Mixed Ag: *A Regime-Based Analysis of Multi-Asset Agriculture Portfolios*

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KEY FINDINGS

- Global population and economic development trends support an increase in demand for agricultural commodities in the coming years.
- A dedicated multi-asset agricultural strategy composed of agribusiness stocks and agricultural commodity futures can serve as a diversifying strategy in portfolios containing broad exposure to stocks and investment-grade bonds in regimes of both high and low economic growth.
- A multi-asset agricultural strategy is also found to produce an attractive upside/downside return profile relative to broad equity and its agricultural equity and futures components across high and low growth regimes. It also exhibits a significantly higher mean upside return relative to investment-grade bonds across both regimes.

ABSTRACT: *For some time now, the prospect that the world is entering a new epoch of elevated prices for agricultural commodities has been a focus of both policymakers concerned with the food security of their citizens and investors looking to benefit from a potential secular uptrend in the demand for food. Investors most commonly access agriculture in public markets through funds that invest in agricultural commodity futures or the common stock of companies that engage in agribusiness. In general, funds that invest in agricultural commodities are either dedicated equity or futures managers. However, there are potentially significant performance benefits to investing in agricultural commodities through a single multi-asset vehicle composed of both agricultural commodity futures and agribusiness stocks. To that end, in this article the author examines the performance of a multi-asset agriculture portfolio in periods of high and low economic growth and compares it with the performance of its individual equity and futures components, as well as the broader stock market and investment-grade bonds. The author finds that in terms of return generation, risk mitigation, and diversification potential relative to core stocks and bonds, the multi-asset agriculture strategy makes a compelling case for inclusion alongside traditional strategies within institutional investors' portfolios.*

TOPICS: ***Portfolio management/multi-asset allocation, performance measurement****

In recent years, the projected and real growth in the world's population, especially in emerging markets, and intermittent spikes in the prices of agricultural commodities have renewed investor focus on food trends and their implications for global markets. Indeed, there is evidence that longer-term trends in the supply and

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demand dynamics of agricultural commodities and products point to the potential for a sustained increase in price levels for both raw and processed agricultural goods. These trends by no means indicate that the world is destined to become a dystopia marked by extreme food scarcity. Nevertheless, increasing global demand for food, feed, fuel, and fiber must be met while taking into account the growing resource constraints (land, water, nutrients) and environmental pressures (soil degradation, deforestation, climate change) facing the planet. Global demographic and macroeconomic trends thus signal that in the coming years, capital investments in all areas related to agricultural production could provide significant opportunities for investors.

Most investors who wish to invest in agriculture have two avenues to do so. The first is through the futures market, where investors can gain direct exposure to individual commodities. The second is through the common stock of companies engaged in agribusiness. Although both commodities futures and agribusiness stocks are connected to the global commodity trade, they are not commonly included together in a dedicated strategy. Rather, commodities futures are generally considered the terrain of specialized commodity managers such as commodity trading advisors, whereas agribusiness stocks typically fall under the purview of equity managers. In this article, the author investigates the behavior of a multi-asset agricultural portfolio through high and low growth regimes and evaluates its structure, performance, and potential diversification benefits for investors.[1]

AG FOR THE LONG RUN

Global population and income dynamics, especially in the developing world, point to increased demand for the majority of agricultural commodities.[2] In particular, both population growth and economic development will likely exert pressure on the world's food supply. Population growth in the developing world is expected to average approximately 2% per annum (p.a.) over the next decade, whereas the BRIC economies (Brazil, Russia, India, China) are anticipated to grow at an annual rate of 2% to 5% over the same period.[3]

In turn, as the populations of developing countries begin to raise their standards of living, they are expected to consume higher value-added foodstuffs such as meat and dairy. Consider that, by 2021, the products projected to experience the highest increase in consumption over the prior ten years are poultry meat (37.2%), sugar (32.5%), vegetable oils (32.1%), and dairy products such as butter (33.4%), cheese (27.8%), and skim milk powder (40.6%). World meat trade overall, comprising beef, pork, poultry, and sheep meat shipments, is expected to post a 1.5% p.a. increase over the last decade as a result of the increased demand from developing countries and firmer demand in developed countries.[4] As a result of expansion in domestic livestock industries and animal inventories, indirect consumption of inputs such as oilseed meals and coarse grains will likely similarly increase as well.

As these structural demographic changes take hold, they will likely exacerbate the relatively high structural volatility already present in agricultural markets. This volatility, driven by unexpected and unpredictable shocks in the context of agricultural market supply and demand, is explained by three fundamental characteristics of agricultural markets:

- Agricultural output varies from period to period as a result of natural shocks such as weather and pests.
- The combined nature of small-demand elasticities with respect to price and similarly low short-run supply elasticities generally induces prices to vary significantly to shift supply and demand back into equilibrium after a supply shock. This becomes even more pronounced if stocks are low.
- Because of the considerable production time in agriculture, supply is unable to flexibly respond to price changes in the short term. The resulting lagged supply response to any price changes can cause cyclical adjustments, adding an extra degree of variability to the markets in question.

