Long-Lived Working Animals As Capital Assets

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By Eldon Ball, Roberto Mosheim and Rachel Soloveichik

A recent review of ERS's productivity accounts recommended that ERS treat dairy cows, breeding beef cows and other long-lived working animals as capital assets (Shumway, et. al 2014). BEA was also given the same recommendation in the international guidelines for national accounts, *System of National Accounts 2008* (SNA 2008). In ERS's farm accounts and BEA's National Income and Product Accounts (NIPA's), long-lived working animals are currently treated as an inventory asset. This paper recalculates the farm accounts and NIPA's when long-lived working animals are re-classified as a capital asset. We show that this reclassification raises farm output and GDP for every year – but the increase is larger for earlier years. As a result, real farm output growth and real GDP growth falls slightly when long-lived working animals are capitalized. Total factor productivity (TFP) growth falls slightly from 1.42% per year to 1.38% per year when year when long-lived working animals are capitalized.

Introduction

In the course of developing multifactor productivity measures for the farm sector, we determined that breeding livestock play a role in the production process which is conceptually similar to that of fixed reproducible equipment. Cows are costly to raise (produce), but once mature they produce milk or beef calves for several periods. Livestock have been analyzed as capital in previous work including Jarvis [1974]. Naturally, we set out to find the usual data on investment, average service lives and depreciation rates. What we found instead were data which correspond closely to important and usually unobserved concepts in neoclassical capital theory such as discard practices, efficiency, salvage values and technical change.

Measures of capital input are required in a large class of econometric models including any which include a production function or an investment function. Most relevant to the duties of Eldon Ball and Roberto Mosheim at ERS is ERS's need to generate multifactor productivity measures. The Department of Agriculture is presently revising its methodology for multifactor productivity measurement of the farm sector along the general lines proposed by Ball [1985]. This paper explores and documents one area of this work. Also, we cannot help but notice that the literature on this topic is quite sparse and given the importance of this subject to the statistical agencies in charge of measuring to national income and wealth as accurately this research fills an important gap.

Conversely, measures of capital output and capital stock are required for many important economic statistics. Most relevant to Rachel Soloveichik at BEA is BEA's need to generate data on capital investment, prices, capital stock and consumption of fixed capital (CFC). In turn, that data is used to produce aggregate economic statistics like GDP, net savings and aggregate stock of fixed assets. BEA is also exploring productivity measurement and started publishing industry-level productivity numbers recently (Rosenthal, Russell, Samuels, Strassner and Usher 2014).

This paper will be divided into two parts. Section 1 gives a theoretical background on capital measurement and then walks readers through the methodology used to capitalize cows. This section also presents some historical investment data for dairy cows and breeding beef cows. Next, Section 2 shows the impact of this paper on nominal farm output, nominal farm inputs, real farm output, real farm inputs and measured total factor productivity (TFP). In order to save space, we will not give the specific procedures and datasets actually used to derive our numbers. However, those procedures are available upon request.

I. Theory and Practice for Capitalizing Livestock

For this paper, animal assets are defined as animals which yield repeat products over a long period of time (SNA 2008 Section 10.92). For example, a breeding beef cow might produce one calf a year from age two until age ten. In contrast, animals raised for meat are not considered capital assets because they provide services only once (when they are slaughtered). Egg-laying chickens, breeding hogs and breeding bulls go provide repeat products, but they generally have short productive lives. Therefore, they are not counted as a capital asset in this paper.

This paper will focus on dairy cows and breeding beef cows because those two animal categories account for the vast majority of farm animal investment. This paper does not study minor animal categories like beehives, goats, working farm horses and working farm dogs. It is possible that some of those animal categories fit the definition of capital assets and could be included in this paper. However, we believe that all of these animal categories are small and unlikely to have much impact on aggregate animal investment, stock or capital services.[1] Furthermore, it is much more difficult to find reliable data for these animal categories. For simplicity, we will drop them from our paper.[2] On the other hand, our treatment of breeding sheep is more complicated. That animal category was once reasonably large, but is now quite small. We chose an intermediate solution for this category. We will include breeding sheep as capital asset in our aggregate investment, prices and capital stock numbers. But we will not discuss them in this paper.

[1] The situation for horses is somewhat complicated. Farm horses definitely fit SNA's definition of capital assets and they were once a major capital category. However, ERS's productivity accounts start in 1948. By that time, automobiles and tractors were widespread and most farm horses were retired or used only for leisure riding. As a result, ERS has chosen not to include farm horses as capital assets in their productivity accounts. In contrast, BEA may include horses in GDP because BEA's accounts start earlier and cover non-farm industries like horse racing.
[2] Even though we did not choose to capitalize these animal categories in our paper, we did collect data for some minor categories. Interested researchers can e-mail us for data on excluded categories as well as data on sheep.

I.a Introduction to Capital Theory

A major problem in the neoclassical theory of the firm is the construction of a capital input measure. The concept of capital appropriate to production theory is somewhat obscure. Not surprisingly, data which are conceptually ideal are rarely available. Instead, assumptions must be made in order to derive a conceptually appropriate measure from available data. A conventional set of assumptions has become so thoroughly entrenched in standard empirical practice that the literature offers little guidance on what to do if appropriate data are available. This work departs from conventional practice in that the assumption it imposes about vintage marginal product is less rigid than the perpetual inventory method. This work flexibly employs information about typical discard practices, the productivity of cows as they age, and the actual number of cows. We believe that this technique works best for livestock because livestock is far more homogenous than other non-biological capital. For example, consider a specific type of equipment like machine tools or even more specific, like lathes. There is still so much diversity in size and design, that a vintage counting model may not be useful.

In a simple production model, a firm generates a maximum amount of output from a vector of inputs according to technical constraints described by a production function. If the firm is a price taker in input markets and if the amount of each input can be adjusted by the firm, it is easy to show that the profit maximizing firm will select an input vector such that the price of each input equals the value of its marginal product.

An extensive literature evolved during the 1950's and 1960's discussing the formal conditions required to aggregate capital assets of different types and different vintages. The present paper will focus mainly on vintage aggregate. Solow [1960] introduced a vintage production model. In this machines of each vintage have their own production function:

$$Y^V = f^V(I(v), L(v)) \qquad (1)$$

Where I(v) is gross investment in capital of vintage v and L(v) is the allocation of labor to capital of that vintage. Then total output is given by the summation across the vintage production functions:

$$Y^V = \sum f^V(I(v), L(v)) \qquad (2)$$

Fisher [1965] has shown that it is possible to derive the aggregate production function from equation (2) if the vintage production functions have a particular form:

$$f^V(I(v), L(v))= F(z(v)\, I(v), L(v)). \quad (3)$$

When (3) holds, the aggregate capital stock can be defined as the sum of individual vintage investments weighted by the efficiency of each vintage, with weights being z(v):

$$J(t) = \sum z(t,v)\, I(t,v) \quad (4)$$

Where J is defined at each point in time, t, to be a function of "vintage" investments made at historical time v.

The literature of these investments perhaps culminated in an article by Hall [1968]. Hall asserts that the vintage coefficient, z(v), measures all changes in efficiency (relative marginal product) that distinguish machines of different vintages. He proposes that z be decomposed into three components: embodied technical change, b(v), disembodied technical change, d(t), and deterioration, Φ(t-v). Thus:

$$z(t,v) = d(t)b(v)\, \Phi(t-v) \quad (5)$$

Embodied technical change, b, is caused by productivity improvements built into new capital goods. A firm will only benefit if it buys new goods. Disembodied technical change represents more general improvements in the productivity of capital. The firm benefits from the disembodied technical change regardless of the vintage distribution of its assets. Deterioration occurs as goods of a particular vintage age, and hence depends on the difference between the present time and the time when the capital goods were made, t-v. It is noteworthy that when the deterioration factor describes a cohort of goods, it consists of two main components: the percentage of the original number of goods remaining at a given age and the relative marginal products of remaining goods.

Hall makes a crucial observation about what was (and still is) conventional practice for capital measurement. The perpetual inventory method (PIM) aggregates past investments as a function of age:

$$PIM = \sum z(t,v)I(t,v). \quad (6)$$

This would appear to lead to the dire conclusion that all technical change (both embodied and disembodied) are assumed away. The assumption is not really that restrictive. Embodied technical change can be introduced into (6) via the investment number.

In any event, conventional practice involves assuming something about z, rather than measuring any of its components. In this paper we develop measures of embodied technical change, b, and deterioration, Φ,from data which are, with some qualifications, conceptually appropriate.

I.c Counting Capital Stock for Production Models and Cows

In the perpetual inventory method (PIM), an aggregate capital number is formed by weighting past investments with an assumed fixed function of age, $\Phi(\tau)= \Phi(t-v)$. In production theory, this function represents the marginal product relative to a new asset, as in expression (6). Formulas analogous to express (6) have long been used by accountants to value total capital stock by weighting past investments with functions that adjust for depreciation. In either case, the PIM formula is applied to data on investments measured in constant dollars, current dollars, or some other currency.

The PIM calculation can be described in terms of a matrix, N, representing the number of assets in service in each year (rows) of each age (columns). The first column represents the number of new assets (gross investment) and later columns represent the number of used assets still in service. If used asset cannot be created or bought from outside the economic unit being studied:

$$N(t+1, \tau+1) \leq N(t, \tau) \qquad (7)$$

For all t, τ. That is, the number of assets of a particular vintage will decline monotonically as it ages. Note that a particular vintage may be “tracked” diagonally through the matric moving down and to the right as it ages. Let $w(\tau)$ be a cumulative survival function for assets from age 0 to age τ:

$$N(t, \tau) = I(t-\tau) * w(\tau) \qquad (8)$$

The gross capital stock, that is the stock of capital goods net of discards, is then defined as $\sum N(t, \tau)$.

With cows, the available data do not fit nicely into the mold for the PIM calculations. Instead of a count of new cows added each year, there are data on the total number of animals, μ. Also available is a series on the total number of cows slaughtered, S(t) and our estimates of the number of cows which die each year, D(t). The lack of investment data at first seemed to create a problem. This was because we were thinking in terms of conventional methods. The counts of all dairy and beef cows from surveys represent actual observations of numbers that a conventional PIM gross stock would estimate by use of discard assumptions! If we were only interested in counting the total number of animals, μ would be the final answer. There would then be no need to account for assets of different vintages. However, a cow's productivity and mortality rate varies as she ages, and therefore it is necessary to estimate the number of animals of each age in order to develop measures of cow capital stocks.

Fortunately, we found additional information which allowed us to estimate the number of cows of each type and each vintage. The methodology will be described in the next section, but for now we assume a known mortality profiles for cows, M(t) = S(t) + D(t). These survival functions were then used to estimate the number of cows of each vintage in each year by applying the following procedure. First, a preliminary estimate of slaughter and death for cows was made[3]:

$$M^*(t+1) = \sum_t N(t, \tau) * (1-w(\tau+1)/ w(\tau)) \quad (9)$$

Next an adjustment ratio, R(t+1) was calculated as the ratio of observed slaughter and death for cows to the sum of these preliminary estimates:

$$R(t+1) = M(t+1)/ M^*(t+1) \quad (10)$$

A ratio less (more) than one indicates an over (under) prediction of slaughter. The adjustment ratios were then used to create <u>final estimates of slaughter by type and age which incorporate the preliminary information about culling practices but also conform to the observed totals:</u>

$$M^{\ddagger}(t+1,\tau+1) = N_D(t, \tau) * R(t+1) * (1-w_D(\tau+1)/ w_D(\tau)) \quad (11)$$

Next the vintage counting matrices were computed for the given year, t:

$$N(t+1, \tau+1)= N_D(t, \tau)- M^{\ddagger}(t+1,\tau+1) \quad (12)$$

Finally, breeding investment in new cows could be computed:

$$B(t+1) = N(t+1, 1)=\mu(t+1)- \mu(t) + \sum M^{\ddagger}(t+1,\tau+1) \quad (13)$$

While the procedures used to estimate these are rather involved, they have been designed to estimate numbers of animals of each vintage taking flexible account of all information and constraints.

[3] As stated, this procedure is applied to successive years. When operating on a given year, it clearly assumed that the previous year has been completed. In order to start the process off, we had to assume the vintage distribution for the first year. The assumption we made was consistent with a stationary population and investment rate in previous years. This initialization year was 1924 which is sufficiently ahead of the first year for which we report results, 1948, so that any biasing effects of this assumption have had a chance to dampen out.

