White-collar Labour, Firm Scale and Lumpy Adjustment

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Abstract

It is found that employment share of white-collar workers is positively correlated with firm size across cross-section, but negatively over time. This paper proposes that this is due to the partial fixity of white-collar labour; fixed input is biased toward white-collar workers. Therefore, those firms with larger fixed input are both larger in size and higher in share of white-collar workers, which causes a positive cross-sectional correlation. However, short-run output expansion increases only variable labour, and therefore decreases the employment share of white-collar workers.

1 Introduction

In this paper, the share of white-collar workers is found to be positively correlated with firm size. However, it is also found that the change in the share of white-collar workers is negatively correlated with the change in firm scale. So, the main aim of this paper is to investigate why the positive cross-sectional relationship between white-collar employment share and firm size is reversed in longitudinal dimension.

There has been a continuous rise in the share of white-collar workers in manufacturing industries. This has usually been attributed to the innovation in general technology which affect entire economy. For example, the PC revolution, which had widespread effects on the economy is considered to be the key factor driving skill biased technological change. However, shifts in skill demand do not happen evenly across firms. Firms with a rising share of white-collar workers coexist with firms with a decreasing share of white-collar workers even when the aggregate share of white-collar workers is rising.

At firm level, a large amount of short-run variation in the white-collar employment share can not be explained by aggregate technological change, given that it is unrealistic to expect technology to deteriorate for such a large portion of firms, accounting for around 40 percent of total firms. There are factors, seemingly not related to technology, which generate variation in white-collar employment share at firm level. Firm size is proposed to be one of those.

The level of production and employment fluctuates at individual firm level more than at the aggregate level. I find that the labour demand for white-collar and blue-collar is not homothetic, so the change in firm size affects the composition of employment as well as the scale of employment. There has been literature on the effect of firm size on a wide range of economic variables including firms' survival rate (Baldwin and Rafiquzzaman, 1995; Disney, Haskel and Heden, 2003), productivity (Leung, Danny, Meh, Cesaire and Terajima, Yaz, 2008), earning or job creation(Hijzen, Upward and Wright, 2010), but it is rare to focus on its effect on relative demand for skilled (white-collar) workers.

It is likely that a significant part of white-collar labour is a fixed input. According to Nam (2014), firms need to hire certain numbers of white-collar workers such as engineers, designers and managers to launch a new product. However, different product is supposed to have a different required level of fixed white-collar employment, unlike Nam (2014).

The empirical finding that the adjustment of white-collar employment is lumpy is consistent with white-collar labour being partially fixed input. The employment of white-collar workers changes less frequently than that of blue-collar workers. However, when it changes, it changes more than the blue-collar workers. This might be explained by the partial fixity of white-collar labour input. For example, the firm's employment of fixed labour is not supposed to change unless the firm changes its product variety to another one with a different minimum required level of fixed labour input. However, once the firm decides to change the product variety, the effect on white-collar labour is discontinuous.

If a firm produces a variety which requires a higher level of fixed white-collar labour input, such as a more sophisticated variety of smart phone, the firm is more likely to be large in size and has a higher employment share of white-collar workers. Therefore, the firm size is positively correlated with white-collar employment share as both of them are positively correlated with the size of fixed white-collar labour input, which is unobservable.

However, short-run expansion of output due to demand shock usually does not involve such upgrading toward more sophisticated product. In such a case, only the variable part of labour input increases with firm size, and the increase in white-collar employment is limited. This leads to a decrease in the share of white-collar workers.

The remainder of the paper is as follows: Section 2 shows the analytical frame work. Section 3 explains the data and implement empirical estimations. Section 4 concludes.

2 Method

2.1 Production function

The production follows CES function as below:

$$P_i \cdot Y_{i,t} = A_i \cdot P_i \cdot K_i^{\alpha} \cdot \left[\beta \cdot \left(a^W \cdot L_{v,i}^W\right)^{\rho} + (1-\beta) \cdot \left(a^B \cdot L_i^B\right)^{\rho}\right]^{\frac{1-\alpha}{\rho}} \tag{1}$$

Here, P_i is the price of good produced by firm i and Y_i is the production quantity of firm i. The real output is not observable at firm level as there is no price indices constructed at individual firm level. Although aggregated price indices is applied, the heterogeneous prices between firms are not fully accounted for. Therefore, what we can observe is only nominal output, which is $P_i \cdot Y_i$. That is why the LHS of the equation (1) is $P_i \cdot Y_i$, instead of Y_i. In this analysis, the $P_i \cdot Y_i$ is the value-added output of each firm deflated by the aggregate GDP deflator.

