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**Revisions to Economic Forecasts and Commodity Prices**

Futures prices should, in principle, embody all available information affecting commodity prices, including developments specific to individual commodities as well as those influencing the global economy more generally. However, as shown in Exhibit 1, futures prices typically projected relatively flat prices going forward from 2003 to 2008 even as commodity prices increased steadily, resulting in a string of upward revisions to the staff's commodity price forecasts. This process temporarily halted in 2009 as the financial crisis sharply restrained global economic activity and commodity demand, but over the past year futures again indicated that commodity prices would remain flat even as spot prices moved up sharply and world economic growth resumed.

The failure of futures to predict the steady rise in commodity prices over the last decade has led some to question whether they incorporate available information into an efficient forecast of future spot prices. The run-up in commodity prices over the last decade is widely attributed to the acceleration in growth among the emerging market economies, particularly China and the rest of emerging Asia. Some have argued that, to the extent that the path of growth in the emerging-market economies (EMEs) was predictable, one should have expected commodity prices to continue to rise over the last decade, rather than remain flat. Importantly, however, market participants *did not* predict the acceleration in emerging Asian growth. As shown in Exhibit 2, the investment banks and private forecasters surveyed in the Consensus Forecasts were repeatedly surprised by

the rate of growth in both China and other Emerging Asia over the period between 2003 and 2008. Mirroring the commodities futures, forecasts of Emerging Asian growth were either flat or downward sloping over this period and were steadily revised upward. Further, at the same time that market participants were underestimating potential commodity demand from the EMEs, forecasts of future supply (Exhibit 3) were steadily revised downward between 2005 and 2010, providing another potential source of upward pressure on prices.

This note briefly examines whether these revisions to market participant's expectations can explain the run-up in commodity prices. In doing so, we make an important distinction between *expected* and *unexpected* components of economic growth and commodity supply. If market participant's forecast revisions (the unexpected components) drive commodity growth, then futures curves may represent reasonably efficient predictions, and the staff may only need to consider amending these predictions to the extent that our own forecasts of economic growth (or future supply) are markedly different from the market's forecasts.

We find that revisions to forecasts of economic activity are statistically significant predictors of price growth for oil and copper, the two individual commodities that we consider, and also of changes in the IMF index of nonfuel commodity prices. Including both actual growth and growth forecast revisions in our analysis, we find that forecast revisions appear to be the more important determinant of the observed changes in commodity prices over the last decade. We also include changes in the broad nominal dollar in our analysis, taking these changes as proxies for unexpected movements in exchange rates (under the assumption that market participants view exchange rates as

likely to follow a random walk). We find that a depreciation of the broad dollar is associated with a roughly equal percentage increase in commodity prices, though this effect is only sometimes statistically significant.

Based on these findings, we propose an alternative forecasting methodology for commodity prices that adjusts the futures path to reflect the staff's assessment of the degree to which market participants will be surprised by future global economic growth and exchange rate movements. We calculate such surprises as the divergence between the Tealbook forecast and private forecasts.

We illustrate how this approach could be implemented based on Tealbook and private forecasts for global growth and the dollar. On average, this alternative approach does about as well as simply using futures curves over the period between 2003 and 2010 (the period for which we have the requisite data to conduct a comparison), a result that underscores the point that both the staff and private forecasters were surprised by the rate of acceleration in emerging market growth over this period. Even so, our alternative approach may be preferred on the grounds that it generates a forecast of commodity prices that is explicitly rooted in and internally consistent with the broader contours of the staff forecast. In addition, as we discuss below, it provides a useful empirical framework for thinking through how alternative assumptions regarding the evolution of global activity and exchange rates might affect global commodity prices.

**Empirical Results**

We examine movements in the spot prices of WTI, copper, and the IMF index of nonfuel commodity prices. As a proxy for the market's expectation of economic growth,

we use surveys of market expectations of GDP growth published by Consensus Forecasts, which receives forecasts of expected growth in the current year and the subsequent year for a number of emerging and advanced economies from investment banks and private forecasters. We construct quarterly measures of expected world growth using GDP-weighted forecasts for the United States, euro area, Japan, Canada, United Kingdom, China, India, South Korea, Brazil, and Mexico, which are available beginning in 2003. As noted in the introduction, we also include changes in the broad nominal dollar, taking this as a proxy for the market surprise in exchange rates under the assumption that market participants view exchange rates as a random walk.

Tables 1 - 3 show our initial results. In line with the results of Gruber ("Modeling Commodity Prices"), the first column of each of these tables shows that there is a positive, usually statistically significant, relation between commodity prices and world GDP growth and a negative relation between commodity prices and changes in the broad dollar over this period. However, as demonstrated in the second column of each table, the coefficient on actual GDP growth becomes statistically insignificant, and in two cases takes the wrong sign, once we include our measure of GDP-growth surprises; in contrast, growth surprises have a positive and generally statistically significant relationship with each commodity price. The inclusion of GDP surprises rather than actual GDP does not affect our finding of a negative relationship between the broad dollar and commodity prices. In most cases we cannot reject that the elasticity between exchange rates and commodity prices is -1, a value that would be predicted by some theories and which is consistent with both other empirical work that we have done.

Some recent research has identified a strong empirical relationship between commodity prices and emerging-market industrial production. In Table 4, we compare our measure of GDP growth surprises to similarly-constructed measures of IP growth. In general, world GDP growth surprises appear to perform better than world IP surprises (for oil and copper, world IP has the wrong sign when both variables are included), but EME IP growth surprises appear to explain commodity prices better than either of these world measures over this particular period.[1] Given the importance of the emerging market economies in recent years, and their relatively heavy share of global manufacturing, this result seems intuitive, although the extent to which it can be extrapolated to other periods is a legitimate question. For example, Gruber finds little difference in the impacts of actual advanced and emerging-market activity in his longer sample.

In Table 5, we include supply measures in our model for WTI prices in addition to the EME IP surprise variable. We use the U.S. Energy Information Administration's forecasts of growth in crude oil production as a proxy for expected supply in our oil price regressions.[2] The results indicate that the supply variables do not seem to help explain quarterly changes in oil prices. This is surprising, but may be partially explained by the endogeneity of supply responses – an exogenous upward movement in supply should cause prices to fall, but at the same time, a rise in prices may be associated with an increase in supply if producers are able to react within the quarter.

