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# Historical Performance of Commodity and Stock Markets

Hector O. Zapata, Joshua D. Detre, and Tatsuya Hanabuchi

This paper examines two interrelated issues in commodity markets, namely, the cyclical relationship between stocks and commodities and the function of commodity and agribusiness indexes in portfolios. A high negative correlation has existed between stock and commodity prices over the past 140 years. Moreover, the two markets have alternated in price leadership with 29–32-year cycles. The recent price dominance in agricultural commodities started in 2000, a result supported by the empirical results of the portfolio allocation analysis. For a risk-averse investor, irrespective of the period analyzed, placing funds in agribusiness and/or agricultural commodity indexes was sound investing.

*Key Words:* agribusiness stocks, agricultural commodities, investment, portfolios, stock market indexes

**JEL Classifications:** G10, G11, Q13

At no other time in the history of agriculture has the financial interest in commodities been as strong as it is today. Publicly traded agribusiness firms and agricultural-related commodity markets have gained unprecedented interest as financial assets for investors seeking profits from diversification. Some early observers of commodity markets (Bannister and Forward, 2002; Rogers, 2004) note that the history of U.S. stock and commodity prices has been characterized by recurring super cycles that last several decades. A case was made that, historically, commodity markets remained an ignored asset class in financial markets and in financial news coverage.

Rogers labeled commodity markets the “world’s best market” and created the Rogers International Commodity Index (commonly

known as RICI) for measuring worldwide trends in commodity prices.<sup>1</sup> Bannister and

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<sup>1</sup> One of the oldest commodity indexes is the Reuters-CRB Futures Index; others include the Thomson Reuters/Jefferies Commodity Research Bureau (CRB) Index, the Dow Jones-AIG Commodity Index, and the Goldman Sachs Commodity Index. On the investment side, precious metals and energy exchange-traded funds have been familiar to investors. Examples are U.S. Oil, iShares Silver Trust, and Standard & Poor’s Depository Receipt (SPDR) Gold Shares. Exchange Traded Notes (ETN) provides a similar investment instrument, an example of which is the Rogers International Commodity Index (RICI)-Total Return ELEMENTS ETN (ticker RJI-<http://www.elementsetn.com/pdfs/ELEMENTS-RJI.pdf>), which is designed to track the performance of the RICE – Total Return Index. This is a worldwide index with three categories: agriculture (34.90%), energy (44%), and metals (21.10%). Agriculture includes 20 commodities, some of which are wheat, corn, cotton, soybeans, sugarcane, live cattle, coffee, cocoa, and rice. Another example is the iPath Dow Jones-AIG Commodity Index Total Return ETN (DJP- <http://www.ipathetn.com/product/DJP/#/indexcomponents>), which is linked to the Dow Jones-UBS Commodity Index Total Return, which, similar to the RJI, includes agriculture (33.61%), energy (34%), industrial metals (15.18%), and precious metals (17.21%).

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Forward (2002) argued that the bull market cycle in commodities would continue into the upcoming decade, and this assessment was based on a descriptive analysis of the relationships between stock and commodity prices. Rogers suggested that commodity markets were the place to be for investors, given the insatiable demand for raw commodities from emerging markets, among other factors, which would continue to increase commodity prices. The aforementioned bull market increased interest in commodity markets causing large financial institutions to begin to add commodities to their portfolios. Judging from the number of agricultural index funds and agriculturally-related commodity price indexes now available for public investment, it is evident that commodities are an attractive asset class. Domanski and Heath (2007) show that by mid-2006, funds with conservative investing strategies holding approximately \$85 billion in managed assets were tracking the Goldman Sachs Commodity Index and the Dow Jones/American International Group (AIG) Index. Not surprisingly, even with huge price declines observed in commodities in mid-2008, they continue to attract investors and perhaps speculative activity.<sup>2</sup>

Moreover, various trends in today's society make investment in agri-food and fiber firms an interesting topic for economic research. First, human health education is becoming the subject of much global interest and the demand for "healthy foods" on both a domestic and international level has increased significantly. Food processors and retailers, like General Mills, Unilever, Kellogg, and Walmart have taken notice of this trend and have introduced their own organic product lines (Associated Press, 2006). Second, the introduction of genetically modified (GM) and functional food products (foods offering additional benefits

that promote optimal health or reduce risks for certain diseases) has been a worldwide topic of debate among producers and consumers. As GM and functional foods have begun to gain worldwide acceptance and governments have begun to relax restrictions governing these foods, agribusiness firms involved in their production stand to make tremendous profit. There is also an unprecedented demand for the inputs used in agricultural production and agribusiness processing by non-agricultural industries. The increase in competition for these inputs may influence the profitability of agribusiness firms, which ultimately affects their share prices and dividend streams.

Finally, many U.S. agribusiness companies are often considered defensive investments and defensive stocks (i.e., stocks with a risk level less than the overall market) and tend to remain stable under difficult economic conditions, making it crucial that we examine the role of agribusiness stocks in portfolios under various market conditions (Ang, Chen, and Xing, 2006; Dirks, 1958; Kahn, 2008). For example, the market crash of 2008 would likely cause investors to reassess their investment strategies, and such reallocation may include defensive stocks, that is, agribusiness stocks. In recent research by Damodaran (2009), the beta value for the U.S. Food Processing Industry was 0.63. Since systematic risk can be estimated by calculating the risk estimator "beta" (as defined in the Capital Asset Pricing Model, the level of risk that is associated with investing in a stock relative to the market as a whole), investors would be expected to gravitate toward defensive stocks during market downturns (Lintner, 1965; Sharpe, 1964).

The apparent countercyclical behavior between stock and commodity prices and the return-risk potential of agricultural-related assets have received insufficient attention in the agricultural economics literature; exceptions include the literature cited in this paper. The purpose of this paper is to address the above two issues, by first providing initial research on the econometric measurement of the strength of the cyclical relationship between stock and commodity markets. The Standard & Poor's 500 Index (S&P 500) and Producer Price Index (PPI

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<sup>2</sup>The role of speculation in the recent commodity price boom has been of considerable research interest (Irwin, Garcia, and Good, 2009a; Irwin, Sanders, and Merrin, 2009b; Sanders, Irwin, and Merrin, 2010). The role of index and swap funds in agricultural and energy commodity futures markets is found in Irwin and Sanders (2010), while some support for a speculative bubble (in the form of bandwagon effects) is found in Frankel and Rose (2010).

for all commodities and for selected components (farm, food, fuel, and metals) are used to represent stock and commodity prices, respectively. A second objective of the paper is to assess the role of agricultural commodities and publicly traded agribusiness companies in investment portfolios.<sup>3</sup> Thus, the paper is organized into two major sections with the first section addressing the issue of stock-commodity cycles, which serves as the motivation for the second section, the function of agribusiness and commodity indexes in portfolios.

