United States Department of Agriculture

U.S. Agricultural Productivity: Measurement, Data, and Sources of Growth

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Overview

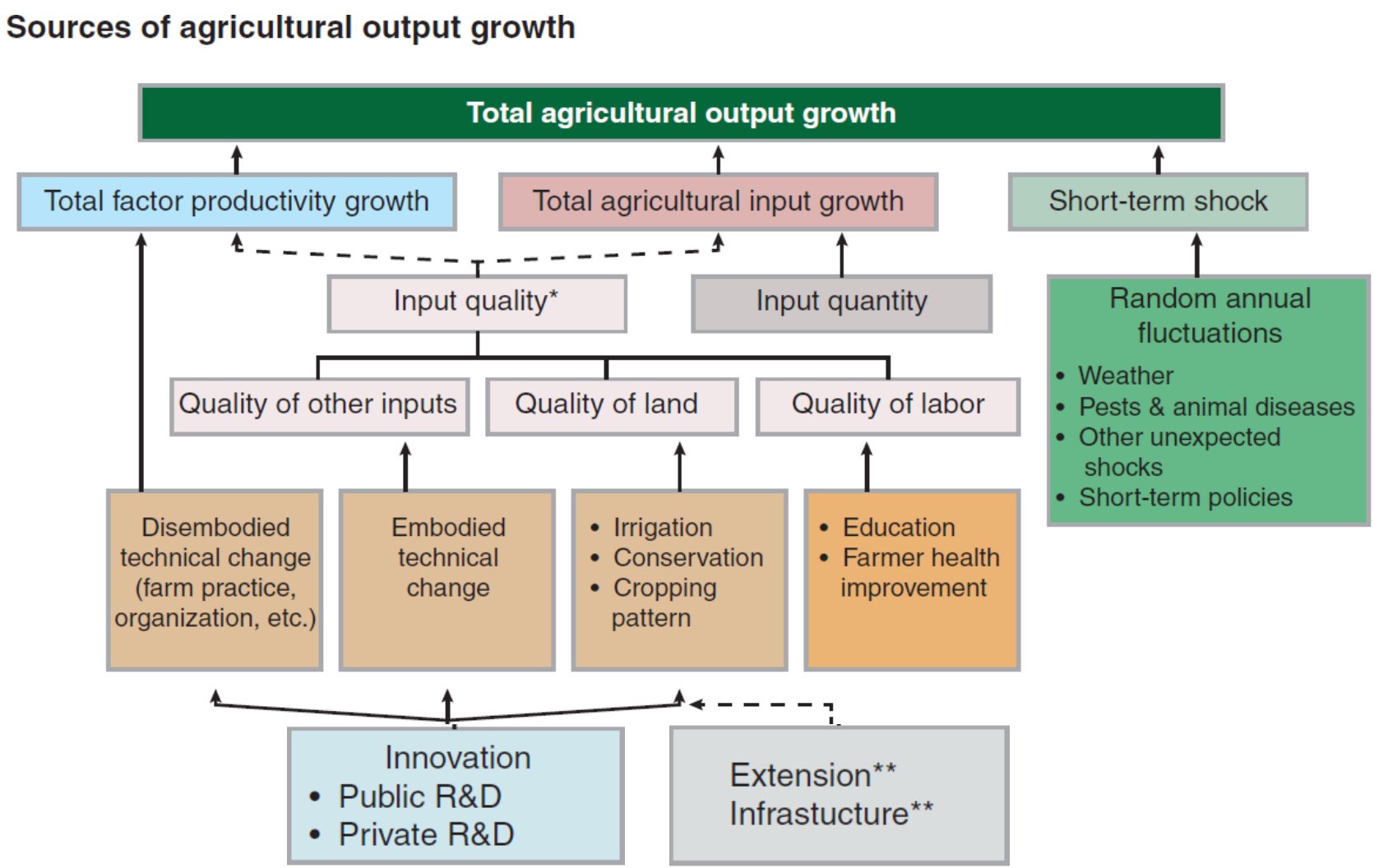
- The U.S. Department of Agriculture (USDA) has been monitoring the farm sector's productivity performance for decades.
- In 1960 the USDA's Economic Research Service (ERS) was the first agency to introduce multifactor productivity measurement into the Federal statistical system.
- Today, having incorporated recommendations made by an **AAEA taskforce (USDA, 1980)** and by a second more recent panel (see **Shumway et al., 2017**), the USDA bases its official productivity statistics on a sophisticated system of production accounts.

