The Future Global Food Situation and Its Financial Implications for US Agriculture: Is This Time Different?

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Once – maybe twice – in every generation, the global economy witnesses a protracted and widespread commodity boom. And in each boom, the common perception is that the world is quickly running out of key materials.

David Jacks, 2013, p. 2

Farmers as a result of a long process of natural economic selection acquire a genius for getting into debt at the wrong time. Those who have the genius for getting into debt at the right time, i.e. the entrepreneurial geniuses, tend to leave agriculture where the opportunities for unusual entrepreneurial activity are not very great, and devote themselves to trading of one sort or another. Consequently those who are left tend to be those whose contribution to society lies in the transformation of physical rather than of financial assets, and they are, not unnaturally, characterized by a certain financial naivety. In particular, there is a strong tendency to project current situations too far into the future: hence at the peak of the price cycle land values are inflated and farmers borrow to acquire farms at these inflated prices, only to lose their equity when the price cycle reaches its lower levels.

Kenneth Boulding, 1947 p. 445.

Prologue

In the early 1980s the Farm Credit System (FCS) began a major strategic review, Project 1995, that was intended to shape its future. At the time the FCS was experiencing record loan volumes and high loan repayment rates. Its share of the agricultural credit market was steadily expanding as farmers invested in land and equipment. Unfortunately, the results of the review were released just before the Farm Credit Administration announced in September 1985 that the FCS would need an infusion of federal funds if it was to remain solvent. The funds were provided in 1987 and repaid, and the System is once again financially successful.

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The experience of the 1980s is instructive today as farmland values hit new highs and commodity prices remain near recent peaks. Today the main driver of farm profitability is the belief that a growing and richer global population will lead to steady increases in the demand for US farm products that will in turn lead to strong profits and ongoing investments to increase agricultural productivity. But this was essentially the story of the late 1970s and early 1980s. It is different today and the 1980s are unlikely to repeat themselves, but the FCS remains a single sector lender whose financial health is strongly coupled to the profitability of American farmers and ranchers.

At this moment in time there seems to be little reason to worry about weak farm financial conditions and credit shortfalls, but an important lesson from the 1980s is how ill-prepared the System was to deal with the last crisis. Crucially, while farmers can choose other lenders, the FCS cannot choose another category of borrowers. Its core mission is to provide a stable and competitively priced supply of credit to American farmers and ranchers. In particular, a co-operatively owned institution has the unique responsibility to its owner/borrowers of ensuring that they can survive during a downtown. This means that it is important for the FCS to have a strategy for serving the credit needs of farmers and ranchers in all phases of the business cycle.

In the paper I lay out one way that the next financial crisis could occur - not with the intent of saying that it will occur in this way, nor to say that its arrival is imminent. The main objective of my paper is to show that for the FCS simply guarding against the return of the last crisis - one that was fueled by weak balance sheets, is not enough. History rarely repeats itself in exactly the same way, but the broad cycles of history do reoccur. And, because of its unique mission the System has a particular responsibility to be prepared for a variety of alternative futures, not just the rosy ones.

The Context

Since 2006, after a period of relatively stable prices, agricultural commodities have experienced generally higher prices, but with considerably higher volatility. At the same time projections for higher levels of global demand and potentially negative supply consequences from global warming have led to expectations of upward price pressure on farm outputs going forward (United Nations, 2013; World Watch, 2013). Farmland prices have accelerated upward in response, under the assumption that an almost fixed supply of farmland, which has a base value determined by the discounted stream of future farm income, is now worth considerably more because of forecast higher commodity prices. While this set of events seems remarkably parallel to the situation in the late 1970s that led to the last major agricultural financial crisis, this time it is seen as different.

The central question is whether recent price trends reflect a cyclical upturn that will be reversed, or whether they reflect long run structural change where tight commodity supply leads to a steady upward trend in commodity prices. In the

former case prices will inevitably decline, potentially by a large amount, but in the latter case, any price declines will be modest and short-lived. A second question is who benefits from these higher prices? Historically higher prices for farmers, whether from markets or government support, have been largely capitalized into land values (Schnitkey and Sherrick, 2011; Weersink *et al*., 2009). But there is some reason to think that this process might not be as strong as it once was, because: a large share of farmland is rented or leased by operators, owners of intellectual property that produces higher yields have pricing power that can capture farm level profits, and farm labor is no longer as readily available as it once was allowing workers to command higher wages.

Historically, US agricultural crises have been triggered by some significant deviation from an expected future, generally following a period of favorable conditions for farm incomes and asset values. In the 19th century these were typically the result of: collapsing demand in export markets, major crop failures, speculative bubbles in financial markets or the collapse of credit for farmers (McNamara, no date). In the 20th century the agricultural depression of the 1920s preceded the Great Depression by almost a decade, reflecting a combination of bad weather and lower demand after the first World War. In the 1980s the most recent agricultural crisis was triggered by rapid increases in interest rates and a global economic slowdown after rapid price increases for commodities and farmland (Brake, 1986).

The financial crisis of the mid 1980s reflected financial stress for farmers and their lenders brought about by collapsing balance sheets. Land values dropped rapidly wiping out many farmers who, with lender complicity, had borrowed more than was sustainable once farm asset values were marked to market. The cause of the collapse in hindsight now appears obvious – too much leverage in the form of high debt associated with volatile asset values. But at the time the collapse was a surprise to most borrowers, lenders and agricultural finance professionals. Although Emil Melichar had predicted this path of events several years earlier in a 1979 paper, his analysis was challenged by most of the agricultural finance industry and by academics who saw little likelihood of excessive debt triggering a financial stress, and who projected steady increases in farm prices and incomes going forward. As noted above, historically, farm financial crises had been associated with collapsing commodity prices causing a decline in farm incomes, but as John Lee noted in 1984, farm incomes were relatively high before the collapse and played no role in the 1980s crisis (Lee, 1984). Similarly, John Brake in reflecting on the 1980s financial crisis observed that it reflected a confluence of, increasing debt service costs, excess production and low sector returns, but not low incomes (Brake, 1986, p. 86).