Note that expressions (11) and (1) achieve essentially the same thing as the "counting PIM" described in expression (1). However, the flexible use of observed information on the numbers of animals and the number slaughtered has led to an improvement our accuracy estimates compared to "counting PIM".

I.d Measuring Cow Capital Stock from 1948 to 2013

In this paper, we track dairy cows and breeding beef cows as two separate capital categories. In our paper and USDA's data, cows are defined as animals which have calved at least once. Therefore, heifers enter the herd when the calf for the first time. Most of the data used is available online at USDA's Quickstats, but some were also taken from old USDA paper publications. In order to save space, we will not list the precise datasets used in this paper, but an Appendix describing the exact sources is available upon request. We then calculate the number of new heifers entering:

$$\text{Number New Dairy Heifers}_t = \text{Dairy Cow Slaughter}_t + \text{Natural Dairy Cow Mortality}_t - (\text{Dairy Cow Herd Count}_{t+1} - \text{Dairy Cow Herd Count}_t) \quad (14)$$

$$\text{Number New Beef Heifers}_t = \text{Beef Cow Slaughter}_t + \text{Natural Beef Cow Mortality}_t - (\text{Beef Cow Herd Count}_{t+1} - \text{Beef Cow Herd Count}_t) \quad (15)$$

Figure 1: Population Demographics for Dairy Cows

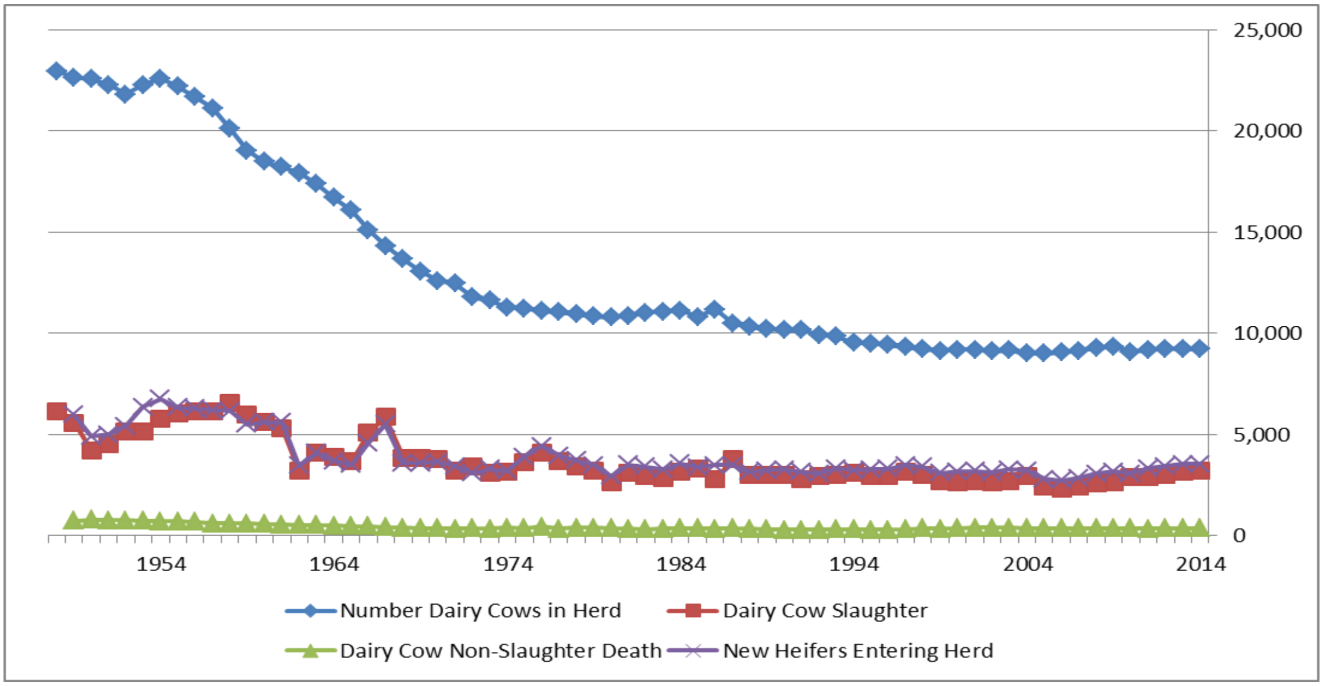
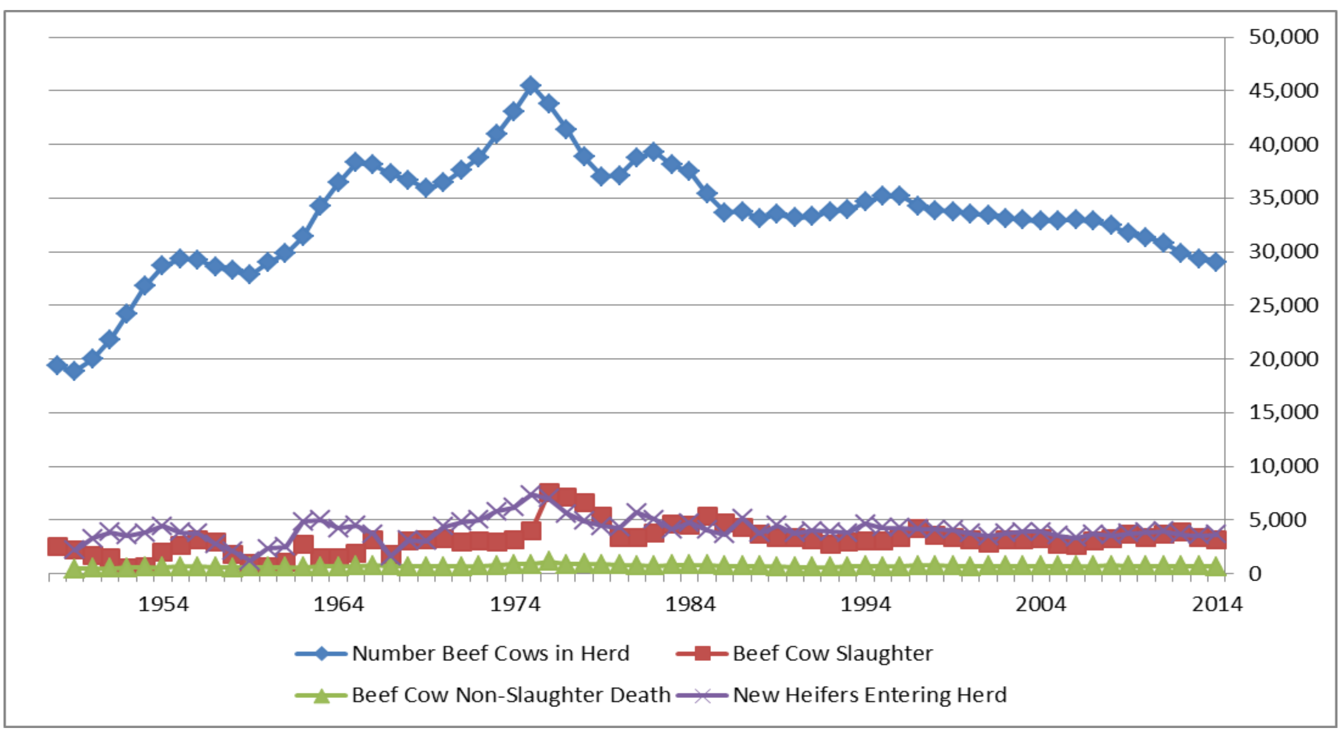


Figure 2: Population Demographics for Breeding Beef Cows



The two cow populations have very different long-term dynamics.   Figure 1 shows that the dairy cow population has been very stable since the 1970's. Because the population is so stable, new heifer entry is almost exactly equal to slaughter + natural mortality. In contrast, Figure 2 shows that the breeding beef cow population peaked in the mid 1970's and has slowly decreasing since then. The breeding beef cow population also shows short-term cattle cycles, with population peaks followed by declines every decade or so. This difference in population dynamics may suggest that the demand for milk is more stable than the demand for beef over time. Alternatively, dairy farmers may face larger adjustment costs and therefore choose to keep their herd size stable despite demand volatility.

We can now calculate the complete population demographics for the dairy cow herd and beef cow herd. We constructed cumulative mortality functions for dairy cows using estimates of conditional survival rates for Holstein cows developed by Nieuwhof, Norman, and Dickinson [1989] and cumulative mortality functions for breeding beef cows using data from Nunez-Dominquez, et. al [1985].[4] When calculating cow demographics, slaughter and death are equivalent methods of leaving the population. Therefore, we combine S(t) and D(t) to get total mortality for cows,

We can now calculate the complete population demographics for the both dairy cows and breeding beef cows.   We start out with the number of new heifers entering each herd. We then calculate annual mortality rates for every age group. By design, the absolute mortality rate is always adjusted to match the observed mortality each year. Therefore, the predicted herd size is precisely equal to the observed herd size. Later in this section, we will use that demographic information to calculate capital stock and capital services. In order to save space, we will not show the table in this paper – but interested researchers can e-mail us for the data.

I.e Changes of Productivity of Cows Due to Age

In the last section we asserted that the first step in creating an aggregate capital stock was to count up how many assets there were of each vintage in each year. We will now show how such counts can be used to develop conceptually appropriate measures of capital inputs. Essentially, all we need to

[4] We adjust the reported mortality rates for early culling. The Nunez-Dominquez, et. al paper started tracking animals when they were first bred. In contrast, we only track animals once they are officially cows – so heifers which were culled before calving are never counted in the herd in the first place. This adjustment lowers mortality rates for young breeding animals from 18% to 7%.

do is weight the vintage counts of assets by productivity. In other words, we need to identify the marginal product of surviving assets. Here again we were extremely fortunate to find data tracking exactly the factors necessary.

We took our data for dairy cow age/efficiency from the National Cooperative Dairy Herd Improvement Program (see Norman, et. al. [1974]).[5] The precise data used in this paper is taken from the 1970's, but data from the 1920's (Wolf 1921) and the 2000's (Rios-Utrera, Calderon-Robles, et. al 2013) show similar age/efficiency patterns for dairy cows. This constant age/efficiency profile greatly simplifies our historical analysis.

We too our data on breeding beef cow age/efficiency from the same Nunez-Dominguez (1985) data used to provide mortality rates.[6] Unfortunately, we were not able to find similar age/efficiency data from the 1920's or 2000's. We will assume that breeding beef cows also display a constant age/efficiency profile over time. In practice, the age/efficiency profile for breeding beef cows is very similar to the age/efficiency profile for dairy cows.

The cohort efficiency at each age is simply the product of the efficiency of surviving animals under assumed management practices, h, and the corresponding cumulative survival function, w. If one were to settle for a perpetual inventory measure of the capital stock, this cohort efficiency would be a natural candidate estimate for Hall's deterioration function, that is:

$$\Phi(\tau) = w_D(\tau)h_D(\tau) \qquad (16)$$

It is noteworthy that even these cohort efficiency schedules are concave to the original during the earlier (and in the PIM), the more highly weighted years of age. This occurs because mortality rates rise steadily with age. Even when individual cow productivity is rising, cohort efficiency still falls. In addition, prices for surviving cows also fall with age because of their shorter expected lifespan.

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[5]For the age/efficiciency profile, we used standardized data on the mean yields per cow of milk and milkfat over a standard 305-day lactation period. The data used were only available for births 1 to 8. Very few dairy cows survive past birth 8, so this omission affects very few cows. We assume that productivity is constant after birth 8.

[6] Like the mortality statistics used earlier, we adjust our age/price profile to remove heifers culled before calving.

