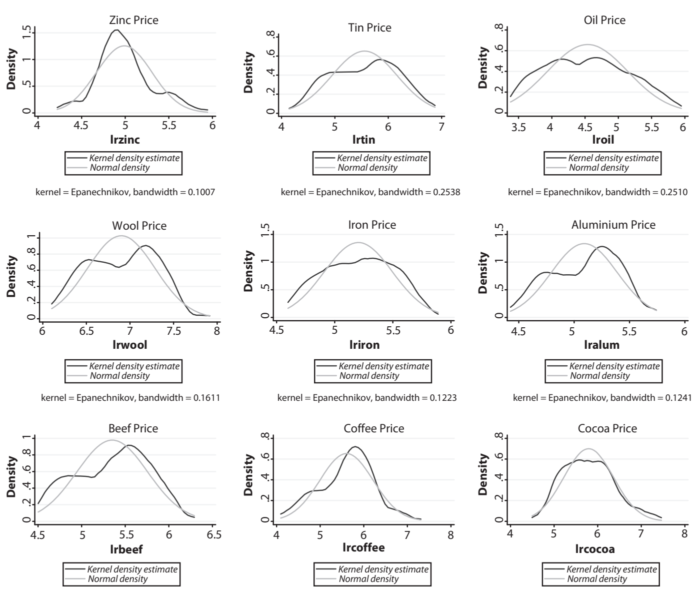
Figure. 7.1
Prices of nine commodities, 1960–2007



Sources: National Bureau of Economic Research (NBER); and United Nations Trade Database.

Figure 7.2
Distribution of the nine commodity prices, 1960–2007



Sources: National Bureau of Economic Research (NBER); United Nations Trade Database; and author's estimates.

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TABLE 7.1

Correlation coefficients of commodity prices (*p*-values between parentheses)

	Zinc	Tin	Oil	Wool	Iron	Aluminum	Beef	Coffee	Cocoa
Zinc	1.0000								
Tin	0.5673	1.0000							
	(0.0000)								
Oil	0.2560	0.1963	1.0000						
	(0.0791)	(0.1812)							
Wool	0.5594	0.7897	-0.0442	1.0000					
	(0.0000)	(0.0000)	(0.7653)						
Iron	0.5748	0.7305	0.1786	0.6100	1.0000				
	(0.0000)	(0.0000)	(0.2246)	(0.0000)					
Aluminum	0.5896	0.7882	-0.1067	0.8381	0.6360	1.0000			
	(0.0000)	(0.0000)	(0.4706)	(0.0000)	(0.0000)				
Beef	0.4558	0.8465	-0.1757	0.7744	0.5567	0.7911	1.0000		
	(0.0011)	(0.0000)	(0.2322)	(0.0000)	(0.0000)	(0.0000)			
Coffee	0.4546	0.8736	0.0444	0.7441	0.5879	0.7328	0.7407	1.0000	
	(0.0012)	(0.0000)	(0.7646)	(0.0000)	(0.0000)	(0.0000)	(0.0000)		
Cocoa	0.4141	0.8802	0.1662	0.7584	0.6032	0.6860	0.7610	0.8899	1.0000
	(0.0034)	(0.0000)	(0.2590)	(0.0000)	(0.0000)	(0..0000)	(0.0000)	(0.0000)	

Source: Author's analysis.

and Rotemberg (1990) noted this strong correlation in the prices of unrelated commodities, which they called "excess co-movement." They found that even after controlling for current and expected future values of macroeconomic variables, this excess co-movement remains.

By using panel we are able to account for this cross-sectional dependence. We are in a position to test jointly the null hypothesis that *all* the commodity prices are stationary ($I(0)$) against the alternative hypothesis that some of them are nonstationary or unit root processes ($I(1)$). The results of the test are given in Table 7.2.

The null hypothesis that all the commodity prices are stationary is not rejected, indicating that all the commodity prices are mean reverting (the two criteria used are for the correction for possible serial correlation; see Hadri and Rao, 2008) for more explanations). This is an important result. It means that shocks have only temporary effects on real commodity prices. The fact that the nine commodity prices are stationary will permit us to use classical econometrics tools to test the Prebish–Singer hypothesis. The latter test is presented in Table 7.3.

All commodities without a break have a significant negative trend except oil, which is positive but not significant. The commodities with a break have a significant negative trend before the break and a positive but insignificant trend after the break. The estimations after the break are not reliable because of the size of the sample (only five observations). We also employed two other tests that do not require *a priori* knowledge of whether the real price of a commodity is stationary or a unit root process. Both tests are univariate, that is, they test one price series at a time, unlike the panel data test.

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TABLE 7.2

Panel stationary test results

	N	*T*	Statistic value	Bootstrap critical values	
				10%	5%
Using tsig criterion	9	48	3.913	11.164	12.617
Using tsig criterion	9	48	2.647	7.824	8.975

Source: Author's analysis.

