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Commodity currencies and currency commodities

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Abstract

There is a large literature on the influence of commodity prices on the currencies of countries with a large commodity-based export sector, such as Australia, New Zealand, and Canada ("commodity currencies"). There is also the idea that because of pricing power, the value of currencies of certain commodity-producing countries affects commodity prices, such as metals, energy, and agricultural-based products ("currency commodities"). This paper merges these two strands of the literature to analyze the simultaneous workings of commodity and currency markets. We implement the approach by using the Kalman filter to estimate jointly the determinants of the prices of these currencies and commodities. Included in the specification is an allowance for spillovers between the two asset types. The methodology is able to determine the extent that currencies are indeed driven by commodities, or that commodities are driven by currencies, over the period 1975–2005.

JEL classification: C32; F31; F41

Introduction

When the value of the currency of a commodity-exporting country moves in sympathy with world commodity prices, it is said to be a "commodity currency". Thus when there is a commodity boom, the appreciation of a commodity currency has the effect of dampening the impact of the boom as domestic currency prices rise by less than world prices, profitability in the export sector rises by less than otherwise, and domestic consumers gain from the appreciation in the form of lower-priced imports. This automatic stabilizer has the effect of moving part of the required adjustment to the boom away from commodity producers and reduces the cyclical volatility of the economies of commodity-exporting countries. Australia, New Zealand, South Africa, and Canada, as well as some other smaller developing countries, all possibly have commodity currencies of varying degrees.

What if, in addition to having a commodity currency, the country is a sufficiently large producer of a certain commodity that it can affect the world price? In other words, what if the country has some degree of power over the world market? A commodity boom appreciates the country's currency, and as this squeezes its exporters, the volume of exports falls. However, as the country is now large, the reduced exports have the effect of increasing world prices further. Thus as the appreciation leads to a still higher world price, the interaction of the commodity currency and pricing power leads to an amplification of the initial commodity boom. To convey the symmetric relationship with commodity currencies, commodities whose prices are substantially affected by currency fluctuations can be called "currency commodities". This paper explores in detail the implications of the phenomena of commodity currencies and currency commodities operating simultaneously. We establish the precise conditions for a country to have a commodity currency, as well

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as the requirements for a currency commodity. The paper also provides preliminary empirical evidence on the extent to which exchange rates are affected by commodity prices and vice versa.

There is a fairly substantial literature devoted to commodity currencies; this literature is predominantly empirical that tends to start with the observed correlation between the terms of trade and real exchange rates in a number of commodity-exporting countries.[1] Closely allied to commodity currencies is ''booming sector'' economics, which analyzes the implications for other sectors of the economy of a surge in one form of exports (mostly taken to be commodities, natural resources in particular). Here, a surge in resource exports leads to a real appreciation of the country's exchange rate that has the effect of hurting other exporters and producers in the import-competing sector. This phenomenon is variously known as ''the Dutch disease'', ''the Gregory effect,'' and ''deindustrialization''.[2] While there is also a substantial literature on the implications of ''large countries'' in international trade related to optimal trade taxes, there is a much smaller literature devoted to the related topic of the link between exchange rates and world prices of commodities. The link is that if a commodity-producing country has some degree of market power, it can pass on increases in domestic costs to foreign buyers of its exports.[3]

The only previous paper that we are aware of that explicitly considers the implications of the joint operation of commodity currencies and currency commodities is Swift (2004). Swift starts with the analysis of Ridler and Yandle (1972) that deals with the dependence of the world price of a certain commodity on the N exchange rates in the world, and notes that if an individual exporting country is ''small'', then a change in the value of its currency has no impact on the world price. Suppose there is a boom that exogenously increases the world price of a certain commodity, such that a number of small countries producing the commodity are all hit simultaneously by a common shock that improves their terms of trade. If these countries all have commodity currencies, then their exchange rates appreciate, and the Ridler and Yandle framework implies that there is a subsequent increase in the world price of the commodity they export. Thus, there are both the initial terms-of-trade shock and then a subsequent reinforcing move related to the commodity–currency mechanism. In this sense, the terms of trade are endogenous, even though the countries are all small individually. Swift analyzes the processes by which these countries adjust to the improvement in terms of trade, and emphasizes that the shocks are larger when the terms of trade are endogenous. While Swift describes and discusses these matters mostly but not exclusively in words, she does not model formally their workings.

The second part of this paper provides some empirical evidence on some of the propositions of the theoretical model using a multivariate latent factor model. The approach enables an assessment of the relative importance of various ''factors'' in explaining volatility in each market in a model where commodity currency and price returns are endogenously determined. This class of models is used in the finance and business cycle literature to explain time series as a function of a set of unobserved (latent) factors.[4] The model of this paper is a three-factor one comprising a common factor, a commodity–currency factor and a commodity–price factor. The idea is that information that is specific to the complete data set is captured by the common factor, information specific to the commodity currencies is captured by the commodity–currency factor, and information specific to the set of commodity price returns in the model is captured by the commodity factor. Spillovers across the two markets can then be modeled by examining the impact of the asset-specific factors (the currency factor or the commodity factor) on the other asset type. The advantage of this approach is that observable variables do not have to be identified and modeled, which is particularly convenient as it implicitly takes into account shocks simultaneously affecting all markets. There are several methods available to estimate this class of models including the generalized method of moments, the Kalman filter, and simulation-based techniques such as indirect estimation.[5] The Kalman filter is adopted in this paper as it is assumed that the quarterly data series are not complicated by features such as nonnormal distributions. The other advantage is that it is simple to extract a time series of the factors when using the Kalman filter. This time series can then be used to examine how the relationship between commodity currencies and price returns has changed over time, which helps to assess some of the propositions raised in the theoretical section of the paper.

The results of the empirical model suggest that commodity returns are more affected by the currency factor than vice versa, although the importance of spillovers across the two market types is relatively small. This is in contrast to most papers, which do not even

[1]Prominent examples of this literature include Amano and van Norden (1995), Blundell-Wignall and Gregory (1990), Blundell-Wignall et al. (1993), Broda (2004), Cashin et al. (2004), Chen and Rogoff (2003), Freebairn (1990), Gruen and Kortian (1998), Gruen and Wilkinson (1994), McKenzie (1986) and Sjaastad (1990). On the theory of the dependence of the real exchange rate on the terms of trade, see Connolly and Devereux (1992), Devereux and Connolly (1996), Edwards (1988, 1989), Edwards and van Wijnbergen (1987), Neary (1988), and Polasek (2004).

[2]Important papers in this area include Corden (1984), Corden and Neary (1982), Gregory (1976), and Snape (1977).

[3]Studies in this tradition are Clements and Manzur (2002), Dornbusch (1987), Gilbert (1989, 1991), Keyfitz (2004), Ridler and Yandle (1972), Sjaastad (1985, 1989, 1990, 1998a, b, 1999, 2000, 2001), Sjaastad and Manzur (2003), and Sjaastad and Scacciavillani (1996).

[4]For examples, see Diebold and Nerlove (1989), Dungey (1999), Mahieu and Schotman (1994), and Stock and Watson (1991).

[5]See, respectively, (i) Hamilton (1994) and Hansen (1982); (ii) Hamilton (1994), Harvey (1981, 1990), and Kalman (1960, 1963); and (iii) Duffie and Singleton (1993), Dungey et al. (2000), Gallant and Tauchen (1996), and Gourieroux et al. (1993).

consider that commodity prices may be endogenous, and only model exchange rates as a function of commodity prices. The implications of this result are that the commodity–currency countries appear to have some degree of market power, at least on a collective basis. The reverse link from the commodity factor to the currency returns is much weaker and is jointly insignificant. Over time as markets have become more competitive and integrated, the role of the commodity–currency factor in determining the currency and commodity returns seems to have become more important.

The structure of the paper is as follows. The next section sets out the analytical framework that merges the economics of commodity currencies with that of currency commodities. Sections "A first look at the data" and "A latent factor model of currencies and commodities" present the empirical part of the paper. The section about a first look at the data provides an initial investigation into the data series, which helps motivate the structure of the latent factor model developed and estimated in the next section, a latent factor model of currencies and commodities. The summary and conclusions section provides some concluding comments.

The analytical framework

As discussed above, the previous literature has tended to analyze only one part of the interaction between world commodity prices and exchange rates, in isolation from the other; that is, it has focused on either the causal link from commodity prices to currency values (the "commodity–currency" model) or the reciprocal link, the impact of exchange-rate changes on commodity prices, which involves pricing power in world markets ("currency commodities"). By contrast, our focus in this paper is on the joint determination of exchange rates and commodity prices, or on the two-way interactions between exchange rates and commodity prices. This section sets out a model of this process.