Outline

In this presentation I will:

- ❑ Introduce the production accounts used to measure U.S. agricultural productivity statistics;
- ❑ Summarize the data sources and some challenges;
- ❑ Present findings from the recent productivity accounts updates;
- ❑ Address sources of growth in U.S. agriculture;
- ❑ Talk about our ongoing research projects and how we communicate with the public regarding our productivity statistics and research findings.

Sources of Agricultural Output Growth



Source: Wang et al. (2015), USDA-Economic Research Service.

Measurement

Production Accounts (I)

- The USDA has constructed production accounts for the farm sector consistent with a gross output model of production.
- Output is defined as gross production leaving the farm, as opposed to real value added.
- Inputs are not limited to labor, and capital, but include intermediate inputs as well.

Production Accounts (II)

- The USDA defined the farm sector in the same way as in the National Income and Production Accounts (NIPA); minor goods and services (i.e.. secondary outputs) that are primary to other industries were included in the primary industry's output.
- We take the existence of certain (inseparable) secondary activities into account when measuring the productive activity of the sector.
- These secondary activities are defined as activities whose costs cannot be separately observed from the primary agricultural activity.

Outputs (I)

- Translog indexes of farm output are formed by aggregating over agricultural goods and the output of goods and services of inseparable secondary activities, using revenue share weights based on shadow values.
- For each category of output, the quantities include quantities sold off the farm, additions to inventory, and quantities consumed in farm households.

Outputs (II)

- The corresponding price reflects the value to the producer; that is, subsidies are added and indirect taxes are subtracted from market values.
- Outputs are grouped into three broad categories:
  - Crops—Food grains, Feed crops, Oil crops, Vegetables and melons, Fruits and nuts, and other crops
  - Livestock—Meat animals, Dairy, Poultry and eggs
  - Other farm related

Inputs

- Indexes of inputs are formed by aggregating over individual agricultural inputs using cost-share weights.
- Inputs are grouped into three broad categories
  - Labor—self-employed vs. hired
  - Capital—depreciable assets (durable equipment, and service buildings), land, and inventory
  - Intermediate goods—feed and seed, energy, fertilizer and lime, pesticides, purchased services, other intermediate.

Labor

- Current U.S. farm sector labor accounts incorporate the demographic cross-classifications of the agricultural labor force (Jorgenson, Gollop, and Fraumeni (1987))
- We construct Tőrnqvist-Theil indexes of price and quantity of hired labor, and self-employed and unpaid family workers based on the cross-classified demographical information.
- As a result, the price and quantity series for labor input are measured in constant-efficiency units, which are adjusted for compositional shifts (or "quality" change in the labor force)

Capital

- The index of capital input is formed by aggregating over the various capital assets using cost-share weights based on asset-specific rental prices.
- Construction of these series begins with estimating the capital stock and rental price for each component of the capital input.
- For depreciable assets, the perpetual inventory method is used to develop capital stocks from data on investment.
- For land and inventories, capital stocks are measured as implicit quantities derived from balance sheet data.

Capital—Depreciable assets (I)

- Measurement of capital input begins with estimating the capital stock and rental price for each asset type.
- Under the perpetual inventory method (PIM), the capital stock at the end of each period is measured as the sum of past investments, each weighted by its relative efficiency, d_τ.

$$K_t = \sum_{\tau=0} d_\tau I_{t-\tau} \qquad (1)$$

- Implicit rental prices are calculated for each asset type using the expected real rate of return (ex ante real rate) following an Autoregressive Integrated Moving Average (ARIMA) process (see Ball et al. (2016) for details).

