Farm Size Economics and Farm Number Development in Illinois
Lessons from a Dynamic Simulation Analysis

by

Daniel Schunk

Introduction

The strong decline in the number of farms over the last decades is a well-known fact. Agricultural Economists have investigated the reasons for this phenomenon and many interesting aspects have been found, though the results are sometimes very contradictory. For example, estimations of technical efficiency of farms of different sizes diverge significantly and so do the conclusions drawn for the results of the different studies.

Based on data provided by the Illinois Farm Business Farm Management Association (FBFM), a dynamic model has been developed that distinguishes between four different farm sizes. Concerning farm economics, the model focuses on the financial efficiency of Illinois Grain Farms as one of the most important drivers form farm growth and decline. Other factors that are assumed to influence the system's behavior, such as tenure ratio and market access information, are also included in the model and influence the system's dynamics.

The useful conclusions that we can draw from our dynamic modeling approach comes from two efforts:

- The detailed econometric calibration of the model to the FBFM data from 1980-1999 gave us insight into the economy-of-size properties of Illinois grain farms
- A sensitivity analysis of the model predictions for the time till 2020 allows us to obtain information on the system's properties and it's dynamic characteristics.

Model Overview

The model distinguishes between four types of farms:

- Type I: 180-499 acre farms
- Type II: 500-999 acre farms
- Type III: 1,000-1,999 acre farms
- Type IV: 2,000++ - acre farms

The economic characteristics of these farm types have been developed using econometric techniques and based on the FBMF data, that have a slightly different distribution of farm size categories (180-430 acres, 340-800 acres, 800-1,200 acres, 1,200++ acres).

Farms with a size smaller than 180 acres have to be treated separately. They are somewhat decoupled from the rest of the system, since the number of part-time farmers is very high in this group and for many of them the economic aspect of farming doesn't play a predominant role.

The financial data is normalized to 1996 price-level.

Furthermore, the Farm Size Dynamics Model consists of three Sectors:

- Individual Farm Economics (Sector I)
- Farm Viability Indicators (Sector II)
- Farm Type Distribution and Land Allocation (Sector III)

The **Individual Farm Economics Sector** models farm cost and revenue based on historical data (1980-1999) and based on future assumptions. This sector tracks all major input and output flows of Illinois corn/soybean farms. Since all input and output flows are associated with monetary flows of the particular farm business, the model gives a possibility to calculate financial efficiency indicators based on assumptions about future technology developments and input usage and based on assumptions about price development.

Certain assumptions concerning cost factors and payments must be made for the Type-II-farms. The model simulates the cost for the other farm types based on econometric and time series relationships. Prices are considered as given for all farms and can be specified exogenously, input amounts vary for the different farm types based on the above mentioned econometric specifications.

The financial efficiency indicator and further variables that characterize the "viability" of farms are combined to obtain a viability indicator for a specific type of farm. The viability indicator serves as a basis for calculating a farm's probability to buy or sell/rent land and thereby drives the dynamics of the whole system.

The detailed calculations of the farms monetary flows allow us to calculate the *Net Farm Income from Operations Ratio*, a financial efficiency measure that is suggested by the Farm Financial Standards Council (FFSC). The 5-year moving average of this measure is taken as an *indicator for the financial stability* of the different types of farms. The economies of scale are captured in the model, so that the particular farm types react individually to different assumptions about prices and input amounts. The **Farm Viability Indicators Sector** (Sector II) combines the financial stability indicator developed in Sector (I) and further variables that characterize the viability of farms to obtain a viability indicator for a specific type of farm. The viability indicator serves as a basis for calculating a farm's probability to buy or sell/rent land.

The Farm Viability Indicators Sector is the link between the detailed economic/financial representation of the farm in sector (I), other factors that are relevant for the development of the different farm size types and Sector III.

