THE RELATIONSHIP BETWEEN THE AGGREGATE ANNUAL WAGE BILLS OF HEATING AND VENTILATION CONTRACTORS, HEATING AND VENTILATION INDUSTRY OUTPUT AND CONSTRUCTION INDUSTRY OUTPUT

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The construction industry is composed of a large number of separate sub-industries. Although the annual performance of the separate industries can be at variance with construction output, the labour market within a specialism may be more influenced by the performance of construction as a whole than the demand for that particular specialism. Taking the heating and ventilation industry as an example of one such specialism and using regression analysis, the annual wage returns of the membership of the Heating and Ventilation Contractors Association from 1957 to 1996 are compared to annual heating and ventilation and construction industry output. The total wages paid by heating and ventilation contractors is determined more by construction industry output than the annual output of the heating and ventilation industry itself.

Keywords: construction industry, heating and ventilation, subcontractors, wages.

INTRODUCTION

Much research into the construction industry has focused its attention, though not exclusively, on main contractors, as has most of the literature, including text books like Raftery (1991), Ruddock (1992) and Gruneberg (1997) or even the more advanced works like Ball (1988), Hillebrandt (1984) and Hillebrandt and Cannon (1989 and 1990) and papers such as Kale and Arditi (2001). Most commentaries on the construction industry are also given from the point of view of main contractors, usually assuming them to be large firms. Clearly Latham (1994) and Egan (1998) both refer to subcontracting but the former is mainly concerned with the problems of main contracting and large projects and the latter is focused on clients' needs and demonstration projects.

A gap, though by no means a vacuum, has opened up in the literature concerning the central role of specialist firms in the construction industry. Relatively little work has been carried out on subcontractors apart from Hillebrandt (1971), Clarke (1981), Ive (1983), Gray and Flanagan (1989) and more recently Hughes, Gray and Murdoch (1997) and Constantino, Pietroforte and Hamill (2001).

Ive and Gruneberg (2000:183) see the proliferation of subcontracting in terms of horizontal fragmentation as firms seek to take advantage of economies of

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specialisation. Gray and Flanagan (1989) describe building work on site as a process of assembling prefabricated components. It is a mixture of many traditional trades and updated techniques, materials and plant. As the number of manufactured components increases, the firms supplying these are often used to assemble them on site employing their own dedicated and trained workforce. Other firms specialise in fixing particular types of components supplied to them by particular manufacturers. This is the case, for example, with heating and ventilation contractors.

This paper primarily examines the relationship between construction output and heating and ventilation output and the annual aggregate wages of Heating and Ventilation Contractors Association (HVCA) firms. Following a discussion of the methodology adopted, the relationship between annual changes in construction output and heating and ventilation output is examined. This is followed by simplified models of the determinants of the aggregate wages of members of the HVCA.

METHODOLOGY

The annual wage returns are the aggregated annual wages certified by each firm's accountants. The annual wage return data has been entered according to the year in which it appears in the HVCA's membership ledger. These returns came into the Association continuously during the year and related to the previous year's accounts of members. A time lag is therefore introduced into the data of approximately one year.

On being elected to the Association, each firm is given a folio number, in general issued in sequence. These folio numbers range from 2 to 4200, representing both the current membership, and firms, which have been past members of the Association since its formation. Unfortunately the computerised wage returns and membership fee data for the years 1980 to 1986 are missing.

For the data prior to 1980, of the 2500 folio numbers representing members of the HVCA, around 500 are missing. The removal of these firms from the ledgers biases the early data in favour of those firms, which survived beyond 1961. Moreover, many of the surviving folios of firms prior to 1980 and since 1987 contain missing data or data that was assessed by the HVCA for subscription fee purposes. These assessments have been excluded from the study. Since 1970 most firms have been assessed in at least one year of their membership. Only data declared by members themselves has been included in this study.

The HVCA data used is not a sample of firms but is in fact a survey of the population of members of the HVCA based on the Association's membership list records for the period 1958 to 1997 as at July 1998, providing data for the years 1957 to 1996. No sampling of the data was carried out. However the use of the population of firms means that the annual aggregate wage bills of the HVCA membership combines an increasing number of firms over time reflecting the growth of the HVCA as well as the growth of individual members. Thus the aggregate data partly reflects the relative growth of the HVCA as a percentage of the total heating and ventilation contractors' market.