Figure 3: Changes in Dairy Cow Efficiency and Price with Age

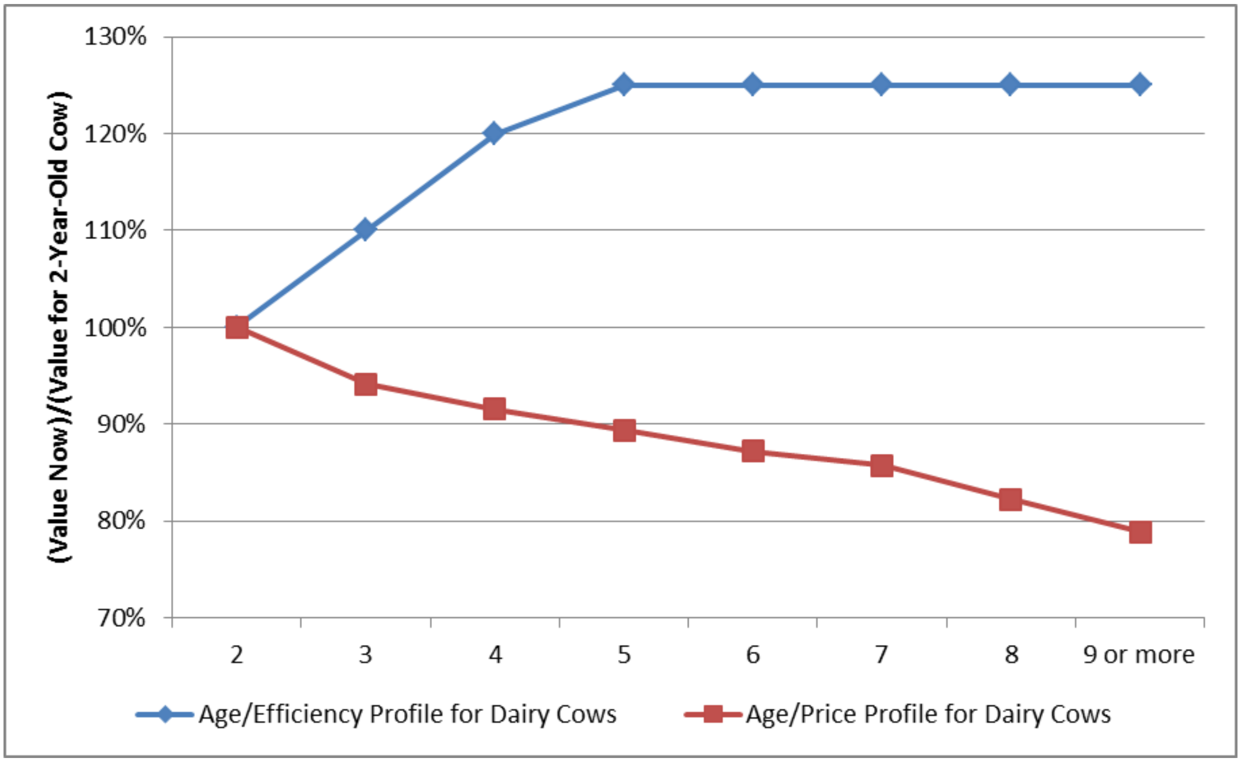
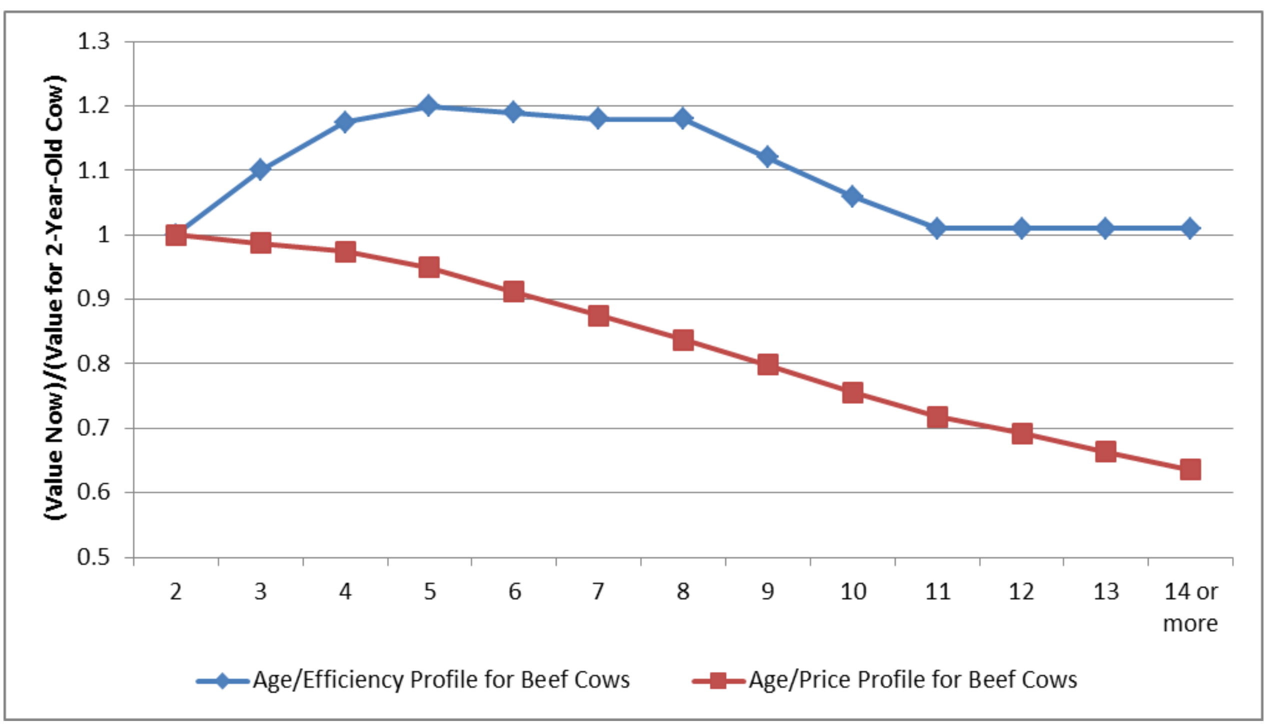


Figure 4: Changes in Breeding Beef Cow Efficiency and Price with Age



Figures 3 and 4 show that dairy cows and breeding beef cows have very similar age/efficiency profiles. The only difference is that dairy cows rarely live beyond age 9, so we do not show their productivity past that point. Note that production per cow rises substantially during the first few years of productive life. This phenomenon is due in large part to the fact that a cow is still maturing when she is first bred. There is an analogue to this phenomenon in investments in fixed equipment or structures in that assets are often put in service before they can be fully utilized and before they are fully "shaken down" for component defects.

I.f Changes of Productivity of Cows Due to Genetic Improvement

Since 1960, farmers have been steadily breeding cows for more milk production and heavier beef calves. Indexes of embodied technical change were constructed by adjusting milk yield in 2009 by the expected progeny difference (EPD). For dairy cows, the EPD, expressed in pounds of milk yield, is a prediction of how future progeny will perform in the traits we have used to define the productivity of the animal. We took our EPD numbers from data published by the Council on Dairy Cattle. This data is available online at https://www.cdcb.us/eval/summary/trend.cfm.[7] For breeding beef cows, genetic quality is expressed in calf weaning weight. Gary Bennett, a researcher at USDA who studies beef cows, was kind enough to supply our main data on genetic improvement. His data goes back to 1972. Before 1972, we use the beef cow quality data collected by Ball and Harper (1990) to track genetic improvement back to 1948.

Our genetic quality indexes implicitly assume that cow quality is linear with genetic improvement. For example, a dairy cow bred to produce 10% more milk is a 10% better animal.[8] Since we assume that heifers are managed to calve as 2-year-olds, the genetic quality numbers were lagged for two years. We refer to these numbers as genetic quality indexes, and use them as measures of the technology truly embodied in vintage investments, v(b).

[7] The quality index developed in this paper uses 2010 as a base year. Results are similar with other base years.
[8] In theory, the value of a capital asset is equal to the value of its output minus input costs. As a result, the assumption that quality is linear with genetic improvement is equivalent to the assumption that input costs are linear with output. It is certainly possible to imagine examples where input costs do not track output. For example, a cow that produces 10% more milk but needs to eat 100% more is probably a bad investment. However, we were not able to find reliable data on genetic changes to input costs over time. For simplicity, we assume input costs track output.

Figure 5: Genetic Improvement vs. Other Contributions to Milk Yield

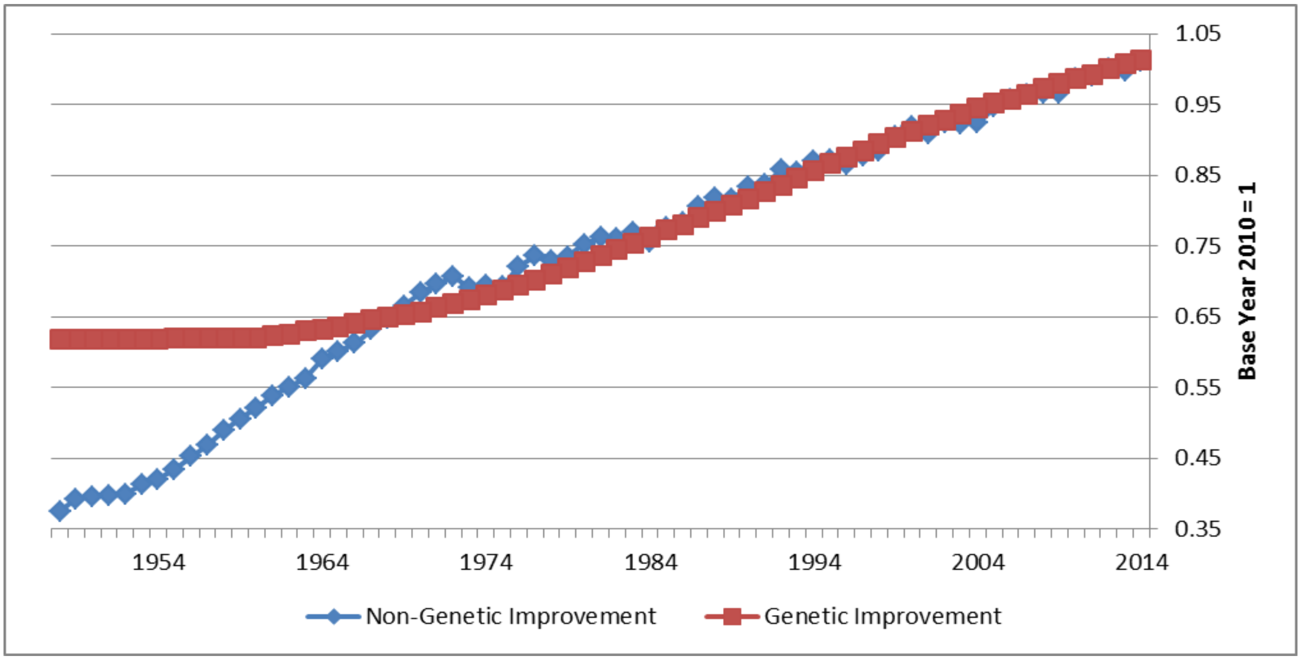
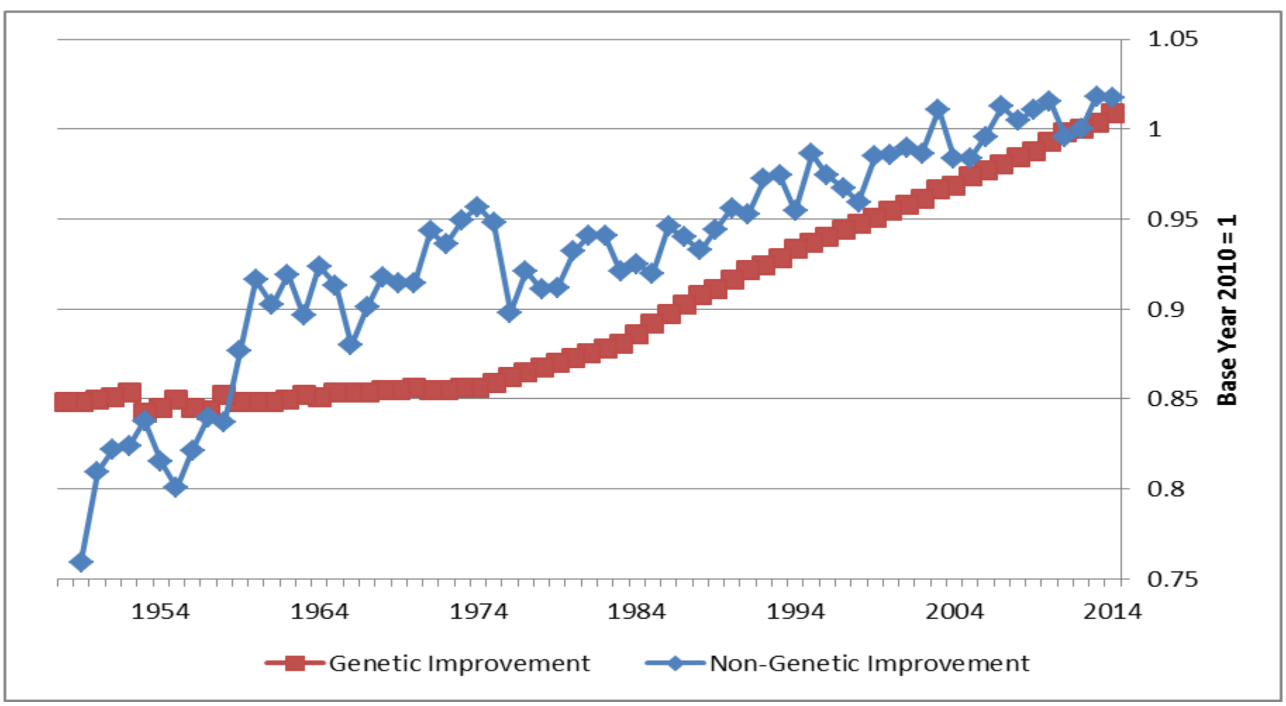


Figure 6: Genetic Improvement vs. Other Contributions to Calf Slaughter Weight



Figures 5 and 6 both show that cow genetic quality has been growing over time. However, quality growth started earlier for dairy cows and has been faster over the time period. This difference may be related to artificial insemination, which was introduced earlier for dairy cows.