A_i is skill-neutral technology level. a_W is high-skilled or white-collar labour augmenting technology, and a_B is blue-collar labour augmenting technology. K_i is capital stock. $L^H_{v,i}$ is the variable part of high-skilled worker's employment, which is equivalent to white-collar workers or non-production workers. L^B_i is low-skilled or blue-collar workers' employment.

2.2 Fixed part of white-collar labour

According to Nam(2014), firms need to hire certain number of white-collar workers as fixed input to produce a new variety of goods. Fair (2008) also mentioned that the demand for non-production worker is fixed in the short run. Each variety have different requirement level of fixed labour input. For example, developing a new car requires more fixed labour than developing a new T-shirts.

However, fixed cost is not entirely fixed. Sutton (1991) proposed that firms endogenously select sunk cost such as advertisement cost. In this paper, firms are supposed to be able to change the level of fixed white-collar labour by changing to another variety with different requirement level of fixed white-collar labour. Firms will change to another variety which requires higher level of fixed labour only if they can exploit excessive profit after paying for such fixed cost.

It is assumed that the employment of fixed part of white-collar labour is determined by the characteristic of the variety, and does not change until the firm changes the variety.

$$L^W_i = L^W_{v,i} + L^W_{f,i}$$

Total white-collar labour input for firm i is the sum of white-collar fixed labour input,$L^W_{f,i}$, and variable labour input, $L^W_{v,i}$. Only the variable part of white-collar labour enter into the CES production function in the equation (1). As the fixed part of white-collar labour input is considered as sunk-cost, it does not affect the optimization decision based on the CES production function.

$$\frac{L^{W_v}}{L^B} = \left(\frac{a^W}{a^B}\right)^{\frac{\rho}{1-\rho}} \cdot \left(\frac{w^B}{w^W} \cdot \frac{\beta}{1-\beta}\right)^{\frac{1}{1-\rho}} \tag{2}$$

The relative employment ratio of variable white-collar labour and blue-collar labour is shown in equation (2). It is derived from the optimization of the CES production function in (1). As the CES product function is homothetic, it is not directly affected by output quantity.

$$\frac{L^H}{L^B} = \frac{L^{H_v}}{L^B} + \frac{L^{H_f}}{L^B} \tag{3}$$

The observed employment ratio of white-collar workers and blue-collar workers is the sum of the employment ratio of variable white-collar labour to blue-collar workers, which is the first term of the equation (3) and equivalent to the LHS of equation (2), and the ratio of fixed white-collar labour to blue-collar workers, which is the second term of the equation (3). Therefore, the observed employment share of white-collar workers can rise without any increase in the ratio of variable white-collar labour to the blue-collar labour if the share of fixed white-collar labour increases. If the ratio of fixed white-collar labour to blue-collar labour is affected by firm scale, then firm scale can affect the employment share of white-collar workers although the production function is homothetic.

2.3 firm size and white-collar share

$$\begin{array}{ll} & \nearrow markup \uparrow \Rightarrow \frac{L^W_f}{L^B} \uparrow \Rightarrow \frac{L^W}{L^B} \uparrow \\ L^W_f \uparrow & \\ & \searrow firmsize \uparrow \end{array}$$

Different goods have different requirement level of fixed input. If a group of varieties requires more white-collar workers as fixed input, less firms will be able to produce those varieties. Then, less firm will enter into the market, and there will be less competition. It will leads to higher mark-up.