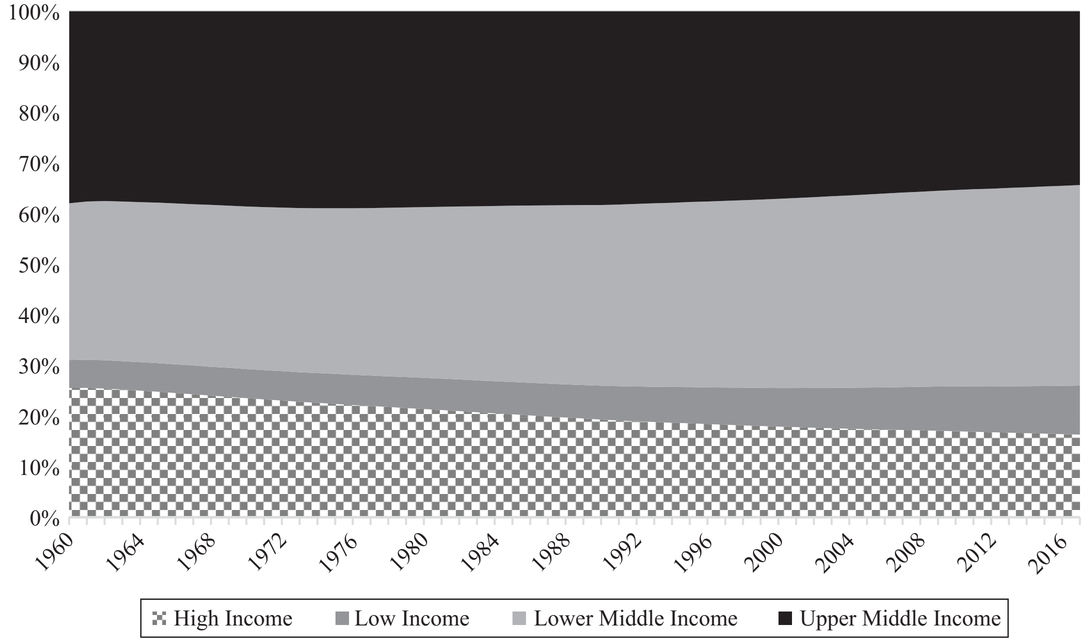
[1] The investment benefits of individual commodities have of course been investigated for many years. See for example, Greer (1978), Erb and Harvey (2006), and Gorton and Rouwenhorst (2006).

[2] For further reading on the topics in this section of the article, see Godfray et al. (2010) and Food and Agricultural Organization of the United Nations (2019).

[3] Sources: OECD; The World Bank; author's own calculations.

[4] Food and Agricultural Organization of the United Nations (FAO); author's own calculations.

Exhibit 1
Global Population Trends



Sources: The World Bank; author's own calculations.

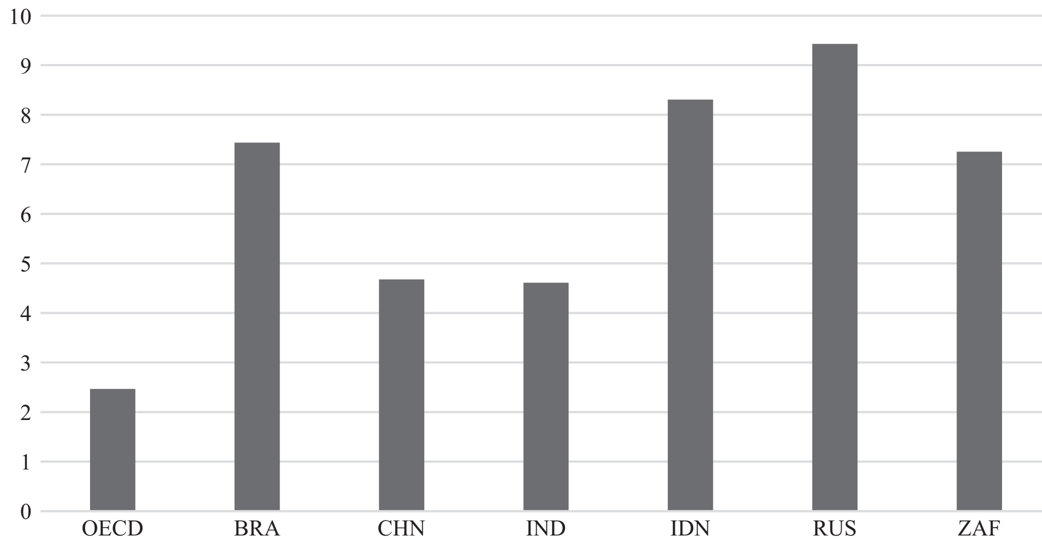
Directly connected to the supply and demand characteristics of agricultural commodities, are demographic and macroeconomic trends that will likely compound the volatility of agricultural markets, underscoring a structural case for investment in the asset class.

The most basic global driver of the consumption of agricultural products is population growth. Simply put, the more people there are, the more food needed. The world's population has grown steadily over the past 50 years and is projected to grow 35% to reach more than 9 billion people by 2050.[5] This absolute increase in the number of human beings merits a consideration of the potentially significant impact it will have on global food demand. But the story of population growth is not simply one of numbers. If we look at the structure of population growth in Exhibit 1, we find that the share of the world's population composed of residents from developed nations is declining, whereas the share of less developed and least developed nations is increasing. This is an important phenomenon because, as countries develop, they typically begin consuming more proteins and dairy. If global population growth is to be increasingly driven by growth in developing nations, then the composition of global food demand will likely include a greater demand for higher value-added products, such as meat, milk and milk-products.

