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# 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. ${ }^{3}$

[^0]

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

[^1]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. ${ }^{8}$

[^2]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 $N^{\text {th }}$ 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 $\left[p_{1, t}, p_{2, t}, \ldots, p_{M, t}\right]$ and $\mathbf{y}_{t}$ is the $1 \times M$ vector $\left[y_{1, t}, y_{2, t}, \ldots, y_{M, t}\right]$. 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 $\left[w_{1, t}, w_{2, t}, \ldots, w_{N-H, t}\right]$ and $\mathbf{x}_{t}$ is the $1 \times(N-H)$ vector $\left[x_{1, t}, x_{2, t}, \ldots, x_{N-H, t}\right]$.

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

$$
\begin{equation*}
F_{t}=\mathbf{p}_{t} \cdot \mathbf{y}_{t}-\mathbf{w}_{t} \cdot \mathbf{x}_{t} . \tag{1}
\end{equation*}
$$

The change in nominal NFI is measured as:

$$
\begin{equation*}
F_{t}^{G}=F_{t}-F_{t-1} \tag{2}
\end{equation*}
$$

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

$$
\begin{equation*}
F_{t}^{G}=\left[\mathbf{p}_{t} \cdot \mathbf{y}_{t}-\mathbf{p}_{t-1} \cdot \mathbf{y}_{t-1}\right]-\left[\mathbf{w}_{t} \cdot \mathbf{x}_{t}-\mathbf{w}_{t-1} \cdot \mathbf{x}_{t-1}\right] . \tag{3}
\end{equation*}
$$

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 $t$.

[^3]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.

$$
\begin{align*}
\mathbf{p}_{t} \cdot \mathbf{y}_{t}-\mathbf{p}_{t-1} \cdot \mathbf{y}_{t-1} \equiv & I_{R}\left(\mathbf{p}_{t}, \mathbf{y}_{t}, \mathbf{p}_{t-1}, \mathbf{y}_{t-1}\right)+  \tag{4}\\
& V_{R}\left(\mathbf{p}_{t}, \mathbf{y}_{t}, \mathbf{p}_{t-1}, \mathbf{y}_{t-1}\right)
\end{align*}
$$

where

$$
\begin{equation*}
I_{R}\left(\mathbf{p}_{t}, \mathbf{y}_{t}, \mathbf{p}_{t-1}, \mathbf{y}_{t-1}\right)=\sum_{i=1}^{M} y_{i, t}^{m}\left(p_{i, t}-p_{i, t-1}\right) \tag{4a}
\end{equation*}
$$

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 $t-1$;

$$
\begin{equation*}
V_{R}\left(\mathbf{p}_{t}, \mathbf{y}_{t}, \mathbf{p}_{t-1}, \mathbf{y}_{t-1}\right)=\sum_{i=1}^{M} p_{i, t}^{m}\left(y_{i, t}-y_{i, t-1}\right) \tag{4b}
\end{equation*}
$$

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:

$$
\begin{array}{r}
\mathbf{w}_{t} \cdot \mathbf{x}_{t}-\mathbf{w}_{t-1} \cdot \mathbf{x}_{t-1} \equiv I_{C}\left(\mathbf{w}_{t}, \mathbf{x}_{t}, \mathbf{w}_{t-1}, \mathbf{x}_{t-1}\right)+  \tag{5}\\
V_{C}\left(\mathbf{w}_{t}, \mathbf{x}_{t}, \mathbf{w}_{t-1}, \mathbf{x}_{t-1}\right),
\end{array}
$$

where

$$
\begin{equation*}
I_{C}\left(\mathbf{w}_{t}, \mathbf{x}_{t}, \mathbf{w}_{t-1}, \mathbf{x}_{t-1}\right)=\sum_{j=1}^{N-H} x_{j, t}^{m}\left(w_{j, t}-w_{j, t-1}\right) \tag{5a}
\end{equation*}
$$

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 $t-1$;

$$
\begin{equation*}
V_{C}\left(\mathbf{w}_{t}, \mathbf{x}_{t}, \mathbf{w}_{t-1}, \mathbf{x}_{t-1}\right)=\sum_{j=1}^{N-H} w_{j, t}^{m}\left(x_{j, t}-x_{j, t-1}\right) \tag{5b}
\end{equation*}
$$