[1] In other regressions, not shown here for brevity, we confirm that EME IP surprises are significant even when actual EME IP or EME GDP (or EME GDP surprises) are included. Moreover, these other variables are not statistically significant when EME IP surprises are present in these regressions.

[2] We are only able to include supply forecasts in our oil price regressions. Copper supply forecasts are only available on a semiannual basis from 2005, which is not a long-enough sample to include in the regressions, and since there is no ready aggregation of supply forecasts across commodities, there are no supply forecasts for the IMF index.

Finally, as a partial check of these results, we have also examined the high-frequency impact of macro announcements relating to Chinese industrial production. Using Bloomberg surveys of market expectations of Chinese IP and Manufacturing PMI announcements, we examined the change in oil prices on the days that IP and PMI figures were released. Examining responses of commodity prices immediately following a macro release may help better isolate the underlying source of movement. We found little relation between IP announcements and daily oil-price movements, but this may reflect that the Chinese government typically releases several other macro indicators at the same time as its IP release. PMI releases do not have this problem, and although the sample is short, they corroborate the finding that commodity prices appear to respond to market surprises (Table 6).

To summarize our results, we find a statistically significant relationship between economic growth forecast revisions and commodity prices. Our results indicate that it is not growth as such that moves commodity prices, but changes in growth that were unexpected by market participants. These results suggest that demand shocks have likely played an important role in explaining movements in commodity prices over the past decade, and can help explain the behavior of futures prices during the run-up in commodity prices between 2003 and 2008. We find less statistical significance for exchange rate movements, but our results are generally consistent with a negative relationship between dollar exchange rates and commodity prices. While these results are suggestive, it should be cautioned that our sample is limited by data availability and that the economic surprises we study are not able to explain the very rapid increase in oil prices over the second half of 2007 and first half of 2008.

**An Alternative Forecast Methodology for Commodity Prices**

Our empirical results suggest that one might adjust the path implied by futures curves for expected market surprises regarding economic growth and the exchange rate. This is consistent with the results reported in Gruber ("Modeling Commodity Prices") which found that economic growth and the exchange rate were the two most important variables in helping to explain (ex-post) movements in commodity prices. While market surprises are by their nature difficult to predict, we outline a potential alternative methodology for forecasting commodity prices that would take the staff's assessment of likely market surprises into account. Our expectation of market surprises is formed by comparing the staff's Tealbook forecast to outside private forecasts, specifically, those reported by Consensus Forecasts. If the Tealbook forecast for global growth is higher than private forecasts, then we would expect the market to eventually be surprised to the upside, and, similarly, if the Tealbook forecast is below private forecasts, we would expect the market to eventually be surprised on the downside.

In constructing our measure of future market surprises to global growth, we compare Tealbook and Consensus Forecasts projections for world GDP. This has a basis in the results presented above, but also is a practical choice; the staff does not currently produce foreign IP forecasts. However, based on our finding that EME IP growth surprises may help explain commodity prices, we are also considering methods of producing foreign IP forecasts for inclusion in the Tealbook and will continue to study the usefulness of methodologies that incorporate measures of industrial production.

In line with the analysis above, we include the Tealbook forecast for the broad nominal dollar in our measure of future market surprises in addition to our projected world GDP growth surprises under the assumption that market participants expect the exchange rate to follow a random walk. Table 7 shows the precise estimates we use to translate our measures of expected market surprises into adjustments to the futures curves forecasts for WTI prices and the IMF nonfuel commodity index. According to these parameters, a 1 percent upward surprise to world GDP is associated with a 14.6 percent rise in the spot price of WTI and an 11.1 percent rise in the IMF nonfuel index.[3] We constrain the exchange rate coefficient to have a unit elasticity, with the implication that a 1 percent depreciation of the dollar should raise commodity prices by 1 percent. Several of our regressions discussed earlier have exchange rate coefficients that are larger than -1, but our imposition of a unit elasticity is in line with a large body of empirical research.

We use our forecasts of market surprises to adjust the path of commodity prices implied by futures curves. If the Tealbook forecast is perfectly in line with the Consensus Forecasts, then there are no predicted market surprises, and the commodity price forecast would simply be the path implied by futures. However, to the extent that the Tealbook forecast differs from the outside forecast, our commodity price forecast would adjust the futures path to incorporate our expectation that market participants will be surprised by economic activity or exchange rate movements. Exhibit 4 shows the adjustment (the dashed line labeled "adjusted forecast") that this alternative methodology would make to the current projection for non-fuel commodity and oil prices in the June

[3] These parameter values accord well with our views on short-run price elasticities of demand. For example, we view the short-run price elasticity of demand for oil to be in the range of -0.05 to -0.1. With unchanged supply, an upward shock to underlying oil demand of 1 percent would translate into 10 to 20 percent increase in price.

Tealbook. It also shows a range of price paths (the dotted lines) that might prevail under different assumptions regarding how much market participants will be surprised by the evolution of global activity and the dollar.

One of the primary benefits of this alternative approach is that it generates a forecast of commodity prices that is explicitly rooted in and internally consistent with the broader contours of the staff forecast. As such, it can provide a useful empirical framework for thinking through how alternative assumptions regarding the evolution of global activity and exchange rates might affect global commodity prices. Exercises such as those shown in Exhibit 4 may allow the staff to better assess the risks to our forecast.

Exhibits 5 and 6 demonstrate how this methodology would have worked at several different points over the last decade in forecasting WTI and the IMF nonfuel commodity price index. During periods in 2010, the staff's forecast for world GDP was above the Consensus Forecast, which would have led us to revise our commodity price forecast above the futures path. In early 2009, the staff predicted a much sharper contraction in world growth than Consensus Forecasts, which would have led us to mark down our commodity price forecast below the path implied by futures curves. In most other periods, the revision to the futures curve would have been fairly modest. Table 8 presents standard forecast evaluation statistics for the futures-based Tealbook forecast and an alternative forecast based on the adjusted futures methodology we have described over the 61 Tealbook forecasts from August 2002 to the January 2010. On average, this alternative approach does about as well as simply using futures curves, a result that

highlights the point that both the staff and private forecasters were surprised by the rate of acceleration in emerging market growth over this period.

