Commodity Price Insurance

A Keynesian Idea Revisited

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Oxford Institute for Energy Studies

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ABSTRACT

Keynes proposed that a 'Commod Control' agency be created after the Second World War to stabilise spot prices of key internationally traded commodities by systematically buying and selling physical buffer stocks. In this paper, the creation of a new Global Commodity Insurer (GCI) is discussed that would operate an international Commodity Price Insurance (CPI) scheme with the objective of protecting national government revenues, spending and investment against the adverse impact of short-term deviations in commodity prices, and especially oil prices, from their long-run equilibrium level. Crude oil is the core commodity in this scheme because energy represents 50% of world commodity exports, and oil price shocks have historically had a significant macroeconomic impact. In effect the GCI would develop a new international market, which is currently missing, designed to protect governments against the risk of declines in their fiscal revenue, and increases in the level of claims on that income especially from social programmes, brought about by short-term commodity price shocks. GCI would take advantage of the rapid growth of trading in derivative securities in the global capital market since the 1980s by selling CPI insurance contracts tailored to the specific commodity price exposure faced by national government, and offsetting the resulting price risk with a portfolio of derivative contracts of five-year or longer maturities, supplied by banks, insurers, reinsurers, investment institutions, and commodity trading companies, with investment grade credit ratings. The difference between the CPI and a buffer stock or export/import control scheme is that it would mitigate the macro-economic shocks posed by commodity price volatility, but not attempt to control commodity prices. The cost of the CPI scheme is estimated by simulating 5-year commodity price paths using a standard log price mean reverting model parameterised from an econometric analysis of commodity price time series.

1. CONTEXT

At the Bretton Woods conference held after the Second World War, Keynes proposed the creation of a Commod Control agency to operate a global commodity price stabilisation scheme. Based on a proposal he had worked on over the previous two decades [for key papers see, Keynes (1938), Keynes (1942), Keynes (1943), Keynes (1944)] he envisaged the establishment of a series of physical buffer stocks for key commodities that would be bought and stored when spot prices were low and then released back to the market when prices were high. The primary objective of the scheme would be to stabilise the prices of these key commodities in a tightly defined range around a long-run sustainable equilibrium level. Combined with an International Clearing Union (ICU) and International Development Bank (IDB), he believed that Commod Control was an essential third agency necessary to prevent the kind of economic dislocation that led to the Great Depression of the 1930s. The ICU became the International Monetary Fund (IMF) and the IDB became the World Bank, but the Commod Control proposal ran into heavy political opposition on both sides of the Atlantic and was never implemented.

The purpose of this paper is to examine how the fundamental objectives of Keynes' scheme could be achieved in a modern context through the implementation of an International Commodity Price Insurance (CPI) scheme under the direction of a new agency that we shall call the Global Commodity Insurer (GCI). This would take advantage of the developments in financial markets that were unavailable to Keynes, especially in the development of markets for derivative instruments now used extensively for the management of market price and credit risk. The objective would remain the same, as in Keynes' original proposal, to protect national economies against macroeconomic shocks brought about by short-term deviations in commodity prices from their long-run equilibrium level.

1.1. Fifty Years of Commodity Price Stabilisation Schemes

Although Keynes' idea for Commod Control was never taken up, five drafts of his original 1938 proposal were published (the last in 1974), and the issue of commodity price stabilisation never disappeared from the international agenda. As a result, a series of commodity stabilisation schemes were set up after the Second World War (World Bank 1999). In 1963, the IMF established the Compensatory and Contingency Financing Facility (CCFF) which provided short-term (3¼–5 year) loans to developing countries to compensate for reductions in export earnings when commodity prices fell. In 1969, the IMF also established the Buffer Stock Financing Facility (BSFF) which provided finance to buffer stock schemes meeting certain strict criteria. Under the auspices of the United Nations Conference on Trade and Development (UNCTAD) five international commodity agreements (ICAs) were also implemented to stabilise prices: the International Sugar Agreement (1954–83), the Tin Agreement (1954–85), the Coffee Agreement (1962–89), the Cocoa Agreement (1972–88), and the International Natural Rubber Agreement (1979–99). The ICA for cocoa, rubber and tin relied wholly or partly on buffer stocks, and those for coffee, sugar and tin wholly or partly on export controls. In 1975, UNCTAD also passed a resolution calling for an Integrated Program for Commodities (IPC) covering ten core commodities and this gave rise to bodies such as the International Grains Council, the International Jute Organisation, and the International Tropical Timber Organisation. The Common Fund for Commodities (CFC), established in 1980, was allocated a $500 million endowment to provide liquidity to the IPC to support their mandate to stabilise commodity prices. Under the Lomé agreement the European Union (EU) also began offering its own compensatory financing schemes to the agricultural sector in African, Caribbean and Pacific countries under the STABEX (1975) and SYSMIN (1985) programs.

All of the ICAs eventually collapsed and as Gilbert (1996) suggests it was perhaps the dramatic collapse of the Tin Agreement that finally “persuaded the developed world that commodity price stabilisation is infeasible”. In the face of the inflationary impact of the second oil price shock, the USA declined to renew its commitment to the agreement, just as there was a rapid accumulation of stocks. As a result, financial resources were quickly depleted, causing large losses to tin traders, and threatening the viability of the London Metal Exchange. The CFC never fulfilled its original purpose and at the time of writing its activities are limited to using the interest accruing from its original endowment to fund commodity research and development programs. Empirical observation of efforts to stabilise commodity prices in the manner prescribed by Keynes is that they have largely failed, sometimes catastrophically. Gilbert gloomily concludes in his obituary to commodity stabilisation agreements “commodity control fits uneasily in an increasingly globalised and competitive world and this perception has resulted in a diminished willingness to resolve the practical difficulties of price stabilisation". However, empirical observation also suggests that despite the numerous failed attempts, national governments of both developed and developing countries continue to express a strong interest in stabilising the prices of primary commodities that are important to their economies and at considerable cost to their taxpayers.

It is estimated that OECD governments spent US$311 billion, in 2001, supporting agriculture, with US$145 billion of that going directly to producers through a variety of market price support mechanisms (OECD 2002). As a result, OECD farmers enjoyed prices that were on average some 31% above world prices. Although there have been reforms, the EU still spent some US$93 billion, or almost 50% of its budget, on its Common Agricultural Policy (CAP) in 2001. The USA spent US$49 billion but in 2002 the government introduced the US Farm Bill (USDA 2002) and proposed a series of counter-cyclical compensation mechanisms that would pay farmers compensation if spot prices for a range of commodities fell below predetermined price levels. Until recently, many developing countries also regularly intervened in agricultural markets and held stockpiles of agricultural products, both for internal consumption and export. Paradoxically, in almost all cases where the IMF has been involved in providing emergency loans to developing countries, these schemes have been disbanded and the remaining stocks sold off as part of an overall package of economic reform and in return for financial assistance.

However, developing countries have not been powerless in their attempts to stabilise commodity prices. OPEC effectively acts as a stock coordinating mechanism, with oil held in store beneath the ground largely controlled by Saudi Arabia. The OPEC statute states explicitly that price stability is the main objective:

> The OPEC statute requires OPEC to pursue stability and harmony in the petroleum market for the benefit of both oil producers and consumers. To this end, OPEC Member Countries respond to market fundamentals and forecast developments by co-ordinating their petroleum policies. Production limits are simply one possible response. If demand grows, or some oil producers are producing less oil, OPEC can increase its oil production in order to prevent a sudden rise in prices. OPEC might also reduce its oil production in response to market conditions in order to counter falling prices. (OPEC 2000)

After the 1973–74 oil price crisis, governments in developed countries also put in place mechanisms and systems that allowed them to intervene in energy markets by either accumulating or occasionally releasing stockpiled oil. The member states of the International Energy Agency (IEA) that are net oil importers have a legal obligation under the International Energy Program, to hold stocks in public and private hands equivalent to 90 days worth of net imports in the previous year. EU member states, including the UK and Denmark who are net oil exporters, are required to hold 90 days worth of inland consumption of refined products (gasoline, middle distillates and fuel oil). In addition, some countries maintain significant stockpiles of coal and nuclear fuel within their national borders often reinforced by significant government control over and/or informal involvement in the procurement of long-term energy supply contracts (e.g. Japan and Korea).

Although nominally held for strategic, security-of-supply reasons, the fact that there has never been an outright curtailment of supply by OPEC, even at the height of the two major oil price crises in the seventies, suggests that the historic pattern of stockpiling energy commodities and their subsequent release onto national markets has really been intended to offset the impact of temporary price shocks. Indeed, the US Strategic Petroleum Reserve (SPR), which has the capacity to store up to 700 million barrels, was used to release crude oil to the domestic market during the Gulf War in 1991, as part of the coordinated IEA program in OECD countries which was announced "to assure the market of supply" at the launch of the allied attack on 17 January 1991 (even though there was no real shortage of oil). The US government openly acknowledges that this release was primarily aimed at stabilising prices (Fossil Energy 2002). As at the end of 2002, the SPR contained 600 million barrels, or enough to cover 53 days worth of imports with a further 100 days worth held by private companies. The cost of purchasing and maintaining the SPR inventory held at the end of 2002 amounted to a total of US$391 million in 2002 (or US$0.65 per barrel), assuming an original construction cost of US$20 billion, a 1.75% annual interest rate, physical losses of 0.5% per annum, plus miscellaneous operating and maintenance costs of US$25 million per annum. If held for five years, a reasonable time-scale over which a sovereign government might wish to manage its own oil price exposure, this would increase to over US$3.50 per barrel. In addition, it is estimated that the cost of waging the second

Gulf War in Iraq was US$30 billion per month and a continuing presence in the Gulf region would cost $10 billion per month.

1.2. Weaknesses of Buffer Stock Schemes

Keynes' initial proposal was that Commod Control should be responsible for acquiring and controlling stocks of key commodities that would be increased if spot prices fell more than 10% below their long-run equilibrium level and depleted by selling stocks if prices rose more than 10% above that level. The question of what constituted the correct equilibrium level was however not well specified. Initially, Keynes suggested that this should be determined by the level of production costs but given the difficulty of estimating costs of peasant farmers in developing economies; he later suggested that it should be determined democratically with each nation's vote being trade weighted.

Objections were raised to this proposal in the UK Treasury which feared that setting the intervention level too high would encourage un-economic levels of production in producer countries (though perhaps not surprisingly there was little comment on the impact of excess consumption in countries such as the UK if the intervention price was set too low). Concerns were also raised that such a scheme would be open to speculative attack by arbitrageurs who would be able to trade against the upper and lower intervention bounds with little risk. Theoretical work by Prebisch (1950) and Singer (1950) suggests that there would be a long-run decline in the terms of trade for developing countries because they were relatively more dependent on primary commodities for export income than developed countries. Time series analysis of commodity prices over the period 1900–1991 by Bleaney & Greenaway (1993) found that there had indeed been a long-term downward trend in the ratio of primary commodity prices compared to manufactured products. However, this trend was negligible over the period 1925–1980 followed by a sudden drop in 1981. Analysis by Spraos (1980) revealed that the results are highly sensitive to the starting point of the analysis and the quality of the data in available data sets, and concludes that this casts significant doubt on previous work that had shown a long-term decline in terms of trade.