### Cyclical Analysis

#### Data

The stock and commodity price indexes used in the cyclical analysis is an updated version of that in Bannister and Forward (2002). Annual values of the S&P 500 covering the period 1871–2010 were calculated from the monthly series available from Shiller (2011). The corresponding annual PPIs were obtained from the Warren and Pearson (1935) study. A U.S. commodity average is constructed from the following components: farm products, foods, hides and leather, textiles, fuel and lighting, metals and metal products, building materials, chemicals and drugs, household furnishing goods, spirits, and other commodities. Data for the period 1891–1913 are from the Wholesale Commodities Price Index by the Bureau of Labor Statistics (BLS). Data for the period 1914–2010 are from the PPI for all commodities in the modern series. The base year for the PPI is 1982 = 100. The components of the PPI for the period 1871–1890 correspond to the components from the Warren and Pearson study, which constructs a U.S. commodity average for farm products, foods, fuel and lighting, and metals and metal products.<sup>4</sup> Data for the period

1891–1970 are from the Wholesale Commodities Price Index by the BLS (farm products, processed foods and feeds, fuels and related products and power, and metal and metal products). Finally, data for the period 1971–2010 are from the corresponding components of the modern PPI, with the same base of 1982 = 100. All annual indexes were crosschecked with those in Bannister and Forward (2002) to facilitate cross-referencing with the existing literature on the subject.

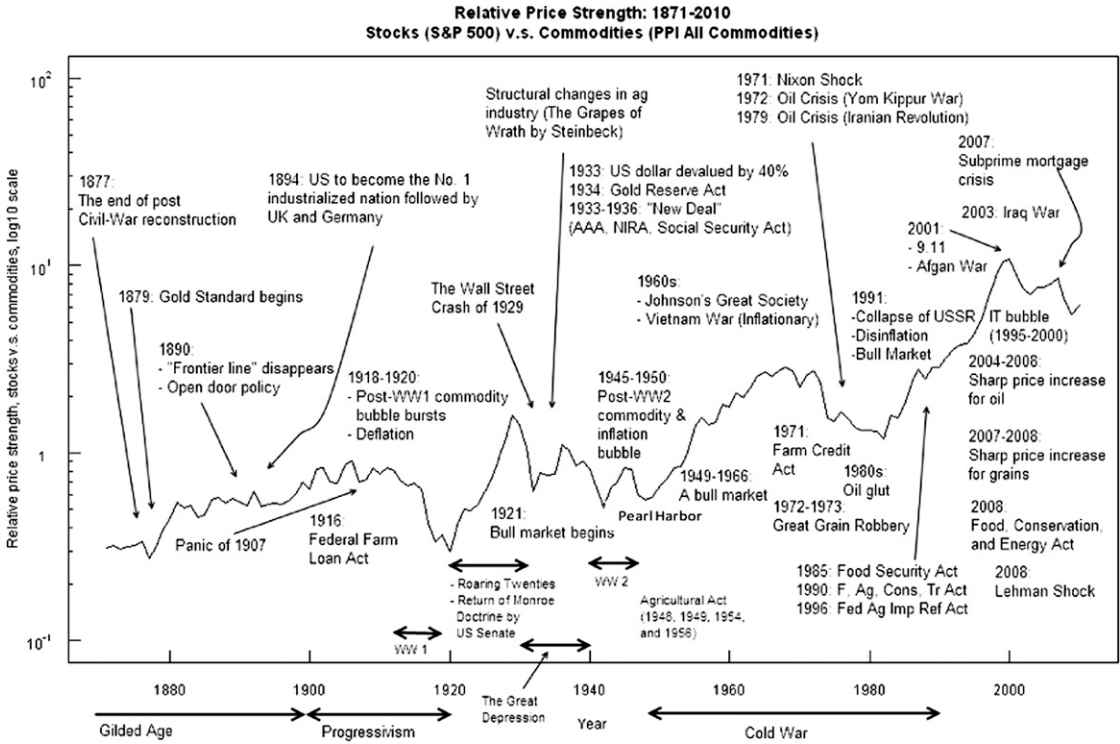
#### *Historical Relationship between Stocks and Commodities*

Historically, there has been a negative correlation between the price movement in stocks and commodities (Rogers, 2004), an observation initially measured by Bannister and Forward (2002) using data starting in 1871 (Figure 1).<sup>5</sup> This century-long co-movement in prices in both markets has been characterized by patterns that resemble business cycles in the U.S. economy and is driven by historical events that surround major turning points in both markets. From 1871–2010, the S&P 500 and PPI for all commodities had a correlation coefficient of  $-0.71$ , which supports the common conception of an overall inverse relationship between stock and commodity prices. A closer examination of Figure 1 highlights salient periods when the ratio of S&P 500 Composite Index to the PPI, referred to as the relative price strength ratio (RS), rises (falls), with increases (decreases) in the ratio interpreted as periods when returns in stocks were higher (lower) than those in commodities. Over this 140-year period, there is a remarkable consistency in the relationship between stocks and commodities. Bannister and Forward (2002) note that there are six major bull markets, whereby stocks and commodities alternate as to which is the performance leader, with each asset class typically taking a turn every 16–18 years: 1906–1923, 1929–1949, 1950–1965, 1966–1982, 1982–2000, and 2000 to 2016–2018, the last period being an estimate

<sup>3</sup> Ideally, a separate paper should have been written on the issue of risk-return relationship in stocks and commodities. However, due to space limitations, we include this additional component into the paper.

<sup>4</sup> A recent evaluation of the long-term returns of the S&P 500 index is found in Siegel and Schwartz (2006). Individual components of the PPI indexes are available at <ftp://ftp.bls.gov/pub/special.requests/ppi/sopnew11.txt>.

<sup>5</sup> Results of other filters are available from the authors upon request.