If a group of varieties require less fixed input, more firms will enter, and it will crowd variety space. If more entrance of firms crowd variety space, it leads to higher elasticities of substitution and lower mark-up as suggested in many papers (Manez and Waterson, 2001, Krugman, 1997, Lancaster, 1980, Hummels and Lugovskyy, 2005). This paper does not assume constant elasticity of substitution as Dixit-Stiglitz, but assume the elasticity of substitution increases as product variety space is crowded out as more firms enter. However, if a group of varieties require higher level of fixed input, only firms which have financial ability to afford large fixed cost expenditure can enter into the market. Cabral and Mata (2003) argued that the limit to financial access is the main obstacles of the firm growth, and many firms, especiall young firms, have less than desirable size due to financial constraint. Therefore, higher requirment level of fixed white-collar labour input for a group of varieties reduce the number of firms, decreasing the elasticity of substiution between them, and increases the mark-up.

Then, higher mark-up leads to higher share of white-collar workers. As in Dixit-Stiglitz model, the share of fixed factor to the variable factor is positively correlated with the markup. The existence of fixed cost result increasing return to scale even under constant marginal cost. Under increasing return to scale, those firms with higher markup reaches break-even production quantity earlier, and the equilibrium production quantity which corresponds to zero-profit equilibrium is lower. Therefore, the lower output quantity leads to lower employment of variable factor, which is biased toward blue-collar workers, relative to the fixed factor, which is biased toward white-collar workers.

If the requirement level of white-collar labour is high, only large firms can enter into the market. Therefore, there is positive correlation between the employment of fixed white-collar labour and the firm size.

As higher level of fixed white-collar labour results both the increase in the share of white-collar workers and the firm size, there is positive correlation between the share of white-collar workers and the firm size although there is no direct causality between the size of firm and the share of white-collar workers.

2.4 the growth of firm size and white-collar share

The employment ratio of white-collar workers to blue-collar workers is the sum of the ratio of fixed part, $\frac{L^{H_f}}{L^B}$, and the ratio of variable part of white-collar labour, $\frac{L^{H_v}}{L^B}$, as in the equation (3). The size of fixed labour input does not change with the firm output unless the firm changes its product variety. The increase in production quantity due to demand shock is not supposed to increase the fixed white-collar labour employment.

Any increase in firm size which is not caused by the change in fixed white-collar labour input does not increase the employment of fixed part of white-collar labour, but increase the employment of blue-collar workers proportionally. Therefore the ratio of fixed white-collar labour to blue-collar labour, $\frac{L^{H_f}}{L^B}$, declines as a result.

Therefore, the ratio of white-collar labour to blue-collar labour, $\frac{L^W}{L^B}$, declines with the growth of firm size unless the ratio of variable part of white-collar labour to blue-collar workers, $\frac{L^{H_v}}{L^B}$, grows fast enough to offset the decline in $\frac{L_f^W}{L^B}$.

3 Empirical Result

3.1 Data

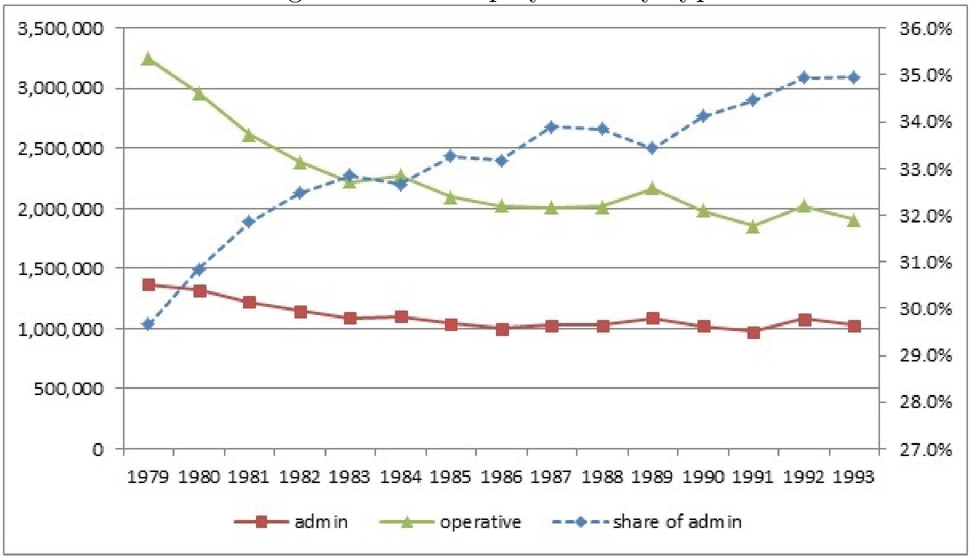
The ARD (Annual Respondent Database) will be used in this paper. It is a firm level database for UK firms. It is based on annual surveys on UK firms. The dataset includes data on firm's total sales, value added, the total number of employees and the number of employees by type.