Market power and commodity pricing

Consider a country that is a dominant exporter of a certain commodity in the sense that a larger volume of exports places downward pressure on the world price. Examples could include oil from Saudi Arabia, wool from Australia and several minerals from Australia such as iron ore, tantalite and possibly coal. In such a case, the country is a price maker, or has market power. This situation is well known in international economics and relates to optimal export taxes, the formation of cartels among exporting nations and price-stabilization schemes. We consider the somewhat different issue of what happens to the world price of such a commodity if there is a major depreciation of the currency of the dominant producing country. If costs do not rise equiproportionally, so that it is a real depreciation, the enhanced revenue drops straight to the bottom line, and domestic producers of the commodity have an incentive to expand production and export more. However, the expansion of exports depresses the world price as, by assumption, the country is large. Accordingly, for such a country, there is an immediate link between the value of its currency and the world price of the commodity. In a series of papers, Sjaastad and coauthors have elaborated this basic model and considered a number of implications of this rich framework.[6]

We develop a simple stylized model of the world market for a commodity in which purchasing power parity holds for the commodity but not for prices in general.[7] This model provides considerable insights into the workings of commodity markets in general, and identifies the nature of "small" and "large" countries in a precise manner. The commodity is produced only in the home country, all of its output is exported, the world market clears continuously, and arbitrage means that prices satisfy relative PPP. That is

$$q^{\mathrm{s}} = q^{\mathrm{s}}\left(\frac{p}{P}\right), \quad q^{\mathrm{d}} = q^{\mathrm{d}}\left(\frac{p^*}{P^*}\right), \quad q^{\mathrm{s}} = q^{\mathrm{d}}, \quad p = Sp^*(1+x), \tag{1}$$

where q^{s} is the quantity supplied of the commodity, p is its price in terms of domestic currency units, and P is an index of costs in general in the home country, q^{d} is the quantity consumed, p^*/P^* is the relative price faced by foreign consumers, S is the spot exchange rate (the domestic currency cost of a unit of foreign exchange), and x represents the "spread" between domestic and foreign prices, which is taken to be a constant. Taking the total differential of the equations in (1), using a hat ("^") to denote proportional change ($\hat{z} = \mathrm{d}z/z$), and writing $\varepsilon \geqslant 0$ for the price elasticity of supply and $\eta \leqslant 0$ for the price elasticity of demand, the solution to the model is

$$\frac{\hat{p}^*}{P^*} = \alpha \hat{R}, \tag{2}$$

where

$$\alpha = \frac{\varepsilon}{\varepsilon - \eta} \tag{3}$$

is the share of supply in the excess supply elasticity, and $R = P/SP^*$ is the real exchange rate, defined such that an increase in R represents a real appreciation of the currency of the producing country.[8] As the supply elasticity $\varepsilon \geqslant 0$ and the demand elasticity $\eta \leqslant 0$, it follows that $0 \leqslant \alpha \leqslant 1$.

Eq. (2) is the fundamental pricing rule for commodities. It states that the change in the world relative price of the commodity is a positive fraction α of the change in the real value of the producing country's currency. Accordingly, a

[6]See Sjaastad (1985, 1989, 1990, 1998a, b, 1999, 2000, 2001), Sjaastad and Manzur (2003) and Sjaastad and Scacciavillani (1996). See also Dornbusch (1987), Gilbert (1989, 1991) and Ridler and Yandle (1972). For a recent application, see Keyfitz (2004).

[7]For an earlier rendition of this model, see Clements and Manzur (2002).

[8]See Clements and Fry (2006) for details of the derivation of result (2).

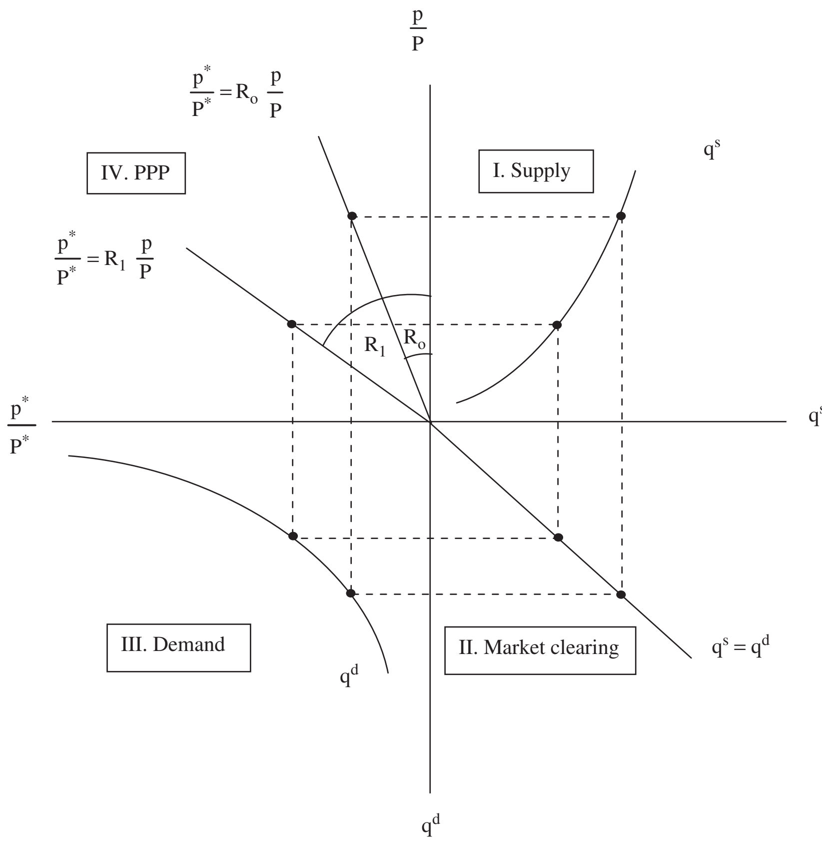

Fig. 1. Workings of the commodity market.

10-percent real appreciation ($\hat{R} = 0.10$), for example, means that the world price rises, but by at most 10 percent. The mechanism is that the real appreciation squeezes firms producing and exporting the commodity, so that the lower volume of exports pushes up their price on the world market. In the case in which $\varepsilon = 1$ and $\eta = -1$, the value of the fraction α is 1/2, so that the 10-percent appreciation leads to a 5-percent increase in the commodity price. Because a small country is unable to affect world prices, the value of α for such a country must be zero. This occurs when the excess supply elasticity $\varepsilon - \eta$ is large. Conversely, when the excess supply elasticity is small, α is near its upper limit of unity, and the country is large.

Fig. 1 illustrates further the workings of the commodity market. Quadrant I contains the supply curve, quadrant III contains the demand curve, and the market-clearing relationship is contained in quadrant II. The link between domestic and foreign nominal prices of the commodity is provided by the *PPP* relation, which takes the form $p = Sp^*$ if for simplicity we take the spread x to be zero. Dividing both sides of this equation by P and using $R = P/SP^*$, we have $p^*/P^* = R(p/P)$. This equation provides a link between domestic and foreign *relative* prices, so it can be considered as a real version of *PPP*. This link closes the model and is represented in quadrant IV of the figure. Here the real exchange rate is given by the slope of the *PPP* ray from the origin. An appreciation of the domestic currency causes this ray to become steeper (with respect to the domestic price axis), and the equilibrium world price rises. Accordingly, we have an increasing relationship between the exchange rate and world prices, as represented by the schedule labeled *MM* in Fig. 2; the elasticity of *MM* is α of Eq. (3).

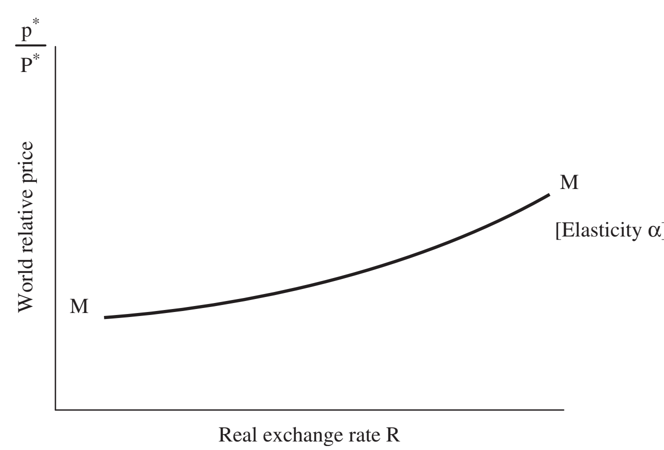

Fig. 2. Market power, commodity price, and exchange rate.

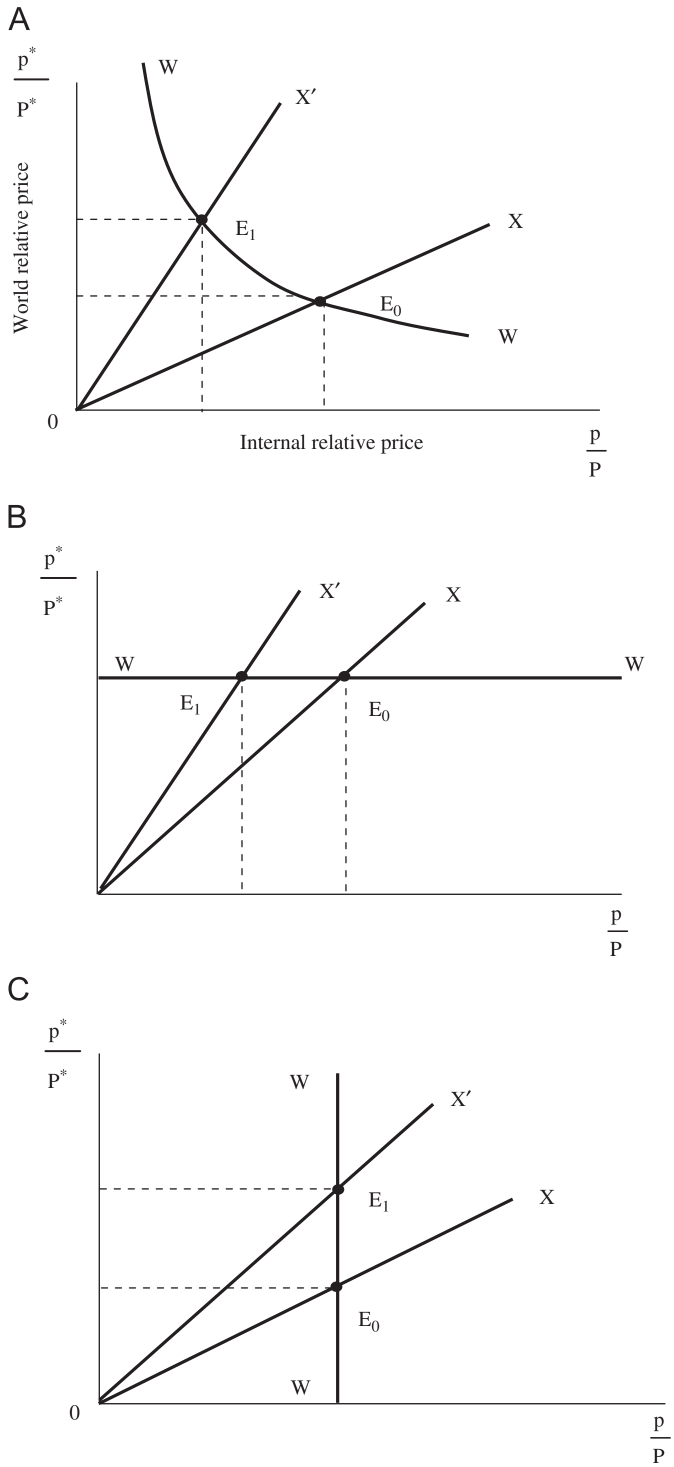

Fig. 3. Impact of appreciation on commodity prices: (A) the general case, (B) the small-country case and (c) the large-country case.

