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DEFLATORS: 1890-1985

by

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ABSTRACT

U.S. AGRICULTURAL RESEARCH DEFLATORS: 1890-1985

Using newly developed time series on U.S. public sector agricultural research expenditures, two new deflators for agricultural research are constructed. These deflators differ from others currently used in the literature in that factor level price indices are weighted with time varying weights which capture the shifting factor mix of research spending by the state agricultural experiment stations (SAES). The substantial differences in measuring real resource allocation to agricultural research using these deflators and alternatives found in the literature, including that used by the National Science Foundation to report official R&D statistics, are demonstrated. In addition, the factor level expenditure series are used to contrast measurement of resource allocation in agricultural research from 1890 to the present using real research service flows as opposed to real research expenditures.

Keywords: United States, USDA, SAES, capital, labor, expenditures.

U.S. AGRICULTURAL RESEARCH DEFLATORS: 1890-1985

Deflators can often be a rather prosaic matter, but if poorly constructed are liable to seriously distort both the qualitative and quantitative analysis of time series data. Mansfield, Romeo and Switzer, for instance, recently showed that the apparent increase in real R&D expenditures in eight U.S. industries[1] over the 1969-79 period seems to have been due to the inadequacies of using a GNP deflator to proxy price increases for R&D inputs.

The purpose of this paper is to develop an agricultural research deflator (ARD) for the U.S. public sector research system which takes account of year to year changes in the factor mix of agricultural research expenditures. A special feature of this index is that it can be used to deflate nominal research expenditures back to 1890. This makes it useful for descriptive and analytical studies of the research process which require a long run perspective.[2] After a brief review of the research deflators in current usage, and the construction methodology used here, we compare the quantitative performance of the ARD deflator vis-a-vis various alternatives on the long run pattern of research spending by the U.S. state agricultural experiment stations (SAES).

I. RESEARCH DEFLATORS

Official R&D expenditure figures are often deflated with single price indices based on the implicit GDP deflator (see NSF and OECD (1986)). Many analytical studies of agricultural research such as Peterson and

Davis also use only one expenditure category and assume all of the appropriate price series move as one. They generally deflate total research expenditures by a salaries-based price series, although some have used the (federal) implicit GDP deflator and others the CPI.

Most of the other commonly used deflator series use two expenditure categories, labor and non-labor, with either fixed or variable index weights.[3] The fixed weight research deflators (see for example Havlicek and Otto) generally use 0.7 and 0.3 labor and non-labor weights respectively. Because of the lack of suitable input quantity data these weights are taken to represent the approximate value share of the labor and non-labor components of total research expenditures.[4]

If the aim of deflating is to express the aggregate cost of research in the current period in the price level of a reference period, then deflating by a base period weighted (Laspeyres) index is an acceptable approach only as long as there are no significant shifts in the composition of the aggregate. Figures 1(a) and (b) present details of aggregate factor ratios for the 48 state agricultural experiment stations (SAES) from 1890 to 1985.[5] From 1890 to 1930, expenditures are broken down into three categories; non-capital expenditures, expenditures for land and buildings, and equipment expenditures. From 1931 to 1985 non-capital expenditures are further broken down into their research labor and operating expense components.

From the mid-1950's onwards there is a remarkable degree of stability in these aggregate factor ratios. From 1955 to 1974 capital expenses averaged 8.5 percent of total expenses - these expenses in turn can be broken down to 3.0 percent land and buildings and 5.6 percent plant and