Henderson, Gloy and Boehlje (2011) review the history of booms and busts in US agriculture in the 20th century and show that periods of strong exports, high commodity prices lead to high market incomes that in turn trigger rapid farmland appreciation. When these conditions are supported by low interest rates the capitalization rate of "expected high future incomes" can lead to several years of double digit increases in farmland prices. However, these periods of boom have always been followed by periods of bust, where falling incomes lead to declining

land values and many farmers become unable to service their debt. The authors note that today aggregate debt is at historically small share of asset values (p. 96-97), and point to this as a factor that might make this time different, especially given projected increased global demand for US farm products (p. 102). But they caution that higher interest rates could be a problem for farmers because: debt is not evenly distributed across the farm population, we may not have a good estimate of the amount of debt, and export markets may not be as strong as projected leading to reduced repayment capacity (pp. 97-101).

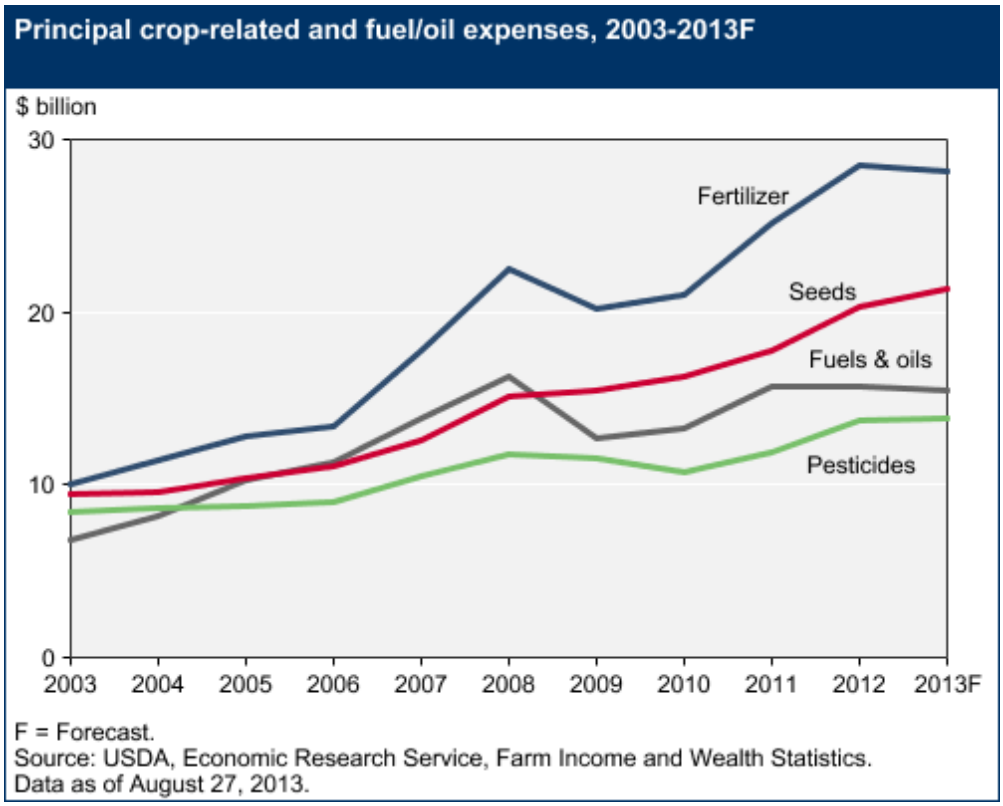
In summary, the current consensus by, farmers, lenders and analysts is that the crisis of the 1980s will not be repeated because leverage is at a historically low level. This time the run-up in land values has not been accompanied by as much of an increase in debt. Lower leverage should allow borrowers to absorb any fall in land values or in income without experiencing major balance sheet consequences. Declines will be painful for borrowers, but will not cause a sector wide financial crisis. In addition, the crop overhangs of the early 1980s have been replaced by low stock to use ratios, But, as Boulding observed in 1947, the story of farming is one of boom and bust, and while history may not repeat itself in precisely the same way, the current situation of fast and large increases in commodity and land prices suggests that it is prudent to think about what may happen if the cycle turns.

In particular, the focus on debt repayment capacity has masked significant increases in operating costs which are squeezing net farm income, even at current price levels. Figure 1 shows expenditure trends for important crop inputs. Expenditures on seed and fertilizer in particular are increasing at a fast rate. Given a fixed stock of land these two inputs are the most important sources of the increased crop output that will be needed to meet projected global demand

Current Medium Term Forecasts.

In this section of the paper the results of three medium term agricultural outlooks are examined. The first is the OECD-FAO medium term outlook where the OECD provides forecasts for its member countries and a number of other major agricultural exporters and importers while FAO provides similar information for middle income and low income developing countries. The second forecast is from USDA and reflects its internal projections of global and US agricultural conditions. The final forecast is from FAPRI –Missouri and it provides a mainly US projection but with "rest of the world" considerations in terms of influences on prices. There are other projections or forecasts, but virtually all follow the same basic trends as these three. Differences occur among forecasts mainly in terms of: how fast output responds to higher prices, assumptions about volatility in supply due to climate effects, how higher incomes in large industrializing countries, especially China, India and Indonesia, will in turn impact, global demand, biofuel use of crops, and growth rates in agricultural productivity.

Figure 1: Expenditure On Purchased Crop Inputs



Despite the recent high degree of volatility in, commodity prices, weather, economic conditions and the policy environment, risk is rarely explicitly included in agricultural forecasts. The FAPRI – Missouri forecast does provide some simulations using different scenarios, but these are mainly the effect of single changes in a key variable, not systematic analysis based on the distribution of past events. In particular, the projection of, current policy, average weather and smooth adjustments in interest rates clearly understates risk going forward.

OECD-FAO

This report was released in early 2013 and provides global projections through 2022. It shows increasing demand for agricultural commodities , mainly driven by income growth in developing countries. Supply is expected to increase at a slower rate than in the previous decade, but with non-OECD countries accounting for a larger share of world agricultural output and trade over time. Crop prices are forecast to fall in the next few years as output increases and demand remains weak, but rise modestly after 2015, but only in nominal terms with inflation adjusted prices remaining flat through 2022. Livestock prices remain high through the next few years, decline slightly in the middle of the decade as supply improves, and then at the end of the forecast period increase somewhat faster than inflation in response to higher incomes in developing countries increasing per capita meat consumption.