In 1957 the Private Contractors Census first began to publish heating and ventilation industry data separate from other specialist contractors in construction (Fleming, 1980 and 1986). This series is included in *Housing and Construction Statistics*, and the *Annual Construction Statistics* on the DETR website, (currently the DTI website) making it possible to carry out a long run comparison between official heating and ventilation industry data and the wage returns of the HVCA. For this reason, it was decided that the main body of the statistical analysis should cover the period starting in 1957.

Fleming (1986:119) points out that one of the most important problems of interpretation of time series research results concerns the method used to convert current prices to constant prices. This especially concerns the choice of index to use for deflating the reported HVCA wage return data. The All New Construction Cost Index, (ANCI), which replaced the Cost of New Construction Index (CNC) in 1978, can be found in *Housing and Construction Statistics*, which is the main source of data on the construction industry (Cannon, 1994). The ANCI as its title suggests is only concerned with new build construction. Beside the ANCI, other new build price indices are also used. According to the notes and definitions given in *Housing and Construction Statistics* 1987-1997, (1998: 196) output price indices used to deflate contractors' output of new work from current to constant prices in different categories of work include public housing, private housing, public non-housing, private industrial and private commercial. Repair and maintenance work is dealt with separately based on the costs of materials and labour.

Because of the above limitations, the ANCI has not been used because it is only concerned with new work. Instead, the deflator used in this paper is based on the annual implied deflator calculated using the current price output series and the output series at 1995 prices, which is based on a composite index including a combination of skilled and unskilled labour, and materials cost indices, used by the DETR. This deflator therefore includes both new build and repair and maintenance work on existing stock. This deflator is not published as a separate index but can be calculated from the published series of total construction output at current prices and total construction output at constant 1995 prices in Table 1.6 in *Housing and Construction Statistics*. As this implied deflator takes both new build *and* repair and maintenance into account, it is referred to in this research as the implied Gross Construction Product Index (GCPI), although this is not its official title. The GCPI covers the period from 1955 to 1996 and was found by dividing all construction output at current prices by all construction output at constant 1995 prices. The implied deflator formed by the inverse of the GCPI was then used to deflate the HVCA annual wage returns and annual heating and ventilation output at current prices.

Long run growth rates may be calculated in a number of ways depending on the nature of the data available. Calculating the geometric mean of annual growth rates relies on data for consecutive years. Where a number of annual changes were found in the wage return data, the geometric mean is the average of these annual changes and provides an average rate of growth. The average growth rate is given as:

$$G = \sqrt[n]{\Pi[1+ (x_t - x_{t-1})/x_{t-1}]} - 1 \qquad (1)$$

where G = the annual average growth rate

x_t = wage return in year t

n = number of years

Π = product of all annual growth rates, t = 1 (base year) to t = n.

Because the available wage return data excludes the years 1980 to 1986 for all firms and missing data occurs in almost all folios in one year or another, regression analysis was also used to find growth rates. This method involves finding the natural logs of the annual real wage returns of individual firms at constant 1995 prices. The linear regression of the time series of the log-transformed annual wage returns for each firm was calculated and the linear trend was used as the measure of individual firms' growth rates. The growth rate of the HVCA members as a whole is calculated using the regression co-efficient of the time series of the log-transformed annual aggregate wage returns. In algebraic terms, the model of growth is given as:

$$WR = ae^{bt} \tag{2}$$

where WR = annual wage returns
a = constant
b = growth rate, and
t = time

Transforming into natural logs, (ln), Equation 2 becomes:

$$lnWR = lna + btlne \tag{3}$$

But ln*e* = 1 and Equation 2 therefore simplifies to:

$$lnWR = lna + bt \tag{4}$$

The coefficient, *b*, is then used as the measure of annual growth.

LONG RUN TRENDS AND GROWTH RATES

Comparing the growth rates of the heating and ventilation industry and construction industry output in Table 1, the trend growth rate of the construction industry between 1957 and 1996, measured as the geometric mean annual growth rate, was only 1.28 per cent per annum while heating and ventilation output grew on average by 2.27 per cent. Overall the heating and ventilation industry therefore grew as a proportion of construction output as its rate of increase was above the average for the industry in general.

