Net Farm Income, Market Prices and Agricultural Productivity Growth in the United States

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1 Introduction

Real net farm income in the United States has been declining slowly but surely. Between 1948 and 2002, U.S. real net farm income decreased in aggregate by about 2.2 Billion $1996 per year – see Figure 1.[1] Yet for most of this period, annual productivity growth was substantial [1, p. 1045].

This juxtaposition of declining net farm income and healthy productivity growth represents one element of the 'farm problem' [8, p. 62]. An additional feature of the problem is that the economic well-being of farmers and their families has been low, both in absolute terms and in relation to non-farm families. This disparity has become less marked over time, but the improvement has been due to growth in off-farm income, which has become an increasingly important part of farm household income.[2] While the income of farm and non-farm households has gradually equalized, the issue of low net farm income remains prominent in the justification of various policies designed to "ameliorate the farm problem" [8, p. 85].

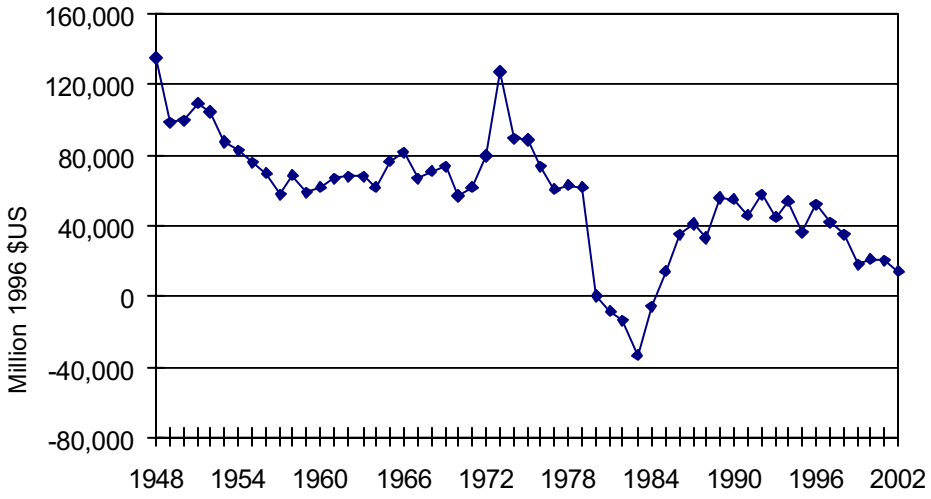
The striking reduction in aggregate real net farm income illustrated in Figure 1 does not take into account another well-known feature of U.S. agriculture – the number of farms has also been steadily declining. In 2002 there were about 2.2 million farms in the United States, 3.4 million fewer than in 1948 [18, pp. 34-35]. This exit of about 63,000 farms per year means that any analysis of net farm income must allow for the effect of reductions in the number of farms.[3]

[1] The net farm income data are derived using price and implicit quantity data from the U.S. agriculture production account (see the Data and Results section for details on the production account data). The data do not include government payments that are not specifically tied to the production of one or more outputs, i.e. decoupled payments. These net farm income data are then deflated using the U.S. all-items CPI (base 1984-1986, scaled to 1996). The deflated series gives an idea of the spending power of net farm income over time.

[2] The proportion of total farm household income accounted for by farming income has decreased significantly over time, from about 50% in 1964 to less than 30% in 1999 [14, p. 4].

[3] Net farm income is often reported in aggregate and is an influential and highly publicized statistic when about used to describe the health of the farm sector. Generally speaking, average net farm income per operation is a secondary statistic, even though it is probably a better indicator. See, for example, [16] or the ERS 2007 Farm Income Forecast (obtainable at www.ers.usda.gov).

Figure 1. Real Aggregate Net Farm Income, United States, 1948-2002



SOURCE: Calculations with ERS Agricultural Productivity database (see Annex 1)

This analysis addresses the farm problem in two stages. First, changes in nominal net farm income are decomposed into market price and productivity growth effects. Bennet indicators provide the elements of price and quantity change in this decomposition.

In the second stage, elements quantified in the first stage are related to changes in the real implicit wage earned by the residual claimants, namely farm operators and unpaid family members that work on the farm. This makes it possible to show how productivity growth and market price changes affect the economic well-being of the farm household.

The next section gives more precise definitions of net farm income and the residual claimant. The third section outlines the methodology used to decompose nominal net farm income growth and the method used to relate this decomposition to changes in the real implicit wage. Data used for the computations and results from the decomposition are presented in the fourth and fifth sections respectively. The last section provides some concluding comments.

2 Net Farm Income and the Residual Claimant

Net farm income (NFI) is defined by the United States Department of Agriculture, Economic Research Service (ERS) as the "share of output earned by operator households and others who share risks" [7, p. 4] – 'others' means other households, corporations and other entities that may be residual claimants. If the others component does not play an important role in the distribution of NFI, then the residual claimants are operators and unpaid family members. As Hottel and Gardner put it, this is the 'essence of family farming'.[4]

The ERS definition provides the basis for NFI measurement within the context of a production account for agriculture. In the account, the revenue from all agricultural outputs equals the cost of all inputs. This means that profit, in the usual sense of the word, will always be zero in the account. To ensure that the equality of cost and revenue holds, the price of one or more inputs must adjust; the prices for these 'residual claimant' inputs are

[4] See [11, p. 553]. The authors nevertheless choose equity capital as the residual claimant. Their approach is generally consistent with analyses of returns in the non-agricultural sector, where capital is the residual claimant and the cost of capital services is measured as the gross operating surplus in the national accounts [6, p. 5].

thereby endogenously determined.[5] Both the total value and the unit value of the residual will depend upon the claimant – if owners of land were the residual claimants, the return to these owners would usually be different from that to owners of another input (e.g. machinery).

In the computations made here, only operator and unpaid family labour will be treated as the residual claimant – this is consistent with the ERS definition of NFI. The methodology developed in the next section nevertheless allows for more than one residual claimant, so that an analyst can choose the residual claimant or set of claimants without being bound by the one chosen here.

3 Methodology

The approach taken in this section is to first establish the manner in which a change in nominal NFI growth can be decomposed into output price change, input price change and productivity growth components. Then the decomposition of the real implicit wage is specified.[6]

Suppose that, in each year, N inputs are used to produce M agricultural outputs and that there are $H < N$ residual claimants. Suppose also that observations on the prices and quantities of all of these inputs and outputs are available. Use the following notation: output prices in year t are the variables $p_{1,t}, p_{2,t}, \ldots, p_{M,t}$, where each price includes any subsidy that is tied to production of that output.[7] Transfer payments made to farmers by governments – i.e. payments that are are decoupled from production – are not included in prices $p_{1,t}, p_{2,t}, \ldots, p_{M,t}$, nor do they appear in the definition of NFI used here.[8]

[5] This endogenous rate of return approach is "the most widely used methodology" for the computation of total (multi) factor productivity statistics [17, p. 14]. Typically, the residual claimant input is one or more productive capital assets. In this case, the endogenous variable is the rate of return, which adjusts to ensure that total revenue equals total cost [17, pp. 3-4],[13, pp. 13-14].

[6] The methodology outlined here need not be restricted to net farm income. It could just as easily be related to net income for any firm or sector – the key is that one or more inputs have an endogenous price or endogenous rate of return that ensured equality of revenue and cost.

[7] Output 'price' may be a price index or a unit value (e.g. $/tonne). Output 'quantity' may be an actual quantity (e.g. '000 tonnes of wheat) or an implicit quantity obtained by dividing the nominal value of output by a price index.

[8] These payments may, however, play an important role in determining the farm household's overall income from farming activity, the decisions made by the operators his/her

Gross output quantities are the variables $y_{1,t}, y_{2,t}, \ldots, y_{M,t}$. Gross output is defined, for any commodity or commodity aggregate i, as total sales of i plus net additions to inventories. Sales of i include consumption of farm output by farm households, and sales made by farms to purchasers outside of the farm sector.

Input prices are the variables $w_{1,t}, w_{2,t}, \ldots, w_{N-H,t}$, where each price includes any rebate that is given for that input; input quantities are the variables $x_{1,t}, x_{2,t}, \ldots, x_{N-H,t}$. Inputs are ordered so that inputs $1, 2, \ldots, N-H$ have explicit prices, i.e. these are not residual claimants. When there is only one residual claimant, the inputs are ordered so that the N^{th} input is that residual claimant.

Total revenue is the sum of the values of individual outputs, i.e. $R_t = \mathbf{p}_t \cdot \mathbf{y}_t$, where $\mathbf{p}_t$ is the $1 \times M$ vector $[p_{1,t}, p_{2,t}, \ldots, p_{M,t}]$ and $\mathbf{y}_t$ is the $1 \times M$ vector $[y_{1,t}, y_{2,t}, \ldots, y_{M,t}]$. Production cost for all but the residual claimant input(s) is the sum of the expenditure on each of the $N - H$ inputs, i.e. $C_t = \mathbf{w}_t \cdot \mathbf{x}_t$, where $\mathbf{w}_t$ is the $1 \times (N-H)$ vector $[w_{1,t}, w_{2,t}, \ldots, w_{N-H,t}]$ and $\mathbf{x}_t$ is the $1 \times (N-H)$ vector $[x_{1,t}, x_{2,t}, \ldots, x_{N-H,t}]$.