Figure 1a - Factor Expenditures as a Percent of Total: 1890-1930

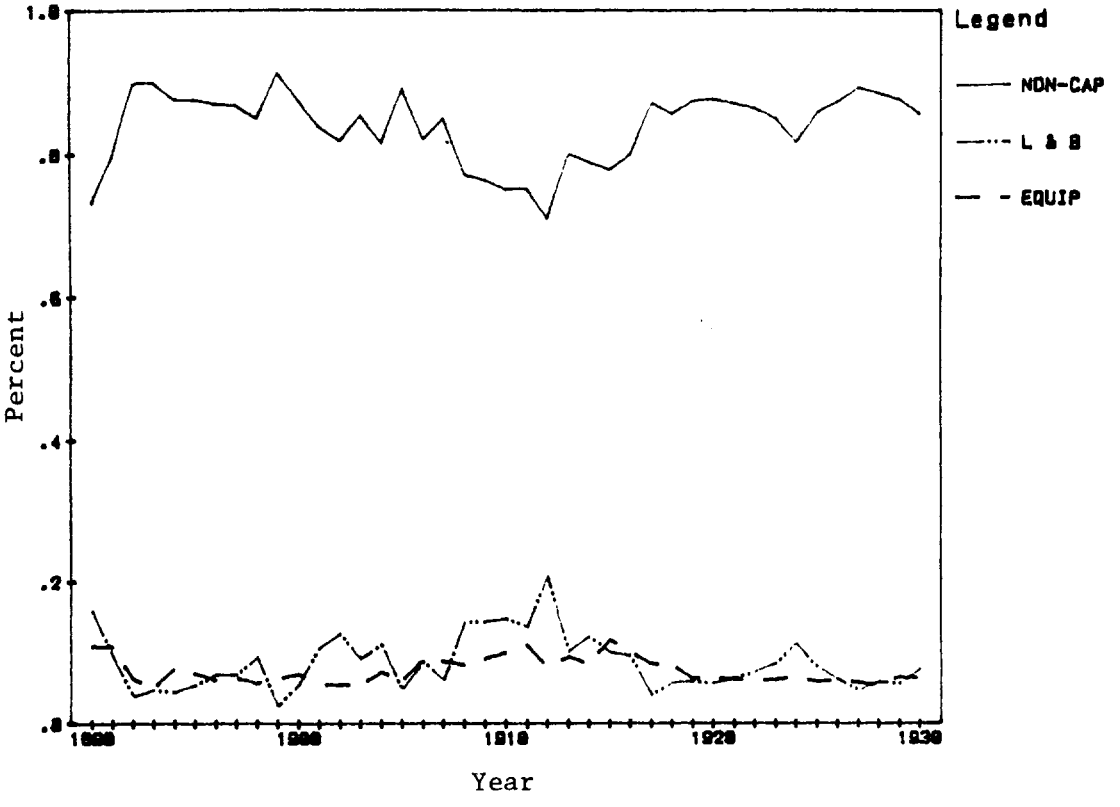
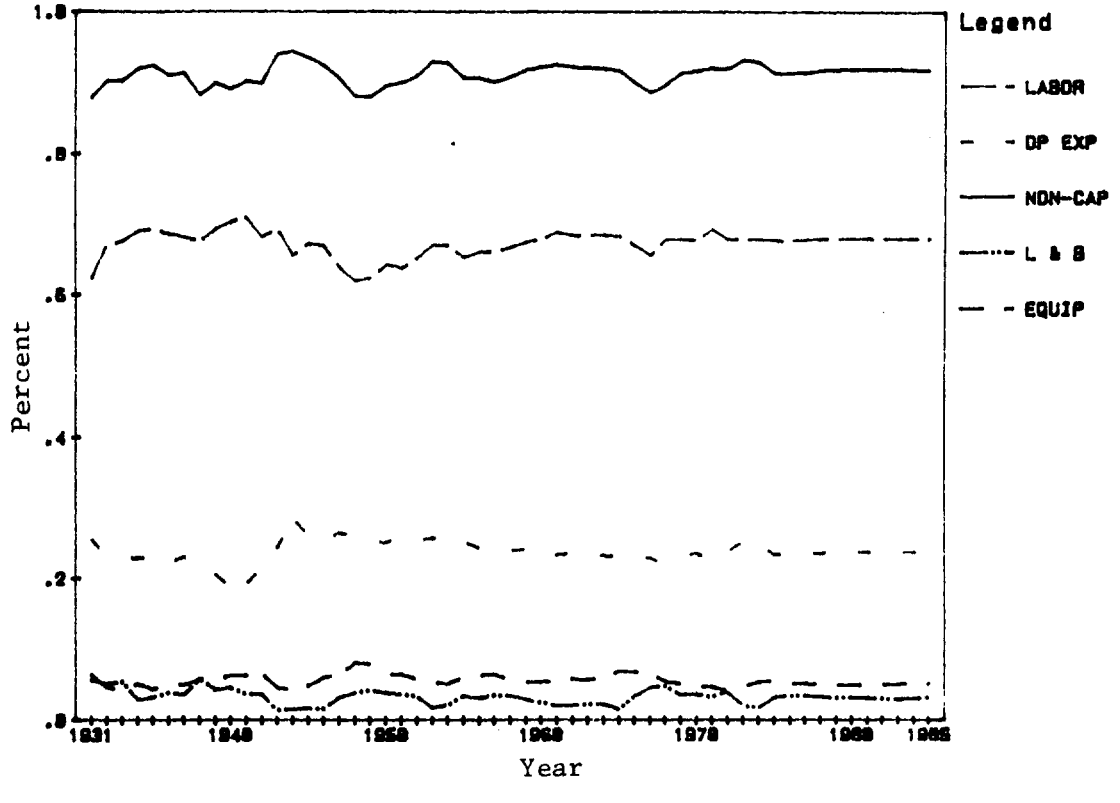


Figure 1b - Factor Expenditures as a Percent of Total: 1931-1985



equipment. Operating expenses averaged 23.7 percent and labor expenses 67.8 percent of total expenses. However, this apparent stability can be quite misleading. Figure 1a shows various factor ratios for the period back to 1890. Even at this level of aggregation the factor ratio pattern for the earlier years is quite different from the more recent past. Excepting the initial two to three years of data recorded after the passage of the Hatch Act in 1887 we observe an erratic but gradual increase in the proportion of total expenditures going to capital rather than non-capital items. This trend peaked in 1912, some twenty-five years after the formal establishment of the experiment station system, when 28.6 percent of total expenditures went to capital goods of which 20.7 percent was spent on land and buildings, and 7.9 percent on plant and equipment. Clearly these rather substantial shifts in factor mix need to be accounted for in any attempt to construct an appropriate deflator for a long-run series of agricultural research expenditures.

The most direct approach is to deflate separately the components of the value aggregate with the appropriate relative price indices (Evenson, and Pardey) such that,

$$\sum_i \frac{P_{ti}X_{ti}}{(P_{ti}/P_{oi})} = \sum_i P_{oi}X_{ti} \qquad (1)$$

where $\sum_i P_{ti}X_{ti}$ is the value aggregate for the t^{th} period, and $\sum_i P_{oi}X_{ti}$ is the desired aggregate value of the level of i inputs in the t^{th} period, X_{ti}, expressed in some reference or base year price, P_{oi}. As Jaffe and OECD (1981) note, an identical result can be obtained by directly

deflating the value aggregates using a current weighted (Paasche) price index so that

$$\frac{\sum_i P_{ti}X_{ti}}{(\sum_i P_{ti}X_{ti}/\sum_i P_{oi}X_{ti})} = \sum_i P_{oi}X_{ti} \qquad (2)$$

where the bracketed denominator is the appropriate current weighted price index.

II. DATA AND CONSTRUCTION

In this paper two, current weighted Paasche indices are developed. First an agricultural research expenditure deflator (ARD) for the 1890 to 1985 period is constructed on the basis of three separate research inputs - two capital expenditure categories, land and buildings, and plant and equipment, and a non-capital expenditure component which includes research labor plus recurrent operating expenses. The second deflator (ARD*), for the post-1930 period, includes four separate categories in which the non-capital component is split into labor and operating expenses.

