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"Commodity Prices, Monetary Policy, and Currency Regimes"

Jeffrey Frankel

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Abstract

Commodity prices are back, with a vengeance. This paper will look at connections between monetary policy, and agricultural and mineral commodities. We begin with the monetary influences on commodity prices (first for a large country, then a small one). The claim is that low real interest rates lead to high real commodity prices. It will conclude with a consideration of the reverse causality: the possible influence of commodity prices on monetary policy under alternative currency regimes, and the argument for PEP (Peg the Export Price).

Introduction

Commodity prices are back, with a vengeance. In the 1970s, macroeconomic discussions were dominated by the oil price shocks and other rises in agricultural and mineral products that were thought to play a big role in the stagflation of that decade.[1] In the early 1980s, any discussion of alternative monetary regimes was not complete without a consideration of the gold standard and proposals for other commodity-based standards.

Yet the topic of commodity prices fell out of favor in the late 1980s and the 1990s. Commodity prices generally declined during that period; it must be that declining commodity prices are not considered as interesting as rising prices (unless you are a commodity producer). Nobody seemed to notice how many of the victims of emerging market crises in the 1990s were oil producers that were suffering, among other things, from low oil prices (Mexico, Indonesia, Russia) or others suffering from low agricultural prices (Brazil and Argentina). The favorable effect of low commodity prices on

[1] A small dissenting minority viewed the increases in prices of oil and other commodities in the 1970s as the *result* of overly expansionary US monetary policy, rather than as an exogenous supply shock (the result of the 1973 Arab oil embargo and the 1979 fall of the Shah of Iran) that caused inflation. After all, was it just a coincidence that other commodity prices had gone up at the same time, or in the case of agricultural products, had actually preceded the oil shocks?

macroeconomic performance -- in the US in the 1990s – delivering lower inflation than had been thought possible at such high rates of growth and employment, was occasionally remarked. But it was not usually described as a favorable supply shock, the mirror image of the adverse supply shocks of the 1970s, and it always received far less attention than the influence of other factors, such as the declining prices of semi-conductors and other information technology and communication equipment. Indeed, anyone who talked about sectors where the product was clunky and mundane as iron ore, crude petroleum, and soy beans was considered behind the times. Agriculture and mining were no longer a large share of the New Economy, and did not matter much in an age dominated by evanescent dotcoms, ethereal digital communication, and externally outsourced services.

Now that oil prices and many broader indices of commodity prices are at or near all-time highs in nominal terms, and are again very high in real terms as well, commodities are once again hot. It turns out that mankind has to live in the physical world after all ! Still, the initial reaction was relaxed, on several grounds. (1) Oil is no longer a large share of the economy; (2) Futures markets showed that the "spike" in prices was expected to be only temporary; and (3) Monetary policy need focus only on the core CPI inflation rate and can safely ignore the volatile food and energy component, unless or until it starts to get passed through into the core rate. But by late 2005, the increase in prices had gone far enough to receive more serious attention. This was especially true with regard to the perceived permanence of oil prices, largely because the futures price had gone from implying that the rise in the spot price was mostly temporary to implying that is mostly permanent.

Certain lessons of the past are well-remembered, such as the dangers of the Dutch Disease for countries undergoing a commodity export boom. But others have been forgotten, or were never properly absorbed.

With regard to point (2), it is curious that so many economists and central bankers are ready to accept that the futures price of oil is an unbiased forecast of the future spot price. This proposition of course would follow from the two propositions that the futures price is an accurate measure of expectations and that these in turn are rational. Both halves of the joint hypothesis are open to question. Few familiar with the statistics of forward exchange rates claim that they are an unbiased predictor of the future spot exchange rate. Few familiar with the statistics of the interest rate term structure claim that the long-term interest rate contains an unbiased predictor of future short term interest rates. Why, then, should we think that the oil futures price is an unbiased predictor of the future spot price? So the backwardation in oil prices in 2004 was not necessarily a reason to be complacent, and the flattening in 2005 was not necessarily a reason to worry.

With regard to point (3), it is time to examine more carefully the claim that if an increase in energy or agricultural prices does not appear in the core CPI, then monetary policy can ignore it. The current fashion is inflation-targeting, by which is usually meant targeting the CPI.[2] To be sure, the emphasis is on the core inflation rate "excluding the volatile food and energy sector." The current leadership of the Federal Reserve has frequently said that the oil-shock component of recent inflation upticks should be ignored and accommodated. But just because agricultural and mineral products are volatile, does

[2] Among many other references: Bernanke, et al (1999), Svensson (1995), and Truman (2003).

not mean that there is no useful information in them. The prices of gold and other minerals used to be considered a useful leading indicator of inflationary expectations, precisely because they moved ahead of sluggish prices of manufactured goods and services. Nor does the volatility mean that excluding such products from the price index that guides monetary policy is the right thing to do, even in those cases where there is little danger of a seemingly ad hoc self-pardon undermining the public credibility of the central bank. The many proponents of inflation targeting will argue that the regime, if properly instituted, makes clear from the beginning that it excludes volatile commodity prices, so that there is no loss in credibility. But then, should it on terms of trade grounds, especially in small open countries? It is not just a matter of wanting to stabilize the traded goods sector, though this is itself an important goal in a world where balance of payments deficits can lead to financial crises. There is also the point that the "core CPI" is not a concept that is especially well understood among the general proposition; thus the public will not necessarily be reassured when the central bank explains that they should not be worried about big increases in food and energy prices; thus targeting the core CPI may not buy as much credibility as targeting (with a wider band) something more easily understood, like the overall CPI, a producer price index, or even an export price index.

It is a tenet of international economics textbooks that a desirable property of a currency regime is that the exchange rate be allowed to vary with terms of trade shocks: that the currency automatically depreciates when world prices of the import commodity (say, oil for the US or Japan, or wheat for Korea or Saudi Arabia) go up, and that it automatically depreciates when world prices of the export commodity (say oil for Saudi Arabia and wheat for Canada) go down. Yet inflation targeting does not have this property. To keep the headline inflation rate constant one must respond to a rise on world markets in the dollar price of imported oil by tightening monetary policy and appreciating the currency against the dollar enough to prevent the domestic price of the importable from rising – the opposite from accommodating the adverse terms of trade shock. It is true that the core inflation rate does not share this unfortunate property with the headline rate [unless the price increase comes in non-mineral commodities like semi-conductors that are in the core]. But the other half of terms of trade shocks are declines on world markets in the price of a country's export commodity. Theory says that when the dollar price of oil goes down, Saudi Arabia or Iraq or Nigeria ought to depreciate against the dollar. But inflation targeting – *either* the headline CPI variety *or* the core CPI variety -- does allow this result. One would need to target a price index that specifically included prominently the price of the exportable. The fundamental difficulty is that excluding the volatile food and energy components is not sufficient to accommodate the terms of trade if some variable imports lie outside those two sectors nor if some exports lie within those two sectors.

Throughout this paper we will adopt the familiar assumption that all goods can be divided into agricultural and mineral commodities, on the one hand, and manufactured goods and services on the other hand, and that the key distinction is that prices of the former are perfectly flexible, so that their markets always clear, and that prices of the latter are sticky in the short run, so that their markets do not.[3] The plan is to look at connections between commodities and monetary policy. We begin with the monetary influences on commodity prices (first for a large country, then a small one). We conclude with the possible influence of commodity prices on monetary policy in a consideration of the proposal to Peg the Export Price (PEP).

1. Effect of short-term real interest rates on real commodity prices

One purpose of this paper is to assert the claim that monetary policy, as reflected in real interest rates, is an important – and usually under-estimated -- determinant of the real prices of oil and other mineral and agricultural products, while far from the only determinant.

The argument can be stated in an intuitive way that might appeal to practioners, as follows. High interest rates reduce the demand for storable commodities, or increase the supply, through a variety of channels:

- by increasing the incentive for extraction today rather than tomorrow (think of the rates at which oil is pumped, copper is mined, forests logged, or livestock herds culled)
- by decreasing firms' desire to carry inventories (think of oil inventories held in tanks)
- by encouraging speculators to shift out of commodity contracts (spot and forward), and into treasury bills.

All three mechanisms work to reduce the market price of commodities, as happened when real interest rates where high in the early 1980s. A decrease in real interest rates has the opposite effect, lowering the cost of carrying inventories, and raising commodity prices, as happened during 2001-2004. As the Fed funds rate rises in 2005-06, one can expect commodity prices eventually to come back down. Call it part of the unwinding of the "carry trade."[4]

a. Theory: The overshooting model

The theoretical model can be summarized as follows. A monetary contraction temporarily raises the real interest rate (whether via a rise in the nominal interest rate, a fall in expected inflation, or both). Real commodity prices fall. How far? Until commodities are widely considered "undervalued" -- so undervalued that there is an

[3] For young readers, I will record that these distinctions were originally due to Arthur Okun (who called them auction goods vs. customer goods).

[4] "Why Are Oil and Metal Prices High? Don't Forget Low Interest Rates," Jeffrey Frankel (published as "Real Interest Rates Cast a Shadow Over Oil," *Financial Times,* April 15, 2005.

expectation of future appreciation (together with other advantages of holding inventories, namely the "convenience yield") that is sufficient to offset the higher interest rate (and other costs of carrying inventories: storage costs plus any risk premium). Only then are firms willing to hold the inventories despite the high carrying cost. In the long run, the general price level adjusts to the change in the money supply. As a result, the real money supply, real interest rate, and real commodity price eventually return to where they were.

The theory is the same as Rudiger Dornbusch's (1976) famous theory of exchange rate overshooting, with the price of commodities substituted for the price of foreign exchange - and with convenience yield, minus storage costs, substituted for the foreign interest rate.[5] The deep reason for the overshooting phenomenon is that prices for agricultural and mineral products adjust rapidly, while most other prices adjust slowly.[6]

The theory can be reduced to its simplest algebraic essence as a claimed relationship between the real interest rate and the spot price of a commodity relative to its expected long-run equilibrium price. This relationship can be derived from two simple assumptions. The first one governs expectations. Let

$s \equiv$ the spot price,

$\bar{s} \equiv$ its long run equilibrium,

$p \equiv$ the economy-wide price index,

$q \equiv s\text{-}p$, the real price of the commodity, and

$\bar{q} \equiv$ the long run equilibrium real price of the commodity,

all in log form. Market participants who observe the real price of the commodity today lying above or below its perceived long-run value, expect it in the future to regress back to equilibrium over time, at an annual rate that is proportionate to the gap:

$$E\,[\,\Delta\,(s-p)\,] = E[\,\Delta q] = -\,\theta\,(q-\bar{q})\,. \qquad (1)$$

Or

$$E\,(\Delta s) = -\,\theta\,(q-\bar{q}) + E(\Delta p). \qquad (2)$$

[5] Frankel (1986).

[6] Frankel (1984)

Following the classic Dornbusch overshooting paper, we begin by simply asserting that reasonableness of the form of expectations in these equations: a tendency to regress back toward long run equilibrium. But, as in that paper, it can be shown that regressive expectations are also rational expectations, under certain assumptions regarding the stickiness of other goods prices (manufactures and services) and certain restrictions on parameter values.

The second equation concerns the decision whether to hold the commodity for another period – either leaving it in the ground or on the trees or holding it in inventories – or to sell it at today's price and deposit the proceeds in the bank to earn interest. The arbitrage condition is that the expected rate of return to these two alternative courses of action must be the same:

$$E\,\Delta s + c = i, \qquad (3)$$

where

$c = cy - sc - rp$

cy = convenience yield from holding the stock

sc = storage costs (e.g., security to prevent plundering by others, rental rate on oil tanks or oil tankers, etc.),

rp = risk premium, which is positive if being long in commodities is risky, and

i = the interest rate.