Nominal NFI in year t, denoted by F_t, is the difference between the total value of agricultural output, R_t, and the cost of all inputs in the account – excluding residual claimant(s) – C_t. So

$$F_t = \mathbf{p}_t \cdot \mathbf{y}_t - \mathbf{w}_t \cdot \mathbf{x}_t. \tag{1}$$

The change in nominal NFI is measured as:

$$F_t^G = F_t - F_{t-1} \ . \tag{2}$$

This means, substituting (1) into (2), that

$$F_t^G = [\mathbf{p}_t \cdot \mathbf{y}_t - \mathbf{p}_{t-1} \cdot \mathbf{y}_{t-1}] - [\mathbf{w}_t \cdot \mathbf{x}_t - \mathbf{w}_{t-1} \cdot \mathbf{x}_{t-1}] \ . \tag{3}$$

The first term in square brackets on the right-hand side of (3) is the change in total revenue between year $t-1$ and year t. The second term in square brackets is the change in the cost of all inputs – excluding residual claimant(s) – between year $t-1$ and year t.

family members regarding on-farm and off-farm work (i.e. labour supply) and decisions about entry into, or exit from, farming.

The difference in value (revenue or cost) between year $t-1$ and year t can be expressed as the sum of price change indicators and aggregate quantity indicators for the commodities or commodity aggregates produced or utilized [4, p. 313]. There are several possible formulas for these indicators, and their properties can be assessed with a range of tests similar to those used to assess conventional index number formulas like the Fisher Ideal price index. Of the candidates, the Bennet price and quantity change indicators fulfill all of the properties needed to meet the requirements of 'well-behaved' indicators [4, p. 331, Prop. 2].

The decomposition of the change in revenue between year $t-1$ and year t can be expressed as the sum of the Bennet indicators of output price and output quantity change [4, pp. 313-314], i.e.

$$\begin{aligned}\mathbf{p}_t \cdot \mathbf{y}_t - \mathbf{p}_{t-1} \cdot \mathbf{y}_{t-1} \equiv\ & I_R\left(\mathbf{p}_t, \mathbf{y}_t, \mathbf{p}_{t-1}, \mathbf{y}_{t-1}\right) + \\ & V_R\left(\mathbf{p}_t, \mathbf{y}_t, \mathbf{p}_{t-1}, \mathbf{y}_{t-1}\right)\end{aligned} \tag{4}$$

where

$$I_R\left(\mathbf{p}_t, \mathbf{y}_t, \mathbf{p}_{t-1}, \mathbf{y}_{t-1}\right) = \sum\nolimits_{i=1}^{M} y_{i,t}^{m}\left(p_{i,t} - p_{i,t-1}\right) \tag{4a}$$

is the Bennet indicator of aggregate output price change;

$$y_{i,t}^{m} = \left(y_{i,t} + y_{i,t-1}\right)/2$$

is the arithmetic average of the quantity of output i in year t and year $t-1$;

$$V_R\left(\mathbf{p}_t, \mathbf{y}_t, \mathbf{p}_{t-1}, \mathbf{y}_{t-1}\right) = \sum\nolimits_{i=1}^{M} p_{i,t}^{m}\left(y_{i,t} - y_{i,t-1}\right) \tag{4b}$$

is the Bennet indicator of aggregate output quantity change; and

$$p_{i,t}^{m} = \left(p_{i,t} + p_{i,t-1}\right)/2$$

is the arithmetic average of the price of output i in year t and year $t-1$.

A change in the cost of all inputs – excluding residual claimant(s) – between year $t-1$ and year t can be decomposed in a similar manner:

$$\begin{aligned}\mathbf{w}_t \cdot \mathbf{x}_t - \mathbf{w}_{t-1} \cdot \mathbf{x}_{t-1} \equiv\ & I_C\left(\mathbf{w}_t, \mathbf{x}_t, \mathbf{w}_{t-1}, \mathbf{x}_{t-1}\right) + \\ & V_C\left(\mathbf{w}_t, \mathbf{x}_t, \mathbf{w}_{t-1}, \mathbf{x}_{t-1}\right),\end{aligned} \tag{5}$$

where

$$I_C\left(\mathbf{w}_t,\mathbf{x}_t,\mathbf{w}_{t-1},\mathbf{x}_{t-1}\right)=\sum\nolimits_{j=1}^{N-H}x_{j,t}^m\left(w_{j,t}-w_{j,t-1}\right) \tag{5a}$$

is the Bennet indicator of price change for the aggregate of all but the residual claimant input(s);

$$x_{j,t}^m=\left(x_{j,t}+x_{j,t-1}\right)/2$$

is the arithmetic average of the quantity of input j used in year t and year $t-1$;

$$V_C\left(\mathbf{w}_t,\mathbf{x}_t,\mathbf{w}_{t-1},\mathbf{x}_{t-1}\right)=\sum\nolimits_{j=1}^{N-H}w_{j,t}^m\left(x_{j,t}-x_{j,t-1}\right) \tag{5b}$$

is the Bennet indicator of quantity change for the same aggregate; and

$$w_{j,t}^m=\left(w_{j,t}+w_{j,t-1}\right)/2$$

i.e. this is the arithmetic average of the price of input j in year t and year $t-1$.

Substitution of (4) and (5) into (3) gives the following decomposition of a change in nominal NFI:

$$F_t^G=I_R\left(\mathbf{p}_t,\mathbf{y}_t,\mathbf{p}_{t-1},\mathbf{y}_{t-1}\right)-I_C\left(\mathbf{w}_t,\mathbf{x}_t,\mathbf{w}_{t-1},\mathbf{x}_{t-1}\right)+PFPG_t, \tag{6}$$

where

$$PFPG_t=\left[V_R\left(\mathbf{p}_t,\mathbf{y}_t,\mathbf{p}_{t-1},\mathbf{y}_{t-1}\right)-V_C\left(\mathbf{w}_t,\mathbf{x}_t,\mathbf{w}_{t-1},\mathbf{x}_{t-1}\right)\right] \tag{7}$$

is partial factor productivity growth. The formulas for the price change indicators in (6) are given by (4a) and by (5a). The formulas for the quantity change indicators in (7) are given by (4b) and by (5b).

Expression (6) shows that a change in nominal NFI between year $t-1$ and year t can be decomposed into three parts: (i) the change in the output price component; less (ii) the change in the input price component; plus (iii) partial factor productivity growth. All of the components are measured in nominal dollars – this means that the productivity measure $PFPG_t$ is the dollar value contribution to nominal NFI from partial factor productivity growth.

Note that expression (6) is the same as that for a single Bennet indicator of overall quantity change when production is cast in a net output

framework – see [5, pp. 5-6]. Expression (6) is also much the same as the expression for the decomposition of profit given in [12, pp. 32-33], once the gross productivity and scale impacts given there are combined and terms are eliminated. With the decompositions in [5] and [12], however, the measure of productivity change is TFPG, rather than PFPG, since profit is the dollar amount of revenue in excess of the opportunity cost of all inputs. Where owners of firms pay a wage or salary to operators (e.g., as in a corporation with common shareholders), such 'pure profit' can exist, since it is disbursed as dividends to the owners once all inputs are assigned a price in the firm's accounts. To measure the change in returns to a residual claimant or claimants, and to decompose this change, expression (6) is therefore more appropriate than the decomposition formulas in [12] or [5].

Similar decompositions to (6) can also be found in [9] and in [15]. These studies, however, not only allow for pure profit, but also treat the change in net income as the ratio of net income in year t to that in year $t-1$, i.e. they use the ratio F_t/F_{t-1} – see [9, p. 3] and [15, p. 4]. Finally, an approach similar in spirit to (6) was applied in [3], but in relation to a measure called 'normal income'.

The measure of productivity growth (7) is partial because the indicator of input quantity change excludes the change in use of the residual claimant(s) input. Partial factor productivity growth (PFPG) can be related to other productivity measures such as labour productivity growth and total factor productivity growth.

When there is only one residual claimant (the N^{th} input), the implicit price for this input is estimated as:[9,10]

[9] As noted earlier, in analyses of the non-agricultural sector, capital is often the residual claimant. In this case, the residual can be related to a cost of capital formula and thereby used to compute an 'internal rate of return' – see [10, p. 346],[13, p. 14].

[10] The real implicit wage need not be positive. For example, the data presented in Figure 1 show that real NFI was negative over the period 1981-1984. An interpretation of this is that, over this period, operators and their families, acting as farm-household members, received a 'negative wage' from the labour they supplied to their farms – in reality this means that they had to use other forms of farm-household income to meet the cost of the other $N-1$ farm inputs, and that they also received no wage at all. It would appear that even this form of subsidization of the farm by farm families was insufficient to prevent the exit of many farms. Although bankruptcy data for this period do not exist, there is little doubt that farm bankruptcies were very common in the U.S. between 1981 and 1984. The early to mid-1980's have been referred to as the "second episode of concern about farmer bankruptcies in the 20th century" [18, pp. 13], i.e., that in terms of farm financial stress,

$$w^I_{N,t} = F_t / x_{N,t} \ . \tag{8}$$

Where this N^{th} input is operator and unpaid family labour, $x_{N,t}$ is the quantity of labour (measured as hours of work) supplied to the farm by the operator and his/her family members, and $w^I_{N,t}$ is the implicit wage that they receive. In other words it is the 'take-home pay' from the labour that they supply to the farm.

