How Does Our Garden Grow?

James MacDonald
USDA Economic Research Service

Presentation to the Osher Lifelong Learning Institute, George Mason University, September 30, 2010

What We'll Cover

- Productivity growth in U.S. agriculture
  - The big picture, and some sources of growth
- How U.S. farming is organized
  - Farm size, location, specialization, and organization
- Technology and farming
  - Methods, choices, environmental risks

I. Productivity Growth in Agriculture

- What it is and why it matters
- From the particular to the aggregate
- Drivers: innovations and diffusion

Why Care About Agricultural Productivity?

1935	**2010**
120 million Americans	*300 million Americans*
1200 million acres of farmland	*920 million acres of farmland*
412 million acres of cropland	*422 million acres of cropland*

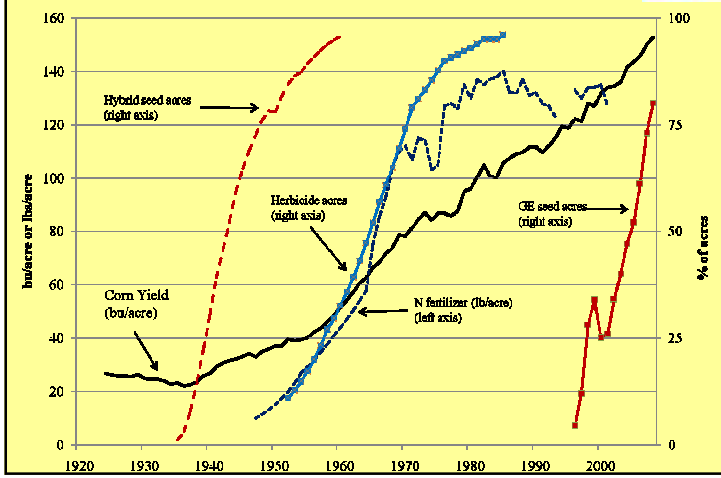
2030

Chinese & Indian Growth, and dietary transition…
Implies greatly expanded demand for meat and feed grains
And for crops used for fuel
Will prices go up? Will we wreck the environment?

Productivity: Let's Start with Corn

88 million acres planted in 2010; used for feed, fuel, food, & industrial applications

U.S. Corn Yields, 1920-2008

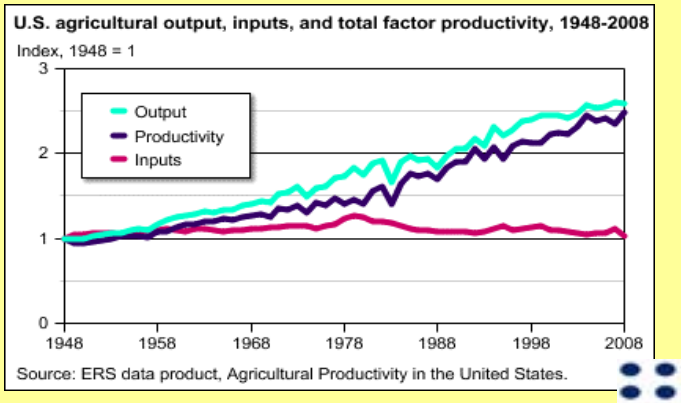


Summary

- Dramatic yield growth through time
- Driven by multiple and successive innovations
  - And rapid diffusion among farms
- Chemicals are one source…
  - They have benefits and risks
- New or better inputs, versus more inputs

Precision Application of Fertilizer, Pesticides, and Herbicides in Louisiana

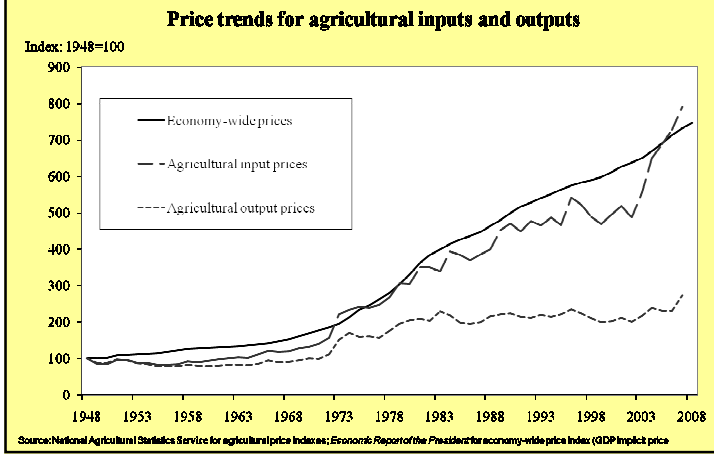
Post-War U.S. Agricultural Sector Productivity