Combine equations (2) and (3):

$$-\theta\,(q-\bar{q}) + E(\Delta p) + c = i,.$$

$$q-\bar{q} = -(1/\theta)\,(i - E(\Delta p) - c)\,. \qquad (4)$$

Equation (4) says that the real price of the commodity [measured relative to its long-run equilibrium] is proportional to the real interest rate [measured relative to a constant term that depends on convenience yield]. When the real interest rate is high, as in the 1980s, money flows out of commodities, just as it flows out of foreign currencies, emerging markets, and other securities. Only when the prices of these alternative assets are perceived to lie sufficiently below their future equilibria will the arbitrage condition be met.] When the real interest rate is low, as in 2001-05, money flows into commodities, just as it flows into foreign currencies, emerging markets, and other securities. Only when the prices of these alternative assets are perceived to lie sufficiently above their future equilibria will the arbitrage condition be met.

b. The simplest test

One can imagine a number of ways of testing the theory.

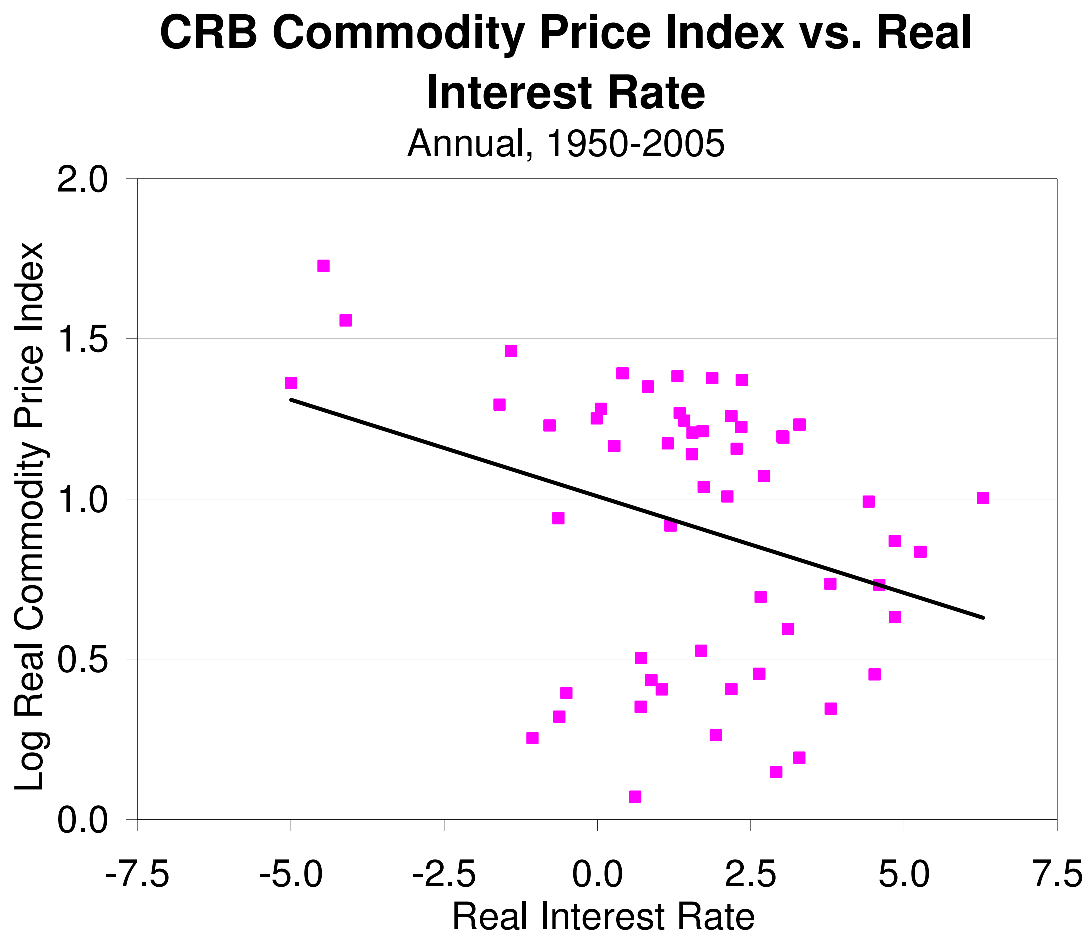
One way of isolating the macroeconomic effects on commodity prices is to look at jumps in financial markets that occur in immediate response to government announcements that change perceptions of monetary policy, as was true of Fed money supply announcements in the early 1980s. Money announcements that caused interest rates to jump up would on average cause commodity prices to fall, and vice versa. The experiment is interesting, because news regarding supply disruptions and so forth is unlikely to have come out during the short time intervals in question.[7]

The relationship between the real commodity price and the real interest rate, equation (4), can be tested directly, because variables can be measured fairly easily. This is the test we pursue here.

We begin with a look at some plots. Three major price indices that have been available since 1950 -- from Dow Jones, Commodity Resources Board, and Moody's, are used in the first three figures. (In addition two others, that started later than 1950, are illustrated in an Appendix I). To compute the real commodity price we take the log of the commodity price index minus the log of the CPI. To compute the real interest rate, we take the one-year interest rate and subtract off the one year inflation rate observed over the preceding year. The negative relationship predicted by the theory seems to hold.

We next apply OLS regression to these data.

[7] Frankel and Hardouvelis (1985).



Source: Global Financial Data Inc.

We should not expect the relationship to hold precisely in practice. It would be foolish to think that the equation captures everything. In reality, a lot of other things beyond real interest rates influence commodity prices. There are bound to be fluctuations both in $\bar{q}$, the long-run equilibrium real price, and c, which includes convenience yield, storage costs, and risk premium, and these fluctuations are not readily measurable. Such factors as weather, political vicissitudes in producing countries, and so forth, are likely to be very important when looking at individual commodities. Indeed analysts of oil or coffee or copper pay rather little attention to macroeconomic influences, and most of their time to microeconomic determinants. Oil prices have been high in 2004-05 in large part due to booming demand from China and feared supply disruptions in the Middle East, Russia, and Venezuela. There may now be a premium built in to the convenience yield arising from the possibilities of supply disruption related to terrorism, Mideast uncertainty, and related risks. Yet another factor concerns the proposition that the world supply of oil may be peaking in this decade, as new discoveries lag behind consumption (Hubbert's Peak). This would imply that $\bar{s}$, the world long run equilibrium real price of oil has shifted upward. Other factors apply to other commodities. In coffee, the large-scale entry of Vietnam into the market has lowered prices in recent years. Corn, sugar, and cotton are heavily influenced by protectionist measures and subsidies in many countries. And so on.

Such effects in individual commodities partially average out when looking at a basket average of commodity prices. This is one reason to use aggregate indices in the tests reported below.

Table 1 reports regressions of real commodity prices over the period 1950-2005. The results are statistically significant at the 5% level for all three of the major price indices that have been available since 1950 -- from Dow Jones, Commodity Resources Board, and Moody's – and significant for one of the two with a shorter history (Goldman Sachs). All are of the hypothesized negative sign. The estimated coefficient for the CRB, -.06, is typical. It suggests that when the real interest rate goes up 1 percentage point (100 basis points), it lowers the real commodity price by .06, i.e. 6 per cent. It also suggests that the estimate for $1/\theta = 6$, so $\theta = .16$. In other words, the expected speed of adjustment per year is estimated at 16%. The expected half-life is about 3 years (.84 to the 3rd power =.53).

Table 1: Regression of log real commodity prices on real interest rates over whole sample (1950-2005). Results by commodity indices, individual commodities and fixed-effects panel of commodities.

Log Real Commodity Prices and Interest Rates sample: **1950-2005** (56 annual observations) *real interest rate in % and real commodity prices in log units*			
	Coefficient	**Std error**	**sig. 5%**
Goldman Sachs (1969-)	-0.080	0.029	*
Dow Jones	-0.070	0.023	*
CRB	-0.060	0.024	*
Moodys	-0.058	0.014	*
Reuters (1959-)	-0.009	0.024	
COMMODITIES (by coefficient in ascending order)			
Sugar	-0.144	0.035	*
Soy bean oil	-0.096	0.030	*
Corn	-0.091	0.032	*
Rubber	-0.090	0.037	*
Wheat	-0.088	0.033	*
Lead	-0.071	0.022	*
Oats	-0.066	0.029	*
Soy beans	-0.064	0.027	*
Cocoa	-0.063	0.035	
Cotton	-0.061	0.030	*
Zinc	-0.050	0.018	*
Cattle	-0.048	0.016	*
FIXED-EFFECTS PANEL	-0.046	0.006	*
Nickel	-0.032	0.018	
Hogs	-0.031	0.022	
Copper	-0.026	0.028	
Tin	-0.026	0.032	
Aluminium	-0.022	0.017	
Coffee	-0.015	0.038	
Palladium	-0.012	0.025	
Silver	0.002	0.031	
Platinum	0.003	0.014	
Oil	0.009	0.028	
Gold	0.025	0.032	
Source: Global Financial Data			

The table also reports results for 22 individual commodities (presented in order of the size of the estimated coefficient). Despite our fears that sector-specific microeconomic factors swamp the macroeconomic influences for individual commodities, the coefficient is of the hypothesized sign in 19 our of 22 cases and is statistically significant in half (11 out of 22). Interestingly oil is the worst of the 22, showing an insignificant positive coefficient ! A fixed effects panel, incorporates the information for all the individual commodities, with the coefficient constrained to be the same. The coefficient is estimated at -.046 and is highly significant statistically.

c. An Effect on Inventories?

Since one of the hypothesized mechanisms of transmission from real interest rates to real commodity prices runs via the demand for inventories, it may be instructive to look at inventory data. Appendices 2 and 3 report the results for oil inventories. The coefficient on the real interest rate is often negative, as hypothesized, and often statistically significant, especially when controlling for other determinants of inventory demand such as the spot-futures spread (representing convenience yield), political risk in the Mideast, and industrial production. But the results are by no means uniform or robust. We have not yet explored inventories for other minerals.

We have also looked at agricultural inventories, as reported in Appendix 4. Here there is strikingly little evidence of an effect of real interest rates.

2. The relationship in small countries

a. Adding exchange rate overshooting to commodity price overshooting

In the preceding analysis, we have expressed everything – nominal commodity prices, CPI, interest rates -- in dollars. In this section we recognize that the US is less than 1/3 of Gross World Product, even if its importance in monetary and financial markets seems to be greater than that.

We could begin by redoing the previous econometrics with global measures of each of the variables, i.e., measuring the commodity price in a GDP-weighted averages of the dollar, euro, yen, etc., measuring the world interest rate as a weighted average of national interest rates, and measuring the CPI and inflation rates as the same-weighted average of national CPIs and inflation rates. But instead we leave this as a possible extension for future research. Instead we take the US variables to be the global variables, and we proceed directly to look at small countries that by definition take the US/global variables as given.

The log spot price of the commodity in terms of currency *j* is given by

$$s_j = s_{(j/\$)} + s_{(\$/c)}, \qquad (5)$$

where $s_{ji/\$)}$ is the spot exchange rate in units of currency *j* per \$ and $s_{(\$/c)}$ is the spot price of commodity c in terms of \$, what has hitherto been called simply *s* for the dollar case.

The real exchange rate between currency j and the dollar is governed by the direct application of the Dornbusch overshooting model.

$$(s_{(j/\$)} - \bar{s}_{(j/\$)}) - (p_j - \bar{p}_j) + (p_\$ - \bar{p}_\$) = -(1/\upsilon)(i_j - i_\$ - [E(\Delta p_j) - E(\Delta p_\$)]). \qquad (6)$$

Combining with equations (4) and (5), …

$$(s_{(j/c)} - \bar{s}_{(j/c)}) = (s_{(j/\$)} - \bar{s}_{(j/\$)}) + (s_{(\$/c)} - \bar{s}_{(\$/c)})$$
$$= (p_j - \bar{p}_j) - (1/\upsilon)(i_j - i_\$ - [E(\Delta p_j) - E(\Delta p_\$)]) - (1/\theta)(i_\$ - E(\Delta p_\$) - \mathrm{c}) .$$

$$(q_{(j/c)} - \bar{q}_{(j/c)}) = -(1/\upsilon)(r_j - r_\$) - (1/\theta)(r_\$ - \mathrm{c}) . \qquad (6)$$

where
$r_\$$ is the US interest rate
r_j is the interest rate in country j .
Equation (7) says the real commodity price observed in country j will be high to the extent either that the local real interest rate is low relative to the US real rate, or to the extent that the US real interest rate is low. This equation can be tested for individual countries with independently floating currencies.