Capital—Depreciable assets (II)

- The implicit rental price of capital is calculated as

$$c = \frac{w_k r}{(1-F)} \quad (2)$$

Where

- w_k denotes the price the firm must pay for a new unit of capital,
- *r* is the real rate of return, which is calculated as nominal yield on investment grade corporate bonds less the rate of asset price inflation (i.e., capital gain),
- *F* denotes the present value of the stream of capacity depreciation on one unit of capital according to the mortality distribution (see Ball et al. (2016) for details).

Capital—Land

- To estimate the stock of land, we construct price and implicit quantity indexes of land in farms.
- We assume that land in each county is homogeneous, hence aggregation is at the county level.
- To obtain a constant-quality stock of land, we compile data on acres of land in farms and average value (excluding buildings) per acre for each county in each state using information from the Census of Agriculture. Intermediate years are interpolated.
- The cost of land service flows is derived using the accounting identity with the value of total product is equal to the total factor outlay.

Capital—Inventory

- Beginning inventories of crops and livestock are treated as capital inputs.
- The number of animals on farms is available from annual surveys, as are the stocks of grains and oilseeds.
- December average prices are used to value commodities held in inventory
- The user cost of inventories is obtained using equation (2), assuming zero decay.

Intermediate Goods

- Intermediate goods consist of all goods and services used in production during the calendar year, including feed and seed, chemicals, energy, and purchased services.
- An important innovation is the use of hedonic price indexes in constructing measures of fertilizers and pesticide consumption, as well as purchased contract labor services.
- A translog index of total intermediate input is constructed for the aggregate farm sector by weighting the growth rates of each category of intermediate input by their value shares in the overall value of intermediate input.

Total Factor Productivity (TFP)

- The USDA model of productivity growth is based on a translog transformation frontier
- It relates the growth rates of multiple outputs to the cost-share weighted growth rates of labor, capital, and intermediate inputs.
- Total factor productivity (TFP) is measured as total agricultural output per unit of aggregate input, with each adjusted for price changes.
- TFP growth is the difference between the growth of aggregate output and the growth of all inputs taken together.

Data

Data Sources (I)

- Data used to construct the accounts come from various sources.
- We use value and quantity of production, marketing, and inventory changes from the ERS farm income balance sheet and from NASS surveys.
- To construct appropriate price indices to deflate nominal dollar values of disaggregated outputs and individual input categories we draw on various public sources, including NASS, BEA, BLS, U.S. Bureau of Reclamation, Department of Energy.

Data Sources (II)