The question of whether commodity price shocks are temporary or persistent phenomena are examined by Cashin, Liang & McDermott (2000) who analyse real prices for the constituent commodities included in the IMF *Index of Fuel and Non Fuel Commodities* (IMF Commodity Index). These were calculated from monthly nominal price data for the period 1957–1998 and deflated by the index of manufacturing unit values (MUV). Their results show that the half-life of a shock (HLS), which is the length of time in which a unit shock to a commodity price series declines to half of its initial magnitude, is typically long-lasting for metals, crude oil and tree crops except for softwoods. Out of 44 commodity price series tested, only 18 commodities exhibited persistence of price shocks of less than five years, which they set as an arbitrary cut-off point beyond which the cost (finance, storage, output-reduction costs) of sustaining a commodity buffer stock scheme would probably become prohibitive. They conclude that this is largely why commodity buffer stock schemes collapsed in the 1980s because "an adverse price shock to any given commodity is likely to engender depressed prices for a long period of time. In such circumstances, government supported price stabilization activities and compensatory financing mechanisms are likely to be ineffective, and external borrowing for consumption smoothing unsustainable". However, it is interesting to note that, although tin has one of the shortest HLS at three months, the International Tin Agreement collapsed spectacularly. Rubber has an HLS of 43 months – by their definition close to the margin of sustainability – and yet the international Rubber Agreement survived for 19 years. Moreover, crude oil has an infinite HLS, suggesting that shocks are permanent, yet the IEA and OPEC continue to successfully operate what are effectively buffer stock schemes on both the supply and demand sides of the market.

The question of how to deal with the stochastic nature of commodity prices is highlighted by Newbery & Stiglitz (1981) who encapsulate the argument in their discussion of alternative optimal commodity stockpiling rules. Two issues arise: first, that the financing and insurance may be so large that it exceeds the potential benefit of stockpiling even if prices are very volatile. More importantly, even if the benefits justify the costs, there is always a possibility that a very long run of low prices followed by an equally long run of high prices might occur or indeed *vice versa*. This means that, no matter what the starting stock level, there would always be some probability that stocks would be depleted before prices fell or that stocks would grow so large that they exceeded total available storage capacity or finance before prices rose again. For all practical purposes, Newbery & Stiglitz conclude that complete price stabilisation in a buffer stock scheme is therefore impossible. Although Keynes suggested that stocks for individual commodities of between three months and one year of total global production should be held, he acknowledged that there might be times when stocks could accumulate so rapidly that export controls might also be required to stem the flow of surplus production on to the world market.

Keynes appears also to have recognised that there would be practical difficulties in determining an appropriate equilibrium price level, and that it certainly could not be fixed for all time but allowed to evolve by up to 5% per annum – though he was not specific about what events should trigger an adjustment, or what rules would determine its level. He also proposed to minimise the cost of Commod Control operations by establishing the organisation in London, where the physical stocks would also be held and financed by the UK government at lower cost than could be achieved if stocks were held in private hands. He appears to have adopted this solution on the basis of estimates produced by Graham (1937), a leading US advocate of commodity price stabilisation, who suggested that interest and insurance costs could be reduced by a central buying organisation, financed through Government borrowing.

From the policy perspective, and regardless of the particular commodity in question, if the upper or lower intervention band in a buffer stock scheme is set respectively below or above the true long-run equilibrium price level, or if a deterministic trend occurs in the equilibrium price level, or if a unit shock occurs that persists and results in a step change in the equilibrium price level, then the upper or lower intervention bands will eventually be permanently breached and the scheme will inevitably collapse. In effect, the buffer stock scheme will be forced into the position of permanent buyer or seller, and effectively transformed into a producer or consumer subsidy scheme requiring a permanent flow of new finance to sustain it. Stochastic trends may also cause a buffer stock scheme to collapse if intervention bands are breached for a sufficiently long period of time such that the initial stock of commodity is exhausted by high prices or the stock of finance is exhausted by low prices. In short, buffer stock schemes rely on price reversion to a sustainable equilibrium price level, correctly identified and agreed upon by both consumers and producers. However, as Gilbert (1996) points out, the demise of the existing buffer stock schemes in the 1980s came about as much because consuming and producing nations could not come to a workable agreement on how to operate the schemes, or were unwilling to provide the necessary finance, with the result that once a significant shock occurred they quickly collapsed.

1.3. The Continuing Case for Commodity Price Stabilisation

In their extensive theoretical analysis Newbery & Stiglitz (1981) conclude, "the benefits of price stabilisation are comparatively small compared with the likely cost of operating buffer stock(s) and that they are not necessarily distributed in favour of the producers". Kanbur (1984) provides a convenient review of the opposing arguments put forward by Keynes and Newbery & Stiglitz, and notes that the latter analysis is largely a microeconomic one and devotes only 30 out of 450 pages to the macroeconomic issues that the Keynesian case rested upon. However, regardless of what the conclusions from the theoretical arguments may be, it is clear is that the notion of commodity price stabilisation is relevant to the geopolitics of the modern world, as evidenced by the continued attention that national governments pay to it and the financial resources that the developed world is still spending in attempting to achieve it, some 60 years after Keynes' original proposal.

After several decades of debates, there is an emerging consensus among economists that export instability has a negative effect on growth. For governments, unforeseen variations in export prices can complicate budgetary planning and can jeopardise the attainment of debt targets. For exporters, price variability increases cash flow variability and reduces the collateral value of inventories: both factors work to increase borrowing costs. Some economists argue that the vulnerability to commodity prices affects the rate of growth of productivity. Others find that vulnerability influences growth through instability of the rate of investment and that of the relative prices (or of the real exchange rate). These two intermediate instabilities, which have negative effects on growth, are clearly related to policy, the implication being that vulnerability weakens policy (Aisenman & Marion 1999). Moreover, the instability of the real producer prices appears to be a factor of lower growth in agricultural production, which itself contributes to a lower global growth and to increased poverty (Guillaumont & Combes 1996).

Governments in both the developed and developing world are exposed to volatile commodity prices through their fiscal revenues, current spending and long-term investment programmes, whether it be arising directly from state control of commodity producing or consuming assets (e.g. OPEC oil producers), through government subsidies that compensate producers and consumers, or direct purchases of commodities for use in the public sector that cannot be directly passed on to consumers (e.g. fuel used in schools, hospitals, and social housing). The impact of such volatility may also be felt as a secondary effect through the flow of tax revenues from the private sector that produces or consumes commodities. In both cases the impact is on either government revenues or spending with the net of those two values representing the public sector borrowing requirement (PSBR). Since this is merely the difference between a large inflow (fiscal revenue) and a large outflow (current expenditure and investment), even a small change in either of these numbers created by commodity price volatility can result in a very large change in the PSBR. The tertiary effect of government exposure to commodity price volatility, therefore, is that it directly affects its ability to meet payments under existing sovereign debt commitments and impacts the cost (i.e. interest rate) on any new borrowing. In extreme cases where a government is unable to meet existing debt repayments and has no alternative but to default on its sovereign debt, this may result in the country being cut off from global capital markets for many years.

Where government deficits cannot be funded by borrowing, perhaps because they are cut off from the financial markets by an earlier default, the only solution that remains is to curtail current spending, and in particular cancel planned investment. If this involves investments in road building, electrification, education, and healthcare programmes the impact may be felt beyond the short term, with negative long-term implications for economic growth, and on the welfare of the population. In an analysis of the impact of the sharp fall in non-oil commodity prices that occurred during the 1980s, Maizels (1992) identifies "the development of human resources in terms of improved health, education, and skills, is an important end in itself, as well as constituting an essential factor in economic growth". He notes that children are particularly vulnerable to economic contractions, and during the 1980s, the nutritional status of children, educational provision, infant mortality and morbidity rates did indeed deteriorate in many developing countries. The adult population also suffered as the number of people living below the poverty line increased and government expenditures on food subsidies (welfare payments), public health and education fell. Since child malnutrition, disease, and illiteracy undermine the mental and physical capacity of the future labour force for an entire generation, what this means is that a short-term commodity price shock that drives prices far below (or above) the long-run equilibrium level can have a long-lasting macroeconomic impact for decades into the future and well after commodity prices have reverted back to the long-run equilibrium level. While many governments recognised the impact on vulnerable groups, the programs they put in place to protect them were often undermined by external financial pressures. This was especially the case where economies were heavily dependent on primary commodity exports. Maizels concludes by proposing what amounts to a call for an international commodity price stabilisation scheme linked to a programme of debt restructuring:

> A substantial alleviation of these external pressures requires positive international policy coordination on a broad front, to include policies to deal with the continuing commodity crisis as well as with the debt overhang and the inadequacy of aid and other financial flows. (Maizels 1992:)

It is worth noting that work such as that by Maizels and others such as UNCTAD (1991) and Bevan, Collier & Gunning (1993), tends to reinforce the limited perception that the macroeconomic impact of commodity price volatility is really just a developing country problem, and mainly one involving agricultural products. In fact, as Greenaway & Morgan (1999) discuss in the preface of their book, "the importance of primary commodities in the world economy is perhaps masked to some extent by a tendency to focus on the growth in the production and trade of manufactured goods since the 1950s". As they rightly point out, since world trade in primary commodities consists of two-way trade flows between developed and developing countries, the issue of commodity prices is a complex interaction between consumers and producers, with all the implications that this has for the world economy as a whole.

All countries, regardless of their state of development, are therefore exposed to commodity price fluctuations through their import-export trade with the rest of the world. Net commodity producing countries (i.e. where primary commodity exports exceed imports) will naturally be mostly concerned about falling commodity prices and *vice versa* for net commodity importing countries. While Keynes lost the political battle to establish Commod Control it is still far from clear that he lost the intellectual battle and had he been proposing it now, in the aftermath of a second Gulf War and the prospect of a long-term military presence and further conflict in the Gulf continues, he might well have received political backing too.

The oil price shocks of 1973–74 and 1978–80 caused major dislocations in developed economies with demand falling and unemployment rising, precisely the effects that had characterised the depression of the 1930s and which motivated Keynes's proposal. Today, the major petroleum exporting countries (plus Russia) and the developed countries face the most important commodity price volatility issues in the twenty-first century. This 'producer/consumer' couplet has a mutual reciprocal and growing interest in promoting energy price stability, including that of natural gas and coal.

The capacity of developed economies to adjust to oil price shocks is becoming ever more limited. While developing countries are traditionally thought of as being most vulnerable to commodity price shocks because of heavy debt burdens and high dependence on one or a few export commodities, the developed world has a greater debt burden as a percentage of GDP, as shown in Table 1. Combined with long-term unfunded welfare liabilities, which will increase for the foreseeable future due to their aging populations, the developed world is also vulnerable to commodity price shocks, and this is not therefore an issue that only concerns developing countries.

Table 1: Allocation of GDP Expenditure and Public Debt Burden in 1999

Economic Groups	**GDP Consumption**		**GDP Investment**	**Public Debt/GDP**
	Public	Private		
Developed Countries	16%	59%	25%	4.0%
Developing Countries	13%	61%	25%	1.3%
OPEC Members	15%	58%	20%	3.1%
Other Developing Countries	13%	61%	25%	1.2%
Eastern Europe	16%	58%	21%	2.1%

Source: *UNCTAD Handbook of Statistics 2002* (GDP) and Bank For International Settlements (Public Debt)

Note: GDP Consumption + GDP Investment = Exports – Imports

Public Debt = Internationally Issued Public Debt Securities + Domestically Issued Public Debt Securities + Consolidated Bank Claims on Public Sector

1.4. An Alternative Mechanism

Since Keynes proposed his original scheme, a revolution has taken place in the global financial, commodity and capital markets. Beginning in the early 1980s, there was a rapid growth in the trading of derivative securities between firms, banks and other financial institutions that allowed risk of all kinds to be managed more efficiently and cheaply than ever before. Although many commodity producers and consumers in developed countries had been managing market price risk for centuries by trading simple derivative instruments such as futures, forwards (and to some extent options) contracts, as Table 2 shows the volume of derivative contracts traded in markets outside commodities during 2001 outstripped that in commodities by a factor of a hundred. Moreover, the growth in derivatives trading even in the late 1990s continued to increase in most markets by an annually compounded rate of between 25and 100 per cent.