**Figure 1.** Historical Relationship between Stocks and Commodity Prices (Source: Adapted from Bannister and Forward, 2002)

based on the historical relationship. Note that these sub-periods relate to major U.S. stock market crashes, macroeconomic events, and/or political events. The first commodity bull market in the period analyzed preceded the crash of 1907, with the next following the 1929 stock market crash (an event of similar proportions to the recent financial crisis in the U.S.). Note that the bear market in stocks (1966–1982), according to this analogy, was also a period of increasing growth in agricultural exports, high inflation, skyrocketing interest rates, and previously unseen high oil prices. The end of that period created a new era for stocks, which included the introduction of technology stocks, the personal computer, the Internet age, and the “dot com” industry boom (and bust). The start of a new century brought commodities into the financial spotlight, and this coincided with the phenomenal economic growth of emerging markets and the implied demand for raw materials, which is assumed to be a main driver of the upward trending commodity prices.

Figure 1 also displays the rich history of commodity markets and their relationship to economic growth, farm policy, the value of the dollar, inflation, energy markets, farm credit, and bio-energy policy. A good discussion of these events and their relevance to stock and commodity markets until 2001 is found in Bannister and Forward (2002). Of more recent interest has been the War on Terror following 9/11, the second war with Iraq in 2003, the subprime mortgage crisis of 2007, and the record high commodity prices that peaked in mid-2008 and thereafter declined sharply until early 2009 (boom and bust in the terminology of Irwin et al. (2009b)). Recently, commodity prices have returned to the pre-financial crisis trend. At the end of November 2011 (Investor’s Business Daily, 2011) the Chicago Board of Trade (CBOT) prices for December 2012 delivery were 680.00 cents/bu for wheat and 552.00 cents/bu for corn, 128.90 cents/lb for cattle (Chicago Mercantile Exchange [CME]), 81.10 cents/lb for hogs (CME), \$15.23/cwt for

September 2012 rough rice (CBOT), and 243.25 cents/lb for coffee (ICE). Where these markets are heading in the near-term and/or long-term is a question that may never be accurately answered, but understanding the cyclical movements in these markets would be valuable information to all stakeholders with an interest in the profitability of the agricultural sector. While Gorton and Rouwenhorst (2006) find that there are no significant differences in the risk premium between commodity futures and equity and bond returns, there is however a negative correlation (Figure 1), which is driven primarily by the different behavior of commodity futures over the business cycle.

### *Stock-Commodity Econometric Cycles*

The estimation of business cycles has been of considerable research interest in economics. A recent issue of the *Journal of Applied Econometrics* was devoted to this theme, and we defer the reader to the articles in that issue, particularly the paper by Harding and Pagan (2005) on important aspects relative to definitions and econometric models of cycles. To our knowledge, an econometric investigation of the cyclical behavior in the relative price strength of stock and commodity prices is missing in the literature. In this paper, we adopt the methodology of Christiano and Fitzgerald (2003) (referred to as CF hereafter) because of its optimality in modeling time series data, which may or may not be stationary. CF approximates an ideal bandpass filter for a time series and computes cyclical and trend components of a time series.

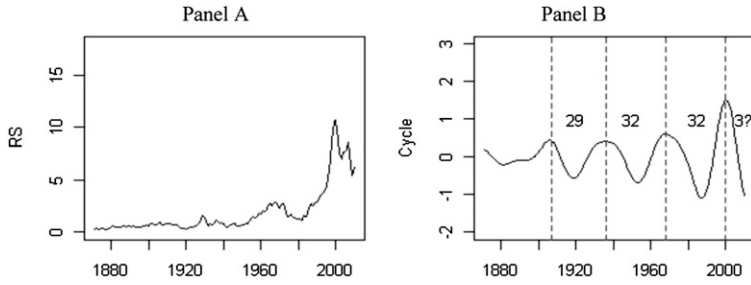
For any time series  $x_t$ ,  $t = 1, 2, \dots, T$ , CF isolates a component ( $y_t$ ) of the series with a period of oscillations between  $p_l$  and  $p_u$  (also referred to periodicities of  $y_t$ ), with  $2 \leq p_l < p_u < \infty$ . The filter weights are chosen in such a way that the estimator of  $y_t$  minimizes a mean squared error criterion. In this framework, the CF filter is a finite sample approximation to the ideal bandpass filter, accommodates unit-root processes, and provides a good approximation in the case of stationary series. For a comparison of the performance of the CF filters relative to other commonly used filters,

such as the Baxter-King filter and the Hodrick-Prescott filter, see Christiano and Fitzgerald (2003).<sup>6</sup> The bounds for the periodicity in the CF filter were chosen so that they would correspond to the hypothesis that, on average, stocks and commodities have alternated in leadership for an average of 18 years (Bannister and Forward, 2002). We set the minimum and maximum values of this periodicity to 18 and 36 years; other values such as those typical of business cycles [2, 8] and [8, 36] were studied but are not presented due to space constraints. Note that CF is an optimal method of estimating the length and amplitude of cycles and carries the same interpretation as that of the other methods. The estimated length of a cycle is the time it takes to move from peak-to-peak. Because RS is considered a measure of price performance, the increasing/decreasing phase of cycles is a measure of the length of time (years) when stocks perform better than commodities and vice versa. The amplitude of the cycle measures how stock or commodity prices spike; the taller/shorter the amplitude, the more/less RS tends to increase or decrease. The amplitude in RS is the result of how stock and commodity prices change leadership (i.e., how fast/slow the two prices change relative to each other).

### *Stocks and Commodities*

Figures 2–6 contain the results of the cyclical analysis for the relative price strength (RS) of stocks and all commodities (Figure 2), stocks and farm products (Figure 3), stocks and food products (Figure 4), stocks and fuel products (Figure 5), and stocks and metals (Figure 6). The relative price strength in stocks-commodities is shown in Panel A of Figure 2 in a log scale. The

<sup>6</sup>An Augmented Dickey-Fuller test, with lags chosen using a modified AIC criterion for a maximum lag of 18 indicates that the hypothesis of a unit root cannot be rejected. This suggests that the relative price strength between stocks and commodities should be filtered with a unit-root specification, which can be easily accommodated in the CF filter. Various moving-average (MA) representations were also used in the CF specification and the results reported here were robust to MA terms of low order.



