Macro/Thematic Report

Malthus's Peak

Recent grain price increases are structural, not cyclical **March 24, 2008**

Investment Conclusions

- *Food Price Inflation will persist*
- *Water Shortages will constrain food production growth*
- *Protein Prices must increase*
- *Farm Land Prices will continue to climb*
- *Farm Incomes will increase*
- *Low Income Emerging Markets will benefit*

Research Analyst:
Nathan Weiss
nweiss@uniteconomics.com
(617) 763-4415

Executive Summary

Thomas Malthus, a British economist, noted in 1798 that populations grow exponentially while food production grows arithmetically. He predicted that food production would eventually become a constraint on population growth. Most market participants focus on Hubbert's peak, but perhaps investors should be worrying about Malthus's peak!

The media is quick to blame ethanol production for the rapid appreciation in soft commodity prices. In reality, global demand for grains has outstripped supply for the past ten years, leaving current inventories at thirty-year lows.

Historically, the main driver of global food demand has been global population growth. Today, global income growth is the primary driver of grain demand. From 2000 to 2005, global per capita income rose from $5,251 to $7,016. As populations prosper worldwide, average calorie consumption per capita increases. In addition, the consequent shift in consumer diets from basic grains to meats and vegetable oils further strains grain demand.

Total world grain area harvested actually peaked in 1981 and has since declined by over eight percent. Grain yields per acre have made up for the declines in grain areas, but there are signs that yield growth is slowing. Examining crop yield data over the last seventy years, it is apparent that the widespread adoption of irrigation is responsible for a large part of the yield growth. Currently forty percent of the world's food supply is grown on irrigated farmland. China grows fifty two percent of their food on irrigated land. The struggle to improve yields will intensify as aquifers are depleted and rivers are polluted or run dry.

The main investment conclusion of this research is that food inflation is likely to persist as agricultural production struggles to keep pace with demand in coming years. Unit Economics will publish several research reports in coming weeks that will build on this secular story, while generating alpha from stock-specific ideas.

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The rocketing price of grain, from corn to rice, have sparked riots and triggered the introduction of price controls around the globe. Last year saw protests in Mexico over the price of tortillas, demonstrations in Italy over high pasta prices and riots over food cost inflation in Jakarta. In Pakistan, soldiers now guard grain stores and other governments, such as China and Russia, have introduced price controls. Global wheat inventories have reached a thirty-year low and inventories in the European Union have plummeted from 14 mln metric tons to 1 mln metric tons in the past year! Surprisingly, these shortages are occurring amid strong increases in harvests globally. The USDA estimates that global wheat production in 2007 increased 2% from 2006, while global coarse grain (73% of which is corn) production increased over 7% in 2007.

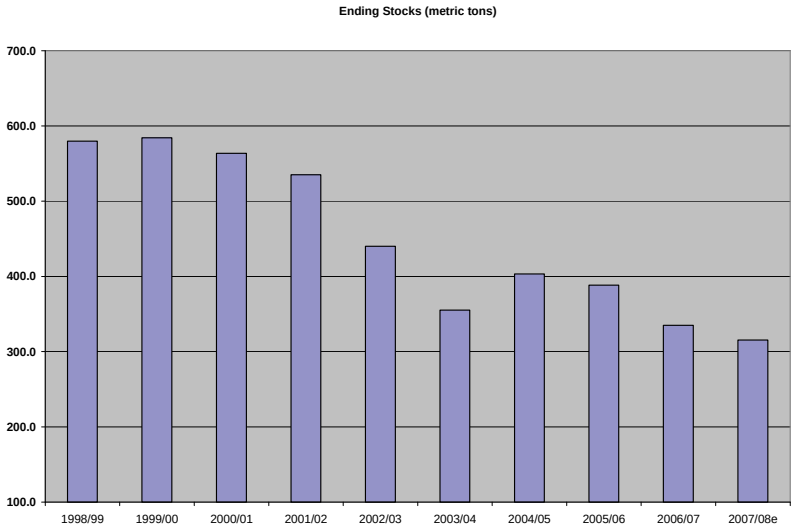
While many investors are quick to blame ethanol production for the rapid appreciation in soft commodity prices, citing that U.S. ethanol production will consume 20% of the domestic corn crop in 2008 (the US produces 38% of the total corn crop globally), this is not the case. Wheat prices, for example, have nearly doubled in the past twelve months. Wheat is of little use in the production of biofuels. Wheat production has dipped from 621.46 mln metric tons in 2005/06 to an estimated 604.960 mln metric tons in 2007/2008. Global ending inventories have fallen, from 147.80 mln metric tons at the end of the 2005/06 season, to an estimated 110.10 mln metric tons at the end of the 2007/08 season – a decline of 37.70 mln metric tons over two years. This annual decline of 18.85 mln metric tons is a shortfall equal to 3.12% of annual global production!