Table 2: Growth in OTC and Exchange Traded Derivatives

	OTC			Exchange Traded		
	Dec. 1998	Dec. 2001	Change	Dec. 1998	Dec. 2001	% Change
	$bn	$bn	%	$bn	$bn	%
Foreign exchange contracts	**18011**	**16748**	**-7.0%**	**80.9**	**93**	**15.0%**
Forwards, forex swaps, futures	12063	10336	-14.3%	31.7	65.6	106.9%
Currency swaps	2253	3942	75.0%	-	-	-
Options	3695	2470	-33.2%	49.2	27.4	-44.3%
Interest rate contracts	**50015**	**77513**	**55.0%**	**12654.9**	**21758.1**	**71.9%**
Forward rate agreements, futures	5756	7737	34.4%	8031.4	9265.3	15.4%
Interest rate swaps	36262	58897	62.4%	-	-	-
Options	7997	10879	36.0%	4623.5	12492.8	170.2%
Equity-linked contracts	**1488**	**1881**	**26.4%**	**1200**	**1946.9**	**62.2%**
Forwards, swaps, futures	146	320	119.2%	292.1	341.7	17.0%
Options	1342	1561	16.3%	907.9	1605.2	76.8%
Commodity contracts	**415**	**598**	**44.1%**	**N/A**	**N/A**	**26.3%**
Other Contracts	**10389**	**14375**	**38.4%**	**N/A**	**N/A**	**265.1%**

Source: Bank for International Settlements

Note: Exchange Traded Commodity contract growth data is contract volume open interest not underlying value
Exchange Traded Other Contracts includes Single Equity option contracts only

Forward (and futures) contract[1] is the simplest of all derivative instruments and obliges the buyer and seller to exchange a commodity at some future date, but at a price agreed today. In practical terms this means that the only difference between a forward contract and a spot contract is the length of time between the date at which the contract is signed and the date of delivery – which is generally one or two days for a spot contract and could be many months or even years for a forward contract. A fundamental arbitrage

[1] Forward contracts and futures contracts are essentially the same instrument, providing the same economic benefit, but the former is a contract traded bilaterally between two private counter-parties and the latter is contract traded on a public (regulated) exchange which formally contracts with the counter-parties and guarantees contractual performance by collecting and disbursing margin payments from them on a daily basis.

relationship (see for example Siegel & Siegel 1990) therefore exists between the price of a commodity for spot and forward delivery. The forward contract price $F_{t,T}$, at today's date *t*, for delivery at some future date *T*, is equal to the spot price today P_t plus the cost of financing the holding of physical commodity $(1+r_{t,T})$ between today and the future delivery date. To this must be added the cost of storing the spot commodity between today and the future delivery date, which is denoted $SV_{t,T}$ less the convenience value foregone when holding a contract for delivery at some future date, denoted $CV_{t,T}$, rather than the physical commodity itself. As a result, the following equation captures the relationship at work:

$$F_{t,T} = P_t(1+r_{t,T}) + SV_{t,T} - CV_{t,T} \qquad [\ 1\ ]$$

Therefore, when the convenience value is equal to zero the difference between the spot and futures price should be just sufficient to cover the cost of financing and storage of the physical commodity. When this occurs the market is said to be at full carry and the spot price will be in contango (below the forward price). However, in almost all commodities for the great majority of the time the market is not at full carry, as the convenience value is almost always greater than zero, and where the convenience value exceeds the cost of finance and storage, the market will be in a backwardation with spot price above forward price. This has implications for a buffer stock scheme that is designed only to provide price stabilisation, and not physical security of supply, because it means that the cost of operating such a scheme will always be greater than the cost of buying and selling forward contracts.[2]

Gilbert (1985) considers whether particular producing or consuming countries benefit from the stabilisation of the price of a commodity that is important to them. In particular he considers an optimal hedging strategy using futures contracts and concludes that for small producers and consumers futures trading is, in terms of risk reduction, a perfect substitute for price stabilisation. Although grounded in an elaborate proof, this conclusion is not surprising since it is based on the fundamental market efficiency assumption that the forward price and expected spot price for any future date are equal. Therefore, a producer or consumer that traded a series of forward contracts

[2] Technically this assumes there is minimal risk of default by either counter-party to the forward contract, that transaction costs are the same in spot and forward contracts, and that the convenience value is greater than zero.

today to fix the price of the entirety of its output for all time should expect to receive the same revenue, per unit output, as if prices had been permanently fixed by a commodity price stabilisation scheme at the true long-run equilibrium price.[3] For large producers, who will be interested in revenue stabilisation, and not price stabilisation, forward trading will be a perfect substitute for the optimal degree of price stabilisation. Gilbert concludes that the crucial advantage that forward contracts offer over an international (spot) commodity price stabilisation scheme is that each producer and consumer can adopt the optimal forward position for its particular circumstances, while a Commod Control agency can only choose a single degree of partial price stabilisation from a feasible set which normally excludes complete stabilisation. Moreover, forward trading offers producers insurance against both price and production disturbances whereas complete price stabilisation makes forward trading impossible: by eliminating the need for price insurance, a buffer stock scheme prevents producers from obtaining production insurance.

However, these conclusions are based on a comparison of costless futures trading with costless buffer stock stabilisation. In the real world, there is financial cost to holding buffer stocks while futures contracts are 'marked to market' every day and the exchange requires initial as well as variation margin to be posted by both the contract buyer and seller. This requires access to credit facilities from which margin payments can be drawn. Although the trading of forward contracts typically does not require margin to be posted if prices rise after a contract has been signed, the buyer of the contract would suffer a credit loss equal to the difference between the contract price and current market price should the seller default (and *vice versa* in the case of falling prices).

It does appear that futures and forward contracts offer at least a theoretically complete solution to the problem of incomplete markets that result in the welfare loss arising from commodity price risk, and at a lower cost than a traditional buffer stock scheme. However, both futures and forward contracts suffer from one major disadvantage, which is that both buyers and sellers are exposed to credit risk. In practice, the act of

[3] Keynes proposed the concept of 'normal backwardation' in his theory of hedging and speculation in which he suggested that forward prices contained a downward bias versus expected future spot prices, representing the premium that producers must pay to speculators to allow them to hedge their production for the long term as consumers tend to have short-term hedging horizons and behave opportunistically in their buying. Subsequent work by others suggests that this risk premium only occurs in some commodity markets and depends on the specific characteristics of production and consumption.

defaulting on an obligation under the terms of a bank loan, bond, or derivative security is merely the exercise of a default option inherent in all such contracts. Lenders recognise this default option and increase the interest rate charged on a debt, require the deposit of collateral or margin in the case of futures and forward contracts, or in the extreme case refuse to make loans to or contract with counter-parties that have a poor credit rating.

Gilbert suggests that difficulty in obtaining credit is the most important reason why producers in less developed countries make relatively little use of futures (or forward) contract trading to hedge their revenues. Even if they could obtain credit, the time horizon over which it could be provided is likely to be limited to one crop season as this may be the only source of collateral against which futures margin may be borrowed or to provide security to a forward contract counter-party. Although Gilbert presents no evidence to substantiate this later conclusion, continuous appraisal of counter-party credit ratings and quantification of current and potential future credit exposures arising from the trading of derivative contracts is an integral part of the risk management activities of large financial institutions. Indeed, the assignment of regulatory risk capital to cover credit risk arising from derivatives contracts is an absolute requirement under the Basle Committee agreement of the Bank for International Settlements and failure to do so would immediately mean a financial institution being excluded by other market participants from entering into new derivative contracts. Such an event is likely to trigger procedures that place it under close administrative supervision control by its central bank. Gilbert suggests that the solution to this credit problem is to provide credit to producers in developing countries, perhaps from an international agency, and over a longer period than is currently available, in order to allow them to hedge. He argues that, in the absence of this it will not be possible for futures and forward contract hedging to result in the benefits implied by his analysis.

However, options are a class of derivative securities that offer a potential solution to the asymmetric nature of the default option inherent in forward contracts while offering many of the benefits in terms of optimal revenue stabilisation. Like a futures or forward contract, an option provides counter-parties with a contractual mechanism to buy and sell a commodity at a specified price today, for delivery at some future date. Nevertheless, the rights and obligations arising from an option contract are asymmetric and this allows the credit risk issues arising from them to be managed more effectively. In exchange for an initial premium payment, the seller confers the right on the buyer of a *call* option, but not the obligation, to buy a commodity at a specified price at some future date. Likewise, in exchange for an initial premium payment, the seller confers the right on the buyer of a *put* option, but not the obligation, to sell a commodity at a specified price at some future date. A call option will only be exercised if the market price is above the pre-specified strike price at the moment of expiry and likewise a put option will only be exercised if the market price has declined below the strike price. Since many readers will already be familiar with the characteristics of options and their pricing, a more extensive introduction will not be given here [for a description of the relationship between forward (and futures) and options contracts and options pricing see for example, Brealey & Myers (2002) and more advanced texts such as Cox & Rubinstein (1985) and Hull (1989)].

A primary commodity producer or consumer, with a poor credit rating, and a financial institution, with an investment grade credit rating, are natural counter-parties to an options contract. This is because it allows the producer or consumer to be insured against volatile prices, without posing a credit risk to the financial institution at any time during the life of the contract and regardless of market conditions, but also since it has no other obligation under the contract than to pay the initial option premium. The commodity producer or consumer faces a potential credit exposure to the financial institution if prices rise above the strike price of a call option or below the strike price of a put option but the credit risk is limited by the investment grade credit rating of the financial institution that makes default a low probability event. However, in addition to allowing the producer to access markets from which it may otherwise be excluded, an option contract would also provide them with an opportunity to continue to benefit from favourable price movements. For example, a producer that has purchased put options for protection against downward price moves will never exercise its option if prices remain above the strike price, but will simply sell at the higher prevailing market price instead. The same argument applies in reverse for a consumer that hedged against rising prices by buying a call option.

The equivalence of the futures price and expected future spot prices for any date in the future also has implications for hedging with options contracts. Suppose a commodity producer were to simultaneously purchase a put option and sell a call option with identical strike prices and expiration dates. Ignoring the incremental transaction cost of two, rather than one, transactions, the market risk and credit risk exposure of the producer would be identical to that arising if it had simply sold a futures contract. Assuming that the options market is unbiased, a consumer that buys a long series of options to hedge the entirety of its production for all time should therefore theoretically receive the same revenue less transaction costs as if it had sold its production under a perfect commodity stabilisation scheme at the long-run equilibrium price. Similarly, consumers who continuously buy call options will expect to pay the long-run equilibrium price plus transaction costs.

The asymmetric nature of options contracts means that they have characteristics that are virtually identical to insurance contracts, in the sense that the buyer of such a contract only pays an initial premium and the rights under the contract need only be exercised when some adverse event takes place. Not surprisingly, insurance companies have begun to operate in derivatives markets, for example in trading sovereign and credit risk, and derivatives market operators have begun to trade risks typically associated with insurance such as weather or catastrophe risk. The existing trade in commodity options therefore represents a starting point for the creation of a market in which governments might insure themselves against commodity price risks. However, in order for CPI contracts to serve the same purpose as a commodity buffer stock scheme, the contracts would have to have expiration dates that are far longer than those typical of commodity derivative contracts currently being traded – which typically have expiry dates of a few months, and at most a few years, from the date of contracting. Since the writing of insurance contracts on an individual life, for 25 years or more, or the issuing of corporate and sovereign government bonds for similar maturities, is a common occurrence in modern financial markets there is no technical or legal reason why insurance contracts of 3–10 year maturities could not be created for commodity price risk.

