

Factoring Emerging Markets Into the Relationship Between Global Liquidity and Commodities

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Abstract

What caused the mid-2000s world commodity price “bubble” and the recent commodity price growth during the economic recovery after the 2007-2009 recession? The classical “supply and demand” interpretation offered by some observers suggests that rapid global industrial growth over the past decade – the so-called “demand channel” – is the key driver of price growth. Others have argued that recent bouts of commodity price growth were directly related to central banks, especially the U.S. Federal Reserve, injecting too much money or “liquidity” into the financial system. They assert that high commodity prices are a result of excessively loose monetary policy.

This paper extends the current research in this area by incorporating emerging economies, the BRIC (Brazil, Russia, India, and China) nations specifically, into global measures. It is hypothesized that factoring BRIC nations into the analysis provides useful information for examining the relationship between commodity prices and global liquidity that is not captured by advanced country data alone.

The statistical model in this paper accounts for the two-way relationships that can exist between output, price, and monetary variables in a globally interconnected system. Various tests of the model consistently suggest that the “demand channel” plays a large part in explaining commodity price growth whether BRIC countries are included or excluded from the analysis. However, excess liquidity may also play a part in explaining price growth. In addition, factoring in BRIC country data leads to the conclusion that unexpected movements in liquidity eventually explain more of the variation in commodity prices than unexpected demand shocks. This specific result is not caught in the sample that only incorporates advanced economies. Therefore, policymakers and researchers should not ignore emerging markets when examining commodity prices and monetary factors in a global context. Studies that exclude these countries lose key information on the effects of global monetary fluctuations.

JEL Classification: E30, E52, Q01

Key words: Commodity price, global monetary policy, BRIC

I. Introduction

The commodity price bubble of the mid-2000s and the slow recovery after 2009 following the Federal Reserve Bank's easy monetary policy have prompted many observers to suggest that the relationship between easy policy and commodity prices is actually causal. Studies by Frankel (1986, 2008) and others on US, euro zone, and globally aggregated variables suggest that expansionary monetary policy has a positive impact on commodity prices. However, several studies also suggest that industrial demand is a key factor in price increases. This "demand-channel" explanation argues that growing worldwide economic growth is an alternative and more plausible explanation for recent commodity price inflation.

Concerns over commodity price inflation are warranted not just because they raise costs for producers of goods and consumers of raw materials, but also because there is evidence to support that they have worked their way into boosting consumer prices overall (Furlong and Ignatio (1996)). Furlong and Ignatio (1996), Krichene (2008), and Evans and Fischer (2011) argue that while commodity price inflation was strongly correlated with US CPI inflation in the 1970s, later on (in the case of Evans and Fischer (2011) in the post-Volcker era (post-1982)), the link between commodities and the CPI became very weak. Besides the explanation that the Federal Reserve has become better at managing inflation, Evans and Fischer (2011) suggest that this weak correlation is due to the fact that raw commodities make up a smaller proportion of the US CPI and that US businesses are less "commodity-intense" in their production, so commodities figure into a smaller share of costs for both households and businesses.

Nonetheless, since the CPI is a key indicator used by central banks, Kirchene (2008) argues that they risk ignoring fluctuations in commodity and other asset markets that do not show up in the CPI. In addition, rapid increases in food prices in developing countries could not sustain themselves and lead to riots, as they did in 2007 and 2008, unless they were the result of external monetary factors. Kirchene suggests that over a 20-month period in 2007-8, the LIBOR rate (a proxy for a global interest rate) explained a large share of the variance in commodity prices. Policy makers in 2007 and 2008 faced a dilemma: by raising interest rates to stem the commodity bubble, they risked pushing the economy into a recession. If central bankers are truly concerned about commodity prices now, they face a similar dilemma as most of the developed world is still languishing in a drawn-out recovery in output and employment.

Movements in commodity prices have been suggested as a leading indicator of inflation and the economy in general. Prices are set continuously and data is reported in real time (Awokuse and Yang (2003)), providing a distinct advantage over CPI, which is reported with a lag and in monthly

increments. Although commodities are subject to “market-specific” shocks which may not transfer into the broader economy, Awokuse and Yang (2003) find that the broad CRB index is a useful leading indicator of the federal funds rate, inflation, and industrial production.

While an analysis of the relationship between global monetary liquidity and commodity prices that only factors in the behavior of the developed world may have passed merit several decades ago, modern analyses that expect to be representative of *global* behavior cannot ignore the role of emerging markets. At the very least, they must show that their results are robust when emerging market data is taken into account. This analysis restricts its inclusion of emerging markets to the so-called “BRIC” countries - Brazil, Russia, India, and China. From Q2 1995 to Q2 2010, the share of world output held by the advanced countries analyzed in this paper shrank by nine percentage points, while the share held by the BRIC countries increased by this exact amount. As a percentage of the sum of money supplies of the 10 advanced countries, euro zone, and the BRIC countries, the share of the money supply from the BRIC countries grew from 6% to 21% over that same period.

Shostak (2006) suggests that China’s expansionary monetary policy in the 2000s coupled with its artificially low exchange rate led to increased demand in China for US dollar-denominated assets, including commodities. In order to maintain its exchange rate China’s Central bank has had to periodically buy US dollars, which increased the liquidity of the yuan. This could create a situation where liquidity expands beyond what is necessary for output, and could instead be funneled into other assets (e.g. commodities), pushing up their price.

This paper uses a Vector Error Correction (VEC) model to examine the relationship between commodity prices, excess liquidity, interest rates, output, and consumer prices. This model allows two-way relationships between all of the variables in the model. Although the variables in this analysis are non-stationary in their levels and $I(1)$, there is evidence that the variables are cointegrated, which is the impetus behind estimating a VEC rather than a Vector Autoregression (VAR).

Like Sousa and Zaghini (2004, 2006), Hua (1998), and Belke et. al. (2010), variables, except commodity prices, are weighted averages or sums that represent global aggregates. However, the difference between those papers and this one is that in this paper two samples are estimated

- ADV – a sample which aggregates 10 advanced economies and the euro zone economies similar to the countries included in the previous literature.
- ALL – a sample which aggregates the countries in the ADV in addition to the BRIC countries.

Since the BRIC countries are beginning to wield more economic power and influence, it is hypothesized that they convey important information in explaining the relationship between monetary factors, industrial demand, and commodity prices, and they should be included in analyses that claim to come from a “global” perspective. If the empirical results between the two samples are noticeably different, then studies that use only ADV leave out important information regarding the economic behavior of emerging market economies.¹

It may be that what matters for economic variables influenced by monetary factors is not necessarily expected movements in interest rates or the money supply but rather “surprises” or shocks in the financial system. Kuttner (2001), using the difference between the actual effective federal funds rate and that predicted by the federal funds rate future market as a proxy for an unexpected shock, finds that expected rate movements have minimal impacts on short-term bonds, while unexpected movements are robustly correlated. Several analyses discussed in Section III revolve around the impact that monetary shocks have on commodity prices. Results presented in this paper mostly revolve around monetary shocks as well. These shocks are examined through impulse response functions and variance decompositions in addition to the relationships determined by Granger causality tests.

Results suggest that past output (proxied by GDP) is the only robust predictor of commodity prices, while a commodity price index is a predictor of consumer prices only for the ADV and not the ALL sample; this situation is the same for the response of consumer prices to shocks to commodity prices. Shocks to excess liquidity positively impact commodity prices in both samples but at different time frames, reinforcing previous research on global liquidity. Shocks to GDP positively impact commodity prices in both samples, which supports the “demand channel” explanations for price inflation. Interestingly, in the ADV sample shocks to excess liquidity explain a much smaller percentage of the variance compared to shocks to GDP, suggesting output fluctuations are more important. However, in the ALL sample, after two years shocks to excess liquidity explain twice as much of the variance in commodity prices compared to shocks to GDP. This result suggests that monetary factors in emerging markets provide important information in explaining commodity price movements. Analyses that only account for advanced economies may overemphasize the demand channel. Despite the theory of Frankel (1986) and the results of other VAR/VEC analyses, the short-term interest rate does not robustly explain commodity prices.

¹ Alternatively, one could estimate a VAR with 9 endogenous variables (a set of four macro variables with averaged advanced-country data, a set of four macro variables with averaged BRIC-country data, and the commodity price index). This might be able to separate the impacts of the advanced and BRIC country economies. However, doing so would greatly reduce degrees of freedom in the model.

Since these results reinforce the past literature on global liquidity and commodity prices, monetary policy makers should consider looking towards controlling excess money supply growth if they wish to curb commodity price growth. Additionally, if coordinated monetary policy is needed to curb commodity price inflation, emerging market central banks should be included since their money supplies are important factors in driving such price growth. BRIC countries are not just becoming powerful in terms of output and industrial demand, but in terms of monetary policy as well.

The rest of the paper is organized as follows. Section II provides an overview of recent commodity price trends and the debates going on in the media, government, and academia. Section III discusses the previous academic literature surrounding monetary factors and commodity prices, especially those with a global-level analysis. Section IV outlines the model that is to be empirically tested. While Section V discusses the data used and methods of aggregation, Section VI reports the results of the unit root and cointegration tests. The empirical results are presented in Section VII. The paper concludes with a summary in Section VIII.

II. The 2000s Commodity Price Bubble and Recovery

Debate still exists and will continue to exist for some time in regards to the causes of the 2000s commodity “bubble.” From Q4 2001 to Q2 2008, the S&P GSCI Commodity Index (See Figure 1 in Appendix A) increased 45.9% per year for a total return of 498%, while excluding energy it increased a still respectable 27.5% per year for a total return of 264%. Tang and Xiong (2010) note that the severe downturn in equity markets following the US “dot-com” bubble caused the financial sector to look to other asset classes. A small negative correlation between equities and commodities that was discovered led many to believe that portfolio risk could be reduced by increasing the weighting of commodity futures. The introduction of several commodity exchange-traded funds (ETFs) in the latter half of the decade, backed by stores of their respective underlying metal, further increased the ease in which commodities could be invested (and liquidated). Commodity ETFs also introduced another demand channel to compete with the industrial sector, further putting upward pressure on price. While over a decade ago, \$6 billion of institutional and retail money was invested in non-oil commodities, by late 2010, this grew to over \$320 billion (Economist, 2010). As investing through commodity indexes became more popular, commodity prices became increasingly correlated with other financial asset classes. Tang and Xiong (2010) find that futures prices of several commodities became increasingly correlated with the price of oil and each other after 2004 and that this correlation was stronger for indexed commodities than

those that were not. In addition, in 2008, when commodity prices experienced their peak and most dramatic gains, volatility in prices was more pronounced for indexed commodities than non-indexed commodities. During these periods, however, correlations among prices in China remained low and did not change, suggesting that “emerging market” demand growth may not have been a large driver of price growth in the US. Baffes and Haniotis (2010) argue similarly that index investing is mostly to blame for the latter days of the bubble and that emerging market growth explains relatively very little.

