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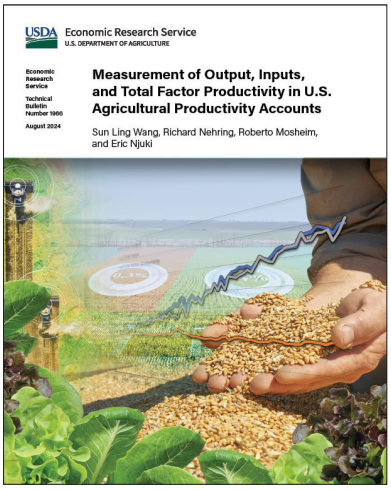
Measurement of Output, Inputs, and Total Factor Productivity in U.S. Agricultural Productivity Accounts

Sun Ling Wang, Richard Nehring, Roberto Mosheim, and Eric Njuki



What Is the Issue?

This report addresses major issues on how USDA, ERS measures output, inputs, and TFP in its U.S. agricultural productivity accounts and how input quality changes are accounted for in the measurement. Agricultural productivity is an indicator that can provide information on the performance of the farm sector. Productivity can be measured by a single factor, like crop production per acre of land (crop yield). However, such measures can be misleading, as the measures can increase through additions to production inputs and not necessarily from technical improvement. In the 1960s, USDA, Economic Research Service (ERS) was the first agency to introduce the total factor productivity (TFP) measurement into the U.S. Federal statistical system. TFP measurement accounts for the use of all inputs under the farm operator's control. TFP growth is the difference between the growth of aggregate output and the growth of all inputs taken together. It measures changes in the efficiency with which inputs are transformed into outputs. However, input quality may change over time. It is necessary to measure inputs in their constant quality unit to avoid overstating the contribution of TFP to agricultural growth. Today, USDA, ERS bases its U.S. agricultural productivity statistics on a sophisticated system of production accounts. Input measures are adjusted for changes in their quality, such as improvements in the efficacy of chemicals or changes in the demographics of the farm workforce.

What Did the Study Find?

Productivity growth is the major driver of U.S. agricultural growth. Between 1948 and 2021, total U.S. farm output grew by 1.46 percent per year. With total inputs (including land, labor, capital, and intermediate inputs) declining slightly by -0.03 percent annually, total factor productivity grew at 1.49 percent per year, single-handedly driving farm output growth over the seven-decade period. In 2021, total farm output was about 2.9 times its 1948 level. Over time, the input composition has changed, shifting from labor and land to more usage of intermediate inputs and durable capital assets. During the period, input quality changes in labor, capital (including land), and intermediate inputs contributed positively to annual output growth by 0.11, 0.04, and 0.04 percentage points, respectively.

Fertilizers and pesticides have undergone significant changes in input quality. Over the decades, U.S. farmers have increasingly relied on intermediate inputs, such as chemical fertilizers and pesticides, in farm production. Fertilizers used in the U.S. agricultural production process include more than 50 different combinations of major fertilizer elements (nitrogen (N), phosphorus (P), and potassium (K)) and have undergone significant changes in quality over time. Pesticides have also altered their potency, persistence, toxicity, absorption rate, and application rate. USDA, ERS measures quality-adjusted prices and quantities for fertilizer and pesticide inputs. The results show that in 2019, the estimates of quality-adjusted and unadjusted fertilizer quantities were 2.5 times and 2 times (respectively) their 1948 level and 15 times and 8 times (respectively) for quality-adjusted and unadjusted pesticide quantities.

The quality of purchased contracted labor services has improved during the study period. USDA, ERS researchers estimated a wage function in terms of worker's years of farmwork experience, gender, educational attainment, language skill, legal status, and related controlled variables. The results show that estimated prices more than doubled in the last three decades. Among the six regions (see figure 6 for the list of regions), California ranked first in the relative level of quality-adjusted price of purchased contracted labor services in 1989, with the Southwest region ranking last. The Southwest region remained at the lowest level for more than 30 years, and the Northwest region's price surpassed California's and became the highest in 2019.

USDA, ERS has adopted an index number approach to measure quality-adjusted prices and quantities for labor and land in U.S. agricultural productivity accounts. With a composition shift among demographic characteristics (including age, educational attainment, gender, and employment type) labor quality has improved over time, contributing an average of 0.11 percentage points to output growth annually between 1948 and 2021. This contribution has been primarily due to higher educational attainment among workers. Land composition has shifted as well, with some higher-value land being reallocated to other uses. As a result, the measured land quality was reduced throughout the period, along with a land quantity reduction. In addition, urbanization and industrialization may have pulled away some more desirable farmland of better quality or with higher prices playing a role in the reductions.

How Was the Study Conducted?

USDA, ERS economists developed various models to measure quality-adjusted prices and quantities for various inputs in the U.S. agricultural productivity accounts. Researchers drew data from different sources, including published and unpublished data from Government statistical agencies and private sectors. Detailed sources of data are described in the box "Major Data Sources for the U.S. Agricultural Productivity Accounts" in the Introduction section.