The merit of this dataset is that the employees are distinguished into administrative workers and operative workers. The administrative workers are roughly equivalent to white-collar workers or non-production workers, who are supposed to have higher education level than blue-collar workers. The operative workers are roughly equivalent to blue-collar workers or production workers. However, the employment is distinguished only until 1995. Since 1995, the dataset does not distinguish between the two types of workers. Therefore, I am going to utilize the period of between 1978 and 1993. The firms in manufacturing sectors will be investigated.

The dataset is composed with selected files and non-selected files. Establishments which submitted survey forms are in the selected files, and the other establishments are in the non-selected files. As only the selected files include all the variables needed for the analysis, only selected files are used for empirical analysis in this paper.

3.2 overview

Figure 1: the employment by type



The employment trends of both administrative and operative workers in UK manufacturing industries is shown in Figure(1). The share of administrative workers in 1979 in UK manufacturing industries was 29.7%. It began to rise gradually and reached the level of 35.0% in 1993. However, the absolute number of administrative workers did not grow for the same period, but decreased gradually. The total employment of the administrative workers decreased by 24.9% from 1,368,887 in 1979 to 1,027,418 in 1993. It is the further decline in the employment of operative workers which increased the share of administrative workers in the manufacturing sector. The operatives employment dropped by 41.1% from

3,244,708 to 1,911,580 for the same period.

Table 1: Employment growth by type of workers

year	Share of admin	total	administrative	operative
1979	29.7%	4,613,595	1,368,887	3,244,708
1980	30.8%	4,280,101	1,320,054	2,960,047
1981	31.9%	3,835,123	1,221,934	2,613,189
1982	32.5%	3,537,837	1,148,747	2,389,090
1983	32.9%	3,313,091	1,088,522	2,224,569
1984	32.7%	3,382,610	1,104,948	2,277,662
1985	33.3%	3,138,484	1,044,024	2,094,460
1986	33.2%	3,028,121	1,004,833	2,023,288
1987	33.9%	3,036,721	1,029,228	2,007,493
1988	33.8%	3,046,362	1,030,752	2,015,610
1989	33.4%	3,258,172	1,089,298	2,168,874
1990	34.1%	3,005,449	1,025,229	1,980,220
1991	34.5%	2,828,766	974,746	1,854,020
1992	34.9%	3,103,535	1,084,632	2,018,903
1993	35.0%	2,938,998	1,027,418	1,911,580

However, such trend is not homogeneous for every firm. Firms show heterogeneous patterns in terms of the annual change in the share of administrative workers. Table 2 shows that 44.6% of firms decreased the share of administrative workers from the previous year while 51.8% of firms increased the share and 3.6% of firms did not change the share from the previous year.

3.3 lumpy adjustment for non-production workers

There has been empirical researches on firms' employment adjustment. For example, Davis and Haltiwanger (1992) reported that 29% of job creation and 23% of job destruction are due to modest employment growth of individual firms.