From Q2 2007 to Q2 2008, commodities exhibited perhaps their most dramatic growth, as the aggregate index grew by about 60%. The spot price of oil during that same period grew by over 90%. Caballero *et al*, (2008) argue that this was a reaction to the beginning of the world financial crisis in early 2007. As mortgage and other bonds became a less lucrative asset, emerging market investors awash with cash from economic and previous commodity price growth pumped more money into commodities in search of a new asset class with which to store their wealth. Underdeveloped financial markets in developing countries led investors there to seek returns abroad. Although commodities were elevated by this speculative growth, once the financial crisis spread into the broader world economy, growth slowed, and the tight conditions in the commodity markets required for a bubble eased. Thus the bubble “popped” and the aggregate index collapsed 64% from June to December 2008.

Similar to growth in commodity prices overall, oil’s incredible price growth during 2008 prompted a disagreement among many analysts. Some, including efficient-market proponent Burton Malkeil, thought that it was due to supply and demand fundamentals like the growing demand in emerging markets, supply disruptions in Nigeria and the Middle East, and record low inventories. Others, like investor George Soros, noted the sharp increase in the amount of transactions in the commodity markets being undertaken by index investors. Some even noted that by June 2008 the extent of the bull market in oil surpassed the extent of the NASDAQ dot-com bubble that burst in 2000 (Patterson and Stanton, 2008). Khan (2009) and Eckaus (2008) argue that even though demand growth proxied through growth in GDP worldwide would be a valid explanation for commodity, price growth (especially oil), rates of economic growth, especially in emerging markets, were not at rates to justify the rapid price increases in the 2007 and 2008. In fact, from the middle of 2007 to the middle of 2008, oil production rose, and consumption fell.

After the collapse in commodity prices in late 2008 and after the recession worldwide generally abated in 2009, prices bounced back. From December 2008 to the end of 2010, the commodity index almost doubled. This rapid commodity price growth coinciding with laggard

growth in the developed world left many wondering whether it was attributed to robust growth in emerging markets and the developing world, ultra-loose monetary policy worldwide, or both.

The Federal Reserve's second round of quantitative easing (QE2) and other expansionary worldwide monetary stances have been blamed for the upward trend in several metals prices in the latter half of 2010 and first half of 2011. In fact, one of the stated goals of the second round of quantitative easing by the Federal Reserve, besides loosening credit markets, was to inflate financial assets such as stocks in order to make American consumers *feel* wealthier and more willing to spend, thereby positively impacting output (Barone 2011). The timing of the QE2 coincided with subsequent increases in prices for Copper, Aluminum, Nickel, Zinc, and Lead. However, the *Economist* (R.A., 2010) notes that the beginning of this upward trend started in *July* before the QE2 announcement and coincided with a reversal of some growth-dampening policies that the Chinese government had previously implemented. Considering that China is one of the largest consumers of these metals, this factor should surely be a contender in explaining the price growth.

As 2011 came, several central banks outside of the US, like the ECB and emerging market banks, began to tighten their monetary policy and criticize the Federal Reserve's relatively loose stance, and accusing it of liquidity spillovers into their markets. Roubini (2011) expressed concern that rising oil and other commodity prices are a result of a "...wall of liquidity chasing assets and commodities in emerging markets, owing to near-zero interest rates and quantitative easing in advanced economies." This has a destabilizing effect on poor countries since up to 2/3 of consumption is tied to oil or food, and Roubini suspects that this played a major part in the "Arab Spring" where popular uprisings began in several Middle Eastern countries in Spring 2011 (Roubini 2011). Looking back to the 2000s commodity bubble, the UN's Food and Agriculture Organization estimated that the run-up in food prices in 2008 drove an extra 75 million people into hunger and led to riots in 34 countries (Katz and Levy 2008). Responding to criticisms of Fed policy, Chairman Bernanke blamed commodity inflation in emerging markets on their own central banks' undisciplined policy stances (Derby 2011).

III. Literature Review

Many of the concerns cited in the popular media provide some direction in determining the problem to be examined and the hypotheses to be tested in this paper. Nonetheless, economic theory and rigorous statistical analysis have also suggested a link between monetary factors and commodity prices.

A discussion of this relationship can begin with the theoretical model of Frankel (1986). This model is similar to the “overshooting” model of Dornbusch (1976) that describes the short-run overreaction of exchange rates to money supply growth in the face of “sticky” manufacturing and consumer prices. Frankel replaces exchange rates with commodity prices and suggests that although commodity prices adjust to a magnitude similar to that of the movement in the money supply, prices *overshoot* in the short run before adjusting back to their long-run equilibrium. This holds whether interest rates or the money supply are targeted since both affect the real interest rate. Frankel (2008) further theorizes that lowering the real interest rate increases the overall price of commodities through three channels – supply, inventory, and financial. Frankel (2008) finds that each one percentage point decrease in the interest rate is associated with a 4-6% increase in commodity prices.

Although Frankel acknowledges the instability of the model (the relationship is found not to hold after 1980), this problem is not addressed further. In addition, the issues of nonstationarity are ignored, bringing the results into question. Thompson and Summers (2010) take up this issue by testing for and finding evidence of nonstationarity in the price series. In addition, they find evidence of a structural break in 1985. Although before the date, a one-percentage point decrease in the interest rate is associated with a 5.2 percent increase in the price index, after 1985 they find that it is associated with a 7 percent *decrease*. Similar structural breaks are found for individual commodities as well. Clearly, there must be other factors omitted from the model that can explain variation in price.

Besides the interest rate, shocks to the money supply have been found to relatively and temporarily increase agricultural prices both in the US (Lapp (1990)) and New Zealand (Robertson and Orden (1990)). In addition, using a VEC model, Saghalian, Reed, and Marchant (2002) found evidence to support overshooting of agricultural prices in response to monetary shocks and a lack of long-run money neutrality due to the unequal increases of prices and the money supply. However, a retesting of several previous VAR models by Isaac and Rapach (1997) with US data found that extending the sample periods with more recent data produced insignificant relationships between monetary shocks and farm prices.

As stated before, one explanation for the 2000s commodity price bubble is that economic growth (the so called “demand channel”), especially from resource-hungry emerging markets, and not loose monetary policy was the primary driver. As Hua (1998) argues, increases in output are associated with increases in industrial production, and, all else equal, this will boost demand of raw materials in the form of commodities. In addition, increases in output translate into increases in

income, which should boost demand for energy and food as consumer goods. Both Hua (1998) and Swaray (2008) estimate error-correction models (ECM) that confirm this relationship between commodity prices and the aggregated output of 22 industrialized countries. In addition, Hua (1998) finds that commodity prices respond negatively to increases in LIBOR from 2 to 6 quarters after.

Reflecting the endogeneity issues inherent in examinations of the relationship between macroeconomic, especially monetary policy, variables, numerous authors have used VARs in order to analyze the impact of fluctuations of the monetary on other macroeconomic outcomes. Anzuini *et al* (2010) estimate a restricted VAR for the US economy. A positive one-percentage point shock to the federal funds rate is estimated to increase commodity prices by about 5.6% after 3 months. Testing different identification schemes and sub-indices support the robustness of the analysis. However, the influence of a monetary shock over the long term is limited compared with other factors. They also find evidence that channels identified by Frankel (2008) (oil inventories, supplies, and futures positions) may be significant in linking monetary growth to commodity prices, but their impact is extremely small, suggesting that the indirect channel of increased economic growth and consumer inflation plays a much larger role in affecting commodity prices as a result of a monetary shock.

Analyses of global liquidity aggregates enable a search for relationships between excess liquidity and globally influenced variables, such as commodity prices. In addition, international markets are so integrated today that the free flow of capital across borders undoubtedly has an effect on domestic variables. Baks and Kramer (1999) analyze a weighted average global real stock return against global variables. Their results suggest that excess global money growth lagged one quarter has a positive and significant effect on real stock returns and that Japanese monetary growth spills over into global asset markets.

Sousa and Zaghini (2004) use a structural VAR (SVAR) to examine the effects of foreign money or “global liquidity” on the euro zone with particular emphasis on the transmission of global shocks. The result of a positive global liquidity shock is similar to what one would expect would happen to output and prices in light of a shock to a domestic monetary base: output, the domestic monetary base, and the price level all rise. In addition, the short-term rate eventually rises, perhaps reflecting a reaction to increased liquidity by the central bank. Variance decomposition suggests that global liquidity plays the most important role in fluctuations in the price level over longer horizons.

Rüffer and Stracca (2006) analyze domestic outcomes and an aggregated global measure of output and prices. Their global liquidity proxy is a weighted sum of monetary aggregates from the US, UK, Japan, and Canada divided by an aggregate of output in order to account for expansion of global liquidity not accounted for by expansion of global output (“excess money”). A real asset price does not respond positively to excess money but does have an inverse relationship with the interest rate in a global aggregate. The response to Japanese, Canadian, and euro zone prices and output to an excess global money shock is similar to that found by Sousa and Zaghini (2004), but the US seems unaffected by global shocks, apart from consumer prices. Only in the euro zone do asset prices increase as a result of a positive shock to excess money.

Belke et. al. (2010) find that deviation of commodity prices from consumer prices is positively related to excess global money growth and negatively related to the interest rate. The long-run relationship they find between commodity and consumer prices suggests that any commodity price inflation will have spillovers in consumer prices as well.

Turning to the effects of commodity price shocks, Sousa and Zaghini (2006) find that positive commodity price shocks appear to have a negative impact on global output and a positive impact on global consumer prices. After two years, commodity prices explain a growing share of the variation in both output and prices. Shocks to domestic variables perform similarly except in some cases for the US. This suggests that not only does the impact of money on domestic variables not differ significantly between countries, but also, central bank strategies may be similar.

IV. Model

The endogenous variables included in the system follows that of Sousa and Zaghini (2004, 2006) and Belke et. al. (2010), which are focused specifically on commodity prices and globally aggregated variables. These are, with their variable names in parentheses, output (GDP), consumer price level (CPI), excess liquidity (MON), interest rate (INT), and commodity prices (COM). These variables capture three main markets: the goods, money, and raw materials markets. Commodity prices are the focus of this analysis, but it is also of secondary interest to see whether commodity prices influence consumer prices. Inflation can impact output while prompting policy makers to raise interest rates and contract the money supply. Including a measure of interest rates in the system draws upon the theory of Frankel (1986) that predicts a negative relationship between interest rates and commodity prices.

Output level is closely correlated with industrial production levels and can be taken as a measure of demand for raw materials (commodities). A possibly better alternative to using GDP

would be to use an Industrial Production index, but these data were not available for all countries in the sample. Testing the response of commodity prices to output fluctuations can help to determine how important the demand channel is to explaining the variation in commodity prices. If the demand channel is found to explain more of the variation in prices than monetary factors, this would not necessarily provide a strong evidence to support the theory that the acceleration in commodity prices from mid-2007 to mid-2008 was mostly attributable to demand. However, it would suggest that demand is a more important determinant overall, especially for the long-term appreciation in prices over the 2000s decade.