In the next section of this paper, the creation of a GCI is discussed which would issue, and then manage the risk arising from CPI contracts designed to stabilise the fiscal revenues, current expenditure, and investment, against fluctuations in commodity prices. Alternative institutional forms of the GCI are also discussed: how it would integrate into the global financial system, and its interaction with existing national subsidy and price mechanisms (e.g. EU CAP, US Farm Bill 2002, OPEC and other existing price support and subsidy schemes) are also considered. The costs of implementing CPI contracts for the major internationally traded commodities are also estimated, based upon an econometric analysis of the long-run equilibrium price for each; the rate at which prices revert to that equilibrium price after a shock; and the residual stochastic price volatility. Finally, the benefits, costs and risk capital requirements of a CPI scheme are estimated.

2. SCHEME

From the point of view of national governments in developing countries, investment in education, immunisation, welfare, road building, electrification and the like may take a decade to complete and a generation before a payoff occurs in terms of an increase in economic growth and welfare of the population. In developed countries the long-term healthcare, social programmes and pension obligations of an aging population stretch into the far distant future. Under these circumstances, short-term (day-to-day or month-to-month) commodity price volatility will be of relatively little consequence to a government, so that any mechanism put in place must also be capable of mitigating the impact of commodity price shocks on a year-to-year basis, over the long term. Overall, given the nature of the electoral cycle, government planning horizons, or just the length of time that a road takes to build or a child to be educated to primary level, a time horizon of 3–10 years seems appropriate. In the remainder of this section, details are given of the CPI scheme which would insure governments against the impact of oil price shocks on their revenues and costs. The overriding objective would be to provide compensating payments to governments of countries that are net producers of commodity(s) if the average annual spot price(s) fall below a pre-specified price floor and reciprocally compensate governments of countries that are net consumers of commodity(s) if average annual spot price(s) rise above a pre-specified strike price.

2.1. Commodity Price Insurance Contract Features

Many of the sovereign governments of countries that would be candidates for using the CPI scheme have little revenue to finance the purchase of hedging instruments. As their credit rating may already be impaired, and the necessary skills may not be available to manage complex hedging programmes locally, the design of the risk management instruments will be constrained by cost and complexity considerations. In addition, forward contracting would commit a government to deliver specific quantities of commodity output to the market and therefore leave it exposed to any shortfall in production brought about by natural disasters, civil disturbance, or war. If that country also happened to account for a large share of global production in that commodity (e.g. Brazil in coffee, Côte d'Ivoire in cocoa, Saudi Arabia in oil) then such a shortfall is also likely to be accompanied by a rise in world prices. The combined effect of the government of a major commodity producing country entering into a hedging programme, based on forward contracting, with a supply dislocation, would be to leave the country with an obligation to cover the shortage it had created where any purchases it attempted to make to cover the shortfall would immediately drive prices sharply higher. The net result would be an increase in the sovereign debt of that country at the time it was least able to service it. Ultimately, the government would be forced to default on its obligations under the hedging programme. For practical operational as well as financial reasons an insurance contract is therefore a more appropriate instrument for managing sovereign government exposure to commodity price risks than, for example, a traditional forward contract based hedging programme. The nature of an insurance contract is that once purchased it requires no further management other than to make a claim should a loss occur. The initial payment of premium imposes no credit risk on the provider of the CPI regardless of the credit quality of the government purchasing the insurance. Finally, the symmetric nature of insurance also means that governments buying CPI contracts would face no other obligation than the payment of an initial premium, so would face no risk of a physical shortfall due to unforeseen disruptions to production.

The basic form of a CPI contract for a generic commodity would be as follows:

1. A CPI contract would provide insurance protection against market price risk in each of the 49 separate commodities, and each of the 8 sub-indices, included in the IMF Commodity Index (see Table 3 for full list);
2. The nominal underlying value of a CPI contract would be tailored to the exposure faced by each sovereign government to commodity price risk;
3. Where a country was a net importer of a commodity, a ‘CPI-Max’ contract would provide insurance against the price of a given commodity rising above a pre-specified upper bound level (‘upper strike price’); and where the country was a net exporter of a commodity, a ‘CPI-Min’ contract would provide insurance against the price of a given commodity falling below a pre-specified lower bound (‘lower strike price’);
4. New CPI contracts would be purchased annually, with premiums paid once and for all up front at the purchase date of the contract, and with a minimum maturity of three years;

5. Contract settlement would occur immediately after the CPI contract expiration date;
6. The settlement amount on each CPI contract would be equal to the difference between the pre-specified strike price and the reference market price calculated from the mean monthly prices published in the IMF Commodity Index for the year immediately preceding the CPI contract expiration date;
7. It is anticipated that sovereign government would continuously adjust the degree of price protection (both in terms of underlying insured value and strike price) to be covered by a CPI contract, depending on their net exposure, as well as the cost they were willing to bear. In practice, they would eventually construct a portfolio of CPI holdings with a variety of maturities, strike prices and underlying nominal contract values;
8. GCI would be the counter-party to all CPI contract sales and purchases, responsible for collecting premiums, and settlement;
9. GCI would call regular tenders to procure appropriate offsetting contracts from the global capital and insurance markets to manage the price risk exposure underlying the CPI contracts it sold. The GCI as aggregator of risk, would benefit from the inherent diversification effects in the portfolio of commodity price risks and thereby reduce the overall cost of operating the global scheme; and
10. The risk of sovereign governments deliberately over-hedging to speculate on future commodity prices would be prevented by limiting the total contract position they held in any given year to some fixed percentage of the national net import-export balance in each commodity.

In order for CPI contracts to serve as an effective insurance against long-term commodity price exposures, the contracts would have expiration dates far longer (at least three years maturity) than those typical of commodity derivatives contracts currently being traded, and in much higher volumes.

2.2. Global Commodity Insurer

It is clear that given the international nature of the CPI contract regime and the fact that it would operate at the governmental level in conjunction with existing institutions (e.g.

World Bank, IMF, OECD, OPEC), such a scheme would have to operate via a central agency. In principle, the GCI could take on many legal forms and functions, but in practice this would be limited by the fact that it would need to act as counter-party in all transactions, at least initially. This means that it could not act merely as an insurance broker of CPI contracts between governments and the international capital market. However, whether it should be structured as an insurance company or insurance exchange and who would provide the organisation with the necessary risk capital is an open question.

If the GCI were set up as an insurance company, its function would be to define the form and structure of CPI contracts appropriate for each sovereign government and then sell them. The risk assumed in the portfolio of contracts sold could be managed either by purchasing offsetting option contracts or reinsurance contracts from the international capital and insurance market, or by funding any losses from its own capital. This structure assumes that the GCI would be both competitor to, and counter-party to, the world's major insurers, financial institutions and commodity trading houses who may be willing to offer similar CPI type contracts to governments without using the GCI as an intermediary. The GCI role would be to act as a catalyst or 'market maker' completing the market by designing and offering CPI contracts. Once the market developed, competing providers of CPI contracts might emerge.

An alternative GCI structure would be to operate as an organised exchange that traded standardised CPI contract components that could be combined and recombined to construct appropriate portfolios, depending on the sovereign government concerned. In this case, the GCI would largely be competing against existing commodity exchanges by offering alternative hedging products that could be bought and sold continuously through brokers. Since the counter-parties would be dealing with each other via the exchange, the GCI role would be to monitor and report traded prices, settle trades that occurred, and manage its credit exposure to the sellers of CPI contracts.

In the case of GCI as CPI market maker it would potentially be taking on significant market risk on any unhedged portion of its CPI sales and credit risk on any hedging contracts it purchased. As an exchange, it would take on no market risk because any CPI contract sold would have an exactly equal and offsetting CPI contract purchase against it and GCI would then only face a potential credit exposure to counter-parties who had sold CPI contracts.

Clearly, the requirement for risk capital if GCI were an exchange would be significantly less than that of a CPI market maker that remained partially or wholly unhedged – but the question of who should supply that capital is still present in both cases. In Keynes' original Commod Control proposal he had assumed that the capital would be provided by either the UK Treasury in the form of gold which would be transferred to it, or sold off in the global market in exchange for buffer stocks of physical commodity, or be provided by the major consuming countries in the form of guarantees or credits which would be temporarily drawn down and replenished as required. The provision of such a government backed guarantee structure is similar to that which has supported the IMF and World Bank since their inception. However, given that developing countries would be unlikely to have the necessary financial resources to provide such a guarantee, then in effect the developed world would be asked to provide risk capital to an organisation that only partially operated to service their needs. An alternative capital structure might be to adopt that used by organised commodity exchanges which typically sell seats or rights to firms who wish to transact or operate on the exchange. In this case, the providers of CPI contracts are obvious candidates to provide capital to the GCI. Since they will clearly be the only source of credit exposure it seems reasonable that they should provide the necessary capital to offset it.

2.3. Integration with the Global Financial System

The question of whether the global financial market would have the capacity to provide the necessary volume of CPI contract cover is crucial since GCI would not be able to rely solely on governments to provide the necessary finance. Since we have assumed that commodity producers and consumers in developed countries are already operating in commodity derivatives markets to the extent that they need to for their own risk management purposes, the provision of further commodity risk capital from this source is unlikely. The only remaining source is the global capital market comprising commercial and investment banks, investment institutions, and insurance companies. Though the appetite of the global capital market for commodity risk is unknown, Table

2 shows that between 1998 and 2001 the total volume of derivatives contracts outstanding was still growing rapidly, albeit commodity instruments were the smallest component of that. On this basis, it appears that the capacity of the global financial markets to provide new capital for the trading of derivative risk is not constrained, nor is its willingness to trade new derivative instruments.

Another potential source of risk capital might be derived from a change in the asset allocation patterns of long-term investors, such as pension funds, who have almost completely avoided primary commodity price exposure except incidentally via the exposures of the bonds and equities of firms in which they have already invested. The Capital Asset Pricing Model (CAPM) and efficient market hypothesis suggest that such investors would benefit if they were to accept some commodity price risk in their portfolios because of the diversification benefits it would bring. Given the size of pension fund assets worldwide, even a small shift of asset allocation strategies might be sufficient to attract all the necessary capital that GCI required. In practice, it seems likely that a tiered approach to acquiring risk capital might be required. Offsetting derivative contracts purchased from capital market participants such as commodity trading houses, producers and consumers as well as investment banks, and investing institutions would be the first and largest source of risk capital. The next level might be made up of conventional loans, bonds, and equity issued to public and private investors. Finally, guarantees provided by governments and/or possibly channelled through the IMF, World Bank, and UNCTAD could provide the final element of the capital base.

Though the response of the global financial system to CPI, and its willingness to bear incremental commodity price risk is uncertain, rough estimates of the potential incremental capacity required can be drawn from the total volume of CPI contracts that would be required if each country were to cover the entire volume of net exports and imports of primary commodities. Since total world primary commodity exports must be equal to the net of total world primary commodity production less domestic consumption of producing countries, and total world net exports must equal total world net imports, then the underlying commodity price exposure is relatively easy to calculate as twice the total world primary commodity exports of approximately US$1.3 trillion per annum, meaning that total net exposure per year to be covered by CPI contracts would equal US$2.6 trillion. Assuming the entire primary commodity export-import trade was to be insured for a period of five years that would mean a total nominal underlying contract volume of US$12 trillion requiring an annual growth rate of 100% per annum in outstanding commodity derivative contracts. Assuming no growth in any other form of derivative contracts, and that each CPI was offset by one additional derivative contract trade, then the total volume of outstanding commodity contracts would grow to approximately 10% of the global total of derivative contracts now outstanding (as summarised in Table 2). Currently commodity derivatives account for approximately 3% of outstanding contracts so the increase would not be significant compared with the current annual growth rate in total derivative contracts outstanding. It therefore appears that such an increase could be absorbed relatively easily without large incremental amounts of risk capital being made available in the derivatives market.