To compare movements in $w^I_{N,t}$ over time, the implicit wage must be converted into real terms, using an appropriate deflator. Deflation of $w^I_{N,t}$ with a consumer price index (CPI) allows the wage to be related to its spending power in purchasing consumer goods to be used by the farm household. Define the real implicit wage as

$$w^{IR}_{N,t} = \left(F_t / h_t\right) / x_{N,t} \ , \tag{9}$$

where h_t is a CPI (with base year b, where $h_b = 1$).

To link the decomposition (6) to changes in the real implicit wage (9), first note that the change in the real wage between any two years $t-1$ and t is

$$w^{IRG}_{N,t} = \left(F_t / h_t\right) / x_{N,t} \ - \left(F_{t-1} / h_{t-1}\right) / x_{N,t-1} \ . \tag{10}$$

Expression (10) can be related to F^G_t in (6) as follows. Add $F_{t-1} / \left(h_t x_{N,t}\right) - F_{t-1} / \left(h_t x_{N,t}\right)$ to the right-hand side of (10) to get

$$\begin{aligned} w^{IRG}_{N,t} = {} & F_t / h_t x_{N,t} - F_{t-1} / h_t x_{N,t} - \\ & \left[F_{t-1} / \left(h_{t-1} x_{N,t-1}\right) - F_{t-1} / \left(h_t x_{N,t}\right)\right] \ . \end{aligned} \tag{11}$$

Note that

$$F_{t-1} / \left(h_t x_{N,t}\right) \equiv w^{IR}_{N,t-1} \left(h_{t-1} x_{N,t-1}\right) / \left(h_t x_{N,t}\right) .$$

With this equivalence and some rearrangement, (11) can be re-expressed as

this period was second only to the years immediately following the Great Depression.

The subsidization of farm operations by the farm household appears to have been important in other years as well, although this is not evident from the aggregate data. For example, in 1997, 60% of farm households appear to have made net contributions to the farm business [14, p. 34].

$$w_{N,t}^{IRG} = F_t^G / (h_t x_{N,t}) \; - w_{N,t-1}^{IR} \left[1 - (h_{t-1}/h_t)\,(x_{N,t-1}/x_{N,t})\right] \quad . \qquad (12)$$

The first term on the right-hand side of (12) is the change in nominal NFI between $t-1$ and t, converted into real dollars per hour of operator and unpaid family labour supplied in year t – this can be viewed as the incremental change in the real implicit wage due to a change in nominal NFI. The second term on the right-hand side of (12) – the 'CPI-hours factor' – captures the effect on a change in the real implicit wage from changes in the CPI (inflation) and from changes in the number of hours supplied to the farm by the operator and his/her family. The ratio h_{t-1}/h_t is less than one when there is positive inflation; when there is no change in any other right-hand side variable, this means that the real implicit wage decreases. Similarly, when the ratio $x_{N,t-1}/x_{N,t}$ is less than one, the operator and family members that work on the farm have increased their labour input. Again, when there is no change in any other right-hand side variable, this increase in hours of work means that the real implicit wage is lower than it otherwise would have been.

The relationship between the decomposition of a change in nominal NFI and changes in the real implicit wage can now be determined. Substitute (6) into (12) to get:

$$\begin{aligned} w_{N,t}^{IRG} = {} & I_R\left(\mathbf{p}_t, \mathbf{y}_t, \mathbf{p}_{t-1}, \mathbf{y}_{t-1}\right) / \left(h_t x_{N,t}\right) - \\ & I_C\left(\mathbf{w}_t, \mathbf{x}_t, \mathbf{w}_{t-1}, \mathbf{x}_{t-1}\right) / \left(h_t x_{N,t}\right) + PFPG_t / \left(h_t x_{N,t}\right) - \\ & w_{N,t-1}^{IR}\left[1 - (h_{t-1}/h_t)\,(x_{N,t-1}/x_{N,t})\right]. \end{aligned} \qquad (13)$$

There are four components to this decomposition. These components are, in real dollars per hour: (i) an output price change component; (ii) an input price change component; (iii) a partial factor productivity growth component; and (iv) a CPI-hours component.

4 Data

The data are comprised of $M = 10$ outputs and $N = 7$ inputs, for the years 1948-2002. The outputs and inputs (with indicator numbers) are listed in Table 1. Nine of the ten outputs are aggregates of commodities and commodity groups that are broadly representative of the crops and livestock composition of U.S. agriculture. The tenth – secondary output – refers to output that is not agricultural in nature, but that is produced using the farm's resources. Examples would be machine and labour services and recreation services (tours, etc.). Further details about both the output and the input data definitions are given in Appendix A.

Of the seven input aggregates, the last (the N^{th}) is operator and unpaid family labour. Inputs 1-6 are the '$N - H$' inputs, and these cover the main input categories: 'capital excluding land' (machinery, buildings and other non-land capital); 'land' (a quality-adjusted measure of land input); hired labour; farm-produced inputs (agricultural outputs that are also used as inputs, for example feed produced and used on the farm); purchased materials (from outside the agricultural sector, such as feed concentrate, fuel, etc.); and purchased services (custom harvesting, veterinarian services, etc.).

The series $p_{i,t}, y_{i,t}$ $(i = 1, 2, \ldots, 10)$, the series $w_{j,t}, x_{j,t}$ $(j = 1, 2, \ldots, 6)$, the series $x_{7,t}$ – the hours of operator and unpaid family labour – and the series h_t (CPI) are given in Appendix A, Table A1 and Table A2 – these series comprise the raw data.

Both output and input mix in U.S. agriculture changed substantially between 1948 and 2002. To illustrate this, it is helpful to create Fisher ideal implicit quantity indexes for crops and livestock, using the five individual crop aggregates $(i = 1 - 5)$ and four individual livestock aggregates $(i = 6 - 9)$ respectively. A third quantity index, that for all outputs, provides the denominator. Denote the crop quantity index as y_t^C, the livestock quantity index as y_t^L and the total output quantity index as y_t. Estimation of log-linear trends with the ratios $y_t^{Cr} = y_t^C/y_t$, $y_t^{Lr} = y_t^L/y_t$ and $y_t^{Sr} = y_{10,t}/y_t$ indicate that the livestock output share fell by about 0.4% each year between 1948 and 2002.[11]

[11] These growth rates were estimated using an exponential trend equation of the form $ln(y_t^{kr})=\alpha^k + \beta^k t$ – where $k = C, L, S$). Since autocorrelation was present in all three equations, a first-order autoregression was estimated for livestock and secondary output, and a second-order autoregression for crops.

Table 1. Output and Input Coverage in the NFI Decomposition Database

OUTPUTS	INPUTS
Crop Aggregates	1. Capital excluding Land
1. Grain and Forage Crops	2. Land
2. Industrial Crops	3. Hired Labour
3.Vegetables	4. Farm-Produced Inputs[3]
4. Fruits and Tree Nuts	5. Purchased Materials[4]
5. Other Crops[1]	6. Purchased Services
	7. Unpaid Operator and Family Labour
Livestock Aggregates	
6. Meat Animals	
7. Poultry and Eggs	
8. Dairy	
9. Miscellaneous Livestock	
Other Aggregates	
10. Secondary Output[2]	

[1] Horticulture, potatoes and fruit, vegetables produced using farm resources but consumed by the farm family.

[2] Output from activities that are not related to crop or livestock production and that use the farm's resources to do this. Examples are value-added activities such as packaging/processing and the provision of services related to agricultural production, such as custom harvesting.

[3] Agricultural outputs that are produced on farm but also used as inputs, for example feed produced and used on the farm.

[4] Purchased from outside the agricultural sector.

Over the same period, there was no statistically significant change in the share of crops, but the share of secondary output grew by about 1.6% per year. These results indicate that there were substantial changes in composition of agricultural output over the period, with livestock activities giving way to crops and to secondary agricultural outputs.

A similar analysis of input/output ratios captures the degree to which input intensities have changed both between inputs and over time. Estimated coefficients from log-linear trend equations show annual reductions of input intensities for capital (-1.0%), land (-2.4%), hired labour (-3.7%), farm-produced inputs (-1.9%) and services (-0.6%), while the intensity of purchased materials actually increased at an average annual rate of about 0.4%.[12,13] Together with the results for outputs, these calculations show that the composition of U.S. agricultural output and the mix of inputs used in production has changed substantially since the late 1940's. While this is a well-known fact, these figures lend precision to the generality that 'things have changed'.

The raw data are used to derive F_t, F_{t-1}, and F_t^G, to calculate the arithmetic means $y_{i,t}^m$, $p_{i,t}^m$, for each i and the arithmetic means $x_{j,t}^m$, $w_{j,t}^m$ for each j. Due to the lag needed to compute changes, all these derived data (other than F_{1948}) cover the years $t = 1949, 1950, \cdots 2002$. These data are then used with the raw data to compute values for the Bennet aggregate output and input price change indicators – $I_R(\mathbf{p}_t, \mathbf{y}_t, \mathbf{p}_{t-1}, \mathbf{y}_{t-1})$ and $I_C\left(\mathbf{w}_t, \mathbf{x}_t, \mathbf{w}_{t-1}, \mathbf{x}_{t-1}\right)$ respectively – and the Bennet aggregate output and input quantity change indicators $V_R(\mathbf{p}_t, \mathbf{y}_t, \mathbf{p}_{t-1}, \mathbf{y}_{t-1})$ and $V_C\left(\mathbf{w}_t, \mathbf{x}_t, \mathbf{w}_{t-1}, \mathbf{x}_{t-1}\right)$ respectively. The nominal implicit wage $w_{7,t}^I$ is computed using the derived series F_t along with the series $x_{7,t}$ and h_t; the derived nominal implicit wage series is then used, along with the raw and other derived data to compute the growth in real implicit wage $w_{7,t}^{IRG}$ series.