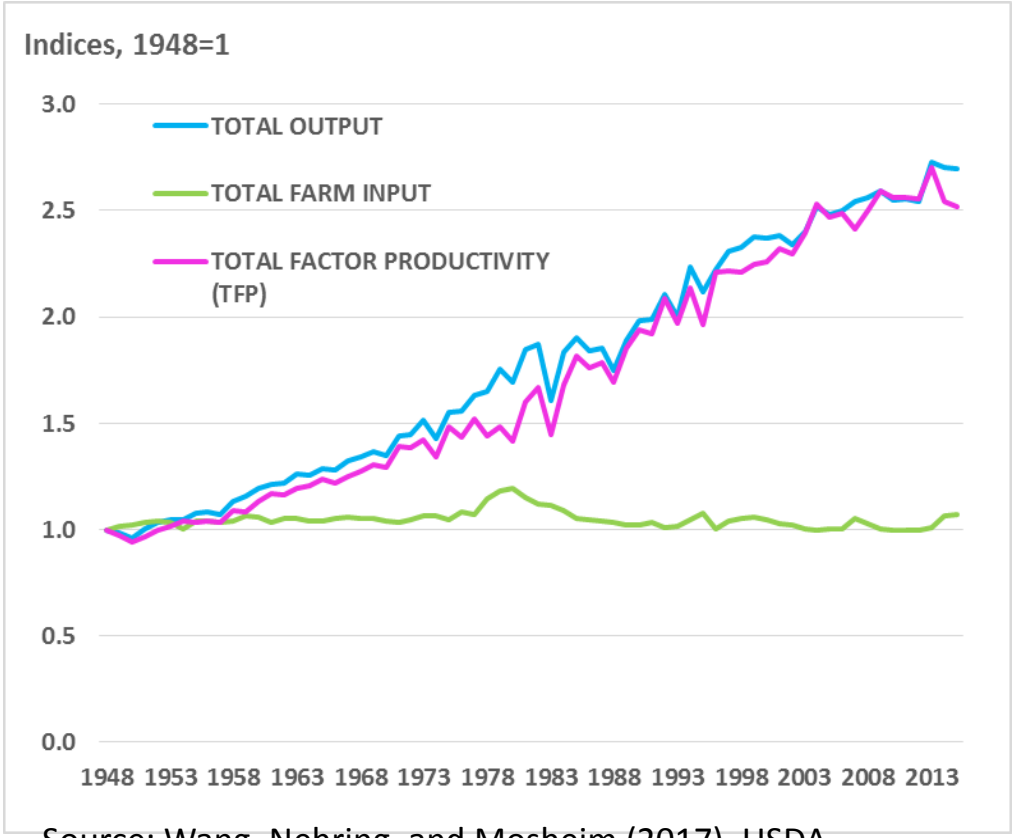
- To construct quality-adjusted prices for agricultural chemicals we use data from the private firms GfK Kynetec AgroTrak database (formerly Doane Marketing Research) and AMIS (AgrAspire - Crop Protection & Seed) along with NASS data.
- To construct quality-adjusted prices for farm workers and purchased contract labor services we also employ micro data from the American Community Survey (ACS), the Census of Population, the National Agricultural Worker Survey (NAWS), and the Agricultural Resource Management Survey (ARMS).

Challenges

- When survey data is discontinued;
- When source data is revised or inconsistent;
- When the definition or measurement of source data is modified

Findings and Sources of Growth

Findings (I)