2.4. Interaction with Existing Schemes

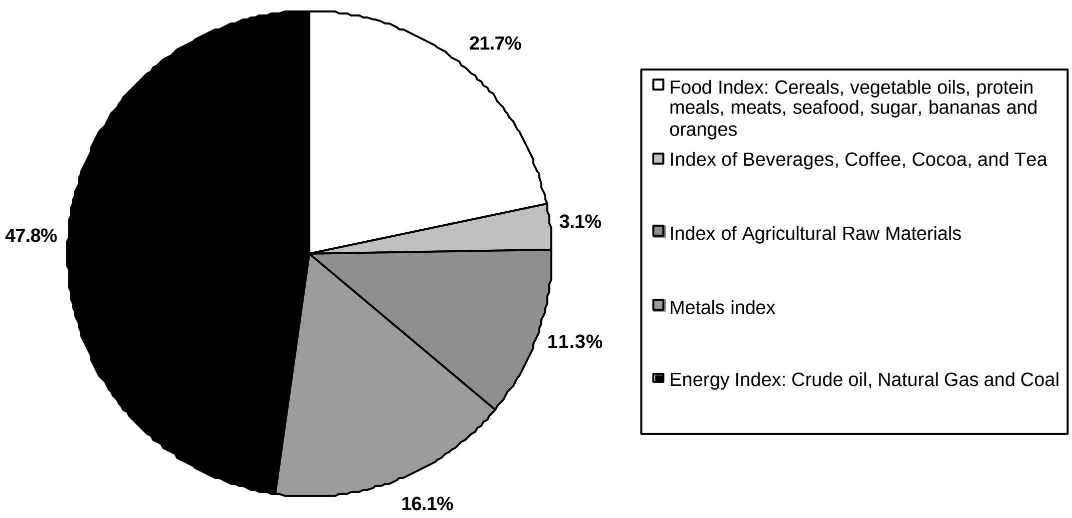
The CPI scheme discussed here is limited to sovereign governments as potential buyers because it is assumed that private individuals and firms could participate in commodity derivative markets, if they wish to. The CPI scheme would therefore be incremental to this existing trade and designed to complete the market by allowing governments to purchase protection against the type of commodity price volatility over time horizons and in volumes that are not currently available to them. However, private firms and individuals would be the ultimate guarantors of CPI contracts through the provision of risk capital to the global derivative, insurance and capital markets from which GCI would purchase offsetting hedging contracts. To this extent, it is entirely possible that private firms might ultimately wish to operate on both sides of the market for CPI contracts, and that secondary trading in these instruments, where GCI would not necessarily be a counter-party, could occur.

The GCI would not aim to interfere with the activities of institutions or exchanges operating in global capital and commodity markets. Neither would it be in conflict with the roles of established international organisations such IMF, World Bank, UNCTAD, Organization of the Petroleum Exporting Countries (OPEC), and International Energy Agency (IEA). Instead, it would work closely with them and supplement their existing functions. Since the CPI contracts would not stabilise prices, but merely offset the consequences of spot price volatility, any actions taken by these existing agencies would be supplementary and complementary to that of the GCI. The fact that GCI would not intervene in commodity spot markets, or indeed trade in them, means that it would be less likely to distort price signals received by private consumers and producers, than any subsidy or price support schemes would. Crucially, the strike prices and cost of the CPI scheme would be determined by markets, not bilateral or multilateral negotiation between governments (as Keynes envisaged), therefore it would be inherently more flexible and robust than a buffer stock scheme. Governments would individually and continuously adjust their long-run equilibrium price expectations and select the appropriate level of protection accordingly.

3. ANALYSIS

The IMF Commodity Index covering the period 1980–2001 is based on 8 sub-indices covering non-fuel commodities, edibles, foods, beverages, industrial inputs, agricultural raw materials, metals and energy. In turn, these sub-indices are calculated from 49 underlying price series for individual spot commodities. Such prices are calculated on a monthly basis from mean daily closing spot prices. The weighting of the individual commodities in the IMF Commodity Index are shown in Figure 1 and are based on the average world export earnings for each commodity reflecting trade flows in the period 1995–1997 (rebased in March 2003 so that the index value for 1995 = 100, in terms of US$). Although these new weights exclude intra-EU trade, the index still represents a convenient starting point for measuring the impact of changes in commodity prices on the global economy. Time series data for the old and new index and underlying components have been collected on a monthly basis since 1980 and are available to download from the IMF website (IMF 2002).

Figure 1: IMF Commodity Index (New 1995–97 Weights)



3.1. Time Series Modelling

The existence of price mean reversion in commodity time series is well established [see for example, Laughton & Jacoby (1995), Pilipovic (1998)]. As it bounds the otherwise unlimited dispersion that occurs in price time series evolving as a geometric (Brownian) random walk it reduces the risk capital required, and hence cost, of managing commodity price volatility through a CPI scheme. The impact of price mean reversion and volatility has been modelled for the IMF Commodity Index, sub-indices, and underlying commodity time series by assuming that the evolution of prices conforms to an arithmetic Ornstein-Uhlenbeck price mean reversion process and successfully applied in oil price time series by Schwartz (1997). For each index or price series, the mean value for each year over the period 1990–2002 was calculated to eliminate any seasonal effects and then the following regression run for each:

$$x_t - x_{t-1} = a + b\,x_{t-1} + e_t. \quad [2]$$

where x_t is equal to the natural log of the annual price or index level, and $x_t - x_{t-1}$ represents the continuously compounded annual return from holding a spot commodity before storage and financing costs. A long-run equilibrium price (m) and price mean reversion (h) parameter were then derived directly from the regression output:

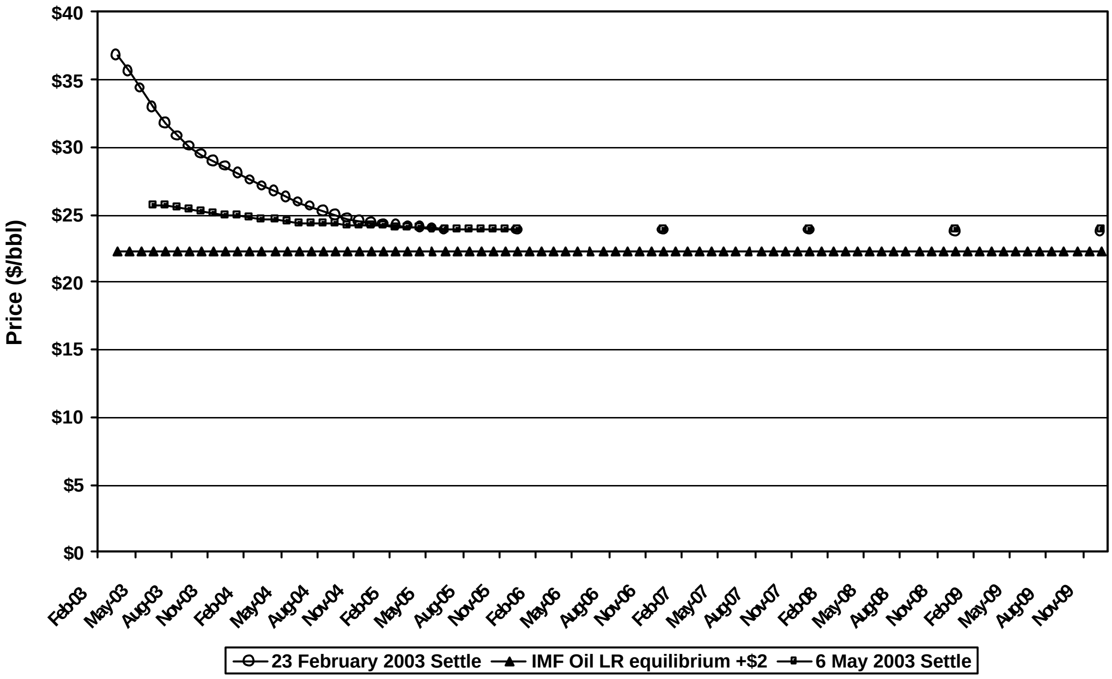
$$m = e^{-a/b} \quad [3]$$

$$h = -\ln(1 + b) \quad [4]$$

The standard deviation (s) of the residual returns from the regression output provides an approximate estimate of the short-run (annual) volatility of prices around the long-run equilibrium level. The results are summarised in Table 3 and show that the long-run equilibrium price for each commodity is within 5% of the mean price over the last ten to twenty years of the twentieth century. The price mean reversion process exhibits a parameter of the order of 2–5% per month, meaning that prices are expected to revert to their long-run equilibrium level within a year or less after a single 25% shock has occurred. The results also provide an index of the relative risk imposed by oil price volatility versus other commodities. It is striking that energy not only constitutes almost 50% of the IMF export weighted index, but also the volatility of oil (and gas) prices (s^2_{Annual}), after adjusting for price mean reversion, are among the highest of all commodities. This further explains why the OPEC-IEA axis receives such strong multilateral support.

In the case of oil, Figure 2 also shows that, despite the extreme price volatility caused by the approaching war with Iraq, the long-run forward price for crude oil (WTI) traded on the New York Mercantile Exchange (NYMEX) remained close to the long-run equilibrium level calculated above. On 24 February 2003, before war broke out, WTI for delivery in December 2009 was trading at US$23.77, while the spot price was US$36.79. On 6 May 2003, shortly after the war had finished, WTI for forward delivery in December 2009 was barely changed at US$23.95, even though the spot price had fallen to US$25.65. The NYMEX is unique among commodity exchanges in having such long-term forward contract quotes, and even though liquidity is very low at this horizon, the forward price quoted here during and after a time of extreme market stress is close to the estimated long-run equilibrium price of US$20.32 (allowing for a US$2.00 barrel premium of WTI over the IMF Oil Index).

Figure 2: Nymex Forward Curve and Long-Run Equilibrium Oil Price



Source: NYMEX closing prices on relevant dates from www.nymex.com

These results suggest that short-term deviations from long-run equilibrium do indeed occur in spot oil prices but that they revert over time and are not therefore a random walk process as typically observed for financial assets (e.g. equities). The fact that a long-run equilibrium price can be calculated for oil and other commodities, all be it with significant periodic deviations, confirms that an international scheme to manage the global economic impact of short-term oil (and possibly other commodity) price volatility is not only theoretically feasible, but that the cost of implementing such a scheme is bounded by economic fundamentals.