**Conclusion**

We have provided evidence that commodity prices have reacted primarily to unexpected revisions to the outlook for world growth over the last decade. These results suggest the possibility of adjusting our commodity price forecast for our expectation of market surprises, contingent on the Tealbook forecast of world growth and exchange rates being correct. On average, this alternative approach would have had only modest impacts on our commodity forecast in recent years, because *both* staff and outside forecasters were surprised by the rate of acceleration in the emerging markets between 2003 and 2008. However, apart from any impact on forecast accuracy, one advantage of the alternative approach we propose is that our commodity price forecast would be tied to the staff outlooks for global activity and exchange rates rather than being based solely on an exogenous, market-determined projection.

**Table 1: Explaining Changes in Oil Prices**

| | (1) | (2) | (3) |
|---|---|---|---|
| Constant | 0.7 | 5.3 | |
| Broad Dollar | -2.4* | -2.4* | -3.0*** |
| World GDP | 1.3 | -0.2 | |
| World GDP Surprise | | 14.3 | 7.4 |
| R^2 | 0.25 | 0.26 | |
| AR 1-3 test: | 1.08 | 0.98 | 0.94 |
| ARCH 1-3 test: | 1.63 | 1.39 | 1.18 |

Dependent variable: Quarterly percent change in the spot price of WTI. Estimation from 2003 Q1 – 2010 Q4. * Indicates statistical significance at the 10 % level, *** at the 1% level.

**Table 2: Explaining Changes in the IMF Non-Fuel Commodity Price Index**

| | (1) | (2) | (3) |
|---|---|---|---|
| Constant | -1.8 | 2.2 | |
| Broad Dollar | -0.4 | -0.4 | -0.9** |
| World GDP | 1.7*** | 0.4 | |
| World GDP Surprise | | 12.1* | 11.4*** |
| R^2 | 0.52 | 0.57 | |
| AR 1-3 test: | 1.06 | 1.65 | 0.18 |
| ARCH 1-3 test: | 0.73 | 1.10 | 0.43 |

Dependent variable: Quarterly percent change in the IMF nonfuel commodity price index. Estimation from 2003 Q1 – 2010 Q4. * Indicates statistical significance at the 10 % level, ** at the 5% level, *** at the 1% level.

**Table 3: Explaining Changes in Copper Prices**

| | (1) | (2) | (3) |
|---|---|---|---|
| Constant | 0.4 | 13.1** | |
| Broad Dollar | -2.1* | -2.1** | -2.9*** |
| World GDP | 2.2* | -2.0 | |
| World GDP Surprise | | 38.8*** | 16.6* |
| R^2 | 0.38 | 0.49 | |
| AR 1-3 test: | 0.73 | 0.78 | 0.30 |
| ARCH 1-3 test: | 0.80 | 0.52 | 0.22 |

Dependent variable: Quarterly percent change in the COMEX spot price of copper. Estimation from 2003 Q1 – 2010 Q4. * Indicates statistical significance at the 10 % level, ** at the 5% level, *** at the 1% level.

**Table 4. GDP Versus Industrial Production**

| | WTI | | IMF Nonfuel Index | | Copper | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Constant | 4.4 | 0.9 | 3.5*** | 2.4** | 7.5*** | 5.7** |
| Broad Dollar | -2.4* | -1.4 | -0.4 | -0.2 | -1.9* | -1.3 |
| World GDP Surprise | 26.1 | -20.6 | 10.6 | 6.7 | 30.4 | 8.0 |
| World IP Surprise | -5.1 | | 1.7 | | -2.0 | |
| EME IP Surprise | | 20.7*** | | 5.3** | | 10.6* |
| R^2 | 0.27 | 0.44 | 0.57 | 0.63 | 0.47 | 0.52 |
| AR 1-3 test: | 0.94 | 1.08 | 2.4* | 1.75 | 0.75 | 0.48 |
| ARCH 1-3 test: | 1.39 | 0.94 | 1.11 | 0.18 | 0.73 | 0.63 |

Dependent variables: Quarterly percent change in spot price of WTI (columns 1 and 2), the IMF nonfuel commodity index (columns 3 and 4), and the COMEX spot price of copper (columns 5 and 6).Estimation from 2003 Q1 – 2010 Q4. * Indicates statistical significance at the 10 % level, ** at the 5% level, *** at the 1% level.

**Table 5. Supply Versus Demand in Explaining WTI**

| | (1) |
|---|---|
| Constant | 4.1 |
| Broad Dollar | -1.4 |
| EME IP Surprise | 13.6** |
| Crude Production | -5.0 |
| Crude Production Surprise | 2.3 |
| R^2 | 0.43 |
| AR 1-3 test: | 0.27 |
| ARCH 1-3 test: | 0.27 |

Dependent variable: Quarterly percent change in the spot price of WTI. Estimation from 2003 Q1 – 2010 Q4. ** Indicates statistical significance at the 5% level.

**Table 6: Response of WTI to Chinese PMI Announcements**

| | (1) |
|---|---|
| Constant | -0.07 |
| PMI | -0.05 |
| PMI Surprise | 0.92* |
| R^2 | 0.04 |
| AR 1-2 test | 1.80 |
| ARCH 1-1 test | 13.64** |

Dependent variable: Daily percent change in the spot price of WTI on days when monthly figures for Chinese PMI are announced. Estimation sample Sept 2009 to present.
* Indicates statistical significance at the 10 % level, ** at the 5% level

**Table 7: Commodity Prices and World GDP Surprises Index**

| | WTI | IMF Nonfuel Index |
|---|---|---|
| World GDP Surprise | 14.6 | 11.1*** |
| *t-statistic* | *1.63* | *3.56* |
| Broad Dollar | -1.0 | -1.0 |
| *t-statistic* | --- | --- |
| AR 1-3 test | 0.16 | 0.28 |
| ARCH 1-3 test | 0.61 | 0.66 |

Regression constrained so that coeficient on the broad dollar is -1. Dependent variables: Quarterly percentage change in WTI and the IMF non-fuel commodity index. Estimation from 2003 Q1 – 2010 Q4.