Figure 2: the change in the share of white-collar workers

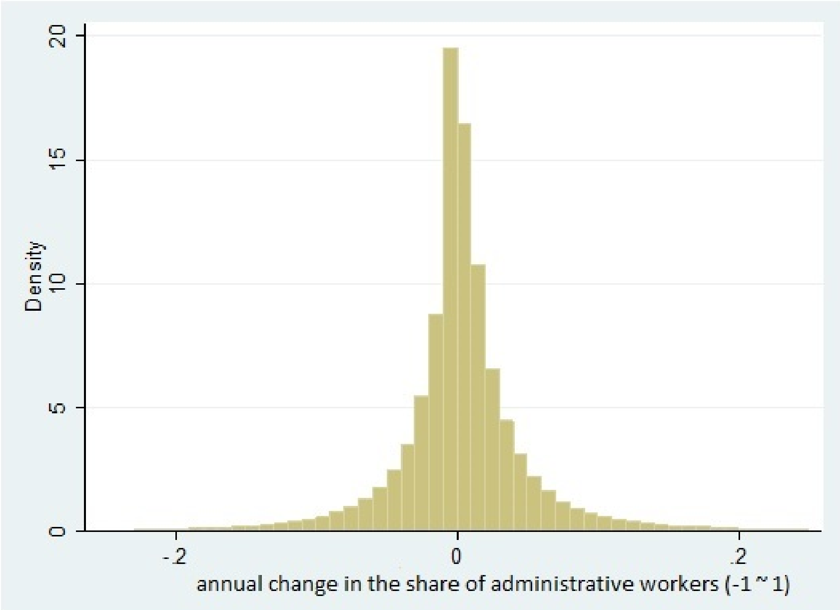


Table 2: The annual change in the share of administrative workers

$\Delta(\frac{L^w}{L})$	share	obs.
> 0	51.8%	44,069
$= 0$	3.6%	3,049
< 0	44.6%	37,954

The firms are grouped into three categories - firms with no employment change, firms with moderated change, firms with large change, and the firms which did not change employment level at all compared with the previous year.

The growth rate of employment is determined as below following Davis and Haltiwanger (1992):

$$g_{i,t} = \frac{L_{i,t} - L_{i,t-1}}{\frac{1}{2} * (L_{i,t} + L_{i,t-1})}$$

$g_{i,t}$ is the employment growth rate of type i at year t. The type is either white-collar workers, blue-collar workers or total number of workers including both white-collar workers and blue-collar workers. $L_{i,t}$ is the employment of type i at year t. If $|g| \leq 0.2$, the employment change is counted as moderated change. If $|g| > 0.2$, it is counted as large change.

In Table 3, the share of firms according to the employment growth rate is shown. The administrative workers are roughly equivalent of non-production workers or white-collar workers or skilled workers. The operative workers are roughly equivalent to production workers, blue-collar workers or unskilled workers.

The share of firms without any employment change in total employment is 5.8%. It is 17.2% for administrative workers, which is significantly higher than the 7.2% for operative workers. This result is consistent with the findings of Hamermesh (1993) and Pfann and Palm (1993) that the adjustment of non-production workers is more rigid than production workers.

However, the share of firms with large employment change, either positive or negative, is higher for administrative workers than the operative workers. The share of firms with large total employment growth rate,$|g|$, exceeding 0.2, either positive or negative, is 15.6%. It is 24.7% for administrative workers, which is higher than 21.3% of operative workers. The share of firms with moderate employment change rate, $|g| \leq 0.2$, is 78.5% for total workers. It is 58.1% for Administrative workers, which is lower than 71.5% for operative workers.

Table 3: Employment growth by type of workers

Employmentgrowth	Administrative	Operative	Total
$\|g\| > 0.2$	24.7%	21.3%	15.6%
$\|g\| < 0.2$	58.1%	71.5%	78.5%
$\|g\| = 0$	17.2%	7.2%	5.8%

If the employment growth is distinguished into the positive and negative growth, then the share of large change for the negative change is higher than for the positive change for every type of workers as shown in Table 4 and Table 5.

This implies higher adjustment cost for firing than hiring. However, the share of large change is higher for white-collar workers for both positive change and

Table 4: Employment growth by type of workers - positive change

Employment growth	Administrative	Operative	Total
$\lvert g \rvert > 0.2$	29.6%	20.4%	14.3%
$\lvert g \rvert < 0.2$	70.4%	79.6%	85.7%

Table 5: Employment growth by type of workers - negative change

Employment growth	Administrative	Operative	Total
$\lvert g \rvert > 0.2$	30.1%	24.7%	18.3%
$\lvert g \rvert < 0.2$	69.9%	75.3%	81.7%

negative change although the share of no change is higher for white-collar workers as well. For any cases, the share of moderate employment change of total workers is shown to be higher than both administrative workers and operative workers.