Finally, excess liquidity is another monetary indicator that can convey information about liquidity in the financial system that interest rates cannot. For example, after the 2008 financial crisis, interest rates have remained near zero in the US and will do so for an “extended period.” During this time, however, the Federal Reserve has injected liquidity into the system through its quantitative easing programs involving purchases of mortgage and long-term treasury debt, which is meant to impact factors other than the short-term rates. By examining the size of the money supply relative to the size of the economy through an excess liquidity indicator, it is possible to account for liquidity that may be in *excess* of that required to accommodate output. This surplus money may be directed into the financial markets where it may find its way into propping up commodity prices.

Despite the similarity between the model in this paper and Sousa and Zaghini (2004, 2006) and Belke et. al. (2010), models used by those authors are structural VARs, which impose restrictions on the contemporaneous effects of certain endogenous variables on others in the system. Using a restricted VAR would allow the theory to more easily shape the empirical model, based on the restrictions chosen by the researcher. To simplify the analysis instead, the VAR used in this paper is unrestricted.

The ordering scheme follows that of Sousa and Zaghini (2006): first is output, then the price level, excess liquidity, the interest rate, and commodity prices (in order: GDP, CPI, MON, INT, COM). Most importantly, commodity prices are ordered last, because they are supposed to represent the reaction to fluctuation in the other macroeconomic variables in the system, both monetary and demand-based.

Granger causality tests, impulse response functions, and variance decompositions are used to analyze the relationships between the endogenous variables in the system. The latter two examine the effect that a shock to one variable has on the others in the system. Shocks to monetary

variables (in this case excess liquidity and short-term interest rates²) can be attributed to three possible sources (see Li, Işcan and Xu, 2010). First, “exogenous policy shocks” are changes to the goals and targets (unemployment, inflation, financial stability, exchange rates) of central bankers. Second, economic agents may change their inflationary expectations not according to “economic fundamentals,” which can cause policy changes. Third, measurement error of real-time data can cause errors in policymaking. Shocks in the context of this analysis are not defined as clearly, since central banks do not respond in the same way to the same macroeconomic fluctuations. In addition, monetary policy differs across countries since financial and economic performance at any moment in time in each country differs. Therefore, shocks to the global monetary variables reflect a generalized worldwide monetary policy stance, rather than some sort of *coordinated* policy.

V. Data and Aggregation Methodology

Data were gathered from IMF’s International Financial Statistics, OECD-Stat, World Bank Development Indicators, the Area Wide Model (AWM) dataset from the Euro Business Cycle Network, Eurostat, and Bloomberg. Data from these sources is available quarterly at best, so this is the frequency of the data. Most of the data was extracted from the IMF, but there are gaps in the data series that are extrapolated by using the growth rate of a similar variable or the same variable from a different source. For example the AWM short-term interest rate is used for the short-term interest rate for the euro zone, but after Q4 2009, the growth rate of the EURIBOR interest rate is used to extrapolate to Q3 2010 since AWM data is only available until Q4 2009. More information on how each specific gap in the data was filled is available upon request.

Every effort is made to estimate a model using the most up-to-date data so that the strong commodity price growth in 2009 and 2010 could be captured in addition to the price growth during the 2000s “bubble.” The furthest that data goes back for all of the BRIC countries without sacrificing data quality is Q2 1995. Therefore, the ALL sample starts at this date due to data availability. Data from the advanced countries is available back to the early 1980s, providing a large number of degrees of freedom and the opportunity to examine the ADV sample over the entire “post-Volcker” era. Unfortunately, when testing this sample for cointegration using the Johansen-Juselius method, the test reports that five cointegrating vectors existed. Since the system is made of up of five endogenous variables, a result that implies five cointegrating vectors suggest that the model might be misspecified. When restricting this sample to the same period of the ALL sample

² Some central banks (e.g. the Federal Reserve) do not target the money supply *per se*, but it is an important indicator that helps to shape policy and central banks can choose to expand or contract it through traditional open market operations, changing the discount rate or the interest paid on excess reserves, quantitative easing, etc.

this result disappears, and no misspecification is suggested.³ Therefore, both the ADV and ALL samples will be estimated from Q2 1995 to Q3 2010.

Table 1 (all tables and figures are provided in Appendix A) displays the shares of world or OECD GDP (adjusted for PPP in current US \$) that each sample represents, from the beginning of the sample period to the end, in addition to showing the rising share that BRIC countries have.⁴ Notice that the ADV sample represents the vast majority of OECD output, suggesting that the countries in the ADV sample account for most of the output from what are considered the richest and most economically powerful countries in the world. However, the ADV's sample as a share of world output dropped by eleven percentage points over the 15-year period. This can mostly be accounted for in the nine-percentage point gain in world output share experienced by the BRIC countries, indicating that they are now much more economically powerful than in years past. Therefore, previous studies whose samples claimed to represent a "global" aggregate yet left out the BRIC countries may have missed the growing ability of these countries to have a significant effect on commodity prices.

The fact that the share lost by the ADV sample was mostly picked up by the BRIC sample indicates that the non-ADV, non-BRIC countries' share of world output remained relatively constant. These remaining countries as a whole did not rise in relative economic power over the sample period. In addition data for much of the developing world is either not available, especially at quarterly frequency, or its quality and comparability is highly suspect. For these reasons, the ALL sample is assumed the best representation of "global" variables with data available.

One important caveat to consider in this global aggregation is that definitions for macroeconomic variables differ across countries. For short-term interest rates a large majority of rates used are a 3-month treasury bill rate, but such rates may not be available for some countries or clearly indicated, so the interest rate closest to a "short-term interest rate" is used. This is not a large problem if one assumes that the short-term rate used would move in a similar fashion to that country's hypothetical 3-month treasury bill rate. However, it might be a problem for the measure of excess liquidity. Different countries have different definitions of broad money, and not all countries track the same monetary aggregates (e.g. not all countries in the sample track and report

³ Originally, an ADV sample restricted to the same period as the ALL sample was going to be estimated anyway in addition to the ADV sample going back to 1980.

⁴ In the ADV sample representing the most important advanced economies, 10 countries and the euro zone are aggregated which include Australia, Canada, Denmark, Japan, Norway, South Korea, Sweden, Switzerland, the UK, and the US. These are the countries selected by Belke et. al. (2010) because they represented a large enough share of world GDP and an even larger share of world financial markets. The ALL sample includes every country in the ADV sample and the four BRIC countries.

M2). Hypothetically, the broad money of country 1 might include all of the different types of accounts and assets as country 2 in equal amounts, but it might include, say, repurchase agreements as well. If the two countries' economies are of equal size, then excess liquidity measure of country 1 would be higher than country 2 solely because of the difference in definitions.

Despite these unharmonized definitions, this method retains some merit. First, taking global money supply and dividing it by global output is arithmetically the same as taking a GDP-weighted average of each country's excess liquidity variable. Second, the broad money definition chosen for each country is assumed the money indicator monitored by the country's respective central bank. For example, when the Federal Reserve directs US monetary policy, it considers M2 when it gauges movements in US broad money. The Bank of England tracks the UK's M4 even though its definition differs from M2. Therefore, what would be considered excess liquidity to one central bank might not be considered excess liquidity to another. If it is assumed from the results of this paper that policy should be shaped around movements in excess liquidity, a central bank cannot respond to movements in a broad money definition that it does not closely track. Therefore, it is assumed that unharmonized definitions will work well enough as proxies for global excess liquidity, and it is not worth going through the trouble and possible measurement error of attempting to construct broad money aggregates with harmonized definitions.

As far as the specific data used for each of the variables in the model is concerned, real GDP transformed into US dollars using PPP exchange rates is used for output. GDP not only represents a measure of industrial activity that suggests a degree of demand for commodities, but it also is a measure of the size of an economy and the degree of economic power and influence that a country can wield. Therefore GDP weights are used to weight the globally aggregated averages. For the price level, CPI is used. Although the CPI does have its flaws as a measure of price,⁵ it is the most widely tracked measure of inflation, and it is readily available for all of the countries in the samples. As stated before, excess liquidity is measured by taking the sum of all countries' broad money measures and dividing it by the sum of GDPs. As Ruffer and Stracca (2006) argue, the behavior of monetary aggregates "may reflect not only contemporaneous output, price and interest rate developments, but also a 'spectrum of yields' on a number of financial and real assets." The excess liquidity indicator purges the effects of nominal spending (nominal GDP) and the interest rate on money demand and could serve as a proxy for a "spectrum of yields" in the financial world which might matter for inflationary pressure. For the interest rate, a short-term nominal interest rate that

⁵ In fact, the Federal Reserve now uses the Personal Consumption Expenditures price index to make policy decisions and relies less on the CPI.

is most similar to a 3-month treasury bill is used. This is done in order to select a rate over which a central bank has some degree of control; in effect, this is supposed to mirror a policy rate.

The commodity price index used is the S&P GSCI. According to Standard and Poor's, "the index is calculated primarily on a world production-weighted basis and is comprised of the principal physical commodities that are the subject of active, liquid futures markets."⁶ Energy commodities account for 66.5% of the weighting. A broad commodity index is used, because, as Belke et. al. (2010) explain, "an advantage of using indices of commodity groups rather than individual commodity prices is that idiosyncratic factors impacting on individual commodity markets should have far less influence at the level of a multi-commodity, broadly-based index."

Oil itself is probably the commodity most widely tracked by the broad economy and most susceptible to broad economic fluctuations. Oil also can have a direct impact on the real economy, as it is such a vital fuel for business and consumer activity. Therefore, including oil in a broad commodity index may produce empirical results that are unable to be generalized to commodities as a whole, since the effect of oil may dominate over the other components. However, using the Johansen – Juselius cointegration test, Swaray (2008) finds that oil and non-fuel commodities move in tandem. In fact, modern farming and mining and other raw material procurement requires a significant energy input. Rising energy prices, oil specifically, raises the costs of commodity extraction, thus pushing up the price of commodities. Due to this assumed correlation between oil and other commodities, an index encompassing energy and non-energy commodity prices is used.⁷

All variables except the interest rate are expressed in log form. Where individual country GDP, CPI, and broad money measures are not extracted from their sources already seasonally adjusted, they are adjusted with the X12-ARIMA method. The specific macroeconomic data series chosen roughly follows the convention used in the previous literature on globally aggregated data and VARs. Besides the excess liquidity indicator, real GDP is used by Ruffer and Stracca (2006), Baks, Kramer (1999), Belke et. al. (2010), and Sousa and Zaghini (2004, 2006); CPI is used by Baks, Kramer (1999), Belke et. al. (2010), and Sousa and Zaghini (2004, 2006), and Anzuini et. al. (2010). A short-term nominal interest rate (a 3-month treasury rate or its closest equivalent) is used by

⁶ <http://www.standardandpoors.com/indices/sp-gsci/en/us/?indexId=spgscirg--usd----sp----->

⁷ The method by which price indexes and interest rates are transformed into global aggregate variables follows the methodology of Sousa and Zaghini (2004, 2006) who construct a GDP-weighted average. Global output is simply a sum of all 15 countries' GDPs. However, while Sousa and Zaghini use a weighted average money supply index as their measure of liquidity, this paper follows the methodology of Ruffer and Stracca (2006), who use a measure of "excess" liquidity that is the ratio of the "global" broad money supply (simple sum) to "global" output. A more detailed explanation of the weighting method is provided in Appendix B.

