LABOUR PRODUCTIVITY TRENDS FOR THE UK CONSTRUCTION SECTOR

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Labour productivity remains the most widely used measure of economic efficiency yet it has serious theoretical and practical difficulties particularly in the case of construction. This paper will address these problems and suggest approaches to overcome them. The model is illustrated by a case study of the UK construction sector over the period 1948 to 1995. The paper commences with a brief discussion of construction productivity. From this the theoretical problems are identified and analyzed. This is set in the context of the UK construction sector and the practical difficulties detailed. The first set of difficulties are concerned with the operation of subcontracting and specifically labour-only subcontracting. The incidence of self-employment in construction creates major problems for data collection. Labour productivity requires an estimate of the numbers employed in construction; identification of those notionally 'self-employed' gives some problems. The second set of practical difficulties relates to the issue of off-site prefabrication. This involves activities being shifted from the site to the factory. Given the way that official statistics are collected, these activities shift from construction to manufacturing. As more tasks are carried out off-site, construction productivity risks being trivialized out of existence. Solutions are proposed for these problems. The approach rests on considering the construction 'product' rather than the 'process'. Thus all labour involved with construction including off-site prefabrication and materials manufacture will be estimated. The Leontief 'input-output' approach is used to synthesize the direct inputs and outputs to and from construction to give total inputs and outputs. The model is applied to the UK construction sector over the post war period. The main results are analyzed.

Keywords: economic efficiency, productivity, product, process, subcontracting

INTRODUCTION

Productivity growth is a key indicator of economic improvement. By far the most easily understood and widely used measure is that of labour productivity.

Labour productivity is defined in terms of the output per head thus:

$$\psi = v / L \qquad \text{(Equation No 1)}$$

where: ψ = average labour productivity

v = value added

L = labour employed

This can be applied to an individual firm or an industry. For an industry, value added is defined as the value of outputs from the industry, less the value of inputs from other

Lowe, J (1997) Labour productivity trends for the UK construction sector. *In:* Stephenson, P (Ed.), *13th Annual ARCOM Conference*, 15-17 September 1997, King's College, Cambridge. Association of Researchers in Construction Management, Vol. 2, 674-83.

sectors. Labour employed includes all those working within the industrial sector in question, employees in employment and the self-employed. Those who are unemployed are not included.

In the case of an individual contractor, the value added would be taken as the gross output less the cost of material accounts, subcontractors' accounts and plant hire costs, etc. Labour employed includes working proprietors and those employed directly by the company but will exclude those employed by subcontractors.

Since this paper is aimed at a time-series analysis, it necessary to present the value added figures in constant price terms.

PROBLEMS WITH LABOUR PRODUCTIVITY

Lowe (1987) identified a number of theoretical and practical difficulties associated with labour productivity. A general objection to labour productivity is that it can be described as little more than a measure of the labour intensity of the process or industry concerned. Thus labour productivity has difficulty coping with factor substitution, such as increased investment in plant and equipment. Despite this, it can be shown that an improvement in labour productivity over time is likely to be indicative of increased productive efficiency (Lowe, 1987) and hence increased economic efficiency.

The more serious theoretical difficulties with labour productivity are specific to construction. These relate to the extensive use of subcontracting, in particular labour-only subcontracting and also off-site prefabrication in the construction sector. Labour employed by subcontractors or notionally self-employed as well as labour employed in off-site prefabrication facilities could distort labour productivity ratios.

There are also practical difficulties involved with the assessment of the numbers of the self-employed in a sector notable for tax evasion and in the computation of indices for constant price series of value added.

This paper will offer some solutions to these difficulties and illustrate this with a case study for the UK construction sector from 1948 to 1995.

SUBCONTRACTING

Certain of the problems can be dealt with if the limitations of labour productivity are recognised. Average labour productivity is not suitable for comparing one firm with another. Certain contractors subcontract many tasks while others subcontract everything. The more tasks that are subcontracted the less reliable the labour productivity ratios for the firm in question will be. In the case of contractors who sublet all tasks, the labour productivity ratio will approach infinity. Thus, the measure is only suited to analysis of the construction sector as a whole or an analysis of a major sub-sector such as civil engineering, general contracting, etc. The distortions brought about by the incidence of subcontracting will be eliminated with the aggregation of figures.