While the analysis recognizes that there are important sources of future volatility, including: climate risk, energy prices, policy development in China, the role of biofuels as a demand for agricultural crops, and uncertainty about the speed of productivity growth in agriculture, the report does not provide specific estimates of the impact of these risk factors. Similarly, there is no discussion of the potential impact of policy changes, including new trade agreements on agricultural output.

Crucially, the report does not look at how farm expenditure will evolve over time, nor does it look at returns to farmers in the form of income or capital gains. But because it provides a global overview the OECD-FAO report establishes a useful context for more detailed analysis of US trends.

USDA

The USDA report released in February 2013 also provides projections through 2022. The focus of the report is on conditions in the US, but global supply and demand estimates influence US projections. USDA projects steady increases in global demand for biofuels that helps support higher prices in out years. Like the OECD-FAO analysis, USDA sees lower crop prices for the next two years and then modest gains in crop prices, but only at a bit over the background inflation rate. US livestock prices remain high through 2014, but then decline for a few years and subsequently increase slowly. Food prices increase at less than the inflation rate after 2014. Prices for US farmers are helped by a declining US dollar which increase exports. Current policy (2008 Farm Bill) is used through the projection period.

Even though prices are not expected to increase markedly, the level of farm receipts remains high by past standards, because the projection period starts from a high price level. Real GDP growth in the US is projected at 2.6% for most of the period and inflation is projected at 2.1%. Interest rates remain at current levels through 2014 and then the prime rate moves steadily upward from 3.4% in 2014 to 7.5% in 2022, a 121% increase in 8 years. Higher interest rates, higher energy and fertilizer prices and other costs push up expenses for crop producers, but livestock producers benefit from lower feed costs in the near term and stable feed prices in the out years. The result is a projected drop in net farm income in 2014 and 2015 to about the level of 2010 and then essentially flat net farm income through 2022.

FAPRI – Missouri

The FAPRI- Missouri baseline report was released in March 2013 and also covers the interval 2013 through 2022. FAPRI focuses on the United States but projects global supply and demand conditions. Core assumptions in the FAPRI analysis are essentially the same as in the USDA and OECD-FAO reports, but FAPRI provides some limited sensitivity analysis for key assumptions (oil prices, weather conditions and biofuel mandates) and far more detail on expenditure. Current farm programs are projected as continuing into the future.

FAPRI shows crop prices declining slightly in 2013 - 2014 with essentially flat prices from this level in out years. Over the forecast interval crop prices fail to reach 2013 levels even under optimistic assumptions, with, for example, corn prices ranging between $3.50 and $6.00 a bushel in the future. But, prices remain above 2007

levels under all but the worst case scenarios. Model results are highly sensitive to assumptions about ethanol demand with biofuels projected as accounting for an increasing share of corn production as the "blend wall" is breached and current mandates are enforced.

Farm receipts fall from a 2013 peak through 2014 and recover slightly in 2015 with future growth rates afterwards of about 2% a year. Livestock receipts are flat through 2017 and then increase at a bit over 2% per year while crop receipts decline considerably through 2015 and then increase at a bit under 2% a year. Cash expenses are projected as increasing at about 2.5% a year after 2015. The result is flat nominal net farm income from 2015 through 2022 and falling real net farm income from 2013 for all years going forward.

Table 1 reproduces production expenses from the report (p.46). Over the period total expenses increase by 19.5% from 2012 levels with energy and interest expenses increasing by more than the average and feed costs declining significantly. The combined category of seed fertilizer and chemicals is about 18% of expenses in 2012 and falls to just under 17% in 2022. Feed is about 19% of expenses in 2012 and falls to 14% in 2022. Interest increases from 4.4% of expenses in 2012 to 6.5% in 2022, with most of the increase occurring after 2016. Cash receipts are projected to increase by 11% between 2012 and 2022 leading to a declining ratio of cash receipts to expenses.

Figure 1: Forecast Expenditure Components: 2012-2022, millions of dollars and %

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	% change
Total Expenses	$333.68	$347.51	$341.89	$343.03	$349.04	$357.22	$365.91	$374.02	$382.69	$390.62	$398.84	19.5%
Feed	$63.71	$63.77	$53.31	$51.23	$52.01	$53.36	$54.60	$55.64	$56.21	$56.61	$56.79	-10.9%
Purchased animals	$22.15	$22.58	$23.95	$24.03	$23.16	$22.44	$22.06	$21.56	$22.43	$23.12	$23.96	8.2%
Seed	$19.86	$20.89	$20.85	$20.66	$20.55	$20.89	$21.46	$22.06	$22.61	$23.10	$23.54	18.5%
Fertilizer & Chemicals	$39.46	$39.99	$39.73	$39.26	$39.11	$39.38	$40.01	$40.76	$41.50	$41.99	$42.60	8.0%
Fuel & Electricity	$20.79	$20.20	$19.76	$19.46	$20.16	$20.84	$21.57	$22.27	$22.79	$23.29	$23.82	14.6%
Interest	$14.63	$15.41	$16.34	$17.32	$19.00	$20.92	$22.29	$23.31	$24.19	$25.00	$25.79	76.3%
Seed Fert Chem share	17.8%	17.5%	17.7%	17.5%	17.1%	16.9%	16.8%	16.8%	16.8%	16.7%	16.6%	
Feed Share	19.1%	18.4%	15.6%	14.9%	14.9%	14.9%	14.9%	14.9%	14.7%	14.5%	14.2%	
Interest Share	4.4%	4.4%	4.8%	5.0%	5.4%	5.9%	6.1%	6.2%	6.3%	6.4%	6.5%	

Summary

All three projections forecast a short term decline in prices over the next few years and then at best a slow increase in prices through the projection period. A return to global economic growth, but at a slow rate, leads to the main increases in agricultural demand, largely reflecting higher per capita incomes in developing countries. Volatility is explicitly excluded from the analysis in all three studies because the projection methods assume average weather conditions and a stable policy and economic environment. Nevertheless, all three documents suggest that in the future volatility is likely to remain at high levels, but the authors are unable to

adequately forecast its effects. Notably, weather, policy and macroeconomic conditions in the larger economy are the three main shock inducers for agriculture.