[ECONOMETRICS STILL TO BE DONE]

b. Adding exogenous terms of trade shocks (in a 3 good model: export commodity, import commodity, and NTGs)

3. The choice of monetary regime

a. Objectives: price stability, output, balance of payments
b. PEP (Peg the Export Price)
c. Vulnerabilities of CPI targeting, fixed exchange rate, and other regimes
d. Comparison of regimes: theory with shocks.

Among the many travails of developing countries in recent years have been fluctuations in world prices of the commodities that they produce, especially mineral and agricultural commodities, as well as fluctuations in the foreign exchange values of major currencies, especially the dollar, yen, and euro. Some countries see the currency to which they are linked moving one direction, while their principal export commodities move the opposite direction.

Consider the difficult position of Argentina, the victim of the worst emerging market financial crisis of 2001. As is well-known, Argentina's "convertibility plan," a rigid currency board, was very successful at eliminating very high inflation rates when it was first instituted in 1991, but later turned out to be unsustainably restrictive. Perhaps it would have been impossible in any case to obey constraints as demanding as the straightjacket of the currency board. But Argentina's problems in the late 1990s became especially severe because the link was to a particular currency, the US dollar, that appreciated sharply against other major currencies, beginning in mid-1995. At the same time, the market for Argentina's important agricultural export products (wheat, meat, and soybeans), declined sharply. Thus the declines in the prices of these commodities expressed in terms of dollars were particularly dramatic. The combination led directly to sharp increases in the ratio of debt to exports. Although the particular strong dollar episode was not predictable when the currency regime was adopted in 1991, the likelihood that large swings of this sort would eventually occur was predictable. This is because the correlation is low between the value of the dollar and the value of commodities (expressed in some common numeraire). It was only a matter of time until they went sharply in opposite directions.

Argentina's difficulties encouraged some to reconsider whether a currency board is a good idea after all. But perhaps more thought should be given to *what* anchor the peso has been pegged to, rather than the tightness of the peg.

The author has suggested a new proposal, called PEP, for Peg the Export Price. The idea is most relevant for a country that is relatively specialized in the production and export of a particular mineral or agricultural commodity. The proposal is to commit to a monetary policy that fixes the local-currency price of the export commodity. It is *not* a proposal to try to stabilize the *dollar* price of the commodity; that would be futile, especially under the assumption that the country in question is too small to affect the commodity price on world markets. Operationally, the most practical way to implement the PEP proposal might be for the local central bank to announce a daily exchange rate against the dollar that varies perfectly with the dollar price of the commodity in question on world markets, and to intervene to defend that exchange rate. That technique would be equivalent to fixing the price of the commodity in terms of local currency.

Monetary theorists have in the past emphasized a particular argument in favor of regimes that fix the value of money: as a means for the central bank to establish a credible commitment against inflation. This argument usually leaves out the question whether one means of fixing the value of the money is superior to another. It is as if it doesn't matter whether the anchor is the dollar or the Swiss franc or gold, or any other stable currency or commodity. In reality, the choice of anchor can make an important difference. Lithuania can get into trouble if it links it currency to the dollar, when most of its trade is with Europe; the euro would be better, because so much of Lithuania's trade is with the European Union. Analogously, Argentina might be better off pegging to wheat, than pegging to the dollar. Ghana might be better off pegging to gold. Chile might be better off pegging to copper. Venezuela might be better off pegging to oil.

Part I of the paper elaborates on the basic argument. Part II shows how the proposal might work concretely through a set of simulations. We consider a list of developing countries that specialize in oil. How would the export competitiveness and financial health of each have been affected over the last 30 years by some alternative currency pegs -- to oil , to the dollar, to the euro or to the yen -- as opposed to the currency regime that it actually followed? A new theoretical appendix can be considered Part III; it compares the stabilizing properties of the proposal to Peg the Export Price to two alternatives: pegging the exchange rate and pegging the CPI.

I. Pros and Cons of Different Monetary Regimes

Much has been written on the arguments for fixed versus flexible exchange rates.[8]

[8] Recent surveys appear in Edwards (2002), Eichengreen (1994), and Frankel (1999, 2003).

The Nominal Anchor Argument for Fixing the Value of Currency

There are a variety of advantages to fixed exchange rates. In recent decades, the leading argument for firmly fixing exchange rates is as a credible commitment by the central bank, to affect favorably the expectations of those who determine wages, prices, and international capital flows by convincing them that they need not fear inflation or depreciation. The desire for a credible commitment to a stable monetary policy arose as a reaction to the high inflation rates of the 1970s, which in the 1980s reached hyperinflation levels in a number of developing countries. But fixing the value of the domestic currency in terms of foreign currency is not the only way that a country can seek a credible institutional commitment to non-inflationary monetary policy.

Governments can achieve anti-inflation credibility by being seen to tie their hands in some way so that in the future they cannot follow expansionary policies even if they want to. Otherwise, they may be tempted in a particular period (such as an election year) to reap the short-run gains from expansion, knowing that the major inflationary costs will not be borne until the future. A central bank can make a binding commitment to refrain from excessive money creation via a rule, a public commitment to fix a nominal magnitude.

Currency boards or other firm exchange rate pegs constitute one of a number of possible nominally anchored monetary regimes. Others include monetarism, inflation targeting, nominal income targeting, and a gold standard. In each case, the central bank is deliberately constrained by a rule setting monetary policy so as to fix a particular magnitude – the exchange rate, the money supply, the inflation rate, nominal income, or the price of gold. Monetary policy is automatically tightened if the magnitude in question is in danger of rising above the pre-set target, and is automatically loosened if the magnitude is in danger of falling below the target. The goal of such nominal anchors is to guarantee price stability.

Preventing excessive money growth and inflation is the principal "pro" argument for fixing the price of gold or some other nominal anchor. What are the disadvantages? The overall argument against the rigid anchor is that a strict rule prevents monetary policy from changing in response to the needs of the economy. The general problem of mismatch between the constraints of the anchor and the needs of the economy can take three forms: (1) loss of monetary independence, (2) loss of automatic adjustment to export shocks, and (3) extraneous volatility.

First, under a free-floating currency, a country has monetary independence. In a recession, when unemployment is temporarily high and real growth temporarily low, the central bank can respond by increasing money growth, lowering interest rates, depreciating the currency, and raising asset prices, all of which work to mitigate the downturn. Under a pegged currency, however, the central bank loses that sort of freedom. It must let recessions run their course. But the last few decades have seen widespread disillusionment, both among academics and practitioners, with the proposition that governments are in practice able to use discretionary monetary policy in an intelligent and useful way. This is particularly true in the case of developing countries. As a consequence, the trend in the 1990s was away from government discretion in monetary policy and toward the constraints of nominal anchors.

The second point is that even if the central bank lacks the reflexes to pursue a skillful and timely discretionary monetary policy, under a floating exchange rate a deterioration in the international market for a country's exports should lead to an automatic fall in the value of its currency. The resulting stimulus to production will mitigate the downturn even without any deliberate action by the government. Some have argued, for example, that Australia came through the 1997-98 Asian crisis in relatively good shape because its currency was free to depreciate automatically in response to the deterioration of its export markets. Canada and New Zealand, like Australia, are said to be commodity-exporting countries with floating currencies that automatically depreciate when the world market for their export commodities is weak. Again, this mechanism is normally lost under a rigid nominal anchor.

A third consideration makes the pegging problem still more difficult. If a country has rigidly linked its monetary policy to some nominal anchor, exogenous fluctuations in that anchor will create gratuitous fluctuations in the country's monetary conditions that may not be positively correlated with the needs of that particular economy.

Each Candidate for Nominal Anchor has its Own Vulnerability

Each of the various magnitudes that are candidates for nominal anchor has its own characteristic sort of extraneous fluctuations that can wreck havoc on a country's monetary system.

- A ***monetarist*** rule would specify a fixed rate of growth in the money supply. But fluctuations in the public's demand for money or in the behavior of the banking system can directly produce gratuitous fluctuations in velocity and the interest rate, and thereby in the real economy. For example, in the United States, a large upward shift in the demand for money around 1982 convinced the Federal Reserve Board that it had better abandon the money growth rule it had adopted two years earlier, or else face a prolonged and severe recession.

- To some, the novel idea of pegging the currency to the price of the export good, which this study puts forward, may sound similar to the current fashion of ***targeting the inflation rate*** or price level.[9] But the fashion, in such countries as the United Kingdom, Sweden, Canada, New Zealand, Australia, Chile and Brazil, is to target the CPI. A key difference between the CPI (or GDP deflator) and the export price is the terms of trade. When there is an adverse movement in the terms of trade, one would like the currency to depreciate, while price level targeting can have the opposite implication. If the central bank has been constrained to hit an inflation target, positive oil price shocks (as in 1973, 1979, or 2000), for example, will require an oil-importing country to tighten monetary policy. The result can be sharp falls in national output. Thus under rigid inflation targeting, supply or terms-of-trade

[9] Among many possible references are Svensson (1995) and Bernanke, et al. (1999).

shocks can produce unnecessary and excessive fluctuations in the level of economic activity. [This point is demonstrated in the new theory appendix.]

- The need for robustness with respect to import price shocks argues for the superiority of ***nominal income targeting*** over inflation targeting.[10] A practical argument against nominal income targeting is the difficulty of timely measurement. For developing countries in particular, the data are sometimes available only with a delay of one or two years.

- Under a ***gold standard***, the economy is hostage to the vagaries of the world gold market. For example, when much of the world was on the gold standard in the 19th century, global monetary conditions depended on the output of the world's gold mines. The California gold rush from 1849 was associated with a mid-century increase in liquidity and a resulting increase in the global price level. The absence of major discoveries of gold between 1873 and 1896 helps explain why price levels fell dramatically over this period. In the late 1890s, the gold rushes in Alaska and South Africa were each again followed by new upswings in the price level. Thus the system did not in fact guarantee stability.[11]

- One proposal is that monetary policy should ***target a basket of basic mineral and agricultural commodities***. The idea is that a broad-based commodity standard of this sort would not be subject to the vicissitudes of a single commodity such as gold, because fluctuations of its components would average out somewhat.[12] The proposal might work if the basket reflected the commodities produced and exported by the country in question. But for a country that is a net importer of oil, wheat, and other mineral and agricultural commodities, such a peg gives precisely the wrong answer in a year when the prices of these import commodities go up. Just when the domestic currency should be depreciating to accommodate an adverse movement in the terms of trade, it appreciates instead. Brazil should not peg to oil, and Kuwait should not peg to wheat.

- Under a ***fixed exchange rate***, fluctuations in the value of the particular currency to which the home country is pegged can produce needless volatility in the country's international price competitiveness. For example, the appreciation of the dollar from 1995 and 2001 was also an appreciation for

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[10] Velocity shocks argue for the superiority of nominal income targeting over a monetarist rule. Frankel (1995) demonstrates the point mathematically, using the framework of Rogoff (1985), and gives other references on nominal income targeting.

[11] Cooper (1985) or Hall (1982).

[12] A "commodity standard" was proposed in the 1930s – by B. Graham (1937) – and subsequently discussed by Keynes (1938), and others. It was revived in the 1980s: e.g., Hall (1982).