[12] The same method used for output trends is employed here. Since autocorrelation was present in the equations for all inputs, first-order autoregressions were estimated for all six inputs and second-order autoregressions were estimated for capital and purchased materials. Note that the mean of annual growth rates and the estimated compound growth rate is similar to the estimated trend rate in all cases.

[13] These results can also be related to partial factor productivity growth rates, where $H = 1$ in each case. Average annual partial factor productivity growth rates by input were as follows: capital, 1.0%; land, 2.2%; hired labour, 3.6%; farm-produced inputs, 1.8%; purchased inputs -0.6%; purchased services, 0.4%. Only purchased inputs displayed negative partial productivity growth.

Figure 2 presents the derived real implicit wage between 1948 and 2002. In contrast with real net farm income, the real implicit wage did not display a noticeable trend; on average, it decreased by only 6 cents/hour each year. There was, however, substantial year-to-year variation – variability around the mean real implicit wage of $8.31/hour can be divided into five distinct sub-periods (**see** Figure 3). For 1948-1964, 1980-1985 and 1999-2002 the average real implicit wage was consistently below the mean, at $6.29/hour, -1.76/hour and $5.43/hour respectively. In the two sub-periods 1965-1979 and 1986-1998, the average real implicit wage was consistently above the mean, at $11.98 and $12.28 respectively. These five sub-periods, since they so clearly define 'above-average' and 'below-average' income performance, will be useful in summarizing the decomposition results that follow in the next section.

Based on these data, farm income – expressed as a real implicit wage – has shown a lack of growth, but has not displayed the steady decline indicated by the aggregate net farm income data (as illustrated in Figure 1). This suggests that a re-phrasing of the farm problem is needed, relative to the language used in the Introduction. In particular, it may be more appropriate to express the farm problem as 'a lack of growth in the real implicit wage, in spite of positive productivity growth', and to analyze the data in this context.

5 Results

Together, the raw and derived data described above provide all of the information needed to compute the decomposition (13) for the period 1949-2002. The results of these computations are summarized in Table 2 – the complete results are given in Table B1.

The data in column (A) of Table 2 are average values for the derived series $w_{7,t}^{IRG}$. The series in columns (B)-(E) are average annual values for series derived using (13), with the following concordance:

$$\begin{aligned}
&\text{(B)} \quad I_R(\mathbf{p}_t, \mathbf{y}_t, \mathbf{p}_{t-1}, \mathbf{y}_{t-1}) / (h_t x_{N,t}) \ ; \\
&\text{(C)} \quad -I_C(\mathbf{w}_t, \mathbf{x}_t, \mathbf{w}_{t-1}, \mathbf{x}_{t-1}) / (h_t x_{N,t}) \ ; \\
&\text{(D)} \quad PFPG_t / (h_t x_{N,t}) \ ; \text{ and} \\
&\text{(E)} \quad -w_{N,t-1}^{IR} [1 - (h_{t-1}/h_t)(x_{N,t-1}/x_{N,t})] \ .
\end{aligned}$$

Figure 2. Real Implicit Wage for Operator/ Unpaid Family Labour, U.S. Agriculture, 1948-2002

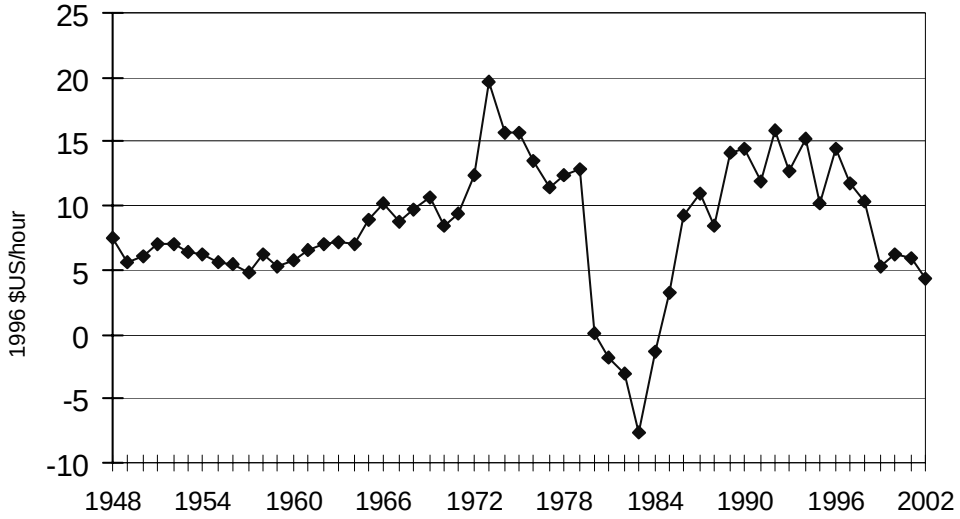


Figure 3. Deviations of Real Implicit Wage from 1948-2002 Average, U.S. Agriculture

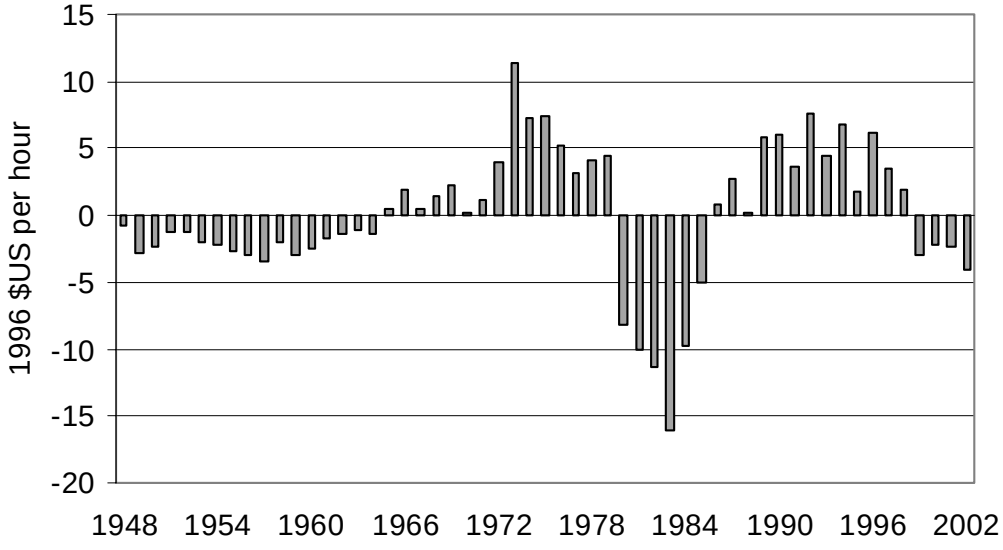


Table 2. Decomposition of Real Implicit Wage to Operator and Unpaid Family Labour, U.S. Agriculture, 1949-2002

ALL VALUES ARE 1996 DOLLARS PER HOUR

			real implicit wage growth decomposition: average annual changes			
period/ sub-period	real implicit wage at start of period/ sub-period*	average annual change in real implicit wage** (A)	output price change component (B)	input price change component (C)	PFPG component (D)	CPI-hours factor (E)
1949-2002	7.53	-0.06	0.75	-1.36	0.64	-0.09
1949-1964	7.53	-0.03	-0.19	-0.18	0.18	0.17
1965-1979	6.98	0.39	2.68	-2.60	0.52	-0.21
1980-1985	12.83	-1.59	0.29	-3.53	1.79	-0.14
1986-1998	3.28	0.54	0.34	-0.42	0.83	-0.22
1999-2002	10.27	-1.49	-0.65	-1.31	0.63	-0.16

* This is the level in the year prior to the start of the period/sub-period. Thus, the real implicit wage at the start of the 1949-1964 sub-period is the level in 1948.

** The average annual change is average of year-over-year changes within each period/sub-period.

So the sum of the series (B)-(E) equals series (A), where differences are due only to rounding.

The results – all are average annual changes measured in 1996 dollars – show that the contribution of PFPG to the change in the real implicit wage for the whole period 1949-2002 was 64 cents/hour, while the output price change component was 75 cents/hour. Both of these effects, however, were negated by the input price change component, which was -$1.36/hour, and to a small negative CPI-hours factor of -9 cents/hour.[14] Market conditions therefore worked against PFPG in elevating the real implicit wage.

The sub-period results in Table 2 illustrate the degree to which there was variability in the relative magnitude of the three main components, depending upon the direction of change in the real implicit wage. Over the 1949-1964 sub-period, output prices decreased – the output price change component was -19 cents/hour – and so, even though the CPI-hours effect was positive, and there was modest PFPG, the real implicit wage fell by 3 cents/hour. For this sub-period, then, the crucial element was the decreased output price.

During the second sub-period, 1965-1979, the real implicit wage increased; an important part of this was the positive output price change component. The PFPG component was about three times that in the first sub-period as well. The input price change component was large but, even with the negative CPI-hours component (due to CPI inflation) this only partially offset the output price change and PFPG components.

Between 1980 and 1985, PFPG, at $1.79/hour, was much higher than in the previous sub-period, but the output price change component, while positive, was only 29 cents/hour. Together, these components were insufficiently large to offset the input price change and CPI-hours component together.