Table 3: IMF Commodity Index Mean Reversion, and Volatility Parameters

Index Constituents	Index Weight %	Regression Coefficients		Parameter Estimates		
		a	b	Mean Price	LR Price	Volatility %
Index of Fuel and Non Fuel Commodities (1995=100)	100.0	3.58	-0.78	98.42	99.36	11.5%
Index of Non-Fuel Primary Commodities (1995=100)	52.2	0.94	-0.21	85.73	83.08	7.7%
Edibles Index (1995=100)	24.7	0.64	-0.15	88.79	82.83	7.5%
Food Index	27.4	0.80	-0.18	89.86	84.21	7.4%
Index of Beverages, Coffee, Cocoa, and Tea	21.7	2.23	-0.51	81.27	81.77	21.5%
Index of Industrial Inputs (1995=100)	3.1	1.92	-0.44	82.97	82.49	9.4%
Index of Agricultural Raw Materials (1995=100)	11.3	0.95	-0.22	86.21	81.51	7.6%
Metals index	16.1	2.82	-0.64	80.70	81.33	10.7%
Energy Index: Crude oil, Natural Gas and Coal	47.8	2.59	-0.55	112.27	115.10	20.1%
Average Petroleum Spot index of UK Brent, Dubai, amd West Texas	39.9	2.60	-0.55	114.98	118.09	21.7%
Aluminum, LME standard grade, minimum purity, cif UK	6.0	7.12	-0.97	1461.20	1491.86	9.3%
Bananas, Avg of Chiquita, Del Monte, Dole, US Gulf delivery	0.6	5.08	-0.82	470.90	472.01	13.1%
Barley, Canadian Western No. 1 Spot	0.4	2.43	-0.53	90.64	95.37	15.4%
Beef, Australia/New Zealand frozen, U.S. import price	1.4	2.22	-0.50	91.81	86.36	6.9%
Coal thermal for export, Australia	2.7	1.41	-0.41	31.69	30.66	13.2%
Coal thermal for export, South Africa	0.7	2.67	-0.79	29.32	29.31	13.2%
Cocoa, ICO price, cif U.S. & European ports	0.7	4.81	-0.66	1357.69	1391.62	21.2%
Coffee, Other Milds, El Salvdor and Guatemala, ex-dock New York	1.4	2.05	-0.44	111.51	106.64	33.5%
Coffee, Robusta, Uganda and Cote dIvoire, ex-dock New York	0.6	0.74	-0.19	71.56	49.91	38.9%
Cocoanut Oil, Philippine/Indonesia, cif Rotterdam	0.2	2.57	-0.41	572.19	558.32	24.2%
Cooper	0.6	2.41	-0.32	1988.32	1851.26	17.8%
Cotton, Liverpool Index A, cif Liverpool	1.1	0.92	-0.22	66.75	60.02	19.1%
Fishmeal, 64/65 percent, any orig, cif Rotterdam	2.6	3.78	-0.60	497.62	521.12	19.0%
Groundnut, US runners, cif European	0.0	2.17	-0.32	916.18	819.18	7.1%
Hides; US, Chicago, fob Shipping Point	3.0	2.54	-0.58	82.62	82.89	6.3%
Iron Ore Carajas	1.8	3.02	-0.90	29.07	29.04	4.9%
Lamb; New Zealand, PL frozen, London price	0.3	4.11	-0.85	127.95	128.00	11.6%
Lead; LME, 99.97 percent pure, cif European	0.3	3.01	-0.48	539.43	553.02	14.7%
Log; soft, export from U.S. Pacific coast	0.6	0.95	-0.19	180.50	142.53	8.6%
Log; hard, Sarawak, import price Japan	2.0	1.55	-0.30	231.52	166.42	12.8%
Maize; U.S. number 2 yellow, fob Gulf of Mexico	1.7	1.93	-0.41	108.42	106.66	16.2%
Russian Natural Gas, in Germany	2.1	3.84	-0.84	97.45	95.73	22.3%
Natural Gas, Indonesian LNG, CIF Japan	1.7	2.51	-0.57	81.41	82.23	18.5%
Natural Gas, US domestic; CIF Henry Hub, LA	0.7	1.94	-0.42	96.48	100.79	26.5%
Nickel; LME, melting grade, cif N Europe	1.2	8.88	-1.01	6631.25	6672.93	18.9%
Oil; Average of U.K. Brent, Dubai, and West Texas Intermediate	39.9	1.64	-0.55	19.78	20.32	21.7%
Olive Oil, less that 1.5% FFA	0.2	3.83	-0.47	3597.63	3613.95	21.6%
Orange Brazilian, CIF France	0.5	5.67	-0.92	474.56	475.03	16.2%
Palm Oil; Malaysia and Indonesian, cif NW Europe	0.8	2.62	-0.43	470.50	464.64	24.6%
Hogs, 51-52% lean, 170-191 lbs; IL, IN, OH, MI, KY	1.0	2.78	-0.69	60.68	57.76	22.7%
Chicken, Ready-to-cook, whole, iced, FOB Georgia Docks	1.0	1.87	-0.45	59.81	61.47	4.3%
Rice; 5 percent broken, nominal price quote, fob Bangkok	1.1	0.65	-0.12	259.08	215.00	14.6%
Rubber; Malaysian, fob Malaysia and Singapore	1.1	0.98	-0.27	42.53	39.69	24.4%
Norwegian Fresh Salmon; farm bred; export price	2.6	0.07	-0.09	3.94	2.07	8.4%
Sawnwood; dark red meranti, select quality	1.4	2.14	-0.34	641.34	568.44	14.6%
Sawnwood; average of softwoods, U.S. West coast	2.4	4.08	-0.72	289.36	289.74	4.8%
Shrimp; U.S., frozen 26/30 count, wholesale NY	1.2	1.82	-1.00	6.16	6.23	11.7%
Soybean Meal; 44 percent, cif Rotterdam	1.1	3.30	-0.63	200.91	194.31	18.5%
Soybean Oil; Dutch, fob ex-mill	0.5	2.31	-0.37	503.84	488.99	19.0%
Soybean; U.S., cif Rotterdam	1.5	1.46	-0.27	243.37	227.02	11.5%
Sugar; EC import price, cif European	0.4	0.49	-0.15	27.49	25.32	5.8%
Sugar; International Sugar Agreement price	1.4	0.38	-0.19	9.65	7.41	20.7%
Sugar; US, import price contract number 14 cif	0.1	1.76	-0.57	21.59	21.51	4.5%
Sunflower Oil; any origin, ex-tank Rotterdam	0.3	4.40	-0.69	573.00	571.37	18.3%
Tea; From July 1998,Kenya auctions, Best Pekoe Fannings. Prior, London	0.4	2.24	-0.42	204.35	203.01	13.0%
Tin; LME, standard grade, cif European	0.3	-0.69	0.08	5353.87	7746.65	9.2%
Uranium, NUEXCO, Restricted Price, US$ per pound	0.7	1.08	-0.46	10.60	10.44	16.4%
Wheat; U.S. number 1 HRW, fob Gulf of Mexico	2.8	1.70	-0.34	146.21	146.04	15.5%
Wool Coarse; 23 micron, AWEX	0.4	3.13	-0.52	388.03	408.00	22.8%
Wool Fine; 19 micron, AWEX	0.6	7.88	-1.21	656.92	670.15	11.0%
Zinc; LME, high grade, cif UK	0.9	4.52	-0.65	1022.44	1006.40	14.2%

Source: IMF Commodity Index and authors' own calculations

3.2. Simulating CPI Prices

Given that stable long-run equilibrium prices do appear to exist for oil (and other commodities) it is reasonable to conclude that such a price level could be used as the basis for designing a scheme to protect national government revenue and expenditure against oil and other commodity price shocks. For example, countries wishing to protect themselves against an oil price rise will effectively be purchasing a portfolio of CPI-Max contracts, and those wishing to protect themselves against an oil price fall will be purchasing a portfolio of CPI-Min contracts. As the payoff on these CPI contracts depends on the mean price of a basket of WTI, Brent and Dubai crude oil over the year before expiration, rather than a price only on a single date, their cost will be significantly lower than that of long-term American style option contracts (assuming that these could even be purchased) typically traded on exchanges such as NYMEX.

Table 4 summarises the theoretical cost of both CPI-Max and CPI-Min contracts of five-year maturity expressed as a percentage of the long-run equilibrium price of each of the commodities and sub-indices in the IMF Commodity Index. These have been calculated by simulating 1000 price paths for each time series to a five-year horizon, and then calculating the mean discounted payoff for CPI-Max and CPI-Min contracts assuming that the initial commodity spot price at time zero is equal to the long-run equilibrium price (*m*), and that the CPI-Max and CPI-Min strike prices are respectively set at 10% above and below the long-run equilibrium level.

The payoffs at the five-year horizon are discounted to present value at the risk free rate assuming an upward sloping term structure for interest rates beginning at 2% for year 1, and increasing at 0.25% per annum thereafter which approximately corresponds to the zero coupon yield curve on a US Government bond as at 31 December 2002. The current spot price and forward prices are assumed to be equal, and therefore the forward price curve is horizontal. More technically, this assumes that the financing, insurance and storage cost of holding each commodity is exactly equal to the convenience yield.

The price paths were simulated from the recursive form of the regression equation [2] above by substituting the *a* and *b* regression parameters summarised in Table 3:

$$x_t = -x_{t-1} + a + b_{xt-1} + s\,\mathrm{dz} \qquad [\,5\,]$$

In order to calculate x_t for the first year, the x_{t-1} value is set equal to a, then for subsequent years, the index or price level calculated from the previous year (x_t) feeds into the calculation for the next year as (x_{t1}).[4] However, the approximate volatility parameter (s) previously estimated cannot be used because distributions of spot commodity log price returns are rarely normal, even after adjusting for seasonality and mean reversion, and prone to significant heteroscedacity (so called 'fat tails'). Any s estimate will therefore inevitably contain some, perhaps significant, estimation error.