Key Points

- Total output up 160% in 60 years (1948-2008)
- Total inputs up 3% in 60 years
  - Labor down 77%
  - Land down 30%
  - Equipment up 68% (but down since 1980)
  - Ag chemicals up 400% (but down since 1980)
  - Energy up 36% (but down since 1980)

An Implication: Real Farm Prices Fall Over Time



Three More Implications:

- Fewer people in agriculture over time
- Farm prices are a shrinking share of retail food prices
  - Therefore, a shrinking impact
- Benefits from ag productivity growth:
  - Lower prices to buyers (ultimately, consumers)
  - *Less resources (land, capital, materials, labor) used in food production*

II. The Organization of Farming: Three Big Facts

- Production is shifting to larger farms
- Most large farms are small family businesses
- Farms are more specialized and more complex businesses than they used to be

US Farm Structure, 1982-2007

	Farms		Market Value of Sales (billions of 2007 $)	
	1982	2007	1982	2007
Total	2,240,976	2,204,793	189	297
Sales Class	-Distribution of farms and sales, by sales class-			
Less than $10,000	42.6	59.8	1.8	0.9
$10,000-$249,999	50.8	30.7	40.8	14.2
$250,000-$999,999	5.9	7.0	30.0	25.7
$1,000,000 or more	0.7	2.5	27.4	59.2
All	100.0	100.0	100.0	100.0

All estimates are in 2007 dollars (that is, adjusted for inflation)

Source: USDA National Agricultural Statistics Service, Census of Agriculture

Some specifics of the size shift…

- In 1987, the average milk cow was on a farm with 80 milk cows in the herd…
  - By 2007, the average was 570 cows
- In 1987, the average bushel of wheat came from a farm that harvested 404 acres of wheat…
  - By 2007, the average was 910 acres
- In 1987, the average head of lettuce came from a farm that harvested 949 acres of lettuce.
  - By 2007, the average was 1,815 acres

A Large Arizona Dairy Farm

Large Farms are Mostly Family Farms

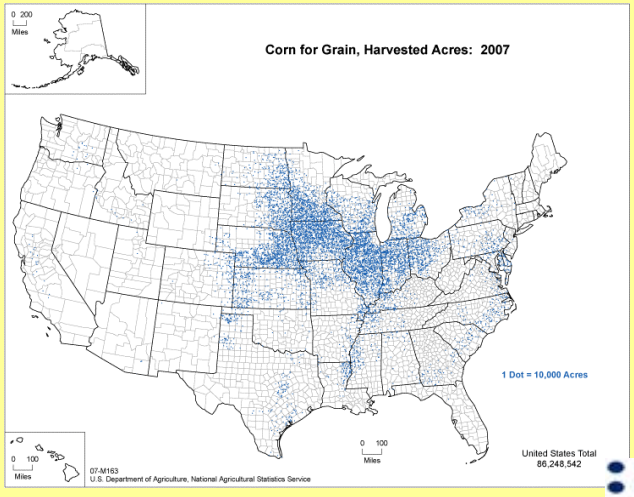
- Family farms (owned and operated)
  - 98% of all farms
  - 85% of all production

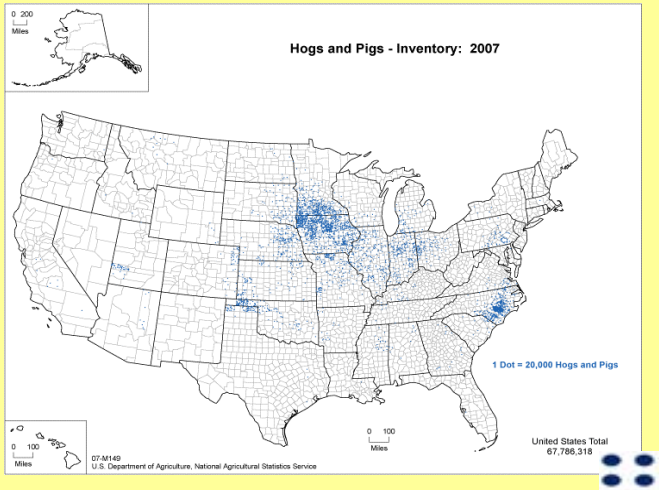
So Where Is Corporate Agribusiness?

