KALDOR'S LAW AND BRITISH ECONOMIC GROWTH 1800-1970

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Kaldor's Law and British Economic Growth 1800-1970[1]

In his inaugural lecture Kaldor {1966} hypothesised that the failure of Britain's growth performance was closely tied to the principles of Verdoorn's Law. He tested his hypothesis on cross section data for a number of countries post world War II. Here we make an attempt to apply the hypothesis to U.K. economic growth since 1800. Cripps and Tarling {1973} followed Kaldor's application to a cross section sample but their estimation method has led to a strong interchange between Rowthorn {1975a},{1975b} and Kaldor {1975}. In this piece it is hoped to throw some further light on this controversy.

The main reason for attempting a time series analysis is (a) it generates new results and (b) there are well known econometric problems in mixing time series and cross section data in the manner of the three above authors (see Kmenta {1971} pp. 508-517). The main problem with using time series data is however that Rowthorn argues (1975a, p. 13) that all observations should have a similar rate of technological progress available (based on a statement of Cripps and Tarling (p.3)). However Cripps and Tarling say that this precondition is necessary for a test of the neoclassical hypothesis typified by the Denison approach to the sources of growth, not of the Kaldor hypothesis. Nor does Kaldor require it as a precondition. Although we cannot be sure of whether this requirement is necessary or can be met, and there is no way to test for its applicability, it is felt that the time series approach can still yield some useful insights.

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1 I would like to thank Peter Law and Dennis Leech for their helpful comments on an earlier draft.

The major points of Kaldor's arguments are:

(1) The growth of gross domestic product is closely related to the growth of manufacturing output but not to the growth of output in other sectors.

(2) In manufacturing the growth of productivity is closely related to the growth of output (Verdoorn's Law) but in other sectors the growth of productivity is not related to the growth of output.

(3) Relationship (2) implies relationship (1) because the growth in productivity in manufacturing indirectly leads to growth in productivity in other sectors.

(4) Because growth in productivity in manufacturing requires increases in the labour force in manufacturing, a supply constraint will hold down the rate of growth of G.D.P. This supply constraint arises from the reduction in the surplus agricultural labour force.

If we let

p_{MF} = rate of growth of productivity in manufacturing

p_{AG} = " " " " " " agriculture

e_{MF} = " " " " employment in manufacturing

e_{AG} = " " " " " " agriculture

q_{MF} = " " " " output in manufacturing

q_{AG} = " " " " " " agriculture

q_{GDP} = " " " " gross domestic product

We may set up our hypothesis :

(i) $q_{GDP} = f_1(q_{MF})$

(ii) $P_{MF} = f_2(q_{MF})$

(iii) $P_{AG} = f_3(P_{MF})$

(iv) $\frac{de_{MF}}{dP_{MF}} > 0.$ But as $P_{MF} \equiv q_{MF} - e_{MF}$,

if $1 > \frac{de_{MF}}{dq_{MF}} > 0$ this condition is satisfied.

This is equivalent to Verdoorn's Law being verified for manufacturing. Relationships (i), (ii) and (iv) should only hold for manufacturing, and especially not hold for agriculture.

<u>Data</u>

To test these hypotheses we have collected data on British growth performance since 1800. The main source is Feinstein {1972}, from 1856, supplemented from Deane and Cole {1969} prior to this, and using Cripps and Tarling's {1973} data for 1965-1970. Care has been taken to standardise for the removal of Southern Ireland for post 1920 data.

All series are defined as logistic growth rates, i.e. if we have two observations for t and $t + n$, the growth rate of x is defined as

$$g_x \equiv \frac{1}{n} (\log_e x_{t+n} - \log_e x_t)$$

Not surprisingly in certain cases the data is incompatible across sources. We have thus always used Feinstein's data where it exists, in preference to any other, except in the case of employment data. We have two series on employment, subscripted 1 and 2. The former uses Dean and Cole's data to 1920, supplemented by Feinstein. The latter uses Deane and Cole's data to 1860 supplemented by Feinstein. As both series behaved similarly only results using the first series are presented.