The **Farm Type Distribution and Land Allocation Sector** (Sector III) models the dynamics of the whole system. The farm's decision to buy, rent land or to go out of business is modeled in this sector and land is reallocated according to the new land distribution every time step.

Limitations of the Model

- The effect of tenure ratios is not captured by the model; tenure is not an endogenous variable, tenure effects are assumed to be exogenous.
- The financial efficiency of farms is modeled in detail, but due to a lack of data sources, the debt structure of the farms is not part of the model; relevant factors such as technological change, productivity growth etc., are not modeled.
- The idea to distinguish between four types of farms according to their acreage is helpful for the analysis, but might be somewhat restricted from an economic point of view.

Results

The econometric analysis for the data from 1980-1999 gives us information on some of the major scale differences of Illinois farms.

Major factors where smaller farms suffer from relatively higher costs:

Fuel/Oil Costs per Acre

Type I farms have more than 10% more fuel and oil cost per acre than Type II, Type III and Type IV farms. This can be attributed to a generally older and less efficient machinery complement of smaller farms and a less efficient use of their machinery complement on a per acre basis. It might also be due to better fuel prices for bigger farms.

Light Vehicle Hire + Machinery Repair Cost

Type I farms pay more than 32% more for light vehicle hire and repair cost than Type II farms, 41% more than Type III farms, and 46% more than Type IV farms. This is obviously influenced by scale effects. The number of light vehicles is relatively invariant to the farm size. Small farms' repair cost, as well as their fuel cost tend to increase relative to big farms, indicating that their machinery capital turnover rate is lower in recent years and they rely more on repairing old machinery than investing in new machinery. This is confirmed by the development of the machinery depreciation cost for small farms. Machinery depreciation cost have gone down significantly over the last 20 years relative to the depreciation cost of bigger farms. Small farms seem to invest comparatively less into new machinery and technology, therefore having a competitive disadvantage in the long run.

Total Building Cost

On a per acre basis, Type I farms pay 25% more than Type II farms, 33% more than Type III farms and 36% more than Type IV farms.

Labor Cost per Acre

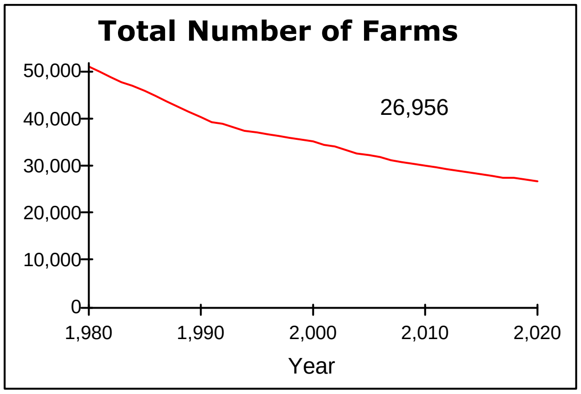
On a per acre basis, Type I farms pay 93% more than Type II farms, 121% more than Type III farms and 125% more than Type IV farms. This mainly comes from the fact that larger farms use their machinery much more efficiently. However, one should keep in mind, that the rate of unpaid labor (family members etc.) is much higher in smaller farms than in bigger farms.

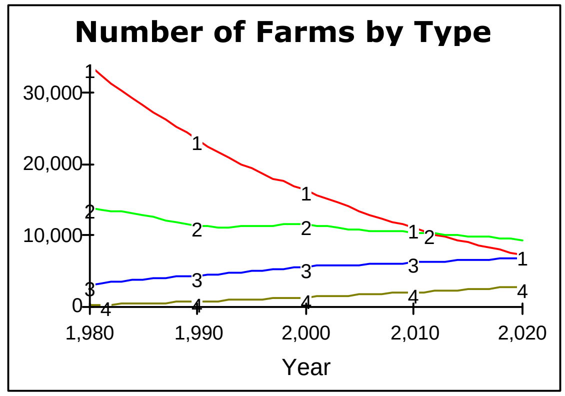
Furthermore, smaller farms tend to have lower crop returns per acre, their marketing is less effective and often they obtain lower prices for their crop.