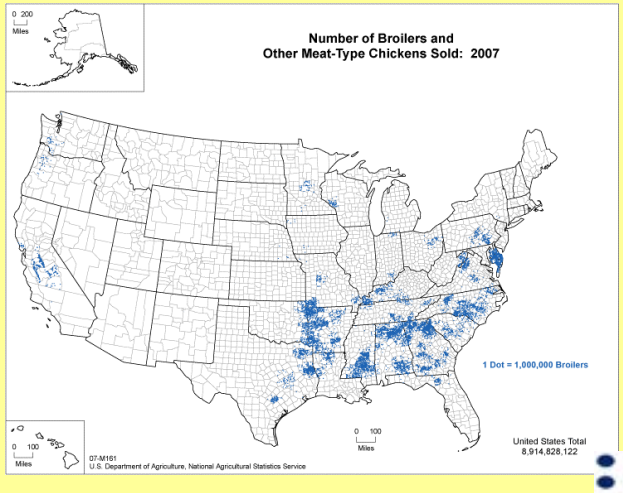
- As production coordinators/integrators
  - Hogs, poultry, some fruits and vegetables
  - Provide inputs to contract growers
- As input producers
  - Seeds and chemicals; equipment; animal genetics
- As product buyers
  - Processors, retailers, wholesalers

Farming is More Specialized (than 50 or 100 years ago)

- Geography
  - Feed (corn, soybeans) in the Corn Belt
  - Livestock at the edges
    - And very localized concentrations
  - Fruit and vegetables on the periphery







Farms Are More Specialized

- Crop operations
  - Usually, 2-4 crops, livestock rare
- Livestock operations
  - Some are livestock only
  - Most still grow corn & grasses (feed)
- Many also specialize in production stages
  - Crops: hire custom service providers
  - Livestock: one stage on a farm

Farms Can Be Complex Businesses: Capital Requirements in Farming

- Land
  - Good Iowa cropland is $4000/acre
- Equipment
  - $250,000-$500,000 for harvester or sprayer
- Housing
  - 4 house GA broiler complex: $870,000
- Breeding livestock
  - High quality milking cow in PA: $1500

How Do Farmers Assemble Assets?

- Rent them
  - 50-60% of cropland is rented
  - Plus equipment, housing, & livestock leases
- Hire them
  - Custom service providers
  - Production contracts (for farmers' growing services)
- Borrow and purchase (debt is important)
- Bring in equity providers

Managing Risks is Really Important

- For marketing and revenues
  - Hedging directly, and through contracts & cash commitments, storage, and diversification
- For production practices
  - Choose chemicals, feeding, seeding to minimize risks of crop failure
- For politics
  - Farmers organize, for risk management and for income enhancement

III. Technology on the Farm

- What do farmers need to provide?
- How do they provide it?
- I'm going to focus on a few examples

What do crops need?

- Seeds
- Soil & sun
- Crop nutrients
  - Water, N, P, K
- Crop protection

How are needs delivered?

- Genetics
- Chemicals
- Biologicals
- Equipment
- Management

An Example: Crop Protection

Protection from what?

- Insects
- Weeds
- Plant diseases

Protection how?

- Chemicals
  - Herbicides, pesticides, fungicides
- Biologicals
  - Bugs that eat bugs; Antibiotics
- Equipment
  - Tillage; Precision agriculture
- Management
  - Crop rotations; Buffers/refuges
- Genetics
  - Breed resistant seeds

An Example: Genetically Engineered (GE) Seeds

Percent of acres planted with GE seeds

Crop	1996	2010
Corn	4	86
Cotton	20	93
Soybeans	8	93

GE: seeds that have had a gene from another plant species inserted in them.

What do GE seeds do?

- Pest resistant (Bt) and herbicide tolerant (HT)
  - Reduce pesticide use
  - Shifts herbicide use
    - One application, less toxic
- Save farm operator time, as well as expense
  - Farm more acres?
- Creates weed resistance?
  - But resistance ought to be managed
- Allows for conservation tillage

Tilling, on the contour, in the 1930's

No-Till Planting on the Contour in Iowa

What's conservation tillage?

- Reduced tillage (up to no-till) to:
  - Retain residues from previous crops
  - Reduce soil erosion
  - Limit run-off (of chemicals and soil)
  - Improve soil quality
- How are GE seeds tied to conservation tillage?
  - No-till goes from 20 to 65 million acres as GE crops expand

Why Limit Run-Off?

- Chemical pesticides & fertilizers; manure
  - Excess N, P, K: that not taken up by plants can reduce water quality
  - If volatilized, can reduce air quality
  - Manure can also contain pathogens
  - Pesticides contain toxics
  - And runoff carries topsoil off as well

So How Do You Limit Run-Off?