Labour productivity is not suitable for international comparisons between, for example, the UK construction sector and the US construction sector. This is liable to be unreliable because of fluctuations in currency exchange rates. This will affect the outcome. For this type of comparison, a pure financial ratio such as capital productivity -the percentage return on capital invested. Thus labour productivity will

be best confined to time series analysis of an industrial Sector and only if a satisfactory constant price series can be identified.

OFF SITE PREFABRICATION

Of more concern is the impact of such factors as off-site prefabrication and the use of hired plant and ready mixed concrete. In the case of subcontracting, the value of the work carried out and the numbers of employees will be classified within construction. However in the case of prefabrication, the work carried out will be classified under manufacturing rather than construction. Similarly in the case of plant hire, this will only be classified as construction if operatives are included within the hire rate. The distortion caused by these factors will not be corrected by the aggregation of individual data to produce industry wide figures.

This can be addressed by considering the construction project rather than the construction industry. Traditional labour productivity is confined to the on-site activities carried out by the contractor. The approach outlined here is intended to identify all the labour used in the construction process including that employed directly and indirectly. This will include materials supply as also transport, professional services etc. The output employed would be gross output rather than value added.

Direct inputs can be synthesized into total inputs by use of the Leontief (1965: 134-155) inverse matrix. The computations are outlined below.

COMPUTATIONAL FORMULAE

The computational framework for the input-output approach is presented below. This starts from the industry-by-industry flow matrix:

	Industry j=1	Industry j=2	Industry j=3	Industry j=4	Industry j=5	Industry j=6	Final demand	Total output
Industry i=1	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}	x_{16}	y_1	z_1
Industry i=2	x_{21}	x_{22}	x_{23}	x_{24}	x_{25}	x_{26}	y_2	z_2
Industry i=3	x_{31}	x_{32}	x_{33}	x_{34}	x_{35}	x_{36}	y_3	z_3
Industry i=4	x_{41}	x_{42}	x_{43}	x_{44}	x_{45}	x_{46}	y_4	z_4
Industry i=5	x_{51}	x_{52}	x_{53}	x_{54}	x_{55}	x_{56}	y_5	z_5
Industry i=6	x_{61}	x_{62}	x_{63}	x_{64}	x_{65}	x_{66}	y_6	z_6
Value added	v_1	v_2	v_3	v_4	v_1	v_1	Σy	
Total input	z_1	z_2	z_3	z_4	z_1	z_1		Σz

Table No 1: Industry-by-industry flow matrix

The gross output for industry i can be represented as the sum of intermediate outputs (x_{ij}) and final demand (y_i):

$$z_i = \sum_{j=1}^{N} x_{ij} + y_i \qquad \text{(Equation No 2)}$$

where: z_i = gross output from industry i

x_{ij} = intermediate outputs industry i to j

y_i = final demand for industry i

The gross input for industry j can be represented as the sum intermediate inputs (x_{ij}) and value added (v_i):

$$z_i = \sum_{i=1}^{N} x_{ij} + v_i \qquad \text{(Equation No 3)}$$

where: z_j = gross inputs to industry j

x_{ij} = intermediate inputs from industry j to i

v_j = value added for industry j

For all industries, the gross outputs (z_i) will be the same as the gross inputs (z_i). Similarly the sum of final demand will be equal the sum of value added. This corresponds to gross national product.

$$\sum_{j=1}^{N} y_i = \sum_{i=1}^{N} y_i \qquad \text{(Equation No 4)}$$

This paper employs the supply-side input-output approach, This differs from the original Leontief (demand-side) model in that intermediate outputs are normalized by row using the total output (row sum) as opposed to normalization of intermediate inputs by column for the original model The first step is to compute the direct allocation coefficients thus:

$$b_{ij} = x_{ij} / z_i \qquad \text{(Equation No 5)}$$

where: b_{ij} = direct allocation coefficients from i to j.