Table 1 Growth rates and correlation coefficients of the first differences of heating and ventilation and construction industry output 1957-1996

	Correlation coefficients (R)			
	Concurrent (1957 - 1996)	**HVI lagged 1 year (1958 - 1996)**	**HVI Growth rate**	**CI Growth rate**
1957 - 1996	0.27	0.22	2.27%	1.28%
1957 - 1973	-0.20	0.46	6.26%	3.99%
1973 - 1996	0.38	0.25	1.42%	1.53%

Notes: all data deflated using the GCPI
HVI = heating and ventilation industry
CI = construction industry
Sources: Construction output data supplied directly by the DETR and Private Contractors= Census.

However, the increase in the share of construction output largely took place in the period before 1973 when heating and ventilation output grew by an average of 6.26 per cent per annum compared to 3.99 per cent for the construction industry as a whole. After 1973 neither construction nor heating and ventilation grew rapidly. The heating and ventilation industry only managed to maintain its relative share of construction utput, as its growth rate was marginally less than construction at 1.42 per cent per annum compared to 1.53 per cent for construction as a whole.

These results run counter to expectations as mechanical and electrical services are generally seen as continuing to increase their share of construction work at least until 1996. Table 1 confirms that the relationship between heating and ventilation industry output and construction output altered in the two periods. The heating and ventilation industry expanded its share of construction output up to 1973. Since 1973 its share of construction output did not increase.

One possible explanation for the increasing share in construction output of heating and ventilation up to 1973 is that by the mid 1970s the retro-fitting and upgrading of central heating and air conditioning systems in existing buildings had already taken place by and large. Moreover, the annual proportion of new build which incorporated heating and ventilation systems had risen since the Second World War but by the mid 1970s had perhaps reached a stable >saturation= level. Thus, any increase in the share of services in recent years may have been due to the increase in other electrical and mechanical elements rather than heating and ventilation.

ANNUAL CHANGES IN OUTPUT

Table 1 also shows the correlation coefficients of the concurrent first differences (annual changes) of construction and heating and ventilation industry output. In the whole period from 1957 to 1996 the correlation coefficient was only 0.27. Between 1957 and 1973 it was even lower at -0.20. From 1974 to 1997 the correlation coefficient of construction and heating and ventilation output was still only 0.38. In the period under discussion there was clearly little relationship between changes in construction output and the heating and ventilation industry.

If the annual variation of output of the heating and ventilation industry follows a pattern significantly different from the construction sector, as a whole, then heating and ventilation output may be seen as independent of the level of construction industry output. To test this proposition for the period between the late 1950s and late 1990s, a number of regressions were run. The first set of regressions are concerned with concurrent data. To test whether or not the level of demand for heating and ventilation contractors reflects the fact that heating and ventilation work tends to take place towards the end of the building production process, a second set of regressions based on heating and ventilation output lagged one year behind construction output is considered in the following section.

The relationship between construction output and demand for heating and ventilation services can be given as a simple probabilistic model of heating and ventilation industry output, such that:

$$HVI = f(CI, e) \quad (5)$$

where HVI = output of the heating and ventilation industry
CI = output of the construction industry
and e = error of prediction.

It would therefore follow that:

$$\Delta HVI_t = f(\Delta CI_t, e) \quad (6)$$

where ΔHVI_t = change in heating and ventilation industry output in year t
ΔCI_t = change in construction industry output in year t

This model becomes:

$$HVI_t = \beta_1 + \beta_2 CI_t \tag{7}$$

and

$$\Delta HVI_t = \beta_3 + \beta_4 \Delta CI_t. \tag{8}$$

Taking Equation 7, a regression model based on GCPI deflated log transformed data for the period 1957 to 1996 produces the following regression results:

$$\ln HVI_t = -7.22 + 1.38 \ln CI_t \tag{9}$$

Std Err of regr, 0.16; R^2, 0.75; df, 38; No. of observations, 40; Std Err of coef., 0.13.

With a relatively high R^2 of 0.75, three quarters of the variation in heating and ventilation can be accounted for by changes in the construction industry. This implies that between 1957 and 1996 there was a long run relationship between heating and ventilation output and construction output.

Running a regression on Equation 8, which relates annual changes in heating and ventilation output to annual changes in construction output for the period from 1959 to 1997, produces Equation 10:

$$\Delta HVI_t = 18.37 + 0.02\, \Delta CI_t \tag{10}$$

Std Err of regr, 189.71; R^2, 0.07; df, 37; No. of observations, 39; Std Err of coef., 0.01.

The coefficient of determination, R^2, of Equation 10 is only 0.07. Thus, annual changes in heating and ventilation output cannot be satisfactorily accounted for by changes in construction output in the same year.