The construction of such a long time series leads to special problems in obtaining the relevant price and quantity variables. Given the unavailability of long run price series which directly measure the four price components which make up the index, we first constructed relevant surrogate price indices. The labor and non-capital prices were proxied by an index of university salaries. Direct measures of average university salary figures (given in Table 1, Appendix I) were available for 1908 to

1985, while salary figures were estimated for the 1890 to 1907 period using a series of salaries of public school teachers (PSSAL) and a series on the salaries of federal employees (FESAL).

First, the salaries for federal employees were extrapolated by regressing FESAL on PSSAL, a constant, and trend from 1892 to 1926. The resulting coefficients (see Table 1) were used to construct federal employees salaries for 1890 and 1891. Next the series on university salaries (UTSAL) was extrapolated. UTSAL was regressed on PSSAL, FESAL, a constant, and trend from 1908 to 1926. The resulting coefficients were used to construct a series on university salaries for 1890 through 1907.

Plant and equipment along with operating expense prices were proxied by the implicit price deflator for state and local government purchases of goods and services (SLGSI). This deflator was published for the 1929 to 1985 period and was estimated for the earlier years on the basis of a partially derived wholesale price index (WPI). WPI67, base year 1967, was available for the years following 1913, while WPI26, base year 1926, was available for 1890 to 1912. First, the WPI series was put on a consistent (1967) basis by using the ratio of the two WPI series in 1926 as a simple conversion factor.[6] Next the implicit price deflator (SLGSI) was regressed on the 1967 base wholesale price index (WPI67) and a constant over the period 1929 to 1982. The resulting coefficients were used to construct a predicted set of implicit price deflators for 1890 to 1928.

Finally, land and building prices were proxied by the Handy-Whitman index of public utility building costs. Direct observations on the Handy-Whitman index (HWBI) are available for 1915 to 1985. The earlier years were again extrapolated by first regressing HWBI on the Riggleman's

Table 1: Coefficient Estimates Used to Predict Price Indices.

	OLS Predictor Equations			
	FESAL	UTSAL	SLGSI[1]	HWBI
Constant	839.535	1309.564	-21.590	17.514
	(38.258)[2]	(14.399)	(7.360)	(5.384)
PSSAL	0.932	2.037		
	(13.368)	(19.848)		
FESAL		-0.298		
		(2.309)		
WPI67C			1.099	
			(44.605)	
RBCI				0.101
				(7.766)
TREND	-6.928	-11.554	--	-0.306
	(3.090)	(2.452)		(3.558)
R^2	.9529	.9968	.9745	.7929
N	35	19	54	19

Data Sources: See notes to Tables 1 and 2, Appendix I.

Dependent Variables: FESAL - federal employee salaries; UTSAL - average university teachers salaries; SLGSI - implicit price deflator for state and local government purchases of goods and services; HWBI - Handy-Whitman public utility building cost index.

Independent Variables: PSSAL - public school teacher salaries; FESAL - federal employee salaries; WPI67C - constructed wholesale price index with 1967 base; RBCI - Riggleman's building cost index.

1. Including a trend resulted in no significant improvement in goodness of fit (R^2 = .9793) but unacceptable (negative) predicted indices for the earlier years.

2. Bracketed figures are t-values.

building costs index (RBCI) - available from 1889 to 1933 - a constant, and a trend. The resulting coefficients were used to construct a predicted Handy-Whitman index for 1889 to 1914.

The resulting UTSALI, SLGSI and HWBI indices for the 1890 to 1985 period are presented in Table 2. Using the current weighted (Paasche) price index from equation (2), the surrogate price indices, and a set of 'quantity' weights derived from value-based factor shares, we constructed the three factor ARD and four factor ARD* deflators, which are also reported in Table 2.

III. APPLICATION TO SAES SPENDING

To get some idea of the quantitative impact of accounting for year-to-year changes in the factor mix of research when constructing a research expenditure deflator, the annual rates of change for six deflators are presented in Table 3. The first three price indices - the implicit GDP deflator, an index of university teacher salaries (UTSALI), and a fixed weight deflator (FW) - have been in common usage to date. The FWARD price index is a fixed weight deflator using 1980 factor shares of labor, operating expenses, land and buildings, and plant and equipment as weights, while the ARD and ARD* deflators are the three and four factor variable weight deflators constructed in this study.

The implied inflation rate varies markedly across deflators and is not consistent over time. For example, during the 1910-19 period, when the proportion of total expenditures going to capital items was increasing quite dramatically, the salaries-only index substantially understates the

Table 2: U.S. Agricultural Research Deflators
(1980 = 100)

Year	UTSALI	SLGSI	HWBI	ARD	ARD*
1890	6.90	3.93	7.89	6.73	-
1891	6.92	3.85	7.72	6.67	-
1892	6.88	3.07	7.62	6.67	-
1893	6.87	3.33	7.52	6.72	-
1894	6.87	2.14	7.36	6.52	-
1895	6.89	2.33	7.28	6.59	-
1896	6.91	1.83	7.13	6.62	-
1897	6.93	1.85	6.97	6.61	-
1898	6.99	2.27	6.91	6.72	-
1899	7.07	3.07	7.04	6.82	-
1900	7.08	3.92	7.12	6.87	-
1901	7.10	3.74	7.14	6.91	-
1902	7.11	4.52	7.05	6.96	-
1903	7.16	4.67	6.95	7.01	-
1904	7.29	4.70	6.96	7.06	-
1905	7.37	4.78	6.97	7.19	-
1906	7.46	5.15	7.02	7.21	-
1907	7.60	5.89	7.10	7.42	-
1908	7.66	5.39	6.89	7.36	-
1909	7.99	6.41	6.58	7.65	-
1910	8.08	7.02	6.66	7.76	-
1911	8.15	5.82	6.47	7.67	-
1912	8.09	6.73	6.28	7.60	-
1913	8.26	6.88	6.48	7.95	-
1914	8.42	6.54	6.33	8.01	-
1915	8.61	6.80	5.52	8.09	-
1916	8.60	10.29	6.17	8.54	-
1917	8.89	17.22	9.09	9.60	-
1918	8.99	20.16	9.42	9.94	-
1919	9.57	21.76	9.42	10.33	-
1920	11.15	25.21	11.04	12.04	-
1921	12.31	12.89	8.44	12.10	-
1922	13.11	12.72	7.47	12.67	-
1923	13.35	13.56	8.44	12.94	-
1924	13.50	12.98	9.42	13.01	-
1925	13.59	14.15	8.77	13.24	-
1926	13.68	13.44	8.77	13.36	-
1927	13.83	12.47	8.44	13.51	-
1928	14.08	12.76	8.44	13.68	-
1929	14.14	10.94	8.44	13.61	-