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:

$$
\begin{equation*}
F_{t}^{G}=I_{R}\left(\mathbf{p}_{t}, \mathbf{y}_{t}, \mathbf{p}_{t-1}, \mathbf{y}_{t-1}\right)-I_{C}\left(\mathbf{w}_{t}, \mathbf{x}_{t}, \mathbf{w}_{t-1}, \mathbf{x}_{t-1}\right)+P F P G_{t}, \tag{6}
\end{equation*}
$$

where

$$
\begin{equation*}
P F P G_{t}=\left[V_{R}\left(\mathbf{p}_{t}, \mathbf{y}_{t}, \mathbf{p}_{t-1}, \mathbf{y}_{t-1}\right)-V_{C}\left(\mathbf{w}_{t}, \mathbf{x}_{t}, \mathbf{w}_{t-1}, \mathbf{x}_{t-1}\right)\right] \tag{7}
\end{equation*}
$$

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 $P F P G_{t}$ 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 $N^{t h}$ input), the implicit price for this input is estimated as: ${ }^{9}, 10$

[^4]\[

$$
\begin{equation*}
w_{N, t}^{I}=F_{t} / x_{N, t} \tag{8}
\end{equation*}
$$

\]

Where this $N^{t h}$ 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 $w_{N, t}^{I}$ 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 $w_{N, t}^{I}$ over time, the implicit wage must be converted into real terms, using an appropriate deflator. Deflation of $w_{N, t}^{I}$ 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

$$
\begin{equation*}
w_{N, t}^{I R}=\left(F_{t} / h_{t}\right) / x_{N, t}, \tag{9}
\end{equation*}
$$

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

$$
\begin{equation*}
w_{N, t}^{I R G}=\left(F_{t} / h_{t}\right) / x_{N, t}-\left(F_{t-1} / h_{t-1}\right) / x_{N, t-1} \tag{10}
\end{equation*}
$$

Expression (10) can be related to $F_{t}^{G}$ 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

$$
\begin{align*}
& w_{N, t}^{I R G}=F_{t} / h_{t} x_{N, t}-F_{t-1} / h_{t} x_{N, t}-  \tag{11}\\
& \quad\left[F_{t-1} /\left(h_{t-1} x_{N, t-1}\right)-F_{t-1} /\left(h_{t} x_{N, t}\right)\right]
\end{align*}
$$

Note that

$$
F_{t-1} /\left(h_{t} x_{N, t}\right) \equiv w_{N, t-1}^{I R}\left(h_{t-1} x_{N, t-1}\right) /\left(h_{t} x_{N, t}\right) .
$$

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].

$$
\begin{equation*}
w_{N, t}^{I R G}=F_{t}^{G} /\left(h_{t} x_{N, t}\right)-w_{N, t-1}^{I R}\left[1-\left(h_{t-1} / h_{t}\right)\left(x_{N, t-1} / x_{N, t}\right)\right] . \tag{12}
\end{equation*}
$$

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:

$$
\begin{align*}
& w_{N, t}^{I R G}=I_{R}\left(\mathbf{p}_{t}, \mathbf{y}_{t}, \mathbf{p}_{t-1}, \mathbf{y}_{t-1}\right) /\left(h_{t} x_{N, t}\right)-  \tag{13}\\
& I_{C}\left(\mathbf{w}_{t}, \mathbf{x}_{t}, \mathbf{w}_{t-1}, \mathbf{x}_{t-1}\right) /\left(h_{t} x_{N, t}\right)+P F P G_{t} /\left(h_{t} x_{N, t}\right)- \\
& w_{N, t-1}^{I R}\left[1-\left(h_{t-1} / h_{t}\right)\left(x_{N, t-1} / x_{N, t}\right)\right] .
\end{align*}
$$

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 $N^{t h}$ ) 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 $h_{t}(\mathrm{CPI})$ 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 loglinear trends with the ratios $y_{t}^{C r}=y_{t}^{C} / y_{t}, y_{t}^{L r}=y_{t}^{L} / y_{t}$ and $y_{t}^{S r}=y_{10, t} / y_{t}$ indicate that the livestock output share fell by about $0.4 \%$ each year between 1948 and 2002. ${ }^{11}$

[^5]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 ${ }^{2}$

[^6]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 $-I_{R}\left(\mathbf{p}_{t}, \mathbf{y}_{t}, \mathbf{p}_{t-1}, \mathbf{y}_{t-1}\right)$ 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 $V_{R}\left(\mathbf{p}_{t}, \mathbf{y}_{t}, \mathbf{p}_{t-1}, \mathbf{y}_{t-1}\right)$ 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 $w_{7, t}^{I R G}$ series.