> whatever currencies were linked to the dollar. Regardless the extent to which one considers the late-1990s dollar appreciation to have been based in the fundamentals of the US economy, there was no necessary connection to the fundamentals of smaller dollar-linked economies. The problem was particularly severe for some far-flung economies that had adopted currency boards over the preceding decade: Hong Kong, Argentina, and Lithuania.
>
> Dollar-induced overvaluation was also one of the problems facing such victims of currency crisis as Mexico (1994), Thailand and Korea (1997), Russia (1998), Brazil (1999) and Turkey (2001), even though none of these countries had formal rigid links to the dollar. It is enough for the dollar to exert a large pull on the country's currency to create strains. The loss of competitiveness in non-dollar export markets adversely impacts such measures of economic health as real overvaluation, exports, the trade balance, and growth, or such measures of financial health as the ratios of current account to GDP, debt to GDP, debt service to exports, or reserves to imports.

To recap, each of the most popular variables that have been proposed as candidates for nominal anchors is subject to fluctuations that will add an element of unnecessary monetary volatility to a country that has pegged its money to that variable: velocity shocks in the case of M1, supply shocks in the case of inflation targeting, measurement errors in the case of nominal GDP targeting, fluctuations in world gold markets in the case of the gold standard, and fluctuations in the anchor currency in the case of exchange rate pegs.

Consider further the case of pegs to the dollar or other major currencies. Each of the currency crisis victims listed above (1994-2001) has since abandoned its links to the dollar or to the basket that included the dollar -- as have Chile, Colombia and others – in favor of greater flexibility. Nevertheless, they continue to exhibit a "fear of floating." Brazil found in 2002 that free floating offered little protection against financial pressure. Few countries are comfortable that they have found the right answer. Alternative suggestions are still welcome.

We now address the question: given a degree of commitment by a country to fix the value of its currency, what anchor should it use? This question is best illustrated – not by those countries who have abandoned pegs for enhanced flexibility, nor even by those who have moved in the opposite direction -- but, rather, by a country that has moved from one rigid peg to another. Lithuania, while retaining a currency board arrangement, responded to the difficulties created by the late-1990s appreciation of the dollar by switching recently from a dollar anchor to the euro. Argentina also debated some sort of switch. Economy Minister Cavallo, in 2001 before his resignation and the abandonment of the convertibility system, had announced an eventual move to a currency board with an anchor defined as a basket of one half dollar and one half euro. In both cases, a large part of the motivation was an overvaluation stemming from the late-90s appreciation of the dollar.

The strong dollar of 1996-2001 was a transitory phenomenon. From 1988 to 1995 the dollar was weak. When the dollar weakens again, it will be the countries that are pegged to the euro that will lose competitiveness. The relevant question is the choice of regime for the longer term, when it is not known which currencies will be weak and which strong, but it is expected that swings in both directions will eventually occur.

For those small countries that want a nominal anchor and that happen to be concentrated in the production of a mineral or agricultural commodity, a peg to that commodity may in fact make perfect sense. For them fluctuations in the international value of their currency that follow from fluctuations in world commodity market conditions would not be an extraneous source of volatility. Rather they would be precisely the sort of movements that are desired, to accommodate exogenous changes in the terms of trade and minimize their overall effect on the economy. In these particular circumstances, the automatic accommodation or insulation that is normally thought to be the promise held out only by floating exchange rates, is instead delivered per force by the pegging option. Thus PEP gives the best of both worlds: adjustment to trade shocks *and* the nominal anchor.

Past writings of the author have illustrated the point with simulations, concentrating on the cases of gold producers, oil producers, agricultural producers, and others.[13] In some episodes, particularly the early 1980s and late 1990s, countries that linked to the dollar got into trouble during a period when the dollar was strong and commodity prices were weak. Eventually they were forced by the adverse terms of trade shocks and a drying up of international finance into a painful currency crisis. The general conclusion from the simulations is that under the PEP proposal, the currency would have depreciated automatically, providing the needed accommodation to the adverse shift in the terms of trade, without the loss in credibility attendant to an abandonment of a declared nominal anchor.

I have not previously published a theoretical model to illustrate the point. Appendix 4 is an attempt to do that. It shows the importance of accommodating shocks to the prices of a country's imports and exports, and the advantages of PEP in helping to do this. The first half of this paper derived some equations linking commodity prices to monetary conditions. These equations could be integrated with appendix 4. Then other shocks could be added: to the long-term equilibrium real commodity price and to global monetary policy. The choice of regime might be seen to be depend on the relative importance of temporary terms of trade shocks versus others.

[13] Frankel 2002, 2003, 2005) and Frankel and Saiki (2002)

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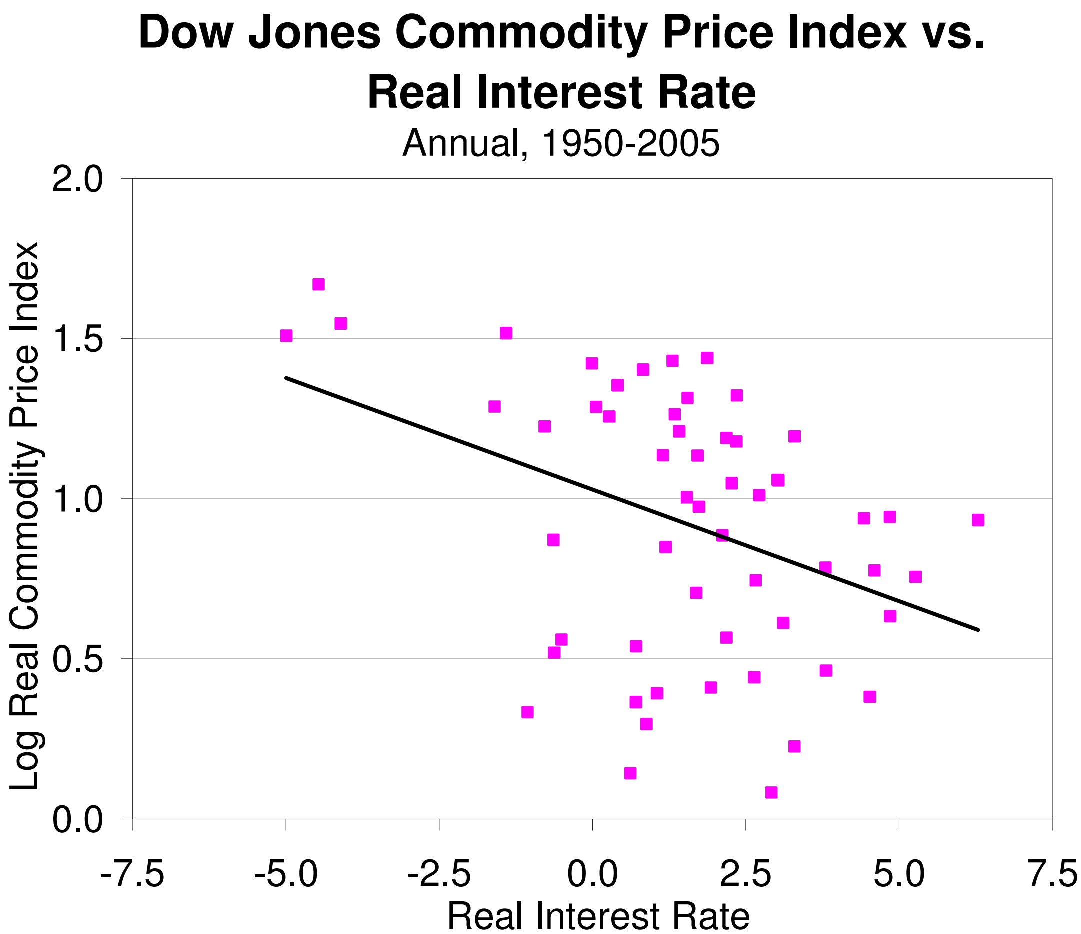
Appendix I to "Commodity Prices, Monetary Policy, and Currency Regimes,"
Jeffrey Frankel; Research Asst.: Ellis Connolly



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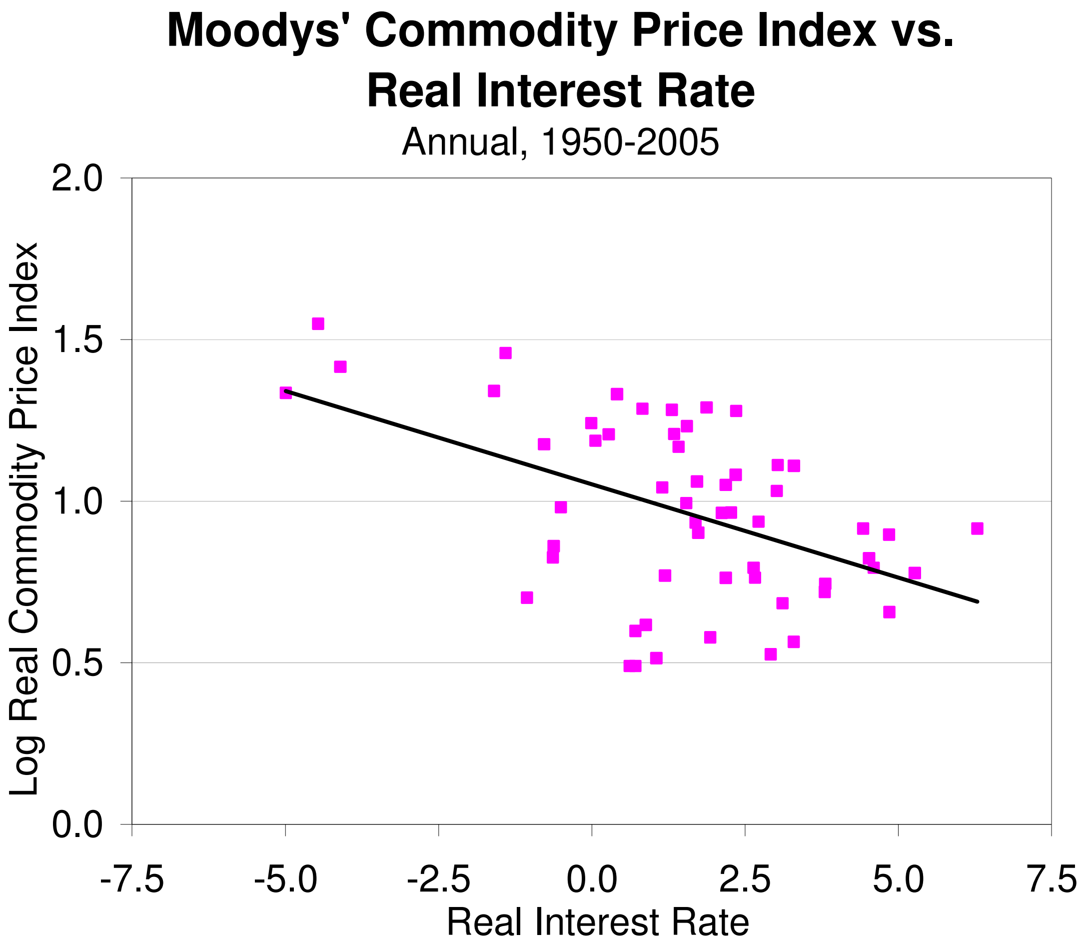