Table 2: U.S. Agricultural Research Deflators (Continued)
(1980 = 100)

Year	UTSALI	SLGSI	HWBI	ARD	ARD*
1930	14.18	10.86	8.12	13.50	-
1931	14.50	10.25	7.47	13.83	12.74
1932	14.39	9.48	6.82	13.78	12.64
1933	13.70	9.83	6.82	13.17	12.28
1934	13.02	10.25	7.79	12.73	12.09
1935	12.33	10.36	7.79	12.10	11.64
1936	12.64	10.06	7.79	12.32	11.74
1937	13.15	10.40	8.77	12.85	12.22
1938	13.23	10.33	8.44	12.78	12.18
1939	13.29	10.17	8.44	12.91	12.26
1940	13.35	10.44	8.44	12.94	12.39
1941	13.36	10.98	9.42	13.07	12.61
1942	13.38	11.85	10.06	13.16	12.83
1943	13.82	12.50	10.06	13.71	13.38
1844	15.18	12.93	10.39	15.02	14.37
1945	14.97	13.61	10.71	14.83	14.48
1946	15.86	14.91	12.34	15.75	15.51
1947	17.14	16.94	14.61	17.05	16.99
1948	18.95	18.62	16.56	18.84	18.75
1949	19.51	19.31	17.53	19.41	19.36
1950	20.91	19.85	18.18	20.74	20.47
1951	22.39	21.57	19.81	22.24	22.03
1952	23.86	22.60	19.81	23.66	23.33
1953	25.06	23.21	21.10	24.89	24.42
1954	26.25	23.90	21.75	26.04	25.43
1955	26.94	24.51	22.73	26.65	26.04
1956	27.62	26.00	24.68	27.43	27.03
1957	29.05	27.27	26.62	28.85	28.43
1958	30.49	28.03	27.27	30.23	29.65
1959	31.92	28.76	28.25	31.65	30.88
1960	34.65	29.67	28.25	34.23	33.03
1961	35.85	30.67	28.25	35.41	34.20
1962	37.44	31.74	28.57	36.93	35.58
1963	39.38	32.62	29.22	38.77	37.18
1964	41.19	33.50	29.87	40.50	38.71
1965	43.21	34.61	30.19	42.42	40.43
1966	45.40	36.29	31.49	44.34	42.26
1967	48.04	38.24	32.47	46.68	44.43
1968	51.03	38.32	34.09	49.54	46.77
1969	54.39	43.06	36.69	53.19	50.55

Table 2: U.S. Agricultural Research Deflators (Continued)
(1980 = 100)

Year	UTSALI	SLGSI	HWBI	ARD	ARD*
1970	58.45	46.27	39.29	57.18	54.30
1971	61.44	49.37	43.18	60.29	57.56
1972	63.94	52.24	46.75	62.80	59.99
1973	67.31	56.02	51.30	66.46	63.62
1974	71.50	61.84	61.69	70.82	68.42
1975	75.87	67.57	69.16	75.21	73.26
1976	80.71	72.24	70.45	79.92	77.93
1977	82.93	77.51	74.03	82.35	81.08
1978	87.41	83.40	80.84	86.99	86.05
1979	93.06	90.71	90.26	92.86	92.30
1980	100.00	100.00	100.00	100.00	100.00
1981	109.39	108.68	105.19	109.23	109.06
1982	119.10	116.41	105.19	118.55	117.90
1983	132.28	123.63	108.12	131.14	129.07
1984	135.99	128.76	112.66	134.91	133.20
1985	144.31	135.03	116.88	142.98	140.78

UTSALI - index of average university teachers salaries; SLGSI - implicit price deflator for state and local government purchases of goods and services; HWBI - Handy-Whitman public utility building cost index.

ARD and ARD* - constructed agricultural research deflators with three and four factor components respectively. See text for detail of calculations.

Table 3: Average Annual Rates of Change for Various Research Expenditure Deflators (compound percent change[1])

	1890-1899	1900-1909	1910-1919	1920-1929	1930-1939	1940-1949	1950-1959	1960-1969	1970-1979	1980-1985
Implicit GDP	--	--	--	--	-0.34	7.01	2.43	2.31	6.66	5.08
University Salaries	0.21	1.27	1.73	2.10	-1.20	4.65	4.50	5.13	5.32	7.69
FW[2]	-0.75	2.16	6.75	-0.30	-0.91	5.37	4.36	4.79	6.02	7.22
FWARD[3]	-0.77	2.06	6.63	-0.29	-0.86	5.43	4.38	4.75	6.11	7.10
ARD	0.05	1.12	3.56	1.46	-0.94	4.91	4.50	4.93	5.54	7.47
ARD*	--	--	--	--	-0.51[4]	5.38	4.40	4.69	6.10	7.10

1. Calculated as (antilog $\hat{b}$ - 1) where $\hat{b}$ is the estimated slope coefficient from an OLS regression of $P_t = a + bt + e_t$.