LAGGED ANNUAL CHANGES IN OUTPUT

When a one year time lag is introduced the correlation between annual changes in heating and ventilation and construction output between 1958 and 1973 increases to 0.46 but falls to 0.25 for the period between 1973 and 1996. Although the statistical relationship of annual changes in the two series is weak, there is a marked difference between the two periods both when the time series are concurrent and when a time lag is introduced.

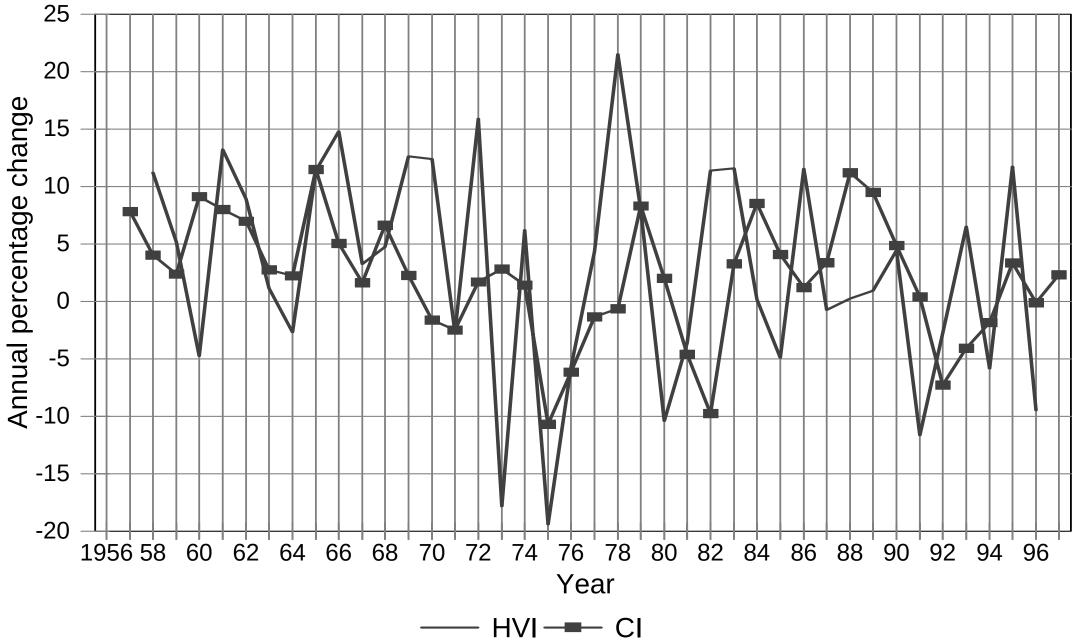
As stated above the first year of the time series of annual data of heating and ventilation output and construction output used here was 1957. However, in order to take both annual changes and a time lag of 1 year into account, the analysis of the lagged data begins in 1959. This allows a regression based on concurrent annual changes to be compared to the results of a regression based on the annual change in construction output in year $t-1$ and the change in heating and ventilation output in year t. When lagged behind construction by one year the model of annual changes in heating and ventilation and construction output from 1959 to 1997 becomes:

$$\Delta HVI_t = 21.52 + 0.02\, \Delta CI_{t-1} \tag{11}$$

Std Err of regr, 191.92; R^2, 0.05; df, 37; No. of observations, 39; Std Err of coef., 0.01.

The value of R^2 derived from Equation 11 is only 0.05, indicating little relationship between heating and ventilation output and the previous year=s construction industry workload.

Figure 1 Annual changes in heating and ventilation output (ΔHVI_t) and construction output (ΔCI_{t-1}) leading by one year 1957-1997



Source: HCS, DETR
Notes: data deflated using GCPI
ΔHVI_t = annual percentage change in heating and ventilation output in year t
ΔCI_{t-1} = annual percentage change in construction output in year t-1
Hence, in 1969 HVI = HVI in 1969 and CI = CI in 1968; construction series has been shifted one year to the right.

Figure 1 shows the annual percentage change of heating and ventilation output in any year and the percentage change in construction output of the previous year. In the years up to 1972 the output of the heating and ventilation industry appears to follow the output of the construction industry. This implies a time lag of two years in changes in heating and ventilation output behind changes in construction output. However, from 1972 there is no such pattern. This points to the fact that the time lag between construction output and heating and ventilation output is not constant over the whole period and the relationship between construction industry output and heating and ventilation output changed after 1972. The relationship between annual construction industry output and heating and ventilation output was not found to be significant according to the results of the correlation coefficients given above and the regressions using either concurrent or lagged data. This does not mean to say that no relationship exists between the level of construction work and output in the heating and ventilation industry. The results given here were based on annual data, whereas quarterly data might be expected to show much closer interdependence.