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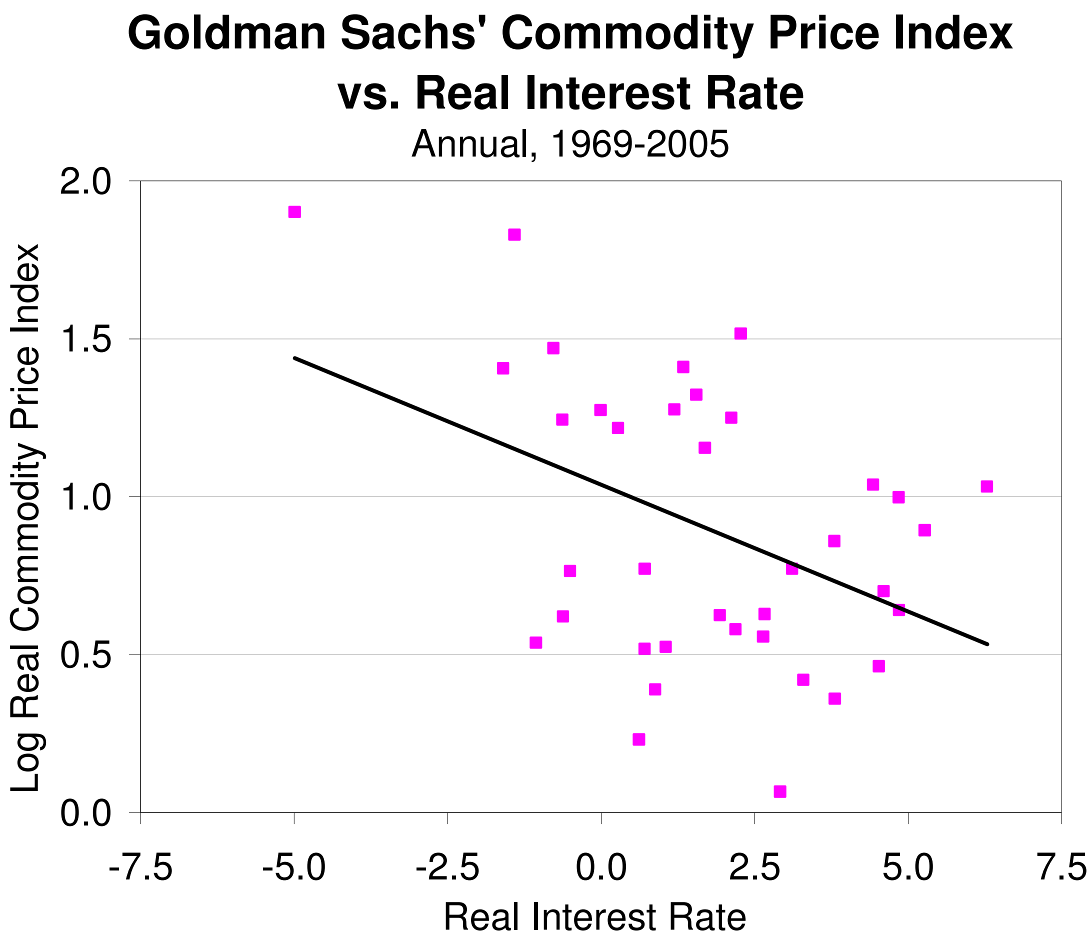

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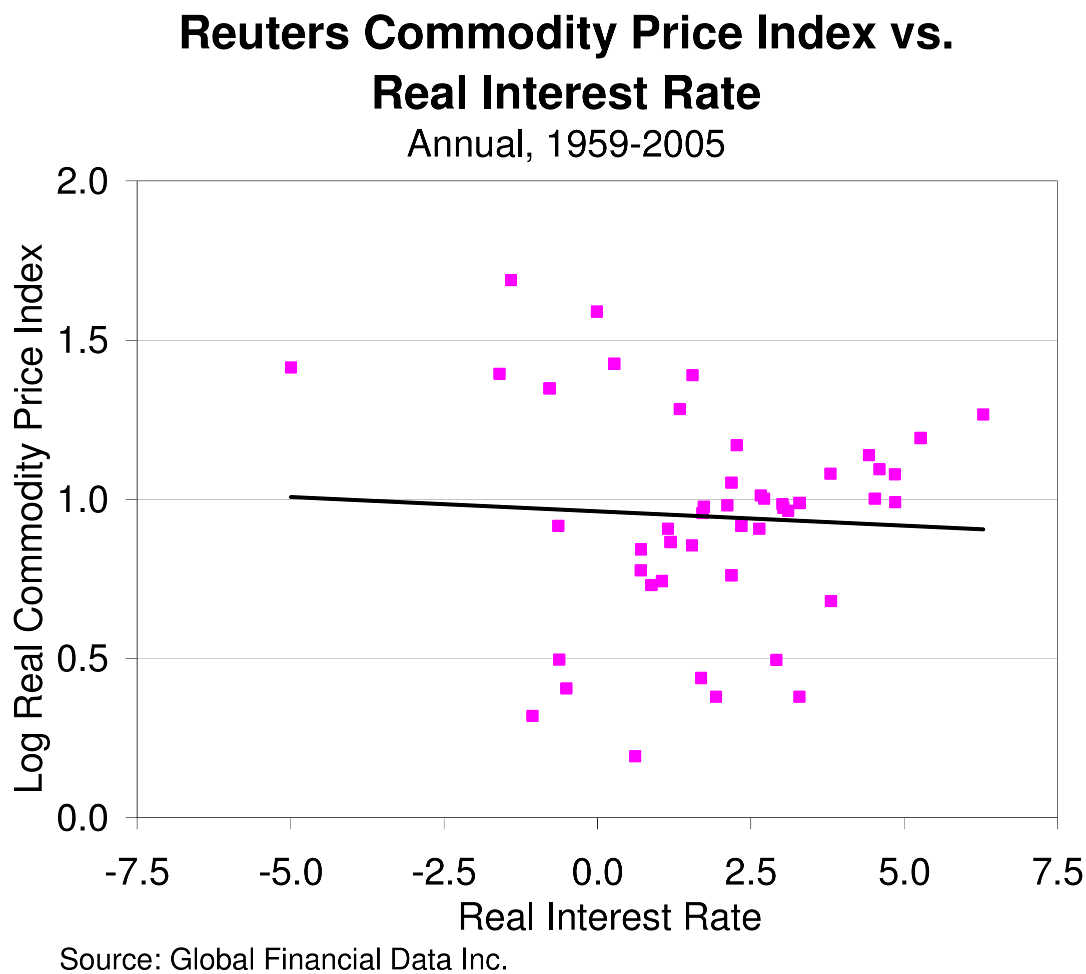


The results in Table 1 suggested that the significant negative relationship between commodity prices and interest rates is reasonably robust across commodity price measures. Is the result is robust over time? It appears that the negative correlation is significant over 1950-1979 (Table 1a). However, since 1980, there does not appear to be a stable relationship between log real commodity prices and the real interest rate (Table 1b). The same is true if the sample is divided at 1976 or 1982.

Table 1a: Regression of log real commodity prices on real interest rates over 1950-1979. Results by commodity indices, individual commodities and fixed-effects panel of commodities.

Log Real Commodity Prices and Interest Rates sample: **1950-1979** (30 annual observations) *real interest rate in % and real commodity prices in log units*			
	Coefficient	**Std error**	**sig. 5%**
Reuters (1959-)	-0.080	0.023	*
Goldman Sachs (1969-)	-0.078	0.028	*
Dow Jones	-0.060	0.015	*
Moodys	-0.052	0.013	*
CRB	-0.044	0.012	*
COMMODITIES (by coefficient in ascending order)			
Sugar	-0.173	0.040	*
Gold	-0.117	0.036	*
Soy bean oil	-0.093	0.021	*
Zinc	-0.090	0.025	*
Oil	-0.085	0.032	*
Corn	-0.071	0.017	*
Cocoa	-0.070	0.037	
Silver	-0.068	0.044	
Palladium	-0.067	0.023	*
Wheat	-0.061	0.024	*
Rubber	-0.058	0.041	
FIXED-EFFECTS PANEL	-0.056	0.006	*
Coffee	-0.055	0.028	
Oats	-0.053	0.015	*
Soy beans	-0.048	0.014	*
Tin	-0.048	0.027	
Lead	-0.042	0.018	*
Cotton	-0.034	0.025	
Platinum	-0.030	0.015	*
Cattle	-0.026	0.014	
Hogs	-0.020	0.024	
Nickel	-0.014	0.017	
Aluminium	0.000	0.011	
Copper	0.029	0.021	
Source: Global Financial Data			

Table 1b: Regression of log real commodity prices on real interest rates over 1980-2005. Results by commodity indices, individual commodities and fixed-effects panel of commodities.

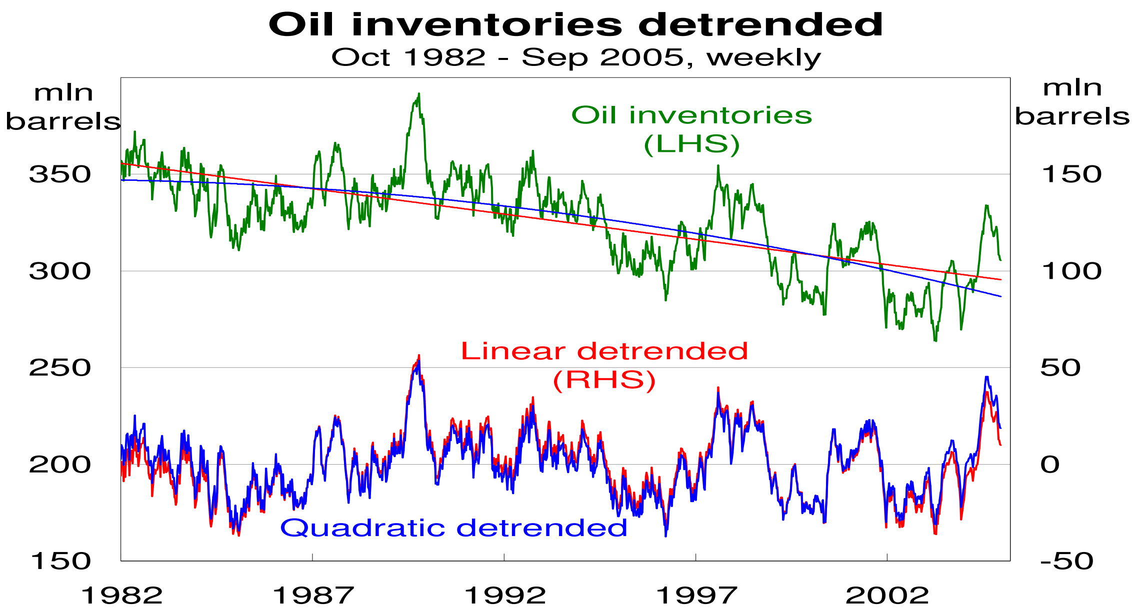
Log Real Commodity Prices and Interest Rates sample: **1980-2005** (26 annual observations) *real interest rate in % and real commodity prices in log units*			
	Coefficient	**Std error**	**sig. 5%**
Moodys	0.014	0.018	
Goldman Sachs	0.033	0.030	
Dow Jones	0.056	0.026	*
CRB	0.076	0.026	*
Reuters	0.108	0.024	*
COMMODITIES (by coefficient in ascending order)			
Nickel	-0.036	0.038	
Palladium	0.012	0.051	
Lead	0.016	0.029	
Cattle	0.020	0.015	
Sugar	0.026	0.049	
Platinum	0.031	0.029	
Oil	0.039	0.044	
Zinc	0.044	0.022	*
Aluminium	0.049	0.022	*
Hogs	0.061	0.030	*
Copper	0.068	0.036	
Rubber	0.069	0.038	
FIXED-EFFECTS PANEL	0.072	0.008	*
Gold	0.078	0.037	*
Soy bean oil	0.079	0.031	*
Wheat	0.081	0.034	*
Cotton	0.084	0.030	*
Corn	0.086	0.034	*
Soy beans	0.087	0.032	*
Oats	0.090	0.040	*
Cocoa	0.120	0.039	*
Silver	0.126	0.045	*
Tin	0.163	0.045	*
Coffee	0.253	0.036	*