In the fourth sub-period, 1986-1998, the PFPG component was much smaller than in the previous sub-period, but at 83 cents/hour, still higher than that in the first two sub-periods. This did not translate into a similar increase in the real implicit wage, which increased by 54 cents/hour, because

[14] With few exceptions, there was an annual reduction in the hours of operator and unpaid family labour over this period and an annual increase in the CPI for all but two years. So the negative effect of the CPI-hours component can be fully attributed to CPI inflation.

the output price change component was only about half that of the combined effect of the input price change and CPI-hours components.

Between 1999 and 2002, the real implicit wage fell by -$1.59/hour. Although the PFPG component was smaller than in the two previous sub-periods, at 63 cents/hour it was still larger than that in the first two sub-periods. A key reason for the decrease in the real implicit wage was the negative output price component – at -65 cents/hour, this amplified the effect of input price change (-$1.31/hour) combined with the CPI-hours component (-16 cents/hour).

Figure 4 summarizes the results by sub-period, comparing the PFPG component with the change in the implicit wage for each period. These results demonstrate that the contribution made by PFPG to the real implicit wage has been substantial, and, although varying between sub-periods, generally increased over time. If one were to look solely at the PFPG numbers, one would expect to find non-trivial growth in the real implicit wage over the same period. Instead, that growth has not occurred; as illustrated in Figure 4, PFPG effects have either been muted (as in the first and fourth sub-period) or negated (as in the other three sub-periods).

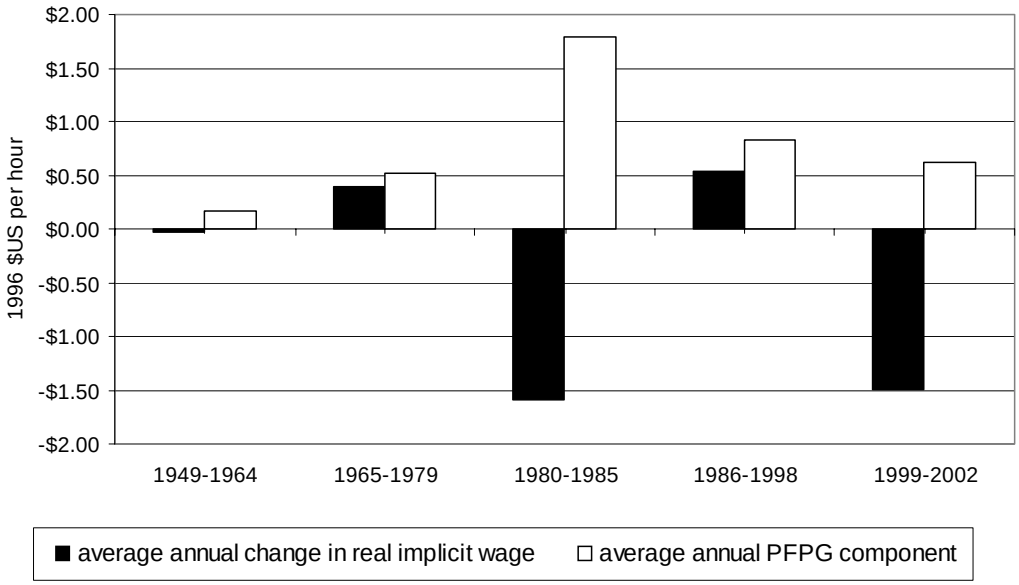
The largest factor driving this result is the input price component. In 3/5 sub-periods, this component was negated or nearly negated the output price components. And, in the other two sub-periods, this the input price component amplified the negative effect of input price changes on the real implicit wage.

Given the importance of input price changes in the relationship between the real implicit wage and PFPG, the question arises: which were the most important elements to this input price change component?

The calculations underlying the results, namely the individual Bennet indicators of input price change, provide the answer.[15] These data show that the price change indicator for land generally exceeded those for other inputs. Since the cost of land in the U.S. production account is determined by the opportunity cost of capital, a large part of the negation of PFPG effects came from increases in the bond rate.

[15] The individual input price change indicators underly the results in column (C) of Table 2 and of Table B1. The interested reader can derive these using the data in Table A2 and expression (5a).

Figure 4. Decomposition of Real Implicit Wage Growth, United States Agriculture, 1949-2002



Purchased materials generally accounted for the second-largest input price change indicator, in spite of only modest price increases for this input. This price change aspect of the indicator is important and is a characteristic of the methodology – see (5a). It is possible to have a relatively large price change indicator for any input, even if there is only a small price change, providing that the quantity used is large enough. This is especially true if the input use is increasing – as the trend analysis in the previous section indicated, purchased materials was the only input used with increased intensity over the 1949-2002 period.

The third most important Bennet indicator of input price change was for hired labour, which generally ranked behind land and purchased materials but ahead of the remaining inputs. When these effects for labour are combined with those for land and purchased materials, over 71% of the average overall Bennet indicator of input price change is accounted for.

6 Conclusion

One objective of this analysis has been to find reasons for an apparent paradox and one element of the 'farm problem', namely that productivity growth in U.S. agriculture has been accompanied by a decline in net farm income (before direct payments). Adjustment for the number of hours worked by operators and unpaid family members shows that the real implicit wage to their labour has been fairly stable between 1949 and 2002. Nevertheless, observed partial factor productivity growth has not led to increases in this wage that would be expected. A Bennet decomposition of growth in the real implicit wage indicates that market price changes have been an important factor in this lack of income growth from productivity improvements.

The results obtained here suggest that the accepted wisdom – namely that agricultural productivity growth is key to the sector's prosperity – has not taken into account the effect of output and input market price changes that happen at the same time. These price changes may amplify, mute or negate potential income gains due to productivity.

In essence, the consequences of productivity growth for net farm income cannot be evaluated only in a partial manner (i.e. holding all prices fixed). While this analysis does not address the possible relationship between productivity growth and movements in output and input prices, it is probable that there is a link, i.e. that the two elements are not independent of each

other. For example, adoption of a higher-yielding variety both by U.S. farm operators and their international competitors may lead to lower international prices. Similarly, demand for inputs created by new productivity-increasing varieties may raise the price of those inputs.

The questions posed by this analysis regarding the relationship between productivity growth and net farm income growth will hopefully stimulate debate on the subject. The other aspect of the analysis – use of the Bennet decomposition methodology – may also lead to greater interest in this straightforward but powerful tool for economic analysis.

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Appendix A. The Data

The data for the aggregates listed in Table 1 were obtained from Eldon Ball (Economic Research Service). While the output and input variables are documented in [1] and at the ERS web site[1], the main features of the data are reiterated here.

The output data underlying the aggregates used here cover over 100 commodities and commodity aggregates. Output for each commodity was derived as the quantity sold to the non-farm sector plus net additions to inventory and consumption by farm-households. Net additions to inventory reflect any use of the commodity within farm and transactions between farms (e.g. grain for feed), since this consumption is assumed to be drawn out of opening stocks; thus, output is measured in gross rather than value-added terms. Price data for each of these commodities was then used, along with the quantity data, to compute Fisher Ideal indexes for the ten aggregates listed in Table A1.

'Capital excluding Land' is an aggregate measure of capital services from: (i) automobiles, trucks, tractors, other farm machinery; (ii) farm structures (excluding residential) and (iii) crop/livestock inventories. Capital stocks for the various items in (i) and (ii) were constructed using investment data and a hyperbolic decay formula. User costs for these items were also constructed based on the formula corresponding to hyperbolic decay, which includes the investment deflators and opportunity cost of capital.

'Land' is a quality-adjusted quantity and price index. The quantity index was constructed using land area and value data for agricultural districts across the United States. The price is an *ex ante* real bond rate.

'Hired Labour' is a quality-adjusted quantity and price index for hired agricultural labour. Changes in the quality of hired labour over time were accounted for using cross-classifications based on characteristics such as age and education. A quantity index for hired labour was then computed using the cross-classified data – the aggregation method gives greater weight to an hour of labour from an employee with a higher marginal product (wage) than one with a lower marginal product. The price index was then computed implicitly as the ratio of total expenditure on hired labour to the quality-adjusted quantity index.

[1] See the web page www.ers.usda.gov/data/AgProductivity/methods.htm.

The 'Farm-Produced Inputs' aggregate is a Fisher Ideal index computed using farm use data for each of the 100 or so outputs produced. These data include seed and feed that are drawn from opening stocks and used on-farm.

The 'Purchased Materials' and 'Purchased Services' aggregates are also Fisher Ideal indexes constructed using data for a variety of materials and services purchased from businesses outside of the agricultural sector. Purchased materials include feed, seed and fertilizer purchased from agricultural input suppliers. Purchased services include veterinary services, custom machine services and equipment leasing.

The final input category, 'Unpaid Operator and Family Labour' is the total hours of unpaid work that operators and their families supplied to their farming enterprises. These data are not used when computing the input cost components of the Bennet decomposition, but do provide the denominator in (10) when computing the real implicit wage to operator and unpaid family labour and in computing the 'CPI-hours inflation factor'

The hours of operator and unpaid family labour are also taken from the ERS database. The CPI data are from the United States Bureau of Labour Statistics (BLS). The input series, hours of operator/unpaid family labour series and the CPI series are given in Table A2.