An alternative presentation of the interactions between the exchange rate and the commodity price is given in Fig. 3. In panel A, the schedule WW is the locus of world and domestic prices for which the world market clears. It is downward sloping as an increase in the domestic price stimulates production, and for the market to continue to clear, this has to be offset by a reduction in the world price to stimulate demand. Clearing of the commodity market implies $\varepsilon(\hat{p} - \hat{P}) = \eta(\hat{p}^* - \hat{P}^*)$, so that

$$\frac{\hat{p}^*}{P^*} = \left(\frac{\varepsilon}{\eta}\right)\frac{\hat{p}}{p} = -\left(\frac{\alpha}{1-\alpha}\right)\frac{\hat{p}}{p}$$

with α defined as above in Eq. (3). This shows that $-\alpha/(1-\alpha)<0$ is the elasticity of the WW schedule. The link between domestic and foreign prices of the commodity is provided by the real PPP relationship discussed above, $p^*/P^* = R(p/P)$. This equation is represented in panel A of the figure by the ray from the origin OX, with slope R. For overall equilibrium, the market must be simultaneously located on WW and OX; that is, at the point of intersection of the two curves E_0. An appreciation of the producer-country currency causes the ray to get steeper and move from OX to OX', so that the equilibrium point shifts from E_0 to E_1, with the world price rising and the domestic price falling. In the small-country case (panel B), the WW schedule is horizontal as $\alpha = 0$, the appreciation has no impact on the world price, and the domestic price falls equiproportionally. Finally, for a large country in the extreme case ($\alpha = 1$), the WW schedule is vertical, the domestic relative price remains unchanged, and the world price rises by the full amount of the appreciation.

The model discussed in this subsection is a simple one that deals with the pricing of a single commodity in a two-country world. However, its predictions are robust as they carry over in a natural manner to a multicountry, multicommodity world in which there is domestic consumption of the commodity. For details, see, for example, Gilbert (1989), Sjaastad (1990), and Ridler and Yandle (1972).

Commodity currencies

In this subsection, we consider the link from commodity prices to exchange rates by employing the "sector approach" introduced by Sjaastad (1980) for the analysis of the impact of protection.[9] We divide the whole economy into three broad sectors: importables (to be denoted by subscript I), exportables (X) and everything else—that is, those goods that do not, and cannot, enter into international trade because of prohibitively high transport costs—which shall be called home goods (H). Under general conditions, the price of home goods is linked to the prices of the two traded goods according to

$$\hat{p}_H = \omega\hat{p}_I + (1-\omega)\hat{p}_X. \tag{4}$$

When complementarity is ruled out, which does not seem unreasonable at this level of aggregation, the value of the coefficient ω lies between zero and one. Eq. (4) shows that

[9] For extensions and elaborations of Sjaastad's model, see Clague and Greenaway (1994), Clements and Sjaastad (1981, 1984), Greenaway (1989), and Greenaway and Milner (1988). See also Choi and Cumming (1986) for early work on the measurement of the transfers across sectors implied by the approach.

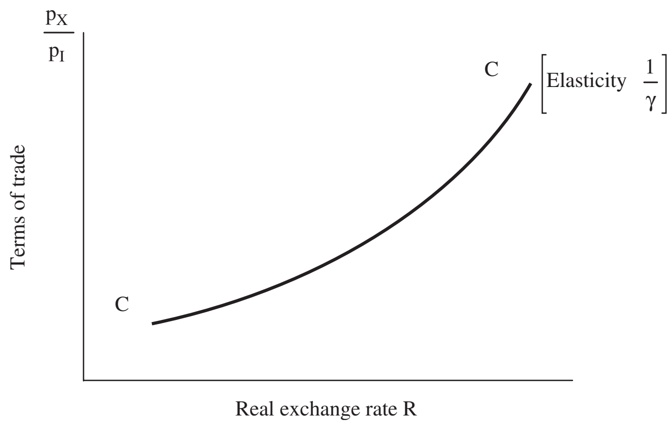

Fig. 4. The reciprocal commodity–currency relationship.

the change in the price of home goods is a weighted average of the changes in the prices of importables and exportables. The weights in this equation reflect the substitutability in both production and consumption between home goods on the one hand and the two traded goods on the other. When home goods and importables are good substitutes, then the weight ω is near its upper value of unity, the prices of these two goods move closely together, and their relative price p_H/p_I is more or less constant. Alternatively, when home goods and exportables are good substitutes, the relative price p_H/p_X is approximately constant.

Next, let the overall index of prices in the country be a weighted geometric mean of the three sectoral prices, so that

$$\hat{P} = \alpha_H \hat{p}_H + \alpha_I \hat{p}_I + \alpha_X \hat{p}_X, \tag{5}$$

where α_i is a weight for sector i ($i = H, I, X$). The weights α_i are all positive fractions with $\Sigma_i \alpha_i = 1$. Using Eqs. (4) and (5), as well as analogous equations for the foreign country, we obtain

$$\hat{R} = \gamma \frac{\hat{p}_X}{p_I}, \tag{6}$$

where

$$\gamma = 1 - \{[\alpha_H(1-\omega) + \alpha_I] + [\alpha_H^*(1-\omega^*) + \alpha_I^*]\} \tag{7}$$

is the elasticity of the home country's real exchange rate with respect to its terms of trade and where asterisks denote foreign-country parameters.[10] On the basis of Eq. (7), the following can be said about the possible values of γ. In both countries, the shares for home goods and importables are positive fractions, while the shift coefficient lies between zero and one. The lower bound of γ obtains when $\omega = \omega^* = 0$, and the value of γ is $\alpha_X + \alpha_X^* - 1$, which can be negative if the exportables sector is small in both countries. The upper bound of γ is obtained when $\omega = \omega^* = 1$, so that here $\gamma = 1 - (\alpha_I + \alpha_I^*)$, which is likely to be a positive fraction.[11] Fig. 4 gives the commodity–currency relationship in the form of levels. For convenience, this is presented in reciprocal form, so that the elasticity of the schedule CC in the figure is $1/\gamma$.[12]

When does a country have a commodity currency?

As the value of a commodity currency moves in sympathy with its terms of trade, Eqs. (6) and (7) provide a framework for the identification of such a currency. For a commodity currency, its elasticity with respect to prices, γ, is a substantial positive number but less than unity (so that the domestic currency price of the commodity rises with the world price). Let Eq. (7) be written as $\gamma = 1 - (\beta + \beta^*)$, where $\beta = \alpha_H(1-\omega) + \alpha_I$, and $\beta^* = \alpha_H^*(1-\omega^*) + \alpha_I^*$. As β and β^* are both likely to be positive fractions, it can be seen that γ will not always be substantially different from zero. In fact, there is a presumption that both β and β^* would be of the order of one-half, which implies $\gamma \approx 0$. The value of one-half is based on the following considerations: the share of home goods in the overall economy could be something like 60 percent in both regions, so that $\alpha_H = \alpha_H^* = 0.6$; suppose the shift coefficient $\omega = 1/2$; and a not unreasonable value for the share of importables in both regions is 20 percent, so that $\alpha_I = \alpha_I^* = 0.2$. These values imply $\beta = \beta^* = 0.5$, so that the elasticity $\gamma = 0$, and the home country does not have a commodity currency in this case. This is, of course, reassuring, as in most cases, we would not expect the currency to be a commodity one; that is, commodity currencies are the exception to the rule.

Under what conditions does a country have a commodity currency? It follows from Eq. (7) that the elasticity γ will be further away from zero and closer to unity when:

- home goods occupy a smaller fraction of the economy (that is, when α_H, α_H^* are both small);
- home goods and importables are good substitutes in consumption and production (that is, when the shift coefficients ω, ω^* are both large);
- importables are relatively less important (that is, when α_I, α_I^* are both small).

[10] In deriving Eq. (6), we have used the *PPP* relationship for the two traded goods and the reciprocal nature of trade in a two-region world. That is, the exports of the home country represent imports by the rest of the world and vice versa for home country imports, so that $\hat{p}_X = \hat{p}_I^* + \hat{S}$ and $\hat{p}_I = \hat{p}_X^* + \hat{S}$. For details, see Clements and Fry (2006).

[11] For a related analysis, see Milner et al. (1995).

[12] In the above discussion, we have moved freely between changes in world prices and changes in domestic prices. This, however, ignores an important point regarding the source of the changed prices: while changes in domestic relative prices brought about by, say, domestic protection policies have no first-order income effects (when starting from an undistorted equilibrium), this is not true for changes in world prices. If domestic prices change because of a worsening of the country's terms of trade, for example, this makes the country as a whole worse off, which has implications for the workings of the market for home goods. Accordingly, the above framework needs modification/reinterpretation to deal with the first-order income effects of changes in the terms of trade. In Clements and Fry (2006), it is shown that the above analysis remains unchanged provided we use a modified shift coefficient $\omega' < \omega$.