The idea that population growth could have the potential to exert significant upward pressure on the demand for food is not new. As early as 1798, Thomas Malthus argued that population growth would increase at a rate surpassing the rate at which the food supply would grow, eventually leading to widespread poverty and famine (Malthus 1798). However, Malthus' original prediction did not come to bear, as advancements in technology during the 19th and early 20th century provided the means by which agricultural yields increased to a level sufficient to meet the world's food needs. Going forward, whether comparable gains in yields will occur is an open question, given that the majority of gains from the use of improved machinery and fertilizer may be behind us. According to the Organisation for Economic Co-operation and Development (OECD), population growth has driven an overall upward price trend across

[5] Sources: United Nations Department of Economic and Social Affairs, Population Division; author's own calculations.

EXHIBIT 2
Average Rate of Food Inflation in Emerging Economies, 2001–2018



Sources: OECD; author's own calculations. BRA = Brazil, CHN = China, IND = India, IDN = Indonesia, RUS = Russia, ZAF = South Africa.

the commodity complex during the last decade, and this is projected to continue. The trend is especially pronounced in emerging markets, as Exhibit 2 shows.

An examination of average annual food price inflation rates for OECD and developing countries over the past decade indicates that they have been both higher and more volatile in the developing world than in the OECD area. Reflecting both the greater weight of basic foodstuffs in the consumer food basket, as well as high rates of inflation in the prices of inputs such as labor, developing countries are subject to far greater food price variation than their more developed counterparts.[6]

Turning to the production of specific commodities, it is expected that global cereals will experience the largest slowdown in production. Cereal production is expected to drop to 1.1% p.a. during the ten year period ending in 2021, down from 2.5% p.a. in the previous decade. A slowdown in both yield growth and arable land expansion is expected to be responsible for the deceleration in the pace of cereal output increase. World production of coarse grains and rice is projected to grow slightly more rapidly at 1.4% and 1.2% p.a., respectively, than global wheat production at 0.9% p.a.[7]

The recent declines in annual growth yields witnessed for every major food crop category are perhaps the starkest representations of this trend, and they are only expected to worsen going forward. Reductions in the yield gap, or the difference between average farm yield and estimated yield, hold the key to maintaining price stability for agricultural commodities. It estimated that reducing the yield gap by 20% in developing countries would have a significant impact on the prices of several commodity groups, including a nearly 45% decrease in the price of rice and nearly a 20% decline in the price of wheat.[8]

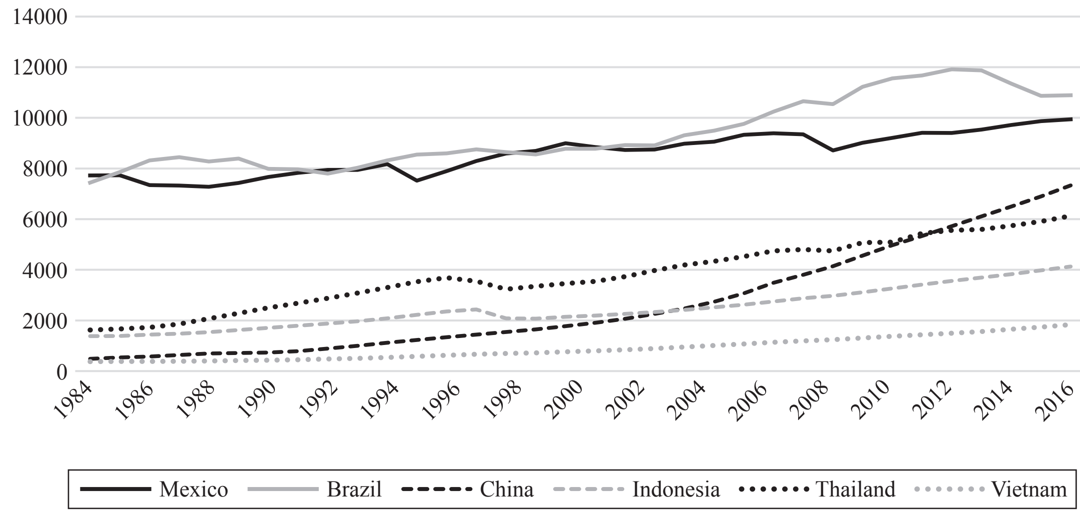
Although global population growth by itself represents a significant added source of demand for agricultural products, it is not simply population growth exerting pressure on global food supplies, but the particular character of population growth—population growth accompanied

[6] We note that even though it remains above 25% for many developing countries, the share of household budgets allocated to food expenditures has declined over recent decades. For instance, a number of African and South Asian countries have experienced significant decreases in food expenditure shares, often from over 50% to approximately 30% to 35%. Food price increases in countries where a large share of income is devoted to food expenditures imply reallocation of expenditure to food from other goods and services, such as education, health, and transport, all of which are needed for economic growth. Sources: The World Bank; FAO; author's own calculations.

[7] Sources: OECD; author's own calculations.

[8] Sources: OECD; author's own calculations.

EXHIBIT 3
Per Capita GDP Growth of Emerging Market Countries



Sources: The World Bank; author's own calculations.

by economic growth in the developing world. Over the next decade, baseline projections call for OECD countries' share of world agricultural trade to decline, positioning the developing world to claim a more influential role in agricultural markets. In Exhibit 3 we can observe the pace at which emerging market per capita GDP has accelerated during the last few decades.