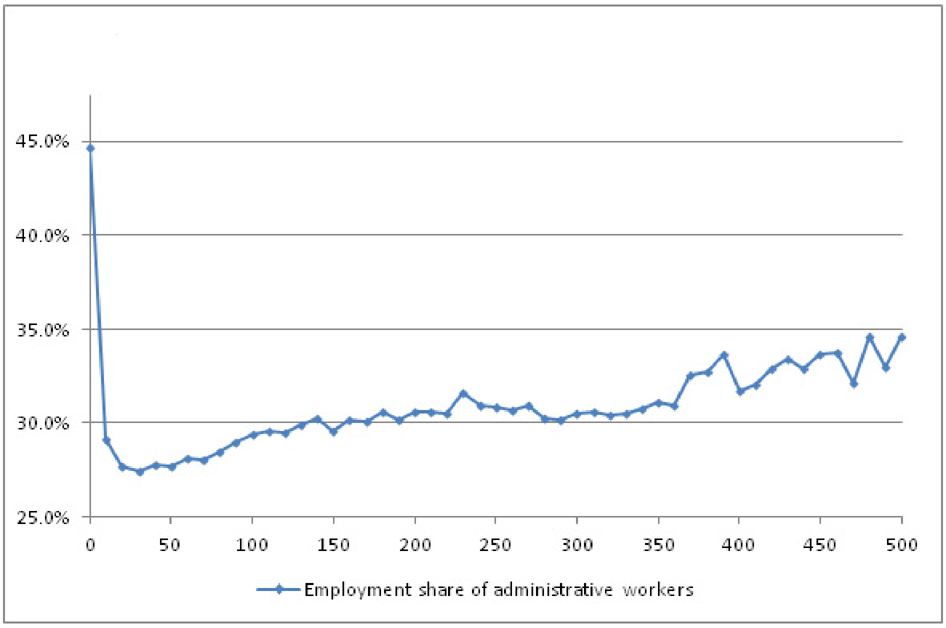
My model suggests that the firm's employment of fixed part of white-collar workers does not change until the firm changes its product variety. That explains the higher share of firms which do not change the employment of white-collar workers. However, once firms change the product variety or add another product variety, then they need to change the employment of white-collar workers discontinuously. That creates lumpy adjustment of white-collar labour.

3.4 the effect of firm size

The share of non-production workers is initially very high, 44.7% for firms with total employment between 1 and 9, but begins to fall until the total employment of the firms reaches 30-39. The share of non-production workers is the lowest, 27.5%, for firms with the total employment between 30 and 39. Then, the share of non-production workers increase with the firm size continuously. When the employment size is higher than 500 employees, the average share of non-production workers is 34.6%.

It is interesting that the share of white-collar workers are decreasing in scale

Figure 3: Employment share of administrative workers by firm size



among small firms. One possible reason is that there might be a lower bound of white-collar employment. For example, firms need to hire at least one white-collar workers - manager of the firm - although it is very small. Then, the share of white-collar workers would increase as firm size decreases.

Does the relative employment share of white-collar workers in the total employment affected by firm scale, either in terms of employment or value added output? Is the relative employment of white-collar workers increasing to scale, or decreasing to scale? Is there any endogeneity behind such relationship between firm scale and white-collar employment share? To investigate it, OLS, Fixed-Effect and Between-effect regressions are implemented and compared each other.

$$ln\left(\frac{L_{i,t}^{H}}{L_{i,t}^{B}}\right) = \alpha + \beta \cdot ln\left(Y_{i,t}\right) + trend + \varepsilon_{i,t} \quad (4)$$

The dependent variable, $ln\left(\frac{L_{i,t}^{H}}{L_{i,t}^{B}}\right)$ is the log of the ratio of white-collar workers to blue-collar workers in firm i at time t. It is regressed for both the log of value added output, $ln\left(Y_{i,t}\right)$. A linear time trend dummy is also included.