*** Indicates statistical significance at the 1 % level.

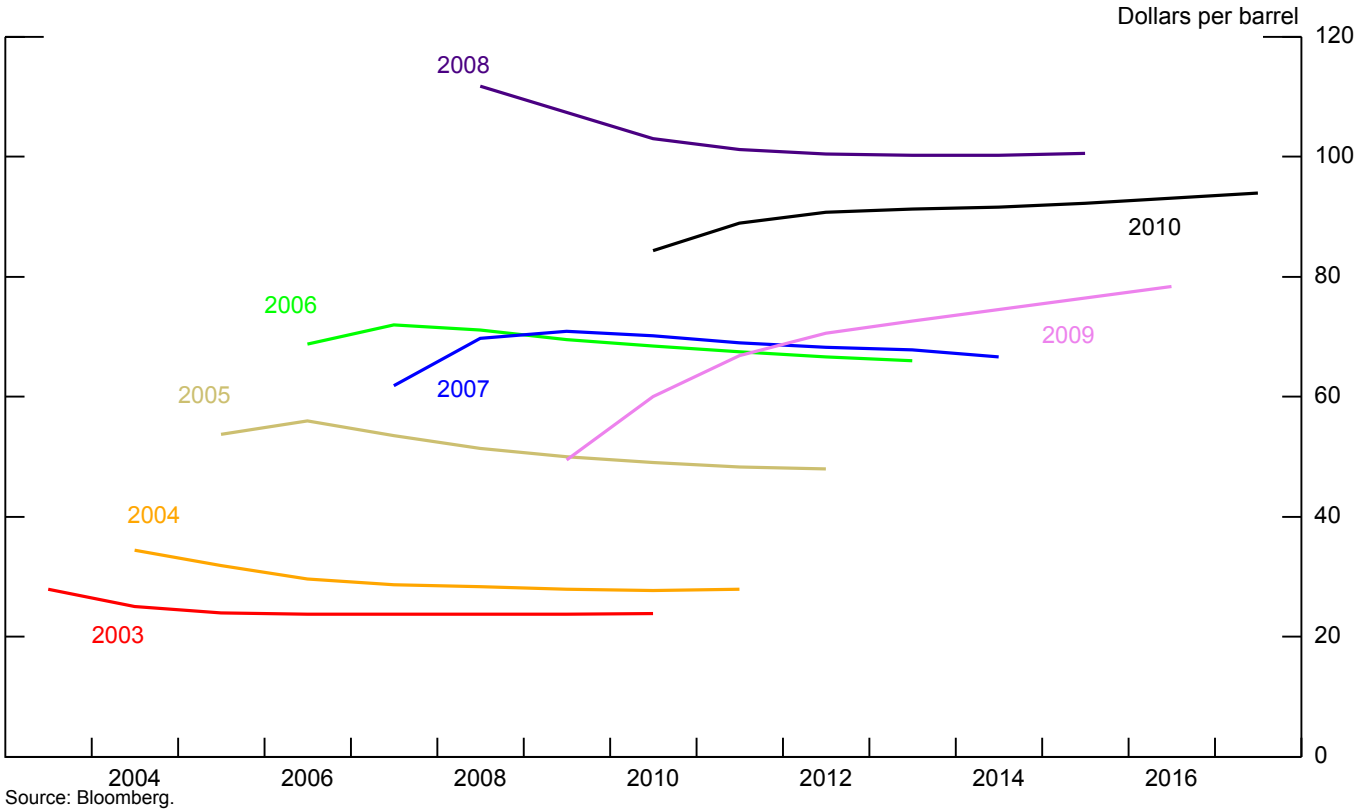
**Table 8: Comparison of Alternative Model to Futures-based Forecast - Four Quarter Percent Changes**

**Sample: 61 Tealbook forecasts from August 2002 to January 2010**

| | | | Mean Error | Root Mean Square Error |
|---|---|---|---|---|
| **IMF Non-Fuel Index** | | | | |
| | **1** | **Tealbook Forecast** | 12.6 | 21.3 |
| | **2** | **Alternative Methodology** | 14.4 | 23.4 |
| **WTI Oil** | | | | |
| | **3** | **Tealbook Forecast** | 20.2 | 40.3 |
| | **4** | **Alternative Methodology** | 22.8 | 42.7 |

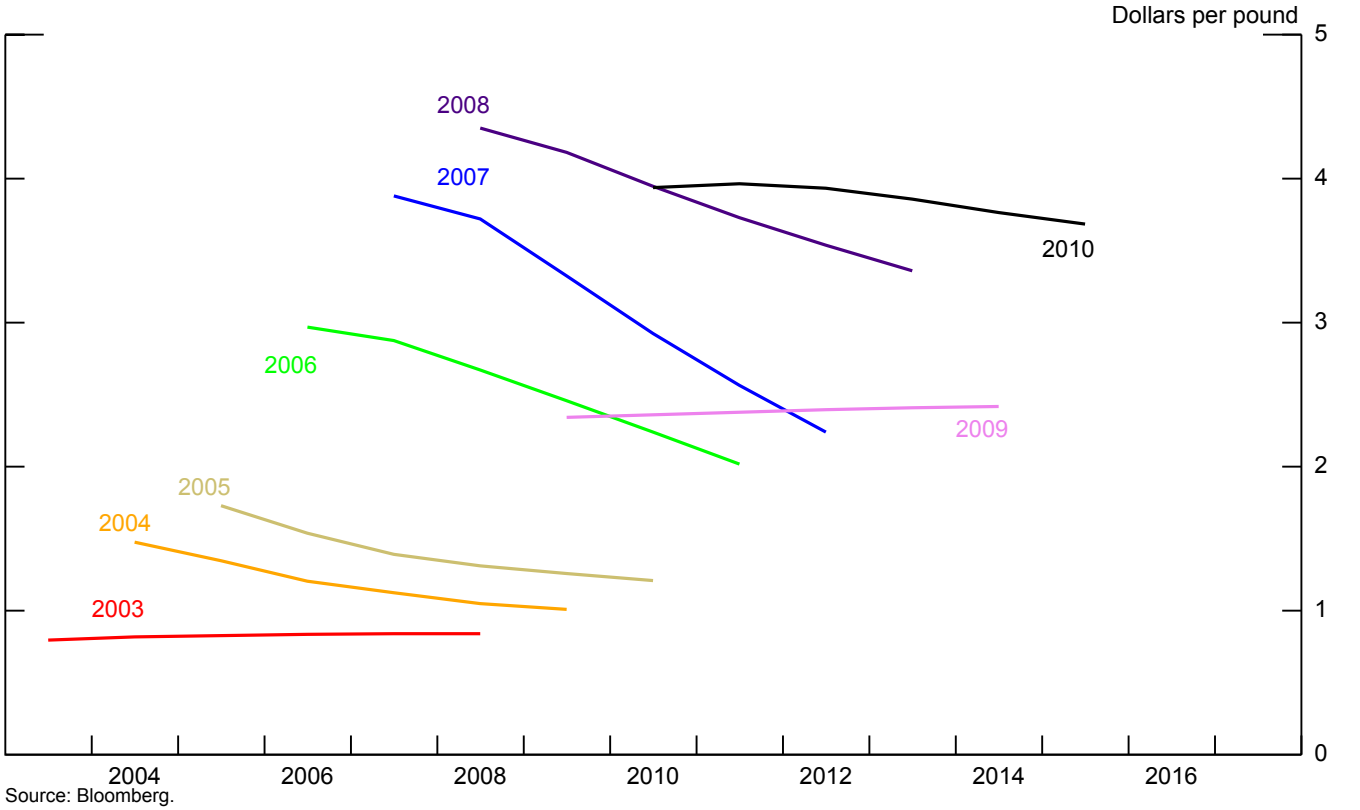
Exhibit 1

**WTI Futures Curves**




Source: Bloomberg.