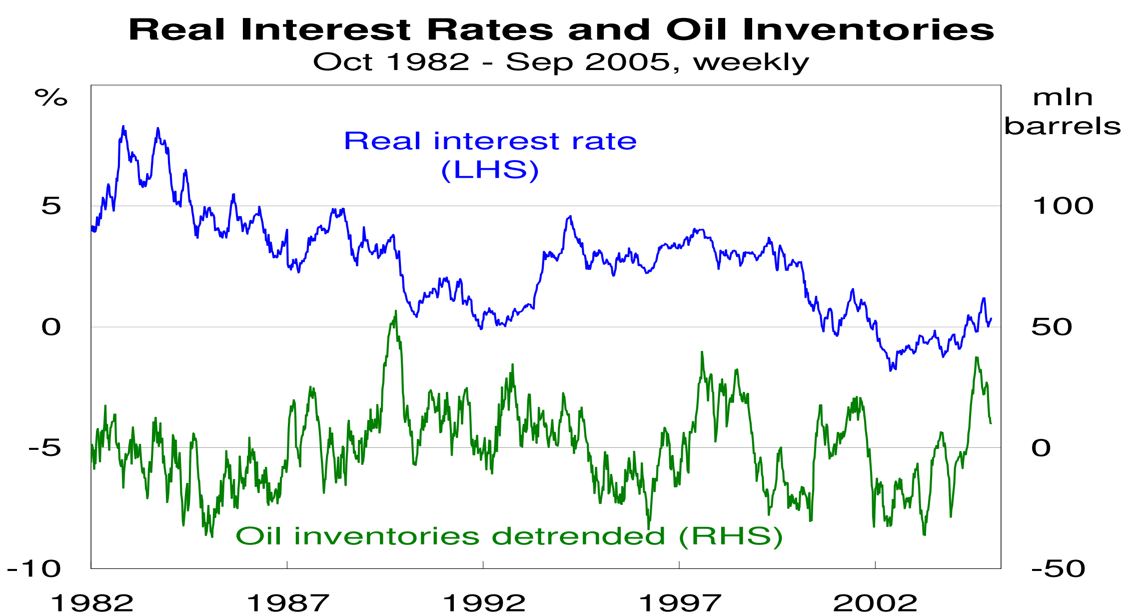
Source: Global Financial Data

Appendix 2: **Relationship between de-trended oil inventories and interest rates**

Various methods have been used to detrend the inventories series: linear, quadratic and the Hodrick-Prescott Filter. To maximize smoothness, the largest possible smoothness parameter was chosen for the HP filter (1 billion). At this level of smoothness, the HP filter series resembled those generated using the linear or quadratic method.

Here are the linear and quadratic detrended series:





Regressions

Six regressions have been estimated to explore this relationship.

- In regression 1, there is no detrending.
- In regressions 2 & 3, linear (αt) or quadratic trends ($\alpha t + \beta t^2$) are included as extra regressors.
- In regressions 4 - 6, I use a two step procedure, first detrending the inventories series and then estimating the relationship.

When the linear detrending method is used, there is a significant negative relationship between the real rate and inventories. However, this result is not particularly robust to the use of alternative detrending methods:

Table 4: Relationship between oil inventories and interest rates

Regressand	**Regressors**	**Real rate coefficient**	**Standard error**	**Sig. at 10%**
1. Inventories	Real rate	5.96	0.29	*
2. Inventories	Real rate & linear trend	-0.69	0.35	*
3. Inventories	Real rate & quadratic trend	-0.36	0.35	
4. Linear detrended inventories	Real rate	-0.31	0.23	
5. Quadratic detrended inventories	Real rate	-0.17	0.23	
6. HP detrended inventories	Real rate	0.04	0.22	

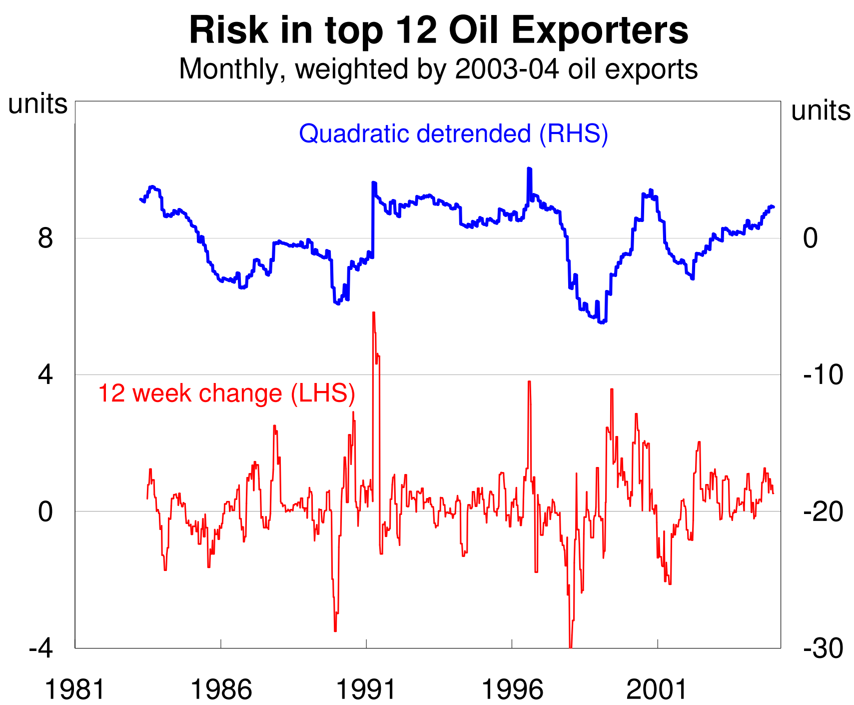
Appendix 3:

Relationship between Inventories and Real Interest Rates using Detrended Inventories: Controlling for Additional Regressors

Here are the results using the following regressors in the model of oil inventories:

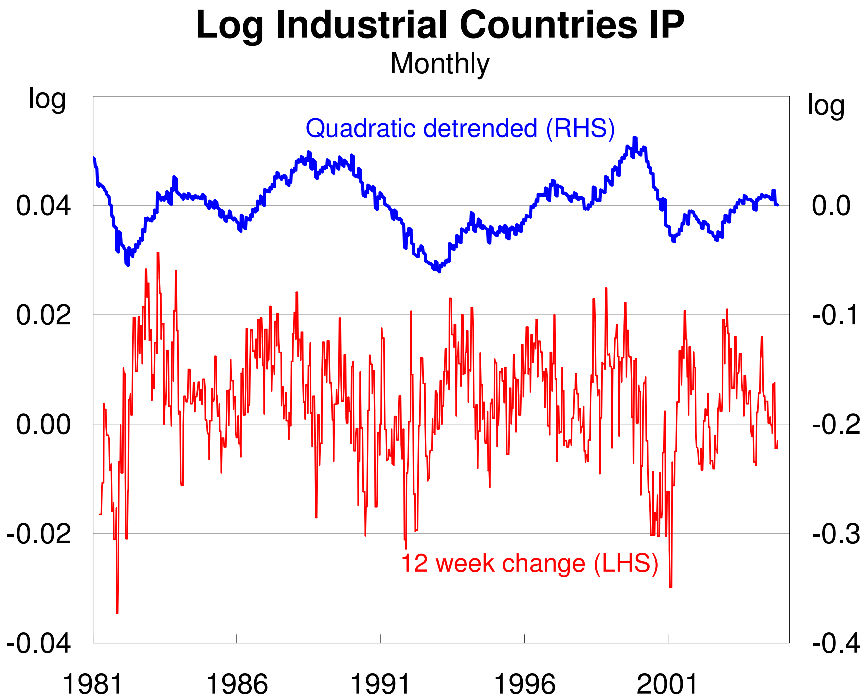
Risk in oil exporting countries (used as a measure of risk of supply disruptions)

We obtained monthly data from the PRS Group on the "composite risk" for each of the top 12 oil exporting countries. The composite risk ratings cover political risk, economic risk and financial risk. We have constructed a single measure for the top 12 oil exporters by arithmetically weighting the composite risk rating for each country by the country's share of world oil exports in 2003 and 2004. The countries included are (in descending order of importance): Saudi Arabia, Russia/USSR, Norway, Iran, Venezuela, UAE, Kuwait, Nigeria, Mexico, Algeria, Libya and Iraq. A fall in the index represents an increase in risk. Since the series trends up over time, we have made the series stationary by detrending or differencing. When differencing, we use a relatively tight 12 week change so there is not a large phase shift.



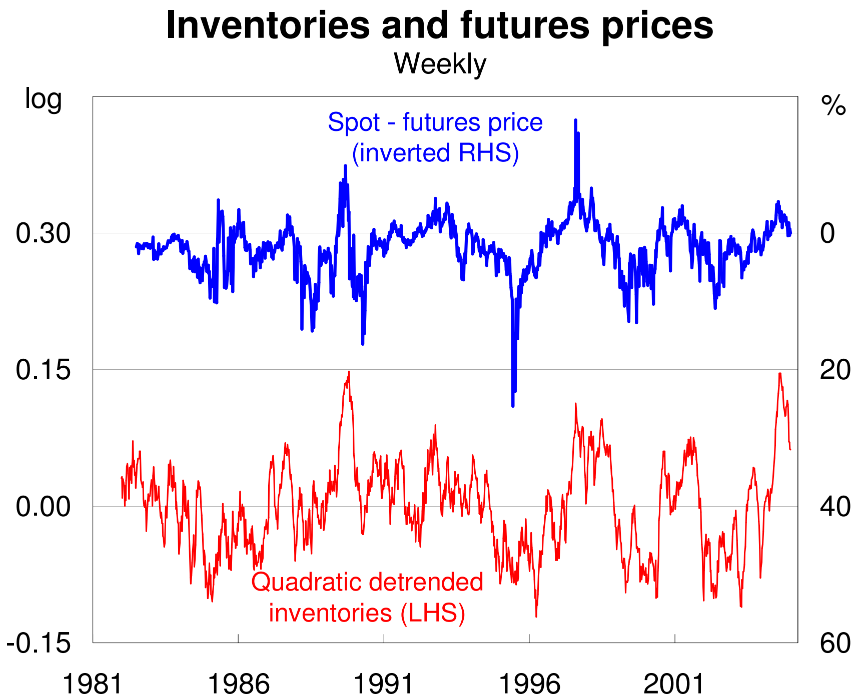
Industrial Countries Industrial Production (used as a measure of sudden changes in demand)

A monthly series of Industrial Production in Industrial Countries has been obtained from the IMF IFS database. Since the data was not seasonally adjusted and displayed a strong seasonal pattern, I seasonally adjusted the data using the X-12-ARIMA algorithm provided in the software Demetra. The series trended up, so detrending or differencing have been used to make the series stationary:



Spot – futures price spread

The spot – futures price spread has been calculated by taking the percentage difference between the first futures contract (which is close to the spot rate) and the third futures contract (s + i – f), adjusting for the three month Treasury rate over the two month period between the contracts (the maturity is not matched perfectly, but I have not found a two month Treasury rate). There is quite a high correlation between this spread and movements in US oil inventories:



Regression results

The relationship between weekly oil inventories and real interest rates is estimated controlling for the three regressors described above. When included individually, the **spot-futures price spread** is significant with the expected sign (when the spot price rises relative to the futures price, oil inventories fall). The 12-week change in **oil exporter risk** is also significant with the expected sign (a negative change in the risk rating leads to an increase in oil inventories). However, **Industrial production** is not significant. The real interest rate coefficient is negative in all these regressions, but is not significant.

When **all the regressors are included simultaneously** (either in levels OR in changes), the spot-futures spread and risk are significant with the expected sign, but IP is significant with a counterintuitive sign (increase in oil demand leads to an increase in inventories). The real rate coefficient is negative and significant. When **lagged inventories** are added, the real rate coefficient is no longer significant.

When the spot-futures spread is assumed to be endogenous and IP and risk are used as instruments, the real rate coefficient is not significant.