Because of data difficulties we have made comparisons of only two sectors, agriculture and manufacturing, in generating our results. This is not felt to be too serious a problem. It should be noted however that in Deane and Cole's data (used for observations to 1860) manufacturing output includes mining and building. Their estimates of output have also been corrected, using the Rousseaux price index (separating manufacturing and agriculture), to generate real output series.

The data is presented in the Appendix. As will be seen the time periods over which the growth rates are calculated vary. In an ideal world we would wish to compare across cyclical peaks. This we have done for post 1920 data, with peaks 1920, 1925, 1929, 1937; 1951, 1955, 1960, 1965, 1969. (There is no comparison pre and post second world war). For earlier years, data on all variables only exist for benchmark years (1801, 1811 .... 1911), so we have had to make the calculations across these years. This must introduce some error, but there is no obvious way out of this problem. Unfortunately this procedure does lead to some outlying observations. We must tread warily in using these to derive our estimates (see Rowthorn's {1975a} comment on Cripps and Tarling). Thus, in the estimates presented below, we take care to present results which exclude war years (1801-1811, 1811-1821) and 1920-1925, which are often outliers.

Estimation

We begin by estimating equations (1) and (2) below.

$$q_{GDP} = \alpha + \beta \; q_{MF} + \mu \qquad (1)$$

$$q_{GDP} = \alpha + \beta \; q_{AG} + \mu \qquad (2)$$

The results are presented in table 1. In equations (a) and (b) the sample is all of Feinstein's data 1856-1965 using annual growth rates. In equations (c) and (d) the sample is all of the data in the Appendix (equations e - h, cover only parts thereof). Bracketed figures are t statistics. These estimates illustrate,

a) whereas q_{MF} always has a coefficient significantly different from zero, q_{AG} only has in one sample, and

b) whereas estimates of equation (1) yield high R^2 those of equation (2) are always low, especially in equation (b) where the coefficient on q_{AG} is significantly different from zero

c) the removal of outliers and war years does not affect these conclusions.

Thus Kaldor's first proposition is borne out by the data[1], our estimate of β in equation (1) being approx. 0.4 if we remove outlying observations (results a, e, g), with $\alpha \simeq 0.01$. We may say therefore that

$$q_{GDP} = 0.01 + 0.4\, q_{GDP}$$

We move on to the second proposition and the test of Verdoorn's Law. Here is where the controversy arises. The hypothesis is that this law will only apply to manufacturing and not agriculture. We state the law as

$$p = \alpha + \beta q + \mu \qquad (3)$$

but

$$p \equiv q - e \qquad (4)$$

We can generate results of equation (3) but a proper test of the hypothesis must take into account equation 4. If we take the equation 3 estimates first (Table 2), using the first employment series to generate productivity measures (use of the second series makes little difference), we can see that in general the coefficient on q is significant for both manufacturing and agriculture regressions across the different samples. In regressions (g) and (h) we correct for autocorrelation and the significance remains (the method used is that of Cochrane and Orcutt and the value of ρ is tabulated).

However we now come to the point of dispute. We ought to combine (3) and (4) for estimation purposes. We can proceed in two ways.

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(1) Kaldor notes that Miss Deborah Paige had already found this for the 100 years to 1961 (Kaldor {1966} fn. p.6).

Table 1 - Regression results equations (1) and (2).

	Dep. Variable = q_{GDP}							
	SAMPLE							
	1856-1965	1856-1965	1800-1969	1800-1969	1831-1969	1831-1969	1831-1911 1925-1969	1831-1911 1925-1969
N	97	97	18	18	16	16	15	15
name	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
constant	0.010 (6.63)	0.019 (7.46)	0.016 (7.55)	0.021 (11.51)	0.010 (4.14)	0.019 (10.18)	0.010 (3.88)	0.019 (10.30)
q_{MF}	0.386 (15.43)		0.189 (2.91)		0.446 (5.106)		0.442 (4.78)	
q_{AG}		0.135 (2.62)		0.069 (0.87)		0.203 (1.851)		0.218 (1.99)
R^2	0.715	0.067	0.346	0.045	0.651	0.196	0.637	0.234
DW	2.13	1.80	1.993	1.595	1.771	1.670	1.796	1.670
F	2.32	6.66	8.47	0.752	26.07	3.425	22.86	3.96