2. Fixed Weight (FW) Laspeyres index with .3 and .7 weights on the capital and non-capital components respectively.

3. Fixed Weight ARD using 1980 (four) factor share weights.

4. Based on observations for 1931-1939 only.

average rate of price increases faced by the state agricultural experiment stations, as compared with the FWARD series. The two fixed weight indices grossly overstate the average rate of price increases over this period as compared with our deflator series.[7]

The quantitative impact of these various deflators on the pattern of real expenditures by the SAES over the 1890-1983 period is clearly visible in Figure 2a. Here percent deviation of real SAES expenditures, calculated using both the single priced deflators and the fixed weight deflator (FW), are measured relative to real SAES spending deflated with the ARD series.

The expenditure series, deflated using the implicit GDP deflator, grossly understates the level of real resources committed to SAES research for the 1929-1965 period, while generally overstating the level of real spending in the more recent years. Except for several years around 1920 the expenditure series deflated using the salaries-only index, appears systematically to understate the level of research resources. In contrast, the fixed weight series appears systematically to bias upward the real resource commitment to agricultural research in the SAES except for the 1916-1929 period.[8]

While ARD deflated expenditures are a suitable reference series by which to assess the quantitative impact of misspecified research deflators, a more appropriate figure for most augmented production function studies which seek to measure the impact of research on agricultural output is an estimate of the real service flows derived from research expenditures, rather than expenditures per se. Given our

Figure 2a - Percent Deviation of Real Expenditures from ARD Deflated Expenditure Series

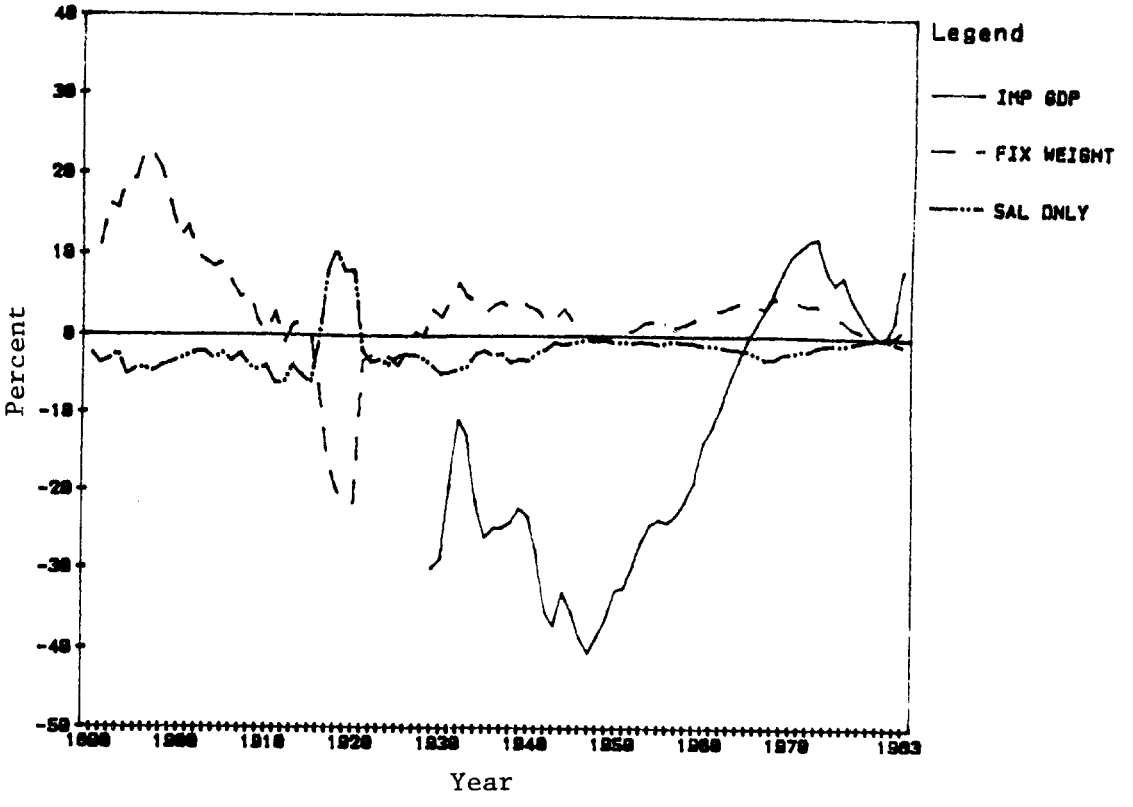
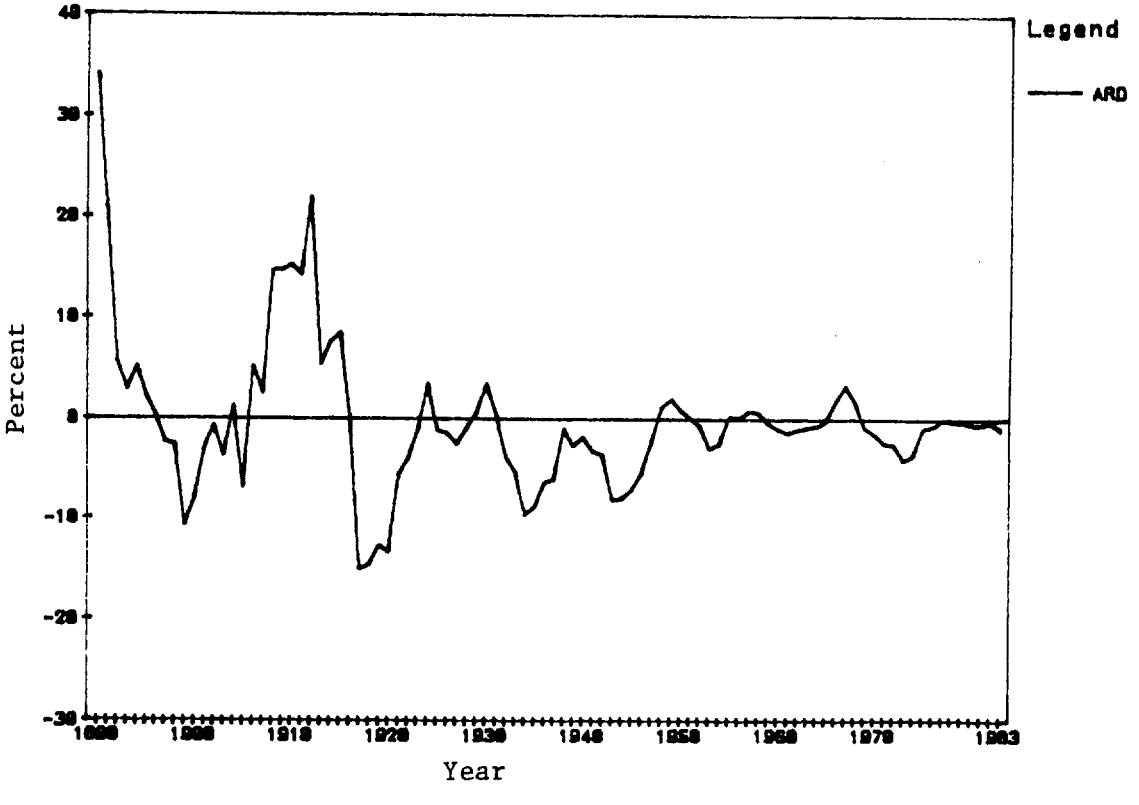