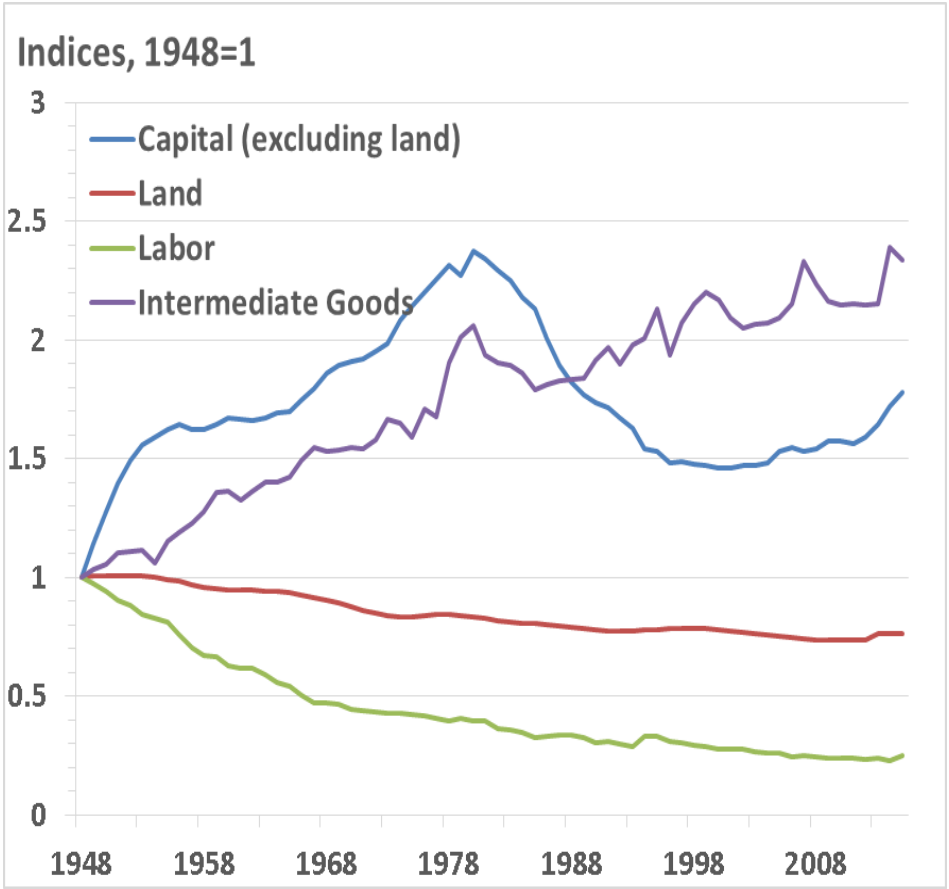


Source: Wang, Nehring, and Mosheim (2017). USDA, Economic Research Service.

Between 1948 and 2015:

- ❑ Agricultural output grew at an average annual rate of 1.48%.
- ❑ Total input use grew at an average annual rate of 0.1%.
- ❑ TFP growth accounted for almost all output growth during the period, growing at 1.38% per year.

Findings (II)



Source: Wang, Nehring, and Mosheim (2017). USDA, Economic Research Service.

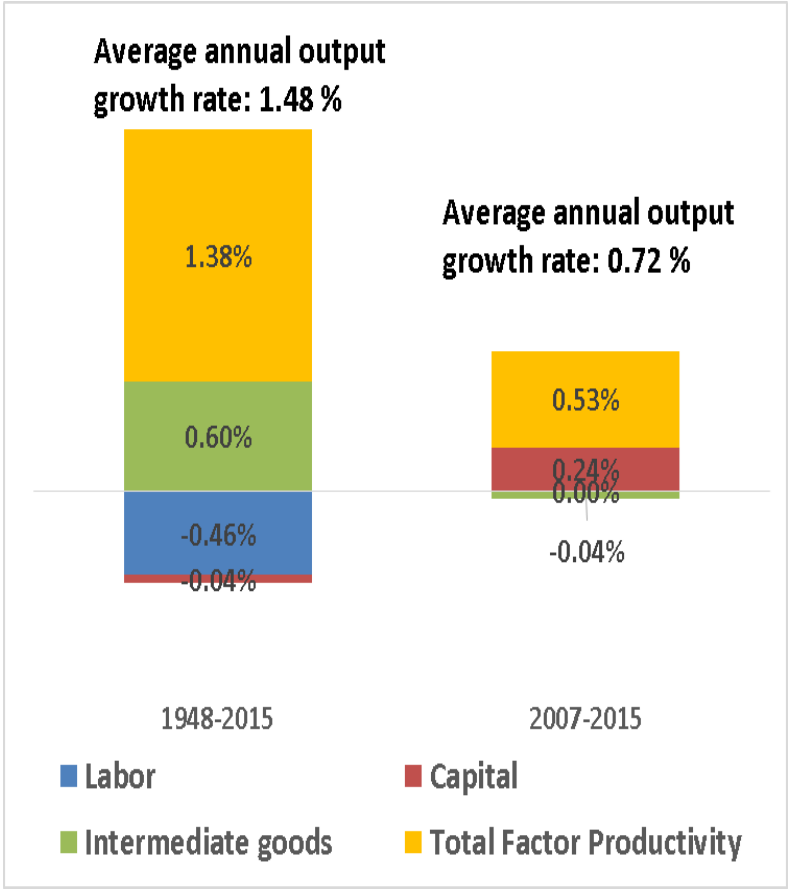
- While aggregate input use only increased slightly during the 1948-2015 period, its composition changed dramatically.
- Between 1948 and 2015,
  - Intermediate goods increased by 134 percent
  - Capital (excluding land) increased by more than three quarters
  - Labor use declined by 75 percent
  - Land use declined by nearly a quarter

