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Problems and Objectives

Since George Stockton Berry designed, built, and operated the first self-propelled combine in 1886, the evolution of farm machinery has transformed and enhanced farm operation performance by increasing speed, scale, efficiency and reliability. When purchasing farm machinery, farmers have benefited from embodied technical change that promotes agricultural productivity growth. According to the USDA/ERS productivity accounts, over the 1948 to 2011 period, agricultural output grew at an average 1.49% annual rate with only a slight growth in inputs averaging only 0.07% per annum. The result is that total factor productivity (TFP) growth accounts for most of output growth at an average 1.42% annual growth rate. While estimates of TFP thus capture the change in output growth that cannot be explained by input growth, Griliches and Jorgenson (1966) suggest that we should try to understand or explain sources of productivity growth. If embodied technical changes or quality changes of various inputs could be quantified then the residual could be attributed to disembodied technical change on the output side.

One way to account for embodied technical change in farm machinery is to construct quality adjusted price and quantity indices based on hedonic measurement. In the hedonic framework a good or service is viewed as a bundle of characteristics which contribute to output or utility derived from its use. Accordingly, the price of the good or service represents the valuation of the characteristics “that are bundled in it”, and each characteristic is valued by its implicit price (Rosen, 1974). Unfortunately, these prices are not observed directly and must be estimated from the hedonic price function.

A hedonic price index was first developed by Court (1939) in a study of automobile characteristics. Since Griliches readdressed this issue in 1961 hedonic measurement has been widely used in studies regarding quality adjusted price measurement, such as Rosen (1974), Nelson, et al. (1994), Triplett (1987, 1989), and Fernandez-Cornejo and Jans (1995). Yet, there has been little work done for agricultural farm machinery based on this approach. As Nelson (1974) mentioned, “failure to adjust for changes in price resulting from an improvement in quality will lead to biased estimates of the true rate of inflation”. Since the inflation rate is important in constructing the real capital investment series, capital stock, and thus the rental service flow in productivity measurement, a biased price index may fail to capture the quality change or the embodied technical change for farm machinery over time and overstate disembodied technical change as a result.

Therefore, the purpose of this project is three-fold: first, to understand the evolution of self-propelled farm machinery, including tractors and combines over time; second, to construct quality adjusted price and quantity indices for different types of farm machinery; and third, to decompose the
farm machinery quantity changes into embodied-technical change and physical quantity change and their impacts on U.S. agricultural productivity measures.

Methodology

Following Griliches (1961), Rosen (1974), Triplett (1989, 2004), Fernandez-Cornejo and Jans (1995), we apply the hedonic method in constructing quality-adjusted price indices for agricultural machinery. A hedonic function of machinery characteristics, such as horse power (HP), size, class, and machinery type are estimated using OLS regression and Box-Cox transformation estimation alternatively and comparisons are made. We construct quality adjusted prices and quantities for different types of farm machinery. We decompose the machinery quantity change into embodied technical change and physical quantity change based on the hedonic estimates. The results are also used to construct a capital stock and rental service flow to analyze the impacts of quality-adjustment of farm machinery in productivity measurement.

Following USDA’s current approach, we apply the perpetual inventory method to construct machinery capital stocks using real machinery investment based on quality-adjusted and -unadjusted price indices. Under the perpetual inventory method, capital stock at the end of each period is measured as the sum of all past investments, each weighted by its relative efficiency which is approximated by hyperbolic efficiency function. The mean service life of the asset is assumed that the underlying distribution is the normal distribution truncated at points two standard deviations above and below the mean service life. The curvature or decay parameter is assigned a value of 0.5, assuming that the decline in efficiency is uniformly distributed over the asset's service life. The implicit rental price as well as capital service flow are then estimated for each asset type.

Data

The data on prices, quantities, and characteristics of farm machinery are drawn from different data sources, including U.S. Bureau of the Census “Current Industrial Reports (series MA-35A): Farm machines and equipment” (1948-1968), Farm Equipment Institute (now the Association of Equipment Manufactures, AEM), and AEM for different time periods. Capital investment expenditures are drawn from USDA-ERS farm income data and productivity accounts. The time period for this study is 1948 to 2011.

Preliminary Results and Discussion

Preliminary results based on hedonic measurement show that the impacts of each characteristic on the machinery price are non-linear. After taking into account the composition shift in equipment characteristics, the quality-adjusted price changes were lower than the un-adjusted inflation rates. The impact of this adjustment caused the annual total factor productivity growth rate to drop by 0.01 percentage points from 1950-2011. Yet, it caused the annual productivity growth rate to drop by 0.13 percentage points over the 1991-2011 period compared with the current USDA’s productivity estimate. These changes can be attributed to the contribution from embodied technical change in farm tractors over
varied periods. The findings show the potential importance of input quality adjustment and can help to explain the sources of productivity growth.