Scenarios

Scenario 1: Baseline

This scenario assumes no substitution effects among major input goods and no sudden changes in factor productivity. Input amounts per acre as well as input and output prices and average yields remain at the average 1995-1999 level.

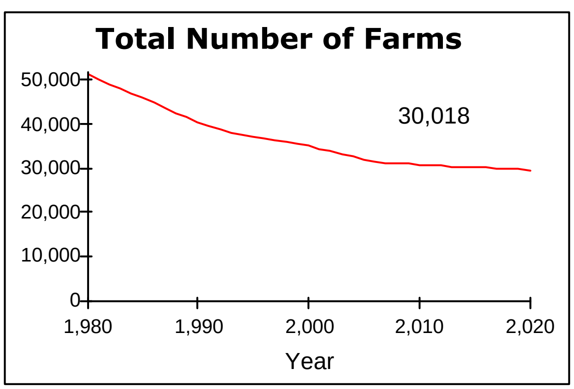


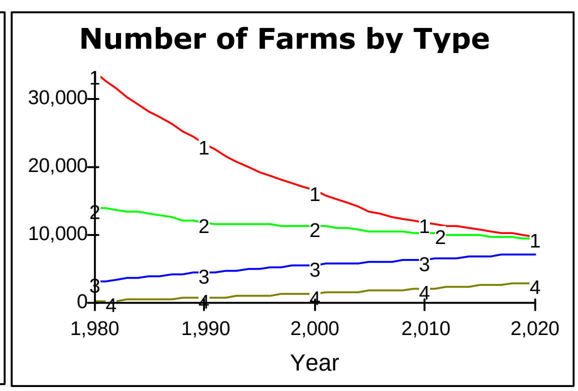


In this scenario the total number of farms continues to decline after 1999, however, the rate of decline decreases over time. The total number of farms in 2020 is 26,956, compared to 35,542 in 2000 and 51,610 in 1980. The number of small farms declines very quickly, the number of Type 3 and Type 4 farms increases slowly.

Scenario 2: Strong Commodity Market

The assumptions are identical with the baseline scenario assumptions, except for the crop prices. In this scenario we assume that the soy price increase to $7.80 between 2004 and 2008 and the corn price increases to $3.10 in the same period. In the simulation, the total number of farms continues to decline after 1999, however, the rate of decline decreases over time. The total number of farms in 2020 is 30,018, compared to the 2020 number of 26,956 in the baseline scenario. The stronger commodity market had a stronger influence on the smaller farms. Their number is proportionally higher than in the baseline scenario, if we compare it with the other farm type numbers.