Sources of Growth by Cyclical Subperiod

	1948-2015	1948-1953	1953-1957	1957-1960	1960-1966	1966-1969	1969-1973	1973-1979	1979-1981	1981-1990	1990-2000	2000-2007	2007-2015
Output growth	1.48	0.96	0.49	3.72	1.12	2.24	2.50	2.45	2.57	0.79	1.79	1.03	0.72
Sources of growth													
Input	0.10	0.66	-0.03	0.75	-0.09	0.00	0.36	1.69	-1.21	-1.32	0.24	0.11	0.20
Labor	-0.46	-0.83	-1.11	-0.88	-0.86	-0.65	-0.41	-0.19	-0.23	-0.45	-0.23	-0.38	0.00
Capital	-0.04	0.57	-0.02	0.00	0.04	0.16	-0.10	0.23	0.11	-0.78	-0.17	-0.12	0.24
Intermediate goods	0.60	0.92	1.10	1.62	0.73	0.48	0.87	1.65	-1.09	-0.09	0.64	0.60	-0.04
TFP	1.38	0.30	0.52	2.97	1.20	2.24	2.14	0.75	3.79	2.11	1.55	0.92	0.53
Sources Decomposition													
Labor													
Hours	-0.57	-1.06	-1.24	-0.92	-1.14	-0.95	-0.46	-0.21	-0.20	-0.52	-0.41	-0.40	-0.08
Quality	0.12	0.23	0.12	0.04	0.28	0.30	0.05	0.01	-0.03	0.07	0.18	0.02	0.08
Capital													
Stocks	0.03	0.99	0.06	-0.09	0.05	0.16	-0.05	0.48	0.16	-0.75	-0.25	0.00	0.29
Quality	-0.07	-0.42	-0.08	0.09	-0.01	0.00	-0.05	-0.25	-0.06	-0.03	0.08	-0.12	-0.06
Intermediate goods													
Quantity	0.64	1.01	0.91	1.74	0.76	0.26	0.98	1.89	-1.51	-0.02	0.61	0.63	0.15
Quality	-0.04	-0.09	0.20	-0.12	-0.03	0.23	-0.11	-0.24	0.41	-0.07	0.03	-0.03	-0.19

Source: Wang, Nehring, and Mosheim (2017). USDA, Economic Research Service.

Summary of Sources of Growth



Source: Wang, Nehring, and mosheim (2017). USDA, Economic Research Service.

- Over the full 1948-2015 period, the contraction in labor input contributes an annual average -0.46 percentage points per year to output growth.
- Intermediate goods' contribution averaged a substantial positive rate of 0.60 percent per year.
- The net contribution of all three inputs was 0.1 percentage points per year, leaving the rest of growth in farm sector output to productivity growth
- Increased labor quality made a positive contribution to output growth, averaging 0.12 percentage points per year.
- Short-term sources of growth can differ from the long-term average. During the 2007-15 subperiod, increased capital input use contributed 0.24 percentage points to the annual agricultural output growth of 0.72 percent, second to TFP's contribution (0.53 percent).