Table A1.1 United States Agricultural Outputs: Crops, 1948-2002

	Crops									
	1. Grain/Forage Crops		2. Industrial Crops		3. Vegetables		4. Fruits and Tree Nuts		5. Other	
Year	price index	implicit quantity	price index	implicit quantity	price index	implicit quantity	price index	implicit quantity	price index	implicit quantity
1948	0.463	29,369	0.410	13,181	0.381	8,518	0.229	4,936	0.263	2,596
1949	0.426	26,585	0.363	14,023	0.310	8,570	0.213	4,357	0.256	2,734
1950	0.383	26,677	0.444	11,108	0.284	8,666	0.276	4,310	0.239	3,178
1951	0.419	25,891	0.439	14,076	0.329	7,897	0.243	4,753	0.275	2,785
1952	0.432	28,078	0.427	14,066	0.421	8,295	0.235	4,667	0.289	2,638
1953	0.399	27,487	0.408	14,560	0.304	8,780	0.251	4,777	0.258	2,730
1954	0.406	27,380	0.407	13,826	0.292	8,177	0.245	4,985	0.255	2,653
1955	0.375	28,201	0.378	14,708	0.309	8,326	0.245	5,206	0.264	2,362
1956	0.361	28,103	0.384	14,433	0.345	8,492	0.262	5,188	0.262	2,629
1957	0.343	29,820	0.377	12,457	0.300	8,353	0.244	5,289	0.297	2,208
1958	0.347	33,967	0.378	13,724	0.304	8,594	0.285	4,897	0.271	2,470
1959	0.333	32,482	0.378	14,932	0.307	8,458	0.284	5,322	0.264	3,077
1960	0.330	35,108	0.362	15,509	0.338	8,385	0.269	5,679	0.277	3,303
1961	0.342	32,611	0.404	16,412	0.297	8,895	0.273	5,898	0.288	3,286
1962	0.389	32,818	0.389	17,111	0.308	8,625	0.262	6,021	0.272	3,707
1963	0.400	34,542	0.396	17,937	0.307	8,610	0.290	5,794	0.280	3,768
1964	0.391	32,937	0.381	17,679	0.381	8,014	0.305	5,910	0.295	3,694
1965	0.393	36,521	0.405	17,808	0.431	8,861	0.267	6,186	0.310	3,712
1966	0.442	36,499	0.445	16,102	0.382	8,957	0.274	6,369	0.327	3,671
1967	0.385	40,168	0.461	15,176	0.374	9,095	0.286	6,349	0.332	3,744
1968	0.372	39,771	0.430	17,332	0.378	9,383	0.328	6,233	0.342	3,779
1969	0.395	40,202	0.405	18,839	0.391	9,123	0.293	7,401	0.348	3,844
1970	0.424	37,390	0.448	18,059	0.395	9,253	0.295	7,015	0.350	3,977
1971	0.399	45,208	0.488	18,459	0.403	9,185	0.316	7,303	0.365	4,089
1972	0.441	43,909	0.521	20,327	0.435	9,326	0.390	6,564	0.394	4,082
1973	0.671	45,986	0.737	21,819	0.578	9,381	0.433	7,949	0.429	4,577
1974	0.878	41,523	0.968	19,126	0.711	10,017	0.422	8,144	0.456	4,329
1975	0.780	48,396	0.741	21,286	0.663	9,690	0.408	8,725	0.478	5,467
1976	0.742	48,705	0.803	20,099	0.653	10,240	0.439	8,461	0.501	5,684
1977	0.651	50,508	0.837	24,405	0.658	10,376	0.515	8,943	0.519	5,918

Table A1.1 United States Agricultural Outputs: Crops, 1948-2002

	Crops									
	1. Grain/Forage Crops		2. Industrial Crops		3. Vegetables		4. Fruits and Tree Nuts		5. Other	
Year	price index	implicit quantity	price index	implicit quantity	price index	implicit quantity	price index	implicit quantity	price index	implicit quantity
1978	0.677	52,782	0.880	24,254	0.691	10,745	0.650	8,861	0.565	7,724
1979	0.745	56,795	0.914	28,235	0.690	10,762	0.682	9,477	0.608	8,056
1980	0.852	51,700	1.007	23,411	0.776	10,642	0.635	10,319	0.633	8,649
1981	0.883	61,357	0.979	27,497	0.952	11,007	0.652	10,134	0.658	8,793
1982	0.856	61,942	0.863	27,111	0.855	11,330	0.674	10,090	0.666	9,450
1983	1.189	42,989	1.054	20,283	0.898	11,246	0.604	10,028	0.699	9,690
1984	0.963	59,276	1.045	25,232	0.948	11,906	0.676	9,958	0.703	10,950
1985	0.856	63,032	0.849	26,305	0.827	12,347	0.706	9,844	0.711	11,336
1986	0.815	58,786	0.823	22,942	0.822	12,212	0.762	9,513	0.726	12,145
1987	0.791	53,518	0.829	25,686	0.882	13,115	0.740	10,890	0.745	13,270
1988	0.931	41,787	0.999	23,464	0.890	12,522	0.772	11,696	0.779	13,727
1989	0.908	53,740	0.929	25,030	1.037	13,032	0.818	11,191	0.833	13,735
1990	0.866	58,162	0.913	27,068	0.993	13,724	0.855	11,001	0.853	14,786
1991	0.829	53,799	0.861	29,305	0.956	14,090	0.909	10,872	0.871	15,153
1992	0.827	63,196	0.844	29,717	0.930	14,624	0.894	11,355	0.881	15,791
1993	0.837	51,338	0.898	26,853	1.038	15,346	0.847	12,174	0.934	15,384
1994	0.864	63,695	0.907	33,568	0.956	17,296	0.817	12,641	0.958	15,940
1995	0.955	53,631	0.920	29,567	1.093	15,679	0.937	11,817	0.978	16,365
1996	1.000	61,108	1.000	31,650	1.000	17,072	1.000	11,904	1.000	16,669
1997	0.862	61,985	0.976	34,541	1.009	16,551	0.934	14,074	1.050	17,160
1998	0.761	63,447	0.877	32,962	1.053	16,441	0.942	12,545	1.063	17,315
1999	0.702	62,550	0.799	33,209	0.993	17,541	0.884	13,463	1.065	17,403
2000	0.707	62,678	0.827	33,062	1.036	17,779	0.877	14,292	1.059	18,539
2001	0.726	60,926	0.936	30,457	1.055	16,784	0.872	13,790	1.059	18,848
2002	0.772	56,986	0.730	32,128	1.194	16,713	0.918	14,204	1.090	18,353

Note: The base year for all price indexes is 1996. All implicit quantities are Millions of 1996 Dollars.
Source: United States Department of Agriculture (USDA), Economic Research Service (ERS)
Contact: Eldon Ball, USDA, ERS, Resource Economics Division
Room N4086, 1800 M Street NW, Washington DC, 20036
telephone: 202-694-5601 ; email: eball@ers.usda.gov

Table A1.2 United States Agricultural Outputs: Livestock, Other, 1948-2002

	Livestock									
	6. Meat Animals		7. Poultry and Eggs		8. Dairy		9. Misc. Livestock		Secondary Output	
Year	price index	implicit quantity	price index	implicit quantity	price index	implicit quantity	price index	implicit quantity	price index	implicit quantity
1948	0.440	19,585	0.965	3,250	0.315	16,348	0.435	577	0.118	3,069
1949	0.372	20,616	0.825	3,768	0.258	16,845	0.369	613	0.122	2,847
1950	0.403	22,074	0.691	4,110	0.254	16,904	0.401	663	0.125	2,629
1951	0.477	23,695	0.801	4,501	0.295	16,590	0.477	838	0.131	2,863
1952	0.407	24,180	0.714	4,661	0.313	16,604	0.404	692	0.136	3,147
1953	0.343	23,980	0.742	4,852	0.281	17,434	0.342	810	0.140	3,263
1954	0.342	24,984	0.582	5,174	0.258	17,712	0.341	824	0.143	3,307
1955	0.290	26,293	0.620	5,197	0.261	17,850	0.288	940	0.144	3,538
1956	0.279	25,474	0.555	5,866	0.270	18,158	0.280	1,274	0.151	3,823
1957	0.330	24,582	0.505	6,085	0.276	18,149	0.332	1,172	0.159	4,471
1958	0.398	25,152	0.518	6,470	0.273	17,966	0.395	816	0.164	5,440
1959	0.360	27,008	0.442	6,769	0.276	17,798	0.358	1,043	0.172	8,220
1960	0.344	26,392	0.463	7,105	0.280	17,982	0.344	1,298	0.177	8,821
1961	0.351	27,520	0.417	7,695	0.282	18,387	0.350	1,182	0.180	8,651
1962	0.363	28,016	0.426	7,652	0.275	18,483	0.362	1,196	0.183	8,425
1963	0.338	29,470	0.428	7,809	0.276	18,339	0.338	1,300	0.186	8,680
1964	0.314	30,297	0.418	8,091	0.280	18,616	0.316	1,488	0.191	7,842
1965	0.368	28,784	0.429	8,359	0.286	18,214	0.366	1,111	0.198	7,890
1966	0.423	29,795	0.469	8,843	0.324	17,590	0.422	1,070	0.208	7,671
1967	0.395	31,165	0.390	9,277	0.339	17,427	0.393	995	0.219	7,958
1968	0.404	31,595	0.423	8,980	0.355	17,213	0.403	1,061	0.230	7,439
1969	0.464	31,693	0.477	9,184	0.372	17,057	0.462	883	0.243	7,020
1970	0.480	33,573	0.444	9,569	0.387	17,198	0.477	766	0.259	6,135
1971	0.466	34,034	0.406	9,741	0.398	17,441	0.464	789	0.280	6,204
1972	0.573	34,329	0.417	10,027	0.411	17,660	0.572	825	0.291	6,070
1973	0.734	35,652	0.713	9,686	0.484	16,989	0.733	798	0.321	6,491
1974	0.634	34,699	0.639	9,731	0.564	17,008	0.632	780	0.374	6,271
1975	0.662	31,498	0.714	9,535	0.592	16,978	0.659	832	0.408	6,497
1976	0.668	32,915	0.704	10,164	0.654	17,691	0.668	909	0.439	6,421
1977	0.658	33,099	0.696	10,356	0.658	18,064	0.657	1,195	0.484	6,385