Looking at the inventory and production data of wheat prior to the ethanol/biofuel era, we can see that wheat inventories fell from 207.90 mln metric tons in 1998/99 to 132.40 mln metric tons at the end of the 2003/04 growing season. This decline in inventories of 15.10 mln metric tons per year, over the five-year period, is not significantly different from the inventory declines seen over the prior two 'post-biofuel' growing seasons. It does not look as if ethanol and biofuel production is to blame for recent wheat price increases.

An examination of coarse grain (primarily corn) data reveals that total coarse grain production globally has grown from 977.34 mln metric tons in 2005/06 to an estimated 1,056 mln metric tons in 2007/08: a total increase of 8.05%. Global ending inventories have fallen from 163.70 mln metric tons at the end of the 2005/06 season to an estimated 110.10 mln at the end of the 2007/08 season – a decline of 53.60 mln metric tons over two years. This annual decline of 26.80 mln metric tons is a shortfall equal to 2.54% of annual global coarse grain production.

The longer-term, 'pre-biofuel' inventory and production data for coarse grains tells a similar story as the data for wheat. Global coarse grain inventories fell from 237.50 mln metric tons at the end of the 1998/99 season to 140.30 mln metric tons in 2003/04. When we calculate the annual decline rate in global coarse grain inventories from 1998/99 to 2003/04, we find the annual decline rate during this period to be 19.44 mln metric tons. Although this is somewhat less significant than the decline rate of 26.80 mln tons in the 'post-biofuel' period, a significant supply/demand imbalance extends back over ten years from today. The conclusion is that, while ethanol/biofuel production has perhaps accelerated and even amplified the global grain shortage, the production shortfall was evident long before Al Gore became a celebrity.

Before moving on to the causes of, and likely responses to, the global grain supply/demand imbalance, for completeness we will briefly examine the third category of grains: rice markets. Total global milled rice production in the 2005/06 season was 417.64 mln metric tons. The current projections for the 2007/08 season are 422.94 mln metric tons, a total increase of 1.27% over two years. Global milled rice inventories fell from 76.80 mln metric tons at the end of the 2005/06 season to an estimated 72.20 mln metric tons at the end of the 2007/08 season. This is an annual decline of 2.10 mln metric tons, or .49% of global production. From the end of the 1998/99 season to the end of the 2003/04 season, milled rice inventories fell by an average annual 10.40 mln metric tons – 2.46% of 2007/08 global production. The following chart shows the total ending stocks for all grains over the prior ten-year period:



Economic Growth as a Driver of Grain Consumption

Historically, population growth has driven food demand. The current global population is estimated by the World Bank Group to have grown from 6.1 bln people in 2000 to 6.4 bln in 2005: a 1.2% annual growth rate. This growth rate has been steady for many years, allowing global farm productivity to keep up with population growth.

Today, global income growth is the primary driver of agricultural product demand. From 2000 to 2005, global per capita income rose from $5,251 to $7,016 according to data from the World Bank Group. This is a stunning 6.1% annual growth rate! While it is well known that income growth leads to incremental demand for discretionary consumer goods - such as automobiles and washing machines - there are crucial changes in an individual's diet that are often overlooked.

The USDA reported the findings of a study of global food consumption and the effects of rising incomes in the February 2008 edition of *AmberWaves*, available on their website. They found that caloric intake per capita increases with Gross National Income per capita. The following table summarizes their conclusions:

Annual GNI/Capita:	<$580	$581-$5,625	>$5,626
Avg Calories per Day:	2,618	3,000	3,348