The firm size can be defined in terms of both output and employment. Therefore, it is regressed for $ln(L)$, the log of total employment as well.

$$ln\left(\frac{L_{i,t}^{H}}{L_{i,t}^{B}}\right) = \alpha + \beta \cdot ln\left(L_{i,t}\right) + trend + \varepsilon_{i,t} \tag{5}$$

Table 6: the effect of firm size - OLS

$ln(\frac{L^W}{L^B})$	(1)	(2)	(3)	(4)
$ln(Y)$	0.163***(0.005)	0.162***(0.005)	-	-
$ln(L)$	-	-	0.098***(0.007)	0.098***(0.007)
trend	-	0.004***(0.001)	-	0.008***(0.001)
Obs.	112,800	112,800	112,800	112,800

Note:
1) L^W: the employment of white-collar (Administrative) workers in the firm
2) L^B: the employment of blue-collar (Operative) workers in the firm
3) ***: significant at 1% error level
4) standard errors in the parenthesis are clustered at firm level

The OLS results are shown in Table 6. Both of the output and the total employment are very highly significant (at 1% significance level) and positively correlated with the share of non-production workers. One percent increase in the firm output is associated with the increases of the relative employment ratio of white-collar workers to blue-collar workers by approximately 0.163 percent. However, there must be a caution to interpret this result, it does not necessarily mean that the white-collar employment share increases by 0.163 percent when a firm increase its output as will be shown later. The scale effect also appears with respect to the employment size as well. One percent increase in the total employment of the firm is associate with the increase of the ratio of white-collar workers by 0.098 percent. The result remains qualitatively the same after including time trend dummy. The coefficients on the trend dummy are positively significant for both regressions : 0.004 for output and 0.008 for employment. It implies that there exist an upward trend in white-collar employment share.

Panel analysis

OLS estimation result includes both direct effect of firm size on white-collar employment share and the indirect effect due to endogeneity. The firm size is positively correlated with the unobserved requirement level of fixed white-collar workers, L_f^W, which is also positively correlated with the white-collar employment share (including both variable part and fixed part of white-collar employment). As significant part of the positive correlation in OLS might come from such endogeneity, panel analysis is also implemented. Because the size of fixed white-collar employment requirement is specific to the characteristic of the product which the firm is producing, it is unlikely to change in short-term although it is not entirely fixed. Therefore, significant part of the effect from the size of fixed white-collar labour, L_f^W, is supposed to be captured by the time-invariant firm-specific fixed effect.

Table 7: the effect of firm size - FE

$ln(\frac{L^W}{L^B})$	(1)	(2)	(3)	(4)
$ln(Y)$	-0.045***(0.006)	-0.053***(0.006)	-	-
$ln(L)$	-	-	-0.183***(0.014)	-0.174***(0.015)
trend	-	0.010***(0.001)	-	0.008***(0.001)
Obs.	112,800	112,800	112,800	112,800

Fixed-effect estimation shows completely different results. The result is on Table 7. The coefficient of the firm size, both in terms of output and employment, turns to negative. The coefficient of the log of value added output is -0.045 and that of the log of employment is -0.183. The values remain qualitatively unchanged after time trend dummy is included. The coefficients on time trend are positive for fixed-effect case as well. These contrasting patterns imply that large part of the positive correlation between firm scale and relative demand for white-collar labour comes from between-firm effect. Therefore, between-effect panel estimation is also implemented.

The between-effect estimation result is shown in Table 8. The coefficient of log

Table 8: the effect of firm size - BE

$ln(\frac{L^W}{L^B})$	(1)	(2)	(3)	(4)
$ln(Y)$	0.173***(0.004)	0.172***(0.004)	-	-
$ln(L)$	-	-	0.098***(0.005)	0.097***(0.005)
trend	-	0.004***(0.002)	-	0.010***(0.002)
Obs.	112,800	112,800	112,800	112,800

output is 0.173, which is slightly larger than the OLS estimate. The coefficient of log employment is 0.098 and also significant at 1% significance level. The coefficients of time trend for log output equation is 0.004 and that of log employment is 0.010. Both are significant at 1% significance level.