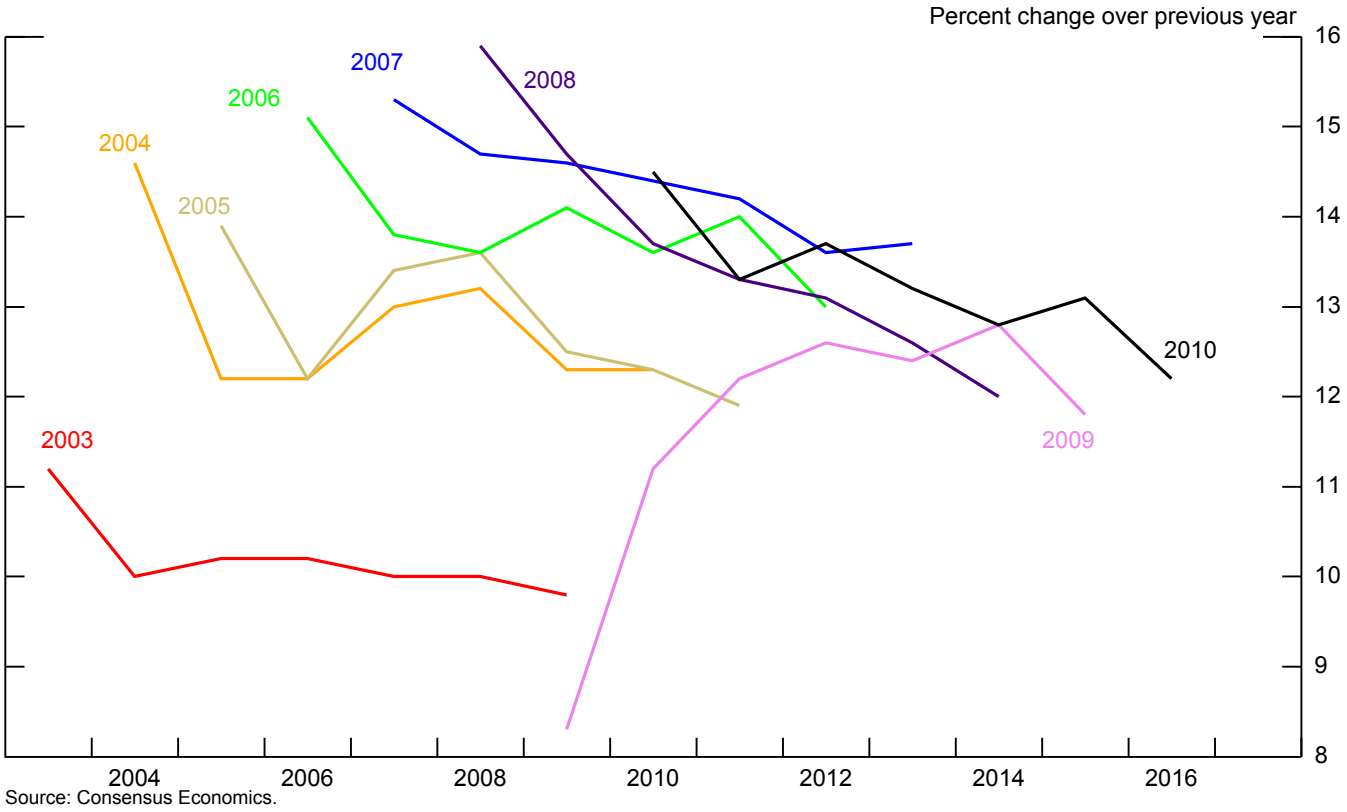
**Copper Futures Curves**




Source: Bloomberg.