TABLE 7.3

One-sided test for a negative trend (P-value inside brackets)

	Growth rate (%) (no break)	Before break	After break
Zinc		-0.0087 (.0055)	0.35078 (0.993)
Tin		-0.033 (0.000)	0.1905 (0.97)
Oil	0.0214 (1)		
Wool	-0.0205 (0.000)		
Iron		-0.0184 (0.000)	0.2339 (0.994)
Aluminum	-0.16 (0.000)		
Beef	-0.024 (0.000)		
Coffee	-0.294 (0.000)		
Cocoa	-0.0254 (0.000)		

Source: Author's analysis.

The first test, proposed by Harvey,[1] Leybourne, and Taylor (2007), does not allow for a structural break. The second test, offered by the same authors, allows for one structural break. Both tests give mixed results when testing for the Prebish–Singer hypothesis. The results of the two tests are not reported here but can be obtained from the authors. Results from panel data tests are more reliable than tests based on single-time series, on at least three accounts: (i) panel data have been shown to be more powerful than their single series counterparts, because of the joint use of all the information in the panel, (ii) panel tests allow for cross-sectional dependence, whereas single-time series tests cannot, by construction, and (iii) our panel tests permit more than one structural break.

[1]We thank Steve Harvey for providing the GAUSS programs.

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Identification of Cycles in Commodity Prices

Commodity prices are well known to have long cycles, which presents serious challenges to policymakers when they seek to devise stable budgets in order to avoid booms and busts. We employ the asymmetric bandpass filter proposed by Christiano and Fitzgerald (2003) to decompose commodity prices into three components:

$$y_t = T_t + LC_t + SC_t,\ t = 1,\ldots,T, \tag{5}$$

where is a secular trend, LC_t is a long-term cyclical element, SC_t is a short-term cyclical element, and Y_t is a real commodity price. We define the trend as all cycle elements lasting more than 30 years, the long-term cycles as those lasting from 10 to 30 years, and short-term cycles as those ranging from 2 to 10 years. These definitions depend on the length of the data we are using and therefore have a certain degree of arbitrariness. Table 7.4 provides some summary measures of the cyclical components when the bandpass filter is applied to the individual commodity prices of our data set. Column 2 shows the standard deviation of the long-term cyclical component (LC_t) and column 3 shows the ratio of the standard deviations of LC_t and the total nontrend cyclical component $(LC_t + SC_t)$. The range of this ratio is from 0.414 (aluminum) to 0.854 (oil), clearly showing the dominance of the long-term component in cyclical commodity price movements.

The mean periodicity (column 4) ranges from 11.7 years (zinc) to 20 years (cocoa). This indicates that common policy initiatives to smooth either commodity prices themselves or producer or consumer incomes around a trend may require economic planning over a long time horizon. (Using longer time series, Harvey and others (2010) found mean periodicity ranging from 23.5 years to 43.3 years.)

Finally, column 5 indicates the first-order autocorrelation measure of persistence in the LC_t component of each series. The estimates are all greater than 0.89, showing extreme persistence in the long-term cyclical elements of the relative primary commodity price series. Therefore, policymakers should be aware that commodity prices may not return to equilibrium for many years and should take appropriate measures, such as adopting a structural budget as Chile has done. (Structural budgets will be explained further below.)

Volatility in Primary Commodity Prices

It is well documented both that primary commodity prices are highly volatile and that this volatility is time varying (Mintz, 1967; Reinhart and Wickham, 1994; for oil, see Dvir and Rogoff, 2009).We test for multiple breaks in commodity price volatility, employing the methods proposed by Bai and Perron (1998, 2003). Figure 7.3 provides visual evidence of this volatility and the changes in it for the nine commodity prices in our sample.

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TABLE 7.4

Summary measures of 10- to 30-year cyclical components (LC_t)

	s.d. (LC_t)	s.d. (LC_t) / s.d. ($SC_t + LC_t$)	Mean periodicity	AR(1) parameter
Zinc	0.141	0.661	11.667	0.918
Tin	0.170	0.824	17.500	0.935
Oil	0.289	0.854	16.500	0.956
Wool	0.140	0.632	12.333	0.904
Iron	0.108	0.777	14.667	0.936
Aluminum	0.073	0.414	12.000	0.924
Beef	0.093	0.710	12.000	0.902
Coffee	0.211	0.690	16.500	0.898
Cocoa	0.178	0.643	20.000	0.952

Source: Author's analysis.

WHAT CAN POLICYMAKERS DO TO COUNTER THESE THREE CHALLENGES?

Secular Downward Trend of Real Commodity Prices

In order to offset the effect of the secular downward trend of real commodity prices, the resource-rich countries must diversify their exports by investing in well run and beneficial manufactures and services. This is more easily said than done. Some resource-rich countries embarked on ambitious diversification (industrialization) programs that were not very successful. For a program to be fruitful, certain necessary reforms must be adopted. Also, to achieve sustainability there must be an effective and judicious application of the Hartwick rule (Hartwick (1977), Hamilton and Hartwick, (2005)), which requires that any depletion of natural capital be offset by a compensating increase in other forms of capital capable of generating as much income as the natural capital they replace.