To meet the anticipated increase in food demand described in the previous section, new sources of food supply will have to be found. Perhaps the most obvious way to stimulate agricultural production is to expand the area on which crops are cultivated. However, as seen in Exhibit 4, the rate of global urbanization has accelerated in recent decades, with the population residing in cities surpassing that residing in rural areas for the first time in 2007, a situation projected to become only more pronounced as time passes. As a result, the amount of arable land available to be put to productive agricultural use is becoming increasingly restricted.

Furthermore, the regions where the amount of available arable land is growing are also the lowest-income regions in the world. Although the potential to expand the territory on which crops are cultivated exists, sizable investments are required to develop viable farmland in these regions. In addition to the challenge of finding an adequate supply of arable land, in recent years, mounting global water scarcity has become an additional source of pressure on crop production through conventional means.[9] The two go hand in hand because the capacity to increase arable land is closely linked to available water supplies. At present, agriculture accounts for approximately 70% of global water usage, but both the absolute amount of water available for agriculture and its utilization are expected to decline; by 2050, global water usage in agriculture will fall to approximately 40%.[10]

The availability of freshwater resources shows a picture similar to that of land availability, with sufficient resources at the global level being unevenly distributed. An increasing number of countries, particularly in the Near Eastern, North African, and South Asian regions, lack land resources, exacerbating their struggles with near-critical levels of water scarcity. Global desertification and climate change are affecting, and will continue to affect, a significant portion of the world's population. According to the level of desertification tension by zone, it is estimated that about 7 million km^2 of land is at low risk of human-induced desertification, 9 million km^2 at moderate risk, 16 million km^2 at high risk, and 12 million km^2 at very high risk.[11] The water scarcity accompanying these levels of desertification places

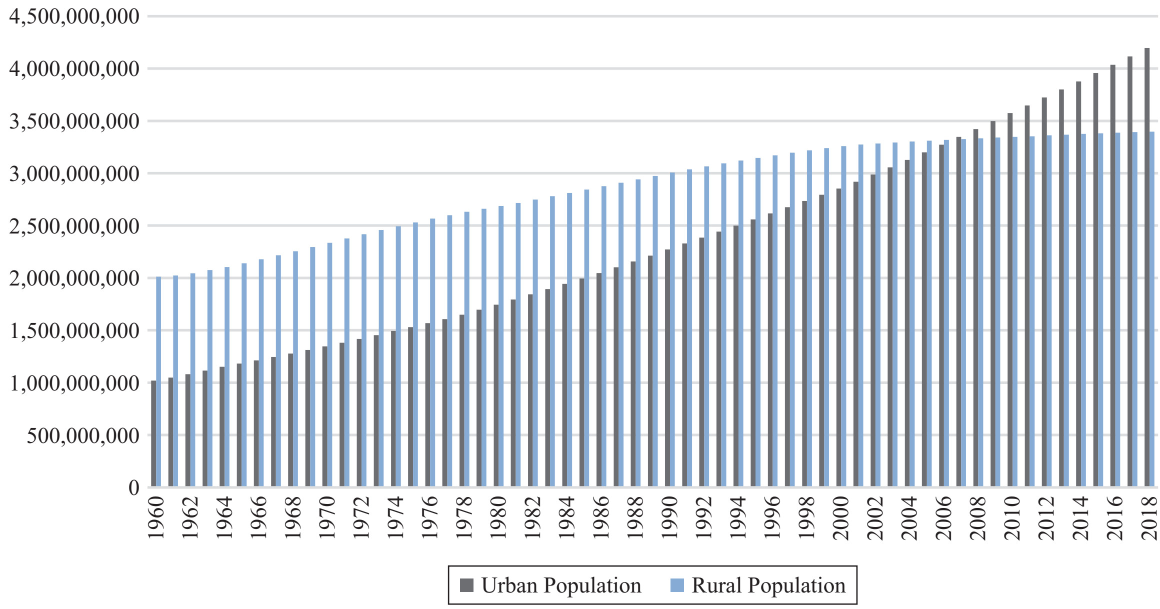
[9] See Chartres and Varma (2010) for an accessible overview of the various dimensions of global water scarcity.

[10] Sources: OECD; author's own calculations.

[11] Source: Author's own calculations.

EXHIBIT 4

Global Urban and Rural Population Mix Over Time



Sources: The World Bank; author's own calculations.

limits on the extent to which irrigation can be expanded. Moreover, the amount of water available for agricultural use has been on a generally declining trend during the last decade. Of greatest concern is the lack of improvement in water usage efficiency in crop production during the last 15 years, underscoring the importance of technological developments in maintaining necessary production levels. In Exhibit 5 we see that water usage efficiency in the post-2000 period has been about the same level as it was in the early 1980s.

In the 20th century, increases in food demand caused by population growth were typically addressed by developing new technologies and methods to improve the scale and quality—and thereby the supply—of agricultural production. The so-called green revolution started in Mexico by Norman Borlaug resulted in the development of many new and improved strains of crops and the increased use of hydrocarbon-based fertilizers and pesticides.[12] These developments had a revolutionary impact on global food production. Although it is quite possible that another wave of revolutionary technological advancement may induce another spurt of agricultural productivity, such a development is not a certainty. As of now, the evidence speaks in favor of future supply challenges for agricultural commodities.