Rüffer and Stracca (2006), Baks, Kramer (1999), Belke et. al. (2010), and Sousa and Zaghini (2004, 2006).

For comparison, the aggregated variables for both the ALL and ADV samples are provided in Figure 1. GDP took a noticeable dip in 1998 for the ALL sample while growth remained positive for ADV, possibly reflecting the effects on the BRIC countries of the Asian and Russian financial crises during 1997-1998. Beginning around 2004, the gap between the ALL and ADV samples begins to close, reflecting the higher rates of growth that the BRIC countries experienced relative to the advanced economies through to the end of the sample period. As the CPI chart shows, when the inflation rates of the BRIC countries are taken into account, the global price level has risen at a faster rate compared with just the advanced countries. The global nominal interest rate is consistently higher for the ALL sample than the ADV sample, reflecting the higher inflation rates of the ALL sample. In particular, around 1995-1996, Russia experienced interest rates at the 100%-300% level as it came off of a period of hyperinflation following the breakup of the Soviet Union.

The comparison of measures of excess liquidity across samples displays a peculiar divergence among the liquidity positions of the advanced and BRIC economies. By this measure, the BRIC countries brought down the average in years prior to 2001, suggesting that there was less excess liquidity in the BRIC countries as a whole than the advanced countries. Both series display a clear upward trend throughout the whole sample, but after Q3 2001 excess liquidity was higher for the ALL sample than ADV, suggesting that money supplies in the BRIC countries were expanding above and beyond what was required for economic growth at a faster rate than the advanced countries. The point at which excess liquidity for the ALL sample became higher than the ADV sample also happened to coincide with the beginning of the 2000s commodity bubble. This is not to suggest that one variable caused the other; it is entirely possible that this situation is purely a correlation and that the two variables are both positively affected by a third variable (e.g. GDP). Rather, it provides a rationale for looking into whether or not commodity prices are affected by excess liquidity from BRIC countries in addition to the advanced economies.

Finally, a constant is added to the model, and, due to the linear trend in each data series and due to the convention used by Rüffer and Stracca(2006), Belke et. al. (2010), and Sousa and Zaghini (2004, 2006), a linear trend is included as well. In all specifications tested in this paper, the trend and constant term are significant in one or more of the equations and is included in the final models.

VI. Unit Root and Cointegration Tests

Before estimating the model it is important that the variables are in stationary form; non-stationarity of macroeconomic variables is a classic problem in time-series analysis. Estimating a model with non-stationary variables could run the risk of producing spurious correlation. In order to detect non-stationarity, three different unit root tests are performed on the five variables: the Augmented Dickey-Fuller (ADF), Dickey-Fuller GLS (DF-GLS), and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests. None of the tests in isolation provide conclusive evidence of stationarity or non-stationarity, so if all three tests agree with each other, then more confidence can be given to the result.

Results of each of the unit root tests on each variable for both data sets are provided in Table 2. In general, the tests suggest that the variables are non-stationary in their level form but stationary in their first-differences. Therefore, the model will be estimated using the first-differences.⁸

Unfortunately, estimating a model in first-differences focuses on short-term fluctuations and tends to eliminate information about the long-run relationships between the variables. Ignoring such information could produce biased results when one is looking to examine structural, long-term relationships. However, if two or more variables are cointegrated with each other, then although their level forms might be non-stationary, there may exist a stationary relationship between the cointegrated level variables in a long-run equilibrium. Indeed, in much of the previous literature, (see Saghaian, Reed, and Marchant (2002), Robertson and Orden (1990), Hua (1998), Swaray (2008) for examples), macroeconomic variables were cointegrated and estimated with models to take this into account.

A VEC model would be estimated similarly to a VAR, but a VEC would account for this cointegration. With a VEC specification, the relationships between the variables are assumed to return to a long-run equilibrium after a shock to one or more variables. This way, the model can incorporate the long-run information of the level forms without running the risk of introducing spurious correlation.

⁸ For the INT variable in the ALL sample, the tests disagreed with each other and with past literature. The ADF test suggested stationarity in 1st differenced form, while the DF-GLS and KPSS tests both suggested that a unit root existed in the level and 1st difference. Because the other variables are stationary in first-differences and because authors in the previous literature have estimated VARs all in first differences, INT will be estimated in its first difference as if it were stationary in that form. However, the reader should be aware that this variable exhibited this peculiar characteristic. It might be worthwhile to test for unit roots over a sample period from 1995 Q2 to 2008 Q3 in order to avoid the structural break that may have occurred during the financial crisis, but this is not pursued.

One often-used method to test for cointegration is the Johansen-Juselius (JJ) Test. This test will report the number of cointegrating vectors that makes the variables cointegrated, also known as the rank of the matrix of variables. Since a trend and intercept is apparent in each series, the rank selected from the JJ Test will be the test run using a trend and intercept. In addition, the Trace method is used to determine the rank.

Before the JJ Test can be run, the appropriate lag length for the VARs for each sample must be determined. Lag lengths are determined by using Final Prediction Error, and Akaike, Schwarz, and Hannan-Quinn information criterion, which mostly suggested that both samples should be estimated at a lag length of one. However, the models were tested for autocorrelation using the LM test, and the lag length was increased and retested until autocorrelation disappeared. This occurred at two lags for the ADV sample and three lags for the ALL sample. Belke et. al. (2010) indicate that "In macroeconomic modeling it is hard to imagine agents using information that reaches back much further than two to four quarters," and they themselves find two quarterly lags to be appropriate for their CVAR according to information criterion.

In both samples, the JJ Test suggests that cointegration exists. However, in the ADV sample the Trace method suggests that four cointegrating vectors exist, while in the ALL sample three cointegrating vectors exist. Therefore, there is a stationary long-run relationship between the level variables that are, by themselves, non-stationary.

Before running the model as a VEC, one more test for cointegration is run in order to provide more confidence in the results. The Pesaran test from Pesaran, Shin, and Smith (2001) is similar to the Trace method, but it only tells whether or not a stationary relationship exists between the variables in level form and not specifically how many cointegrating vectors exist. This test is performed by including the lagged level forms of the endogenous variables at a lag length that is one period greater than the furthest lagged differenced variables in the VAR. In the case of the ADV sample, the level forms at lag three are included, while in the ALL sample, the forms at lag four are. In both samples each one of the VAR equations is run with the lagged level variables added, and a Wald test is performed to determine the joint significance of the level variables. The F-stat is compared with the critical values given by Pesaran, Shin, and Smith (2001). Table 3 provides the results of the Pesaran test.

Only one equation in each sample unambiguously suggests that cointegration exists. The test statistic for the equation with CPI as the dependent variable in the ADV sample provides an ambiguous result. Thus, there is mixed evidence for the presence of cointegration, despite it appearing in similar analyses in the literature. The JJ test suggests cointegration, while the Pesaran

test does not strongly suggest it. One reason why this mixed result may exist is that the sample period is relatively short, roughly fifteen years. The case could be made that that is not a long enough period for variables to display a clear return to long-run equilibrium that could be picked up by the Pesaran test, even though they might clearly display cointegration if the sample was extended.⁹

The purpose of this model is to examine the structural relationships between these variables. Leaving these long-run variables out could introduce bias causing a misinterpretation of these relationships. With that in mind, one could argue that long-run impacts should be controlled for (i.e. cointegration should be assumed) if their inclusion improves the fit of the overall model. The Table 4 uses Adjusted-R², Akaike Information Criterion, and Schwarz Criterion, as gauges of model fit. In every situation (except the Schwarz Criterion in the ALL sample), the model with long-run information included (i.e. the VEC specification¹⁰) is a better fit for the data. Since the JJ test suggests cointegration, the Pesaran test does not strongly imply no cointegration, and the models that assume cointegration are a better fit, The final models are then estimated as VECs which included the third and fourth lagged level variables in the ADV and ALL samples, respectively.

VII. Empirical Results

From the results of the Granger causality tests (Table 5) using a cutoff of a 10 percent level of significance, a few relevant structural relationships are suggested. In the ADV sample, commodity prices Granger cause GDP and CPI, but this is not the case for the ALL sample. For CPI especially, this is a peculiar result, since the CPIs in emerging countries are more heavily weighted with commodities compared to advanced countries. Therefore, one would expect that at the very least if commodity prices Granger caused CPI in advanced countries, then it would Granger cause it in a sample that included emerging countries as well. Note, however, that CPI in the ADV sample also Granger causes commodity prices.

In the ADV sample, CPI Granger causes the short-term interest rate. Assuming that this is a positive relationship, this suggests that higher rates of inflation across advanced countries induce central banks to tighten monetary policy through interest rates. In the ALL sample, although each of the other four endogenous variables jointly Granger cause the global short-term interest rate, none of them individually Granger cause the interest rate. It is possible that interest rates respond

⁹ See Hakkio and Rush (1991) for a discussion on the long-run implications of cointegration.

¹⁰ The VEC models were run in eViews as unrestricted VARs with the lagged level variables included as “exogenous” parameters. This is an alternate way of running a VEC model in eViews instead of selecting the VEC option.

differently to economic conditions between advanced and emerging economies to a degree that makes aggregation into a single rate meaningless for global-level analysis.

While excess liquidity (MON) does not appear to Granger cause commodity prices in either sample or CPI in the ADV sample, it does Granger cause CPI in the ALL sample. This suggests that while inflation in advanced countries may be unaffected by movements in excess liquidity (apart from shocks), an aggregate that includes inflation in emerging countries *is* sensitive to excess liquidity.

The dominant factor in both samples that drives commodity prices appears to be GDP. GDP Granger causes commodity prices at a level of significance greater than 1 percent. This lends support to the theory that fluctuations in commodity prices are mostly demand driven, assuming that this is a positive relationship.

These Granger causality tests only examine the impact of the short-run variables, so they do not say anything about the significance of any long-run impacts. By estimating the coefficients of the lagged level variables from each VEC, the direction of the long-run impact of one variable on another can be determined. For example, to find the long run impact of CPI on GDP in the ADV sample, the coefficient on the level variable for CPI lagged 3 quarters is divided by the coefficient on the level variable for GDP lagged 3 quarters and then multiplied by negative one. Table 6 provides the estimated long-run impacts and their directions. Unfortunately, most “long-run” coefficients were not significant (t-stats did not exceed 2), so the direction of their estimated long-run impacts should be interpreted with caution. The only impacts for which both level coefficients were significant were for the long-run impacts of CPI and MON on GDP. Both indicated that increases in the price level and excess liquidity negatively impact the output in the long run.