[^7]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 $w_{7, t}^{I R G}$. The series in columns (B)-(E) are average annual values for series derived using (13), with the following concordance:
(B) $I_{R}\left(\mathbf{p}_{t}, \mathbf{y}_{t}, \mathbf{p}_{t-1}, \mathbf{y}_{t-1}\right) /\left(h_{t} x_{N, t}\right)$;
(C) $-I_{C}\left(\mathbf{w}_{t}, \mathbf{x}_{t}, \mathbf{w}_{t-1}, \mathbf{x}_{t-1}\right) /\left(h_{t} x_{N, t}\right)$;
(D) $P F P G_{t} /\left(h_{t} x_{N, t}\right)$; and
(E) $-w_{N, t-1}^{I R}\left[1-\left(h_{t-1} / h_{t}\right)\left(x_{N, t-1} / x_{N, t}\right)\right]$.


Figure 3. Deviations of Real Implicit Wage from 19482002 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

| period/ sub-period | real implicit wage at start of period/ sub-period* | average annual change in real implicit wage** | eal implicit wage growth decomposition: average annual changes |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | output price change component | input price change component | 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 |

[^8]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

[^9]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 subperiods, at 63 cents/hour it was still larger than that in the first two subperiods. 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.

[^10]

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.

## References

[1] Ball, V. E., J.-C. Bureau, R. Nehring and A. Somwaru (1997). "Agricultural Productivity Revisited", American Journal of Agricultural Economics, 79, 1045-1063.
[2] Ball, V.E., F.M. Gollop, A. Kelly-Hawke and G.P. Swinland (1999). "Patterns of State Productivity Growth in the U.S. Farm Sector: Linking State and Aggregate Models", American Journal of Agricultural Economics, 81, 164-179.
[3] CSO (1961). "Productivity Measurement in Agriculture", Economic Trends, No. 91 (a publication of the Central Statistical Office, U.K.)
[4] Diewert, W.E. (2005). "Index Number Theory Using Differences Rather than Ratios", The American Journal of Economics and Sociology, 64, 311-360.
[5] Diewert, W.E. (2000). "Productivity Measurement using Differences Rather Than Ratios", Discussion Paper 2000/1, School of Economics, University of New South Wales.
[6] Diewert, E., A. Harrison and P. Schreyer (2004). "Cost of Capital Services in the Production Account". Paper presented at the meeting of the Canberra Group, London, September.
[7] ERS (2002). Agricultural Income and Finance Outlook, AIS-79, Economic Research Service, United States Department of Agriculture, September.
[8] Gardner, B.L. (1992). "Changing Economic Perspectives on the Farm Problem", Journal of Economic Literature, 30, 62-101.
[9] Gordon, D.V., D.P. Dupont, K.J. Fox and R.Q. Grafton (2003). "Profit and Price Effects of Multi-Species Individual Transferable Quotas", Discussion Paper 2003-08, Department of Economics, University of Calgary.
[10] Harper, M.J., E. R. Berndt and D. O. Wood (1989). "Rates of Return and Capital Aggregation Using Alternative Rental Prices"; in Jorgenson, D. W. and R. Landau (eds.), Technology and Capital Formation, Cambridge:MIT Press.
[11] Hottel, J.B. and B.L. Gardner (1983). "The Rate of Return to Investment in Agriculture and Measuring Net Farm Income", American Journal of Agricultural Economics, 65, 553-557.
[12] Han, S.-H. and Hughes, A. (1999). "Profit Composition Analysis: A Technique for Linking Productivity Measurement \& Financial Performance", Research and Information Paper TRP 99-5, New South Wales Treasury.
[13] Hulten, C.R. (2001). "Total Factor Productivity: A Short Biography", in Hulten, C.R., E.R. Dean and M.J. Harper (eds), New Developments in Productivity Analysis, Chicago: University of Chicago Press.
[14] Mishra, A.K., H. S. El-Osta, M. J. Morehart, J. D. Johnson, and J. W. Hopkins (2002). "Income, Wealth, and the Economic Well-Being of Farm Households", Agricultural Economic Report No. 812, Economic Research Service, United States Department of Agriculture
[15] Lawrence, D., W.E. Diewert and K.J. Fox (2004). "The Contributions of Productivity, Price Changes and Firm Size to Productivity", paper downloaded as a pdf from the worldwide web via the url: http://www.ipeer.ca/SSHRC.htm
[16] Schnepf, R. (2006). "The U.S. Farm Economy", Congressional Research Service report RS21970, September 6 (available on worldwide web as a pdf file via the url http://fpc.state.gov/documents/organization/75261.pdf)
[17] Shreyer, P. (2004). "Measuring Multi-Factor Productivity when Rates of Return are Exogenous", paper presented at the SSHRC International Conference on Index Number Theory and the Measurement of Prices and Productivity, Vancouver, June 30-July 3. Paper downloaded as pdf from the worldwide web via the url: http://www.ipeer.ca/SSHRC.htm
[18] Stam, J.M. and B. L. Dixon (2004). "Farmer Bankruptcies and Farm Exits in the United States, 1899-2002", Agriculture Information Bulletin Number 788, Economic Research Service, United States Department of Agriculture.
[19] USDA(2000). "Commodity Costs and Returns Estimation Handbook, Report of the AAEA Task Force on Commodity Costs and Returns, February (available on worldwide web as a pdf file via the url http://www.economics.nrcs.usda.gov/care/Aaea).