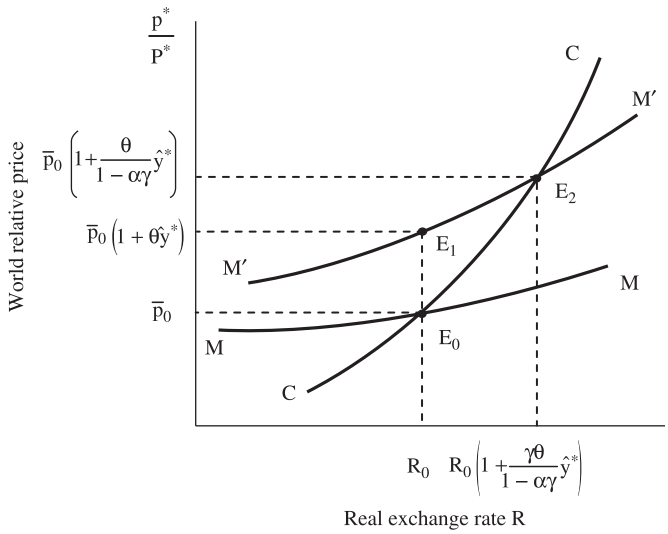

Fig. 5. Impact of a commodity boom.

Note that the first and last conditions jointly imply that γ will be larger when exportables account for a larger share of the economy. We thus obtain the following simple rule. *A country is more likely to have a commodity currency when* (*i*) *exportables are relatively important in the economy and* (*ii*) *the shift coefficient ω is large (nearer unity).*

Interactions between commodity and currency markets

In this subsection, we combine the results of the above discussion to consider the joint implications of market power and commodity currencies. To simplify matters, in what follows, we assume that the home country's terms of trade, p_X/p_I, coincide with the relative commodity price, p^*/P^*.[13] This means that the country under consideration is a commodity exporter, and as P^*, the index of prices in the rest of the world, now also plays the role of the price index of the country's imports, these imports are a ''representative market basket'' of goods from the rest of the world. Thus the country is specialized in its exports and diversified in imports, a pattern of trade not dissimilar to that of many developing economies.

The schedule MM in Fig. 5 is from Fig. 2 and gives the relation between the world price of a commodity and the country's real exchange rate on account of its market power. The upward slope of the schedule implies that the country has some degree of market power as a real appreciation increases the world price. The elasticity of MM is the coefficient α in Eq. (3). When the country has no market power, $\alpha = 0$, and MM is horizontal. The CC schedule of Fig. 5 is the commodity–currency relationship, from Fig. 4. The elasticity of CC is $1/\gamma > 0$, so that when the country does not have a commodity currency, $1/\gamma \to \infty$ and the schedule is vertical. The elasticity of MM lies between zero and unity, while that of CC is always greater than unity. This means that where the two curves intersect, CC is unambiguously steeper than MM.[14] As can be seen, the initial overall equilibrium in the commodity and currency markets pertains at the point E_0.

Next, we analyze the general equilibrium effects on prices and the exchange rate of a commodity boom resulting from an exogenous increase in world demand for the commodity. To do this, we need to extend the demand Eq. in (1) to include foreign real income y^*:

$$q^{\mathrm{d}} = q^{\mathrm{d}}\left(\frac{p^*}{P^*}, y^*\right) \text{ with } \lambda = \frac{\partial(\log q^{\mathrm{d}})}{\partial(\log y^*)} > 0,$$

so that λ is the income elasticity of demand for the commodity. This yields an extended version of the fundamental pricing rule (2):

$$\frac{\hat{p}^*}{P^*} = \alpha\hat{R} + \theta\hat{y}^*, \tag{8}$$

where $\theta = \lambda/(\varepsilon - \eta) > 0$ is the elasticity of the world price with respect to income. The second term on the right-hand side of Eq. (8), $\theta\hat{y}^*$, is the initial increase in prices resulting from the income increase $\hat{y}^*$, with the real exchange rate held constant. In the case in which the income elasticity λ is unity and $\varepsilon = -\eta = 1/4$, which are not unreasonable values for the short term, the elasticity θ takes the value of 2. Thus as the elasticity of commodity prices with respect to world income is two, prices exhibit a form of ''excess volatility''.

In terms of Fig. 5, the effect of the increase in income is to shift the MM schedule up equiproportionally to $M'M'$, so that at the preexisting exchange rate R_0, the price increases by the initial amount, $\theta\hat{y}^*$, and the market moves from the point E_0 to E_1. However, as we are dealing with a commodity currency, this price increase leads to an appreciation, which causes the price to increase further, with the move from E_1 to E_2. It can be thus seen that the interaction of market power and a commodity currency has the effect of amplifying the initial increase in prices. That is, setting $\hat{p}_X/p_I = \hat{p}^*/P^*$, we can combine Eqs. (6) and (8) to yield

$$\frac{\hat{p}^*}{p} = \left(\frac{\theta}{1-\alpha\gamma}\right)\hat{y}^* \geqslant \theta\hat{y}^*. \tag{9}$$

The inequality in this equation follows from α lying between zero and one, and $0<\gamma<1$ for a commodity currency. Thus, if $\overline{p}_0$ denotes the initial equilibrium relative price associated with the point E_0, and if we hold constant the value of the exchange rate at R_0, it follows from Eq. (8) that the new price at E_1 is $\overline{p}_0(1+\theta\hat{y}^*)$. When the exchange rate is allowed to appreciate, Eq. (9) implies that the commodity price rises further to $\overline{p}_0\{1+[\theta/(1-\alpha\gamma)]\hat{y}^*\}$ at the equilibrium point E_2. Continuing with the numerical

[13] Note that as p_X/p_I and p^*/P^* are both relative prices, which reflect real factors independent of currency units of measurement, we are not mixing currencies in taking these prices to be the same. Note also that we only require the weaker condition that p_X/p_I be proportional to p^*/P^*.

[14] This is a stability condition; see Clements and Fry (2006).

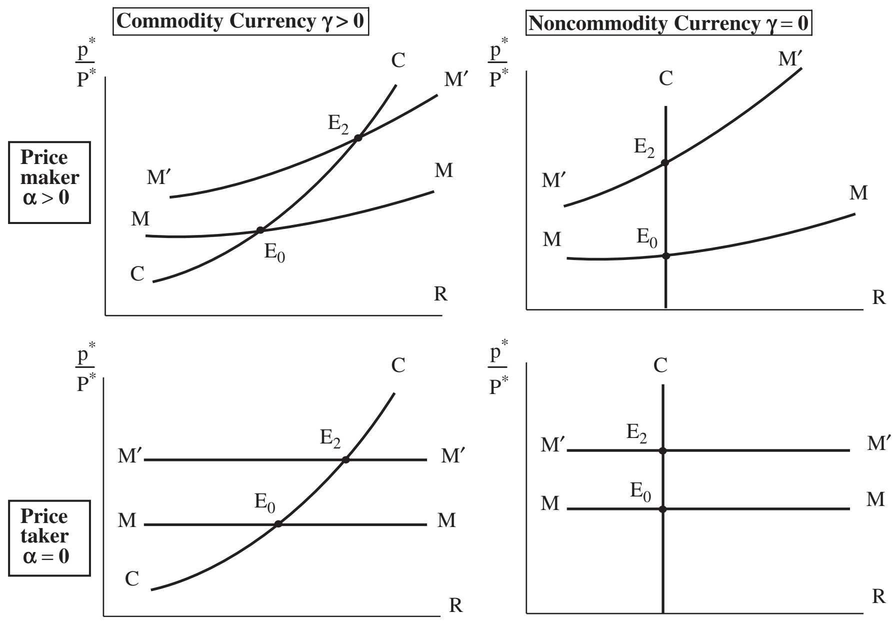

Fig. 6. Interactions between market power and commodity currency: the four possibilities.

example of the above paragraph whereby $\theta = 2$ and the market power elasticity $\alpha = 1/2$, suppose additionally that the commodity–currency elasticity $\gamma = 1/2$. These values imply that the coefficient of income in Eq. (9) is

$$\left(\frac{\theta}{1-\alpha\gamma}\right) = \frac{2}{1 - 1/2 \times 1/2} \approx 2.7.$$

Thus, relative to the partial equilibrium effect of Eq. (8), the general equilibrium interaction between the commodity and currency markets adds another $0.7/2 = 35$ percent to the volatility of prices.

Combining Eqs. (6) and (9), it can be seen that the commodity boom also results in a currency appreciation:

$$\hat{R} = \left(\frac{\gamma\theta}{1-\alpha\gamma}\right)\hat{y}^{*}. \tag{10}$$

Thus in terms of Fig. 5, the exchange-rate increases from R_0 to $R_0\{1 + [\gamma\theta/1-\alpha\gamma]\hat{y}^{*}\}$. The result is that the world price rises and the currency appreciates; but as the proportionate appreciation is less than the price rise, domestic producers benefit as the internal relative price also rises. That is, from the definition of the real exchange rate R, $p/P = (1/R)(p^{*}/P^{*})$, and Eqs. (9) and (10), we have[15]

$$\frac{\hat{p}}{p} = \frac{\hat{p}^{*}}{p} - \hat{R} = \left(\frac{(1-\gamma)\theta}{1-\alpha\gamma}\right)\hat{y}^{*} > 0.$$

A typology of commodities and currencies

Fig. 5 considered the implications of a commodity boom when the country: (i) has a commodity currency ($\gamma > 0$) and (ii) is a price maker ($\alpha > 0$). Fig. 6 explores the implications of the 2×2 possible combinations. The top left panel is a "stripped-down" version of Fig. 5, which is the general case of a commodity currency and some degree of market power. Immediately below this is the situation of a price taker ($\alpha = 0$) and a commodity currency ($\gamma > 0$). As can be seen, in this case, the boom causes the price to increase by less than previously; the price rises by just the vertical distance between the two schedules MM and $M'M'$, which in proportionate terms is $\theta\hat{y}^{*}$. The currency appreciates, but by less than before. In the general case, the boom initially increases the price, and because of the commodity currency, the exchange rate then appreciates. When the country is a price maker, this appreciation serves to push up the world price further (as profitability in the export sector is squeezed), which, in turn, leads to a further appreciation. However, when the country is a price taker, there are no "second round" effects, and so the initial effect of the boom is the end of the story. Accordingly, when the country is a price taker and has a commodity currency, the boom causes the world price to rise by less, and the currency appreciation is dampened.