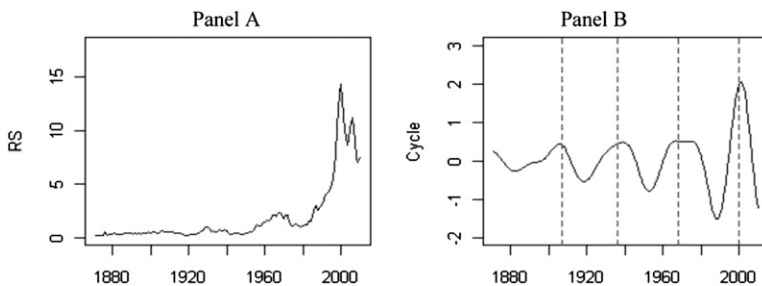
**Figure 2.** Stocks versus All Commodities and the CF Cycle

ratio of prices between stocks and commodities remained approximately flat from 1871 until the early 1920s. Variability in the RS index increased during the Great Depression of 1929 and has remained so to 2010. A salient pattern in this panel is the sharp rise, followed by a sharp decline in stock price performance over the last two decades; in fact, from about 1980 to the late 1990s, stocks had a phenomenal run, which has since reversed. The Christiano-Fitzgerald econometric cycle is illustrated on the right panel (Panel B) in Figure 2 for the entire period 1871–2010. Cycles were also estimated for the sub-periods 1871–1941 and 1942–2010, which confirmed robustness of the results, but are omitted due to space constraints. Three main patterns emerge from these econometric cycles. The first is that the cycle amplitude between stocks and all commodities has increased significantly; in Panel B, this pattern is observed in the conic shape enclosing the cyclical waves, which are the widest from the 1960s onwards. The second observation is that these peaks and troughs of the cycles have become sharper (it takes less time for a turning point in the RS index) but the overall length of

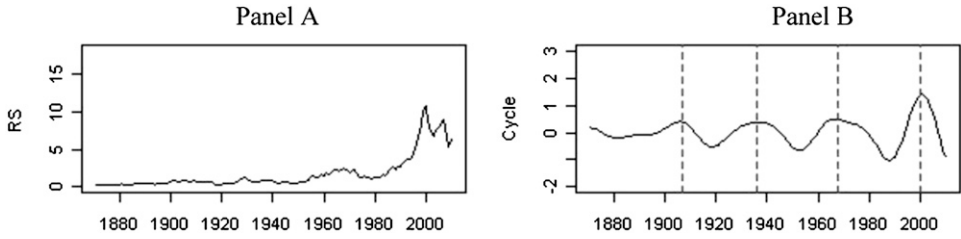
the cycles has remained approximately constant. For example, the length of the cycles in Panel B, Figure 2, from peak-to-peak was about 30 years, with the first three cycles reaching a peak at about 0.5 compared with 1.5 for the last cycle (a similar observation holds for troughs). Third, dividing the period of analysis into sub-periods that split at the middle of World War II has no significant effect on the estimated cycles (not shown in Figure 2), relative to the cyclical behavior over the entire period (Panel B, Figure 2). Overall, the Christiano-Fitzgerald cycle suggests that stocks and commodities tend to alternate in price performance leadership about 31 years on average. This lends considerable support to Bannister and Forward’s (2002) initial observation that stocks lead and lag commodity prices for periods of about 18 years.

*Stocks and Farm Commodities*

How applicable are the above cyclical findings when evaluating the relationship between stocks and farm products? Agricultural commodities have characteristics and uses that separate them



**Figure 3.** Stocks versus Farm Products and the CF Cycle



**Figure 4.** Stocks versus Food Products and CF Cycle

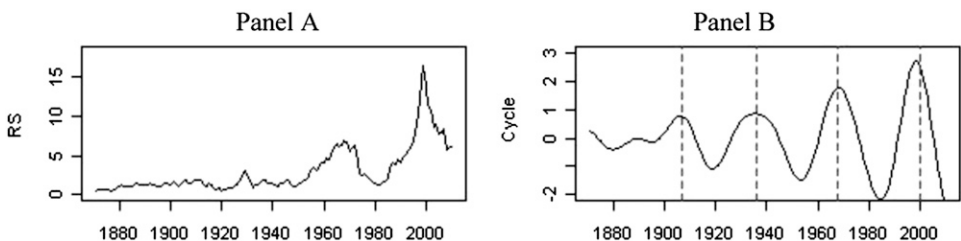
from other commodity markets, but they are also linked with those commodities that serve as inputs into agricultural production, for example, energy and metals. From a market structure point of view, economic theory suggests that the demand for raw agricultural commodities is derived from that of processed products (e.g., foods) and that supply is determined at the farm level. Naturally, this economic logic suggests that price determination arises as market fundamentals change at various levels of the marketing system and are reflected at the farm level through the interaction of primary supply and derived demand. The supply side is assumed more responsive to increasing prices and less responsive to price declines (asymmetric supply response) (Tomek and Robinson, 1990). Thus, when prices of farm commodities increase, investment in agriculture increases through the purchase of plants, property, and equipment. This sets in a capital investment cycle, driven by asset fixity that can theoretically last for many years.

Figure 3 shows the relationship between stocks and farm commodities, with Panel A containing a plot of the relative price strength between the two. Compared with the RS in Panel A, of Figure 2, it is clear that the two graphs are nearly replicas of each other; the

main difference is the vertical scale, which is wider for the RS between stocks and farm commodities. The Christianiano-Fitzgerald cycles for the entire period are shown in Panel B of Figure 3. This cycle also appears to mimic that in Panel B, Figure 2, except for the level and amplitude of the cycle, which is wider between stocks and farm commodities (the range is from  $-1.5$ – $2.0$ ) than that of stocks versus all commodities (the vertical range of about  $-1.0$ – $1.5$ ). One major difference between the two is the flatter peak occurring around 1965–1980, which is in agreement with stagnant stock prices during that period relative to all commodity markets.

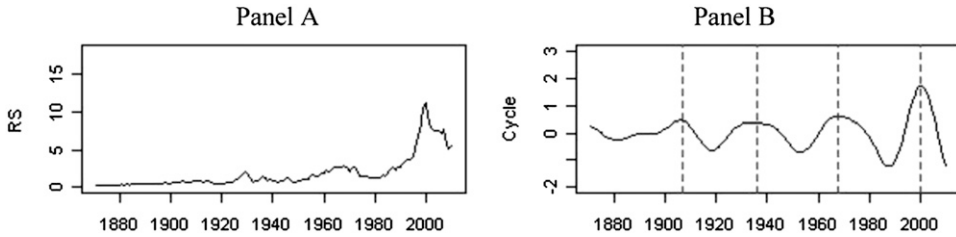
Figure 4 relates to processed food products such as cereal and bakery products, bread, soft cakes, pies, flour, milled rice, meats, beef, processed poultry, and other products, these are post-farm gate value-added products. Notice that the cyclical pattern between food products and farm products is identical in length, except for the amplitude of the cycle, which matches that of stocks and all commodities.