Impulse response functions explain reactions of an endogenous variable to a “shock” in the error term of one of the VEC equations. Care should be taken before these shocks are interpreted to be movements in economic variables that are truly *unexpected* by economic agents in the real world. As Rudebusch (1998) shows, when looking at the Federal Funds rate, most monetary policy shocks in VAR models in the literature are uncorrelated with shocks as perceived by the Federal Funds rate futures market. Nonetheless, whether this discrepancy is true for other macroeconomic variables or those measured on a global scale like in this paper remains unknown. For now we assume that shocks to the error terms are exogenous to the model and unexpected by agents in the system.

Only the impulse response functions (Figure 2) and variance decompositions (Figure 3) that are relevant to this analysis are provided; results for the remaining variables are available on

request. Between the ALL and ADV samples, positive shocks to GDP positively impact commodity prices one and two quarters after the shock. This provides more evidence to support the “demand channel” explanation for part of the rise in commodity prices. However, while there is a negative reaction to this shock in commodity prices in the fourth quarter in the ADV sample, this effect disappears in the ALL sample.

In the second quarter after a positive shock to excess liquidity commodity prices are positively impacted in both samples, but the effect is smaller and marginally significant in the ALL sample. In addition, prices are negatively impacted in the fourth quarter after the shock and then positively again in the sixth and seventh quarters in the ALL sample. Including the emerging markets into the global aggregate conveys important information about excess liquidity in the BRIC countries that is ignored by shocks to excess liquidity in the advanced countries. This also provides additional evidence to support the idea that excess liquidity shocks can push commodity prices higher and that demand growth cannot account for all commodity price inflation. Note that shocks to the interest rate do not significantly impact prices, whether it is consumer or commodity prices. In fact, in the ADV sample, shocks to the interest rate positively impact commodity prices. These results for the interest rate are in contrast with the previous studies on global aggregates (Belke *et al* (2010), Hua (1998), and Swaray (2008)) and the predictions of theory of Frankel (1986). It appears that monetary flows into the commodity markets are indicated by excess liquidity in the system rather than flows that are signaled by the nominal interest rate.

Shocks to commodity prices do not robustly impact CPI. In the ADV sample, the effect is just barely significantly positive, while in the ALL sample, there is no significant impact. This result is similar to the peculiar result of the Granger causality test, as one would expect that if commodity prices did not affect CPI in the ALL sample, then it should not impact it in the ADV sample.

It is in the variance decompositions that the differences between the ADV and ALL samples are more clearly demonstrated. In explaining the variation in CPI, the share explained by shocks to GDP after two quarters out drops from about 40% in the ADV sample to 20% in the ALL sample. Shocks to excess liquidity explain less than 10% in the ADV sample, but this share gradually grows to explaining 40% of the variation in CPI in the ALL sample. Most importantly to this analysis, shocks to GDP explain roughly 35% of the variation in commodity prices in the ADV sample, but this eventually drops to about 20% in the ALL sample. Although shocks to excess liquidity appear to explain relatively very little in the variation in commodity prices in the ADV sample, this influence eventually grows to about 45%.

This discrepancy between the two samples suggests that assuming that only advanced countries are needed to serve as proxies for global fluctuations ignores information provided by fluctuations in BRIC country variables. Examining only advanced countries misattributes a large portion of the variation in commodity prices to shocks in GDP. When including excess liquidity in BRIC countries into the aggregate, a larger portion of the variation in prices appears to be attributed to shocks to excess liquidity. When it comes to unexpected shocks in macroeconomic variables, shocks to excess liquidity explain more of the variation in commodity prices than do shocks to output. This diminishes the influence of the demand channel, which many commentators argued was the main driver of the 2000s commodity bubble. This result supports the idea that unexpectedly excessively loose monetary policy on a global scale could be an important driver of the commodity bubble.

Also, note that shocks to the interest rate explain relatively very little in the variation in commodity and consumer prices and that shocks to commodity prices explain very little in the variation in CPI; this holds for both samples. Once again, this demonstrates that when factoring in shocks to excess liquidity among other macroeconomic variables, shocks to the global interest rate perform relatively poorly in indicating variation in prices. As the Granger causality tests suggested, measures of an overall “global” interest rate may be meaningless in an aggregated context.

VIII. Conclusion and Policy Implications

The results of the impulse response functions and variance decompositions confirm some of the previous findings reported in Belke et. al. (2010), Hua (1998), and Swaray (2008) that suggest that positive shocks to liquidity positively impact commodity prices. In particular, both samples suggest that this is a short-run impact that occurs after two quarters. However, in the sample that includes information about liquidity from BRIC countries, excess liquidity positively affects commodity prices after six and seven quarters as well. The insignificant results of Granger causality tests of the effect of monetary variables on commodity prices suggests that this relationship is limited to movements in liquidity that is unexpected by agents in the system. These “shocks” could be attributed to a number of factors including exogenous monetary policy changes such as the unprecedented responses by the Federal Reserve during and after the 2008 global financial crisis.

Despite this monetary influence, Granger causality tests, impulse response functions, and variance decompositions for both samples all point to the positive influence that increased global economic demand has on commodity prices. This supports the argument that accelerated rates of

economic growth in emerging economies is partially responsible for elevated commodity prices in the past decade. Nonetheless, according to the variance decompositions, when BRIC countries are included in the global aggregate the demand channel reduces in importance. The impact of shocks to excess liquidity rises in importance when BRIC liquidity is accounted for.

This discrepancy between samples has two implications for research and policy. First, empirical research that claims to analyze relationships at a “global” level needs to account for the growing influence of emerging economies and not simply the advanced economies. Otherwise, results may be biased as they were when too much of the forecast error variance in commodity prices was attributed to shocks to output when it should have been attributed to shocks to excess liquidity. Second, those who criticize expansionary monetary policy in the advanced countries, especially by the Federal Reserve, for pushing up commodity prices should also direct their attention towards monetary authorities elsewhere, especially the BRIC countries, since information on excess liquidity from these countries adds to the influence that global excess liquidity has on commodity prices. Third, monetary policymakers in the advanced countries need to closely monitor liquidity in the BRIC countries, since the discrepancies between the ALL and ADV samples suggests that BRIC excess liquidity affects commodity prices in a way that cannot be captured by examining advanced country data alone.

Despite the theory of Frankel (1986) and the findings of previous global VAR/VEC analyses, interest rates, especially shocks, have a minimal impact on consumer and commodity prices. Perhaps future studies should include an interest rate in their analysis that more closely reflects interest rates associated with information used by commodity consumers, producers, and investors. Some analyses such as Hua (1998) use the LIBOR rate, which is highly associated with developed financial markets in the advanced economies. Data quality and availability in the BRIC countries severely limited the length of the time period analyzed and the frequency of the data. Finding longer sample periods or higher frequency data can help to minimize bias in future research. In this paper, monetary aggregates and short-term interest rates were loosely connected to monetary policy. It would also be interesting to directly examine how special programs like quantitative easing influenced global liquidity.

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Appendix A – Tables and Figures

Table 1 - GDP shares

	1995	2009
ADV as a % of OECD	92%	89%
ADV as a % of World	61%	50%
BRIC as a % of World	15%	24%
ALL as a % of World	76%	74%

Source: World Bank Development Indicators

Table 2 - Unit Root Tests

Stationarity indicated in **bold**

ADV Sample

Level	GDP	CPI	MON	INT	COM
ADF	-1.7079* (0.7360)	-2.3872* (0.3824)	-2.2859* (0.4350)	-2.9710* (0.1486)	-3.1161* (0.1117)
DF-GLS	-1.8675*	-2.3562*	-2.0708*	-2.810789*	-2.916968‡
KPSS	0.1672‡‡	0.1889‡‡	0.1447‡	0.0777♦	0.1527‡‡

1st Difference

ADF (no trend)	-3.4685†† (0.0122)	-6.0294††† (0.0000)	-4.0883††† (0.0020)	-4.2204††† (0.0013)	-6.0158††† (0.0000)
DF-GLS	-3.7162††	-6.0672†††	-4.0488†††	-3.7257†††	-6.0739†††
KPSS	0.0717♦	0.0926♦	0.0489♦	0.0751♦	0.0587♦

ALL Sample

Level	GDP	CPI	MON	INT
ADF	-2.4926* (0.3307)	-2.2418* (0.4583)	-2.6290* (0.2695)	-2.1107* (0.5290)
DF-GLS	-2.3819*	-2.1441*	-2.5662*	-1.2772*
KPSS	0.0952♦	0.2132‡‡	0.1281‡	0.1667‡‡

1st Difference

ADF (no trend)	-3.8276††† (0.0045)	-5.4421††† (0.0000)	-3.5459††† (0.0099)	-6.2455††† (0.0000)
DF-GLS	-3.4190††	-5.4366†††	-3.6561††	-1.3940*
KPSS	0.1077♦	0.0567♦	0.0543♦	0.1438‡

2nd Difference

DF-GLS				-1.6456*
KPSS				0.0866♦

‡ Rejection of the null of unit root at the 10% level; therefore series is non-stationary

‡‡ Rejection of the null of unit root at the 5% level; therefore series is non-stationary

‡‡‡ Rejection of the null of unit root at the 1% level; therefore series is non-stationary

‡ Rejection of the null of unit root at the 10% level; therefore series is non-stationary

‡‡ Rejection of the null of unit root at the 5% level; therefore series is non-stationary

‡‡‡ Rejection of the null of unit root at the 1% level; therefore series is non-stationary

♦ Failure to reject of the null of unit root at the 10% level; therefore series is stationary

* Failure to reject the null of unit root at the 10% level; therefore series is non-stationary

Notes: p-values are in parentheses; COM is the same for both samples

Table 3 - Pesaran Test

Critical Values at 10% L.O.S.