The top right panel of Fig. 6 represents the price maker/noncommodity currency case. Here the price rises by the same amount as in the previous case, by $\theta\hat{y}^{*}$, but now there is no change in the exchange rate as the country does not have a commodity currency. The final case of a price taker/noncommodity currency is given in the bottom right panel, and the outcome is identical to the previous case—the price rises by $\theta\hat{y}^{*}$, and the exchange rate remains unchanged.[16]

[15] For a geometric analysis, see Clements and Fry (2006).

[16] Clements and Fry (2006) consider further applications of the framework to: (i) a currency fad in which there is a shift in investor sentiment towards the currency of the home country, (ii) technological change that creates new alternatives for the commodity, and (iii) globalization that injects an added degree of flexibility into the domestic economy.

A first look at the data

The section on the analytical framework outlined the conditions necessary for a commodity currency and market power in commodity markets. The next section addresses these issues by specifying and estimating a multivariate latent factor model to examine the joint determinants of the currency and commodity prices. This section provides a preliminary analysis of the data set to motivate the multivariate model of a latent factor model of currencies and commodities.

The data set consists of $m = 3$ "commodity currency" exchange-rate variables, $n = 1$ additional currencies, and $v = 5$ commodity price variables. The commodity currencies include the Australian dollar (AUD_t), the Canadian dollar (CND_t) and the New Zealand dollar (NZD_t). The British pound (GBP_t) represents the additional currency. The ith nominal exchange rate $S_{i,t}$ is transformed into a real rate ($R_{i,t}$), which is expressed in terms of US dollars (USD_t) per unit of national currency:

$$R_{i,t} = \frac{P_{i,t}}{S_{i,t}P_t^*},$$

where $P_{i,\ t}$ and P_t^* represent the national and US consumer price indices, respectively. Demeaned continuously compounding percentage returns of the commodity currencies ($CE_{i,t}$) are computed by taking the quarterly difference of the natural logarithm of the real exchange rates, subtracting the sample mean and multiplying by 100. The additional currency, denoted E_t, is similarly transformed.

The International Monetary Fund (IMF) publishes an index of commodity prices and five subindices capturing the major commodity groups. The choice of $v = 5$ commodity price variables is motivated by the IMF's subclassifications and includes agricultural materials (AGR_t), beverages (BEV_t), food (FOO_t), metals (MET_t), and oil prices (OIL_t).[17,18] The kth commodity price index is expressed in real terms by deflating by the US consumer price index. Commodity price returns ($PC_{k,t}$) are determined analogously to those for the currencies. The vector Y_t

$$Y_t = \{CE_{i,t}, E_t, PC_{k,t}\}, \tag{11}$$

summarizes the data. The sample period extends from Quarter 1, 1975, when the IMF first began constructing the indices, to Quarter 3, 2005 ($T = 123$ observations). The data are expressed in quarterly terms, as some consumer price indices used for deflation are only available on a quarterly basis.

The data set is contained in Fig. 7, and Tables 1 and 2 present descriptive statistics and the variance–covariance and correlation matrices, respectively.[19] Table 1 indicates that the commodity price returns are generally more volatile than the currency returns. Oil returns contain the largest minimum and maximum over the sample period. Of the currency returns, the Canadian dollar is the least volatile and the New Zealand dollar is the most volatile. The Jarque–Bera tests indicate mixed evidence of normality. The null hypothesis of normality cannot be rejected for the Australian and Canadian dollar returns, or for metal price returns, but is rejected for the remaining series. Normality is assumed for convenience of estimation in a latent factor model of currencies and commodities.

Table 2 presents the correlations and covariances of the data. The correlations reveal some interesting features. The commodity currencies are positively correlated with each other but are negatively correlated with the pound, reflecting the different structures of the respective economy types. Commodity returns are positively correlated across the board with the exception of oil and beverages. As expected, commodity–currency returns are generally positively correlated with commodity price returns. The exceptions where correlations are negative (albeit small) are for the Australian dollar with oil, the Canadian dollar with food, and the New Zealand dollar with beverages.

In forming a view on the lag structure of the model, the lag length criteria of Akaike (AIC), Schwarz (SC), and Hannan–Quinn (HQ) and the sequentially modified LR test statistic of a vector autoregression (VAR) of the data are presented in Table 3. The AIC, SC, and HQ statistics show that a structure of one lag is sufficient to characterize the system as a whole, although the likelihood ratio test indicates an optimal structure of four lags.[20]

To motivate the model developed in a latent factor model of currencies and commodities, the results of bivariate Granger causality tests are shown in Table 4. The results suggest that the commodity currencies Granger cause commodity returns rather than the other way around. The hypothesis that the Australian dollar does not Granger cause agriculture, food, metal, and oil returns is rejected at the 0.05 level of significance. The same is true for the Canadian dollar with food and metals, and for the New Zealand dollar with agriculture, food, and metals. Conversely, the null hypothesis is not rejected in all cases of commodity prices not Granger causing the commodity currencies. Finally, the pound Granger causes the New Zealand dollar, food prices, and metal price returns. These

[17] An oil price index is used to proxy the energy index, as the IMF's energy index is only available from 1992.

[18] All data are sourced from the IMF International Financial Statistics database except for the oil price index, which is from Datastream. The codes for currencies are: Australian dollar (193..AG.ZF…), Canadian dollar (156..AE.ZF…), New Zealand dollar (196..AG.ZF…), and British pound (112..AG.ZF…). Codes for the consumer price indices are: Australia (19364...ZF…), Canada (15664…ZF…), New Zealand (19664…ZF…), England (11264…ZF…), and the USA (11164…ZF…). Codes for the commodities are: agricultural raw materials (00176BXDZF…), beverages (00176DWDZF…), food (00176EX-DZF…), metals (00176AYDZF…), and oil (WDI76AADF).

[19] All calculations in Section 3 were performed in EVIEWS 5.

[20] See Clements and Fry (2006) for correlograms of each series, which indicated that there is some temporal dependence among the individual variables, with the exception of the Australian dollar. The commodity price returns tend to exhibit the strongest autocorrelation.

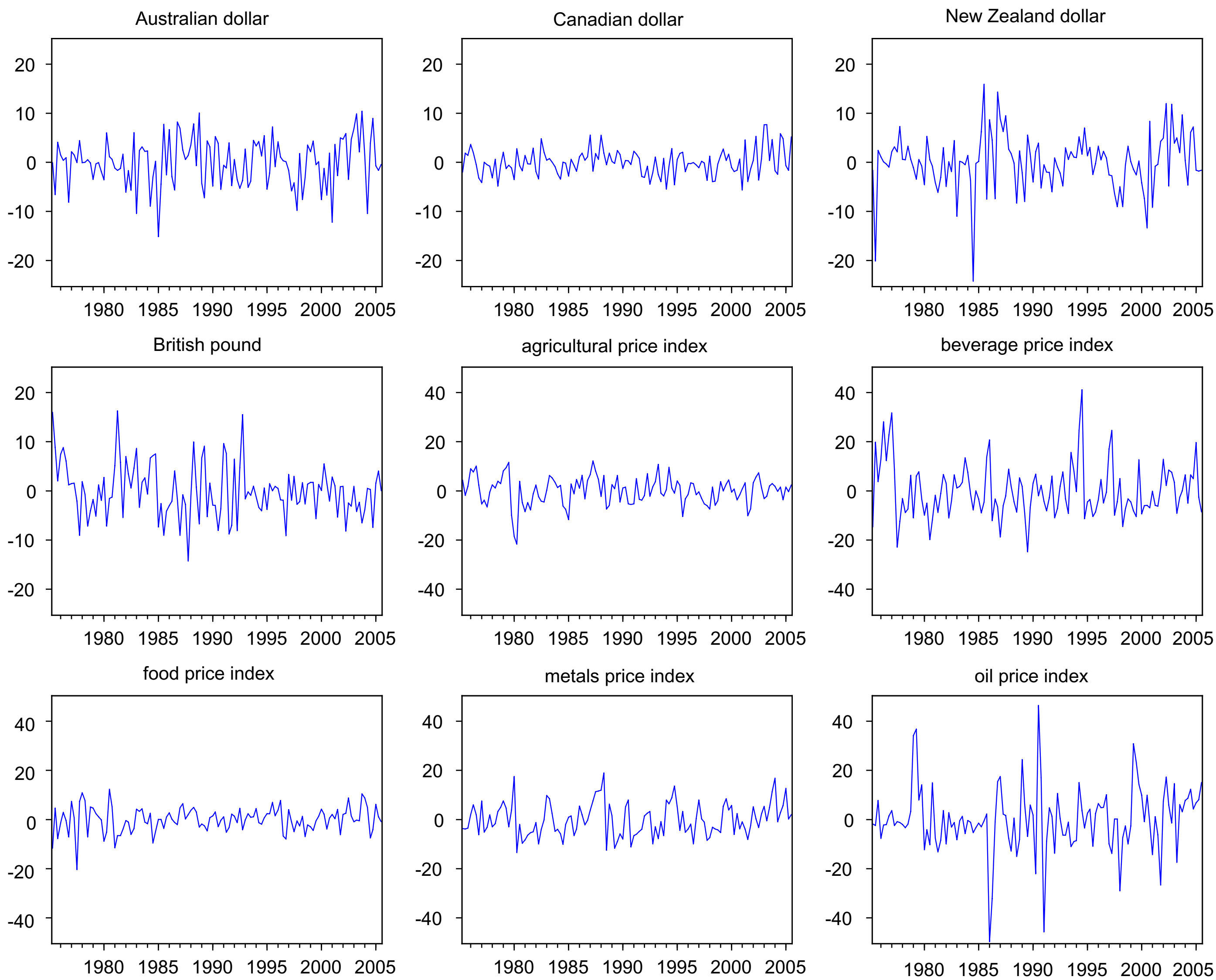

Fig. 7. Real percentage demeaned currency and commodity price returns.