Figure 2b - Percent Deviation of ARD Deflated Expenditures from Service Flow Series



ability to separate capital (land and buildings plus plant and equipment) from non-capital expenditures, it is possible to calculate the real service flows from the two capital categories. Adding them to real non-capital expenditures yields a measure we call total real service flows from research expenditures. The land and buildings were assumed to have a 25 year service life while plant and equipment were assumed to have only a 10 year service life. For practical purposes, both service flow profiles were proxied by a One-Hoss Shay assumption with zero salvage value.[9]

Figure 2b plots the percentage deviation of real SAES research expenditures (deflated with the ARD series) from a real service flow series. Clearly the long run pattern of real service flows substantially differs from the pattern of SAES research expenditures. The expenditure series appears to overstate significantly the level of real resources flowing directly into SAES research during the earlier establishment years, when a substantial fraction of total expenditures were committed to durable infrastructure (see Figure 1a). From 1916 through to the late 1940s the expenditure series generally understates service flows, as it does again rather consistently since the late 1960s.

IV. SUMMARY

Using a newly developed time series of the changing factor mix of SAES research expenditures, we constructed several agricultural research deflators which can be used to deflate long run series of U.S. agricultural research expenditures. Comparing these new indices with those used previously to deflate research expenditures leads us to revise

substantially our measures of the real level of support afforded SAES research, and the rate of change in this support over time. Converting research expenditures to a real service flow measure also revises substantially the pattern of resources actually used by the SAES to perform agricultural research.

It remains to be seen what impact these revised deflators and service flow measures have on the estimated rate of return to U.S. public sector agricultural research expenditures. The evidence presented in this paper opens the possibility of a substantial revision to current estimates.

FOOTNOTES

1. These included the chemical, petroleum, electrical equipment, primary metals, fabricated metal products, rubber, stone clay and glass plus textile industries.

2. Pardey and Craig, for instance, used a long run expenditure series to show that the output effect of agricultural research spending may persist for at least 30 years - around double the prevailing norm assumed in the literature.

3. In many of these studies labor includes personnel and operating costs, so more appropriately should be called non-capital expenses. The operating cost category includes expenditures on heat, light, chemicals, seed, fertilizer, publications, and other sundry supplies.

4. Other attempts to construct (fixed weight) agricultural research deflators include Sonka and Padberg - for the 1947/8 to 1978/9 period - and Murphy and Kaldor - for the 1973/4 to 1977/8 period.

5. The post-1974 figures represent predicted factor ratios based on a ten year moving average. A change in the reporting methods of SAES research expenditures meant that it was no longer possible to calculate factor shares from the published statistics. For 1985 the imputed factor shares are, labour expenses (68.1 percent), operating expenses (23.7 percent), land and buildings (3.15 percent), and plant and equipment (5.06 percent).

6. An alternative procedure is to regress WPI67 on WPI26 for the overlapping period, 1913 to 1951, and use the resulting coefficients to construct the 1890 to 1912 years for a 1967 based index. This method was rejected because the percentage changes from year-to-year in the resulting WPI67 series, for years 1890 to 1912, were much closer to the same year-to-year percentage changes in the 1926 based WPI, than with the regression based extrapolation of the 1967 based WPI.

7. These ARD deflators are in essence value or cost indices which capture the combined effect of yearly price and quantity (ie. factor share) changes. However, as equation (2) shows, they allow us to express research expenditure aggregates in terms of base year prices, in contrast to the cost per scientist index developed by Milton which, as NSF (1970) points out, does not permit removal of the inflation effect from an R&D expenditure series.

8. Huffman and Evenson recently report a 'price index for agricultural research' running from 1890 to 1985 but unfortunately give no details of how it was constructed. When applied to SAES expenditures it gives a percent deviation pattern similar in nature to the series deflated with the implicit GDP index presented in Figure 2a.