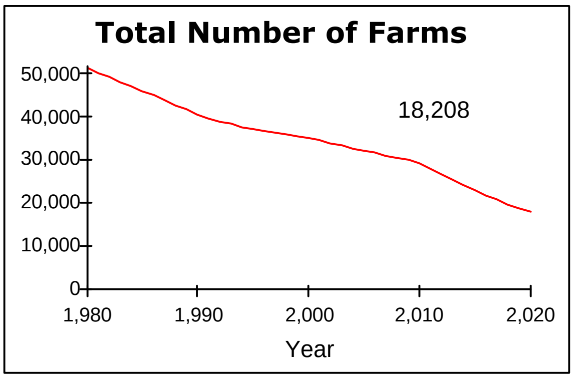


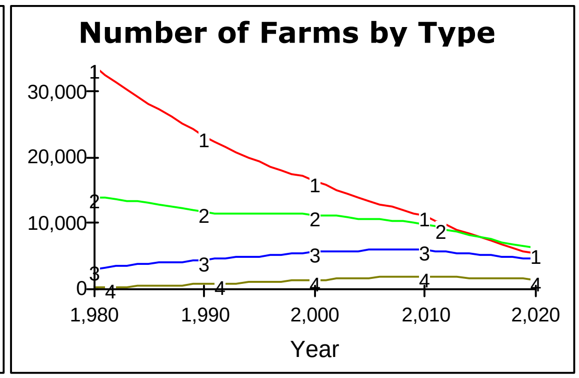


Scenario 3: Strong Commodity Prices

Again the assumptions are identical with the baseline scenario assumptions, except for the input prices. *All* input costs are assumed to grow linearly between 2004 and 2008, due to a price increase. In 2008 they are 10% above the real cost level of 2004, which is the rough average of the 1995-1999 period. No productivity or technology changes are assumed, so the farms are neither able to reduce their input amounts nor do they substitute them, nor do they discover alternative production technologies.

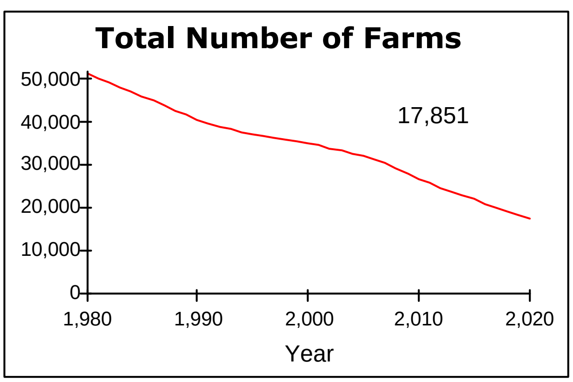
The simulation yields that the total number of farms continues to decline after 1999, however, the rate of decline decreases over time. The total number of farms in 2020 is 18,057, compared to the 2020 number of 26,956 in the baseline scenario. The 10% increase in input prices even stops the increase in the number of the Type III and Type IV farms after 2010. This implies that the average farm size grows quickly after 2010.

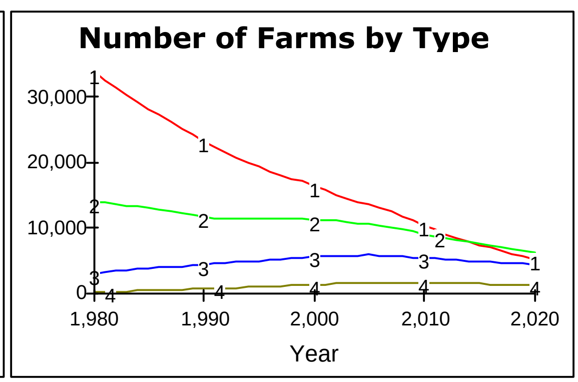




Scenario 4: Higher Machinery Costs

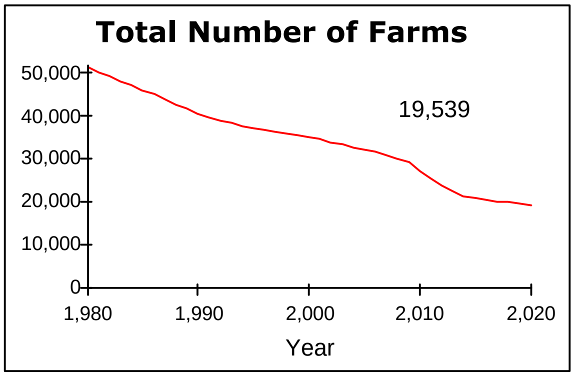
The assumptions are identical with the baseline scenario, however, we assume that fuel prices rise up to $2 in 2003 and cost for machinery repairs, light vehicles and machinery hire are 30% higher from 2003 on than 1995-1999 average level. This increase has a relatively strong effect, as can be seen below. This may seem striking, however, we should keep in mind all other prices are unchanged, i.e. crop prices etc., they all remain the same and do not react.