All three forecasts see a period of moderation in prices and a decline in farm income from the 2013 peak, with at best modest increases in the medium term. None projects a continuing run of large price increases, even though they see demand increasing steadily in the future, mainly due to higher incomes in developing countries and, in some cases, a steady increase in the use of biofuels based on farm commodities. The main focus of all three analyses is the supply of farm outputs and the prices these outputs will command in global markets. The FAPRI report pays the most attention to the potential consequences for farm incomes, but even in this case the implications of changing technology on the cost structure of agriculture are not well developed. In this regard while productivity is recognized as the key driver of the increases in yield that allow output to expand, the analysis appears to assume that productivity increases will not alter the mix of inputs used by farmers or their relative prices.

Higher interest rates are forecast in all three studies, as are higher energy costs. These will surely increase production costs, and if costs increase faster than output increases then net incomes will fall given the projections of weak commodity prices. Crucially, very little focus is placed on the effect of these higher expenses. Even in the FAPRI report, which has the most extensive discussion of cost of production, the main analysis is on prices and quantities of outputs with little attention to how increases in production costs can alter net income.

Long Run Commodity Price Trends

The three medium term forecasts can be seen as being consistent with other studies that examine long run trends in commodity prices. While increased demand due to an increasing and wealthier global population is an argument for higher food prices, the evidence from history is that short term increases in agricultural commodity prices induce a large enough supply response that these prices soon fall. Whether farmers are better or worse off after the increase in output depends crucially on whether prices fall by more than the supply of commodities increases, and how their cost of production changes.

In a recent paper Jacks (2013) shows that global commodity prices follow long super-cycles where periods of low prices induce only small increments to supply until eventually demand grows to exceed supply causing prices to increase. At this point super-normal profits provide an incentive to bring new supply onto the market, which in turn lowers price and the cycle repeats. Real commodity prices are calculated for 30 commodities, including 13 agricultural commodities, from 1850 through 2012.

In addition he examines long run trends and short term volatility to provide a more complete perspective on real commodity prices. Jacks finds that there are important differences between hard (minerals and energy) and soft (agricultural) commodities in terms of very long term price trends. For hard commodities the downward trend in real prices is not as steep and appears to be have reversed since 1975. For soft

commodities, including grains, coffee, cotton, and beef, the long run trend remains negative (p. 3). Sitting on top of trends are the super-cycles, which produce 10 to 35 year upswings in prices followed by similar length declines (p. 3). Super cycles lead to 20% to 50% oscillations in prices about trend. Importantly for many commodities in the sample, the most recent upswing began in the 1990 to 2000 interval, and, based on past experience, these commodities are approaching peak prices (p.4).

Finally, short term boom bust cycles, with average price increases over 1 to 2 years, and with 2 to 4 year length price declines some time later, produce much of the volatility in commodity prices, with 30% to 100% deviations from trend being common (p.17). These booms and busts can occur at any stage of the super-cycle and either reinforce or mitigate its effect. The most recent sequence of short term boom-bust cycles started from busts in the 1990s followed by new boom intervals in the 1990s and 200Os (pp. 17-18).

Jacks concludes his analysis by noting that real commodity price cycles have increased in duration and amplitude since the 1970s,and there is little reason to believe that volatility will decline going forward (p. 23). He also notes that the recent commodity price increases over the last decade, while steep, reflect the combination of starting from both a trough in in the super-cycle and troughs in short term boom-bust cycles in the 1990s (p.23). This suggests that in the near term more moderate or declining prices may be expected, which is consistent with the three medium term projections for agriculture.

Huchet- Bourdon (2011) provides additional short term analysis of agricultural price volatility over the last 50 years with a focus on the 2006-2009 period. She finds that 2006-2008 price spike closely resembles the period of the late 1970s, but that volatility in agricultural prices is not uncommon and does not appear to have increased recently (p. 6). She notes that the magnitude of volatility is sensitive to the way commodities are specified, the interval studied, and the specific measure of volatility (p. 9). She too notes that the 1990s were a period of relatively low volatility which makes the more recent experience seem even less stable.

These projections of a recent peak in commodity prices are consistent with the price forecasts from the three outlook studies discussed previously. Certainly higher demand could lead to a sustained period of higher commodity prices and a reversal of the very long term trend of falling agricultural prices. But for prices to remain high there will have to be a both a steady increase in demand over time and increases in supply that are certainly no larger than the rate of increase in demand. This has not happened in the past, which explains why agricultural commodities have experienced falling prices. Moreover, for farmers to benefit financially from higher prices their cost of production also has to increase at a slower rate than cash receipts, otherwise net income will fall over time.

Capitalization and Farmland Values

In the 20th century higher farm incomes, whether from high commodity prices or government payments have been associated with an increase in farmland values (Henderson, Gloy and Boehlje, 2011). While farm operators could have used higher incomes to increase family expenditure or diversify their asset holdings they typically chose to use it to acquire more farmland. At the time, the vast majority of farmland was owned by the operator, so t the household could choose to take its returns either as current income or as increased wealth. Since farmland is effectively fixed in supply the competition for land increased its price. The result was an apparent increase in wealth for all farmers.

Consequently, the price of farmland is typically expressed as reflecting the discounted stream of future net farm income. Or, more precisely, the discounted stream of future cash rent values. Higher incomes or higher rents imply a higher land value and higher discount rates imply a lower value. Cash rents are a better numerator than cash receipts because they reflect the ability of the farm operator to pay a residual amount to the landlord after paying the full amount to household labor, management and capital. Most importantly, higher cash receipts is not a good numerator because higher revenue may be offset by higher farm expenditures.

Economies of size, if not scale, in farming that reflect the mechanical revolution that replaced animal power with tractors have led to larger farms as new technologies have led farmers to get bigger in order to remain competitive (Cochran, 1958). For farmers trying to expand their business to capture scale economies, higher farmland prices could be justified because the higher priced incremental land may have allowed large enough economies of scale across the entire farm to pay for the new land. Tax considerations may have also encouraged farm households to increase wealth over income because the effective tax rate on capital gains was lower. And, periods of high farmland prices tend to attract outside investors, who may or may not intend on operating a farm, but who see farmland as a good component for a diversified investment portfolio. Thus higher income can lead to increased demand for farmland.