In this regard, an example of good practice is Botswana, which applied the Hartwick rule rigorously and successfully by investing the rent from its exploitation of diamonds in top-rated funds (see Lange and Wright, 2004). The Hartwick rule is generally prescribed for countries with exhaustible resources, but it is also beneficial to resource-rich countries with declining real commodities prices, even if their resources are not exhaustible, as is the case for cotton, coffee, and cocoa. The resource-rich countries may also enter into international commodity agreements to keep the real prices of their resources at acceptable levels.

Long Cycles in Real Commodity Prices

The fluctuations of real commodity prices between relatively high and low levels, often for long periods, as shown above, pose serious challenges to policymakers working to achieve price stability and maintain the financial soundness of the economy. A countercyclical policy is to be adopted to smooth the cycles of commodity prices. A rule of thumb is to save during boom times and spend during

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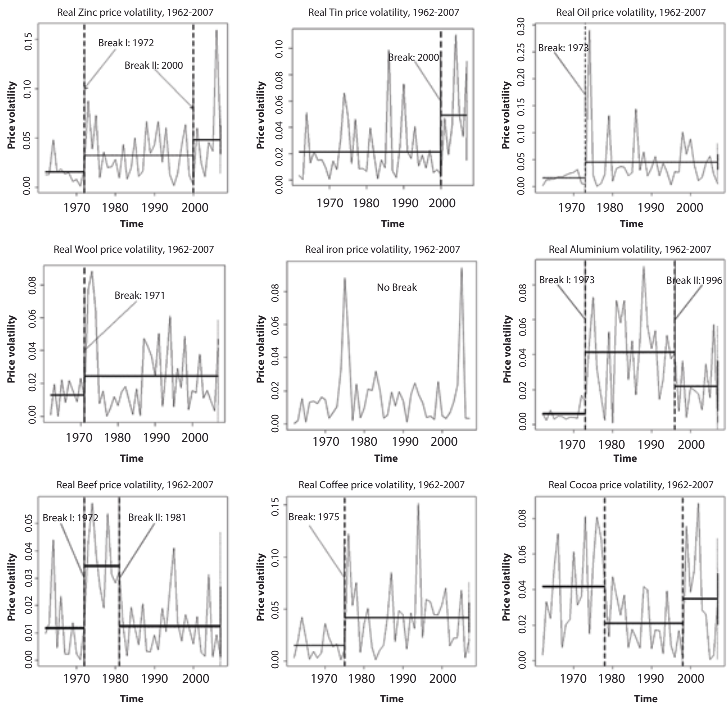
Figure 7.3
Volatility for the nine real commodity prices, 1962–2007



Source: Author's analysis.

bust times. But—save and spend by how much, and when? The structural budget suggested by the IMF and adopted, adapted, and implemented successfully by Chile achieved a spectacular countercyclical policy.

The structural budget, unlike the effective budget, must reflect a medium- to long-term view of the economy. Roughly, it prescribes saving during economic prosperity and spending during the lean years, within structural budget limits. In a nutshell, it amounts to fixing the cyclical components at their medium/long run levels. For Chile, these were (i) output (GDP), (ii) price of copper, and (iii) price of molybdenum. In order to insulate the estimation of these three components from possible contamination by politics, in Chile the estimations are undertaken independently by expert panels (for more information on structural budget, see Rodríguez, Tokman, and Vega (2007) and Frankel (2011).

High and Changing Volatility of Real Commodity Prices

Many solutions have been proposed in the literature and practiced to protect resource revenues from the effects of the volatility of commodity prices. Stabilization funds have been suggested to insure against future shocks. Such

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funds should be commodity specific. Hedging strategies using financial instruments also have been employed. Another tool used to protect credit-rationed commodity-exporting countries from volatility effects is to provide external finance facilities. Studies on this topic include those by Mintz (1967) and Reinhart and Wickham (1994). It should be noted that generally, the export of more than one commodity will not hedge the exporting country against adverse commodity price movements.

SUMMARY

In this chapter, we have reviewed the main causes of the challenges policymakers encounter in conducting fiscal policy in resource-rich countries: the secular decline of real commodity prices, long cycles, and relatively high and time-varying volatility. If real, these challenges constitute acute problems to policymakers conducting fiscal policies to realize stable and sustainable budgets over the long run (avoiding booms and busts) and across generations (to prevent inequity across generations). Investigating and testing these three characteristics through a sample of nine real price commodities observed over 48 years (1960–2007), we found that all the commodities in our sample are mean-reverting (stationary) based on a panel stationary test. We also discovered that the nine commodities are, pairwise, positively and significantly correlated except with the real price of oil. That is, the correlations between oil and the rest are not significant. The significant correlations we discovered will magnify cycles and volatilities. We also uncovered the fact that these cycles range from 12 to 20 years. As expected, it was shown that real commodity prices are relatively volatile and that the volatility is time-varying. Finally, we have summarized the successful policy solutions reported in the literature as they apply to these three challenges.

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