Table 2 - Regression results equation (3)

	$p = \alpha + \beta q$							
name	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
	1800-1969	1800-1969	1831-1969	1831-1969	1831-1911 1920-1969	1831-1911 1920-1969	1800-1969	1800-1969
dep. variable	P_{MF_1}	P_{AG_1}	P_{MF_1}	P_{AG_1}	P_{MF_1}	P_{AG_1}	P_{MF_1}	P_{AG_1}
constant	0.0013 (0.246)	0.009 (2.379)	0.0042 (0.5545)	0.0086 (1.9769)	-0.002 (-0.371)	0.0083 (1.8488)	0.0052 (0.976)	0.023 (1.506)
q_{MF}	0.6549 (4.112)		0.6038 (2.253)		0.7596 (3.987)		0.557 (3.54)	
q_{AG}		0.9528 (5.490)		1.14304 (4.5857)		1.1228 (4.360)		0.902 (8.44)
R^2	0.5139	0.6533	0.2661	0.6003	0.5501	0.5939	0.457	0.817
DW	1.7548	0.4765	2.0064	0.6839	1.4417	0.4318	1.916	2.564
F	16.91	30.15	5.076	21.03	15.89	19.01	12.655	66.96
ρ							-0.032	0.859

a) substitute for q from (4) to (3) to derive

$$p = \frac{\alpha}{1-\beta} + \frac{\beta}{1-\beta} e + \frac{1}{1-\beta} \mu \qquad (5)$$

or

b) substitute for p from (4) to (3) to derive

$$e = -\alpha + (1-\beta) q - \mu \qquad (6)$$

Cripps and Tarling undertake estimation using (5) whereas Kaldor argues that we should use (6). Basically the reasons are that equations (5) and (6) are alternative reduced forms of the system (3) and (4), where in (5) e is considered exogenous and in (6) q is considered exogenous and e endogenous. It is accepted that p is endogenous. A priori restrictions should dictate whether (5) or (6) is to be used. Use of (5), Rowthorn shows, using Cripps and Tarling's data refutes Kaldor's Law. In Table 3 results are presented that show likewise, (equation (e) corrects for autocorrelation).

These results are indicative of the results across other samples showing a non-significant relationship between p_{MF} and e_{MF}, but significant relationships between p_{AG} and e_{AG}. If we accept these results Kaldor's Law is turned on its head.

We turn then to the estimation of equation 6, i.e. regressing e on q with q considered exogenous. The results are presented in Table 4. As can be seen from equation (a), results across the whole sample give reasonable support to Verdoon's Law applying in manufacturing, whereas (b) suggests it does not apply to agriculture (the coefficient on q_{AG} is not significant).

Table 3 - Regression results.

$p = \alpha + \beta e$

	SAMPLE				
	1801-1969	1801-1969	1821-1969	1921-1969	1801-1969
	(a)	(b)	(c)	(d)	(e)
dep. variable	p_{MF1}	p_{AG1}	p_{MF1}	p_{AG1}	p_{AG1}
const.	0.022 (4.718)	0.0146 (2.635)	0.023 (7.65)	0.009 (2.063)	0.0088 (2.092)
e_{MF1}	-0.342 (-1.728)		-0.659 (-2.859)		
e_{AG1}		-0.9027 (-2.518)		-1.1607 (-4.1455)	-1.184 (-4.437)
R^2	0.073	0.2838	0.3687	0.5511	0.5666
DW	1.902	1.4557	1.5922	1.7592	1.7531
F	1.274	6.342	8.175	17.18	19.609
ρ					-0.0058

Table 4 - Regression results equation (6)