REGIME FRAMEWORK

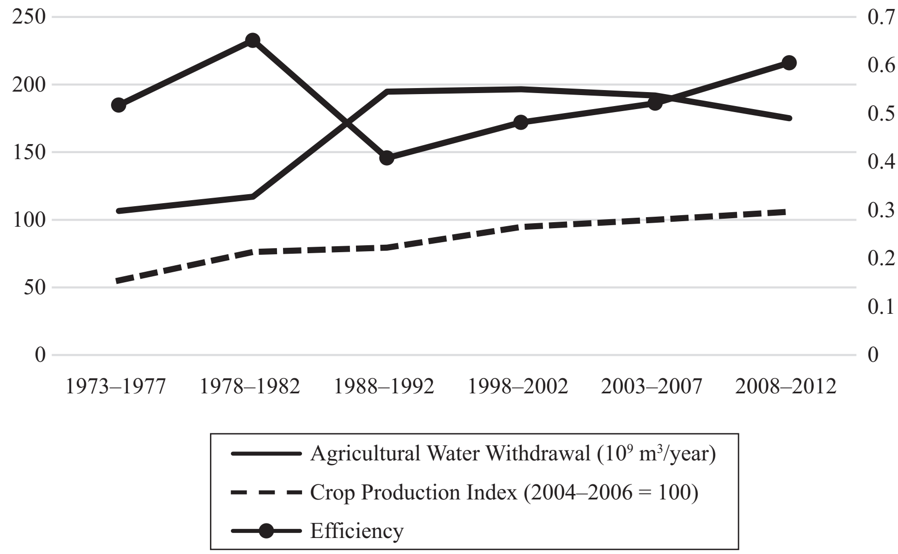
We evaluate the performance of our hypothetical multi-asset agriculture strategy across economic regimes characterized by high and low macroeconomic growth. We implement our regime classification using Filardo's (1994) extension to Hamilton's (1989) well-known regime-switching model.[13] Filardo follows Hamilton in setting up his model as an autoregressive process:

[12] See Hesser (2006) for an overview of Borlaug's work.

[13] We note that the use of a regime-switching framework in the present study is intended to provide an ordered way of demarcating economic and market history in order to uncover asset and portfolio performance in discrete economic states, not as a way to forecast regimes or build a trading strategy based on such forecasts. Traditional regime-switching models have a relatively poor track record as forecasting tools and, in our view, do not serve as the ideal foundation from which to build a trading strategy. See Simonian and Wu (2019b) for a literature review of regime-switching models and an alternative, trading-oriented regime-switching model based on spectral clustering.

E X H I B I T 5

Water Usage Efficiency



Sources: OECD; author's own calculations.

$$y_t = \mu_{S_t} + \phi_1(y_{t-1} - \mu_{S_{t-1}}) + \phi_2(y_{t-2} - \mu_{S_{t-2}}) \quad (1)$$

where y_t is an economic variable, μ_{S_t} is the intercept, s_t is a regime process, and ϕ is the autocorrelation with random shocks $\varepsilon_t \sim N(0, \sigma^2)$. Period-to-period transitions from one regime to another are expressed thus:

$$P(S_t = s_t \mid S_{t-1} = s_{t-1}) = \begin{bmatrix} p_{00,t} & p_{10,t} \\ p_{01,t} & p_{11,t} \end{bmatrix} \quad (2)$$

However, Filardo extended Hamilton's model by also allowing for exogenous regressors to influence transition probabilities:

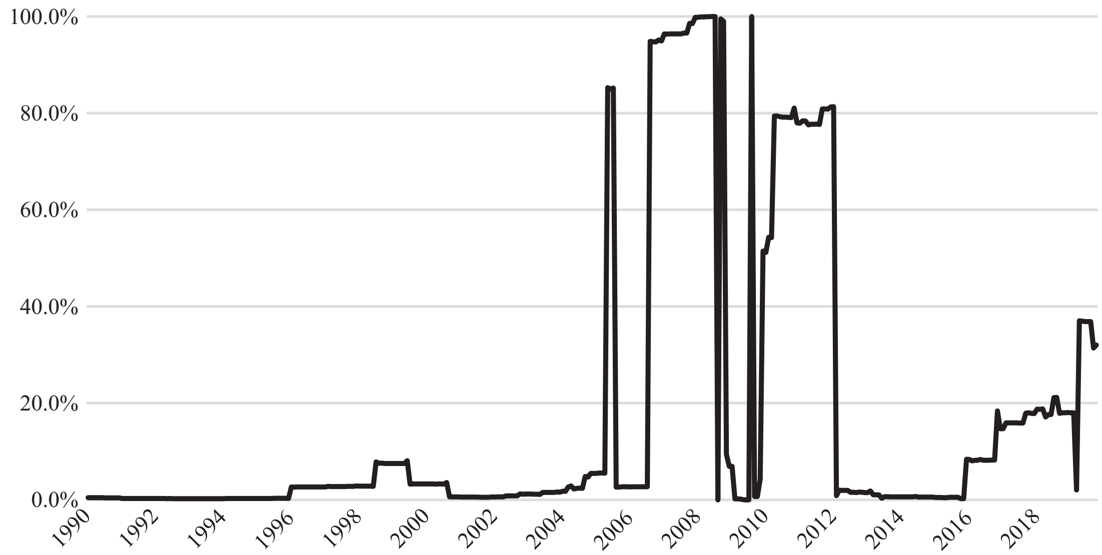
$$p_{i,j,t} = \frac{\exp\left\{x'_{t-1}\beta_{i,j}\right\}}{1 + \exp\left\{x'_{t-1}\beta_{i,j}\right\}} \quad (3)$$