Despite all of the genetic improvement, genetics still account for less than half of the total increases in milk production and calf output. Modern farmers have developed better feeding techniques, better milking techniques and other non-genetic methods to improve yield. We will exclude all of these improvements from our capital quality measure. These non-genetic productivity improvements will be counted in overall farm TFP growth instead.

I.g Productive Capital Stock and Wealth Stock for Cows

Our proposed measure of the real capital input in each year, J(t), is the sum of the number of cows of each vintage weighted by functions of their age, h(τ), and of the year of their vintage, b(v):

$$J(t) = \sum_{\tau} h(\tau)\ b(t-\tau)\ N(t,\tau) \qquad (17)$$

where t-τ = v, the year the cohort was first bred. This capital stock represents the inherent capacity of the animals in the herd to produce output (milk).

We will calculate the productive stock of cows using two separate methods. The first method combines the demographic data calculated earlier with the age/efficiency profiles in Figures 3 and 4, the genetic quality data in Figures 5 and 6 and a base price per heifer to get a real production stock in dollars. We will call the first method the Ball/Harper method because it follows their 1990 paper. The second method assumes a fixed mortality schedule over time. This method is commonly used in the economic literature to estimate productive capital stock, wealth stock and deterioration for a wide variety of models. We follow the economic literature and call this method the perpetual inventory method (PIM). For the purpose of this paper, we use 2009 as a base year.

Figure 7: Productive Capital Stock of Dairy Cows, Ball/Harper vs. PIM

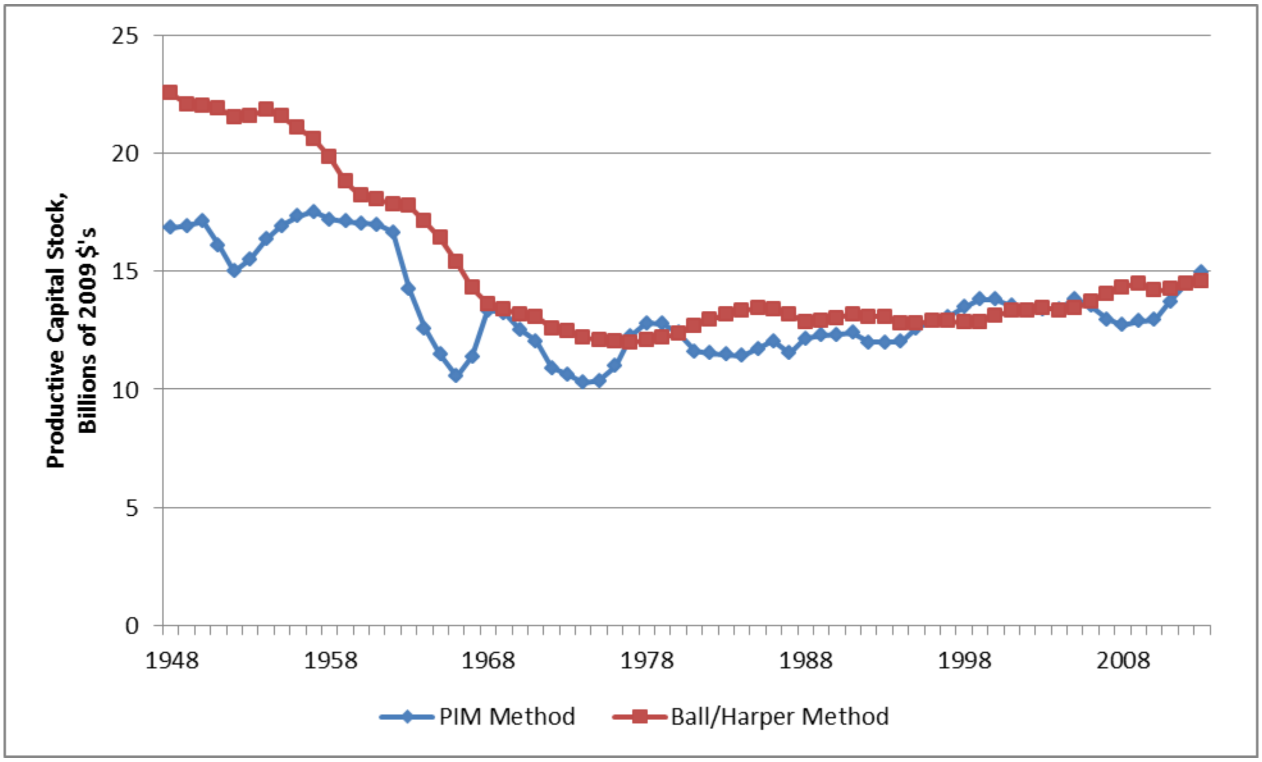
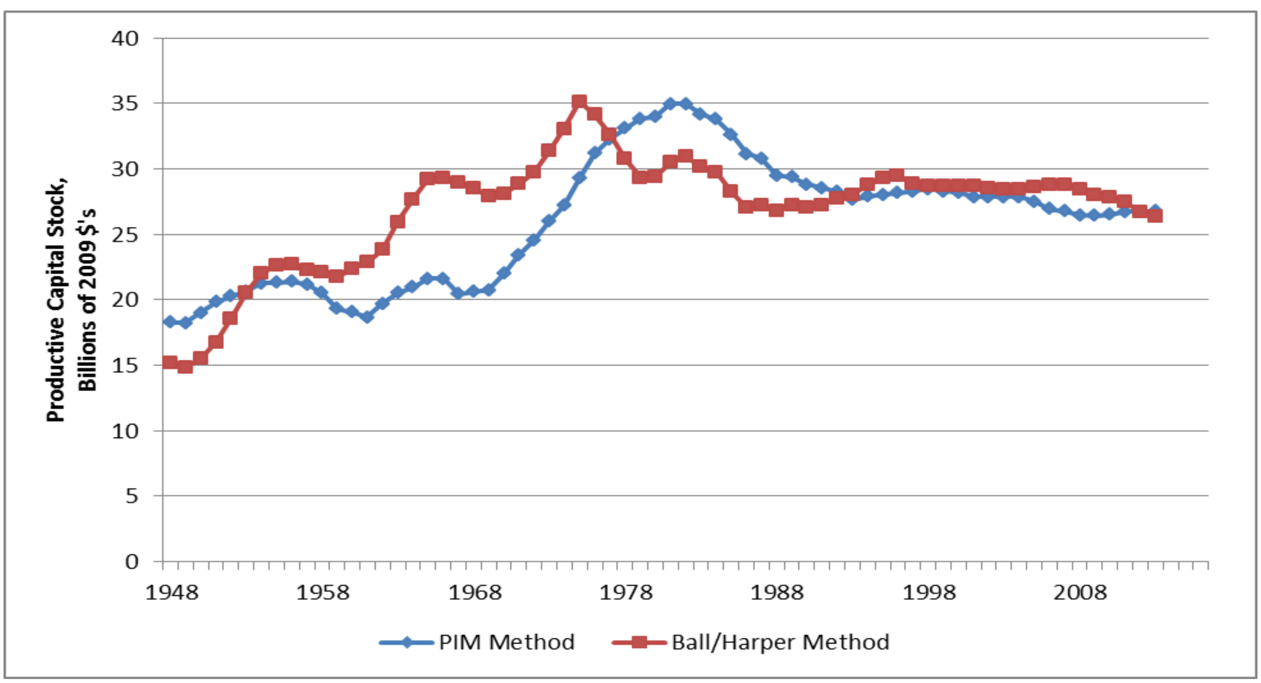


Figure 8: Productive Capital Stock of Beef Cows, Ball/Harper vs. PIM



Figures 7 and 8 show that the two methods produce similar results in recent years, but the Ball/Harper method produces much higher dairy cow capital stock numbers before 1970. Changing management practices are the main cause of this difference. Since 1968, farmers shifted to breeding dairy cows earlier, providing less grazing time and milking them more intensely. This shift is associated with dramatic increase in the mortality rate.[9] The Ball/Harper method allows for lower mortality rates before 1970 and higher mortality rates after 1970. In contrast, the PIM method forces mortality rates to be constant over time. The Ball/Harper method has a much less dramatic effect for breeding beef cows, but there are significant differences in the late 1970's when herd sizes fell dramatically.

The results in Figure 7 show why it is preferable to measure productive stock based on actual asset data rather than just breeding investment. The PIM estimates would suffer from a serious bias if they were generated from deterioration functions based on some presumed functional form. This is the case in virtually every estimate of capital input used in production function or productivity measurement work. This second source of bias is minimized when an empirically based approach and a flexible functional form are used as was the case in work on structures by Hulten and Wykoff [1981] and on machine tools by Hulten, Robertson and Wykoff [1989].[10] The Bureau of Labor Statistics [1983] attempted to limit this second source of bias in its business sector capital measures by imposing a hyperbolic deterioration schedule form and then by estimating a "shape" parameter from available evidence. However, even perfect data on the functional form cannot solve the problem of changing depreciation rates over time.

Despite the dramatic divergence before 1970, the PIM method and Ball/Harper method produce similar estimates of productive capital stock in recent years. Furthermore, the PIM method is much simpler to implement. Going forward, it is likely that ERS analysts will use the PIM method to calculate productive capital stock for the farm productivity measures. However, we will use the Ball/Harper method to calculate historical capital stocks because it is more accurate before 1970.

It is very important to note that the real production capital stock shown in Figures 7 and 8 is not a reliable proxy for the real wealth stock of cows. Cow mortality rates increase with age, so an older cow has a much shorter expected future lifespan than a young cow. Therefore, the same productive

[9] It is possible that these changes directly harmed cow health. However, it also possible that cow health has not changed and modern farmers are simply more aggressive about culling poor performers.
[10] In the work of Hulten, Wykoff and Robertson, a Box-Cox function is stochastically estimated with data on used asset prices. They recognize that prices are not a direct indicator of efficiency. In order to estimate efficiency they impose geometric decay in which prices and efficiency decay on the same schedule.

capital stock represents less wealth stock if the average cow is older. At this point we have described how productive stocks are efficiency (marginal product) weighted aggregates of vintage investments. Quantities have been described in terms of efficiency adjusted counts and are therefore in fairly natural units. This data is ideal for measuring real capital inputs for ERS's productivity statistics. However, other economic statistics also require data on nominal investment, prices and capital stock. For ERS, measured farm output depends on the nominal value and prices for investment in cows by farmers. BEA uses that farm output data to calculate overall GDP and other components to the national accounts.

We have not been able to find any recent data on cow prices by age. Accordingly, we cannot calculate the wealth stock of cows directly. Instead, we use an economic model to estimate prices by age. To estimate the price structure prevailing in each year, we adopted the capital asset pricing assumptions usually used in neoclassical production theory. At the end of each time period, purchase and rental prices are estimated for assets of each age by assuming that the price of an asset is to equal the discounted future rents it will generate plus its discounted salvage value:

$$P(t,v) = \sum_{X=t+L} c(0)z(t,t-x)w(x-v)/w(t-v)*(1-r)^{x-t} + \sum_{X=t+L} p_s(t)[w(x-v)-w(x-v+1)]/w(t-v)*(1-r)^{x-t} \quad (19)$$

The first line of expression (19) represents the discounted future capital services like milk or calves. The second line represents the discounted salvage value from slaughtered cows. In our empirical work, a real discount factor of 4% was used. We then multiplied those age/price profiles by the demographic data estimated earlier to calculate real wealth stock over time. In order to save space, we will not show graphs for real wealth stock over time. However, the numbers for each year are given in Tables 5 and 6 in Appendix A.