ADV Sample			ALL Sample		
Dep. Variable	F-stat	Result	Dep. Variable	F-stat	Result
Δ RGDP	2.251	no cointegration	Δ RGDP	2.340	no cointegration
Δ CPI	2.972	ambiguous	Δ CPI	3.697	cointegration
Δ MON	3.672	cointegration	Δ MON	1.708	no cointegration
Δ INT	2.352	no cointegration	Δ INT	1.104	no cointegration
Δ COM	1.064	no cointegration	Δ COM	1.700	no cointegration

Table 4 - Comparison of Model Fit

ADV Sample

Adjusted-R²

Dep. Variable	ΔRGDP	ΔCPI	ΔMON	ΔINT	ΔCOM
L-R included	0.629	0.581	0.639	0.556	0.575
not included	0.578	0.492	0.534	0.491	0.572

	Akaike information criterion	Schwarz criterion
L-R included	-29.247	-26.227
not included	-28.277	-26.145

ALL Sample

Adjusted-R²

Dep. Variable	ΔRGDP	ΔCPI	ΔMON	ΔINT	ΔCOM
L-R included	0.554	0.584	0.652	0.413	0.562
not included	0.481	0.447	0.622	0.406	0.525

	Akaike information criterion	Schwarz criterion
L-R included	-27.913	-24.006
not included	-27.171	-24.151

Table 5 - Granger Causality Tests

ADV Sample

Dependent variable: Δ RGDP

Excluded	Chi-sq	p-value
ΔCPI	15.37785	0.0005
Δ MON	1.310898	0.5192
Δ INT	0.423823	0.8090
ΔCOM	4.671602	0.0967
All	20.85097	0.0076

ALL Sample

Dependent variable: Δ RGDP

Excluded	Chi-sq	p-value
ΔCPI	12.78546	0.0051
ΔMON	9.193505	0.0268
Δ INT	0.429312	0.9341
Δ COM	2.331124	0.5066
All	19.24144	0.0829

Dependent variable: Δ CPI

Excluded	Chi-sq	p-value
ΔRGDP	16.80843	0.0002
Δ MON	2.308153	0.3153
Δ INT	3.566596	0.1681
ΔCOM	6.452635	0.0397
All	53.82122	0.0000

Dependent variable: Δ CPI

Excluded	Chi-sq	p-value
ΔRGDP	29.04524	0.0000
ΔMON	7.100639	0.0688
ΔINT	9.64327	0.0219
Δ COM	6.03073	0.1101
All	63.06572	0.0000

Dependent variable: Δ MON

Excluded	Chi-sq	p-value
ΔRGDP	7.619528	0.0222
ΔCPI	5.488917	0.0643
Δ INT	0.004187	0.9979
Δ COM	2.009606	0.3661
All	27.77509	0.0005

Dependent variable: Δ MON

Excluded	Chi-sq	p-value
ΔRGDP	9.205386	0.0267
Δ CPI	0.940509	0.8156
Δ INT	2.940834	0.4008
Δ COM	0.772342	0.8561
All	32.06436	0.0014

Dependent variable: Δ INT

Excluded	Chi-sq	p-value
Δ RGDP	4.372917	0.1123
ΔCPI	5.149174	0.0762
Δ MON	1.813842	0.4038
Δ COM	3.876191	0.1440
All	19.27495	0.0135

Dependent variable: Δ INT

Excluded	Chi-sq	p-value
Δ RGDP	4.388929	0.2224
Δ CPI	2.08839	0.5543
Δ MON	1.079492	0.7820
Δ COM	0.068344	0.9953
All	21.13584	0.0484

Dependent variable: Δ COM

Excluded	Chi-sq	p-value
ΔRGDP	13.95322	0.0009
ΔCPI	9.726949	0.0077
Δ MON	3.336818	0.1885
Δ INT	2.398765	0.3014
All	45.13677	0.0000

Dependent variable: Δ COM

Excluded	Chi-sq	p-value
ΔRGDP	19.77027	0.0002
Δ CPI	1.655177	0.6469
Δ MON	1.959744	0.5808
Δ INT	5.323697	0.1496
All	50.90374	0.0000

Note: Variables that Granger cause the dependent variable at the 10% level or greater are highlighted in bold

Table 6 - Implied Long Run Impacts

		<u>Impacted Variable</u>					
		GDP	CPI	MON	INT	COM	
ADV Sample	Impa	GDP		1.214	-0.130	-8.466	-15.093
	ct of	CPI	-2.600		3.095	19.670	9.004
	Varia	MON	-0.893	0.541		-30.494	-9.753
	ble	INT	0.007	-0.005	0.013		0.134
		COM	0.040	0.140	-0.129	3.170	

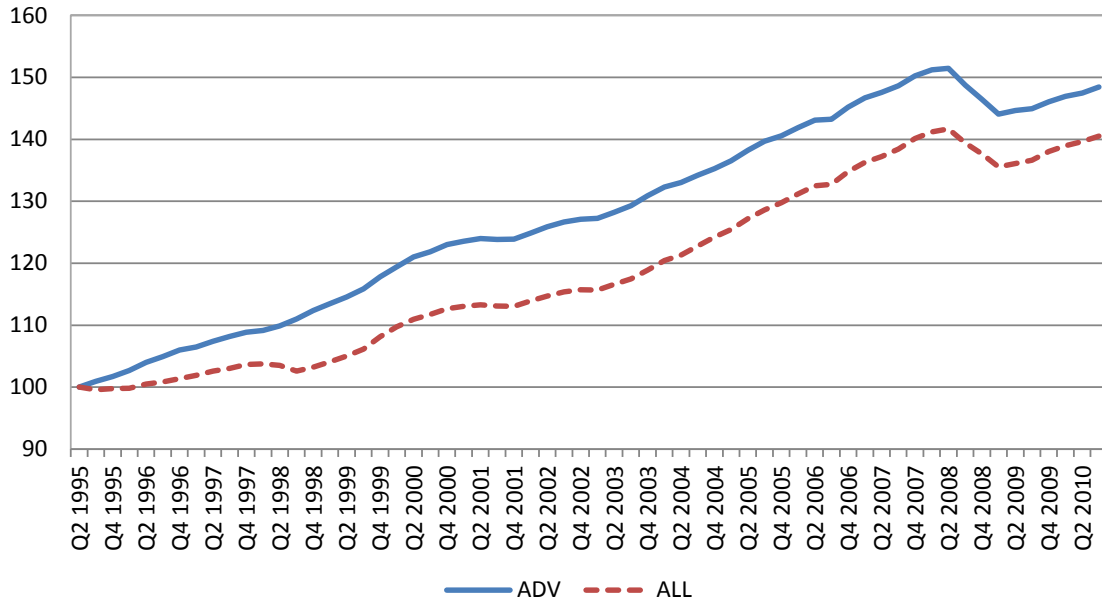
		<u>Impacted Variable</u>					
		GDP	CPI	MON	INT	COM	
ALL Sample	Impa	GDP		4.537	0.700	39.375	16.029
	ct of	CPI	-1.256		2.529	58.198	-2.253
	Varia	MON	-0.638	2.532		-0.638	7.017
	ble	INT	0.011	-0.016	-0.008		-0.039
		COM	0.048	-0.149	-0.109	-0.972	

Note: bold numbers indicate both coefficients have t-stats greater than 2 and are therefore significant

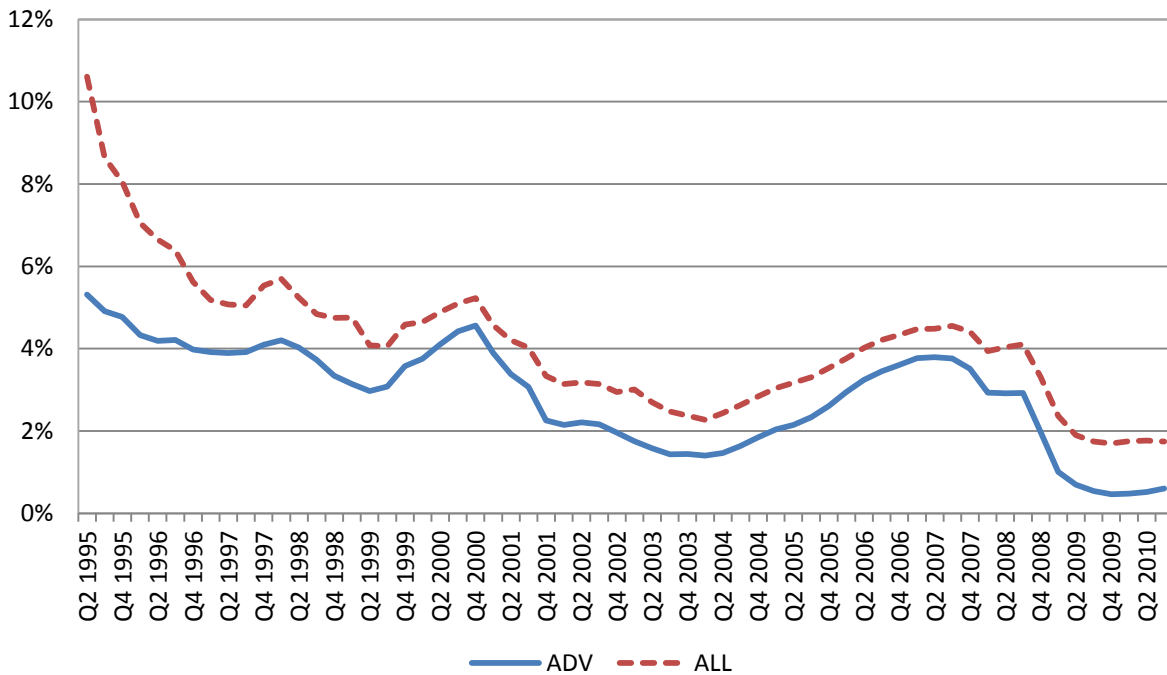
Figure 1 – Global Aggregates 1995Q2 – 2010Q3

Global GDP Index

(1995 Q2 = 100)