These coefficients can be amalgamated to form a matrix:

$B = Z^1 X$ (Equation No 6)

where Z^{-1} = inverse of diagonal matrix[1] of z_i (N x N)

B = allocation matrix (N x N)

X = intermediate flow matrix (N x N)

It follows that:

$z_i^T B + v = z_j$ (Equation No 7)

where z_i^T = transpose of gross output column vector

z_j = gross input row vector

v = value added row vector

Since $z_i^{-T} = z_j$ it follows that:

$z_j - z_j B = v$ (Equation No 8)

$z_j [I - B] = v$ (Equation No 9)

$v\,[I - B]^{-1} = z_j$ (Equation No 10)

where I = identity matrix[2]

[I – B] = inverse Leontief (supply-side) matrix

[1] A diagonal matrix bas the elements of a vector along its leading diagonal and zeros in other cells. In this case multiplication by the inverse diagonal matrix is equivalent to division of each element by Its row total.

[2] The identity matrix bas values of 1 on the leading diagonal and zeros elsewhere. Pre- or post-multiplication of any matrix by the identity matrix bas no effect.

The vector of direct profits can be synthesized in total profits as follows:

$$p[I-B]^{-1} = \pi \quad \text{(Equation No 11)}$$

where p = row vector of direct industrial profits

π = row vector of total industrial profits

The vector of direct profits can be synthesized in total profits as follows:

$q[I - B]^{-1} = \theta$ (Equation No 12)

where q = row vector of direct employment

θ = row vector of total industrial employment

DATA SOURCES FOR CASE STUDY OF THE UK CONSTRUCTION SECTOR 1948 TO 1995

The remaining problems outlined are concerned with the practical difficulties involved with obtaining data. These will be illustrated in the context of this case study.

Data on value added is published annually in the UK National Accounts in current prices subdivided by industry; the constant price series are only published in the form of index numbers. Since 1948 the following have been used as base dates to present constant price data: 1954, 1958, 1963, 1970, 1975, 1980, 1985 and 1990. The 1990 constant price series covers the years 1982-95, the 1985 series covers 1977-91, 1980 series 1961-86, 1975 series 1956-81, 1970 series 1951-76, 1963 series 1948-71. In addition the 1958 series covers 1948-64, and the 1954 series 1948-59.

The constant price series is obtained by 'chaining' together the various constant price series. The 1963 series is used for the years 1948-50. This is first adjusted to 1970 prices using 1954 as the link date. The 1963 series is multiplied by v 1954 in 1970 prices and divided by v 1954 in 1963 prices. This extended 1970 series from 1948-55 is now adjusted to 1975 prices using 1958 as the link year as before. The new 1975 price series covering 1948-60 is adjusted to 1980 prices using 1963 as the chain date. This produces a series in 1980 prices is available for 1948-76, this is updated to 1985 prices using 1980 as the link date. Finally the 1985 series from 1948-81 is adjusted to 1990 prices using 1985 as the link date.

Data on labour employed can be taken from the UK National Accounts, which gives figures for employees in employment broken down into industrial groups. Unfortunately the data for the self-employed is not subdivided into industries. It is not

adequate to spread the self-employed on a pro-rata basis across the industrial groups since the self-employed tend to concentrate in certain industrial groups notably agriculture and construction. By contrast the energy and water supply grouping has virtually no self-employment for much of period studied.

The labour force survey published in Employment Gazette provides an estimated breakdown of the self-employed by industry. This is generally published for alternate years when a survey has been carried out. Intermediate years and those not covered by the survey are obtained by interpolation.