I.h Breeding Investment for Cows, Nominal and Real

For dairy cows, the calculation is relatively simple. Fortunately for us, NASS tracks the price of replacement dairy heifers. That data is available online at USDA's Quickstats. We can easily calculate:

$$\text{Nominal Investment}_t = (\text{Number New Heifers}_t) * (\text{Price Per Dairy Heifer}_t) \quad (20)$$

Calculating prices is slightly more difficult. NASS's data gives the price per animal – but Figure 3 shows that quality has been steadily increasing over time. We calculate quality-adjusted prices:

$$\text{Price Index}_t = [(\text{Price Per Dairy Heifer}_t)/(\text{Genetic Quality of Dairy Cows}_t)]/$$

$$(\text{Price Per Dairy Heifer In Base Year}) \quad (21)$$

$$\text{Real Investment}_t = (\text{Number New Dairy Heifers}_t) * (\text{Price Per Dairy Heifer}_t)/\text{Price Index}_t) \quad (22)$$

The calculation is slightly harder for breeding beef cows. Unlike dairy cows, most breeding beef cows are raised in-house rather than purchased on the market. As a result, there are relatively few market transactions for replacement beef heifers and no official price series. As an alternative, we use prices for 750lb **feeder** heifers. The vast majority of beef heifers not used for breeding are sold to feedlots for meat production. Therefore, the price for feeder heifers is a good measure of the opportunity cost to ranchers of sending young heifers to the breeding herd. Unlike the dairy cow price series, the beef heifer price series tracks animals of a fixed quality over time and so we do not need to adjust prices per head for quality improvement.

On average breeding beef cows are more valuable than feeder heifers. The typical feeder heifer is around 16 months old and weighs 750 pounds. In contrast, new breeding cows are typically around 24 months old and weigh 900 pounds. We were not able to find precise data on the costs for raising a beef heifer from a 750 pound feeder heifer to a 900 pound breeding cow. For simplicity, we assume that market value tracks weight linearly. Therefore, a 900 pound beef cow is worth 20% more than a 750 pound feeder heifer.

Given that assumption, we can then calculate nominal investment, prices and real investment:

$$\text{Nominal Investment}_t = (\text{Number New Heifers}_t) * (\text{Price Per Feeder Heifer}_t)*120\% \quad (23)$$

Calculating prices is slightly more difficult. NASS's data gives the price per animal – but Figure 7 shows that genetic quality has been steadily increasing over time. We calculate quality-adjusted prices:

$$\text{Price Index}_t = [(\text{Price Per Feeder Heifer}_t)/(\text{Genetic Quality of Beef Cows}_t)]/$$

$$(\text{Price Per Feeder Heifer In Base Year}) \quad (24)$$

$$\text{Real Investment}_t = (\text{Number New Heifers}_t) * (\text{Price Per Heifer}_t)/\text{Price Index}_t) \quad (25)$$

Figure 9: Nominal Investment in Cow Capital, Relative to Total Farm Output

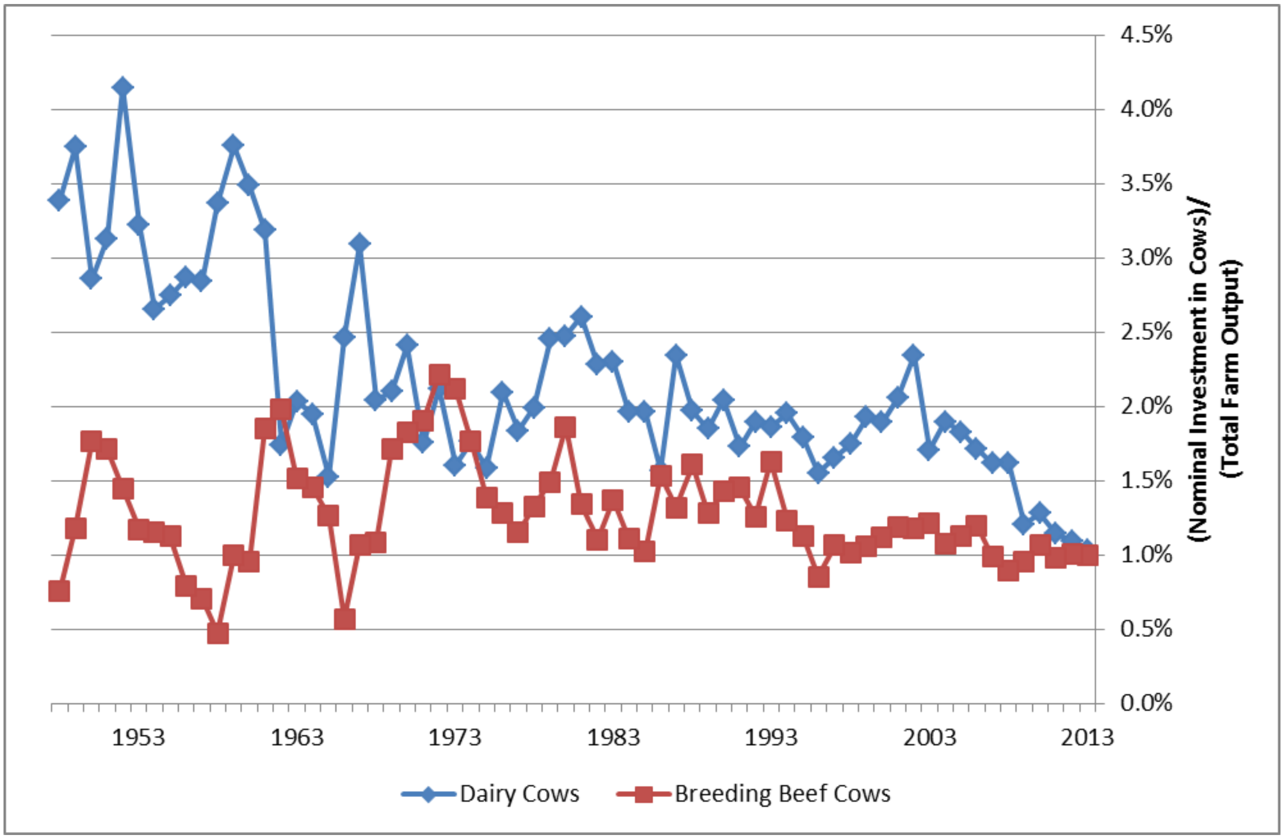


Figure 9 shows that nominal investment in dairy cows has grown slower than overall farm output and nominal investment in breeding beef cows has grown at approximately the same rate as overall farm output. As a result, nominal farm output growth falls slightly when dairy cows are treated as a capital asset. Figure 9 also shows that the nominal investment share for cows is volatile. Most of this volatility is caused by fluctuations in the price of heifers over time. However, real investment is also quite volatile for breeding beef cows.

The investment data above assume that cows do not enter the capital stock until they actually calve for the first time (and become cows). Before they calve, they are considered inventory assets just like animals raised for meat. As a robustness check, we also experimented with treating calves and heifers set aside for replacement cows as capital assets from the instant they are set aside. We found that this treatment sometimes changed the annual investment numbers, but had no effect on average investment in the long-term. Furthermore, it was very difficult to identify the calves and heifers which were set aside for replacement cows or estimate their value. Because of these practical problems, we treat all new cows as capital investment on the day they first calve and enter the working herd.

I.i Deterioration for Cows

We calculate deterioration of cow capital using a residual methodology. First, we use the population demographic data calculated earlier and the age/price profile for cows to calculate the wealth stock of cows from 1948 to 2013. Next, we compare the actual change in the wealth stock over time to the change that would occur if deterioration was zero:

$$\text{Deterioration}_t = \text{Breeding Investment}_t - (\text{Wealth Stock}_{t+1} - \text{Wealth Stock}_t) \qquad (26)$$

The calculations above assume that the meat from slaughtered cows is part of capital services, just like the milk and beef calves produced each year. As a robustness check, we also experimented with treating slaughtered cows as negative investment just like used tractors traded in at the dealership.[11] We found that this treatment produces lower numbers for both investment and deterioration. However, both treatments had similar impacts on farm output growth, farm value-added growth and measured total factor productivity. In practice, treating slaughtered cows as negative investment created a number of problems. We had great difficulty estimating the negative investment value of slaughtered cows annually. Furthermore, measured deterioration and investment rates were sometimes very volatile. Because of these practical problems, we chose not to treat slaughtered cows as negative investment.

2. Changes to Individual ERS Tables

This section is somewhat preliminary. ERS is currently revising their published numbers for farm output, farm balance sheets, farm inputs and farm productivity in many ways. We do not yet know the precise table formats or aggregate numbers that will be published in September 2015. For this paper, we use ERS's currently published numbers and table formats, without any adjustment for other revisions.

[11] This treatment is consistent with SNA's recommendations for GDP statistics in Sections 10.94 and 12.71

II.a Changes to Measured Farm Inventory

ERS currently tracks all cattle, sheep and hogs in the category ‘livestock inventory’. This category plays a limited role in the calculation of farm output. Total farm output includes **changes** in private inventories. If breeding rates are higher than mortality rates, then the inventory of long-lived farm animals increases. That change raises measured farm output. However, measured farm output is the same regardless of average livestock inventory. This paper recommends that ERS track dairy cows and breeding beef cows as capital assets. In that case, we must be careful to ensure that they are not counted in farm inventory.

In order to avoid double-counting, we will adjust ERS’s livestock inventory numbers to only include cattle raised for meat. ERS’s current farm inventory numbers are taken from the National Agricultural Statistics Service (NASS). NASS currently publishes aggregate numbers for ‘change in livestock inventory’ but does not report ‘change in livestock inventory’ by animal category. We have not been able to determine the precise methodology that NASS uses to value livestock inventory – and therefore we cannot easily recalculate ‘change in livestock inventory’ when dairy cows and breeding beef cows are removed.

In this paper, we will adjust NASS’s livestock inventory numbers based on the **slaughter** value of working cows. For example, the number of dairy cows in the herd fell by 9,000 in 2013. Over the same time period, dairy cows had an average slaughter value of $1,245. Accordingly, we calculate that the decrease in dairy cows contributed -$1.1 million to aggregate ‘changes in livestock inventory’. In other words, we calculate that the published number for ‘changes in livestock inventory’ would be $1.1 million higher if NASS did not include dairy cows in their livestock inventory calculations.

It is important to note that our estimates of the wealth stock of long-lived working animals is **not** equal to the difference between NASS’s current numbers for livestock inventory values and our adjusted livestock inventory value. The difference is caused by measurement methodologies rather than theory. Both our paper and NASS’s inventory values rely on the same datasets tracking the number of animals by livestock category. However, NASS uses slightly different techniques than we do to estimate the average price per animal. As a result, our numbers for wealth stock need not match NASS’s values for the same animals. In practice, the difference is generally small. Results are similar if we constrained the adjustment to 'changes in livestock inventory' to match our wealth data perfectly.