Recent research suggests that agricultural commodity markets and energy markets are becoming more closely linked. As the price of oil increases, the cost of producing, processing, and transporting commodities (crops and



**Figure 5.** Stocks versus Fuel and the CF Cycle





**Figure 6.** Stocks versus Metals and the CF Cycle

livestock) increases. This linkage has been strengthened by the increasing production of biofuels, which in the U.S. is driven by corn production (Hertel and Beckman, 2010). The trend and variability of the relative price strength of stocks to fuel prices is shown in Figure 5. Notice that this ratio has more variability compared with the other RS ratios, but the general pattern is similar to that in farm prices. The salient pattern that emerges for the entire period and for the other two sub-periods is that the RS for stock-fuel cycles are identical to those in the stock-all commodity cycles; the cycle amplitude, however, is much more pronounced for the stock-fuels relative prices. In the case of metals (Figure 6), the behavior of the RS and the resulting cycles in stock-metals are identical to those in stock-all commodities (Figure 2) and for stock-food relative price strength (Figure 4).

Upon aggregating the results on the RS between stocks and all of the various components of the PPI considered in this analysis, it is found that on average, using the Christiano-Fitzgerald trend-cycle decomposition, the stock-commodity cycles are about 31 years long. Consequently, the length of the peak-trough segment, that is, when commodities are outperforming stocks, is about 15 years. It is important to note that the cycles are not perfectly symmetric (asymmetric behavior was specified in the CF filter). This provides considerable support to Bannister and Forward's (2002) observation that on average, stocks and commodities have alternated in price leadership; our results suggest that the alternating performance in stocks and commodities last for about 15 years, a bit shorter than the previously mentioned 18 years.

The real question is what can be done with the information on the cycles of stocks and commodities. The findings on the robustness in the cyclical pattern found for various commodity groups (i.e., farm, food, fuels, and metals) would suggest that agricultural commodities, and perhaps agribusiness companies, present an investment opportunity during the time commodities are in the price leadership position (down-phase of the RS cycle). If the opportunity exists, it is essential we examine how investors could incorporate agricultural commodity and agribusiness indexes into their portfolios, when they also have access to broad market indexes. An empirical analysis of this argument is provided in the next section.

### Return-Risk Analysis

Given that we are currently in the down-phase of the current RS cycle, we would expect that investors would seek to invest in agribusiness and/or agriculturally-related commodity indexes even if they have the option of investing in broad market indexes. To answer these questions, we examine the optimal asset allocations among indexes across four different periods: 2006 quarter two (Q2)–2011 quarter one (Q1), 2006 Q2–2007 Q4, 2008 Q1–2011 Q1, and 2009 Q3–2011 Q1. The first period covers the entire period for which we have data and starts in Q2 2006 and ends in Q1 2011. The second period examines the market conditions prior to the reduction in economic activity in 2008 (the National Bureau of Economic Research stated that the recession in the United States began in December 2007); the third period examines from the recession forward; and finally the last

period analyzed eliminates the recession from the analysis. These various periods of analysis allow us to explore how changes in market conditions influence optimal portfolio allocations when an investor has access to agricultural indexes and/or commodity indexes as well as broad market indexes.

To conduct this analysis we utilize the following methods: linear programming, MOTAD (Minimization of Total Absolute Deviations), and Target MOTAD models. Since linear programming does not assume any risk criteria on the part of the investor, it may lead to suboptimal solutions when investors are risk-averse, which is why we utilize MOTAD and Target MOTAD models (Dorward, 2001; Gali and Brown, 2000; Moschini and Hennessy, 2001; Peng and Bosch, 2001; Qiu, Prato, and McCamley, 2001; Qiu, Prato, and Prato, 1998; Skelton and Turvey, 1994; Teague, Bernardo, and Mapp, 1995). A MOTAD model is designed to replace the mean-variance decision criteria, which assumes the decision maker's utility being quadratic if returns follow a non-normal distribution (Hazell, 1971). A Target MOTAD model is a modified MOTAD model whose key advantage is that it does not require a specific functional form for the decision maker's utility (Tauer, 1983). Furthermore, the solutions to the Target MOTAD model satisfy the second-order stochastic dominance criteria when used to develop optimal portfolio allocations for risk-averse investors. If we assume all investors are risk-averse, then these investors will always prefer a second-order stochastically dominant portfolio to dominated ones. Hence, the solutions for the Target MOTAD model are in accordance with the decision criteria for risk-averse investors. Moreover, if there are multiple solutions in a MOTAD or Target MOTAD model, we can sort the solutions from the most-risk-averse to the least-risk-averse based upon the values of the lambda parameter.

For this analysis, we assume that an investor has \$100 to invest in the first quarter for each of the four periods that we examine, which is held constant across all methods used to determine optimal portfolio allocations. The first step in constructing the quarterly data for each index is to keep the last day value of a month

for each index to represent the monthly value of the index. To do this, we utilize the adjusted closing values from our data sources. Finally, we take the average of the monthly values for the corresponding quarterly value. A return on the indexes is computed as the value of the current value minus the lag one value, divided by the lag one value.

Let  $x_j$  be the amount of money out of \$100 allocated for index  $j$ ,  $c_{ij}$  be the return on index  $j$  in quarter  $t$ ,  $\bar{c}_j$  be the mean of  $c_{ij}$  that is in the data period,  $y_t$  be the negative deviations,  $p_t$  be the probability of the realization of the set of returns on the indexes in quarter  $t$  occurring (we set an equal weighting among the quarters in each of the four data periods),  $\lambda$  be a constant, parameterized from zero to a very large number for the MOTAD model, and  $\lambda'$  be also a constant, parameterized from a very large number to zero in the Target MOTAD model. The formulation for the linear programming model is given by:

$$(1) \quad \begin{aligned} \max_{x_j} E(z) &= \sum_{j=1}^{12} \bar{c}_j x_j \\ \text{subject to} \quad &\sum_{j=1}^{12} x_j \leq 100. \end{aligned}$$

The formulation for the MOTAD Model is:

$$(2) \quad \begin{aligned} \max_{x_j} E(z) &= \sum_{j=1}^{12} \bar{c}_j x_j \\ \text{subject to} \quad &\sum_{j=1}^{12} x_j \leq 100, \\ &\sum_{j=1}^{12} c_{ij} - (c_j) x_j + y_t \geq 0 \quad (\text{for all } t), \\ &\text{and} \quad \sum_{t=1}^{\# \text{ of Quarters}} p_t y_t = \lambda, \\ &\text{where } \lambda = 0 \rightarrow \text{Very Large Number.} \end{aligned}$$