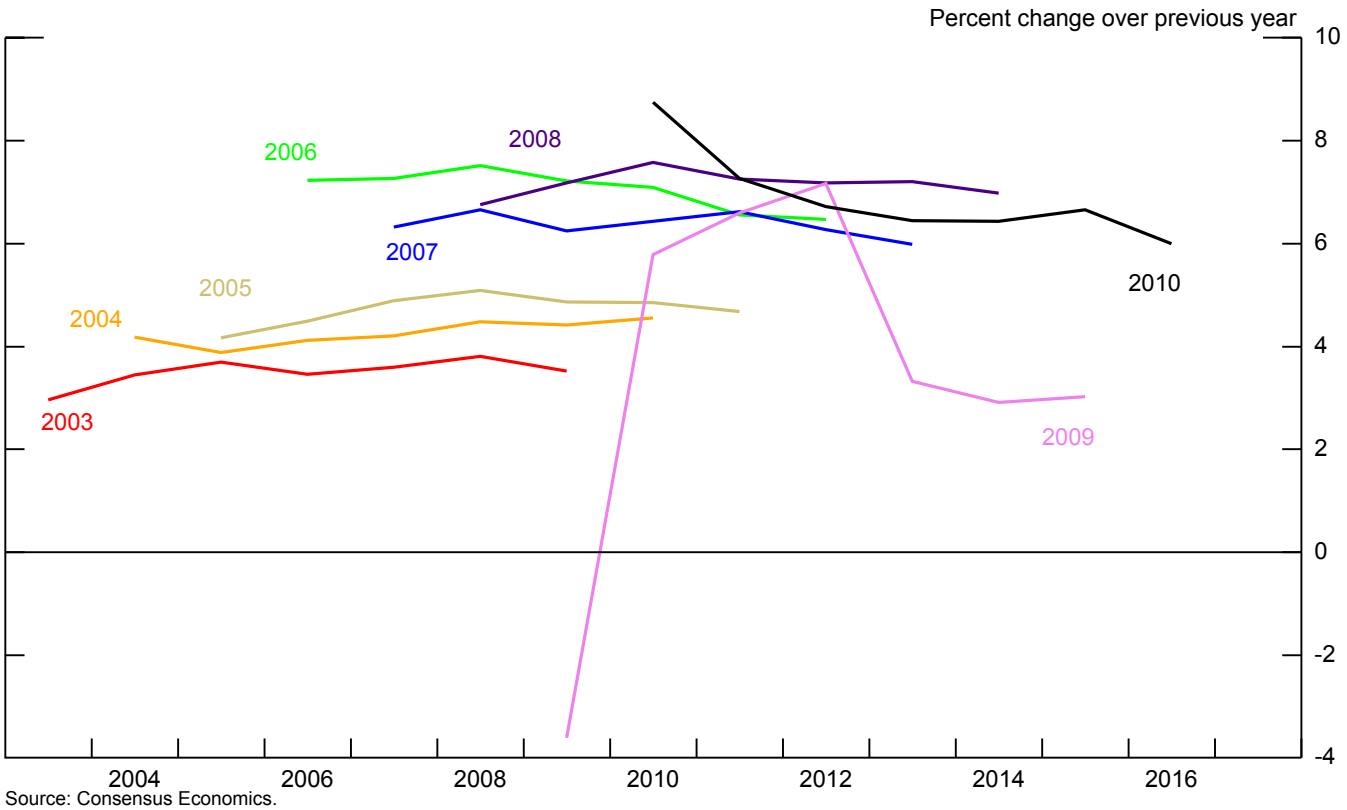
Exhibit 2

**Chinese Consensus IP Forecasts**




Source: Consensus Economics.

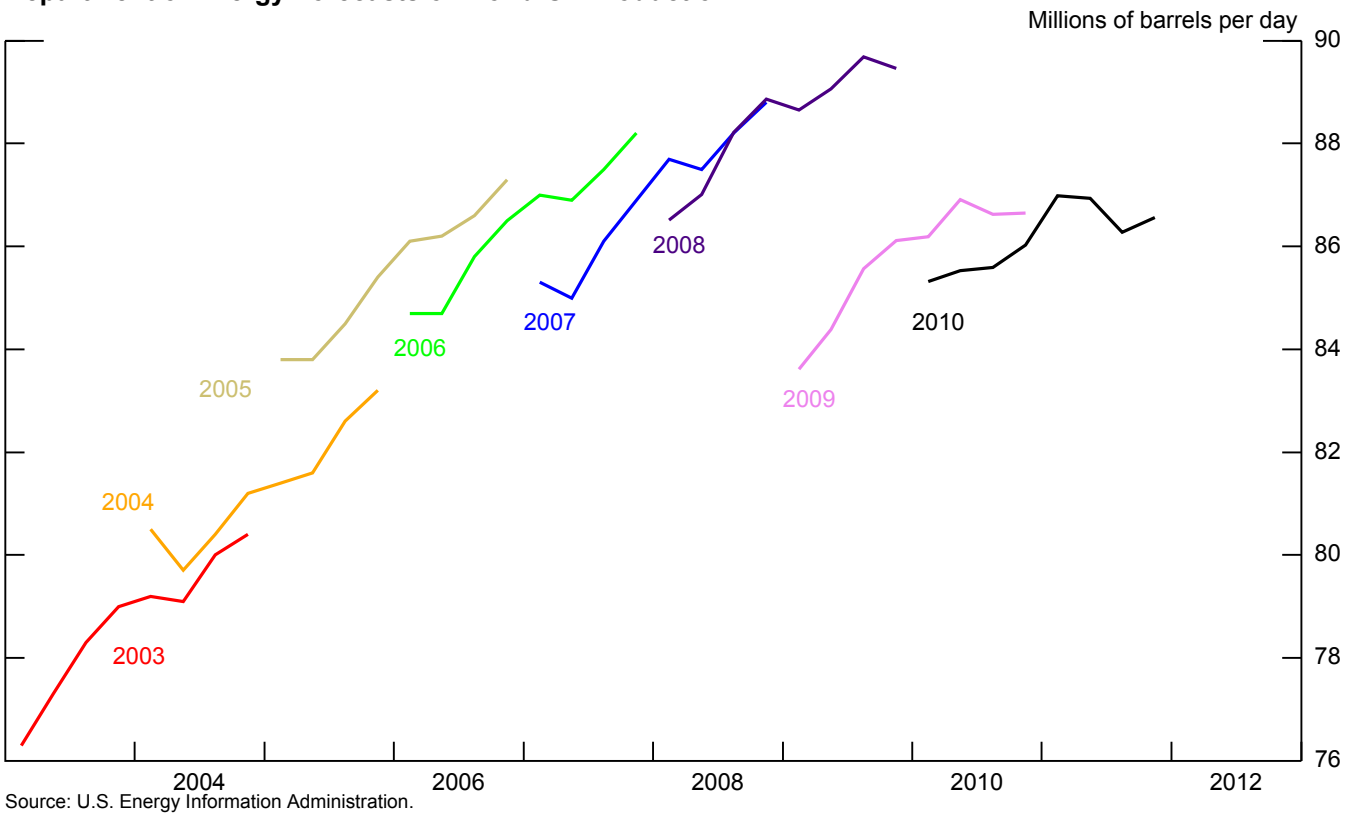
**EME Asia ex China IP Forecasts**




Source: Consensus Economics.