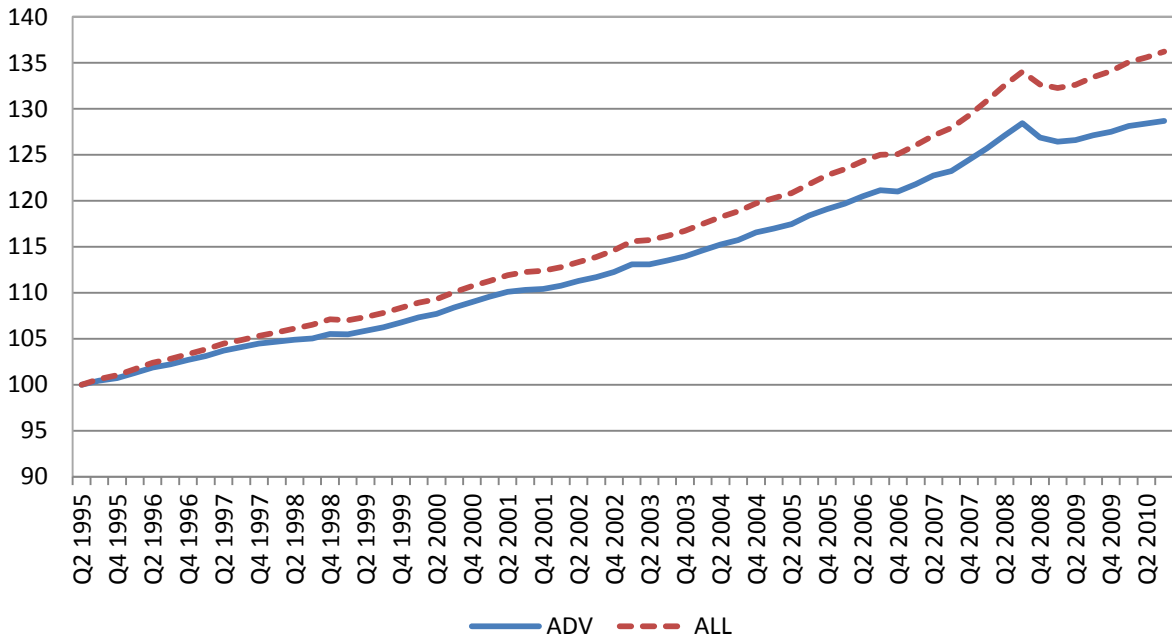


Global Nominal Interest Rate

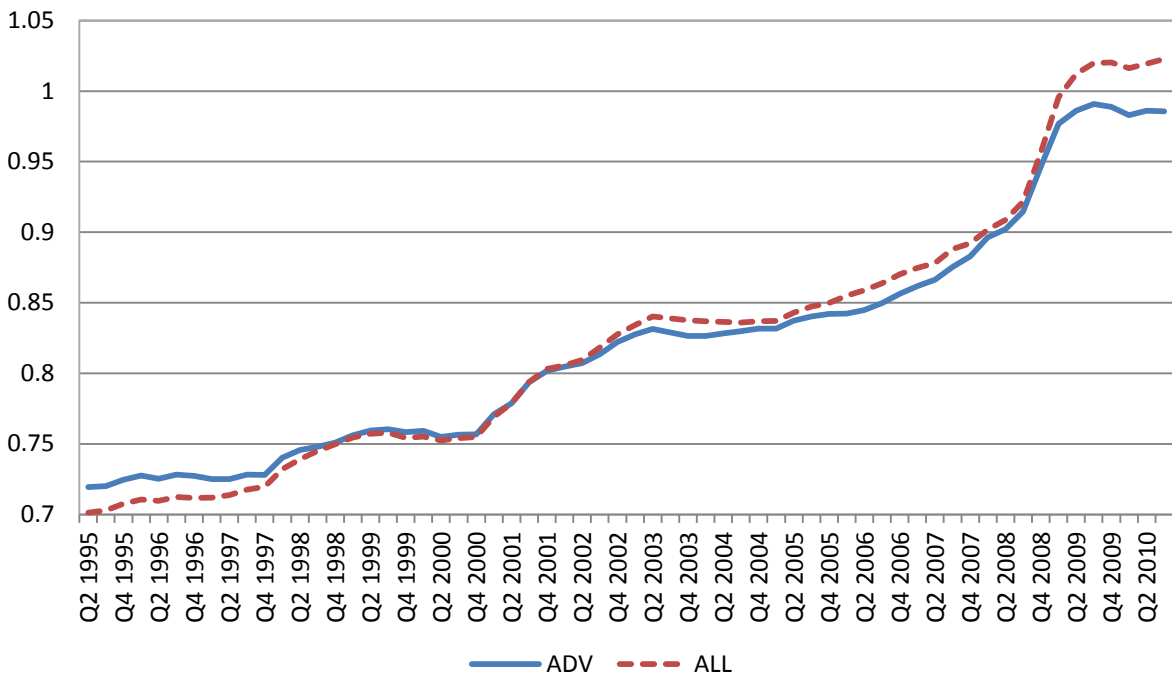


Global CPI Index

(1995 Q2 = 100)



Global Excess Liquidity



S&PGSCI Index

(January 1 1970 = 100)

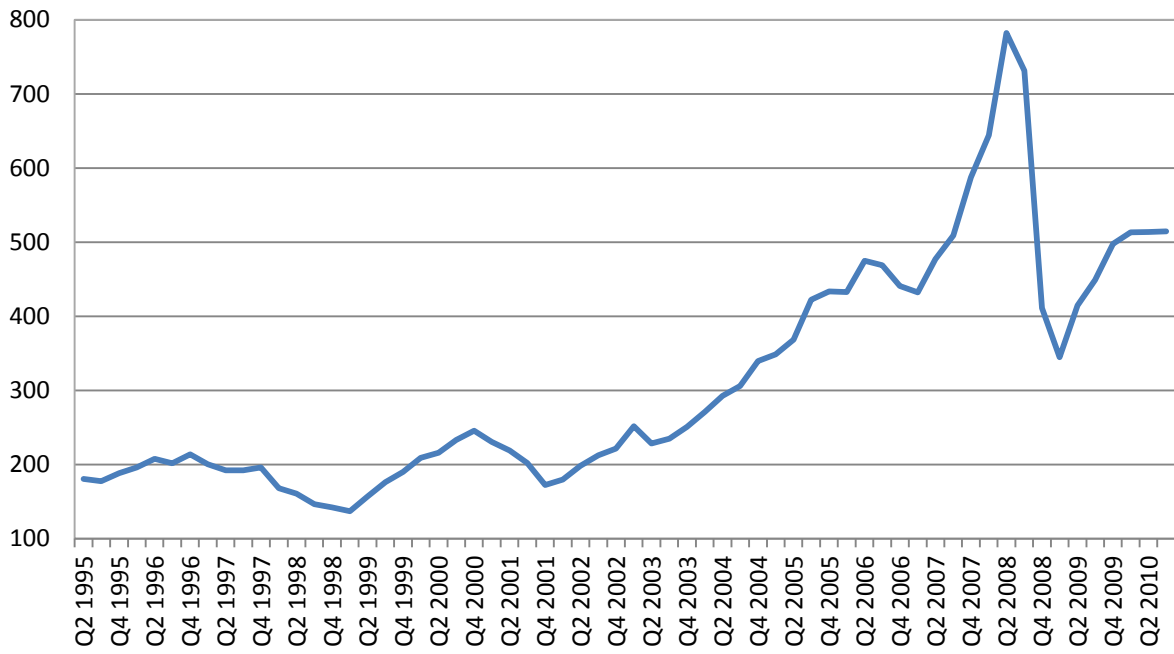
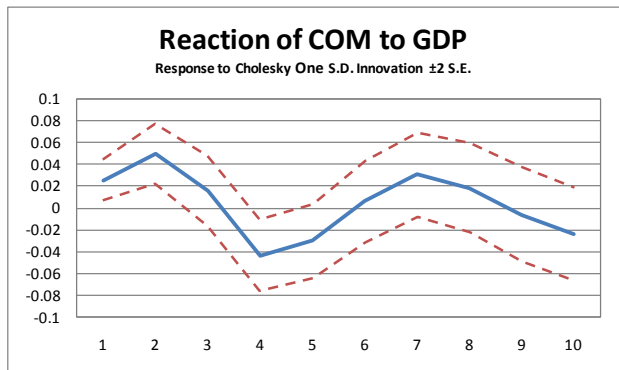
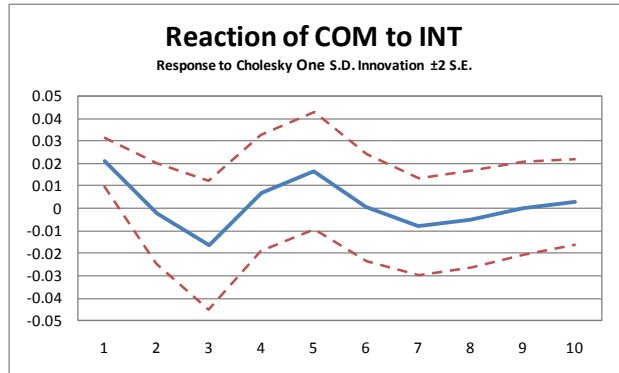
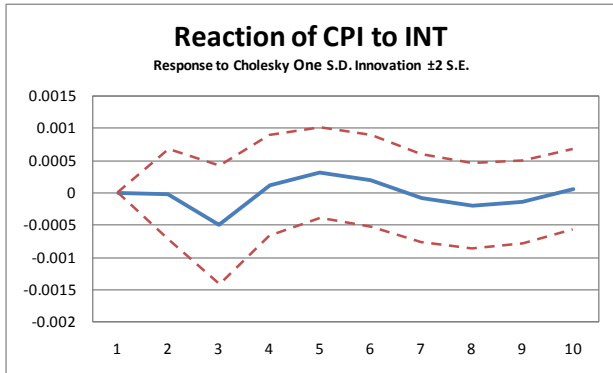
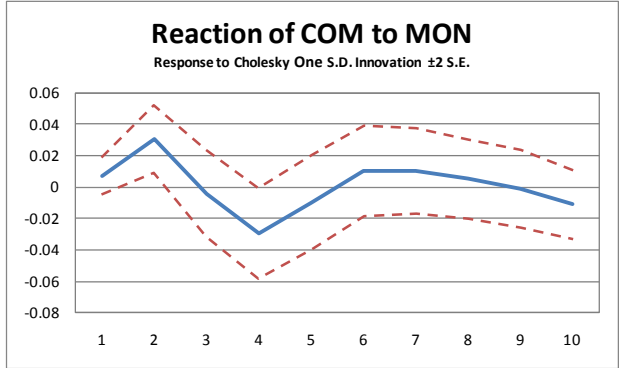
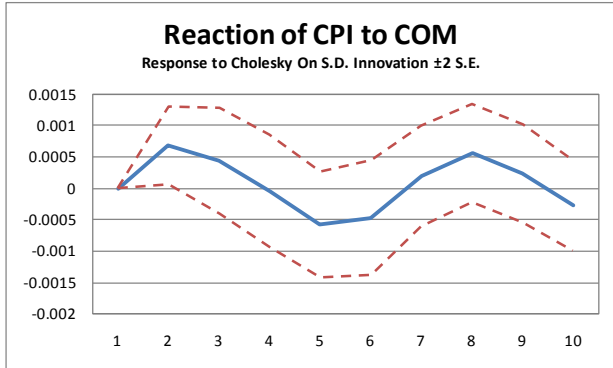