II.b Changes to Nominal Farm Output

This table is taken from ERS's table 'Value-added to the U.S. Economy by the Agriculture Sector'.[12] The table is available from 1910 to 2015 – but we focus on the period 1948 to 2011 because that period is also tracked in ERS's farm productivity statistics. Capitalizing working farm animals directly changes the line 'inventory adjustment' (line 20) and also requires a new line 'Own-account production of animal capital' (line 21). In turn, these two lines affect the summary lines 'value of livestock production' (line 13) and 'value of agricultural sector production ' (line 27). Table 1 shows how ERS's published table might change for selected years:

Table 1: Nominal Livestock Production and Overall Farm Output

		1950	1970	1990	2008	2009	2010	2011
13	Value of Livestock Production (Old)	18,144	30,768	90,037	139,755	117,809	139,875	163,416
13	Value of Livestock Production (Revised)	19,592	32,986	96,609	149,279	125,282	148,443	173,042
20	Inventory Adjustment (Old)	607	690	436	-544	-1,423	-490	-813
20	Inventory Adjustment (Revised)	418	498	400	-160	-1,107	-196	-88
21	Own-Account Production of Animal Capital	1,637	2,410	6,609	9,140	7,157	8,273	8,902
27	Value of Agricultural Sector Production (Old)	30,576	52,614	188,497	361,076	327,363	350,296	415,883
28	Value of Agricultural Sector Production (Revised)	32,024	54,833	195,068	370,600	334,836	358,864	425,508

[12] http://www.ers.usda.gov/data-products/farm-income-and-wealth-statistics/value-added-years-by-state.aspx

Figure 10: Change in Nominal Farm Output

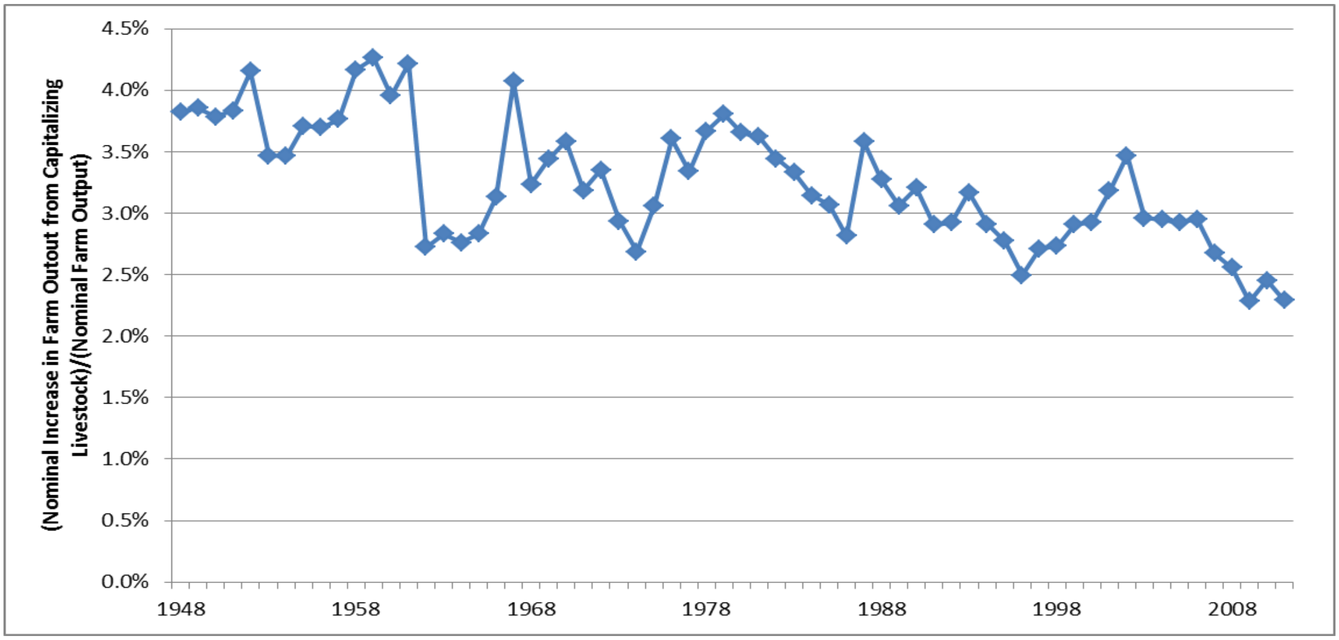


Figure 10 tracks closely with the nominal investment data shown earlier in Figure 9. However, individual years are sometimes different because Figure 10 shows both our adjustments to measured livestock inventory and investment in working livestock.

II.c Changes to Nominal Farm Value Added

This table is taken from the same ERS table as nominal farm output. Capitalizing working farm animals impacts the summary lines 'gross value added' (line 49), 'capital consumption' (line 50) and 'net value added' (line 51). Table 2 shows how ERS's published table might change for selected years"

Table 2: Nominal Farm Value Added and Capital Consumption

		1950	1970	1990	2008	2009	2010	2011
49	Gross Value Added (Old)	20,941	30,623	99,343	159,703	139,093	158,922	196,701
49	Gross Value Added (Revised)	22,389	32,842	10,5915	169,227	146,566	167,490	206,327
50	Capital Consumption (Old)	2,665	6,904	18,130	28,691	30,091	30,677	32,094
50	Capital Consumption (Revised)	4,423	9,367	24,791	38,146	37,742	39,095	41,833
51	Net Value Added (Old)	18,276	23,716	81,213	131,012	109,002	128,245	164,607
51	Net Value Added (Revised)	17,966	23,475	81,123	131,081	108,824	128,395	164,494

Figure 11: Change in Net Farm Value Added

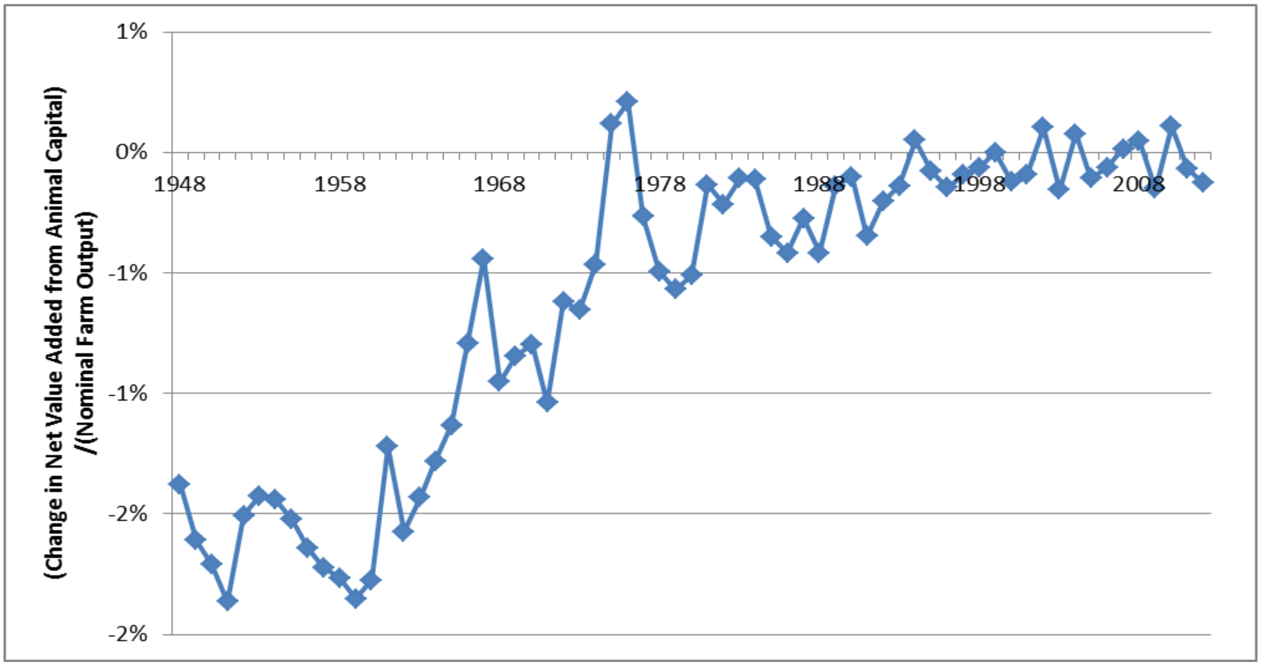


Figure 11 shows that capitalizing working livestock has little effect on net farm value added. Intuitively, the increased gross farm output is almost precisely canceled out by the increased capital consumption. The net effect is slightly negative before 1975 and close to zero afterwards.

II.d Changes in Real Farm Output

This table is taken from ERS's published spreadsheet calculating farm productivity.[13] Once again, we focus on the period 1948 to 2011. Capitalizing cows impacts the summary lines 'real total output' (column 2), 'real livestock and products' (column 4), 'real meat animals' (column 6). In addition, we add a new column tracking capital investment in working animals 'real own-account investment in animals' (line 8). Table 3 shows how ERS's published table might change for selected years:

[13] http://www.ers.usda.gov/data-products/agricultural-productivity-in-the-us.aspx

Table 3: Real Livestock Production and Overall Farm Output (2005 $'s)

		1950	1970	1990	2008	2009	2010	2011
2	Real Total Output (Old)	107,022	152,359	221,914	281,720	282,965	281,174	279,238
2	Real Total Output (Revised)	114,944	160,695	230,434	291,083	292,176	291,423	289,431
4	Real Livestock and Products (Old)	60,907	87,282	103,644	130,843	129,828	130,840	131,567
4	Real Livestock and Products (Revised)	68,828	95,618	112,164	140,206	139,039	141,089	141,761
6	Real Meat Animals (Old)	38,936	60,567	61,030	66,808	67,194	67,667	67,605
6	Real Meat Animals (Revised)	38,274	60,084	60,966	67,202	67,559	67,945	68,131
8	Real Own-Account Production of Animal Capital	8,583	8,818	8,554	8,969	8,846	9,971	9,668

Figure 12: Change in Real Farm Output

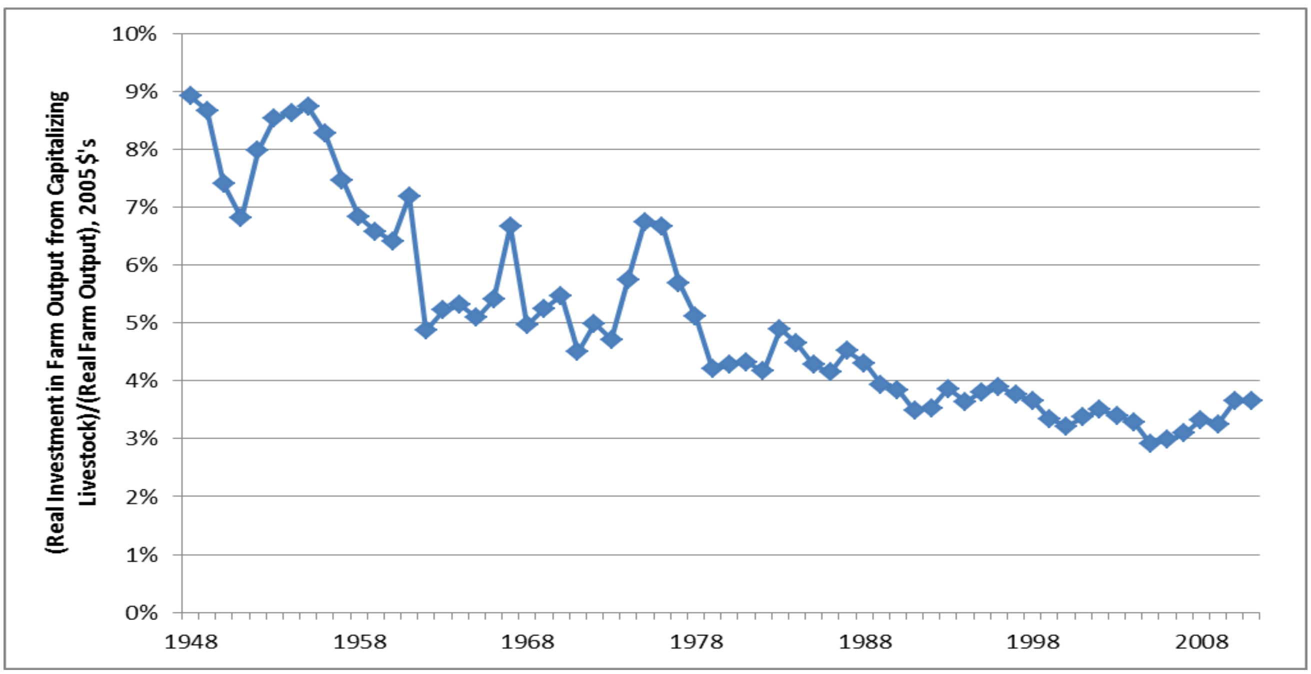


Figure 12 shows the same general pattern as the nominal changes shown in Figure 10. However, the average inflation rate for working cows is larger than the average inflation rate for other types of farm output. As a result, capitalizing working livestock lowers real growth rates for farm output by more than it lowers nominal growth rates.