Table	Articulation	Years	Type of table	Source	Published
1935	36 × 36	–	Non-official [3]	Barna (1952)	Journal
1948	8 × 8	1948-49	Summary	*National Income and Expenditure* (1952)	CSO
1948	47 × 51	–	Semi-official [4]	Stewart (1956).	Journal
1950	11 × 11	1950-52	Summary	*National Income and Expenditure* (1956)	CSO
1954	46 × 46	1953-58	Benchmark	*Studies in Official Statistics No 8*	CSO
1963	73 × 73	1959-65	Benchmark	*Studies in Official Statistics No 16*	CSO
1968	91 × 91	1966-68	Benchmark	*Studies in Official Statistics No 22*	CSO
1970	91 × 91	1969-70	Update [5]	*Business Monitor PA 1004*	BSO
1971	60 × 60	1971	Update	*Business Monitor PA 1004*	BSO
1972	60 × 60	1972	Update	*Business Monitor PA 1004*	BSO
1973	35 × 35	1973	Summary	*Economic Trends* June 1978	CSO
1974	103 × 103	1974-76	Benchmark	*Business Monitor PA 1004*	BSO
1979	100 × 100	1977-81	Benchmark	*Business Monitor PA 1004*	BSO
1984	102 × 102	1982-84	Benchmark	*Input-output Tables for the UK* 1984	CSO
1985	102 × 102	1985-87	Update	Diskette from CSO	CSO
1990	123 × 123	1988-95	Benchmark [6]	*Input-output Tables for the UK* 1990	CSO

Table No 2: Data sources

The input-output data used for synthesizing the value added figures to gross output and direct labour inputs to total labour are included in Table No 2 above. Full details of the process are given in Leontief (1965) and in the context of the construction sector in Lowe (1994). The tables used are aggregated to 6 broad industrial categories:

1) Agriculture, forestry and fishing; 2) Energy and water supply, 3) Manufacturing 4) Construction, 5)Transportation and distribution, 6) Services.

COMPUTATIONS

The derivation of the constant price series for construction value added is included in Table No 3. The figures are in millions of pounds.

The computations of the series for conventional labour productivity and for input-output 'total' labour productivity are given in Table No 4. The figures for employment are in thousands. The cash figures are in millions of pounds. The productivity ratios are in thousands of pounds worth of output per operative.

[3] This input-output table is included in the paper for purposes of comparison. Tibor Barna compiled it after the Second World War using data from the 1935 census.

[4] Semi-official input-output tables for 1948 of [47 x 51] were compiled at the University of Cambridge and published by Stewart (1958). They were not compatible in format with the other tables used in the analysis and the Summary tables were used

in preference. They were used to help to adjust the 1948 and 1950 Summary tables into line with the 1980 Standard Industrial Classification.

[5]Updates from the 1968 tables were prepared and published for 1970, 1971 & 1972 in the Business Monitor PA 1004 series, Business Statistics Office.

[6] Input-output balances have been published in *Economic Trends* since 1989 as part of the reconciliation process for the national accounts. Full symmetrical input-output tables are produced every four to five years.

Year	Current prices	Constant (1963) prices	Constant (1970) prices	Constant (1975) prices	Constant (1980) prices	Constant (1985) prices	Constant (1990) prices	Index	Value added 1990
1948	570	1,210						1963	15,190
1949	617	1,264						1963	15,887
1950	639	1,256						1963	16,772
1951	699	1,208	1,630					1970	15,180
1952	752	1,245	1,678					1970	15,635
1953	830	1,332	1,796					1970	16,733
1954	893	1,394	1,999					1970	18,617
1955	977	1,397	1,882					1970	17,536
1956	1,100	1,475	1,986	5,122				1975	18,562
1957	1,127	1,470	1,983	5,088				1975	18,441
1958	1,180	1,465	1,974	5,075				1975	18,393
1959	1,236	1,548	2,087	5,336				1975	19,339
1960	1,363	1,628	2,196	5,617				1975	20,358
1961	1,523	1,753	2,362	6,052	12,096			1980	21,941
1962	1,674	1,769	2,385	6,106	12,199			1980	22,127
1963	1,771	1,771	2,374	6,092	12,173			1980	22,081
1964	2,013	1,971	2,615	6,715	13,423			1980	24,347
1965	2,164	2,024	2,733	7,030	14,054			1980	25,492
1966	2,270	2,042	2,779	7,157	14,299			1980	25,936
1967	2,393	2,115	2,885	7,445	14,879			1980	26,988
1968	2,596	2,157	2,952	7,632	15,265			1980	27,689
1969	2,746	2,107	2,931	7,579	15,149			1980	27,478
1970	2,874	2,049	2,874	7,431	14,853			1980	26,941
1971	3,513	2,083	2,963	7,559	15,111			1980	27,408
1972	4,050		3,015	7,699	15,394			1980	27,922
1973	5,146		3,075	7,887	15,201			1980	27,572
1974	5,775		2,814	7,070	13,616			1980	24,698
1975	6,695		2,661	6,695	12,895			1980	23,389
1976	7,495		2,555	6,601	12,341			1980	22,384
1977	8,076			6,574	12,856	16,787		1985	22,690
1978	9,315			7,023	13,320	17,921		1985	24,224
1979	11,114			6,782	13,771	18,287		1985	24,717
1980	12,882			6,421	12,882	17,287		1985	23,366
1981	13,539			5,684	12,315	15,941		1985	21,546
1982	14,614				12,547	17,191	23,249	1990	23,249
1983	16,518				13,011	18,287	24,745	1990	24,745
1984	17,956				13,217	19,152	25,920	1990	25,920
1985	19,229				13,771	19,229	25,991	1990	25,991
1986	20,855				14,041	20,017	27,059	1990	27,059
1987	24,570					21,710	30,228	1990	30,228
1988	30,394					24,152	32,862	1990	32,862
1989	35,341					25,575	34,750	1990	34,750
1990	35,604					25,825	35,604	1990	35,604
1991	31,421					23,575	32,756	1990	32,756
1992	30,204						31,296	1990	31,296
1993	29,107						31,047	1990	31,047
1994	31,137						32,222	1990	32,222
1995	31,815						31,901	1990	31,901