When utilizing the MOTAD model, risk-averse decision makers will prefer solutions with smaller values for  $\lambda$ . For the Target MOTAD models, we impose a set of restrictions so that the allocations to the investment choices yield non-negative profits in each quarter. The Target MOTAD Model is given by:

$$\begin{aligned}
 \max_{x_j} E(z) &= \sum_{j=1}^{12} \bar{c}_j x_j \\
 \text{subject to } &\sum_{j=1}^{12} x_j \leq 100, \\
 (3) \quad &\sum_{j=1}^{12} c_{tj} x_j + y_t \geq 0 \quad (\text{for all } t), \\
 \text{and } &\sum_{t=1}^{\# \text{ of Quarters}} p_t y_t = \lambda', \\
 &\text{where } \lambda' = \text{Very Large Number} \rightarrow 0.
 \end{aligned}$$

For the Target MOTAD model as with the MOTAD model, risk-averse decision makers prefer solutions with large values for  $\lambda'$ . Large values for  $\lambda'$  translate into small values for  $\lambda$ .

#### Target MOTAD and MOTAD Data

The indexes utilized include 11 publicly traded indexes (the Dow Jones Industrial Average Index (DJIA), the NASDAQ Composite Index, the S&P 500 Index (S&P500), the Russell 2000 Index (RTY), the AMEX Composite Index (AMEX), the S&P Global Agribusiness Composite Index (S&PGAC), the S&P Global Agribusiness Index (S&PGA), the S&P Goldman Sachs Commodity Index (S&PGSCI), Dow Jones-UBS Commodity Index (DJUBSCI), the Rogers International Commodity Index (RICI), and the Thomson Reuters/Jefferies CRB Index (TRJCRB)) and one non-publicly traded agricultural index by Kramer and Schnitkey (2011), which is referred to as Kramer and Schnitkey's Agricultural Index (KS). The DJIA, NASDAQ, S&P500, RTY, and AMEX represent broad market indexes, that is, indexes that may contain representation from all industries. The remaining seven indexes are indexes that are directly linked to agribusinesses and/or agricultural commodities.

The daily return data needed for each of these indexes were obtained from a variety of sources. First, daily data for the DJIA, NASDAQ, S&P500, RTY, and AMEX are obtained from Yahoo Finance. Daily data for the S&PGAC and the S&PGA are retrieved from Standard and Poor's. Bloomberg provides daily data for S&PGSCI and DJUBSCI. RICI and CRB daily data are obtained from Rogers

International and Wharton Research Data Services, respectively. The daily data for the KS agricultural index are constructed according to the indexer's specification, using data from Yahoo Finance (Kramer and Schnitkey, 2011).

#### Target MOTAD and MOTAD Results

The performance of the 12 indexes (the 11 publicly traded indexes and the non-traded KS Ag Index) are shown in Table 1; this table contains the quarterly rates of returns over the entire sample period, as well as the sample means for each of the four periods. First, for the overall period (2006 Q2–2011 Q1), the S&PGA has the fewest number of quarters in which returns are negative: three (2008 Q3, 2008 Q4, and 2010 Q2). The most striking result from the dataset is that the two pure agribusiness indexes (S&PGA and KS) have fewer quarters of negative returns than all of the broad market indexes (KS and AMEX both have five quarters of negative returns). An interesting result occurs during the fourth quarter of 2008, the severest part of the recent financial crisis. In that quarter, the returns to the commodity-related and agricultural indexes are worse than returns to the non-thematic broad market indexes. This poor performance for the commodity-related indexes began in the third quarter of 2008 and continued through the first quarter of 2009, when oil prices began to decline. A similar pattern is observed for the second quarter of 2010, when oil prices began their downward trend in the last half of the first quarter of 2010.

Sample means for each of the periods suggest that agribusiness and/or commodity related indexes tend to perform at least as well as, if not better than, the general stock indexes. For the overall period (2006 Q2–2011 Q1), commodity-related index returns (returns between 4% and 5%) tend to perform well compared with broad industry index returns (returns of around 1%). For the pre-crash period (2006 Q2–2007 Q4), the S&PGA (9.4%) and the KS Agricultural Index (8.4%) outperformed the rest of the commodity-related indexes, which outperformed the broad industry indexes. For the period including the crash (2008 Q1–2011 Q1),

**Table 1.** Quarterly Rates of Return per Dollar of Investment from 2006 Q2 – 2011 Q1

Year	Quarter	DJIA	NASDAQ	S&P500	RTY	AMEX	S&PGAC	S&PGA	S&PGSCI	DJUBSCI	RICI	TRJCRB	KS
2006	2	0.022	(0.037)	(0.001)	(0.008)	0.039	0.012	0.049	0.093	0.051	0.059	0.035	0.055
2006	3	0.017	(0.021)	0.017	(0.029)	0.006	(0.008)	0.009	(0.029)	(0.036)	(0.037)	(0.054)	(0.020)
2006	4	0.074	0.104	0.072	0.090	0.032	0.079	0.079	(0.047)	0.001	(0.023)	(0.051)	0.077
2007	1	0.013	0.012	0.016	0.023	0.053	0.047	0.106	0.013	(0.001)	(0.005)	(0.004)	0.099
2007	2	0.077	0.059	0.059	0.042	0.078	0.058	0.132	0.067	0.018	0.045	0.010	0.113
2007	3	0.009	0.014	(0.013)	(0.048)	0.002	0.094	0.088	0.086	0.003	0.083	0.028	0.068
2007	4	0.002	0.042	0.010	(0.005)	0.053	0.125	0.197	0.148	0.051	0.118	0.086	0.194
2008	1	(0.083)	(0.151)	(0.104)	(0.116)	(0.072)	0.073	0.039	0.095	0.119	0.119	0.114	0.052
2008	2	(0.010)	0.041	0.008	0.032	0.016	0.032	0.108	0.211	0.073	0.108	0.107	0.114
2008	3	(0.082)	(0.061)	(0.086)	(0.009)	(0.127)	(0.154)	(0.205)	(0.118)	(0.137)	(0.115)	(0.107)	(0.166)
2008	4	(0.203)	(0.288)	(0.255)	(0.292)	(0.296)	(0.319)	(0.400)	(0.431)	(0.356)	(0.410)	(0.358)	(0.409)
2009	1	(0.158)	(0.093)	(0.148)	(0.169)	(0.027)	(0.002)	0.033	(0.133)	(0.111)	(0.126)	(0.119)	(0.095)
2009	2	0.108	0.215	0.149	0.193	0.121	0.164	0.272	0.221	0.103	0.147	0.112	0.219
2009	3	0.130	0.147	0.130	0.157	0.119	0.036	0.117	0.091	0.048	0.056	0.062	0.112
2009	4	0.074	0.057	0.059	0.020	0.035	0.068	0.076	0.116	0.091	0.089	0.079	0.088
2010	1	0.025	0.050	0.031	0.080	0.039	(0.002)	0.050	(0.000)	(0.031)	(0.026)	(0.021)	0.041
2010	2	(0.011)	0.006	(0.012)	0.041	(0.008)	(0.072)	(0.089)	(0.000)	(0.025)	(0.022)	(0.028)	(0.065)
2010	3	0.011	(0.013)	(0.004)	(0.029)	0.053	0.139	0.112	0.024	0.047	0.049	0.043	0.124
2010	4	0.078	0.137	0.100	0.148	0.096	0.159	0.141	0.128	0.130	0.133	0.133	0.196
2011	1	0.081	0.079	0.088	0.106	0.090	0.102	0.090	0.169	0.091	0.141	0.127	0.155