THE INFLUENCE OF CONSTRUCTION INDUSTRY OUTPUT ON AGGREGATE WAGES IN A SPECIALIST SUBSECTOR

Having compared the annual changes in the output of the heating and ventilation industry and construction industry, a model may now be developed to determine incomes in the heating and ventilation industry. The model of aggregate wages adopted here assumes that,

$$W_t = 3w_{it} \qquad (12)$$

where W_t = aggregate wages of all firms in period t, and
w_{it} = total wages paid by the ith firm in period t.

At an individual firm level,

$$w_{it} = r_{it} \, . \, l_{it} \qquad (13)$$

where r_{it} = average wage rate paid by the ith firm in period t, and
l_{it} = number employed by the ith firm in period t.

In turn,

$$l_{it} = d_{it}/x_{it} + e \qquad (14)$$

where d_{it} = demand for the services of the ith firm in year t, (measured as the value of output)
x_{it} = labour productivity of the ith firm in period t, and
e = the random disturbance term

Substituting (13) and (14) into Equation (12)

$$W_t = 3r_{it}\,(d_{it} / x_{it} + e) \qquad (15)$$

In this study WR_t is used as a proxy for W_t. Assuming demand for heating and ventilation contractors is related to the level of construction industry output, the determinants of aggregate wage returns may be given as the following function:

$$WR_t = f\,(CI_t, e) \qquad (16)$$

where WR_t = aggregate wage returns in year t
and CI_t = construction industry output in year t

If construction industry output is assumed to be the source of heating and ventilation demand, Equation 16 becomes:

$$WR_t = \alpha + \beta_1 CI_t \qquad (17)$$

where α = constant.

Then from the data,

$$\ln WR_t = -6.62 + 1.13 \ln CI_t \qquad (18)$$

Std Err of regr, 0.08; R^2, 0.90; df, 31; No. of observations, 33.

The relatively high value for R^2 suggests that long run changes in wage returns are related to construction industry output. A further simplification of the model can be derived if wage returns are viewed as a function only of heating and ventilation output. Using GCPI deflated data and running a regression on wage returns and heating and ventilation industry output produces the following equation:

$$WR_t = \alpha + \beta_1 HVI_t \qquad (19)$$

where HVI_t = heating and ventilation output in year t.

$$WR_t = 0.41 + 0.66HVI_t \quad (20)$$

Std Err of regr, 0.13; R^2, 0.75; df, 31; No. of observations, 33.

The relatively low value of R^2 for Equation 20 compared to the value given for R^2 in Equation 18 indicates that the aggregate wage bills of heating and ventilation contractors is more related to changes in construction in general than to the heating and ventilation industry.

CONCLUSIONS

In summary, wage returns appear to be more responsive to construction output than heating and ventilation output. This implies that the labour market for heating and ventilation engineers is not separate from the rest of the construction industry and wages and conditions are determined at least partly by the state of the construction market as a whole and not just by conditions in the heating and ventilation industry itself. There is not a separate labour market for heating and ventilation. It is part of the construction industry labour market and firms in heating and ventilation must compete for labour in that market. It is this competition in the construction industry labour market that is reflected in the significantly higher R^2 coefficient of the construction industry output compared to the coefficient of heating and ventilation industry output in Equations 18 and 20.

Thus the main points to emerge from this statistical analysis are that:

- The long run growth rate of the heating and ventilation industry exceeded the long run growth rate of construction from 1957 to 1997.
- Apart from the mid 1970s to the mid 1980s, changes in the construction industry series in any given year are a poor guide to changes in the heating and ventilation industry.
- While there is evidence of a long run relationship between the heating and ventilation industry and construction the annual variation in heating and ventilation output between 1957 and 1997 does not appear to be determined by short run (i.e. annual) changes in construction, though quarterly data may reveal very short run linkages.
- Wage returns were more sensitive to changes in construction output than changes in heating and ventilation output in the period between 1957 and 1996.
- Introducing time lags of one year into the regressions of wage returns, heating and ventilation output and construction output does not help to account for the determinants of heating and ventilation output.

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