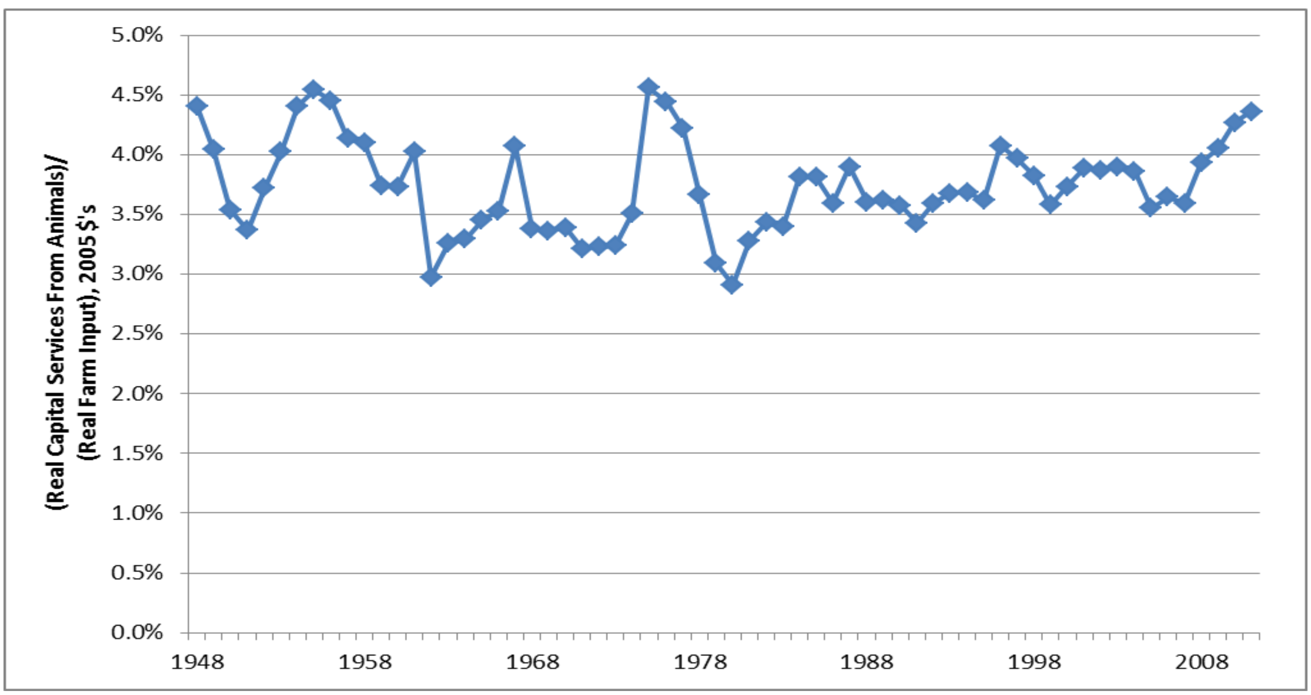
II.e Changes in Real Farm Inputs

Once again, this table is taken from ERS's published spreadsheet calculating farm productivity.[14] Once again, we focus on the period 1948 to 2011. Capitalizing cows impacts the summary lines 'real total farm input' (column 28) and 'real capital services' (column 30). In addition, we add a new column tracking the capital services from working animals 'real capital services from animals' (line 32). Table 4 shows how ERS's published table might change for selected years:

Table 4: Real Livestock Production and Overall Farm Output (2005 $'s)

		1950	1970	1990	2008	2009	2010	2011
28	Real Total Farm Input (Old)	269,241	285,991	275,810	276,499	271,576	272,124	271,723
28	Real Total Farm Input (Revised)	278,764	295,693	285,670	287,388	282,575	283,743	283,578
30	Real Capital Services (Old)	76,293	79,335	69,075	63,384	63,948	63,799	63,709
30	Real Capital Services (Revised)	85,817	89,036	78,934	74,272	74,947	75,418	75,564
32	Real Capital Services from Animals	9,523	9,702	9,859	10,889	10,999	11,619	11,855

Figure 13: Change in Real Farm Inputs



[14] http://www.ers.usda.gov/data-products/agricultural-productivity-in-the-us.aspx

Figure 13 shows that real capital services from working livestock has hovered around 4% of real farm inputs (2005 $'s) from 1950 to 2011. This result is in sharp contrast to the Figure 12, which showed that capitalizing working livestock raises measured farm output much more in 1948 than it does in 2011. This difference produces a decline in measured TFP that we will soon show.

II.f Change in Measured Total Factor Productivity (TFP)

Once again, this table is based on ERS's published spreadsheets. ERS publishes real farm output and real farm input, so it is simple to calculate annual TFP. However, ERS does not publish a table giving measured TFP directly – so there is no table to revise.

Figure 14: Change in Measured Farm TFP

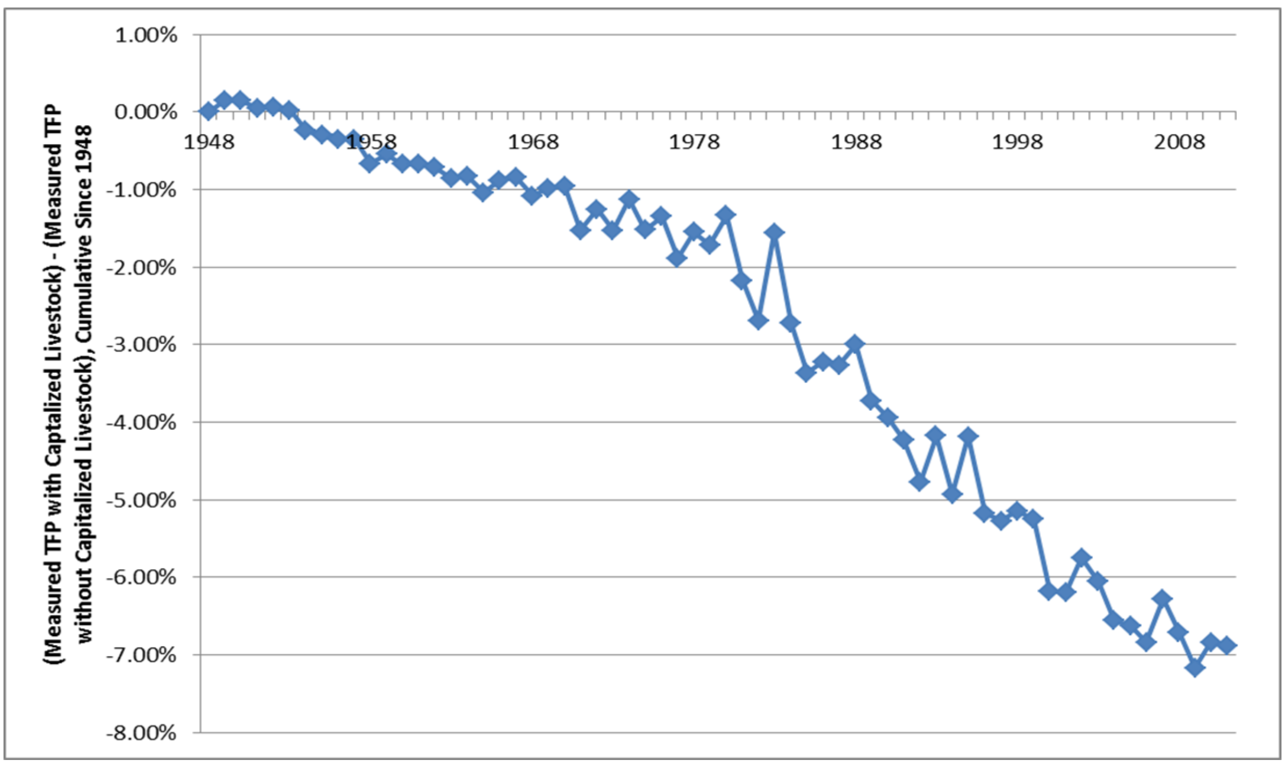


Figure 14 shows that measured TFP growth is significantly lower when livestock are treated as capital assets. Between 1948 and 2011, average TFP growth falls from 1.42% per year to 1.38% per year. Figure 14 shows cumulative TFP growth, so the effect appears to grow over time. In fact, the reduction in annual TFP growth hovers around -0.05% per year from 1960 onwards. However, the measured TFP growth is relatively stable at -0.05% per year from 1960 onwards, HoAt first glance, this result might seem to suggest that farmers have become less productive raising animals. In fact, we find that real investment in working cows tracks real capital services from working cows very closely. The real reason for the lower average TFP growth shown in Figure 14 is simple. Between 1948 and 2011, the farm sector currently tracked by ERS enjoyed dramatic TFP gains. Our paper adds a new input and output component to ERS's farm accounts. This new component has had TFP growth near zero between 1948 and 2011. Therefore, its inclusion in the ERS farm accounts lowers average TFP growth.

The drop in measured TFP shown in Figure 14 is not sensitive to our quality index for cows. It is definitely true that real output growth falls if cow quality has grown slower than we show in Figures 5 and 6. However, real input growth falls by approximately the same rate when cow quality growth is slower. The net effect of slower cow quality growth on measured TFP is nearly zero. Conversely, faster cow quality growth also has virtually no effect on measured TFP growth.

Conclusion

A recent review of ERS's productivity accounts recommended that ERS treat dairy cows, breeding beef cows and other long-lived working animals as capital assets (Shumway, et. al 2014). BEA was also given the same recommendation in the international guidelines for national accounts, *System of National Accounts 2008* (SNA 2008). In ERS's farm accounts and BEA's National Income and Product Accounts (NIPA's), long-lived working animals are currently treated as an inventory asset. This paper recalculates the farm accounts and NIPA's when long-lived working animals are re-classified as a capital asset. We show that this reclassification raises farm output and GDP for every year – but the increase is larger for earlier years. As a result, real farm output growth and real GDP growth falls slightly when long-lived working animals are capitalized. Total factor productivity (TFP) growth also falls from 1.42% per year to 1.38% per year when long-lived working animals are capitalized.

Appendix A: Annual Numbers for Productive Stock, Wealth Stock, Prices, Investment, Depreciation and Inventory Change

Table 5: Investment, Prices, Stock and Deterioration of Dairy Cows

	Population, in 2012 New cow units				Dairy Cow Prices			Nominal Values (Billions of $'s)			
	Genetic Quality Index	Productive Stock (Ball/Harper)	Productive Stock (PIM)	Wealth Stock	Per Head	Adjusted for Quality	Price Index	Investment	Capital Stock	Implied Depreciation	Inventory Adjustment
2014	101.31%	10,305	10,573	8,802	1,451	1,432	100.9	-	12.60	-	
2013	100.68%	10,277	10,545	8,724	1,380	1,371	96.6	4.85	11.96	4.74	0.01
2012	100.00%	10,215	10,183	8,664	1,430	1,430	100.8	4.75	12.39	4.66	-0.08
2011	99.22%	10,083	9,672	8,507	1,420	1,431	100.9	4.75	12.17	4.52	-0.05
2010	98.63%	10,040	9,124	8,331	1,330	1,348	95.1	4.49	11.23	4.25	0.16
2009	98.00%	10,248	9,081	8,497	1,390	1,418	100.0	3.95	12.05	4.18	-0.04
2008	97.28%	10,122	8,977	8,359	1,950	2,005	141.3	5.84	16.76	5.57	-0.08
2007	96.47%	9,914	9,143	8,193	1,830	1,897	133.8	5.29	15.54	4.97	-0.04
2006	95.75%	9,696	9,535	8,114	1,730	1,807	127.4	4.71	14.66	4.57	-0.03
2005	95.13%	9,473	9,754	8,055	1,770	1,861	131.2	5.01	14.99	4.90	-0.01
2004	94.47%	9,428	9,453	7,945	1,580	1,673	117.9	5.34	13.29	5.16	0.09
2003	93.60%	9,503	9,441	8,008	1,340	1,432	100.9	4.13	11.47	4.23	-0.02
2002	92.77%	9,405	9,407	7,907	1,600	1,725	121.6	5.12	13.64	4.94	0.03
2001	91.99%	9,392	9,544	7,902	1,500	1,631	115.0	4.68	12.89	4.67	0.00
2000	91.24%	9,269	9,726	7,859	1,340	1,469	103.6	4.14	11.54	4.07	-0.03
1999	90.38%	9,073	9,732	7,755	1,280	1,416	99.9	4.11	10.98	3.96	0.03
1998	89.44%	9,054	9,497	7,716	1,120	1,252	88.3	3.84	9.66	3.79	0.04
1997	88.45%	9,104	9,224	7,690	1,100	1,244	87.7	3.82	9.56	3.79	0.04
1996	87.52%	9,104	9,085	7,687	1,090	1,245	87.8	3.55	9.57	3.54	0.02
1995	86.61%	9,061	8,876	7,660	1,130	1,305	92.0	3.65	9.99	3.62	0.02
1994	85.65%	9,056	8,473	7,551	1,170	1,366	96.3	4.07	10.31	3.92	0.14
1993	84.63%	9,259	8,462	7,694	1,160	1,371	96.6	3.57	10.55	3.76	0.04
1992	83.59%	9,253	8,448	7,643	1,130	1,352	95.3	3.63	10.33	3.56	0.13
1991	82.73%	9,322	8,735	7,777	1,100	1,330	93.8	3.18	10.34	3.36	0.00
1990	81.65%	9,209	8,689	7,678	1,160	1,421	100.2	3.85	10.91	3.71	0.03
1989	80.68%	9,129	8,663	7,641	1,030	1,277	90.0	3.34	9.75	3.29	0.05
1988	79.86%	9,076	8,577	7,636	990	1,240	87.4	3.22	9.47	3.21	0.14
1987	78.95%	9,356	8,128	7,647	920	1,165	82.2	3.56	8.91	3.57	0.16
1986	78.05%	9,481	8,498	7,878	820	1,051	74.1	2.26	8.28	2.51	0.06
1985	77.24%	9,536	8,262	7,881	860	1,113	78.5	3.01	8.77	3.02	0.00