We can estimate that - in addition to the 1.2% annual population expansion over five years - rising global incomes have elevated the world's per capita calorie demand 3% - 4%. Combining the calorie demand from population growth over this period with the increased calorie consumption due to income growth, we arrive at a total estimated calorie annual demand growth of 4.7%. The income effects, however, do not stop there. According to the USDA, meat contributes just 4% of total calories in low-income countries (those with under $580 in annual per capita GNI); between 7% and 11% in lower and upper middle-income countries ($581-$5,625 annual per capita GNI); and 13% in high-income countries (over $5,625 annual per capita GNI). If we make some educated assumptions, meat as a percentage of total calories likely rose from 10% of global diets in 2000 to 11.5% in 2005. While estimates vary, using a conservative 5:1 conversion rate for cereal grain calories to meat calories, the slight 1.5% shift in global caloric intake from cereal grains to meat results in an 8.94% increase in cereal grain consumption: a 1.69% annual increase! The following USDA table illustrates this point - keeping in mind that China, which represents 20% of the world's population, increased meat consumption by 20.4% in total over this period:

Beef: Per Capita Consumption Summary Selected Countries
Kilograms Per Person

	2003	2004	2005	2006	2007 (p)	2008 (f)
Beef						
Argentina	62.7	64.4	62.0	63.9	65.9	63.8
Australia	40.9	38.7	37.8	36.9	37.0	36.9
Brazil	34.5	34.9	36.5	37.0	37.3	37.6
Canada	32.9	31.5	32.9	32.8	32.6	30.7
China, Peoples Republic of	4.9	5.2	5.4	5.6	5.9	6.0
European Union 1/	17.7	17.7	17.6	17.6	17.5	17.4
Egypt	7.6	8.3	9.4	9.6	8.2	0.9
Hong Kong	15.4	14.9	15.8	16.0	16.3	17.0
India 2/	1.4	1.5	1.5	1.5	1.6	1.6
Japan	10.6	9.2	9.3	9.1	9.5	9.6
Korea, South	12.8	9.7	9.1	10.2	10.5	10.9
Mexico	22.2	22.4	22.7	23.3	23.3	23.3
New Zealand	39.7	34.1	33.7	38.5	38.1	37.1
Russian Federation	16.2	15.7	17.1	16.3	16.8	17.2
South Africa	13.9	15.0	15.8	16.9	15.8	16.1
Taiwan	4.7	3.8	4.4	4.7	4.7	4.7
Turkey	9.4	9.2	9.0	8.8	8.6	8.6
Ukraine	8.5	10.7	11.2	10.1	9.0	7.8
United States	42.5	43.2	42.8	43.1	42.6	41.7
Uruguay	49.7	56.5	55.6	53.6	56.0	54.3

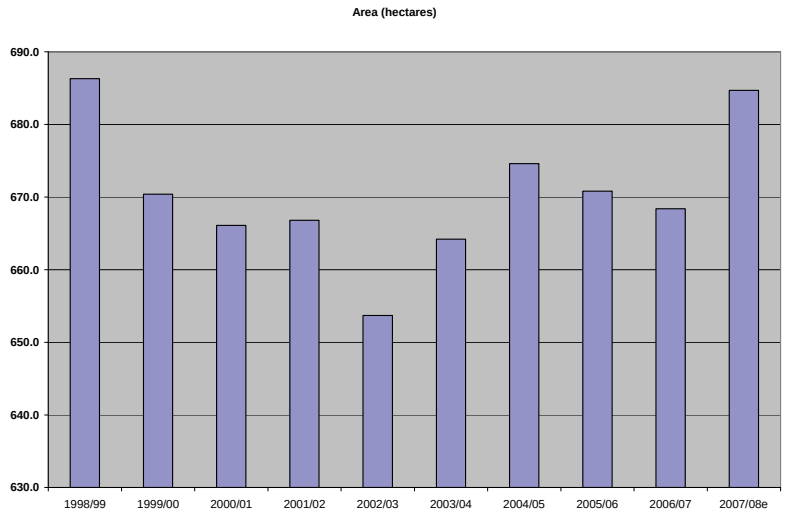
Sources: USDA -FAS attache reports, official statistics, and results of office research. Population statistics from U.S. Census Bureau, Population Division, International Programs Center.

Total grain demand likely surged 23.84% between 2000 and 2005, or 4.37% per year. This upsurge represents the net effect of population growth, added to increases in total calorie intake and meat consumption - both the result of rising global income. This growth rate ignores the fact that rising incomes increase demand for other superior economic goods, such as vegetable oil, milk and butter; which require even more grain, both for animal feed and for vegetable oil production. According to the USDA: "Explosive growth in Chinese demand for vegetable oils, attributed to changing consumer preferences as incomes rise, is causing both soybean and vegetable oil imports to surge to record levels as the market attempts to balance amid rising prices." The actual estimated annual growth in global grain consumption from 2001 to 2006 was 4.9%.