Table A1.2 United States Agricultural Outputs: Livestock, Other, 1948-2002

	Livestock									
	6. Meat Animals		7. Poultry and Eggs		8. Dairy		9. Misc. Livestock		Secondary Output	
Year	price index	implicit quantity	price index	implicit quantity	price index	implicit quantity	price index	implicit quantity	price index	implicit quantity
1978	0.881	32,921	0.747	10,852	0.718	17,893	0.879	1,026	0.524	7,044
1979	1.071	33,676	0.763	11,698	0.812	18,183	1.067	1,075	0.591	7,020
1980	0.994	34,939	0.773	11,847	0.870	18,944	0.990	1,271	0.663	6,159
1981	0.964	34,842	0.808	12,313	0.930	19,591	0.960	1,453	0.740	5,189
1982	0.993	33,525	0.772	12,331	0.918	19,984	0.987	1,656	0.756	8,128
1983	0.947	34,065	0.803	12,424	0.883	20,593	0.945	1,999	0.781	8,497
1984	0.959	33,379	0.961	12,747	0.874	19,870	0.958	2,174	0.799	8,207
1985	0.912	33,315	0.841	13,327	0.853	21,070	0.910	2,315	0.771	9,531
1986	0.930	33,254	0.916	13,868	0.820	21,092	0.929	2,324	0.748	9,099
1987	1.057	33,667	0.763	15,085	0.833	21,047	1.056	2,292	0.790	10,699
1988	1.073	34,364	0.832	15,447	0.826	21,395	1.070	2,389	0.839	13,221
1989	1.103	34,309	0.956	16,083	0.913	21,239	1.097	2,351	0.875	14,371
1990	1.233	34,147	0.893	17,119	0.927	21,812	1.224	2,152	0.887	14,462
1991	1.189	35,201	0.848	17,860	0.826	21,809	1.182	2,241	0.880	15,252
1992	1.105	35,543	0.831	18,696	0.882	22,291	1.100	2,651	0.886	14,919
1993	1.176	35,386	0.890	19,512	0.861	22,269	1.171	2,664	0.912	15,640
1994	1.019	36,423	0.903	20,475	0.874	22,721	1.021	3,359	0.922	15,675
1995	0.966	36,771	0.897	21,267	0.860	22,981	0.965	3,644	0.932	17,384
1996	1.000	35,361	1.000	22,455	1.000	22,795	1.000	3,610	1.000	15,970
1997	1.079	35,663	0.970	22,950	0.908	23,112	1.075	3,337	0.988	17,699
1998	0.917	36,703	0.982	23,374	1.037	23,295	0.913	4,063	0.917	19,961
1999	0.929	37,282	0.938	24,413	0.964	24,104	0.925	4,211	0.889	21,330
2000	1.054	37,522	0.879	24,826	0.831	24,842	1.048	3,943	0.897	20,005
2001	0.769	39,928	0.974	25,202	1.008	24,529	0.767	5,062	0.926	20,874
2002	0.951	37,738	0.804	26,179	0.817	25,174	0.950	4,079	0.943	20,518

Note: The base year for all price indexes is 1996. All implicit quantities are Millions of 1996 Dollars.
Source: United States Department of Agriculture (USDA), Economic Research Service (ERS)
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Table A2. United States Agricultural Inputs and Consumer Price Index, 1948-2002

	1. Capital excl. Land		2. Land		3. Hired Labour		4. Farm-Produced Inputs		5. Purchased Materials		6. Purchased Services		7. Operator/Unpaid	
	price	implicit	real rate	constant $ value	price	implicit	price	implicit	price	implicit	price	implicit	Family Labour	CPI
Year	index	quantity	of return	(Million $1996)	index	quantity	index	quantity	index	quantity	index	quantity	(million hours)	1996=1
1948	0.110	18,898	0.09%	827,770	0.166	18,144	0.413	17,408	0.276	21,179	0.147	13,889	17,920	0.154
1949	0.110	21,503	0.07%	830,622	0.167	16,857	0.374	19,825	0.260	24,027	0.147	13,516	17,766	0.152
1950	0.109	23,939	0.07%	832,605	0.161	17,574	0.328	18,938	0.259	25,598	0.147	14,060	16,439	0.154
1951	0.122	26,135	0.08%	833,482	0.172	16,968	0.372	18,630	0.278	27,860	0.158	15,416	15,574	0.166
1952	0.126	26,716	0.08%	833,014	0.174	16,579	0.389	18,810	0.293	27,844	0.159	16,450	14,812	0.169
1953	0.129	28,812	0.11%	831,065	0.171	16,105	0.344	19,012	0.264	28,675	0.168	15,633	13,707	0.170
1954	0.125	29,969	0.11%	827,271	0.173	15,184	0.351	17,648	0.280	27,650	0.170	15,219	13,315	0.171
1955	0.128	30,515	0.12%	821,155	0.175	14,923	0.327	18,053	0.244	32,030	0.172	15,892	13,538	0.171
1956	0.139	30,902	0.16%	812,885	0.191	13,627	0.314	18,349	0.234	33,492	0.180	16,550	12,892	0.173
1957	0.158	30,579	0.26%	803,337	0.209	13,073	0.295	18,718	0.230	35,005	0.187	16,774	11,858	0.179
1958	0.165	30,405	0.30%	794,053	0.220	13,169	0.295	20,904	0.246	35,120	0.188	17,725	10,996	0.184
1959	0.177	30,672	0.35%	786,953	0.232	12,854	0.283	20,782	0.244	36,443	0.191	20,811	11,007	0.185
1960	0.179	31,033	0.38%	783,372	0.243	12,856	0.292	19,784	0.232	37,927	0.194	20,252	10,629	0.189
1961	0.180	30,851	0.38%	782,157	0.251	12,797	0.272	19,758	0.250	36,902	0.196	19,907	10,060	0.191
1962	0.182	30,781	0.39%	781,634	0.263	12,776	0.304	20,125	0.253	38,972	0.199	20,075	9,752	0.192
1963	0.183	31,021	0.38%	780,536	0.270	12,754	0.325	20,916	0.261	40,812	0.201	19,832	9,344	0.195
1964	0.183	31,442	0.39%	778,014	0.304	11,502	0.315	20,345	0.258	41,969	0.206	19,117	8,836	0.198
1965	0.188	31,820	0.41%	773,413	0.332	10,828	0.316	19,229	0.265	42,389	0.210	19,478	8,628	0.201
1966	0.191	32,716	0.41%	766,786	0.371	9,754	0.363	21,078	0.277	44,675	0.215	19,646	8,042	0.207
1967	0.203	33,693	0.51%	758,268	0.404	9,062	0.324	20,116	0.277	47,371	0.225	20,442	7,578	0.213
1968	0.200	34,933	0.48%	748,054	0.433	8,770	0.300	20,731	0.268	48,539	0.235	19,967	7,204	0.222
1969	0.212	35,543	0.57%	736,456	0.458	8,846	0.317	20,730	0.262	52,757	0.247	19,282	6,942	0.234
1970	0.243	35,925	0.82%	724,018	0.476	8,914	0.342	20,721	0.274	55,160	0.262	18,376	6,755	0.247
1971	0.251	36,244	0.87%	711,836	0.482	8,815	0.344	20,096	0.283	55,583	0.281	18,316	6,592	0.258
1972	0.261	36,754	0.94%	701,186	0.499	8,779	0.361	21,722	0.292	56,419	0.292	18,226	6,494	0.266
1973	0.293	37,347	1.22%	693,341	0.580	8,909	0.553	21,807	0.392	58,437	0.312	19,432	6,478	0.283
1974	0.333	38,988	1.38%	689,517	0.637	9,482	0.779	21,135	0.480	58,959	0.350	19,453	5,705	0.314
1975	0.310	40,234	1.00%	690,259	0.680	9,630	0.723	20,193	0.556	51,438	0.389	19,686	5,625	0.343
1976	0.320	41,178	1.03%	693,645	0.756	9,738	0.723	21,126	0.568	55,080	0.414	20,805	5,482	0.363
1977	0.371	42,109	1.63%	697,218	0.829	9,499	0.642	20,316	0.588	53,696	0.448	21,276	5,302	0.386
1978	0.414	43,123	2.10%	698,518	0.914	8,932	0.623	23,160	0.599	60,123	0.486	24,742	5,057	0.416
1979	0.494	43,948	2.78%	695,867	0.957	9,268	0.692	24,396	0.677	62,922	0.537	26,058	4,809	0.463
1980	0.644	45,867	4.43%	690,287	1.000	9,190	0.820	25,519	0.779	63,153	0.598	23,474	4,676	0.525