9. Under these assumptions it is easy to show that the total service flow of capital in period t′ is given by $k \sum_{t=t'}^{t'-(T-1)} C_{ot}$ where C_{ot} is the gross (undepreciated) market value of a capital asset purchased in period t with a service life of T and

$$k = \frac{r}{1+r}\left[\frac{1}{1-\left[\frac{1}{1+r}\right]^{T}}\right]$$

Yotopoulos derives the continuous form version of this service flow estimator. Here r, the long run real rate of interest, was set at 0.04. Extending the service life, T, from 25 to 40 years in the case of land and buildings made only minor differences to the service flow estimate.

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Appendix I

Table 1: Average Salaries of College and University Teachers at Large Public Institutions for the Academic Years (ending in year shown): 1908-1985.[1]

Academic Year	Average Salary in Current Dollars	Academic Year	Average Salary in Current Dollars[2]
1908	1656	1947	3705
1909	1728	1948	4098
1910	1746	1949	4217
1911	1763	1950[3]	4521
1912	1748	1951[4]	4840
1913	1785	1952[3]	5159
1914	1821	1953[4]	5418
1915	1861	1954[3]	5676
1916	1860	1955[4]	5824
1917	1923	1956[3]	5971
1918	1943	1957[4]	6281
1919	2068	1958[4]	6591
1920	2410	1959[5]	6901
1921	2661	1960[5]	7492
1922	2834	1961	7750
1923	2886	1962	8094
1924	2919	1963	8513
1925[4]	2939	1964	8906
1926	2958	1965	9341
1927	2991	1966	9816
1928	3045	1967	10387
1929	3056	1968	11033
1930	3065	1969	11760
1931	3134	1970	12637
1932	3111	1971	13284
1933[4]	2963	1972	13823
1934[4]	2815	1973	14552
1935	2666	1974	15459
1936	2732	1975	16403
1937	2843	1976	17450
1938	2861	1977	17930
1939[4]	2874	1978	18897
1940	2886	1979	20120
1941[4]	2889	1980	21620
1942	2892	1981	23650
1943	2988	1982	25750
1944	3282	1983	28600
1945	3236	1984	29400
1946	3429	1985	31200

Notes to Table 1:

1908-1942: Unless otherwise indicated, taken from Stigler (1950) Table 29, p. 44. Stigler's figures prior to 1932 are based on Viva Boothe's Salaries and the Cost of Living in Twenty-seven State Universities and Colleges 1913-32, Ohio State University Press, 1932, and annual bulletins of the Office of Education.

1943-1949: Taken from Stigler (1950) p. 45.

1950-1982: Unless otherwise stated, taken from various issues of the annual bulletin published by the American Association of University Professors (AAUP). They represent the weighted average salary of teachers across all ranks (i.e. full, associate, and assistant professors, plus instructors). The weights represent the proportion of personnel in each professional category. This is analogous to the procedure used by Stigler to construct average salary estimates for the earlier period.

The post-1958 salary figures used by Cline and Davis represent the salary figures for associate professors only. The earlier Stigler figures are a weighted average across all teacher ranks. To maintain consistency in the series we opted also to use a weighted average across all ranks.

1983-1985: Taken from U.S. Bureau of the Census, Statistical Abstract of the United States, various annual issues. The figures for average salaries across all ranks for teachers working in public colleges and universities are reported in a table on 'Institutions of Higher Education - Average Salaries and Fringe Benefits for Faculty Members, By Type of Control.'

1. Reported on a standard academic year (9-10 month) basis.

2. Labeled UTSAL in other tables. Excludes fringe benefits.

3. Calculated from salary data reported in the 1956 AAUP bulletin Vol. 42, No. 1, p. 37. The Cline and Davis figures for 1950 to 1958 were calculated as a linear interpolation of the 1949 and 1959 figures.

4. Obtained by linear interpolation.

5. Calculated as total compensation minus fringe benefits, which were estimated at 6.0 percent of total compensation, based on the compensation and salary figures for 1961.

Table 2: Raw Data for Research Deflator Calculations

Year	UTSAL	FESAL	PSSAL	RBCI	HWBI	SLGSI	WPI67	WPI26
1889	-	-	-	75.3	-	-	-	-
1890	-	-	256	73.3	-	-	-	56.2
1891	-	-	264	70.9	-	-	-	55.8
1892	-	1096	270	70.9	-	-	-	52.2
1893	-	1101	276	71.1	-	-	-	53.4
1894	-	1110	283	69.2	-	-	-	47.9
1895	-	1104	289	69.8	-	-	-	48.8
1896	-	1084	294	68.3	-	-	-	46.5
1897	-	1057	298	66.5	-	-	-	46.6
1898	-	1025	306	67.5	-	-	-	48.5
1899	-	1017	318	74.4	-	-	-	52.2
1900	-	1033	328	79.9	-	-	-	56.1
1901	-	1047	337	83.6	-	-	-	55.3
1902	-	1061	346	83.8	-	-	-	58.9
1903	-	1067	358	84.0	-	-	-	59.6
1904	-	1066	377	87.4	-	-	-	59.7
1905	-	1072	392	90.6	-	-	-	60.1
1906	-	1084	409	95.1	-	-	-	61.8
1907	-	1094	431	100.6	-	-	-	65.2
1908	1656	1102	455	97.2	-	-	-	62.9
1909	1728	1106	476	90.9	-	-	-	67.6
1910	1746	1108	492	96.3	-	-	-	70.4
1911	1763	1116	509	93.4	-	-	-	64.9
1912	1748	1128	529	90.7	-	-	-	69.1
1913	1785	1136	547	100.0	-	-	36.0	69.8
1914	1812	1140	564	98.3	-	-	35.2	68.1
1915	1861	1152	578	100.9	17	-	35.8	69.5
1916	1860	1211	605	115.6	19	-	44.1	85.5
1917	1923	1295	648	142.9	28	-	60.6	117.5
1918	1943	1380	689	170.9	29	-	67.6	131.3
1919	2068	1520	810	212.8	29	-	71.4	138.6
1920	2410	1648	936	251.3	34	-	79.6	154.4
1921	2661	1593	1082	201.8	26	-	50.3	97.6
1922	2834	1625	1188	174.5	23	-	49.9	96.7
1923	2886	1658	1224	214.0	26	-	51.9	100.6
1924	2919	1708	1247	215.4	29	-	50.5	98.1
1925	2939	1776	1263	206.7	27	-	53.3	103.5
1926	2958	1809	1277	208.0	27	-	51.6	100.0
1927	2991	-	-	206.2	26	-	49.3	95.4
1928	3045	-	-	206.8	26	-	50.0	96.7
1929	3056	-	-	207.0	26	28.6	49.1	95.3