1984	76.33%	9,479	8,060	7,781	895	1,173	82.7	3.14	9.12	3.02	-0.01
1983	75.43%	9,327	8,089	7,690	1,030	1,365	96.3	3.32	10.50	3.20	-0.02
1982	74.48%	9,153	8,132	7,579	1,110	1,490	105.1	3.66	11.30	3.49	-0.06
1981	73.63%	8,955	8,184	7,376	1,200	1,630	114.9	4.28	12.02	3.94	-0.03
1980	72.74%	8,705	8,732	7,296	1,190	1,636	115.3	3.66	11.94	3.53	0.03
1979	71.95%	8,610	9,007	7,277	1,040	1,446	101.9	3.66	10.52	3.63	0.05
1978	71.02%	8,535	9,017	7,281	675	950	67.0	2.50	6.92	2.50	0.03
1977	70.13%	8,473	8,637	7,274	504	719	50.7	1.96	5.23	1.96	0.01
1976	69.51%	8,529	7,740	7,134	477	686	48.4	2.14	4.90	2.04	0.03
1975	68.85%	8,629	7,313	7,093	412	598	42.2	1.58	4.24	1.56	0.01
1974	68.15%	8,652	7,241	7,060	500	734	51.7	1.72	5.18	1.70	0.08
1973	67.44%	8,819	7,504	7,228	496	735	51.9	1.54	5.32	1.67	0.05
1972	66.80%	8,913	7,682	7,237	397	594	41.9	1.42	4.30	1.43	0.16
1971	66.27%	9,250	8,499	7,658	358	540	38.1	1.03	4.14	1.26	0.03
1970	65.65%	9,296	8,830	7,664	332	506	35.7	1.33	3.88	1.33	0.10
1969	65.29%	9,506	9,324	7,930	300	459	32.4	1.10	3.64	1.23	0.11
1968	64.96%	9,692	9,405	8,308	274	422	29.7	0.99	3.50	1.15	0.10
1967	64.53%	10,282	8,032	8,408	260	403	28.4	1.47	3.39	1.51	0.12
1966	64.06%	11,056	7,442	8,685	246	384	27.1	1.16	3.34	1.27	0.15
1965	63.62%	11,717	8,098	9,261	212	333	23.5	0.67	3.09	0.87	0.08
1964	63.16%	12,169	8,873	9,628	209	331	23.3	0.78	3.19	0.90	0.08
1963	63.01%	12,608	10,042	10,026	215	341	24.1	0.85	3.42	0.98	0.07
1962	62.60%	12,636	11,740	10,483	221	353	24.9	0.71	3.70	0.87	0.04
1961	62.30%	12,760	11,977	10,632	224	360	25.4	1.24	3.82	1.30	0.03
1960	62.03%	12,909	12,009	10,738	223	360	25.3	1.32	3.86	1.36	0.08
1959	62.02%	13,317	12,055	11,019	233	376	26.5	1.40	4.14	1.50	0.17
1958	62.02%	14,080	12,117	11,537	210	339	23.9	1.27	3.91	1.45	0.15
1957	62.02%	14,724	12,341	12,066	167	269	19.0	0.96	3.24	1.10	0.06
1956	61.95%	15,114	12,211	12,318	154	248	17.5	0.96	3.06	1.02	0.04
1955	61.95%	15,441	11,939	12,521	147	237	16.7	0.91	2.96	0.96	0.03
1954	61.89%	15,700	11,531	12,699	150	242	17.1	0.90	3.07	0.94	-0.03
1953	61.89%	15,591	10,942	12,511	178	287	20.3	1.10	3.60	1.05	-0.04
1952	61.89%	15,439	10,572	12,166	244	395	27.8	1.55	4.80	1.42	0.07
1951	61.82%	15,734	11,348	12,497	248	401	28.3	1.19	5.02	1.32	0.04
1950	61.82%	15,748	12,067	12,760	199	322	22.7	0.94	4.11	1.02	0.01
1949	61.82%	15,818	11,934	12,773	185	299	21.1	1.15	3.82	1.15	0.03
1948	61.82%	16,150	11,881	12,822	186	301	21.2	1.23	3.86	1.24	0.12

Table 6: Investment, Prices, Stock and Deterioration of Breeding Beef Cows

	Population, in 2012 New cow units				Beef Cow Prices			Nominal Values (Billions of $'s)			
	Genetic Quality Index	Productive Stock (Ball/Harper)	Productive Stock (PIM)	Wealth Stock	Per Head	Adjusted for Quality	Price Index	Investment	Capital Stock	Implied Depreciation	Inventory Adjustment
2014	100.88%	31,875	32,360	25,285	1,801	1,786	217.0	-	45.55	-	-
2013	100.35%	32,020	32,507	25,389	1,290	1,286	156.2	4.67	32.76	4.64	0.60
2012	100.00%	32,495	32,495	25,781	1,237	1,237	150.4	4.36	31.90	4.74	0.96
2011	99.82%	33,362	32,467	26,431	1,118	1,120	136.1	4.06	29.55	4.74	0.44
2010	99.30%	33,775	32,197	26,630	939	946	115.0	3.72	25.02	3.78	0.23
2009	98.77%	33,997	32,103	26,714	813	823	100.0	3.14	21.71	3.09	0.40
2008	98.42%	34,607	32,140	27,086	862	876	106.4	3.24	23.35	3.48	0.28
2007	98.07%	34,957	32,504	27,340	911	929	112.9	3.23	24.91	3.37	0.06
2006	97.72%	34,969	32,744	27,317	894	915	111.2	3.29	24.42	3.18	-0..05
2005	97.37%	34,754	33,445	27,270	921	946	114.9	3.09	25.11	2.96	-0.03
2004	96.84%	34,554	33,821	27,217	858	886	107.7	3.02	23.36	2.85	0.08
2003	96.67%	34,577	33,848	27,211	755	781	94.9	2.94	20.55	2.90	0.0
2002	96.14%	34,647	33,821	27,216	653	680	82.6	2.56	17.78	2.47	0.12
2001	95.79%	34,854	33,825	27,372	718	750	91.1	2.71	19.66	2.75	0.08
2000	95.44%	34,896	34,269	27,534	696	730	88.7	2.45	19.17	2.49	0.08
1999	95.09%	34,918	34,356	27,652	606	638	77.5	2.27	16.76	2.28	0.06
1998	94.74%	34,910	34,579	27,672	555	586	71.2	2.24	15.37	2.20	0.14
1997	94.39%	35,133	34,355	27,837	592	627	76.2	2.45	16.48	2.49	0.36
1996	94.04%	35,864	34,201	28,378	469	498	60.5	1.95	13.30	2.15	-0.02
1995	93.68%	35,593	34,056	28,153	536	572	69.5	2.30	15.08	2.12	-0.19
1994	93.33%	34,926	33,885	27,619	598	640	77.8	2.57	16.51	2.18	-0.35
1993	92.81%	34,040	33,573	26,794	674	726	88.2	3.12	18.05	2.46	-0.06
1992	92.46%	33,751	34,308	26,637	634	686	83.4	2.41	16.90	2.24	-0.26
1991	92.18%	33,113	34,705	26,199	680	738	89.7	2.67	17.82	2.32	-0.04
1990	91.63%	32,893	34,979	26,047	673	734	89.2	2.69	17.52	2.48	0.18
1989	91.08%	33,045	35,675	26,293	619	680	82.6	2.31	16.28	2.37	-0.21
1988	90.80%	32,560	35,866	25,864	588	647	78.7	2.63	15.20	2.33	0.33
1987	90.26%	33,032	37,422	26,368	532	590	71.7	2.00	14.03	2.19	-0.07
1986	89.71%	32,836	37,856	25,967	429	478	58.1	2.22	11.14	1.98	0.64
1985	89.16%	34,315	39,630	27,205	429	481	58.5	1.57	11.68	2.03	0.78
1984	88.62%	36,167	41,042	28,655	433	489	59.4	1.77	12.42	2.33	0.21
1983	88.08%	36,630	41,523	28,979	419	475	57.8	1.98	12.13	2.04	0.48
1982	87.81%	37,640	42,476	29,928	428	487	59.2	1.77	12.81	2.14	-0.23
1981	87.54%	37,065	42,485	29,508	434	495	60.2	2.20	12.79	1.98	-0.69

1980	87.27%	35,666	41,261	28,273	483	553	67.2	2.76	13.65	2.12	-0.04
1979	87.00%	35,652	41,116	28,473	524	602	73.2	2.23	14.91	2.29	0.94
1978	86.73%	37,366	40,212	30,092	376	433	52.7	1.66	11.31	2.24	0.89
1977	86.46%	39,629	39,205	32,120	250	289	35.1	1.23	8.03	1.71	0.54
1976	86.19%	41,466	37,928	33,636	234	272	33.1	1.31	7.89	1.64	0.41
1975	85.92%	42,682	35,562	34,180	197	230	27.9	1.38	6.74	1.47	-0.46
1974	85.65%	40,193	33,052	31,876	235	274	33.3	1.73	7.49	1.16	-0.50
1973	85.65%	38,140	31,624	30,077	331	386	46.9	2.04	9.95	1.44	-0.67
1972	85.51%	36,178	29,845	28,313	256	300	36.4	1.49	7.26	1.02	-0.30
1971	85.51%	35,055	28,471	27,274	225	263	32.0	1.12	6.14	0.89	-0.23
1970	85.65%	34,172	26,730	26,335	210	245	29.8	1.00	5.53	0.82	-0.10
1969	85.51%	33,887	25,218	25,774	205	240	29.2	0.90	5.29	0.78	0.14
1968	85.51%	34,699	25,038	26,370	175	205	24.9	0.52	4.62	0.63	0.10
1967	85.37%	35,203	24,814	26,772	163	191	23.2	0.51	4.36	0.57	0.13
1966	85.37%	35,635	26,254	27,679	165	193	23.5	0.27	4.57	0.42	0.03
1965	85.37%	35,510	26,242	27,664	150	175	21.3	0.56	4.14	0.55	-0.23
1964	85.09%	33,623	25,471	26,216	131	154	18.7	0.58	3.43	0.38	-0.25
1963	85.23%	31,516	24,960	24,626	148	174	21.1	0.63	3.65	0.40	-0.38
1962	84.93%	28,933	23,935	22,369	161	189	23.0	0.80	3.59	0.43	-0.21
1961	84.80%	27,786	22,692	20,983	149	176	21.4	0.72	3.13	0.51	-0.12
1960	84.80%	27,217	23,148	20,618	144	170	20.7	0.36	2.98	0.31	-0.15
1959	84.80%	26,438	23,482	20,148	160	189	22.9	0.37	3.23	0.30	0.06
1958	85.23%	26,831	24,964	20,891	151	177	21.5	0.18	3.14	0.31	0.05
1957	84.38%	27,077	25,709	21,413	116	137	16.7	0.24	2.48	0.28	0.07
1956	84.52%	27,588	25,990	22,053	95	112	13.6	0.26	2.09	0.33	0.00
1955	84.95%	27,472	25,867	22,003	100	118	14.3	0.37	2.20	0.38	-0.05
1954	84.52%	26,784	25,817	21,477	101	119	14.5	0.39	2.16	0.33	-0.15
1953	84.24%	25,003	25,123	19,990	90	107	13.0	0.40	1.80	0.26	-0.23
1952	85.37%	22,572	24,651	18,152	143	168	20.4	0.54	2.60	0.32	-0.33
1951	85.09%	20,371	24,109	16,439	184	217	26.3	0.65	3.03	0.32	-0.29
1950	84.95%	18,842	23,122	15,075	150	177	21.5	0.58	2.26	0.37	-0.14
1949	84.80%	17,999	22,172	14,324	109	129	15.7	0.36	1.57	0.28	0.05
1948	84.80%	18,462	22,181	14,877	126	149	18.1	0.28	1.88	0.35	0.07

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