Yet, most agricultural land has limited opportunity cost. While land relatively close to urban areas is "developable" and has a higher inherent value based on the expected time to conversion, the majority of farmland has no significant value other than in farming. Notably, in the United States much of the farmland in the Northeast was abandoned over the last fifty years because it was not viable with current technology and prevailing prices. This suggests that, because it has low opportunity cost, any payment to most farmland is a pure economic rent. Changes in the price of the land do not alter its use and the supply of farmland is invariant. Thus, in the last and all previous financial crises, farmland fell in value, but virtually all of it remained in production as farmland, albeit with a new owner.

On the other hand, farmland is vital if one wishes to be a farmer, and for farm operators who wish to expand there can be an intense competition for land in close

proximity to their existing farms. Importantly, this behavior has had implications for how net farm income is allocated. Because the farm household historically has owned, operated and lived on the farm and provided most of the labor and capital investment, there has been a tendency not to allocate net income among payments to family labor, payments to management and payments to land in a precise way that reflected their actual contribution to creating the income. Since it was all one pot of money that accrued to the same people, the division was not important. In particular, there was a tendency to pay land more than an appropriate share and labor less. This can be explained as reflecting: preferential tax treatment of capital gains versus earned income, an interest in gaining control of additional land both for expansion and intergenerational farm transfer, and perceptions that farmland was an appreciating asset.

Increasing Agricultural Output

Given projected increases in global population and global incomes, the medium term demand path for agricultural products is fairly well understood, with only the role of biofuels as a relatively uncertain factor. Note all three forecasts suppose that biofuels demand will increase through 2022, in part because conventional energy prices will increase as global population and income increase, and in part because of climate change concerns. If demand increases are relatively certain, then supply response becomes crucial in determining prices and income levels for farmers. But there is less certainty about how supply will increase between now and 2022.

The OECD-FAO study predicts increased share of global supply from developing counties, in part from an increased quantity of land in agriculture, but mainly from their adoption of existing technology. In the OECD countries, including the United States, almost all increases in output will have to come from new technologies that increase productivity. While some CRP land will return to production in the near term the amounts projected by USDA and FAPRI are not large, and by 2022 both studies show CRP enrollments as returning to the statutory maximum. Consequently, the rate of productivity increase, and which factors of production capture the returns from higher productivity, will have a large impact, not just on supply, but also on future financial conditions in US agriculture.

There are three main paths to increasing agricultural output. The first is to expand the amount of land used for production. In the United States and globally, prior to the 20th century this was the main path, but in the US since 1900 there has been little change in the quantity of land in farms. Land has changed uses, with some land near cities being removed from farming, and some remote land reverting to bush, and yet other land being brought into production. In addition, there has been a considerable shift in the use of farmland between cropland and pasture. The second major path to increasing production was the mechanical revolution where machines replaced animals and people as sources of power. This process of capital deepening had its major effect in the mid 20th century, especially after the Second World War as draft animals were replaced by tractors that were cheaper and capable of more work (Dimitri, Effland and Cochrane, 2005). Importantly, replacing livestock with

machines allowed crops to be diverted from feed for draft animals to direct and indirect human consumption. The mechanical revolution has allowed fewer farmers to produce higher output per acre by allowing more timely production practices and facilitated the conversion of pasture land that could not be tilled using draft animals to crop production (Ruttan, 2002; Mundlak, 2005).

While the mechanical revolution continues and capital investments on farms continue to expand, the main benefits of advances in mechanical technology now come in the form of reduced costs of production, not higher output per acre. Further capital deepening may alter the structure of agriculture with fewer and larger farms producing a bigger share of output, but it appears to have limited capacity to significantly increase output per acre in the United States. Henderson, Gloy and Boehlje note that, unlike the past, in this most recent boom cycle capital investments by farmers in new equipment have been constrained (p. 96). This is consistent with Mundlak's claim that increased farm output in the United States will no longer come from the mechanical revolution, but from the third path - new biology (Mundlak, 2005, p.1019).

An important dimension of the shift from output increases based on mechanical technologies to output increases based on biological technologies is the factor of production that is saved or substituted as a result of adopting the new technology. Mechanical technologies mainly substitute capital for labor, either human or livestock, whereas biological technologies substitute improved operating inputs for land (Ruttan, 2002, p. 163). Because land is a fixed factor, improvements in biological technologies have the potential to reduce the constraint land places on output growth, and to reduce the size of the economic rents that have historically accrued to land.

The biological revolution has multiple dimensions, including improved seeds and animal genetics, as well as improved pesticides and vaccines to reduce losses to a variety of pests, and, increasingly, the interaction of these two phenomena. Seeds are now tailored to be resistant to specific pesticides or to specific pests. Livestock are engineered to improve feed conversion and their feed is tailored to ensure that there are no missing nutrients that can slow weight gain.

This biological revolution has important implications for financial conditions in agriculture. First, an increasing share of the research that underpins biological advances is being conducted by the private sector, instead of in USDA research facilities or at Land Grant Universities, which historically provided most of the new technology to farmers. Importantly, the shift in who conducts it has resulted in research becoming a private good instead of a public good. Whereas farmers used to freely receive the benefits of research, now they have to pay for it.

Because the new technologies can offer major improvements in yield and lower costs per acre or per animal they have the potential to significantly increase farm profits. But typically the companies providing the new technology act to capture the majority of the potential profits through increasingly complex pricing strategies that

reflect their ownership of the underlying intellectual property. While farmers benefit from the biological revolution, or else they have no incentive to adopt it, they do not benefit as much as they would if input supply companies did not act as profit maximizers and made their research freely available to farmers as a public good.

One clear consequence of the biological revolution is that seed, which used to be a farm origin input when producers saved seed from the current crop for future use, is now a manufactured input, like fertilizer, that the farmer buys from a specialized manufacturer each year. Today, higher crop prices result in higher seed prices as the manufacturer acts to capture available economic rents. Tailored seed and pesticide combinations further increase the pricing power of the input supplier, who now sells farmers packages of inputs as a bundle, and also provides the financing for the purchase.