Farmed Acreage

In 1798, British economist Thomas Malthus observed that population grows exponentially while food production grows arithmetically until it reaches some upper limit dictated by the amount of arable land. He predicted food production would eventually become a constraint on population growth. While most market participants obsess over Hubbert's Peak, perhaps we should be worrying about Malthus's peak!

The total world grain area harvested actually peaked in 1981 and by 2006 had declined over 8.0%. More important, despite recent increases in grain prices, there has been no 'supply response' in total acres harvested. From December 31, 2005 to December 31, 2006 corn prices increased 85% and wheat prices increased by 49%; yet the total global grain area harvested actually FELL by .36% according to the USDA. Given the massive run-up in commodity prices through 2007, it is equally interesting to note: the USDA expects the total global area harvested in the 2007/08 season to climb by only 2.43%, a figure that many see as very aggressive. The following table shows the total global hectares devoted to grains over the past ten years:



Given the noise in the data it is difficult to determine if the acreage increase in the 2007/2008 season is sustainable (assuming estimates prove to be accurate). The better question is: does it matter?

Grain Yields

The average annual increase in grain yields has varied by decade, with a high of 3.1% in the 1960s to a low of 1.4% in the 1990s. The increased use of irrigation, chemicals, fertilizer and electronic technology have boosted yields in past years. While some doomsday scientists insist developed nations have reached the technological limits of grain yields, history generally tells us otherwise. The lower yield growth rates of the 1990s, however, are likely the most representative indicator of future yield growth rates. Given that global populations are growing by 1.2% annually, the day of Malthus's predictions that population growth will be limited by food production may be at hand. Recall from the above industry data: globally we already consume 3.12% more coarse grains per year than we produce and 2.54% more wheat than we produce.

In a world with no further economic growth, over the course of three years the supply and demand for grains will come back into balance. As we noted earlier, given recent economic growth rates, grain demand is likely rising in excess of 4% per year. To balance grain supply and demand over the next five years, given the current production shortfalls, global harvested grain acres need to rise by almost exactly 4% per year, assuming a 1.4% annual increase in yields.

Historical data indicates this type of growth rate is impossible. Remember that despite the pre-season grain price spikes (wheat prices are up nearly 100% YOY), the global increase in harvested grain acres is expected to be 2.4%. To maintain a 4% annual growth rate for five years would require a 21.6% total increase in global harvested land over five years! This amount of land is clearly not available. In addition, there are some significant barriers to increased crop production, particularly the availability of water.

Water, Water Everywhere

It is estimated that 40% of the world's food supply is grown on irrigated farmland. This 40% of production occurs on only 19% of total cropland. It would seem yields and productivity have grown so strongly over the past fifty years because irrigation has become much more prevalent. While hard data on productivity and irrigation statistics are unavailable, we do know that large-scale irrigation was first introduced in the 1940s. In the past seventy years, global grain yields have increased by an average of 2.3% per year, according to USDA estimates. This means food production on a constant amount of land in 2008 would have been 4.91X the production on the same land in 1938. If 40% of current food production is grown on the 19% of irrigated land, then irrigated land is, on average, roughly twice as productive as non-irrigated land. If we remove the production growth attributable to irrigation in our simple model, 2008 grain production goes from 4.91X 1938 levels to 3.92X. In other words: without irrigation, grain yields would have increased by 1.97% per year instead of 2.3%. Could the recent drop in yield improvements in the last ten years be a sign of water becoming a scarce commodity? What if the amount of water available for irrigation fell (or was reduced by government mandate)?

In China, 52% of their food supply is grown on irrigated land. In Egypt and the Middle East, virtually all of their food is grown on irrigated land. Globally, irrigation accounts for 69% of water withdrawn and 87% of all water consumed by humans.