Table 4: Simulated Theoretical Cost of CPI-Max and CPI-Min Contracts

Index Constituents	Index Wt %	LR Price	Strike Prices		CPI Values		CPI % of LR Price	
			CPI-Max	CPI-Min	CPI-Max	CPI-Min	CPI Call	CPI Put
Index of Fuel and Non Fuel Commodities (1995=100)	100	99.36	109.30	89.42	1.12	0.79	1.13%	0.72%
Index of Non-Fuel Primary Commodities (1995=100)	52.2	83.08	91.39	74.77	0.91	0.63	1.10%	0.69%
Edibles Index (1995=100)	24.7	82.83	91.11	74.55	1.10	0.77	1.33%	0.85%
Food Index	27.4	84.21	92.63	75.79	0.92	0.71	1.09%	0.76%
Index of Beverages, Coffee, Cocoa, and Tea	21.7	81.77	89.94	73.59	4.83	2.72	5.90%	3.03%
Index of Industrial Inputs (1995=100)	3.1	82.49	90.73	74.24	0.86	0.53	1.04%	0.59%
Index of Agricultural Raw Materials (1995=100)	11.3	81.51	89.66	73.36	0.82	0.63	1.00%	0.70%
Metals index	16.1	81.33	89.46	73.20	0.92	0.47	1.13%	0.53%
Energy Index: Crude oil, Natural Gas and Coal	47.8	115.10	126.62	103.59	4.92	3.04	4.28%	2.40%
Average Petroleum Spot index of UK Brent, Dubai, amd West Texas	39.9	118.09	129.90	106.28	5.81	3.53	4.92%	2.71%
Aluminum, LME standard grade, minimum purity, cif UK	6	1,491.86	1641.04	1342.67	9.59	4.54	0.64%	0.28%
Bananas, Avg of Chiquita, Del Monte, Dole, US Gulf delivery	0.6	472.01	519.21	424.81	7.91	6.11	1.68%	1.18%
Barley, Canadian Western No. 1 Spot	0.4	95.37	104.91	85.83	3.04	1.93	3.18%	1.84%
Beef, Australia/New Zealand frozen, U.S. import price	1.4	86.36	95.00	77.73	0.29	0.15	0.34%	0.16%
Coal thermal for export, Australia	2.7	30.66	33.73	27.60	0.74	0.54	2.42%	1.60%
Coal thermal for export, South Africa	0.7	29.31	32.24	26.38	0.52	0.35	1.76%	1.09%
Cocoa, ICO price, cif U.S. & European ports	0.7	1,391.62	1530.78	1252.45	70.90	39.03	5.09%	2.55%
Coffee, Other Milds, El Salvdor and Guatemala, ex-dock New York	1.4	106.64	117.31	95.98	13.49	6.98	12.65%	5.95%
Coffee, Robusta, Uganda and Cote dIvoire, ex-dock New York	0.6	49.91	54.90	44.92	12.86	4.68	25.77%	8.53%
Cocoanut Oil, Philippine/Indonesia, cif Rotterdam	0.2	558.32	614.15	502.48	46.78	24.30	8.38%	3.96%
Cooper	0.6	1,851.26	2036.38	1666.13	98.03	58.27	5.30%	2.86%
Cotton, Liverpool Index A, cif Liverpool	1.1	60.02	66.03	54.02	4.33	2.45	7.22%	3.71%
Fishmeal, 64/65 percent, any orig, cif Rotterdam	2.6	521.12	573.23	469.00	22.05	13.81	4.23%	2.41%
Groundnut, US runners, cif European	0	819.18	901.10	737.26	4.63	3.31	0.56%	0.37%
Hides; US, Chicago, fob Shipping Point	3	82.89	91.18	74.61	0.15	0.08	0.18%	0.09%
Iron Ore Carajas	1.8	29.04	31.95	26.14	0.00	0.00	0.01%	0.00%
Lamb; New Zealand, PL frozen, London price	0.3	128.00	140.80	115.20	1.34	0.75	1.05%	0.53%
Lead; LME, 99.97 percent pure, cif European	0.3	553.02	608.32	497.72	15.56	10.25	2.81%	1.69%
Log; soft, export from U.S. Pacific coast	0.6	142.53	156.78	128.28	2.31	1.75	1.62%	1.11%
Log; hard, Sarawak, import price Japan	2	166.42	183.06	149.78	4.65	3.16	2.79%	1.72%
Maize; U.S. number 2 yellow, fob Gulf of Mexico	1.7	106.66	117.33	96.00	3.87	2.43	3.63%	2.07%
Russian Natural Gas, in Germany	2.1	95.73	105.30	86.16	4.50	3.20	4.70%	3.04%
Natural Gas, Indonesian LNG, CIF Japan	1.7	82.23	90.45	74.01	2.93	1.83	3.56%	2.02%
Natural Gas, US domestic; CIF Henry Hub, LA	0.7	100.79	110.87	90.71	8.54	4.79	8.48%	4.32%
Nickel; LME, melting grade, cif N Europe	1.2	6,672.93	7340.22	6005.64	217.58	129.21	3.26%	1.76%
Oil; Average of U.K. Brent, Dubai, and West Texas Intermediate	39.9	20.32	22.35	18.28	1.00	0.61	4.92%	2.71%
Olive Oil, less that 1.5% FFA	0.2	3,613.95	3975.35	3252.56	223.04	127.39	6.17%	3.20%
Orange Brazilian, CIF France	0.5	475.03	522.54	427.53	13.58	8.78	2.86%	1.68%
Palm Oil; Malaysia and Indonesian, cif NW Europe	0.8	464.64	511.10	418.17	41.67	20.64	8.97%	4.04%
Hogs, 51-52% lean, 170-191 lbs; IL, IN, OH, MI, KY	1	57.76	63.53	51.98	2.96	1.89	5.12%	2.98%
Chicken, Ready-to-cook, whole, iced, FOB Georgia Docks	1	61.47	67.61	55.32	0.01	0.00	0.01%	0.00%
Rice; 5 percent broken, nominal price quote, fob Bangkok	1.1	215.00	236.50	193.50	13.59	7.48	6.32%	3.16%
Rubber; Malaysian, fob Malaysia and Singapore	1.1	39.69	43.66	35.72	3.80	2.10	9.57%	4.82%
Norwegian Fresh Salmon; farm bred; export price	2.6	2.07	2.28	1.87	0.05	0.03	2.27%	1.20%
Sawnwood; dark red meranti, select quality	1.4	568.44	625.29	511.60	18.75	12.75	3.30%	2.04%
Sawnwood; average of softwoods, U.S. West coast	2.4	289.74	318.72	260.77	0.03	0.01	0.01%	0.00%
Shrimp; U.S., frozen 26/30 count, wholesale NY	1.2	6.23	6.86	5.61	0.06	0.04	1.03%	0.65%
Soybean Meal; 44 percent, cif Rotterdam	1.1	194.31	213.74	174.88	7.16	4.88	3.68%	2.29%
Soybean Oil; Dutch, fob ex-mill	0.5	488.99	537.89	440.09	29.36	15.23	6.00%	2.83%
Soybean; U.S., cif Rotterdam	1.5	227.02	249.73	204.32	5.17	3.40	2.28%	1.36%
Sugar; EC import price, cif European	0.4	25.32	27.85	22.79	0.17	0.09	0.67%	0.34%
Sugar; International Sugar Agreement price	1.4	7.41	8.15	6.67	0.62	0.39	8.37%	4.84%
Sugar; US, import price contract number 14 cif	0.1	21.51	23.66	19.36	0.01	0.00	0.06%	0.01%
Sunflower Oil; any origin, ex-tank Rotterdam	0.3	571.37	628.51	514.23	23.21	12.85	4.06%	2.04%
Tea; From July 1998,Kenya auctions, Best Pekoe Fannings. Prior, London	0.4	203.01	223.31	182.71	4.98	3.58	2.45%	1.60%
Tin; LME, standard grade, cif European	0.3	7,746.65	8521.32	6971.99	365.49	233.17	4.72%	2.74%
Uranium, NUEXCO, Restricted Price, US$ per pound	0.7	10.44	11.48	9.39	0.40	0.23	3.85%	1.99%
Wheat; U.S. number 1 HRW, fob Gulf of Mexico	2.8	146.04	160.64	131.43	5.51	3.84	3.77%	2.39%
Wool Coarse; 23 micron, AWEX	0.4	408.00	448.80	367.20	25.52	13.58	6.26%	3.03%
Wool Fine; 19 micron, AWEX	0.6	670.15	737.16	603.13	7.62	4.50	1.14%	0.61%
Zinc; LME, high grade, cif UK	0.9	1,006.40	1107.04	905.76	21.58	16.17	2.14%	1.46%

[4] The data were held on an Excel spreadsheet and sampled randomly with equal weights using a VBA routine to collect data from each run. Though the underlying random number generator set has a repeat cycle of 1,000,000 only 70,000 values are used in each simulation run here so this is unlikely to have produced a systematic repeatin g pattern that would have introduced a significant bias.

While alternative ‘jump diffusion’ time series models are available, and additional parameters could be added to the current model, this would simply change the nature of the estimation error. In any case, further parameter estimation is unnecessary because the simulation approach allows the residual empirical (unknown) distribution to be sampled directly. The empirical distribution was constructed from the 9 residual return values produced from each of the time series regressions and then duplicating them by multiplying by –1 to produce a mirror image set of 9 returns of exactly equal and opposite magnitude. By combining the original and the mirror image set, this simple bootstrapping process not only doubles the size of the sample data set, but also automatically produces a symmetric distribution of returns with a zero mean. Sampling randomly from this distribution, with replacement, should therefore produce an unbiased set of random returns with no systematic trend component.

The discounted payoff of a CPI contract of any time horizon (t) and assuming an annually compounded risk free discount rate (r^t) is:

$$\text{CPI-Max Payoff} = \text{Max}[0, e^{(x_t - 1.1m)}/(1+r_t)^t] \qquad [6]$$

$$\text{CPI-MIN Payoff} = \text{Max}[e^{(x_t - 1.1m)}/(1+r_t)^t, 0] \qquad [7]$$

3.3. Portfolio Effects

Inspection of the values in Table 4 reveals that the cost of a CPI on either the IMF Commodity Index or sub-indices is generally lower than the cost of CPI on an individual commodity. This is because of the well-known diversification effect of holding a basket of commodity price exposures that do not move up and down in lock step. For an industrialised country, without significant natural resources, and therefore essentially a primary commodity importer (e.g. Japan), the overall main IMF commodity index is likely to be a good proxy for the overall commodity price exposure which the economy faces, and the most effective method for offsetting the government’s exposure would be to purchase CPI-Max contracts on the main IMF commodity index. Using the data in Table 4, the cost of purchasing a trade weighted basket of CPI-Max contracts on all the individual commodities would therefore be 1.76% of the underlying contract value versus 1.41% for a single CPI-Max contract of the same underlying contract value, but paying off against the main IMF Commodity Index.

In contrast, most developing countries are both commodity producers and consumers and the significance of portfolio effects in reducing the costs of adopting a CPI scheme is much greater than for a developed country that is only a commodity importer. Pindyck & Rotemberg (1990) suggest that commodity prices tend to exhibit a surprising level of co-movement and that this is the "result of 'herd' behaviour" above and beyond what might be expected to arise from a "response to common macroeconomic shocks". A possible explanation for the Pindyck & Rotemberg observation is that a single broadly based macroeconomic demand shock that causes a general increase (or decrease) in demand for all commodities would tend to drive prices up (or down) from their long-run equilibrium level which then revert over time without a further shock. In other words, there will appear to be a co-movement of prices both away from and towards the equilibrium level even though only one shock occurred. Once the mean reversion effect has been removed, many of the return series appear to be uncorrelated or even negatively correlated.

This co-movement of prices and corresponding correlation in raw price returns therefore means that where a country is both an exporter and importer of commodities, the impact of a price rise (or fall) in exported commodity prices will tend to be more or less partly offset by a price rise (or fall) in imported commodity prices.

In the special case of an economically diverse OECD economy (e.g. Japan) with significant sovereign debt, few commodity exports, and a wide range of commodity imports, it would be much less costly to buy CPI-Max contracts indexed and paying off against the entire IMF Commodity Index than to buy CPI contracts on individual commodities. Likewise, the government of a predominantly commodity-exporting country may find it more appropriate to buy CPI-Min contracts based on either the whole IMF Commodity Index or one or more of the 8 sub-indices. In both cases, the objective is to insure against a macroeconomic shock brought about by a general rise or fall in commodity prices, but take advantage of portfolio diversification effects to reduce the cost of purchasing the initial protection. In general, most economies are likely to be unaffected by a rise in one or a few commodity prices, unless they have a particularly heavy exposure to one, as this is likely to be offset by a fall in several others. However, as already discussed, a coordinated unidirectional shift in a wide range of commodity prices, as happened in the 1980s, can cause significant economic dislocation. It is this particular problem that CPI contracts indexed against a basket of commodities, rather than a single commodity, are well suited to manage at relatively low cost.

3.4. Results Summary

The analysis above shows that all the sub-index and individual spot commodity time series included in the IMF Commodity Index exhibited price mean reverting properties as evidenced by the *b* parameter from each regression being statistically significant at the 90% interval in each time series. Moreover, the speed of reversion in each case varied between 25 and 75% per annum, suggesting that shocks would not be so persistent as to threaten the viability of a CPI scheme from the outset. Though the mean reversion parameter estimation procedure will have accounted for much of the heteroscedacity ('fat tails') typically observed in commodity price returns, sampling directly from the empirical distribution of regression residuals means that there has been no need to estimate a volatility parameter based on the standard assumption that returns are normally distributed. As a result, the distribution of simulated five-year notional price paths that have been produced take into account the actual rather than approximated theoretical behaviour of commodity prices. The CPI values produced are not therefore subject to parameter estimation errors which are introduced when assumptions are made about the behaviour of commodity price returns (e.g. such as standard lognormal distribution of prices typically used in financial market models).