Sample Means for Selected Periods													
Period	DJIA	NASDAQ	S&P500	RTY	AMEX	S&PGAC	S&PGA	S&PGSCI	DJUBSCI	RICI	TRJCRB	KS	
2006 Q2–2011 Q1	0.009	0.015	0.006	0.011	0.015	0.031	0.050	0.035	0.006	0.019	0.010	0.048	
2006 Q2–2007 Q4	0.030	0.025	0.023	0.009	0.038	0.058	0.094	0.047	0.013	0.034	0.007	0.084	
2008 Q1–2011 Q1	(0.003)	0.010	(0.003)	0.012	0.003	0.017	0.026	0.029	0.003	0.011	0.011	0.028	
2009 Q3–2011 Q1	0.056	0.066	0.056	0.075	0.060	0.061	0.071	0.076	0.050	0.060	0.056	0.093	

the thematic agricultural indexes (a return of around 2.8%) outperform most of the broad market indexes (returns of 1% or less). It is worth noting that the RTY outperforms all of the other broad market indexes as well as several of the commodity-related indexes. This would imply that the RTY, a small cap index composed of 2000 companies, successfully captures sectors that are overlooked in other indexes available for investment. In the post-crash period analysis (excluding the quarters of economic downturn, 2009 Q3–2011 Q1), the thematic indexes experience higher returns when compared with the pre-crash period (2006 Q2–2007 Q4), especially for the commodity-related indexes DJUBSCI (5% versus 1.3%), RIC1 (6% versus 3.4%), and TRJCRB (5.6% versus 0.7%). This result also holds true for the non-thematic indexes. Again, RTY experiences the largest increase in returns for any of the broad market indexes (7.5% versus 1%). These results imply that some of the components in these indexes (RTY, DJUBSCI, RIC1, and TRJCRB) successfully capture segments of the economy that are growing post economic crash. This result further suggests that market conditions have changed, causing some industries, including agricultural commodities, to be better off than they were prior to the economic recession.

*Optimal Portfolio Entire Period*

Table 2 contains the solutions for each of the three models for the entire period. When reading the solution tables for the MOTAD and Target MOTAD models, models that are only applicable for risk-averse investors, the top solution corresponds to the most risk-averse investor and the bottom solution corresponds to the least risk-averse investor (the interpretation of these tables are maintained throughout the results section). The profits discussed hereafter are expected profits. First, we wish to review the optimal asset allocations for the entire period (2006 Q2–2011 Q1). As one might expect from the descriptive statistical analysis, S&PGA, which has only three quarters of negative returns, is the only investment allocation for the linear programming model, yielding a profit of

**Table 2.** Optimal Portfolio Entire Period: 2006 Q2–2011 Q1

LP Solutions												
Optimal Obj. Func.	DJIA	NASDAQ	S&P500	RTY	AMEX	S&PGAC	S&PGA	S&PGSCI	DJUBSCI	RIC1	TRJCRB	KS
1	5.02											
MOTAD Solutions												
Optimal Obj. Func.	DJIA	NASDAQ	S&P500	RTY	AMEX	S&PGAC	S&PGA	S&PGSCI	DJUBSCI	RIC1	TRJCRB	KS
1	0											
2	5.02											
Target MOTAD Solutions												
Optimal Obj. Func.	DJIA	NASDAQ	S&P500	RTY	AMEX	S&PGAC	S&PGA	S&PGSCI	DJUBSCI	RIC1	TRJCRB	KS
1	0											
2	4.96											
3	5.02											
							\$73.92					\$26.08
							100					

\$5.02. The corresponding MOTAD model offers an optimal allocation of no investment for the most risk-averse investors. The Target MOTAD model suggests risk-averse investors should have an allocation of \$73.92 for the S&P Global Agribusiness Index and \$26.08 for the KS index, yielding a profit of \$4.96.

#### *Optimal Portfolio Pre-Crash*

Optimal solutions for the pre-crash period (2006 Q2–2007 Q4) can be found in Table 3. The MOTAD solutions suggest somewhat different allocations based upon how risk-averse an investor is than both the linear programming (LP) and the Target MOTAD solutions, which suggest the S&PGA should be the sole investment allocation. An investment of \$100 would generate an expected profit of \$9.43. Of interest is the more defensive nature of the allocations obtained via the MOTAD model. Investment occurs mainly between the two thematic agricultural indexes from the S&P with some diversifications among the broad market indexes (DJIA and AMEX) and a commodity index (S&PCSCI). What is notable here is that the investment allocation is tilted away from the broad market indexes: an indication that the agricultural indexes are defensive in nature (less volatile), a result that is reinforced by the fact that they are part of the investor's portfolio irrespective of the investor's aversion to risk. Moreover, the results of the MOTAD model suggest that more diversification occurs at higher levels of risk aversion increase.

#### *Optimal Portfolio Post Crash*

Table 4 provides the solutions for the optimal allocation for the post-crash period (2008 Q1–2011 Q1). Of particular interest for this period is that we observe a shift from being a majority invested in the agricultural indexes (S&PGA) into the commodity related indexes (S&PGSCI), as the risk aversion of the investor increases. This result furthers the notion that agricultural commodities as an investment perform well when the market is in a state of decline. Furthermore and irrespective of the model, no investment allocations are suggested for the

non-thematic indexes. This likely reflects the strong impact of the recession that occurred during this period of analysis. In addition, we find that any optimal solution from any one of these model yields the smallest expected profit relative to other periods.