3.5 the change in administrative workers' employment share

Table 9: the effect of the change in the firm output

$\Delta ln(\frac{L^W}{L^B})$	(1)	(2)	(3)
$\Delta ln(Y)$	-0.040***(0.004)	-0.036***(0.004)	-0.022***(0.007)
$\Delta ln(Y) * D_{neg}$	-	-	-0.025***(0.010)
year dummies	No	Yes	Yes
Obs.	84,046	84,046	84,046

Note: $D_{neg} = 1$ if $\Delta ln(Y) < 0$

$$\Delta ln\left(\frac{L_{i,t}^H}{L_{i,t}^B}\right) = \alpha + \beta_1 \cdot \Delta ln\left(Y_{i,t}\right) + D_{year} + \beta_2 \cdot D_{negY} \cdot \Delta ln\left(Y_{i,t}\right) + \varepsilon_{i,t} \qquad (6)$$

$$D_{negY} = 1\, if\, \Delta ln\left(Y_{i,t}\right) < 0$$

$\Delta ln\left(\frac{L_{i,t}^H}{L_{i,t}^B}\right)$ is the annual change in the log of the ratio of white-collar workers to blue-collar workers in firm i between time t and $t-1$. $\Delta ln\left(Y_{i,t}\right)$ is the annual change in the log of output. D_{year} is set of dummies for each year. Each dummy correspondents to any common disturbance, specific to that year, affecting the white-collar employment share across all firms. Aggregate skill-biased technology shock specific to the year is supposed to be captured by the year dummy. However, the positive and negative changes in output might have heterogeneous effect on the white-collar employment share. Therefore, the interaction dummy term is included. $D_{negY} = 1$ if the change in output is negative.

$$\Delta ln\left(\frac{L_{i,t}^{H}}{L_{i,t}^{B}}\right) = \alpha + \beta_1 \cdot \Delta ln\left(L_{i,t}\right) + D_{year} + \beta_2 \cdot D_{negL} \cdot \Delta ln\left(L_{i,t}\right) + \varepsilon_{i,t} \quad (7)$$

$$D_{negL} = 1\, if\, \Delta ln\left(L_{i,t}\right) < 0$$

The regression results on the annual differences are shown in Table 9 and Table 10. The difference in the log employment share of white-collar workers is negatively correlated with the difference in the log of output. One percent increase in value added output from the previous year decreases the relative employment ratio of white-collar workers by 0.040 percent. The inclusion of year dummies decrease the absolute size of coefficient slightly from -0.040 to -0.036.

However, if the interaction dummy, which becomes 1 if the change in value added is negative, is included, the coefficient changes from -0.036 to -0.022. The coefficient on the interaction dummy term is negative, which is -0.025, and this means that the negative correlation between the change in firm size (in terms of value added output) and the employment share of administrative workers is stronger for negative change than positive change.

The negative correlation is even larger for employment change. One percent increase in the employment from the previous year decreases the relative employment ratio of white-collar workers by 0.249 percent. The inclusion of year dummies just slightly decrease the magnitude of the coefficient from -0.249 to -0.245. The coefficient of the interaction dummy for negative change is positive, which is 0.069. This is in contrast with the result for the change in output. This implies that the negative relationship between the change in firm size and the employment share

Table 10: the effect of the change in the firm employment

$\Delta ln(\frac{L^W}{L^B})$	(1)	(2)	(3)
$\Delta ln(L)$	-0.249***(0.017)	-0.245***(0.017)	-0.284***(0.033)
$\Delta ln(L) * D_{neg}$	-	-	0.069*(0.040)
year dummies	No	Yes	Yes
Obs.	84,046	84,046	84,046

Note: $D_{neg} = 1$ if $\Delta ln(Y) < 0$

of white-collar workers is weaker for negative firm size change if the firm size is measured in terms of employment.

This result is also in line with Dunne, Haltiwanger, and Troske (1996), which reported that white-collar employment share is negatively correlated with business-cycle in the US manufacturing industries.

4 Conclusion

The share of white-collar workers is found to be positively correlated with firm size in UK manufacturing industries. However, this positive correlation is mostly due to cross-sectional dimension, and a negative correlation is found in longitudinal dimension. This implies that firm size is positively correlated with only the firm-specific time-invariant effect.

This paper suggests that this is due to the positive correlation between minimum required level of white-collar workers to produce a firm's product variety and the size of the firm. Short-run variation in output does not affect fixed labour input, and affects white-collar employment, which is biased toward fixed input, disproportionately less than blue-collar employment.

The importance of fixed white-collar labour has been overlooked in existing literature, but it plays a crucial role in this paper. One important implication of this paper is that any empirical analysis on firm dynamics or skill demand can be misleading if fixed labour input is ignored.

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