Table A2. United States Agricultural Inputs and Consumer Price Index, 1948-2002

	1. Capital excl. Land		2. Land		3. Hired Labour		4. Farm-Produced Inputs		5. Purchased Materials		6. Purchased Services		7. Operator/Unpaid	
	price	implicit	real rate	constant $ value	price	implicit	price	implicit	price	implicit	price	implicit	Family Labour	CPI
Year	index	quantity	of return	(Million $1996)	index	quantity	index	quantity	index	quantity	index	quantity	(million hours)	1996=1
1981	0.830	45,372	6.41%	683,459	0.982	9,148	0.853	23,570	0.838	60,266	0.663	22,296	4,734	0.579
1982	0.858	44,784	6.55%	677,036	1.218	8,209	0.832	25,233	0.808	57,235	0.690	24,238	4,635	0.615
1983	0.914	43,752	6.82%	672,248	1.063	9,068	1.008	26,172	0.821	57,307	0.699	23,842	4,332	0.635
1984	1.005	41,757	7.18%	668,760	1.148	8,448	0.865	21,536	0.824	58,989	0.721	22,909	4,393	0.662
1985	0.912	40,933	5.46%	665,889	1.336	7,357	0.787	22,144	0.768	56,175	0.723	23,464	4,184	0.686
1986	0.819	38,537	3.96%	662,993	1.295	7,094	0.653	21,029	0.713	58,810	0.721	21,703	3,826	0.699
1987	0.865	36,291	4.11%	659,500	1.298	7,254	0.606	19,949	0.728	57,663	0.754	22,373	3,752	0.724
1988	0.905	35,021	4.02%	655,061	1.399	7,621	0.831	18,982	0.802	59,026	0.795	22,504	3,825	0.754
1989	0.907	33,984	3.66%	650,162	1.644	6,996	0.860	16,678	0.838	58,987	0.839	24,066	3,910	0.790
1990	0.940	33,335	3.98%	645,518	1.907	7,105	0.831	19,026	0.833	62,060	0.866	23,132	3,812	0.833
1991	0.924	33,000	3.87%	641,963	1.868	7,151	0.774	19,319	0.832	63,414	0.873	24,270	3,845	0.868
1992	0.904	32,152	3.76%	640,331	1.953	6,718	0.758	18,553	0.830	62,905	0.887	23,570	3,666	0.894
1993	0.919	31,482	3.91%	641,154	2.171	6,592	0.803	18,402	0.836	65,403	0.918	26,559	3,495	0.921
1994	0.965	30,523	4.12%	643,566	2.222	6,553	0.838	18,563	0.869	66,788	0.934	27,586	3,558	0.945
1995	0.996	30,228	4.40%	646,468	2.309	7,165	0.877	19,192	0.894	69,042	0.960	28,748	3,606	0.971
1996	1.000	29,348	4.58%	648,924	2.553	6,493	1.000	17,415	1.000	65,564	1.000	27,647	3,623	1.000
1997	1.030	29,186	4.90%	650,124	2.570	6,833	0.965	17,838	0.972	70,494	1.004	29,291	3,576	1.023
1998	1.014	28,983	4.71%	649,616	2.683	6,960	0.839	18,237	0.880	75,729	0.990	30,859	3,402	1.039
1999	1.123	28,885	6.11%	647,387	2.664	7,299	0.733	19,133	0.851	76,910	0.993	31,742	3,479	1.062
2000	1.159	28,678	6.38%	643,767	2.537	6,921	0.745	18,356	0.904	73,532	1.035	29,980	3,404	1.098
2001	1.119	28,622	5.77%	639,096	2.725	6,854	0.823	17,256	0.934	73,487	1.069	30,630	3,359	1.129
2002	1.134	28,698	5.99%	633,771	2.844	6,837	0.864	16,864	0.929	74,518	1.084	28,613	3,330	1.147

Note 1: The base year for all price indexes is 1996. All implicit quantities are Millions of 1996 Dollars.

Input Data Source: United States Department of Agriculture (USDA), Economic Research Service (ERS)

Input Data Contact: Eldon Ball, USDA, ERS, Resource Economics Division, Room N4086, 1800 M Street NW, Washington DC, 20036. Telephone: 202-694-5601 ; email: eball@ers.usda.gc

CPI Source: United States Department of Labor, Bureau of Labour Statistics (BLS)

Note 2: CPI data data obtained by following the menu starting from http://stats.bls.gov/cpi/home.htm#data. The specifics of the series are:

Series Id CUUR0000SA0, Not Seasonally Adjusted, U.S. city average, All items, Base Period: 1982-84=100

Table B1. Decomposition of Real Implicit Wage to Operator and Unpaid Family Labour, U.S. Agriculture, 1949-2002

ALL VALUES ARE 1996 DOLLARS PER HOUR

			implicit wage growth decomposition*			
year	real implicit wage per hour	change in real implicit wage* (A)	output price growth component (B)	input price growth component (C)	productivity growth component (D)	CPI-hours factor (E)
1948	7.53	-	-	-	-	
1949	5.55	-1.98	-1.94	0.43	-0.63	0.16
1950	6.03	0.48	-0.01	0.41	-0.29	0.37
1951	7.05	1.01	1.60	-0.81	0.36	-0.13
1952	7.04	-0.01	-0.34	-0.33	0.44	0.22
1953	6.36	-0.68	-1.80	0.52	0.09	0.51
1954	6.19	-0.17	-0.51	-0.23	0.43	0.14
1955	5.60	-0.59	-0.98	0.55	-0.08	-0.08
1956	5.40	-0.19	-0.17	-0.22	0.00	0.19
1957	4.85	-0.55	0.10	-0.60	-0.33	0.28
1958	6.26	1.41	1.04	-0.61	0.75	0.24
1959	5.34	-0.92	-0.92	-0.30	0.35	-0.05
1960	5.82	0.48	-0.16	-0.15	0.69	0.10
1961	6.63	0.81	0.37	-0.24	0.41	0.27
1962	7.00	0.37	0.85	-0.59	-0.04	0.14
1963	7.21	0.21	-0.01	-0.47	0.48	0.21
1964	6.98	-0.23	-0.29	-0.11	-0.14	0.32
1965	8.87	1.88	1.52	-0.60	0.91	0.05
1966	10.16	1.29	2.99	-1.27	-0.81	0.38
1967	8.83	-1.33	-1.98	-0.52	0.88	0.30
1968	9.76	0.93	0.18	0.48	0.19	0.09
1969	10.59	0.82	1.98	-0.95	-0.04	-0.16
1970	8.47	-2.11	1.54	-2.70	-0.66	-0.30
1971	9.44	0.97	-0.33	-0.96	2.41	-0.15
1972	12.32	2.89	4.39	-1.19	-0.16	-0.16
1973	19.67	7.34	14.61	-7.74	1.16	-0.69
1974	15.64	-4.03	6.99	-7.75	-3.72	0.45
1975	15.67	0.04	-3.70	-0.34	5.18	-1.10
1976	13.51	-2.16	0.57	-1.23	-1.03	-0.47

Table B1. Decomposition of Real Implicit Wage to Operator and Unpaid Family Labour, U.S. Agriculture, 1949-2002

ALL VALUES ARE 1996 DOLLARS PER HOUR

			implicit wage growth decomposition*			
year	real implicit wage per hour	change in real implicit wage* (A)	output price growth component (B)	input price growth component (C)	productivity growth component (D)	CPI-hours factor (E)
1977	11.50	-2.01	-1.47	-3.50	3.35	-0.39
1978	12.38	0.88	6.53	-3.32	-2.04	-0.29
1979	12.83	0.45	6.35	-7.36	2.15	-0.69
1980	0.06	-12.76	3.18	-12.09	-2.65	-1.20
1981	-1.81	-1.88	1.53	-10.17	6.77	-0.01
1982	-3.02	-1.21	-1.80	-0.90	1.42	0.07
1983	-7.70	-4.68	7.41	-3.07	-8.91	-0.11
1984	-1.38	6.32	-2.76	-1.50	10.16	0.42
1985	3.28	4.66	-5.80	6.52	3.96	-0.02
1986	9.18	5.90	-0.63	7.54	-1.25	0.24
1987	10.96	1.78	0.95	-1.27	2.24	-0.15
1988	8.52	-2.43	4.79	-3.87	-2.72	-0.64
1989	14.19	5.67	1.87	-1.04	5.40	-0.57
1990	14.38	0.20	0.47	-1.53	1.64	-0.38
1991	11.96	-2.42	-2.37	0.77	-0.12	-0.70
1992	15.91	3.95	-0.97	0.26	4.45	0.22
1993	12.77	-3.15	2.43	-1.53	-4.34	0.30
1994	15.18	2.42	-1.47	-1.89	6.32	-0.54
1995	10.11	-5.07	2.10	-1.85	-4.70	-0.62
1996	14.44	4.33	3.48	-3.72	4.90	-0.33
1997	11.81	-2.64	-2.49	-0.17	0.16	-0.14
1998	10.27	-1.53	-3.71	2.90	-1.14	0.42
1999	5.30	-4.97	-2.94	-2.13	0.55	-0.45
2000	6.21	0.91	0.63	-2.01	2.34	-0.06
2001	5.93	-0.28	-0.01	-0.21	0.03	-0.09
2002	4.30	-1.63	-0.27	-0.90	-0.42	-0.04
average 1948-2002	8.31	-0.06	0.75	-1.36	0.64	-0.09

* Note that these are all changes in relative to the previous year.