$e = \alpha + \beta q + \mu$

name	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
	1800-1969	1800-1969	1800-1969	1800-1969	1831-1911 1920-1969	1831-1911 1920-1969	1831-1911 1920-1969	1831-1911 1920-1969
dep. variable	e_{MF1}	e_{AG1}	e_{MF1}	e_{AG1}	e_{MF1}	e_{AG1}	e_{MF1}	e_{AG1}
constant	-0.001 (-0.246)	-.009 (-2.38)	-0.005 (-0.975)	-0.23 (-1.51)	.002 (0.37)	-.008 (-1.85)	.0007 (.183)	-.0031 (-2.38)
q_{MF}	0.345 (2.167)		0.442 (2.81)		0.241 (1.26)		0.364 (2.611)	
q_{AG}		0.0471 (0.271)		0.977 (0.914)		-0.123 (-0.471)		0.209 (2.66)
R^2	0.2269	0.0046	0.341	0.547	0.109	0.017	.328	0.264
DW	1.7548	0.4765	1.916	2.56	1.44	0.43	1.54	1.52
F	4.696	0.737	7.77	18.15	1.593	0.228	5.86	4.32
ρ			-0.032	0.859			-0.304	-0.66

These results are not changed materially by the use of the other labour input series. This comparison of sectors is still relevant when we correct for the autocorrelation present.

However when we come to the exclusion of observations for 1811-1801, 1821-1811, and 1920-1925, our results change. We present in (e) (f) (g) (h) the results for the exclusion of all three observations, although the pattern of the results just excluding the first two is similar. Comparing (e) and (f) Verdoorn's Law appears to apply to neither sector. When we correct for autocorrelation using the Cochrane-Orcutt method (equations (g) and (h)) our results indicate Verdoorn's Law applying to both agriculture and manufacturing.

We thus have the conclusion that,

a) our tests depend, at this stage, heavily on the sample used, and

b) the correction for the apparent autocorrelation is important to our conclusions. We return to this below.

The third aspect of Kaldor's hypothesis is that the growth in productivity in agriculture is indirectly related to growth in productivity in manufacturing.

i.e. $$p_{AG} = p_{ag}(p_{MF}, q_{AG}) \qquad (7) \qquad \frac{dp_{ag}}{dp_{MF}} > 0$$

As $p \equiv q - e$

we may write, linearising (7),

$$q_{AG} - e_{AG} = \alpha + \beta (q_{MF} - e_{MF}) + \gamma q_{AG}$$

$\beta > 0, \gamma > 0,$

$$\therefore \quad e_{AG} = - \alpha - \beta q_{MF} + \beta e_{MF} + (1 - \gamma) q_{AG}$$

Running this across the whole sample we get

$$e_{AG1} = -.0072 + .0138\, q_{AG} - 0.244\, q_{MF} + 0.609\, e_{MF1}$$
$$(-1.226) \quad (.088) \quad (-1.382) \quad (2.54)$$

$$R^2 = 0.3204, \quad DW = 0.6119, \quad F = 2.199 \quad N = 18$$

and correcting for autocorrelation

$$e_{AG1} = -.0204 + .088\, q_{AG} - 0.111\, q_{MF} + 0.335\, e_{MF1}$$
$$(-1.21) \quad (0.894) \quad (-1.16) \quad (2.622)$$

$$R^2 = .7041, \quad DW = 2.073 \quad \rho = 0.888, \quad F = 10.32, \quad N = 17.$$

These coefficients are taking the right signs with the coefficient on q_{AG} implying $\gamma < 1$, but the coefficients on q_{MF} and e_{MF} should be the same and they are not. This equality could be imposed as a restriction, but as we implicitly impose it in estimation below we do not present any further results on this. The significance and sign of the coefficient on e_{MF} would appear to lend support to Kaldor's hypothesis. These results can be improved slightly by restricting the sample. However when we realise that through equation (6) e_{MF} is a function of q_{MF}, we should have as a reduced form for estimation an equation of the form

$$e_{AG1} = \alpha + \beta\, q_{AG} + \gamma\, q_{MF} + \mu$$

but fitting this equation leads to very low R^2 and no significant coefficients were estimated.