- Seeds and no-till were one example
- Equipment
  - Precision ag to focus/reduce chem applications
- Field and crop management
  - Rotations to limit chemical applications
  - Stripping & contouring to limit erosion & run-off
- Land investment
  - Terracing & tiling--drainage investments

Contour Strip-cropping of Corn and Alfalfa in Minnesota

To Sum Up…

- Farmers use chemicals, seed genetics, equipment, capital investment, and management to protect crops and raise production…
- …while confronting environmental risks

Another Example: Irrigation on the Farm

- Here's the basics:
  - 16 percent of harvested U.S. cropland is irrigated
  - But irrigated acreage generates nearly half of the value of all crops sold
  - And agriculture accounts for over 80 percent of water consumed in U.S.
  - Major interest in conservation & efficiency

Irrigation circles for wheat, alfalfa, potatoes, and melons in Oregon

Irrigation in Yuma, AZ

Level furrow

Drip

Technology in Animal Agriculture: Major Issues

- Breeding/Genetics
- Feeds
- Manure Management

Some Background

- Broiler chickens
  - 1955: 73 days to produce a chicken, at 2.85 pounds of feed for each pound of meat.
  - 2006: 35 days, and feed conversion is 1.85
- Market hogs
  - 1992: feed conversion is 3.83 (lb. feed per lb. gain)
  - 2004: feed conversion is 2.65
- Dairy manure
  - 1950: 250 million lbs/day
  - 2000: 123 million lbs/day

How Does This Happen?

- Breeding
- Feed and feed formulations
- Housing
  - Comfort, sanitation, and climate controls

A Rotary Milker In New York

A Sow Complex in Ohio

2400 sows
birth 50,000 pigs each year, which are then raised on contract farms

This is Industrial Livestock Production: What are the Problems?

- Uniformity and taste?
- Antibiotics
  - Widely used in beef, pork, and poultry
  - Treatment, prevention, and growth promotion
  - Does this contribute to resistance and health risks?
- Manure:
  - Less per pound of meat, but it's all in one pla
  - What are the environmental and health risks?

Hog Barns and Lagoon in Georgia

Manure: What Can Be Done?

- Expanding Federal and State manure regulations
  - Governing storage and land application
- Creates expanded interest in:
  - Feed & breeding alternatives to minimize wastes
  - Expanded land application
  - Energy applications

What's Happening with Animal Antibiotics?

- Statutory proposals, retailer pressure, and regulatory shifts
- The science is very complicated…
- But I see efforts to reduce feeding antibiotics
  - Development of vaccines
  - Sanitation and testing procedures
  - Feed formulations

Technology Summary

- There's a lot of ways to produce most commodities
- Production can generate significant social costs
  - Environmental & public health risks
- How do we limit risks and feed the world?
  - When do farmers have the right incentives?
  - When do we need to regulate farm practices?

Conclusions

- Farms are small businesses
  - Neither corporate behemoths nor poor peasants
- Farm productivity growth has been dramatic
  - And needs to be in the future
  - Primarily based on technological innovations, and their diffusion
- Farmers respond to incentives
  - And there are lots of ways of producing farm commodities

Contacts

- Jim MacDonald, USDA/ERS
  - macdonal@ers.usda.gov ; 202-694-5610
- ERS website
  - http://www.ers.usda.gov/
- NASS (National Agricultural Statistics Service) website: http://www.nass.usda.gov/index.asp

U.S. Structural Change: Livestock

The midpoint farm size:
half of production is on larger farms

Livestock	1987	2007
	Herd size	
Dairy	80	570
	Head Removed	
Broilers	300,000	681,600
Hogs	1,200	30,000
Fattened Cattle	17,532	35,000
Cattle, <500 lbs	50	128

Source: USDA National Agricultural Statistics Service, Census of Agriculture

Field Crop Production Shifts to Larger Farms

The table shows the center of production, by acres. Half of all acreage is on larger operations, and half on smaller.

Crop	*1987*	*2007*
	-Harvested acres-	
Corn	200	600
Soybeans	243	490
Wheat	404	910
Cotton	450	1090
Rice	295	700

Source: Census of Agriculture microdata

The Trend is not Confined to Field Crops

Florence medians, (weighted by harvested acres).

Selected Crops	*1987*	*2007*
	-Harvested acres-	
Asparagus	160	240
Lettuce	949	1815
Tomatoes	400	820
Apples	83	146
Almonds	203	450
Oranges	450	1113

Source: Census of Agriculture microdata

Timing guide

- Intro/Section 1: 12 slides, 16 minutes (12:01)
- Section 2: 14 slides, 19 minutes (12:20)
- Section 3a: 15 slides, 24 minutes (12:44)
- Section 3b/close: 12 slides, 21 minutes (1:05)