Productivity Growth and Agricultural Output

Historically agriculture has exhibited a high enough rate of productivity growth that farm commodity prices in the long run have trended down over time, despite a growing global population and increased levels of income, which shift demand out. Given an almost fixed land base, productivity is now seen as the major driver of higher levels of farm output. Productivity is typically explained as coming from one of two sources. The first is improvements in the quality of specific inputs that lead to higher levels of output. The other is through improvements in the way the set of inputs is combined – Total Factor Productivity (TFP). Essentially TFP measures the unexplained residual change in output after incorporating the effect of all the known input factors, including the quantities used and quality adjustments (Lipsey and Carlaw, 2001).

Input quality changes over time. For example, a two wheel drive 40 horsepower tractor is less productive than a four wheel drive 150 horsepower tractor, which, in turn, is less productive than the same tractor equipped with GPS technology. Similarly, over time, operator labor has become more productive as a result of higher levels of human capital, and fertilizer and pesticides have become more productive as a result of better chemistry (Fuglie, MacDonald and Ball, 2007). These quality improvement's allow the same physical quantity of an input to produce a higher level of output. But, even after incorporating input quality effects USDA finds that TFP accounts for virtually all the increase in output between 1948 and 2004 (Fuglie, MacDonald and Ball, 2007, p. 2).

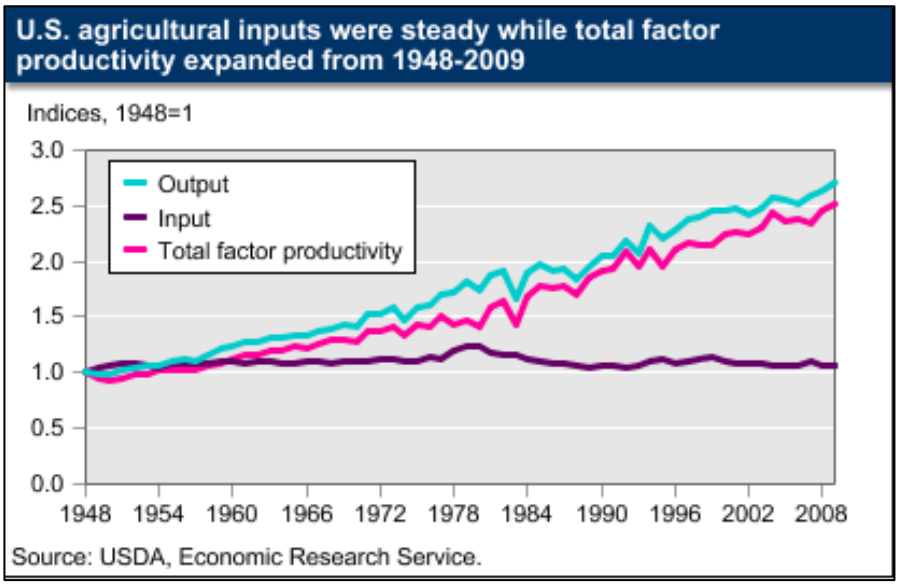
Because USDA concludes that TFP is now the main driver of agricultural output, and because TFP, by definition, measures increases in output that cannot be assigned to any specific factor of production (Lipsey and Carlaw, p. 3), there is a windfall gain that is available for the residual claimant to farm profits. In essence the perspective of USDA is that technological change in US agriculture is largely a "free good" for farmers. Historically this may have been the case, when new farm technologies were developed directly by USDA researchers or through the USDA supported Agricultural Experiment Stations at Land Grant universities. This research

immediately became public domain and was freely available for adoption. But this is no longer the case.

Because TFP is a residual, the benefits it creates do not necessarily accrue to any specific input. TFP benefits can be allocated to any party that can develop a claim on the residual income from farming. This could include the farm operator, the farmland owner, or, indeed, input suppliers and output processors if they have sufficient pricing power to allow them to extract these economic rents. Of course the financial benefits from higher TFP can be reduced by falling commodity prices when output expands in response to the introduction of new technology.

Analysis by ERS shows that agriculture is relatively unique in that output growth over time is largely explained by productivity growth and not by growth in the quantity of inputs, which is the case for most other sectors (Ball, 2011, p. 5). Between 1948 and 2009 TFP increased at an average annual rate of 1.63% while input use increased at .11% annually (Figure 2). Crucially, over the period both labor and land have had a reduced impact on growth in output. Both capital (equipment, buildings, breeding herds etc.) and material inputs (energy, feed, fertilizer, pesticides, seed etc.) continue to have a positive impact on output growth rates. These data tend to confirm the argument that the mechanical and biological revolutions are the driving forces in increasing agricultural output.

Figure 2: Drivers of Increased Output In US Agriculture



Yet, if these revolutions are the source of increased agricultural output, economic logic would suggest that the providers of the new technologies should appropriate at least some of the benefit from the increased output. Improved tractors should sell for higher prices, as should improved seed. However, while USDA adjusts capital stock figures for changes in quality due to depreciation and technological

improvements and also adjusts fertilizer and pesticide use for quality changes it does not perform a similar adjustment for seeds. As Figure 3 shows, seed as a share of purchased inputs, less outlays for feed and replacement livestock,[2] has increased from about 8% of the total in 1990 to just under 15% in 2011, a 44% increase. In this period the cost share of seed expenses has overtaken pesticide expenses as seed has moved from being an item that farmers supplied themselves from previous harvests, to a patent protected input that is purchased from companies specialized in plant breeding. The higher expenditure on seed reflects the willingness of farmers to pay significant amounts for proprietary technology because it offers higher yields or lower total production costs. Not surprisingly, the companies providing the seed set prices that ensure that they capture a significant share of the incremental revenue associated with using their seed.

A key feature of much of this proprietary seed is that it is tailored to be used with specific pesticides. In essence farmers typically buy a seed/pesticide bundle to get the maximum benefit. When both seed and pesticide expenses are considered they have gone from just under 18% of purchased input costs, net of feed and livestock replacement, to 22% in 2011.

Also if land is playing a smaller role in explaining increases in agricultural output logic suggests that it should be earning a smaller factor share and farmland values should not be accelerating. The fact that land prices have increased steadily since the mid 1980s suggests that farmland remains the major residual claimant on profits in agriculture. Even though most farmland has low opportunity cost and would remain in agriculture, irrespective of the price it is able to command, benefits from farm programs and higher market revenues have historically been capitalized into farmland prices.

Is This Time Different?