Ongoing Research Projects

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Communications

Ongoing Research Projects

- Quality-adjusted input prices—land, labor, agricultural chemicals, capital, purchased services;
- Bilateral agricultural productivity analysis for US-China;
- Causes and effects of productivity growth;
- State productivity analysis;
- Long-lived livestock capital estimates

Communications

- ERS webpage
- ERS Publications
- External Publications
- Conferences

References

- Ball, Eldon, Sun Ling Wang, Richard Nehring, and Roberto Mosheim. 2016. Productivity and Economic Growth in U.S. Agriculture: A New Look. *Applied Economic Perspectives and Policy* (2016) vol. 38, number 1, pp.30-49.
- Jorgenson, Dale., Frank M. Gollop, and Barbara M. Fraumeni. 1987. Productivity and U.S. Economic Growth. Cambridge, MA: Harvard University Press.
- Shumway, C. Richard, Barbara M. Fraumeni, Lilyan E. Fulginiti, Jon D. Samuels, and Spiro E. Stefanou. 2017. Measurement of U.S. Agricultural Productivity: A 2014 Review of Current Statistics and Proposals for Change. Contractor and Cooperator Reports No. (CCR-69), August 2017. USDA, Economic Research Service.
- Wang, Sun Ling, Paul Heisey, David Schimmelpfennig, and Eldon Ball. *Agricultural Productivity Growth in the United States: Measurement, Trends, and Drivers.* USDA, Economic Research Service, July 2015.
- Wang, Sun Ling, Richard Nehring, and Roberto Mosheim. 2017. Agricultural Productivity in the U.S., USDA, Economic Research Service. http://www.ers.usda.gov/data-products/agricultural-productivity-in-the-us/uses-and-publications.aspx

Questions/Comments

U.S. agricultural productivity statistics
http://www.ers.usda.gov/data-products/agricultural-productivity-in-the-us.aspx

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Labor—Demographical Characteristics

- The compensation and labor hours of labor input are cross-classified by **two** sexes, **eight** age groups, **six** (**five** in the pre-1980 dataset**)** educational groups, and **two** employment classes.
- In total, Matrices with **192** elements (**160** in the pre-1980 dataset**)** are compiled for hours worked and compensation per hour, based on data drawn from the decennial Census of Population, American Community Survey, Current Population Survey, and BEA's National Income and Product Accounts.

Sex		
(1) Male		
(2) Female		
Age:		
(1) 14--15 years	(2) 16-17 years	(3) 18-24 years
(4) 25-34 years	(5) 35-44 years	(6) 45-54 years
(7) 55-64 years	(8) 65 years and over	
Education:		
(1) 1-8 years grade school	(2) 1-3 years high school	
(3) 4 years high school	(4) 1-3 years college	
(5) 4 years college	(6) more than four years college	
Employment class:		
(1) Wage/salary worker		
(2) Self-employed/unpaid family worker		

ERS data webpage

(https://www.ers.usda.gov/data-products/agricultural-productivity-in-the-us.aspx)

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Agricultural Productivity in the U.S.

This data set provides estimates of productivity growth in the U.S. farm sector for 1948-2015, and estimates of the growth and relative levels of productivity across U.S. States for 1960-2004.

Note that the national data series has been revised (see Update and Revision History for details), and updates of the State-level statistics are suspended in light of reduced ERS resources and the discontinuance of key source data series. The quality of the national statistics is preserved.

- National Tables, 1948-2015
- CSV Format of National Data
- State-Level Tables, Relative Level Indices and Growth, 1960-2004-Outputs
- State-Level Tables, Relative Level Indices and Growth, 1960-2004-Inputs
- State-Level Tables, Relative Level Indices and Growth, 1960-2004-Total Factor Productivity
- State Ranking Tables
- State-Level Tables, Price Indices and Implicit Quantities of Farm Outputs and Inputs by State, 1960-2004

Data Set	Last Updat-ed	Next Up-date
National Tables, 1948-2015		
Table 1. Indices of farm output, input, and total factor productivity for the United States, 1948-2015	10/10/2017	
Table 1a. Price indices and implicit quantities of farm output and inputs for the United States, 1948-2015	10/10/2017	
Table 2. Sources of growth: U.S. farm sector (average annual growth rates, percent), 1948-2015. Includes decomposition into quantity and quality of inputs.	10/10/2017	