Figure 2 – Impulse Response Functions

ADV Sample



ALL Sample

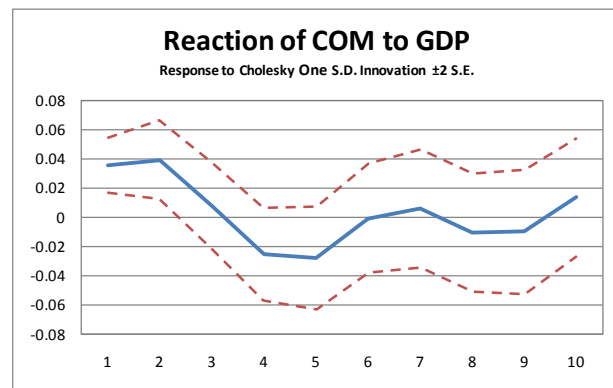
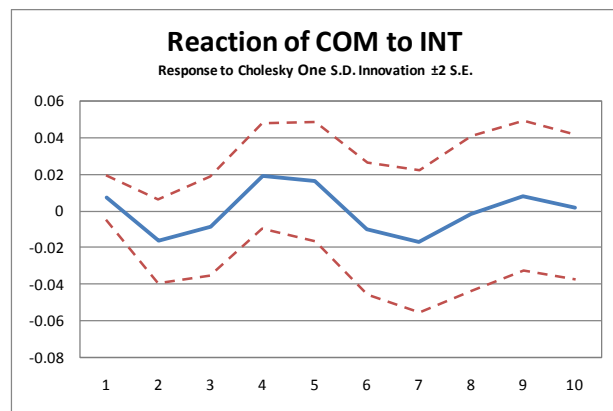
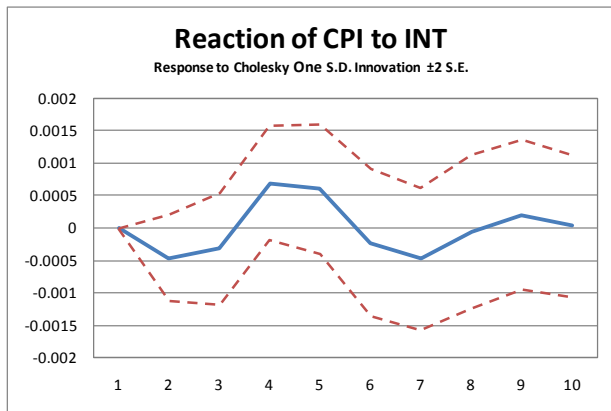
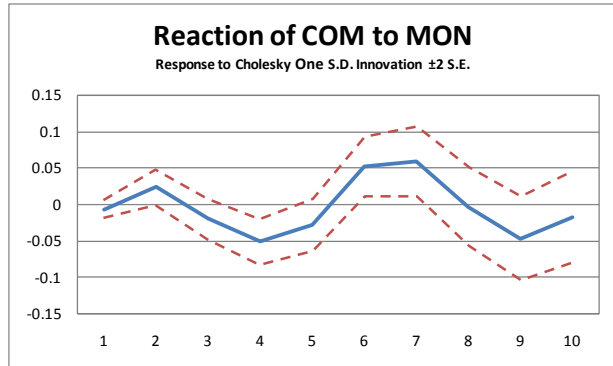
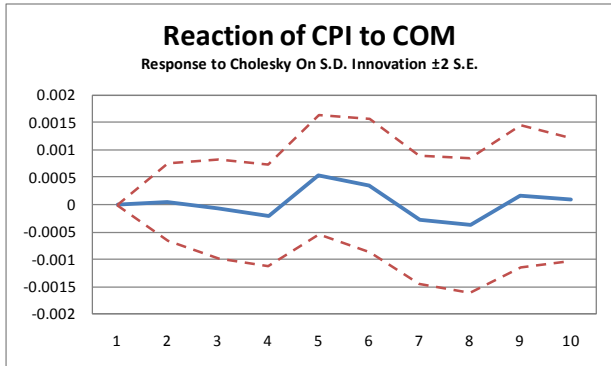
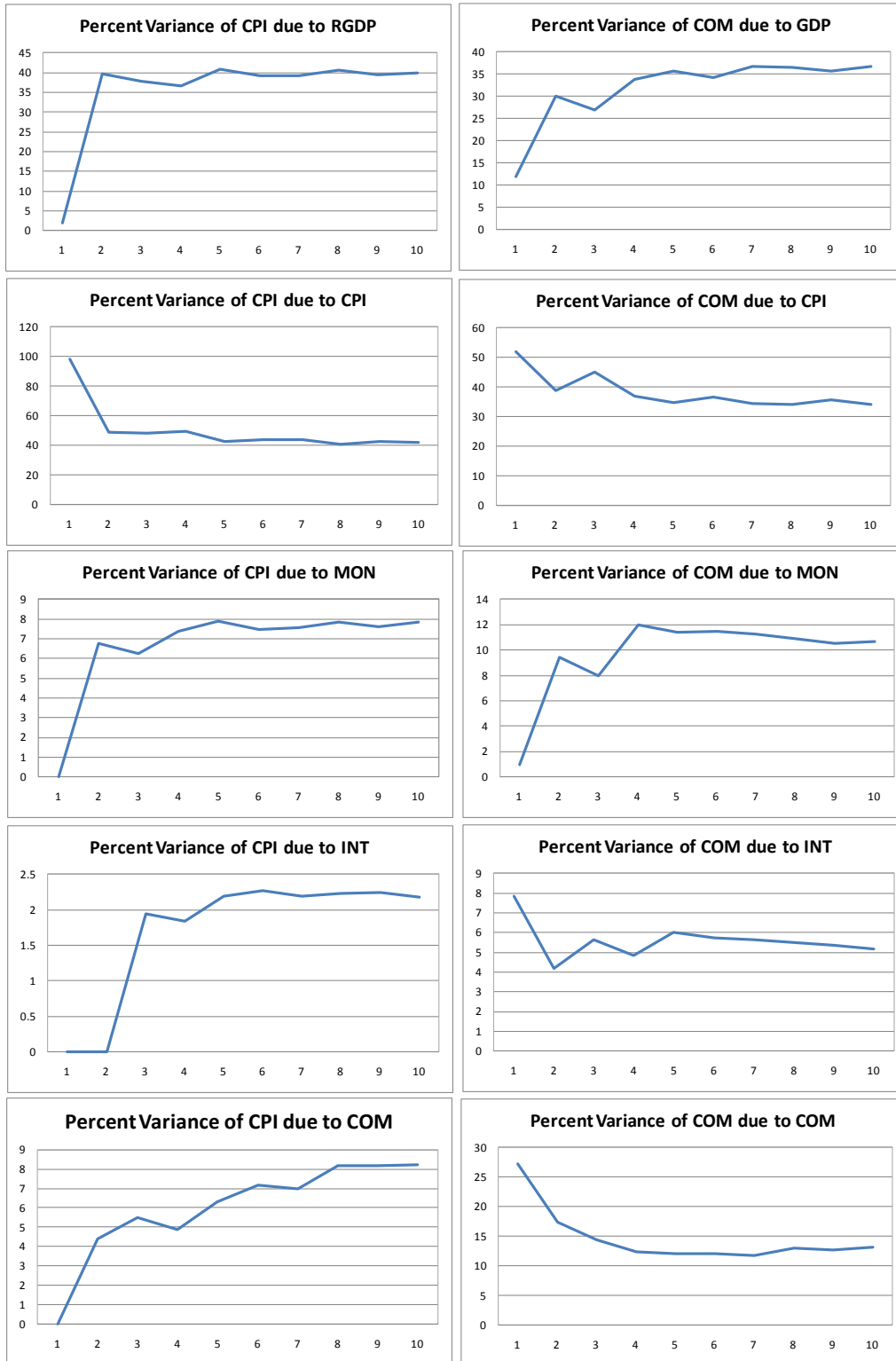
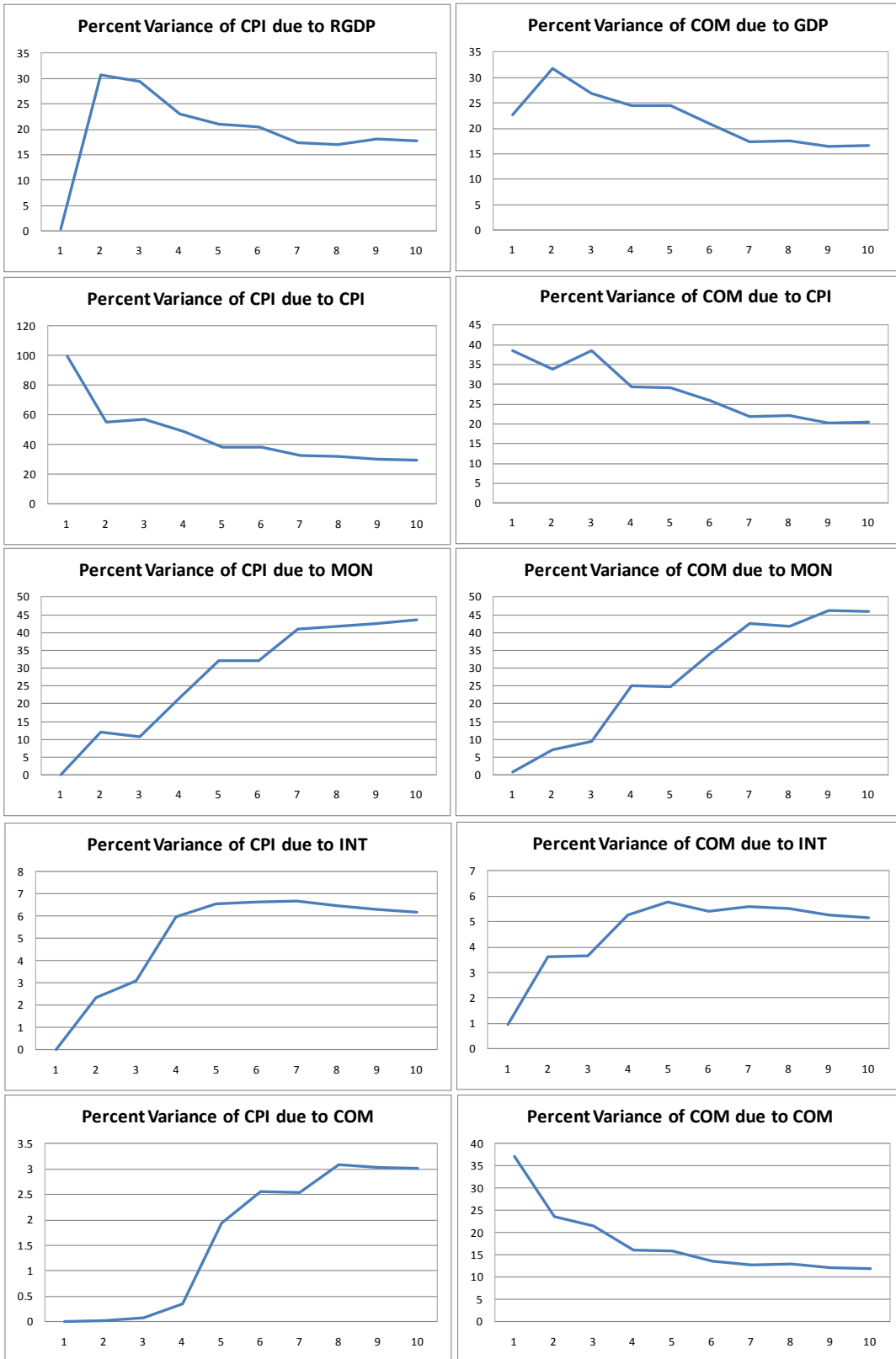


Figure 3 – Variance Decomposition

ADV Sample



ALL Sample



Appendix B – Global Aggregation Method

First, country currencies were converted into US dollars at PPP exchange rates. This method accounts for differences in the purchasing power of one dollar in different countries. Specifically, the formula, adapted from Sousa and Zaghini (2004, 2006)¹¹ adjusts the nominal market exchange rate, E , for the level of inflation in country i relative to the US. The formula is as follows:

$$E_{\text{currency in country } i \text{ per USD}} \times \frac{\frac{CPI_{it}}{CPI_{it-1}}}{\frac{CPI_{US,t}}{CPI_{US,t-1}}}$$

While output and excess liquidity were aggregated into global variables by summing GDPs and broad money supplies, CPI and the interest rate were calculated by taking a weighted average of each variable using GDP of country i relative to the GDP of the entire sample as weights. For example for CPI in the ALL sample at time t :

$$Global\ CPI_{ALL,t} = \sum_{i=1}^{15} \frac{GDP_{it}}{GDP_{Total\ in\ ALL\ sample,t}} \times CPI_{it}$$

¹¹ I am indebted to Andrea Zaghini for sharing the methodology for how the PPP exchange rates were calculated in Sousa and Zaghini (2004, 2006).