#### *Optimal Portfolio Post Crash Excluding Recession Quarters*

The results for the post-crash period excluding the moments of severe turmoil (2009 Q3–2011 Q1) are found in Table 5. The solution from the LP model, as well as the most risk-loving solutions from the MOTAD and the Target MOTAD, suggests an investor would allocate all \$100 to the KS Index (agricultural thematic index), yielding a profit of \$9.31. What is notable for this period is that the Target MOTAD solution for the most risk-averse investor contains the highest amount of money allocated to a non-thematic index irrespective of the period analyzed (61% of the money allocation for the RTY), yielding a profit of \$8.18. The MOTAD solution also favors non-agricultural and/or commodity indexes for risk-averse investors (AMEX). As risk aversion declines, allocation switches from the AMEX to the RTY, the SPGSCI, and KS index. These results suggest that at high levels of risk aversion an investor wants the broad market diversification associated with the AMEX but also requires access to an agricultural stock index, S&PGA, which provides exposure to agricultural companies.

#### **Summary and Conclusions**

This paper has addressed two financial issues of commodity markets in their relationship to stock markets. The first section of the analysis focused on studying the cyclical leadership between stocks and commodity markets from 1871–2010, using U.S. historical series for the S&P 500 Composite Index and the Producer Price Index for all commodities and for individual components of the PPI, namely, farm and food products, fuels, and metals. Results from this research show that over the study period, stock and commodity prices had a negative



**Table 4.** Optimal Portfolio Post Crash: 2008 Q1–2011 Q1

LP Solutions												
Optimal Obj. Func.	DJIA	NASDAQ	S&P500	RTY	AMEX	S&PGAC	S&PGA	S&PGSCI	DJUBSCI	RICI	TRJCRB	KS
1	2.88											\$100
MOTAD Solutions												
Optimal Obj. Func.	DJIA	NASDAQ	S&P500	RTY	AMEX	S&PGAC	S&PGA	S&PGSCI	DJUBSCI	RICI	TRJCRB	KS
1	0											
2	2.75						\$54.59	\$45.41				
3	2.87						5.35	94.65				
4	2.88							95.20				\$4.80
5	2.88							100				
Target MOTAD Solutions												
Optimal Obj. Func.	DJIA	NASDAQ	S&P500	RTY	AMEX	S&PGAC	S&PGA	S&PGSCI	DJUBSCI	RICI	TRJCRB	KS
1	0											
2	2.88						\$0.28	\$99.72				
3	2.88							100				





correlation ( $-0.71$ ). An examination of the relative price strength between stocks and commodities suggests that stocks and commodities in the United States have alternated in price leadership with cycles of 29–32 years (an average length about 31 years). In interpreting the increasing phase of the relative-price strength cycle as an indicator of periods when stocks outperform commodities, one conclusion is that such phases last about 15 years.

Price performances in stocks and commodities have been dominated by commodities over the past decade (a down-phase in the RS cycle that started in 2000). The dominant conclusion from the cyclical results is that price dominance in agricultural commodity markets should expire in the next few years, under the assumption that the cyclical pattern identified in this analysis will repeat as it has over the past 140 years. This result appears to be robust for farm, food, energy, and metal markets. The rise in commodity prices experienced from 2000 to mid-2008 and their return to that trajectory post-financial crisis in the United States clearly signals a renewed appetite for commodities as financial assets. Thus, the findings here suggest that such dynamics will change in the next few years. The agricultural community, and financial interest at large, will benefit from research that sheds more light on the factors causing the interplay between stocks and commodities.

Numerous refereed and popular press articles have been written recently about the determinants of agricultural and mineral commodity markets (Frankel and Rose, 2010). As they point out, the fundamental factors driving real commodity prices (besides global output and inflation) include volatility, inventories, and the spot-forward spread. Clearly, inflation, the national debt in the United States and other countries, exchange rates, the demand for commodities in emerging market economies, and the increasing interest in bio-energy production deserve closer examination. Commodity price dynamics resulting from these changing factors, along with changes in supply and demand in emerging markets, will determine trends in commodity prices and their turn in leadership with stocks. Future analyses on the impact of such factors on business cycles will have

immediate relevance to the super cyclical interplay between stocks and commodities of relevance to this research. A better understanding of these price dynamics should continue to be a fruitful area of future research. Likewise, future research on alternative investment cycles should complement the results reported in this study.

Since the profitability of agriculture is linked to the pricing performance of agricultural commodities, and perhaps as importantly, to the financial capital flowing into commodity markets, the second section of the paper addressed the role of agribusiness and agriculturally-related commodity indexes in a risk-averse investor's portfolio since the second quarter of 2006. The findings in the first section, which highlight the price dominance of agricultural commodities, point to agribusiness and agriculturally-related commodity indexes' ability to play a major role in a risk-averse investor's portfolio. Results of the analysis, irrespective of the period analyzed, show that investors would prefer investments in agribusiness indexes and/or agriculturally-related commodity indexes. Of particular interest, the period that eliminates the recession from the analysis (2009 Q3–2011 Q1), shows the highest investment in the commodity indexes, a result consistent with stock-commodity cycle analysis conducted in the first part of the paper. Moreover the results support previous research which suggests that agribusiness stocks and commodities are more defensive in nature (less volatile in turbulent market times), as the investment allocation is tilted away from the broad market indexes.

Future research would seek to construct long-term indexes of various agricultural stocks and compare their performance to that of alternative investments. One could easily see taking these indexes and then incorporating them into a farm operator's portfolio of investment decisions. Given that farm operators are seeking to add value to their operation by expanding up- and/or downstream, one-way to do this is by owning a financial asset. Moreover, future research in this area should seek to explore which segments of the agricultural sector are enhancing the defensive nature of investment in agricultural and/or commodity related indexes. One might wonder if the current thematic

indexes are truly representative of the entire U.S. agricultural sector or if they are overlooking sectors of agribusiness stocks that are less susceptible to price variability and more defensive in nature given their business focus. Paraphrasing Gorton and Rouwenhorst (2006), the “facts and fantasies about commodity futures” markets will change in the next few years, based on their empirical price history. Consequently, future research examining the role of commodities and agribusiness as part of investment portfolios should shed better light on this golden age of commodity prices.

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