Table 2: Raw Data for Research Deflator Calculations (Continued)

Year	UTSAL	FESAL	PSSAL	RBCI	HWBI	SLGSI	WPI67	WPI26
1930	3065	-	-	202.9	25	28.4	44.6	86.4
1931	3134	-	-	181.4	23	26.8	37.6	73.0
1932	3111	-	-	157.0	21	24.8	33.6	64.8
1933	2963	-	-	170.0	21	25.7	34.0	65.9
1934	2815	-	-	-	24	26.8	38.6	74.9
1935	2666	-	-	-	24	27.1	41.3	80.0
1936	2732	-	-	-	24	26.3	41.7	80.8
1937	2843	-	-	-	27	27.2	44.5	86.3
1938	2861	-	-	-	26	27.0	40.5	78.6
1939	2874	-	-	-	26	26.6	39.8	77.1
1940	2886	-	-	-	26	27.3	40.5	78.6
1941	2889	-	-	-	29	28.7	45.1	87.3
1942	2892	-	-	-	31	31.0	50.9	98.8
1943	2988	-	-	-	31	32.7	53.3	103.1
1944	3282	-	-	-	32	33.8	53.6	104.0
1945	3236	-	-	-	33	35.6	54.6	105.8
1946	3429	-	-	-	38	39.0	62.3	121.1
1947	3705	-	-	-	45	44.3	76.5	152.1
1948	4098	-	-	-	51	48.7	82.8	165.1
1949	4217	-	-	-	54	50.5	78.7	155.0
1950	4521	-	-	-	56	51.9	81.8	161.5
1951	4840	-	-	-	61	56.4	91.1	180.4
1952	5159	-	-	-	61	59.1	88.6	-
1953	5418	-	-	-	65	60.7	87.4	-
1954	5676	-	-	-	67	62.5	87.6	-
1955	5824	-	-	-	70	64.1	87.8	-
1956	5971	-	-	-	76	68.0	90.7	-
1957	6281	-	-	-	82	71.3	93.3	-
1958	6591	-	-	-	84	73.3	94.6	-
1959	6901	-	-	-	87	75.2	94.8	-
1960	7492	-	-	-	87	77.6	94.9	-
1961	7750	-	-	-	87	80.2	94.5	-
1962	8094	-	-	-	88	83.0	94.8	-
1963	8513	-	-	-	90	85.3	94.5	-
1964	8906	-	-	-	92	87.6	94.7	-
1965	9341	-	-	-	93	90.5	96.6	-
1966	9816	-	-	-	97	94.9	99.8	-
1967	10387	-	-	-	100	100.0	100.0	-
1968	11033	-	-	-	105	100.2	102.5	-
1969	11760	-	-	-	113	112.6	106.5	-

Table 2: Raw Data for Research Deflator Calculations (Continued)

Year	UTSAL	FESAL	PSSAL	RBCI	HWBI	SLGSI	WPI67	WPI26
1970	12637	-	-	-	121	121.0	110.4	-
1971	13284	-	-	-	133	129.1	114.0	-
1972	13823	-	-	-	144	136.6	119.1	-
1973	14552	-	-	-	158	146.5	134.7	-
1974	15459	-	-	-	190	161.7	160.1	-
1975	16403	-	-	-	213	176.7	174.9	-
1976	17450	-	-	-	217	188.9	183.0	-
1977	17930	-	-	-	228	202.7	194.2	-
1978	18897	-	-	-	249	218.1	209.3	-
1979	20120	-	-	-	278	237.2	235.6	-
1980	21620	-	-	-	308	261.5	268.8	-
1981	23650	-	-	-	324	284.2	293.4	-
1982	25750	-	-	-	324	304.4	299.3	-
1983	28600	-	-	-	333	323.3	-	-
1984	29400	-	-	-	347	336.7	-	-
1985	31200	-	-	-	360	353.1	-	-

Data Sources:

UTSAL (average university teachers salaries):

1908-1985 - See notes to Table 1, Appendix I.

FESAL (federal employee salaries):

1892-1926 - Historical Statistics, Part 1, Series D790, p. 168.

PSSAL (public school teachers salaries):

1890-1926 - Historical Statistics, Part 1, Series D792, p. 168.

RBCI (Riggleman's building cost index):

1889-1933 - Historical Statistics, Part 2, Series N138, p. 629.

HWBI (Handy-Whitman public utility building cost index):

1915-1970 - Historical Statistics, Part 2, Series N129, pp. 627-28.

1971-1985 - Statistical Abstract of the United States, various annual issues.

SLGSI (implicit price deflator for state and local government purchases of goods and services):

1929-1970 - Historical Statistics, Part 1, Series E15, p. 198.

1971-1982 - Statistical Abstract of the United States, various annual issues.

1983-1985 - Survey of Current Business, various January issues.

WPI67 (wholesale price index, 1967 base)

1913-1970 - Historical Statistics, Part 1, Series E23, p. 199.

1971-1982 - Statistical Abstract of the United States, various annual issues.

WPI26 (wholesale price index, 1926 base)

1890-1951 - Historical Statistics, Part 1, Series E40, p. 200.