Table 1
Descriptive statistics of currency and commodity returns

	Currencies				Commodities				
	AUD	*CND*	*NZD*	*GBP*	*AGR*	*BEV*	*FOO*	*MET*	*OIL*
Mean	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Max.	10.420	7.672	15.902	16.267	12.245	41.167	12.307	18.925	46.437
Min.	–15.145	–5.643	–24.213	–14.294	–21.757	–24.784	–20.342	–13.432	–49.693
Std. dev.	4.896	2.656	5.778	5.402	5.674	10.940	5.014	6.700	13.322
Jarque–Bera	2.420	4.360	53.897	6.551	17.929	27.632	17.081	4.092	53.450
Probability	0.298	0.113	0.000	0.038	0.000	0.000	0.000	0.129	0.000

preliminary tests suggest that perhaps it is the case that commodity prices are driven by currency movements rather than the other way around. The next section explores whether or not this is true when the system is modeled jointly rather than on a bivariate basis.

A latent factor model of currencies and commodities

Although there are many empirically based papers written on "commodity currencies", there is usually an implicit assumption that either commodity prices are

Table 2
Correlations (upper diagonal), variances (diagonal), and covariances (lower diagonal) of currency and commodity returns

	Currencies				Commodities				
	AUD	*CND*	*NZD*	*GBP*	*AGR*	*BEV*	*FOO*	*MET*	*OIL*
Currencies									
AUD	23.777	0.503	0.655	–0.271	0.066	0.032	0.020	0.232	–0.005
CND	6.488	6.994	0.298	–0.116	0.079	0.008	–0.092	0.115	0.075
NZD	18.380	4.540	33.112	–0.454	0.203	–0.001	0.062	0.247	0.044
GBP	–7.098	–1.645	–14.046	28.938	0.003	0.029	–0.143	–0.179	–0.224
Commodities									
AGR	1.808	1.178	6.612	0.085	31.932	0.143	0.308	0.298	0.027
BEV	–1.686	0.230	–0.041	1.709	8.829	118.712	0.142	0.226	–0.044
FOO	–0.487	1.178	1.775	–3.850	8.688	7.703	24.933	0.298	0.027
MET	7.558	2.036	9.501	–6.407	8.897	16.442	9.939	44.518	0.165
OIL	–0.326	2.628	3.339	–16.004	16.920	–6.326	1.810	14.587	176.034

Table 3
Lag selection criteria of a VAR of currency and commodity returns

Lag	Log *L*	*LR*	*AIC*	*SC*	*HQ*
1	–3228.064	n.a.	56.086*	57.988*	56.858*
2	–3170.768	97.112	56.488	60.291	58.032
3	–3111.125	91.992	56.850	62.555	59.166
4	–3032.124	109.797*	56.883	64.491	59.972

Notes: 1. * indicates lag order selected by the criterion.
2. *LR* is the sequential modified *LR* test statistic (each test at 5% level), *AIC* is the Akaike information criterion, *SC* is the Schwarz information criterion, and *HQ* is the Hannan–Quinn information criterion.

exogenous and currency commodities are a function of these prices (Cashin et al., 2004; Freebairn, 1990; Gruen and Kortian, 1998), or to a lesser degree, vice versa (Amano and van Norden, 1995). Chen and Rogoff (2003) raise the possibility that commodity prices may be endogenous in OLS models estimating commodity price elasticities of the real exchange rates of Australia, Canada, and New Zealand under various parameterizations. However, they do not estimate a multivariate model. Broda (2004) considers the potential endogeneity of the terms of trade but finds that it is rare for commodity-exporting countries to have market power. Empirical papers modeling the case where the two effects are operating simultaneously are those using the VAR framework where the nature of the model allows feedback mechanisms between variables (Hatzinikolaou and Polasek, 2005; Fisher, 1996). However, the analysis generally focuses on the effects of commodity prices or the terms of trade on currencies and not the other way around (for an exception, see Fisher, 1996).

The model specified in this paper examines the concepts in the analytical framework and addresses this gap in the empirical literature by jointly examining the determinants of currency and commodity price returns as a function of a set of independent latent factors. Influences that are common to each subset of variables are captured by a single time series (factor), which is intuitively likely to be a function of more than one observable variable. The advantage is that observable variables do not have to be identified and modeled. It is particularly convenient to adopt such a specification, as it can implicitly take into account shocks simultaneously affecting each type of market, such as business cycle shocks or shocks to the US economy, without formally modeling such linkages (see Chen and Rogoff (2003) and Freebairn (1990) for discussions of the difficulties in accounting for the many influences on exchange rates). This class of models is common in the finance literature and in high-frequency data exchange-rate models as well as models common in the business cycle literature; see Diebold and Nerlove (1989), Dungey (1999), Mahieu and Schotman (1994) and Stock and Watson (1991). An advantage of the framework is parsimony. The model provides an understanding of the importance of linkages across the markets while controlling the number of parameters to be estimated.

The three key factors in the model are a common factor capturing information common to the complete data set, a currency factor specific to the returns of the commodity currencies, and a commodity factor capturing information specific to the set of commodity returns in the model. The joint impact of (commodity) currency returns on commodity returns, and the corresponding joint impact of commodity returns on the commodity exchange-rate returns, can be assessed by examining spillovers across each market, allowing insight into the hypotheses regarding the relationship between the commodity currencies and commodity prices presented earlier. Namely, the model provides a convenient decomposition of the importance that each factor plays in contributing to volatility in the returns of each asset. The importance of: (i) the commodity–currency factor to the determination of commodity currencies, (ii) the commodity factor to the determination of commodity returns, and (iii) spillovers across each type of market can then be assessed. The factor model describing the data in (12) can be separated into a

Table 4
Bivariate Granger causality between currency and commodity returns

Currency to currency			Commodity to commodity			Currency to commodity			Commodity to currency		
Hypothesis		*p*-Value	Hypothesis		*p*-Value	Hypothesis		*p*-Value	Hypothesis		*p*-Value
From	To		From	To		From	To		From	To	
AUD	*CND*	0.556	*AGR*	*BEV*	0.003*	*AUD*	*AGR*	0.028*	*ARG*	*AUD*	0.930
	NZD	0.522		*FOO*	0.137		*BEV*	0.555		*CND*	0.978
	GBP	0.306		*MET*	0.190		*FOO*	0.001*		*NZD*	0.826
				OIL	0.043*		*MET*	0.031*		*GBP*	0.331
							OIL	0.022*			
CND	*AUD*	0.114	*BEV*	*AGR*	0.589	*CND*	*AGR*	0.137	*BEV*	*AUD*	0.721
	NZD	0.982		*FOO*	0.666		*BEV*	0.223		*CND*	0.976
	GBP	0.970		*MET*	0.084		*FOO*	0.042*		*NZD*	0.316
				OIL	0.363		*MET*	0.012*		*GBP*	0.100
							OIL	0.295			
NZD	*AUD*	0.830	*FOO*	*AGR*	0.274	*NZD*	*AGR*	0.027*	*FOO*	*AUD*	0.886
	CND	0.825		*BEV*	0.255		*BEV*	0.435		*CND*	0.412
	GBP	0.095		*MET*	0.561		*FOO*	0.000*		*NZD*	0.537
				OIL	0.411		*MET*	0.030*		*GBP*	0.984
							OIL	0.113			
GBP	*AUD*	0.433	*MET*	*AGR*	0.432	*GBP*	*AGR*	0.163	*MET*	*AUD*	0.881
	CND	0.187		*BEV*	0.510		*BEV*	0.475		*CND*	0.430
	NZD	0.042*		*FOO*	0.011*		*FOO*	0.000*		*NZD*	0.416
				OIL	0.007*		*MET*	0.004*		*GBP*	0.380
							OIL	0.753			
			OIL	*AGR*	0.777				*OIL*	*AUD*	0.738
				BEV	0.172					*CND*	0.878
				FOO	0.189					*NZD*	0.841
				MET	0.916					*GBP*	0.646

commodity–currency ($CE_{i,t}$) returns component, an additional currency (E_t) returns component, and the commodity price returns ($PC_{k,t}$) component. The following provides the specification for each component.

Commodity–currency returns specification

Eq. (12) shows the factor model for the commodity–currency returns:

$$CE_{i,t} = \lambda_i V_t + \varphi_i CF_t + \gamma_i PCF_{t-1} + \sigma_i U_{i,t}, \quad i = 1, \ldots, m. \tag{12}$$

The commodity–currency returns are a function of a common factor (V_t), which is included in all equations of the system, a commodity–currency returns factor (CF_t) referred to as the currency factor, and an idiosyncratic term ($U_{i,t}$), with loadings λ_i, φ_i, and σ_i, respectively. The inclusion of the pound (E_t) in the model (described in the additional currency returns specification section) and the implicit inclusion of the US dollar as the numeraire currency should provide sufficient information to identify the common factor, V_t. The existence of the commodity–currency returns factor is supported by Table 2 showing that the commodity currencies are positively correlated with each other but negatively correlated with the pound.

To examine the extent to which commodity–currency returns are a function of commodity price returns and vice versa, cross-market linkages between the two markets are modeled through spillovers. Spillovers from the commodity returns series to the commodity currencies are modeled through the lagged commodity price factor (PCF_{t-1}), with loading γ_i. The commodity price factor at time t is specific only to the commodity returns series and is described in more detail in (16) and (17) below.