## 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 qualityadjusted quantity index.

[^11]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/Fora | e Crops | 2. Industrial | Crops | 3. Vegetables |  | 4. Fruits and | Nuts | 5. Other |  |
|  | price | implicit | price | implicit | price | implicit | price | implicit | price | implicit |
| Year | index | quantity | index | quantity | index | quantity | index | quantity | index | 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

| Year | Crops |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 1. Grain/Forage Crops |  | 2. Industrial Crops |  | 3. Vegetables |  | 4. Fruits and Tree Nuts |  | 5. Other |  |
|  | price | implicit | price | implicit | price | implicit | price | implicit | price | implicit |
|  | index | quantity | index | quantity | index | quantity | index | quantity | index | 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 telephone: 202-694-5601 ; email: eball@ers.usda.gov
Table A1.2 United States Agricultural Outputs: Livestock, Other, 1948-2002

| Livestock |  |  |  |  |  |  |  |  | Secondary Output |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 6. Meat Animals |  | 7. Poultry and Eggs |  | 8. Dairy |  | 9. Misc. Livestock |  |  |  |
|  | price | implicit | price | implicit | price | implicit | price | implicit | price | implicit |
| Year | index | quantity | index | quantity | index | quantity | index | quantity | index | 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 |  |  |  |  |  |  |  |  | Secondary Output |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 6. Meat Animals |  | 7. Poultry and Eggs |  | 8. Dairy |  | 9. Misc. Livestock |  |  |  |
| Year | $\begin{aligned} & \text { price } \\ & \text { index } \end{aligned}$ | implicit quantity | price index | implicit quantity | price index | implicit quantity | price index | implicit quantity | price <br> 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 |

[^12]Table A2. United States Agricultural Inputs and Consumer Price Index, 1948-2002

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

| Year | 1. Capital excl. Land |  | 2. Land |  | 3. Hired Labour |  | 4. Farm-Produced Inputs |  | 5. Purchased Materials |  | 6. Purchased Services |  | 7. Operator/Unpaid |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\begin{aligned} & \hline \text { price } \\ & \text { index } \\ & \hline \end{aligned}$ | implicit quantity | $\begin{aligned} & \text { real rate } \\ & \text { of return } \end{aligned}$ | constant $\$$ value (Million $\$ 1996$ ) | $\begin{array}{r} \hline \text { price } \\ \text { index } \\ \hline \end{array}$ | $\begin{aligned} & \text { implicit } \\ & \text { quantity } \end{aligned}$ | $\begin{gathered} \hline \text { price } \\ \text { index } \\ \hline \end{gathered}$ | $\begin{aligned} & \text { implicit } \\ & \text { quantity } \end{aligned}$ | $\begin{array}{r} \hline \text { price } \\ \text { index } \\ \hline \end{array}$ | implicit quantity | $\begin{aligned} & \hline \text { price } \\ & \text { index } \\ & \hline \end{aligned}$ | implicit quantity | $\begin{aligned} & \text { Family Labour } \\ & \hline \text { (million hours) } \\ & \hline \end{aligned}$ | $\begin{array}{r} \text { CPI } \\ 1996=1 \\ \hline \end{array}$ |
| 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 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.ge 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

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

| year | implicit wage growth decomposition* |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | real implicit wage per hour | change in real implicit wage* <br> (A) | output price growth component | input price growth component | productivity growth component | 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.


[^0]:    ${ }^{1}$ 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 19841986, 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).

[^1]:    ${ }^{4}$ 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 nonagricultural 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].

[^2]:    ${ }^{5}$ 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

[^3]:    family members regarding on-farm and off-farm work (i.e. labour supply) and decisions about entry into, or exit from, farming.

[^4]:    ${ }^{9}$ 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,

[^5]:    ${ }^{11}$ These growth rates were estimated using an exponential trend equation of the form $\ln \left(y_{t}^{k r}\right)=\alpha^{k}+\beta^{k} t$ - where $\left.k=C, L, S\right)$. 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.

[^6]:    ${ }^{1}$ 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.

[^7]:    ${ }^{12}$ 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.

[^8]:    * 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.

[^9]:    ${ }^{14}$ 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.

[^10]:    ${ }^{15}$ 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).

[^11]:    ${ }^{1}$ See the web page www.ers.usda.gov/data/AgProductivity/methods.htm.

[^12]:    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
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