where $p_{i,j,t}$ is the probability of transitioning from regime i to regime j in period t. In our implementation, we use industrial production as our endogenous regressor and the effective federal funds rate as our exogenous regressor to generate a classification of high and low states of economic growth.[14] Monetary policy is of course an important driver of economic expansions and contractions, and its impact on asset prices has been the subject of theorizing and model building in economics and finance for decades. Indeed, the term *monetary transmission mechanism* (MTM) describes the various economic and financial channels through which monetary policy affects capital markets and the economy at large.[15] Industrial production is no exception, of course, and is in fact highly sensitive to movements in interest rates, as well as consumer demand. As such, the dynamics of industrial production are intimately connected to the demand for both raw and processed agricultural commodities. In Exhibit 6 we show the regime classification generated by our model over the measurement period.

[14] Industrial Production Index, Change from Year Ago, Index 2012 = 100, Monthly, Seasonally Adjusted; Effective Federal Funds Rate, Percent, Monthly, Not Seasonally Adjusted. Source: Federal Reserve Bank of St. Louis.

[15] See Mishkin (1996, 2001) for an overview of the major transmission channels and the basic theory that describes their mechanics. Much of the academic research on the MTM has focused on analyzing empirical evidence to determine the extent to which the data under consideration support one or more channels as genuine transmission mechanisms and to what degree (See e.g., Bernanke and Gertler 1995; Taylor 1995).

EXHIBIT 6
Probability of Low-Growth Regime



CASE STUDY

Our case study analyzes the performance of a hypothetical equally weighted portfolio consisting of the common stock of six agribusiness companies (ADM, TSN, DE, GIS, CAG, HRL)[16] and six agricultural commodities (soybeans, corn, wheat, sugar, live cattle, lean hogs).[17] We choose to use a simple equal weighting to discover whether the combination of agricultural stocks and futures provides any basic structural investment value. Our findings in this article obviously do not preclude the application of more sophisticated portfolio optimization or trading methodologies to the asset mix considered here. The particular stocks used in the portfolio have been chosen so that the portfolio has exposure to various agribusiness sectors and for their long and contiguous time series. Agribusiness has been marked by a high degree of merger and acquisition activity over the years, and it is a challenge to find representative companies that have been in their present form for a sufficient amount of time to be suitable for time-series analysis. Moreover, some of the largest agribusiness companies are privately held and are thus also excluded from consideration for time-series analysis. Our sample data span the period from February 1990 through November 2019. The test period contains three bull and two bear equity markets, as well as cyclical periods of both rising and falling US investment-grade bond yields.

Our first observation is that our hypothetical multi-asset agriculture portfolio possesses a high degree of diversification at the intra-portfolio level and has the potential to provide diversification in relation to traditional stocks and bonds, which we proxy with the S&P 500 Index and a diversified basket of investment-grade corporate bonds respectively.[18] In Exhibit 7 we show the regime-specific correlation matrices of our portfolio constituents. As the exhibit shows, the constituents of the portfolio are relatively uncorrelated with one another across both regimes. This can be seen by the low average correlation value for each asset, listed on the far right of each matrix.

Turning to the performance of our multi-asset portfolio and its constituents, in Exhibit 8 we show both regime-specific performance (Panels A and B) and

[16] The listed tickers are for Archer-Daniels Midland Company, Tyson Foods Incorporated, Deere & Company, General Mills Incorporated, Conagra Brands Incorporated, and Hormel Foods Corporation, respectively. Source: NYSE.

[17] Source: Chicago Board of Trade.

[18] ICE BofAML US Corp Master Total Return Index Value, Index, Monthly, Not Seasonally Adjusted. Source: Federal Reserve Bank of St. Louis.

EXHIBIT 7

Asset Correlations in High- and Low-Growth Regimes (February 1990–November 2019)