Following the lag specification tests in a first look at the data, the common and currency returns factors are modeled as $AR(1)$ processes with loadings ρ_V and ρ_{CF} where

$$V_t = \rho_V V_{t-1} + \eta_{V,t} \tag{13}$$

and

$$CF_t = \rho_{CF} CF_{t-1} + \eta_{CF,t}. \tag{14}$$

The idiosyncratic factors that capture the component of each return series not explained by the other factors are assumed not to exhibit autocorrelation.

Additional currency returns specification

The additional currency return variable is included in the model to help identify the common influences (V_t), and to separate movements in the commodity currencies from currency markets in general. This is particularly important as the currency returns are expressed in terms of US dollars per unit of national currency, and the unit of account from which the commodity price indices are constructed is also expressed in US dollar terms. Excluding a common factor from the model specification may result in the detection of spurious linkages.[21] The specification of the additional currency returns is

$$E_{j,t} = \lambda_j V_t + \sigma_j U_{j,t}, \quad j = 1, \ldots, n. \tag{15}$$

These returns are a function of the world and the idiosyncratic factors with loadings λ_j and σ_j. No additional linkages are considered.

Commodity returns specification

The commodity returns equation is

$$PC_{k,t} = \lambda_k V_t + \delta_k PCF_t + \beta_k CF_{t-1} + \sigma_k U_{k,t}, \quad k = 1, \ldots, v. \tag{16}$$

Commodity returns are a function of the common factor (V_t), the commodity price returns factor (PCF_t), spillovers from the previous period's currency returns factor (CF_{t-1}) and an idiosyncratic factor $U_{k,t}$. The parameter loadings on these factors are λ_k, δ_k, β_k, and σ_k. The commodity factor is also an $AR(1)$ process

$$PCF_t = \rho_{PCF} PCF_{t-1} + \eta_{PCF,t}. \tag{17}$$

The complete factor model

The model can be expressed in matrix form as

$$Y_t = \Lambda F_t + \Delta F_{t-1} + W_t, \tag{18}$$

$$F_{t+1} = \Psi F_t + V_t, \tag{19}$$

where Y_t in (18) is a function of the latent factors contained in F_t (namely V_t, CF_t, and PC_t and the idiosyncratics) with parameter loadings Λ, and spillovers, which are modeled through the lag of the latent factors (F_{t-1}) with parameter loading Δ. The state equation in (19) shows that the factor (F_{t+1}) is an autoregressive process with loading Ψ. The error matrices V_t and W_t are vector white noise processes, such that

$$E(V_t V_\tau') = \begin{cases} Q & \text{for } t = \tau, \\ 0 & \text{otherwise} \end{cases} \tag{20}$$

and

$$E(W_t W_\tau') = \begin{cases} R & \text{for } t = \tau, \\ 0 & \text{otherwise.} \end{cases} \tag{21}$$

Here, $W_t = 0$, and hence, $R = 0$.[22] For details on the Kalman filter algorithm, see Harvey (1981, 1990), Hamilton (1994, Chapter 13), and Lütkepohl (1993, Chapter 13).

Variance decompositions

The assumption of independence of the factors of which each asset return is a function enables the results to be interpreted in terms of the contribution of each factor to the overall volatility of each asset. This provides a convenient mechanism for interpretation of the results. The volatility of currency and commodity returns can be decomposed in terms of the factors by squaring of both sides of (12), (15), and (16) and taking expectations. The decomposition of the variances for the commodity currencies is

$$E[CE_{i,t}^2] = \frac{\lambda_i^2}{1-\rho_V^2} + \frac{\phi_i^2}{1-\rho_{CF}^2} + \frac{\gamma_i^2}{1-\rho_{PCF}^2} + \sigma_i^2, \quad i = 1, \ldots, m. \tag{22}$$

where $\lambda_i^2/1-\rho_v^2$ represents the contribution of the world factor to volatility in commodity currency i, $\phi_i^2/1-\rho_{\mathrm{CF}}^2$ represents the contribution of the currency factor, $\gamma_i^2/1-\rho_{\mathrm{PCF}}^2$ is the contribution of spillovers from the commodity factor, and σ_i^2 is the contribution of the idiosyncratic factor. The decomposition of the additional currencies and the commodity price series is expressed analogously.

Empirical results

Tables 5 and 6 present the volatility decompositions of the data and the parameter estimates of (12)–(17). For all data except the Australian dollar, idiosyncratic factors are most important in explaining volatility of the returns. The common factor is most important to the pound and the New Zealand dollar, contributing 43.95 and 32.93 percent of volatility. It is not surprising that these variables are similar as they seem related as reflected by the Granger causality tests. The common factor contributes under 7 percent to volatility of the Australian dollar, and 0.03 percent to Canada. Of the commodity returns, metals are most affected by the common factor (7.64 percent), with the other commodities affected by less than 4 percent. These results are reflected in the parameter estimates, which show that the common factor is significant only for the Australian, New Zealand, and British currencies and metal price returns. It is of interest to note that the signs on the parameter estimates for the commodity currencies are

[21] A version of this model was estimated excluding the additional currency (i.e., without the common factor, V_t), and it was found that the currency factor had a substantial impact on the commodity price returns. Some factor models for currency markets include an additional "numeraire" factor where a parameter is held fixed across all equations (see Dungey, 1999; Dungey et al., 2003; Mahieu and Schotman, 1994). As the contribution of this factor to overall asset market volatility is minimal in most applications, it is excluded here.

[22] The model in (18)–(21) is estimated using maximum likelihood and the Kalman filter. The likelihood function is maximized using the procedure MAXLIK in Gauss 5.0 with the BFGS iterative gradient algorithm and numerical derivatives.

Table 5
Volatility decomposition of currency and commodity returns (percentages)

Variable	Common factor	Currency factor	Commodity factor	Spillovers from		Idiosync.
				Commodities	Currencies	
Australian dollar	6.49	80.93		0.44		12.14
Canadian dollar	0.03	29.78		0.69		69.50
New Zealand dollar	32.93	28.67		0.83		37.56
British pound	43.95					56.05
Agriculture	1.91		28.64		2.08	67.37
Beverages	2.03		23.54		0.01	74.42
Food	3.92		7.21		5.23	83.64
Metals	7.64		21.09		2.34	68.93
Oil	3.62		2.51		2.71	91.16

Table 6
Parameter estimates for currency and commodity returns (p-values in parentheses)

Variable	Common factor	Currency factor	Commodity factor	Spillovers from		Idiosync.
				Commodities	Currencies	
Australian dollar	–1.076 (0.031)	–4.337 (0.000)		–0.247 (0.579)		1.682 (0.108)
Canadian dollar	–0.042 (0.872)	–1.444 (0.000)		–0.169 (0.487)		2.209 (0.000)
New Zealand dollar	–2.847 (0.000)	–3.033 (0.000)		–0.398 (0.417)		3.478 (0.000)
British pound	3.023 (0.000)					3.905 (0.000)
Agriculture	–0.676 (0.359)		–2.298 (0.001)		–0.804 (0.143)	4.590 (0.000)
Beverages	1.359 (0.268)		–4.063 (0.002)		0.113 (0.927)	9.407 (0.000)
Food	–0.840 (0.142)		–1.001 (0.042)		–1.109 (0.030)	4.439 (0.000)
Metals	–1.593 (0.030)		–2.325 (0.000)		–1.007 (0.118)	5.474 (0.000)
Oil	–2.205 (0.124)		–1.613 (0.215)		–2.178 (0.092)	12.660 (0.000)
ρ_V	0.486 (0.008)					
ρ_{CF}		–0.058 (0.599)				
ρ_{PCF}			0.641 (0.000)			
Log likelihood	–3,390.90					

the same but are opposite to those of the pound. The signs on the commodity returns are also the same as for the commodity currencies with the exception of beverage returns. All markets excluding the pound and beverages are affected in the same way by the common factor.

The (commodity) currency market factor plays an important role in affecting the volatility of the commodity currencies. The contribution to volatility for Canada and New Zealand is just under 30 percent and is about 81 percent of the volatility of the Australian dollar. The Australian dollar appears to dominate movements amongst the commodity–currency markets, although the contribution of the factor for all three series is quite large. The parameter estimates of the currency factor are significant for the three currency return series as shown in Table 6, with the signs of the loadings on the currency factor for all three series being the same.

The commodity returns factor plays a mixed role in explaining volatility in the commodity markets. Agricultural materials, beverages, and metals are most affected by the commodity factor, with a contribution of between 20 and 30 percent of volatility. Food and oil are the least affected. Oil is the only commodity where the commodity factor is not significant. This result makes sense in that the oil industry is much different in nature from the other commodity industries, particularly given the role that OPEC is able to play in consciously altering supply and hence the price of oil. Similar to the case for the currency factor on the currencies, the parameter loadings on the commodity factor on all commodities are of the same sign.

Commodity currencies or currency commodities?

The volatility decomposition in Table 5 shows that commodities are more affected by spillovers from the commodity–currency factor than commodity–currency returns are affected by the commodity factor.[23] This suggests that perhaps the commodity-exporting nations do exhibit a small degree of market power. The commodity

[23]An additional parameterization was also estimated whereby a factor common to the commodity currencies and commodity prices was specified to control for joint contemporaneous movements across the two types of markets. The volatility decompositions of this model were quite similar to the ones presented here. Namely, the spillover effects across the two types of asset markets were much the same.