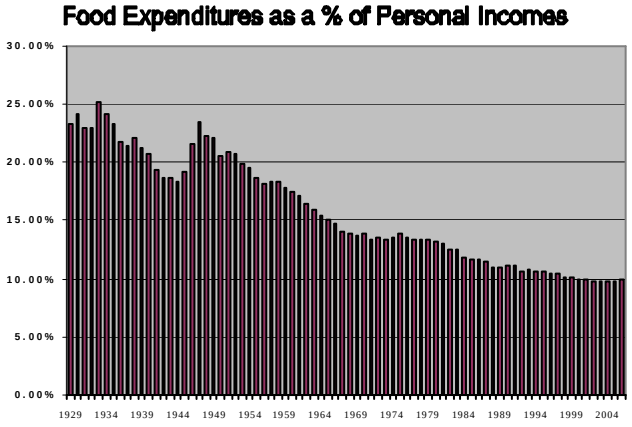
The largest aquifer in the United States, the Ogallala Aquifer, lies beneath parts of eight midwestern states. It provides 20% of the water used for irrigation nationally. The depth of the water level generally ranges from 50 to 300 feet below the land surface, making it an ideal and convenient source of fresh water. Since widespread irrigation was implemented in the 1940s, water levels have declined by more than 100 feet. Today the average saturated thickness is 200 feet. In the 1980s and 1990s, the rate of depletion of the water saturated thickness averaged 2.7 feet per year. In total 5.5 mln hectares are irrigated with water from the Ogallala Aquifer today. By 2020 the amount of land irrigated by the aquifer is predicted to drop 20%. To put this into perspective, the United States in total has 20.6 mln hectares dedicated to wheat production.

In China, the Yellow River has been a major source of water for centuries. In 1972, for the first time, the water from the Yellow River did not reach the sea for fifteen days. As populations and farming have grown, dry periods have lengthened. In 1997, water failed to reach the sea for 226 days and now often does not reach the Shandong Province, the source of 17% of China's grain production. Of the remaining rivers, 80% are estimated to be too low and/or too polluted to support fish life. In a study conducted by the Geological Environmental Monitoring Institute in Beijing, it was reported that under the Hebei Province in the middle of the North China Plain, the average level of deep aquifer water was falling nearly 10 feet per year.

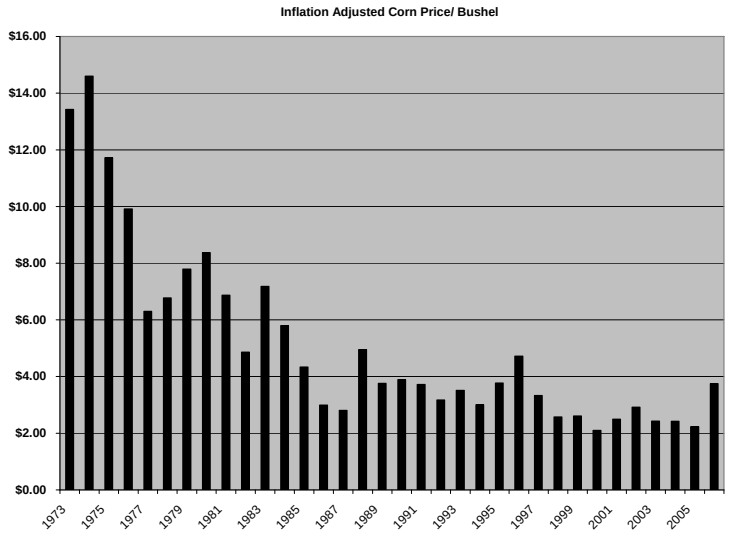
Investment Conclusions

Food Price Inflation Is Here to Stay

Clearly food expenditures as a percentage of personal incomes in Western economies will rise in coming years, reversing the downtrend of the past seventy years. The following table shows food expenditures as a percentage of personal incomes in the United States from 1929 to 2006:



How high food prices must go to cut off demand is anyone's guess. One interesting statistic from the Canada's *StarPhoenix* newspaper is that from 1961 to 1970 the price of crude was static at $1.80 per bbl and wheat, on avg, was $1.58 a bushel. Today, wheat is worth less than a tenth the value of a barrel of crude. The following chart shows the inflation-adjusted corn price from 1973 to 2007:



In a rising commodity price environment, a company with greater exposure to the appreciating commodity is better able to pass along the price increases to their customers. Recent examples include the airline industry or the tire industry, where major (25%+) portions of COGS are commodity costs. Companies with less direct exposures, such as retail stores, often see intense pricing competition as marginal volumes and economics drive short-term behavior. We expect low-end restaurants and food retailers will fare quite poorly in the next few years due to commodity price inflation.