	ADM	TSN	DE	GIS	CAG	HRL	Soybeans	Corn	Wheat	Sugar	Cattle	Hogs	SP500	IG Corp	Average ρ
Panel A: Low-Growth Regime															
ADM	1.00	0.32	0.32	0.22	0.15	0.27	0.08	–0.01	0.13	–0.13	0.13	–0.06	0.41	0.02	0.15
TSN	0.32	1.00	0.28	0.10	0.28	0.29	–0.05	–0.08	0.10	–0.06	–0.04	0.15	0.33	–0.14	0.13
DE	0.32	0.28	1.00	0.12	0.21	–0.07	0.28	0.23	0.28	0.17	0.04	–0.09	0.57	–0.01	0.20
GIS	0.22	0.10	0.12	1.00	0.43	0.37	0.13	–0.16	–0.05	–0.03	–0.04	0.08	0.33	–0.08	0.13
CAG	0.15	0.28	0.21	0.43	1.00	0.19	0.03	–0.08	–0.03	–0.03	–0.04	0.16	0.27	–0.10	0.13
HRL	0.27	0.29	–0.07	0.37	0.19	1.00	–0.05	–0.21	0.04	–0.15	–0.04	0.10	0.14	0.11	0.07
Soybeans	0.08	–0.05	0.28	0.13	0.03	–0.05	1.00	0.71	0.45	–0.05	–0.19	0.07	0.13	0.07	0.13
Corn	–0.01	–0.08	0.23	–0.16	–0.08	–0.21	0.71	1.00	0.63	–0.19	–0.25	–0.07	–0.02	–0.02	0.04
Wheat	0.13	0.10	0.28	–0.05	–0.03	0.04	0.45	0.63	1.00	–0.05	0.10	–0.01	0.14	0.07	0.14
Sugar	–0.13	–0.06	0.17	–0.03	–0.03	–0.15	–0.05	–0.19	–0.05	1.00	0.18	0.06	0.08	0.26	–0.02
Cattle	0.13	–0.04	0.04	–0.04	–0.04	–0.04	–0.19	–0.25	0.10	0.18	1.00	0.01	0.13	0.32	0.00
Hogs	–0.06	0.15	–0.09	0.08	0.16	0.10	0.07	–0.07	–0.01	0.06	0.01	1.00	0.08	0.01	0.04
SP500	0.41	0.33	0.57	0.33	0.27	0.14	0.13	–0.02	0.14	0.08	0.13	0.08	1.00	–0.16	0.22
IG Corp	0.02	–0.14	–0.01	–0.08	–0.10	0.11	0.07	–0.02	0.07	0.26	0.32	0.01	–0.16	1.00	0.03
Panel B: High-Growth Regime															
ADM	1.00	0.13	0.25	0.21	0.25	0.21	0.03	0.12	0.11	0.11	0.04	–0.02	0.31	0.02	0.15
TSN	0.13	1.00	0.28	0.15	0.39	0.44	0.06	0.09	0.01	–0.11	0.02	0.10	0.36	0.03	0.16
DE	0.25	0.28	1.00	0.04	0.28	0.18	0.35	0.33	0.24	0.03	0.16	0.16	0.54	0.00	0.24
GIS	0.21	0.15	0.04	1.00	0.43	0.27	–0.03	0.08	0.04	0.04	0.09	–0.03	0.27	0.04	0.13
CAG	0.25	0.39	0.28	0.43	1.00	0.38	0.09	0.16	0.14	0.05	0.07	–0.01	0.39	0.04	0.22
HRL	0.21	0.44	0.18	0.27	0.38	1.00	0.01	0.11	0.15	0.13	0.07	0.06	0.31	0.05	0.19
Soybeans	0.03	0.06	0.35	–0.03	0.09	0.01	1.00	0.62	0.44	0.14	0.10	0.01	0.22	–0.01	0.17
Corn	0.12	0.09	0.33	0.08	0.16	0.11	0.62	1.00	0.57	0.16	0.06	0.03	0.21	0.04	0.21
Wheat	0.11	0.01	0.24	0.04	0.14	0.15	0.44	0.57	1.00	0.13	0.01	0.05	0.16	0.06	0.17
Sugar	0.11	–0.11	0.03	0.04	0.05	0.13	0.14	0.16	0.13	1.00	–0.01	–0.06	0.04	–0.08	0.05
Cattle	0.04	0.02	0.16	0.09	0.07	0.07	0.10	0.06	0.01	–0.01	1.00	0.12	0.09	0.17	0.07
Hogs	–0.02	0.10	0.16	–0.03	–0.01	0.06	0.01	0.03	0.05	–0.06	0.12	1.00	0.05	0.03	0.04
SP500	0.31	0.36	0.54	0.27	0.39	0.31	0.22	0.21	0.16	0.04	0.09	0.05	1.00	–0.02	0.24
IG Corp	0.02	0.03	0.00	0.04	0.04	0.05	–0.01	0.04	0.06	–0.08	0.17	0.03	–0.02	1.00	0.03

longer-term buy-and-hold performance (Panel C).[19] For our regime-specific results, we show upside and downside returns, with upside return defined as the mean return above 0% and downside return defined as the mean return below that threshold. In the high-growth regime, we see that although the multi-asset portfolio gives up some upside return relative to its equity and commodity components and the broad equity market, it provides significantly improved performance on the downside. In the low-growth regime, the multi-asset portfolio produces upside return comparable to the broad equity market but with significantly improved downside return. Although it produces less upside return relative to its equity and commodity components, it provides better downside protection. Perhaps expectedly, in both high and low growth regimes, the multi-asset portfolio provides less downside protection relative to investment-grade bonds but compensates with a considerably higher level of upside return.

When we examine the longer-term buy-and-hold performance of the multi-asset portfolio, it looks even stronger when compared to its equity and commodity components, the broad equity market, and investment-grade corporate bonds. It provides a return comparable to or higher than its equity and commodity compo-

[19] Buy-and-hold portfolios are rebalanced to an equal weighting at a quarterly frequency.