This leads us into our final estimation process. We have just seen some of the simultaneity in the model being introduced, and how it affects the results. We have also seen all the way through a high degree of autocorrelation in our results. It has been suggested by Kaldor that the rate of growth of output may be a function of the rate of growth of exports and therefore is not exogenous to the system. This may be part of the reason for the autocorrelation present. Set the model up as follows

$$p_{MF} = \alpha + \beta\, q_{MF} \qquad (8)$$

$$p_{MF} \equiv q_{MF} - e_{MF} \qquad (9)$$

$$p_{AG} \equiv q_{AG} - e_{AG} \qquad (10)$$

$$p_{AG} = \gamma + \delta\, q_{AG} + \theta p_{MF} \qquad (11)$$

$$q_{MF} = a + b\, X_{MF} \qquad (12)$$

Equation (1) is overidentified, so we need to use two stage least squares to estimate the coefficients of this system.[1] The results for equations 8, 11, 12 for two samples are presented below, with q_{AG} and X_{MF} considered as predetermined variables.

Sample 1800 - 1970:

$$p_{MF1} = \underset{(0.267)}{0.0065} + \underset{(0.546)}{0.4696}\; q_{MF}$$

$R^2 = 0.473$, $DW = 1.78$, $N = 18$, $F = 14.35$

$$p_{AG1} = \underset{(-0.195)}{-.0047} + \underset{(4.186)}{1.058}\, q_{AG} + \underset{(0.591)}{0.648}\; p_{MF1}$$

$R^2 = 0.655$, $DW = 1.066$, $N = 18$, $F = 14.25$

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(1) Rowthorn argues that (12) should contain a term in p_{MF}. The main problem with including this is that then equation (12) does not pass the rank condition for identification and thus cannot be estimated. However it is of interest that by taking up Kaldor's suggestion equation (8) appears as overidentified and thus the use of indirect least squares (applying ordinary least squares to reduced forms) as above is inappropriate.

$$q_{MF} = 0.0285 - 0.0224 \; X_{MF}$$
$$(4.20) \qquad (-0.113)$$
$$R^2 = 0.008 \quad DW = 1.9397 \quad N = 18 \quad F = 0.0127$$

Sample 1830-1911, 1925-1970:

$$p_{MF1} = -0.0103 + 1.1213 \; q_{MF}$$
$$(-0.681) \qquad (1.621)$$
$$R^2 = 0.2642, \quad DW = 1.4952, \quad N = 15, \quad F = 4.667$$

$$p_{AG1} = 0.00135 + 0.875 \; q_{AG} + 0.102 \; p_{MF}$$
$$(0.332) \qquad (9.236) \qquad (0.405)$$
$$R^2 = 0.8851 \quad DW = 1.7624 \quad N = 15 \quad F = 46.21$$

$$q_{MF} = 0.0140 + 0.319 \; X_{MF}$$
$$(1.587) \qquad (1.068)$$
$$R^2 = 0.0807, \quad DW = 1.4277 \quad N = 15 \quad F = 1.4182$$

Considering the results for both samples we can see that using the appropriate estimation method leads to the conclusion that:

a) Verdoorn's Law does not apply to manufacturing

b) Verdoorn's Law appears to apply to agriculture

c) Productivity growth in agriculture seems unrelated to productivity growth in manufacturing

d) The growth of manufacturing output appears to be uncorrelated with the growth of exports.

In essence, therefore, little remains of Kaldor's set of hypotheses.

Conclusions

We have tested Kaldor's hypotheses on data summarising British growth experience since 1800 and it has found to be wanting. The core of the analysis - that Verdoorn's Law should apply to manufacturing with significantly more force than to agriculture only holds when we use a sample with known outlying observations and do not correct for the auto-correlation present. Moreover once we explicitly introduce an estimation method to take account of the apparent simultaneity in the model even this result is no longer sustainable.

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Bibliography

F. Cripps and R. J. Tarling {1973} , Growth in Advanced Capitalist Economies, Cambridge University Press.

P. Deane & W. Cole {1969}, British Economic Growth 1688-1959, Cambridge University Press.

C. H. Feinstein {1972}, National Income, Expenditure and Output of the U.K. 1855-1965, Cambridge University Press.

N. Kaldor {1966}, Causes of the Slow Rate of Economic Growth of the United Kingdom, Cambridge University Press.

N. Kaldor {1975}, "Economic Growth and the Verdoorn Law", Economic Journal, December 1975 pp. 891-896.

J. Kmenta {1971}, Elements of Econometrics, Macmillan.

R. Rowthorn {1975a}, "What remains of Kaldor's Law?", Economic Journal, December 1975, pp. 897-901.

R. Rowthorn,{1975b}, "A reply to Lord Kaldor's Comment", Economic Journal,

B. R. Mitchell {1971}, The Fontana Economic History of Europe Statistical Appendix 1700-1914. Fontana.

B. R. Mitchell & P. Deane {1962}, Abstract of British Historical Statistics, Cambridge University Press.

Appendix

Data:

	q_{GDP}	q_{MF}	e_{MF1}	e_{MF2}	q_{AG}	e_{AG1}	e_{AG2}	X_{MF}
1801-1811	.019	.003	.019	.019	.067	.005	.005	-.0137
1811-1821	.025	.086	.034	.034	.003	.000	.000	.0223
1821-1831	.035	.054	.022	.022	.008	.000	.000	.0151
1831-1841	.023	.015	-.010	-.010	.017	.005	.005	.0287
1841-1851	.022	.031	.016	.016	.037	.010	.010	.0425
1851-1861	.010	.005	.011	.011	-.009	-.004	-.004	.0468
1861-1871	.023	.032	.008	.009	.002	-.009	-.012	.0612
1871-1881	.017	.018	.007	.005	-.004	-.005	-.008	.0239
1881-1891	.019	.021	.013	.001	.006	-.006	-.008	.0142
1891-1901	.021	.017	.014	.008	-.009	-.006	-.007	.0137
1901-1911	.014	.016	.012	.008	.004	.006	-.001	.0409
1920-1925	.017	.017	-.029	-.029	.018	-.019	-.019	.0326
1925-1929	.020	.029	.011	.011	.022	-.011	-.011	.0064
1929-1937	.019	.035	.010	.010	.002	-.018	-.018	-.0331
1950-1955	.028	.037	.012	.012	.013	-.018	-.014	.0292
1955-1960	.024	.028	.006	.006	.031	-.018	-.015	.0235
1960-1965	.033	.031	.003	.003	.030	-.034	-.034	.0362
1965-1969	.023	.028	-.009	-.009	.009	-.036	-.036	.0638

Sources: Growth rates derived from data as follows.

q_{GDP} : 1801-1861, Dean & Cole {1969}, Table 3.7, p.166, price deflator from Mitchell & Deane {1962}.

1861-1965 Feinstein {1972}, Table 6.
1965-1969 Cripps and Tarling {1973} p.56.

q_{MF}
1801-1861 as for q_{GDP}
1861-1965 Feinstein {1972} Table 51
1965-1969 as for q_{GDP}

e_{MF1}
1801-1920 Deane & Cole {1969} Table 31, p.143
1920-1968 Feinstein {1972} Table 59
1965-1969 as for q_{GDP}

e_{MF2}
1801-1861 Deane & Cole {1969} Table 31, p.143
1861-1965 Feinstein {1972} Tables 59 and 60
1965-1969 as for q_{GDP}

continued/...

q_{AG}	1801-1861	as for q_{GDP},
	1861-1965	Feinstein {1972} Table 8
	1965-1969	as for q_{GDP}
e_{AG1}	1801-1920	Deane & Cole {1969} Table 31, p.143
	1920-1965	Feinstein {1972} Table 59
	1965-1969	as for q_{GDP}
e_{AG2}	1801-1861	Deane & Cole {1969} Table 31, p.143
	1861-1965	Feinstein {1972} Tables 59 and 60
	1965-1969	as for q_{GDP}
X_{MF}	1801-1871	Mitchell {1971} pp. 62-65
	1871-1965	Feinstein {1972} Table 15
	1965-1969	Monthly digest of Statistics, Table 138,

price deflators for 1801-1861, implicit national income deflator of Deane & Cole {1969}, 1861-1965 Feinstein {1972} Table 61.

Definitions

q_{GDP} = rate of growth of gross domestic product

q_{MF} = " " " " manufacturing output

e_{MF1}, e_{MF2} = rate of growth of employment in manufacturing

e_{AG1}, e_{AG2} = " " " " " " agriculture

q_{AG} = rate of growth of agricultural output

X_{MF} = " " " " exports