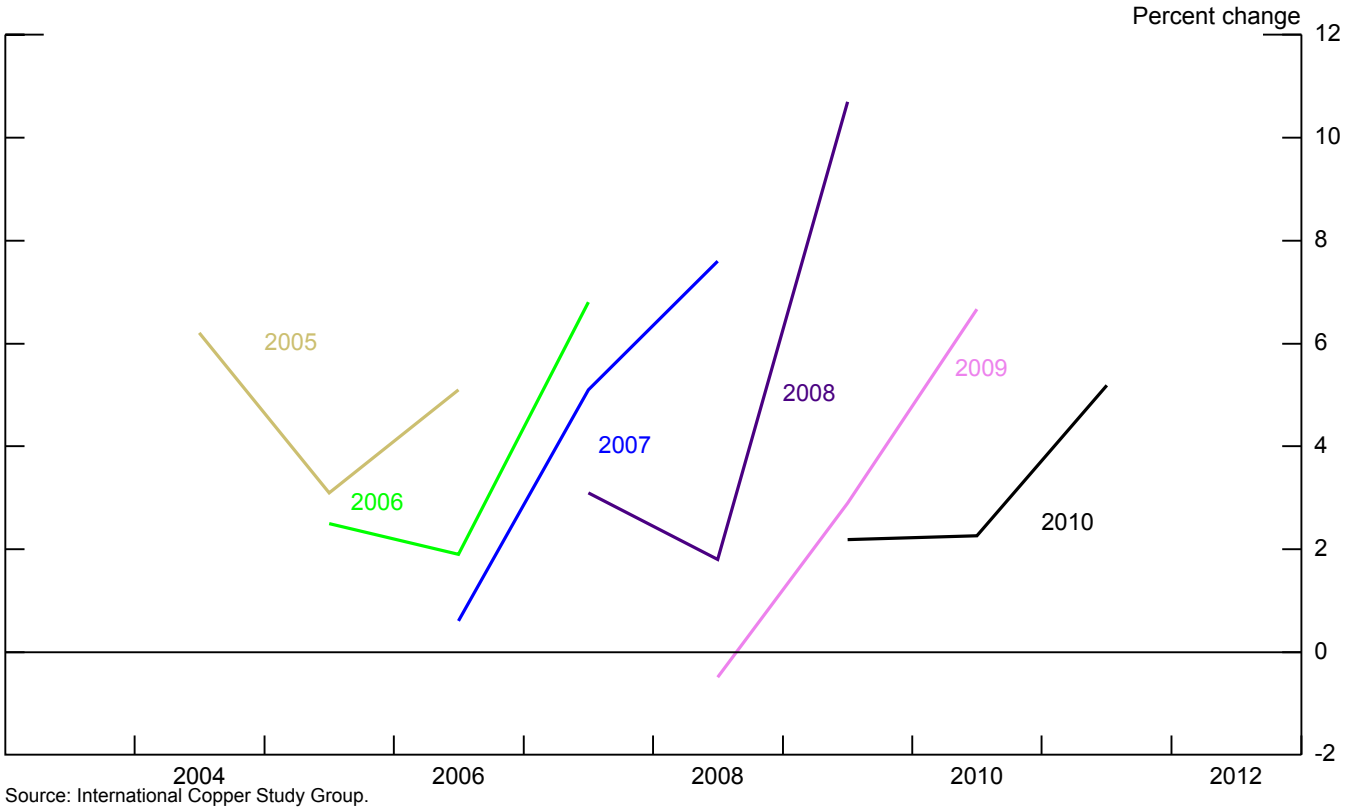
Exhibit 3

**Department of Energy Forecasts of World Oil Production**




Source: U.S. Energy Information Administration.

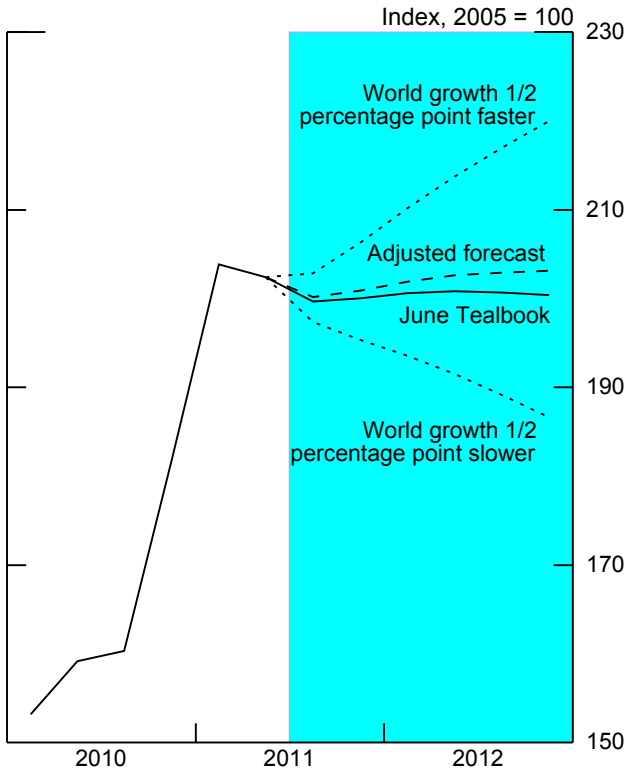
**Copper Production Forecasts**

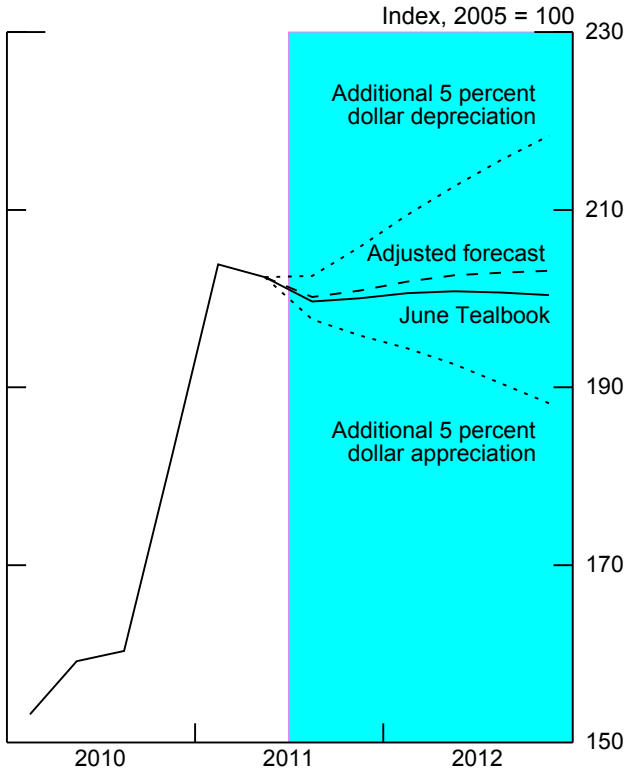



Source: International Copper Study Group.