Exhibit 8

Regime-Specific and Buy-and-Hold Performance

Panel A: Regime-Specific Performance (February 1990–November 2019)—Individual Assets

	ADM	TSN	DE	GIS	CAG	HRL	Soybeans	Corn	Wheat	Sugar	Cattle	Hogs	SP500	IG Corp
Mean Upside Return: High Growth	6.46%	7.50%	6.71%	4.48%	5.16%	4.86%	5.30%	6.20%	6.54%	8.17%	3.91%	8.07%	3.22%	1.18%
Mean Downside Return: High Growth	–5.23%	–6.54%	–6.30%	–4.09%	–5.82%	–4.74%	–4.47%	–5.27%	–6.06%	–6.76%	–3.24%	–7.85%	–3.53%	–0.85%
Mean Upside Return: Low Growth	5.50%	6.39%	6.70%	3.29%	5.34%	4.11%	5.95%	7.98%	10.95%	7.50%	4.29%	8.70%	2.30%	0.98%
Mean Downside Return: Low Growth	–7.48%	–7.15%	–5.33%	–3.85%	–3.37%	–4.40%	–7.86%	–6.66%	–6.62%	–6.22%	–4.25%	–9.59%	–3.27%	–0.71%

Panel B: Regime-Specific Performance (February 1990–November 2019)—Portfolios

	Multi-Asset Portfolio	Equal-Weight Agribusiness Stock Portfolio	Equal-Weight Commodity Portfolio	SP500	IG Corp
Mean Upside Return: High Growth	2.86%	3.55%	3.22%	3.22%	1.18%
Mean Downside Return: High Growth	–2.42%	–3.50%	–2.82%	–3.53%	–0.85%
Mean Upside Return: Low Growth	2.80%	3.17%	3.63%	2.30%	0.98%
Mean Downside Return: Low Growth	–2.34%	–3.15%	–3.15%	–3.27%	–0.71%

Panel C: Buy-and-Hold Performance (February 1990–November 2019)

	Multi-Asset Portfolio	Equal-Weight Agribusiness Stock Portfolio	Equal-Weight Agricultural Commodity Portfolio	SP500	IG Corp
Buy-and-Hold Annualized Return	8.9%	9.3%	4.1%	7.8%	6.9%
Buy-and-Hold Annualized Standard Deviation	12.2%	15.4%	15.0%	14.2%	4.4%

nents and the broad equity market, while providing significantly higher return relative to investment-grade corporate bonds. Moreover, it exhibits lower volatility relative to its equity and commodity components and the S&P 500 over the measurement period.

CONCLUSION

Global population growth and rising incomes in the developing world have potentially set the stage for a marked acceleration in food prices in the coming decades. As nations advance along the path of development, their populations will transition to higher value-added diets, not only increasing demand for foodstuffs such as meat and dairy products but also exerting pressure on the inputs critical to the cultivation of livestock, such as grains. In the past, advancements in technology played a significant role in meeting the world's food needs, but it is unclear whether investment in food science and technology will pay the same productivity dividends it has in the past. Given these potentialities, agriculture may be poised to become a significant investment opportunity. In this article, the author analyzed the performance of a dedicated multi-asset agricultural portfolio consisting of agribusiness stocks and agricultural commodity futures in periods of high and low economic growth. The multi-asset portfolio was found to possess a high degree of intra-portfolio diversification and showed itself to be a diversifier for broad equity and bond exposure, in both high and low growth regimes. Furthermore, the multi-asset portfolio provided a positively asymmetric upside/downside return profile in absolute terms and relative to the broad equity market and the portfolio's equity and commodity components. Taken together, the foregoing points make a convincing case for the inclusion of multi-asset agriculture strategies in institutional investors' portfolios.

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ADDITIONAL READING

Great Expectations: *A Tactical Asset Allocation Framework for Diversified Real Asset Portfolios*
Joseph Simonian and Chenwei Wu
The Journal of Portfolio Management
https://jpm.pm-research.com/content/45/2/38

ABSTRACT: *Diversified real return strategies are multi-asset portfolios structured to possess a heightened sensitivity to inflation relative to traditional stocks and bonds. The majority of such strategies focus on a single measure of inflation, the Consumer Price Index. However, a more comprehensive way to construct inflation-sensitive portfolios is in terms of expected and unexpected inflation, the latter defined as the difference between a particular measure of inflation expectations and realized inflation. To that end, in this article, the authors describe an investment framework that dynamically classifies each type of inflation as belonging to one type of state: a stable state, in which inflation continues its longer-term trend, and a deviant state, in which expected or unexpected inflation departs significantly from its longer-term average. The authors show how the framework can be used to build portfolios using information from both stable and deviant states to outperform realized inflation through different market environments.*

Minsky vs. Machine: ***New Foundations for Quant-Macro Investing***

Joseph Simonian and Chenwei Wu

The Journal of Financial Data Science

https://jfds.pm-research.com/content/1/2/94

ABSTRACT: *Systematic macro investors' use of the regime-switching models that have been developed in academia over the last several decades is infrequent at best and, when used, generally tangential to their core investment process. The roots of this less-than-enthusiastic uptake can be found in two familiar sources: models that possess an overly complex formal structure and poor predictive ability. As a remedy to the current state of affairs, the authors present a new foundation for regime-based investing, one based on spectral clustering, a graph theoretic approach to classifying data. Drawing inspiration from the work of Hyman Minsky and John Geanakoplos, the authors present a macro framework that uses measures of growth, inflation, and leverage to define regimes and drive portfolio decisions. To the latter end, the authors show how the framework can be used to build portfolios using information about regimes as defined, to outperform a no-information equal-weight portfolio both out-of-sample and in bootstrapped and cross-validated simulations. The authors thus show that spectral clustering can provide both an elegant mathematical description of the leverage cycle and a robust foundation for quant-macro investing.*