The cost of a CPI contract based on the IMF Commodity Index is significantly lower than the mean cost of CPI contracts based on one of the sub-indices, or indeed individual commodities, because of the impact of portfolio effects. Since every country has a unique portfolio of exposures to both commodity imports and exports, the impact of portfolio effects would be an important factor in reducing the overall cost of CPI below the cost of maintaining an equivalent buffer stock scheme. The sampling method employed here maintained the temporal link between residual returns in each time period, across all the series. This has allowed a more precise estimate to be made of the true cost of a number of CPI contracts covering realistic commodity portfolio exposures than if a set of correlation coefficients had been calculated and applied to a covariance matrix.

The only theoretical assumption that has been made about the behaviour of commodity prices is that they do not exhibit deterministic trends. This assumption is implicit in the decision to create symmetrical distributions from the original raw residual returns output from the regression analysis. Although the previously cited literature is not definitive about the presence or absence of long-run trends in real or nominal commodity prices, over a five-year simulated price series, the impact is unlikely to be a significant source of error. In practice, if CPI contracts were being continuously bought and sold buyers and sellers would have the opportunity to incrementally adjust their expectations of long-run equilibrium price levels, reversion, volatility, and correlation parameters. Prices of CPI contracts would thus evolve accordingly as forward and options prices currently do in existing commodity derivative markets – albeit at shorter maturities.

4. IMPLICATIONS

Despite the obvious commodity price risk exposure of governments and the risk it poses to the long-term economic development of national economies, few governments currently take any step to mitigate that risk by hedging their exposure. Likewise, despite the IMF objective of promoting global economic stability, recent discussion on the most appropriate mechanisms for restructuring sovereign debt when countries get into financial difficulty makes no reference to managing commodity price risk, but focuses only on economic reform. We believe this is a serious omission because the stability of the global economy cannot be effectively managed without addressing one of its main contributors, namely commodity price risk exposure of national governments. To this end, we believe that a CPI mechanism needs to be put in place, alongside IMF (and World Bank) sponsored economic reforms that will allow governments to manage their commodity price exposures. In the case of countries with heavy debt burdens, or those receiving IMF support, a commitment to use CPI contracts to mitigate the impact of commodity price volatility could become an integral part of any economic restructuring and debt rescheduling negotiation process.

4.1. Benefits

The CPI mechanism discussed in this paper would avoid many of the weaknesses and criticisms of buffer stock schemes. Although long-run equilibrium prices and strike prices 10% above and below were identified for illustration purposes in the previous section, there would in practice be no need to establish any pre-determined intervention price level or intervention rules in a CPI scheme. Even if CPI contracts had an original ten-year maturity, rather than five as suggested here, the fact that they pay off against mean spot prices occurring over the final year before maturity would ensure that the impact of any unexpected shock that permanently changed the long-run equilibrium price level for a commodity would be rapidly subsumed into the portfolio of CPI contracts held by a government as long as new contracts were regularly signed each year to replace the ones that were about to come to maturity. Given the statistical properties of the commodity price series tested, and the inherent flexibility of a market-based approach to the CPI contract, the probability of the CPI scheme being overwhelmed by stochastic and deterministic trends, or permanent price shocks, is significantly lower than a buffer stock scheme based on mechanistic intervention rules and government financing.

4.2. Costs and Funding

There are essentially three sources of costs to operating the GCI and the CPI contract portfolio that it manages. The first, and smallest, is the administrative cost of running the GCI. A reasonable cost estimate for operating a major commodity exchange comes from the New York Mercantile Exchange (NYMEX) which had operating costs of US$140 million for the year to December 2001. As well as direct operating costs, the GCI would also require some initial physical infrastructure cost expenditure plus working capital, which for NYMEX amounts to US$94 million of Net Assets. Added together, these figures suggest that GCI would require a single US$2 million up-front investment by each government that participated in the CPI scheme, plus a further US$1 million per year membership fee, to cover operating costs. In addition, a small commission or trading spread on each CPI contract could be applied to cover transaction processing costs, legal fees, and other direct costs such as costs of trading offsetting hedge contracts. Given the requirement for computer systems, people who are trained in commodity market transactions processing, as well as office space the cost of operating GCI as an insurer would not be significantly different. In total, if one hundred governments were to participate in the GCI, annual revenues would be of the order of US$250–500 million per annum.

4.3. Capital Requirements

If operated as a CPI exchange, the requirement for risk capital would be minimal providing that the counter-parties wishing to sell CPI hedging contracts paid the credit risk insurance cost. If the GCI agency operated as an insurer, or market maker for CPI contracts, the capital requirement would be significantly higher if it were taking market risk as principal that was not perfectly offsetting hedging contracts purchased from third parties. The amount of risk capital required to support such an operation would depend on the amount of exposure that remained unhedged. Typically, banks and large commodity trading houses estimate the risk capital required to support a portfolio of derivative transactions by estimating the 95th percentile (one-tailed 95% confidence interval) of the distribution of portfolio returns over the life of the outstanding derivative contracts – the Capital at Risk (CaR) value.

Table 5 contains simulated values for the CaR at the 95%, 99% and 99.9% confidence interval assuming the GCI has sold an unhedged portfolio of one CPI-Max and one CPI-Min, both with a five-year maturity, covering the entire IMF Commodity Index. As previously, the initial underlying contract value of both CPI-Max and CPI-Min is assumed to be equal to the long-run equilibrium price of $99.36 and the respective strike prices of each is 10% respectively above and below that price. A sample of 1000 five-year price paths was simulated with the discounted value of the CPI portfolio payoff calculated for each price path. The initial premium collected on both the CPI-Max and CPI-Min sale was subtracted from the discounted payoff to estimate the total capital loss or gain on each price path. The payoffs were ranked with the largest positive payoff first and the largest negative payoff last. The 95% confidence interval is equal to the 950th ranked value, the 99% confidence interval is equal to the 990th highest ranked value, and the 99.9% confidence interval is the 999th highest ranked value. The values in Table 5 show that to be confident of being able to meet 99% of the potential incidences of capital loss that might occur, the GCI would need to hold a capital reserve equal to 13.76% of the underlying exposure – that is US$100 in this case. It is not US$200 (i.e. the total underlying contract value) since only the CPI-Max or the CPI-Min can pay off at any one time. In practice, GCI would need to hold a very small fraction of this amount of risk capital, of the order of 5–10%, if it were to follow a policy of purchasing nearly, or exactly, offsetting portfolios of hedge contracts from the capital market. Therefore if GCI sold and hedged US$20 billion of underlying contract value, split evenly between CPI-Max and CPI-min contracts, it would need the order of US$150 million of risk capital.

Table 5: Global Commodity Insurer Capital at Risk

Confidence Interval	**95.00%**	**99.00%**	**99.90%**
Discounted Capital Loss	10.52	13.67	17.46
Equilibrium Contract Price	99.36	99.36	99.36
Capital at Risk	10.59%	13.76%	17.57%

Source: Author's own calculations

4.4. Conclusion

Establishing a CPI scheme to insure fiscal revenues and government spending against commodity price shocks that create short-turn deviations from the sustainable long-run equilibrium level appears to be economically and technically feasible. By exploiting the option-like properties of an insurance contract, a CPI scheme would have a substantially lower cost than that of a comparable physical commodity buffer stock regime and amount to approximately 1–2% of the total value of global primary commodity import-export trade per annum. In the specific case of oil, which would be the core commodity in the CPI scheme, the results suggest that the cost to a sovereign government of managing its exposure to oil price risk would be at most US$1.00 per barrel, which is one third of the cost of operating a physical buffer stock scheme such as the SPR of around US$3.50 per barrel over the same period and therefore a lesser burden to tax payers in the long run.

In addition, the credit risk issues that typically exclude developing countries from participation in long-term financial market transactions could be entirely avoided. The capacity of the global financial system to manage the increased volume of trading in commodity derivatives that would be required to underpin the issuance of CPI contracts, also appears to be sufficient to cover the entire global primary commodity import-export trade. Politically, conditions appear to be more favourable than after the Second World War when Keynes proposed Commod Control. The developed world has become, and will continue to become, increasingly exposed to commodity price volatility, and particularly energy, as a result of the decline in their primary and secondary industrial base. This means that a CPI scheme would no longer be viewed as a mechanism for transferring financial assistance from the developed to developing world. Nor would it replace existing commodity stabilisation agreements such as those operated by OPEC and IEA in oil, or subsidy schemes such as CAP in agricultural commodities. Instead, the increasing mutual interdependence of developed and developing nations in the global economy provides a backdrop of common economic interest that should increase the probability of a CPI scheme succeeding.

Given the apparently favourable economic and political conditions, what is currently missing is a coordinating agency to focus liquidity in the trading of commodity derivative contracts at maturities beyond 12–24 months that are typically available in commodity derivative markets. The role of the GCI would be to complete the market for commodity derivatives by providing CPI contracts of an appropriate five- to ten-year maturity, and indexed to mean annual commodity prices. This would more closely match the long-term nature of government investment programmes and the non-linear response of their fiscal revenues and public sector spending to changes in commodity prices. The open question that remains is to what extent a CPI scheme would impact the long-run equilibrium level and volatility of spot commodity prices, since it might create a large concentration of open interest in option contracts at specific strike prices as counter-parties attempted to hedge sales of CPI contracts to GCI.

As for changes in the long-run equilibrium level of prices, it appears that the CPI is less likely to induce a change than a buffer stock scheme which has the overt objective of intervening to drive prices down to, or up from, their current level towards a pre-determined upper or lower bound intervention level. Assuming sufficient capital is available to sustain a buffer stock scheme, then prices could be maintained at a level above or below the true long-run equilibrium price for a long period, creating a subsidy to either producers or consumers until the eventual collapse of the scheme. The operation of the CAP had precisely this effect before it was reformed in the 1990s, as US agricultural policy continues to do today, by creating large surplus stocks of agricultural commodities as a result of over-production stimulated by artificially high prices sustained by a lower intervention bound. These are eventually disposed of at, or below, world market prices. In Europe and the USA, this has benefited farmers but increased taxes and the cost of agricultural products for consumers. In the rest of the world, farmers would have been forced out of business, undercut by European and US agricultural products dumped on their markets, and consumers would have benefited, had it not been for the fact that their governments have often also increased taxes on consumers to keep their farmers in business through subsidies. A CPI scheme implemented without any other intervention in commodity markets would not have this effect.

The effect of combining a CPI with an existing buffer stock scheme such as OPEC is more interesting to consider – in particular the moral hazard problem that OPEC countries who had fully covered their production might no longer be interested in maintaining price discipline. Specifically, if one or a few OPEC countries managed to purchase CPI contracts to hedge their maximum possible current production volumes plus an incremental volume to cover future increases, the threat of retaliation by other OPEC members, which would result in a price crash, would not have any deterrent effect. Spot and forward prices would fall, but would not rise again until other unhedged OPEC members withdrew capacity to compensate for the increased production by those who had purchased CPI-in contracts. However, this kind of behaviour is very unlikely to occur since the moment it became public that even one OPEC member was attempting to force through a long-term increase in production via a CPI contract, all other OPEC members would immediately retaliate by attempting to contract CPI volumes sufficient to cover their maximum current and future potential output. Prices in the forward market would immediately collapse due to the increase in availability of long-term supply. This would immediately restore price discipline, unless OPEC members irrationally persisted in contracting at these lower price levels, at which point a new long-run equilibrium level would be established. Since OPEC has largely been successful in sustaining spot and short-term forward oil prices well above the competitive level for three decades there is no reason to believe that the introduction of a CPI scheme would cause this consensus to collapse in the long-term forward market.

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