Clearly the last ten years have been a boom phase for agriculture. The crucial question is what happens next. While there are forecasts that demand will lead to further price increases that will lead to high farm profits this is not the consensus from medium term forecasts. Instead these project relatively stable prices through 2023 and supply effectively keeping up with demand. The forecasts are clear that they expect high volatility going forward and that shocks can arise from numerous causes, but with downside shocks, such as interest rate increases, being perhaps more likely than upside shocks.

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[2] Purchased inputs reported by USDA are for all farms. Only feed and replacement livestock are clearly identifiable with livestock farms so the calculations on expenditure shares shown in Figure 2 will understate the share of actual expenses for seed and pesticides on crop farms because there are still purchased input costs associated with livestock farms in the denominator.

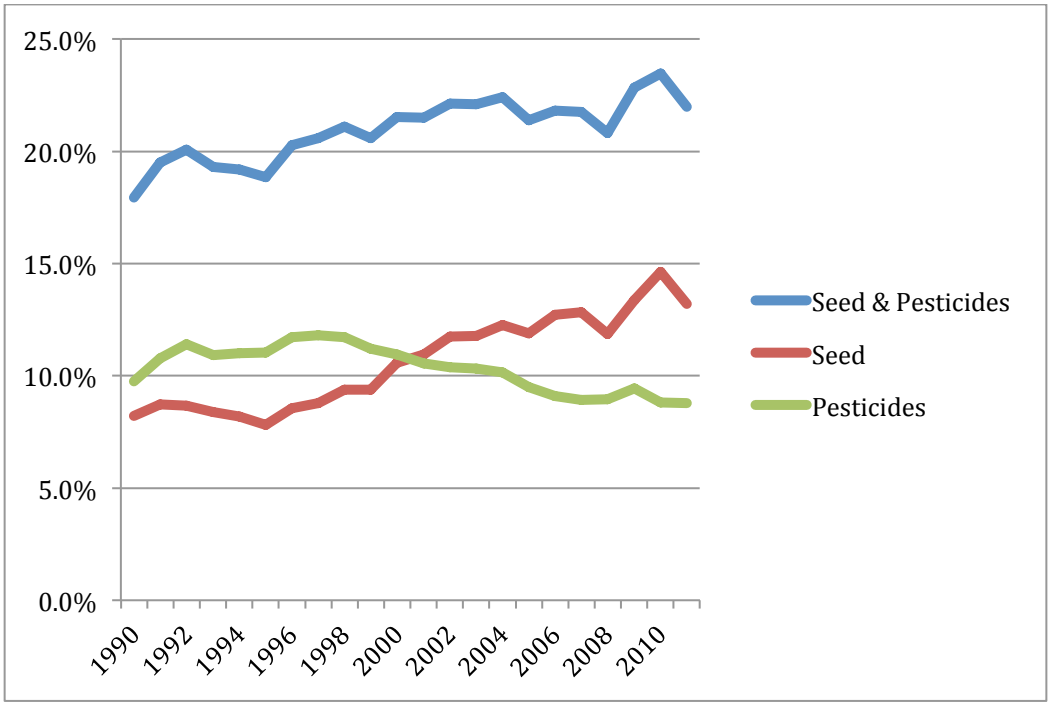

Figure 3: Seed and Pesticide Share of Purchased Inputs

The crucial question from an agricultural finance perspective is, what happens once prices and gross incomes become flat. Both Melichar's model of farmland prices being driven upward by expectations of further increases in prices and Jack's historical data showing commodity booms are followed at some interval by significant price declines suggest that this time will not be different. In contrast, the argument made by Henderson, Gloy and Boehlje and by USDA is that the combination of low leverage and higher levels of global household incomes offers the possibility that a period of flat prices, or slower price gains, may not lead to a bust.

This paper sets out a third possibility that looks at a new dynamic. If increases in US farm output now mainly reflect the biological revolution, then a new dynamic exists that alters the returns available to both farmers and farmland. There is general agreement that in the past higher prices and incomes have been capitalized into land values, although there is some controversy over the rate at which this occurs (Kirwan and Roberts, 2010; Gutierrez, Westerlund and Erickson, 2007). But this analysis supposes that land has the strongest residual claim on farm profits. Under this scenario higher profits induce competition for the fixed stock of farmland by farmers and investors that drives up prices.

It is a model that is very consistent with observed behavior, so it cannot be ignored. But USDA productivity data shows that both labor and land account for a declining share of increases in farm output, so these factors play a smaller role over time in

output. This implicitly raises the question of why either should necessarily capture future benefits from higher levels of revenue. Moreover, it is clear that there has been a change in how new agricultural technology is being provided, with for-profit firms now producing a large amount of proprietary innovations in farming, in contrast to an earlier time when public agencies conducted virtually all agricultural research and made it freely available to farmers.

These firms can be expected to extract as much value from their research results as they can by charging prices that capture most of the yield improvements and any reductions in production costs. Once again the data on shares of expenditure going to seed and other purchased inputs is consistent with this hypothesis. Firms producing biological innovations should be able to do this because, as Ruttan observed, the biological revolution is mainly land substituting, while the mechanical revolution was labor substituting. And, as Henderson, Gloy and Boehlje observe, there has not been a large increase in equipment sales in this cycle, possibly reflecting the shift in importance of access to biological advances.

All this would argue that farmland is effectively becoming less scarce over time. If true it could lead to a decoupling of the connection between higher crop prices and higher farmland prices. Smart biological input providers can adopt complex pricing strategies, including a high degree of price discrimination, that capture most of the benefits from their innovations, leaving relatively less for both farmers and land owners. Doing so would result in slower rates of TFP growth in agriculture, but not in the growth of output because higher expenditures on purchased inputs would capture the output growth and not leave it as a residual.

There are several implications for lending and lenders. The first would be a rotation away from term debt to operating debt as farmers have to pay for inputs at the beginning of the year and then repay these loans after harvest. If debt is only measured at year end, this would lead to an apparent reduction in farm debt levels, even though at mid-year debt would be quite high. Ongoing access to operating credit becomes crucial in this scenario, especially for large commercial farms that are the most aggressive adopters of new technology. The second is a potential shift away from traditional farm lenders as a source for credit. Operating credit can be easily supplied by the large corporations that provide inputs as part of a package that provides the farmer with credit and the input. If these firms bundle the two functions then they can use transfer pricing strategies to further increase profits by either offering a low price input or low cost finance.