Table No 3: Value added for construction (£M)

Year	Value added	Employees	Self-employed	Direct labour	Direct productivity	Gross output	Total labour	Total productivity
1948	15,190	1,334	116	1,450	10.48	22,399	2,448	9.15
1949	15,887	1,322	116	1,438	11.05	23,513	2,443	9.62
1950	16,772	1,326	109	1,434	11.70	27,085	2,650	10.22
1951	15,180	1,331	118	1,449	10.48	25,607	2,686	9.53
1952	15,635	1,325	110	1,435	10.90	26,256	2,659	9.87
1953	16,733	1,338	111	1,449	11.55	26,411	2,627	10.06
1954	18,617	1,359	132	1,491	12.49	28,791	2,693	10.69
1955	17,536	1,385	138	1,523	11.51	28,693	2,806	10.22
1956	18,562	1,431	147	1,578	11.76	30,378	2,876	10.56
1957	18,441	1,413	143	1,556	11.85	30,368	2,852	10.65
1958	18,393	1,374	154	1,528	12.04	30,054	2,805	10.71
1959	19,339	1,417	148	1,565	12.36	32,671	3,091	10.57
1960	20,358	1,458	149	1,607	12.67	34,518	3,172	10.88
1961	21,941	1,516	144	1,660	13.22	36,491	3,248	11.23
1962	22,127	1,552	145	1,697	13.04	37,038	3,291	11.25
1963	22,081	1,582	145	1,727	12.79	37,385	3,318	11.27
1964	24,347	1,659	143	1,802	13.51	40,538	3,420	11.85
1965	25,492	1,746	163	1,909	13.35	42,226	3,563	11.85
1966	25,936	1,725	166	1,891	13.72	43,257	3,651	11.85
1967	26,988	1,591	260	1,851	14.58	44,926	3,570	12.58
1968	27,689	1,554	275	1,829	15.14	45,748	3,532	12.95
1969	27,478	1,463	293	1,756	15.65	44,140	3,262	13.53
1970	26,941	1,339	300	1,639	16.44	44,236	3,122	14.17
1971	27,408	1,262	328	1,590	17.24	46,096	3,091	14.91
1972	27,922	1,300	377	1,677	16.65	44,796	3,015	14.86
1973	27,572	1,380	442	1,822	15.13	50,415	3,569	14.13
1974	24,698	1,329	423	1,752	14.10	47,340	3,544	13.36
1975	23,389	1,314	362	1,676	13.96	44,450	3,415	13.02
1976	22,384	1,309	341	1,650	13.57	42,004	3,356	12.52
1977	22,690	1,270	291	1,561	14.54	43,321	3,117	13.90
1978	24,224	1,199	365	1,564	15.49	46,365	3,173	14.61
1979	24,717	1,239	343	1,582	15.62	46,413	3,205	14.48
1980	23,366	1,243	375	1,618	14.44	46,226	3,241	14.26
1981	21,546	1,130	388	1,518	14.19	44,283	3,043	14.55
1982	23,249	1,067	400	1,467	15.85	54,979	3,236	16.99
1983	24,745	1,044	417	1,461	16.93	55,497	3,187	17.41
1984	25,920	1,037	472	1,509	17.17	62,019	3,261	19.02
1985	25,991	1,055	478	1,533	16.95	57,115	3,132	18.23
1986	27,059	1,027	495	1,522	17.77	58,526	3,117	18.78
1987	30,228	1,049	550	1,599	18.90	62,056	3,233	19.20
1988	32,862	1,091	601	1,692	19.42	74,563	3,901	19.11
1989	34,750	1,129	730	1,859	18.69	78,618	4,147	18.96
1990	35,604	1,143	723	1,866	19.08	80,854	4,165	19.41
1991	32,756	1,053	657	1,710	19.16	77,508	3,927	19.74
1992	31,296	951	597	1,548	20.22	77,018	3,615	21.31
1993	31,047	865	571	1,436	21.62	74,119	3,506	21.14
1994	32,222	871	599	1,470	21.92	75,638	3,558	21.26
1995	31,901	838	600	1,438	22.18	75,403	3,540	21.30