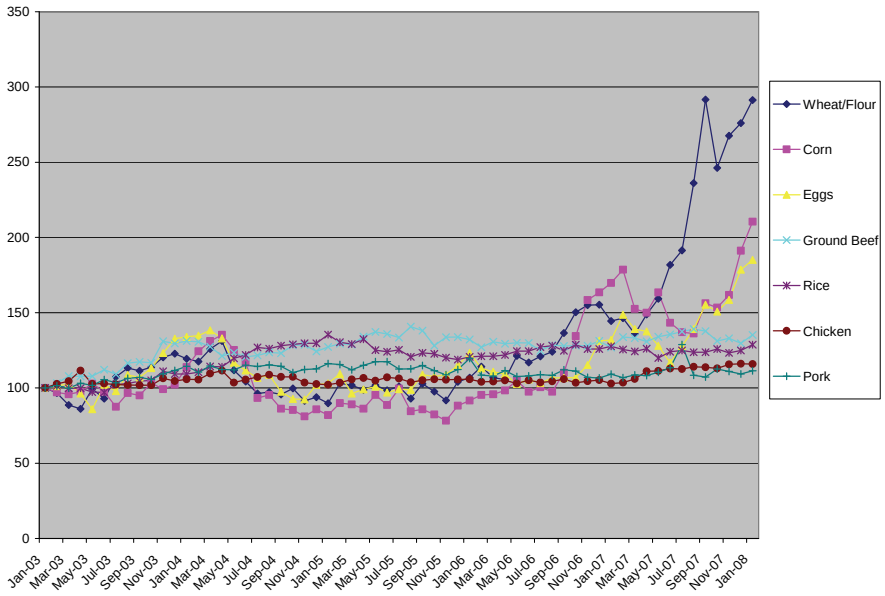
Water Shortages Will Constrain Food Production

Many investors appreciate the current water shortages, but only think of it in terms of water infrastructure and drinking water for urban areas. In reality, 87% of all water consumed and 69% of all water withdrawn is used for irrigation. The true draught will not be under Los Angeles, but rather Burlington, Colorado. Investments in hydroponics (which uses only 5% of the water needed for traditional agriculture) and companies focused on increasing irrigation efficiencies will be very interesting.

Protein Prices Will Increase

Protein production will provide numerous investment opportunities, both long and short. Feed costs are currently inflicting a dramatic squeeze on most protein producers. Already we are witnessing curtailments in beef and chicken production. Pilgrim's Pride recently exited the turkey business entirely and announced it will close a chicken processing facility and 6 of their 13 distribution centers "in response to the crisis facing the U.S. chicken industry from soaring feed-ingredient costs resulting from corn-based ethanol production."

While feed prices for animals have soared, prices of animal proteins in general have hardly moved. This trend is starting to change, however. The following chart shows the change in price of various grains versus the change in price of animal proteins since January 2003:



Farm Land Prices and Farm Incomes will Increase

As economic rents go, so go asset prices. In 2005 Iowa State University determined that the average farmland value in the state of Iowa was $2,914 per acre. Recent estimates have valued the same farmland at around $5,000 per acre. If grain prices stay at current levels, up 2.6X from 2005 levels, on average, land prices should increase to $7,576 per acre. These estimates are based on revenues per acre. More likely, profits per acre will increase by a greater amount, driving land prices above revenue-based estimates.

Low Income Emerging Markets Will Ultimately Benefit

The implications for Third World countries of a new, permanently higher price floor for grain prices are fascinating. A hypothetical African farmer cultivating half an acre of corn with hand tools, at a meager yield of 50 bushels an acre, can generate a $100 corn crop at $2.00 a bushel. At the current price of $6.00 a bushel, that figure jumps to $300.

In the 1990s South Africa generated, on average, 7% of their GDP from the agriculture sector. Cereals and grains accounted for more than 60% of the acres under cultivation. The recent tripling of corn prices should, theoretically, add some 12.6% to local GDP – a large and likely permanent addition. The risk will be the governments' ability to deal with the initial food cost inflation and to keep the economy functioning during the distress that this will create. Though local demand in emerging economies will likely be an incredible investment theme going forward, the risk to local economies and political structures from rapid food price inflation will require investors to pay close attention to the geopolitical situation.

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