Table 5a: Relationship between inventories and interest rates

Weekly data (1114-1190 observations depending on data availability)

Non-stationary variables detrended by including quadratic terms in each regression

	Real rate	Spot-futures	IP	Δ IP	Risk	Δ risk	Inventories (t-1)
Real rate only	**-0.064**						
	0.097						
Spot-futures spread	**-0.093**	**-0.760***					
	0.077	0.039					
IP	**-0.057**		**0.008**				
	0.101		0.059				
12 week Δ IP	**-0.014**			**-0.178**			
	0.103			0.136			
oil exporter risk	**-0.095**				**0.000**		
	0.103				0.001		
12 week Δ oil exporter risk	**-0.192**					**-0.009***	
	0.100					0.001	
Spot-futures, IP, risk	**-0.394***	**-0.821***	**0.397***		**-0.002***		
	0.089	0.041	0.062		0.001		
Spot-futures, IP, risk and lagged inventories	**-0.056**	**-0.079***	**0.052***		**0.000**		**0.931***
	0.032	0.013	0.020		0.000		0.009
Spot-futures, Δ IP, Δ risk	**-0.211***	**-0.727***		**0.131**		**-0.005***	
	0.085	0.040		0.126		0.001	
Spot-futures, Δ IP, Δ risk and lagged inventories	**-0.017**	**-0.071***		**0.009**		**0.000**	**0.937***
	0.032	0.012		0.045		0.000	0.009
<u>Instrumental Variables</u>							
Spot-futures; instruments: IP and risk	**-0.068**	**0.343**					
	0.124	0.178					
Spot-futures; instruments: Δ IP and Δ risk	**-0.159**	**-1.313***					
	0.102	0.212					

Asterisks indicate significance at the 5% level of significance.

The results are reasonably similar under detrending by including quadratic terms in each regression or through a first stage regression of each non-stationary regressor on a quadratic trend, with the residuals used in the second stage regression where inventories is the regressand.

Table 5b: Relationship between inventories and interest rates

Weekly data

Inventories, IP and oil exporter risk detrended using first stage regressions with quadratic trends

	Real rate	Spot-futures	IP	Δ IP	Risk	Δ risk	Inventories (t-1)
Real rate only	**-0.031**						
	0.065						
Spot-futures spread	**0.021**	**-0.754***					
	0.053	0.039					
IP	**0.011**		**-0.003**				
	0.065		0.058				

12 week Δ IP	**0.043**			**-0.200**			
	0.070			0.133			
oil exporter risk	**-0.154***				**0.000**		
	0.076				0.001		
12 week Δ oil exporter risk	**-0.226***					**-0.009***	
	0.077					0.001	
Spot-futures, IP, risk	**-0.131***	**-0.806***	**0.304***		**-0.002***		
	0.067	0.042	0.062		0.001		
Spot-futures, IP, risk and lagged inventories	**-0.027**	**-0.076***	**0.044***		**0.000**		**0.933***
	0.023	0.013	0.019		0.000		0.009
Spot-futures, Δ IP, Δ risk	**-0.066**	**-0.723***		**0.089**		**-0.005***	
	0.065	0.041		0.127		0.001	
Spot-futures, Δ IP, Δ risk and lagged inventories	**-0.003**	**-0.070***		**0.006**		**0.000**	**0.937***
	0.024	0.012		0.044		0.000	0.009
<u>Instrumental Variables</u>							
Spot-futures; instruments: IP and risk	**-0.145**	**0.282**					
	0.086	0.179					
Spot-futures; instruments: Δ IP and Δ risk	**0.076**	**-1.368***					
	0.072	0.231					

Asterisks indicate significance at the 5% level of significance.

Appendix 4
Relationship between Agricultural Inventories and Real Interest Rates, using Detrended Inventories

Annual inventories data have been obtained from the US Department of Agriculture for 12 agricultural commodities. For comparative purposes, I also include results using a series for petroleum inventories from the Energy Department. To make the results easier to compare across commodities, I have logged the inventories series, so the coefficients are semi-elasticities.

Quarterly inventories data are available for some commodities, but the seasonal patterns are extremely strong, so I have converted all the commodities to a common annual frequency.

Five regressions have been estimated to explore this relationship for each commodity:

- In regression 1, there is no detrending.
- In regressions 2 & 3, linear (αt) or quadratic trends ($\alpha t + \beta t^2$) are included as extra regressors.
- In regressions 4 & 5, I use a two step procedure, first detrending the inventories series and then estimating the relationship.

The data suggest there is no systematic negative relationship between real interest rates and agricultural inventories. The different specifications do not appear to have a significant effect on the results.

The relationship has also been estimated for the fixed effects panel of the nine commodities with data available from 1950-2004. This sample is broken in 1982 to test for any effect from the change in monetary policy regime. The results suggest there is a spurious positive relationship between interest rates and inventories.

Relationship between agricultural inventories and interest rates

Annual data

	Sample	1. Log inventories		2. Log inventories with linear trend		3. Log inventories with quadratic trend		4. Linear Detrended Log inventories		5. Quadratic detrended log inventories	
hay	1950-2004	**0.023**	*	**0.008**		**0.005**		**0.007**		**0.004**	
		0.008		0.005		0.005		0.004		0.004	
rice	1956-2004	**0.050**		**0.029**	*	**0.019**	*	**0.029**	*	**0.018**	*
		0.027		0.013		0.010		0.013		0.009	
barley	1950-2005	**0.050**	*	**0.048**	*	**0.026**		**0.045**	*	**0.023**	
		0.019		0.020		0.020		0.019		0.018	
sheep	1950-2005	**-0.045**		**0.016**	*	**0.016**	*	**0.015**	*	**0.014**	*
		0.026		0.007		0.007		0.006		0.006	
hogs	1950-2004	**-0.006**		**-0.009**		**-0.010**		**-0.008**		**-0.008**	
		0.004		0.005		0.006		0.004		0.004	
cattle	1950-2005	**0.007**		**0.006**		**-0.008**		**0.006**		**-0.007**	
		0.010		0.010		0.004		0.010		0.004	
wheat	1950-2004	**0.074**	*	**0.069**	*	**0.063**	*	**0.065**	*	**0.053**	*
		0.010		0.010		0.010		0.009		0.009	
soybeans	1950-2004	**0.100**	*	**0.023**		**-0.011**		**0.021**		**-0.010**	
		0.041		0.016		0.009		0.015		0.008	
oats	1950-2005	**-0.031**		**0.014**		**-0.013**		**0.013**		**-0.011**	
		0.020		0.015		0.011		0.014		0.009	
corn	1950-2004	**0.070**	*	**0.033**	*	**0.027**	*	**0.031**	*	**0.023**	
		0.021		0.011		0.013		0.011		0.012	
wool	1976-2003	**0.020**		**0.018**		**-0.013**		**0.018**		**-0.008**	
		0.014		0.016		0.028		0.015		0.016	
cotton	1965-2004	**0.004**		**0.010**		**0.045**		**0.010**		**0.039**	
		0.029		0.032		0.032		0.030		0.030	
petroleum	1973-2004	**0.029**	*	**0.024**	*	**0.001**		**0.024**	*	**0.000**	
		0.010		0.004		0.003		0.004		0.003	
Panel	1950-2004	**0.029**	*					**0.025**	*	**0.010**	*
		0.009						0.004		0.003	
Panel	1950-1981	**0.028**	*					**0.027**	*	**0.016**	*
		0.010						0.007		0.005	
Panel	1982-2004	**0.038**	*					**0.041**	*	**0.004**	
		0.008						0.007		0.006	

Asterisks indicate significance at the 5% level of significance.

Appendix 5:
Stabilizing Properties of Pegging the Export Price vs. Exchange Rate and CPI Rules

We compare three possible policy regimes: (1) a fixed exchange rate (2) the PEP proposal (fixed price of the export in domestic currency, so that the dollar exchange rate varies perfectly with the dollar price of the export commodity on world markets, and (3) a CPI rule. The approach, incorporating the advantages both to rules and discretion, follows Rogoff (1985), Fischer (1988) and Persson and Tabellini (1990), who in turn added disturbances to the inflation-bias model of Barro and Gordon (1983). For an application of the model that includes the results for three more regimes -- discretion, a money rule, and a nominal GDP rule -- see Frankel (1995).

This version of the model extends it beyond the usual single sector. One sector is NonTraded Goods; the other is the Tradable sector – an importable commodity *Im* on the consumption side and an exportable commodity *X* on the output side. We assume only one export commodity, with the price determined on world markets. An interpretation that would be more realistic for most countries would be a basket of export goods. In the case of each of the possible nominal anchors, proponents sometimes have in mind a target zone system. The assumption of a rigid rule in our theoretical analysis makes the analysis simpler. It must be acknowledged from the outset, however, that attaining a target precisely would be in practice be difficult in the case of a basket that included any goods other than agricultural and mineral products traded on centralized exchanges. It would be even more difficult for a CPI target. For these cases, a target zone would be more realistic.[i]

We assume an aggregate supply relationship in each of the two production sectors:

$$y_n = \overline{y_n} + b(p_n - p_n^e) + u_n \qquad (1)$$

$$y_x = \overline{y_x} + d(p_x - p_x^{\,e}) + u_x \qquad (2)$$

where y_n and y_x represent the log output of the nontraded and export sectors, respectively; $\overline{y_n}$ and $\overline{y_x}$ potential output in the two sectors; p_n and p_x the log prices in the two sectors in domestic currency, and p_n^{e} and p_x^{e} the expected log price levels (or they could be the actual and expected inflation rates, respectively); and u_n and u_x the supply disturbances.[ii]

We assume that the country is small, i.e., a price-taker on world markets for both its export good and its import good:

$$p_x = s + \varepsilon_x\,, \qquad (3)$$

where *s* is the log of the exchange rate, the spot price of dollars in terms of domestic currency, and ε_x represents the fluctuating dollar price of the export commodity on world market; and

$$p_{im} = s + \varepsilon_{im}\,, \qquad (4)$$

where ε_{im} represents the fluctuating dollar price of the import good in terms of dollars. (Both log prices are assumed mean zero, for convenience.)

The consumer price index includes the nontraded good and the import good, with weights *f* and *(1-f)*, respectively:

$$cpi = (f)p_{im} + (1\text{-}f)p_n \quad , \qquad (5)$$

while the GDP price index consists of the prices of the nontraded good and the export good:

$$p = (f)p_x + (1\text{-}f)p_n \quad . \qquad (6)$$

**

The objective is to stabilize the general price level (CPI) and output in the two sectors. The quadratic loss function is stated as:

$$L = a\,(cpi)^2 + f(y_x\text{-}y_x{'}\,)^2 + (1\text{-}f)(y_n\text{-}y_n{'}\,)^2, \qquad (7)$$

where *a* is the weight assigned to the inflation objective, and we assume that the lagged or expected price level relative to which the CPI is measured can be normalized to zero. The international ("foreign") and nontraded sectors have weights in the economy *f* and *(1-f)*, respectively. We impose $y_n' > \overline{y_n}$ in both sectors, which builds in an expansionary bias to discretionary policy-making.

(i) <u>Discretionary policy vs. a money rule</u>

Under full discretion, the policy-maker each period chooses Aggregate Demand so as to minimize that period's ***L***, with price expectations given. We can treat the central bank as choosing the money supply that minimizes the quadratic loss function, or else parameterize the decision in terms of one of the price indices. The standard result is an inflationary bias that results from discretion due to time inconsistency; it is large if desired output levels are substantially greater than potential output, if aversion to inflation is low, and if the short-run output gains from expansion are high.

Under any of the rules -- whether it is the money supply, exchange rate, export price, or CPI that is fixed – the central bank gives up on affecting output levels on a discretionary basis, and instead set the target variable at the level that gives zero inflation in expected value terms. Knowing this, the public's expected inflation will be zero. Thus the expectation terms drop out.