Table 7
Likelihood ratio tests of spillover factors

Hypothesis	LR statistic	p-value
1. Commodity factor in commodity currency returns ($H_0 : \gamma_i = 0, \quad \forall\, i = 1, \ldots, m$)	0.969	0.808
2. Currency factor in commodities returns ($H_0 : \beta_k = 0, \quad \forall\, k = 1, \ldots, v$)	9.463	0.092*

Note: * denotes significance at the 10% level.

factor parameters in the currency markets are not significant for any country, and the contributions to the currency return volatilities are close to zero. These results are reinforced by likelihood ratio tests contained in Table 7. The joint test of the hypothesis that the parameter loadings of the commodity factor in the commodity–currency returns is zero, a test of H_0: $\gamma_i = 0$, $i = 1, \ldots, m$, in Eq. (12), is unable to be rejected with a p-value of 0.808. Table 6 shows that the estimates of the loadings of the commodity factor in the currency returns [the γ_i in Eq. (12)] have the same signs as the commodity factor in the commodity returns themselves [the δ_k in Eq. (16)]. This confirms prior expectations as commodity currencies and commodity prices tend to move in the same direction. The same is generally true of the signs of the currency factor in the currency returns and the spillovers into the commodity returns [cf. φ_i in (12) with β_k in (16)].

The impact of the currency market factor on commodities is slightly more important, although it accounts for less than 5.5 percent of volatility for all markets. Spillovers to beverages are least important, reflecting that Australia, Canada, and New Zealand are not producers of beverages.[24] Spillovers from the currency factor to commodities are most important for food (5.23 percent), followed by oil (2.71 percent), metals (2.34 percent), and agricultural materials (2.08 percent). The parameter estimates are only significant in the case of food and oil, although the likelihood ratio tests show that the hypothesis that the parameter loadings of the currency factor in the commodity returns are jointly zero [H_0: $\beta_k = 0$, $k = 1, \ldots, v$, in Eq. (16)] is rejected. It is peculiar that the spillovers from the commodity currencies to the oil returns are significant. However, this may reflect other aspects specific to the oil market, including (i) the widespread complementary nature of the oil in the production process of many goods, including other commodities and (ii) the role of OPEC in managing oil prices.

Globalization and latent factors

The Kalman filter provides a time series of each of the factors in the model. This facilitates analysis of changes in the importance of each factor over time to the returns of the series, which is particularly relevant to the effects of globalization discussed in Clements and Fry (2006), where it is argued that increases in volatility over time may be a reflection of globalization enhancing the flexibility of the economy. Table 8 presents the contribution that each factor makes to the returns of each asset over sample subperiods to assess how the influence of each factor changes over time. The first subperiod is from the beginning of the sample to Quarter 4, 1982.[25] This coincides with the period prior to deregulation of the financial systems of Australia and New Zealand. The second subperiod extends from Quarter 1, 1983 to Quarter 4, 1990, followed by decompositions separated into 5-year blocks.

There are certain patterns evident in the subperiod decompositions, although the results are quite stable over time. The commodity currencies are more affected by the commodity–currency factor over time, and spillovers from the commodity price market to currency returns become marginally less important. It is possible that the reason for the increasing importance of the currency factor is that the commodity economies are increasingly subject to interlinkages with other economies as the level of integration increases. That this is reflected more in the currency factor than in the common factor may be because the economies considered are competing in the same markets. For commodity returns, the commodity factor is marginally less important over time. Spillovers from currency markets are increasingly important, although again, the effects are small relative to the impacts from other factors.

Summary and conclusions

Most research, both theoretical and empirical, into the exchange rates of countries that are prominent commodity producers assumes that these rates are a function of commodity prices. Countries that are commonly thought to have "commodity currencies" include Australia, Canada, and New Zealand, as well as many developing countries that are rich in natural resources. Few papers consider the opposite case of "currency commodities", whereby the value of an exchange rate of a commodity-exporting country can have an impact on commodity prices. This situation can arise if a country is a large producer of a commodity and is thus able to influence world prices; another possibility is that a group of commodity-exporting countries may have combined market power and are hence able to influence the world prices of commodities. This paper considered issues surrounding the joint determination of the prices of commodity currencies and currency commodities in both a theoretical and an empirical framework. The theoretical framework provided conditions necessary for the existence of a commodity–currency

[24] For a summary of the commodity-producing countries and their principal exports, see Cashin et al. (2004).

[25] The sample loses three observations at the beginning because of the construction of the returns data set and the initialization of the factors in the Kalman filter.

Table 8
Volatility decomposition of currency and commodity price returns over time (percentages)

Variable	Common factor	Currency factor	Commodity factor	Spillovers from		Idiosync.
				Commodity	Currency	
1975:Q3–1982:Q4						
Australian dollar	13.94	79.38		2.55		4.13
Canadian dollar	0.03	13.80		1.88		84.28
New Zealand dollar	54.80	21.79		3.71		19.69
British pound	49.69					50.31
Agriculture	0.97		34.47		0.45	64.11
Beverages	1.41		38.93		0.00	59.66
Food	1.74		7.61		1.01	89.65
Metals	5.52		36.29		0.73	57.46
Oil	4.09		6.75		1.32	87.84
1983:Q1–1990:Q4						
Australian dollar	9.79	84.50		0.88		4.83
Canadian dollar	0.04	28.82		1.28		69.86
New Zealand dollar	39.12	23.59		1.31		35.98
British pound	53.43					46.57
Agriculture	1.74		31.57		1.33	65.36
Beverages	2.31		32.37		0.01	65.32
Food	3.87		8.64		3.65	83.84
Metals	7.49		25.08		1.62	65.81
Oil	3.41		2.87		1.80	91.91
1991:Q–1995:Q4						
Australian dollar	9.26	84.73		0.86		5.15
Canadian dollar	0.04	24.60		1.06		74.31
New Zealand dollar	38.29	24.48		1.32		35.91
British pound	47.05					52.95
Agriculture	1.65		30.64		1.35	66.36
Beverages	1.92		27.68		0.01	70.39
Food	3.85		8.80		3.87	83.48
Metals	7.25		24.89		1.68	66.18
Oil	3.31		2.85		1.87	91.97
1996:Q1–2000:Q4						
Australian dollar	8.13	86.47		0.78		4.62
Canadian dollar	0.04	27.63		1.06		71.27
New Zealand dollar	35.67	26.50		1.27		36.56
British pound	46.17					53.83
Agriculture	1.64		31.38		1.56	65.42
Beverages	1.77		26.13		0.01	72.10
Food	3.54		8.31		4.13	84.03
Metals	6.96		24.54		1.86	66.63
Oil	2.99		2.65		1.96	92.40
2001:Q1–2005:Q3						
Australian dollar	6.65	88.92		0.63		3.80
Canadian dollar	0.03	27.70		0.84		71.44
New Zealand dollar	33.62	31.41		1.18		33.79
British pound	47.22					52.78
Agriculture	1.65		31.53		1.96	64.86
Beverages	1.80		26.53		0.01	71.66
Food	3.41		8.00		4.97	83.62
Metals	6.87		24.17		2.30	66.67
Oil	2.96		2.62		2.42	92.00

and market power in commodity markets, as well as an analysis of the simultaneous workings of both effects. One use of this approach is the identification of "hidden", or potential, market power, which may be of value to companies producing and consuming commodities that are priced by formal periodic "contract negotiations" such as iron ore. Another attraction of the approach is that with the bidirectional causality, the links between exchange rates and currency prices are stronger than that implied by traditional unidirectional commodity–currency models. In other words, we can account for more of the substantial volatility of currency and commodity prices by allowing for spillovers from one asset class to another.

The empirical section of the paper provided an examination of quarterly real exchange rate and commodity price returns since the mid-1970s in order to uncover evidence on the existence of commodity currencies and currency commodities. The commodity currencies considered were the Australian dollar, the Canadian dollar, and the New Zealand dollar, and the commodities were the IMF's indices of agricultural materials, beverages, food, metals, as well as oil prices. To uncover the simultaneous relationships between the two types of assets, a multivariate latent factor model was specified and estimated. The model decomposed volatility of the asset returns in the model into a set of independent factors consisting of a common factor, a commodity–currency factor, a commodity factor, and spillovers across each type of market. Spillovers from currencies (commodities) to commodities (currencies) were modeled by the lagged impact that the factor specific to the exchange-rate (commodity) returns had on the commodity (currency) returns. The model also contained an idiosyncratic factor, which captured all movements not due to the joint factors.

The empirical results are contrary to common modeling and theoretical assumptions invoked in contemporary analyses of commodity currencies—we found less evidence that currencies are affected by commodities than that commodities are affected by the currencies. Spillovers from commodities to currencies contributed less than 1 percent to the volatility of the currency returns, while spillovers from currencies to commodities generally contributed between 2 and 5.2 percent to the commodities. These results suggested that commodity–currency models failing to account for endogeneity between currency and commodity returns may be misspecified.

This research is subject to several caveats.

- The commodity price data are obtained from the database of the IMF. The components of the commodity prices considered (agricultural materials, beverages, food, metals, and energy/oil) are not specifically tailored to the economies considered in the model. In future research, it may be worthwhile to use commodity price indices that are more representative of the commodities in which Australia, Canada, and New Zealand are dominant, or even to use relevant commodity prices themselves.
- Rather than examining the joint determination of currencies and commodities in a general framework with a number of currencies and commodities as adopted here, an alternative would be to assess the endogenous determination of a currency and commodity pairing. For example, one hypothesis could be that Australia is a price maker in the market for iron ore. Our model could be extended to examine this hypothesis in conjunction with the hypothesis that the price of iron ore has an impact on the Australian dollar by examining spillovers from the idiosyncratic factor specific to the exchange rate to the commodity price, and vice versa. This framework may indicate evidence of more specific sources of market power across the asset markets.
- Little attention has been devoted to the role of the terms of trade in the model. The role of the terms of trade is probably an important element in the story linking the endogenous determination of both exchange rates and commodity prices. Some of the commodities considered are representative of the exports of the countries included in the model, and others are considered imports. It is hence feasible to establish the impact that each commodity has on the terms of trade of each country, but again it is probably more desirable to have a series of commodities less generic in nature, as well as to consider the role of other imports, not commodity based such as manufactured goods, in order to analyze this situation comprehensively. Future research may explore this issue further.

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