Table No 4: Construction productivity

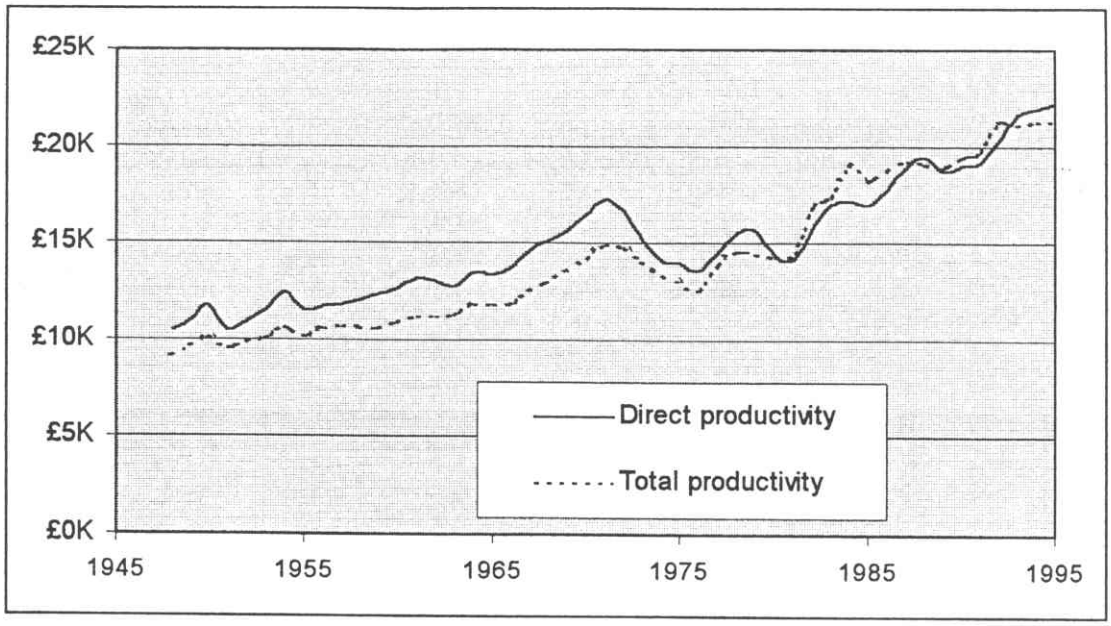

Figure No 1: Direct and total productivity 1948-95

RESULTS

The results of the computation of the direct and total labour productivity are presented in Figure No 1. It demonstrates that there is a fair correspondence between the two series. Direct productivity appears to be ahead of total productivity until the early 1980s and to lag beyond that point. Growth is steady rather than spectacular with falls corresponding to major and minor recessions affecting construction in the UK.

The case study demonstrates that the model outlined can be implemented.

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