To consider alternative regimes, we must be explicit about the money market equilibrium condition. (In the discretion case, one can leave it implicit that the money supply, *m* in log form, is the variable that the authorities use to control demand.)

$$m = p + y - v, \qquad (9)$$

where *y* represents an index of total output, and *v* represents velocity shocks.

Under a money rule, the money supply is fixed at the level that gives an expected price level of zero. Some algebra produces the loss function for the case of the money rule. It dominates discretion if the inflationary bias is large, but the money rule performs badly if velocity shocks are large, because they are needlessly passed through to the economy.[14] This result is well-known; we concentrate here on the comparison of the exchange rate rule, export price rule, and CPI rule.

(ii) Pegged Exchange Rate

There is no point in specifying an elaborate model of the exchange rate. All the empirical results say that most of the variation in the exchange rate cannot be explained (even ex post, to say nothing of prediction) by measurable macroeconomic variables, and thus can only be attributed to an error term that we here call *e*. But we must include the money supply in the equation; otherwise we do not allow the authorities the possibility of affecting the exchange rate. Our equation is simply:

$$s = m - y + e. \qquad (10)$$

Combining with equation (9),

$$s = p - v + e. \qquad (11)$$

The velocity and exchange rate shocks may be correlated; since they will always be appearing together, it does not matter. Indeed, we could have just specified equation (11) directly, with a single error term, if we did not want to consider a money target as one of the regimes.

Under the fixed exchange rate rule, *s* is pegged at the level to give $E(cpi)=0$, which is $s=0$. From equation (11), the domestic output price index is now determined by currency conditions:

$$p = v - e \quad . \qquad (12)$$

At the same time, the definition of the price index as the weighted average of two sectors, in equation (6), brings in the price of nontraded goods:

$$p = (f)(s+\varepsilon_x) + (1-f)p_n \qquad (13)$$

Combining the two equations for *p*,

$$(f)(s+\varepsilon_x)+(1-f)p_n = v - e.$$

With the exchange rate fixed, the price of nontraded goods is also determined:

$$p_n = \frac{1}{1-f}\,(v - e - f\varepsilon_x). \qquad (14)$$

$$y_n = bp_n + u_n = b\left[\frac{1}{1-f}(v - e - f\varepsilon_x)\right] + u_n\,. \qquad (15)$$

(Notice that a positive price shock in world markets imposes deflation on the domestic market, because the monetary authorities must contract if they are to avoid currency depreciation. This is a variety of "Dutch Disease.")

The spirit of the simulations in Frankel (2003) and Frankel and Saiki (2002) is that export revenue – perhaps as a ratio to debt -- is the key variable to stabilize.[15]

[14] A nominal income target avoids the problem of the velocity shocks that cripple the money rule. Frankel (1995) shows the equations.

[15] The idea is that, for emerging market countries, international capital markets in practice do not seem willing to fund transitory shortfalls in export earnings; to the contrary, "sudden stops" by foreign investors are the leading source of large economic contractions, and are best moderated by assuring a high and stable level of export earnings.

Export revenue in dollars is defined as

$$s + p_x + y_x \, . \qquad (16)$$

With equation (2), the variable component of export revenue is

$$s + p_x + d(\, p_x \,) + u_x$$
$$= s + (1+d)(\, p_x \,) + u_x \; . \qquad (17)$$

In the case of the exchange rate target,

$$= \quad (1+d)\varepsilon_x \; + \; u_x$$

Clearly export sector disturbances are a problem.

We also look at the more conventional macroeconomic objective function, where the objective is to stabilize the price index and output levels.

$$L = a \quad (cpi)^2 \quad + \quad f(y_x\text{-}y_x')^2 \; + \quad (1\text{-}f)(y_n\text{-}y_n')^2$$
$$= a\,(fp_{im}\text{+}(1\text{-}f)p_n)^2 \; + \; f(dp_x\text{+}u_x)^2 \text{+} \; (1\text{-}f)(bp_n\text{+}u_n)^2 \qquad (18)$$
$$= a(f\varepsilon_{im}\text{-}f\varepsilon_x \text{+}(v\text{-}e))^2 + f(d\varepsilon_x\text{+}u_x)^2 + (1\text{-}f)[b\frac{1}{1-f}(v\text{–}e\text{-}f\varepsilon_x) + u_n]^2 \qquad (19)$$

This value of the loss function is the basis on which to compare the fixed exchange rate with alternative regimes.

(iii) Pegged Export Price

Now we consider the PEP proposal: fixing the export price in terms of domestic currency or, equivalently, determining the exchange rate so as to vary perfectly with the dollar price of the export commodity on world markets.

$$p_x = 0 \;\; => \;\; s = \text{-}\,\varepsilon_x \, . \qquad (20)$$

From equations (5) and (6),

$$cpi = fp_{im}\text{+}(1\text{-}f)p_n = \; f(\text{-}\,\varepsilon_x + \varepsilon_{im}\,) + (1\text{-}f)p_n \qquad (21)$$
$$p \;\; = \;\; fp_x\text{+}(1\text{-}f)p_n = \quad 0 \quad + \quad (1\text{-}f)p_n \qquad (22)$$

Combining equation (22) with equation (12),

$$v - e = \;\; (1\text{-}f)p_n,$$

which determines the nontraded goods price, and quantity:

$$p_n \quad = \;\; (1/f)\,(v\text{-}e) \qquad (23)$$
$$y_n \quad = \;\; b/(1\text{-}f) \;\; (v\text{-}e) + u_n \qquad (24)$$

To repeat, equation (17), export revenue is given by

$$= s + (1+d)(\, p_x \,) + u_x \;\; .$$

If the export price is pegged, and using (20), export revenue is given by

$$= \;\; \text{-}\,\varepsilon_x \quad + \quad u_x \qquad (25)$$

If the objective is taken to be stabilizing export revenue, then pegging the export price looks very good: export revenue is unambiguously more stable under the PEP rule than under the exchange rate rule, so log as $d>0$. [16]/ This is consistent with some of the simulation results presented earlier.

[16] Unless ε_x and u_x happen to be negatively correlated in the right way. A negative correlation is possible: if a good harvest domestically coincides with a good harvest worldwide, and thus lowers the world price.

Turning now to the more standard macroeconomic quadratic loss function, we substitute into equation (18),

$$L = a\,[\,f(\,\varepsilon_{im} - \varepsilon_x\,) + ((1\text{-}f)/f)\,(v\text{-}e)\,]^2 + f(u_x)^2 + (1\text{-}f)[\,b/(1\text{-}f)(v\text{-}e) + u_n]^2 \qquad (25)$$

In this model, the expected loss under the PEP rule is likely to be smaller than under the exchange rate rule. Specifically, even if there are no export price shocks, then the expected loss is smaller under the PEP rule if $(1\text{-}f)/f < 1$, *i.e.,* $f > 1/2$, i.e., the foreign sector is larger than the domestic sector. To the extent that export price shocks are non-zero, then the case is stronger, because ε_x enters the middle and third terms of the loss function for the exchange rate rule (such shocks affect both output of the export commodity and output of the nontraded good), whereas pegging the export price insulates the real economy against them. If the ε_x shocks are large, then the PEP rule dominates regardless of parameter values.

(iv) CPI rule

The last regime we consider is inflation targeting, which has gained popularity in recent years. We interpret inflation targeting as using monetary policy to fix the CPI. It turns out that this requires varying the exchange rate so as to exacerbate terms of trade shocks.

By definition of the regime, $cpi = 0$.

From equations (5) and (4), it follows that $(f)(\,s + \varepsilon_{im}\,)+(1\text{-}f)p_n = 0$. (26)

From equations (6) and (11),

$$s = (f)p_x + (1\text{-}f)p_n - v + e.$$

Substituting in from (3),

$$s = (f)\,(s + \varepsilon_x\,) + (1\text{-}f)p_n - v + e\,. \qquad (27)$$

Combining (26) and (27),

$$s = e\text{-}v + f\,(\,\varepsilon_x - \varepsilon_{im}\,) \qquad (28)$$

Notice that when an increase in the price of the import good on world markets worsens the terms of trade, the exchange rate must fall (the currency appreciates); the reason is to prevent the CPI from going up, but this is the opposite of what one hopes to get out of a flexible exchange rate.

We need nothing more to evaluate the export revenue criterion. Substituting (28) into equation (17), export earnings are given by

$$= e\text{-}v + f\,(\,\varepsilon_x - \varepsilon_{im}\,) \quad + (1+d)(\,e\text{-}v + f\,(\,\varepsilon_x - \varepsilon_{im}\,) + \varepsilon_x\,) + u_x \qquad (29)$$

The u_x term is the same as in equation (25), the PEP case. The coefficient of ε_x is greater by $f(2+d)+d$. In addition, $e\text{-}v$ shocks and ε_{im} shocks impinge on export earnings, via their effects on the exchange rate. Thus export revenue is likely to be more variable under the CPI target than under the PEP rule (unless these shocks happen to be negatively correlated in a very particular way).

A tougher test to meet is the macroeconomic loss function, for which we need to first find the equilibrium in the nontraded goods market. From equation (26),

$$p_n = -(f\,/1\text{-}f))(\,s + \varepsilon_{im}\,)\ .$$

With (28), $p_n = -(f/1\text{-}f))[\ e\text{-}v + f(\varepsilon_x - \varepsilon_{im}) + \varepsilon_{im})\ ]$ (30)

Substituting into equation (1),

$$y_n = -\ b(f/1\text{-}f))[\ e\text{-}v + f\,\varepsilon_x + (1\text{–}f)\,\varepsilon_{im}\ ] + u_n \quad (31)$$

Not only do export price shocks affect the nontraded goods market under the CPI rule, as they also did under an exchange rate rule, but now import price shocks do so as well. Again, the reason is that an increase in import prices requires a monetary contraction and currency appreciation, if the CPI is not to rise.

When the CPI is fixed, the first term in the loss function, equation (18), disappears:

$$L = \quad f[d(s+\varepsilon_x)+u_x]^2 \quad + \quad (1\text{-}f)[bp_n+u_n]^2$$

Substituting from (28) and (30)

$$= f[d(\ e\text{-}v + f(\varepsilon_x\text{–}\varepsilon_{im})+\varepsilon_x)+u_x]^2 + (1\text{-}f)[\ -b(f/1\text{-}f))[\ e\text{-}v + f\,\varepsilon_x+(1\text{–}f)\,\varepsilon_{im}] + u_n]^2. \quad (32)$$

Compare to the loss function (25) under the PEP rule

$$L = a\ [\ f(\ \varepsilon_{im} - \varepsilon_x\ ) + ((1\text{-}f)/f)\ (v\text{-}e)\ ]^2 + f(u_x)^2 + (1\text{-}f\ )[\ b/(1\text{-}f)(v\text{-}e) + u_n]^2\ .$$

Terms of trade shocks and exchange rate shocks hurt more under the PEP rule than under inflation targeting if *a* is large: if stabilizing the CPI is the highest priority then a CPI rule does the best by definition. But shocks to world export and import market prices destabilize both output terms under the CPI rule, while the real economy is insulated from them under the PEP rule; thus if *a* is small (relative to *b* and *d*), the PEP rule dominates. [iii]

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[i]. Rogoff (1985b) warns that the welfare-ranking among the candidate variables for rigid targeting need not be the same as the welfare-ranking among the candidate variables for partial commitment.

[ii]. We assume that expectations are formed rationally. Some, however, may prefer to think that, because of the existence of contracts, these expectations are formed well in advance of the period in which actual inflation and output are determined. It should also be noted that, if the parameters *b* and *d* are thought to depend on the variance of the price level, then our results could be vulnerable to the famous Lucas critique.

[iii] The coefficients on export supply shocks and nontraded supply shocks are the same under all three rules. The comparison for exchange rate shocks depends on a number of parameters.