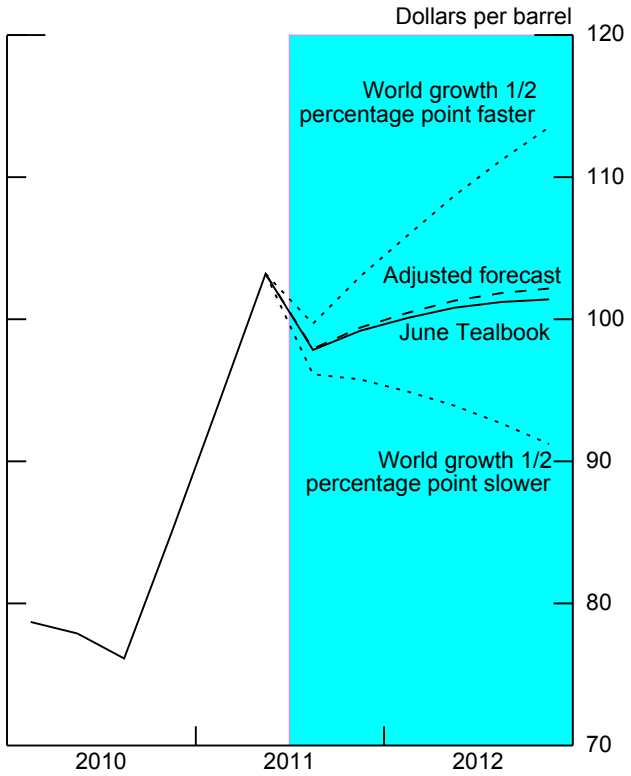
Exhibit 4

## Forecasts of Prices of Non-Fuel Commodities




## Forecasts of Oil Prices



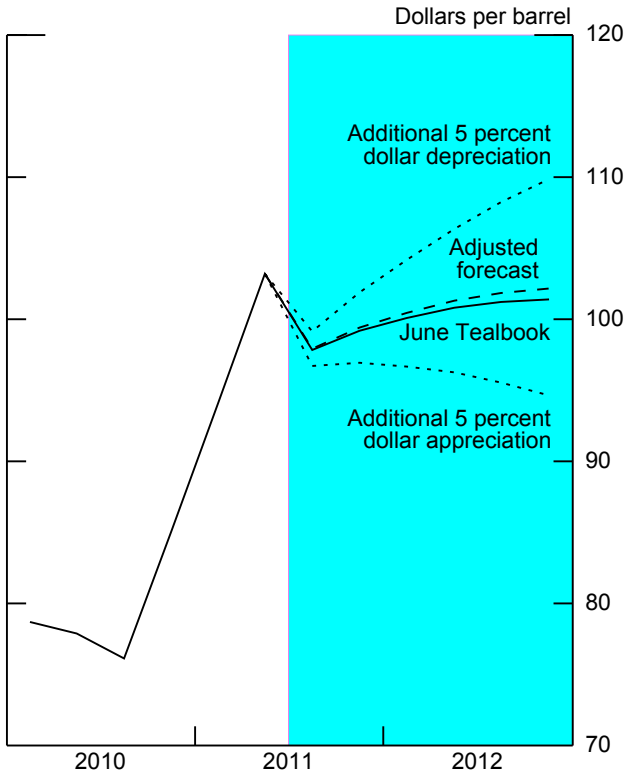
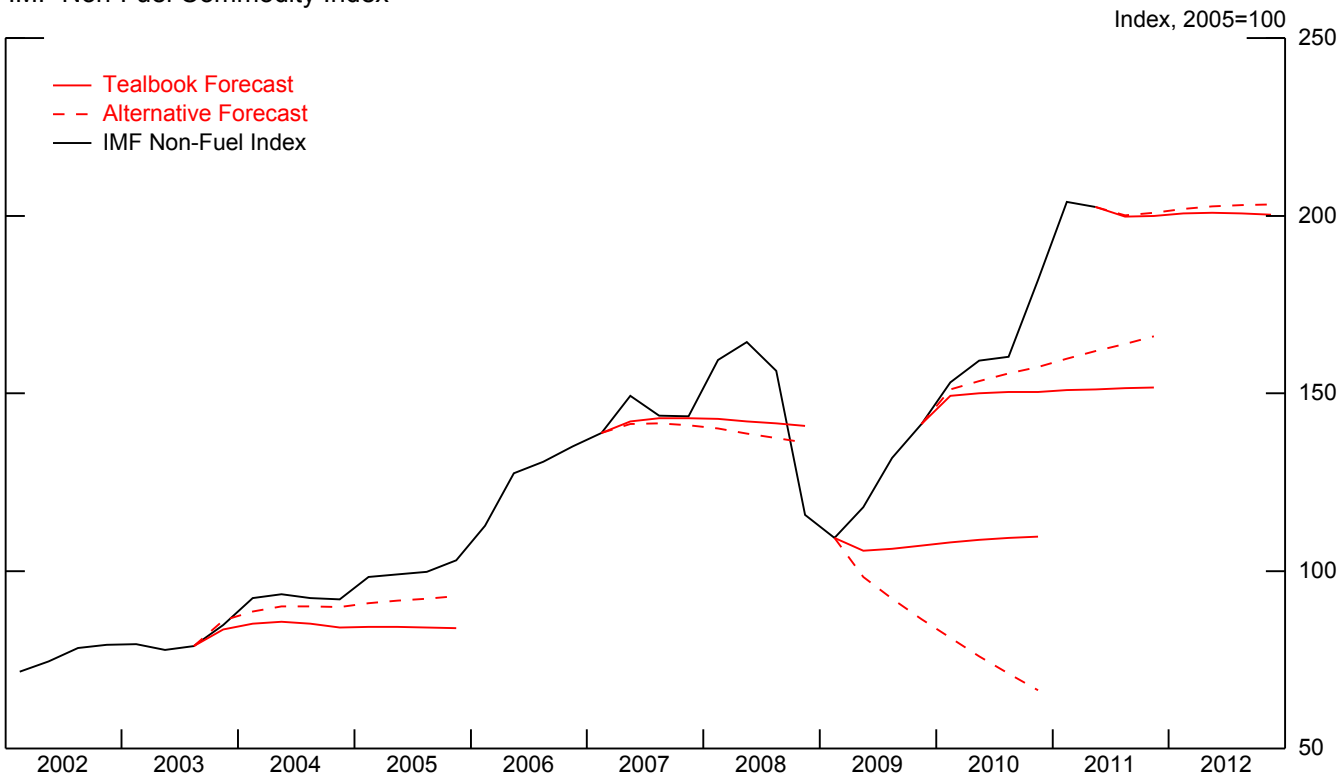



Exhibit 5

IMF Non-Fuel Commodity Index




WTI Oil