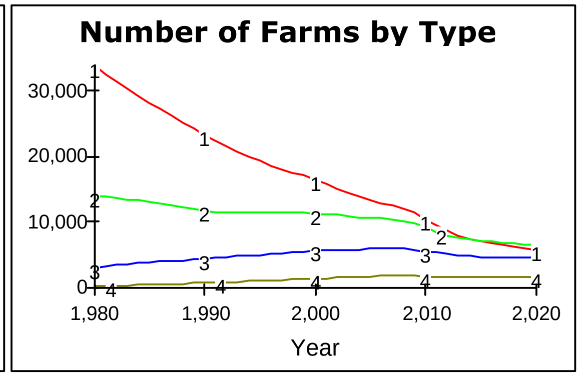




Scenario 5: Reduced Yields

In this scenario we assume, ceteris paribus, that the soy and corn average yield level drops by 15% in the years from 2005 to 2010, inclusive. This leads to a strong decline in the number of farms beginning in 2009; small farms suffer particularly strong. Even in the sector of the bigger farms, a concentrations process takes places between 2011 and 2016, but their number continues to increase afterwards. Notice that the whole process is a lagged one. This can partly be attributed to the use of the 5-year moving average of the *Net Farm Income from Operations Ratio*. For this scenario the model also predicts that about 5% of the acreage is not harvested between 2008 and 2012.





Conclusions

The drop in the total number of farms is accelerated by higher input prices and slowed down by a strong commodity market.

Less favorable economic conditions for farming will have a particularly strong negative effect on the smaller farms. The 5-year moving average Net Farm Income from Operations Ratio of the small farms doesn't improve relative to the bigger farms.

Though a strong commodity market is not able to stop the decline in the number of small farms, it has a somewhat stabilizing effect on the number of small farms.

The future of small farms will depend upon their efficiency to use inputs. Crop returns being generally similar between small and big farms, big farms have a competitive advantage on the input side. Future farming businesses will improve their competitiveness through adoption of input efficient and output increasing technology, such as precision farming. If small farm businesses are not able to keep step with this development, their financial situation will deteriorate. The model shows a great long-term sensitivity in this respect: Even a 20% decrease in fertilizer amounts for the big farms will have detrimental long-run effects for the small farms. Similarly, efficiency questions play an important role. As seen above, smaller farms suffer more from increases in energy prices, since their energy efficiency is lower.

The quick increase in the size of big farms will create a reinforcing loop, increasing the big farms' competitive advantage even more. Small farms, in contrast, will have no chance to increase in size any more. This can already be seen in the still very balanced Scenario 3.

Furthermore, changes in the input supply and product processing sectors will also be beneficial for bigger farms. Those sectors are becoming more concentrated; this will create many possibilities for contracting with big farms; contracting with smaller farms will be significantly less.

References

Agricultural Census. U.S. Department of Agriculture. 1982, 1987, 1992, 1997.

Agricultural Prices. Annual Summary. U.S. Department of Agriculture. 1980-1999.

Christensen, D.A. and E.O. Heady (1983). U.S. agricultural finance response to rising petroleum prices. Energy in Agriculture, 2, 61-74.

Economic Indicators of the Farm Sector, Production and Efficiency Statistics, U.S. Department of Agriculture, selected years 1980-1999.

Illinois Agricultural Statistics 1980-2000. http://www.agr.state.il.us/agstats.htm

R.S. Kingwell and D.J. Pannell (Eds). MIDAS, a bioeconomic model of a dryland farm system. Pudoc, Wageningen, Netherlands 1987.

Lim H, Shumway, C.R. (1997) Technical change and model specification: U.S. agricultural production. American Journal of Agricultural Economics 79:543-54.

Sterman, John D. Business Dynamics—Systems Thinking and Modeling for a Complex World. Irwin McGraw-Hill. Boston 2000.

1980-1999, Summary of Illinois Farm Business Records, Commercial Farms: Production/Costs/Income/ Investments, University of Illinois at Urbana-Champaign Cooperative Extension Service.