The new alternative has implications for whether this time it will be different. Most importantly, it suggests that even if prices remain high farmers will be caught in cost squeeze reflecting efforts by producers of operating inputs to extract more money from farmers. Because purchased inputs now provide most of the increments to output, farmers have limited alternatives to paying the "going price" for seed, chemicals and fertilizer. In turn this could put downward pressure on cash rents, which would then lead to downward pressure on land values. This reflects the fact

that most farmland has no alternative demand, so if inputs absorb a greater share of fixed amount of revenue there is inevitably less money available to pay for land.

A second implication is that the sector may be becoming even more exposed to a credit squeeze. Farmers require ongoing access to credit, but if input providers perceive that bundling credit with their products is not an effective sales strategy they could easily back away from their finance role. This would leave traditional farm lenders facing increased demand, probably at a time when farm financial positions are already troubled.

Conclusion

Essentially we can choose from three conflicting stories about the future. One is relatively optimistic and two are more pessimistic. The first, and more conventional, optimistic story is that there is an essentially fixed stock of farmland, and producers compete for this land as a way to capture the higher profits brought about by an expanding demand for farm outputs. In this story the benefits of higher prices are capitalized into land values and land owners reap a large share of the increase in demand from higher global population and higher global incomes. But in this story most of the increase in output has to come from higher Total Factor Productivity because land is fixed in supply. If these productivity increases are mainly free, then it is possible that land owners could capture most of the benefits from producing higher levels of output per acre. But, to the extent that higher productivity reflects more and better input use then these inputs, and not farmland, will likely capture much of the resulting increase in revenue.

The second story also sees the global demand for agricultural products increasing, resulting in higher market revenue. In this story the fixed stock of farmland also requires that increases in output come mainly from the biological revolution, which allows each acre of land to produce more and not from Total Factor Productivity. Higher yields mainly reflect increased fertilizer inputs and the use of embodied technology in the form of patented seeds and patented herbicides. The producers of these inputs are few in number and adopt sophisticated pricing strategies that ensure that they capture a large share of the extra revenue associated with the use of their products. In this scenario there are limited incremental returns to farmland because it is a fixed factor and has low opportunity cost.

The third story has an unhappy ending. In this story, following the price projections in Jacks, the recent interval of high prices reflects the overlap of an up phase of the commodity super-cycle and an episodic boom in agricultural prices. In this scenario recent higher prices induce new investments in producing more output and this is sufficient to bring about a build-up of stocks that in turn depress agricultural prices and return them to their long term declining trend. This is the scenario from history, where the cure for high food prices has always been these high prices. New investments in productivity soon push the growth of output ahead of the growth in demand, and prices decline.

For lenders which story unfolds is important. Farmland values can only stay at current levels under the first story. In the other two cases farmland values are not sustainable because, as Melichar made clear in 1979, once expected capital gains on farmland stop increasing, farmland prices fall. While current debt to equity ratios may be low enough to provide an adequate asset cushion, so balance sheets are not vulnerable, farm net income will decline with either the higher input costs of the second story or the commodity price declines of the third story. Lower income levels will make it harder to service debt, and if interest rates move up in the near term then existing debt will be more expensive for farmers to service.

In addition, if the second story plays out, farmers will need larger amounts of operating credit to finance the more costly purchased inputs required to increase output. While many farmers show no debt at the end of the year, a large share of these farmers are thought to take out operating credit lines in the spring and pay them off in the fall, so the use of operating credit is larger than USDA debt statistics suggest. In this environment farm net incomes will not increase as fast as expenses do. This situation may be problematic for lenders, especially if volatility of yields and prices remains high, making operating credit lines more risky.

In their recent book, *This Time Its Different: Eight Centuries of Financial Folly,* Reinhart and Rogoff demonstrate that countries have centuries long histories of countries periodically defaulting on sovereign debt. Each time after a default the country promises it will never default again and investors buy its bonds. But default reoccurs. Similarly, the history of US agriculture is a story of commodity booms followed at some varying interval by a commodity and farmland bust. While it is possible that this time it is different, history suggests it won't be.

Next Steps for the System

Supposing I am right, or more importantly, simply supposing that this time is no different and history does repeat itself, what does this mean for the System. The most obvious thing is that there should be a strategy to deal with two distinct phenomena. The first is to be able to respond in a coherent manner to a farm financial crisis, irrespective of how it evolves. In the 1980s a bad situation was made worse by the initial inability to respond proactively to the problem. Indeed, much of what the System did initially made things worse. Roughly thirty years have passed since the last crisis, but there a still some people in the System who were involved in the events of the mid 1980s. At a minimum it would seem useful to develop some framework for them to provide a review of what went wrong then and how similar problems might be prevented should another farm financial crisis emerge.

The second point of my paper is that there could be a radical change in the underlying drivers of agricultural productivity and where profits from farming are captured. In the past farmers have been almost indifferent between taking agricultural profits in the form of income or in the form of capital gains through appreciating land values. This has meant that land loans have been a major share of agricultural lending and a core competence of the FCS. Historically commercial

banks have been less willing to commit to long term farmland mortgages because of liquidity and risk concerns, which has given the FCS a larger market share.

But what if the returns from farming are now mainly captured by the providers of advanced farm technology - seed, chemicals and equipment? In this environment the challenge for both commercial banks and the FCS is competition from captive finance arms of input suppliers and processors. As farmers become integrated into supply chains that work on a contract basis instead of arm's length markets, their relationship with the upstream and downstream members of the supply chain becomes more complex and can include financial services. Clearly these suppliers and buyers know as much or more about a farmer than a traditional lender, which only provides credit. Consequently they may be in a better position to assess credit risk and they can use transfer pricing to make their loans appear cheaper.

But is this a better situation for the farmer or rancher? Possibly not, and the System is uniquely positioned to offer an alternative based upon a different form of financial relationship. While it cannot be a bundled service provider, like an input supplier or a processor, it can offer a financial relationship that is not based on profit maximization by the lender. Farmers are likely to recognize that credit from input suppliers or processors further binds them into a relationship where they have little bargaining power. The System can, and should, offer an alternative in the form of co-operatively based credit as an alternative that provides greater flexibility.

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