The effect of computerisation on the wage share in United Kingdom workplaces

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Supplemental On-Line Data

Appendix

A – Data

I use data from the 2004 and 2011 Workplace Employment Relations Survey (WERS), a linked employer-employee survey which provides nationally representative data on workplaces in Britain with five or more employees. I use three components of the survey: face-to-face interviews with managers responsible for employment relations (Financial Performance Questionnaire (FPQ) and The Management Questionnaire (MQ)); and the self-completion questionnaire from workplace samples of employees (The Survey of Employees Questionnaire (SEQ)).

The workplace's income level, identified in FPQ, is defined as the workplace income received over the last year from sales of goods and services net of intermediate costs (value of purchases of goods, services and materials). I used the ONS overall price index to adjust for inflation over the 2004-2011 period.

The wage share is defined as the costs of compensating employees relative to workplace income, net of intermediate costs over the last year.

$$(1)\ Wage\ share = \frac{compensation\ of\ employees}{Net\ total\ income}$$

Excluding non-positive values of wage share and extreme values of wage share that are at least twice as large as the workplace income, the matching of the SEQ, FPQ and MQ surveys resulted in a sample of workplaces with complete values on all variables in 391 workplaces from the 2004 survey and 303 from the 2011 survey.

The use of ICTs is proxied by the share of employees who use computers (from the MQ).

Labour inputs are defined using the total number of employees in the workplace, the share of professional employees over the total workplace workforce and the share of intermediate employees over total workplace workforce. The share of professional occupations is defined using the top three occupational category of the Standard Occupational Classification (SOC) 2000 (Office for National Statistics, 2010) over the total number of employees, and the share of intermediate occupations is defined using the intermediate category. Both variables are derived using the Survey of 25 randomly chosen employees (SEQ), whilst the total number of employees in the workplace is from the Management Questionnaire (MQ). The SEQ achieved a 54% response rate in 2011 and 61% in 2004.

I use the SEQ to derive the average workplace level of effort and monitoring. The level of effort is the workplace average of agreement by employees, on a 5-point scale, with the statement that the job requires very hard work, ranging from strong agreement (5) to strong disagreement (1); and the level of monitoring is the workplace average of the employees summative index of a battery of Likert items capturing the degree of perceived influence on tasks, pace, method and timing of work, all ranging from 'a lot' (1) to 'none' (4).

The influence of unions is defined by the share of employees with pay negotiated by unions, which is taken from the MQ and captures at the same time whether one or more unions are involved in setting pay and the coverage of pay negotiations. The answer categories vary from 0 (none) to all (6).

Management practices include the adoption of improvement groups (also called quality circles), just-in-time techniques, and employee involvement in decisions. Improvement groups and just-in-time techniques are coded as binary variables. The response categories of the variable employees involvement in decisions are 1(none) to 4 (a lot). All these indicators are from the MQ.

The measure of capital per worker is the sum of the value (in thousands of pounds) of all land and all types of equipment (including software) adjusted for depreciation and divided by the total number of employees (from the FPQ). I used the ONS overall price index to adjust for inflation over the 2004-2011 period.

Other control variables include the industry in which the workplace operates (two-digit Standard Industrial Classification (SIC)), financial performance and globalisation. Financial performance is defined using the manager's assessment, ranging from 5 ('A lot better') to 1 ('A lot worse'), of workplace performance relative to other workplaces in the same industry. The indicators of globalisation are whether the workplace faces competition from abroad, and the company's UK market share, which are both taken from the MQ. It should be noted that the distributional effects of operating in a global market depend on whether competing firms utilise mainly low wage labour, which is usually the case for imports from low-income countries. This is the reason why in research on the effect of trade globalisation on the income distribution of rich countries, the preferred indicator is imports of manufactured goods from low-income countries. In WERS, we do not know whether the firms from abroad, with which the firm in question is competing, are from a high- or low-income countries. Hence, the available indicators capture the effect of both competition with firms in low-income countries — which shifts the distribution in favour of capital — and of competition with firms in high-income countries, which has an uncertain distributional effect.

In line with common practice in research on firms wages and outputs, I use natural logs of all continuous variables, because coefficients on the natural-log scale are directly interpretable as approximate proportional differences. As capital per worker, the share of employees using

computers, the share of professional employees and work effort contains 0s, I add 1 to each of them before the log-transformation. The variables are also normalised to their means to aid interpreting the non-linear effects.

B – The translog production function

A four-input — high skill occupations (L), intermediate skills occupations (I), capital (K), and computers (C) — translog production function can be written as follows, where the income (output) level and the inputs are expressed in logarithms (Christensen et al., 1973). Control variables are omitted in Equation 2. The use of both linear, quadratic and interaction terms make the translog function a flexible tool but increase the number of parameters to be estimated and interpreted. The production function omits the non-linear and interaction terms regarding management practices. The reason is that those parameters do not show significant effects and their inclusion does not improve the explanatory power of the model.

$$(2) \ \ln Y = \alpha_0 + \beta_K \ln K + \beta_L \ln L + \beta_I \ln I + \beta_C \ln C + \beta_{KK} \ln K^2 + \beta_{LL} \ln L^2 +$$
$$\beta_{CC} \ln C^2 + \beta_{II} \ln I^2 + \beta_{KC} \ln KC \ \ + \ \ \beta_{KL} \ln KL + \beta_{KI} \ln KI + \beta_{CL} \ln CL +$$
$$\beta_{CI} \ln CI + \beta_{LI} \ln LI$$

In order to compute income (output) elasticities, a linear combination of the parameters with respect to each factor input is needed (Belotti et al.., 2013).

$$(3) \ \frac{\partial \ln Y}{\partial \ln K}(s_K) =$$
$$\beta_K \ \ + \ \ \beta_{KK} average \ln K + \beta_{KC} average \ln C +$$
$$\beta_{KL} average \ln L + \beta_{KI} average \ln I$$

$$(4) \ \frac{\partial \ln Y}{\partial \ln L}(s_L) = \beta_L \ \ \ \ + \ \ \ \ \beta_{LL} average \ln L + \beta_{KL} average \ln K + \beta_{CL} average \ln C +$$
$$\beta_{LI} average \ln L$$

$$(5) \ \frac{\partial \ln Y}{\partial \ln I}(s_I) = \beta_I \ \ \ \ + \ \ \ \ \beta_{II} average \ln I + \beta_{KI} average \ln K + \beta_{CI} average \ln C +$$
$$\beta_{LI} average \ln L$$

$$(6) \ \ \ \frac{\partial \ln Y}{\partial \ln C}(s_C) = \beta_C \ \ \ \ + \ \ \ \ \beta_{CC} average \ln C + \beta_{KC} average \ln K + \beta_{CL} average \ln L +$$
$$\beta_{CI} average \ln I$$

The bias of computers with respect to the other factor inputs is given by the coefficients β_{KC}, β_{KL}, β_{CL} and β_{CI}.

The elasticity of substitution is defined as $\sigma_{AES} = \frac{\beta_{JC}}{s_C * s_J} + 1$ (Allen Elasticity of Substitution (AES) (1938), Behar (2007)), where J is either L, K, or I. It measures the percentage change in the ratio of two factor inputs in response to a percentage change in their marginal contribution to income. As it corresponds to the slope of an isoquant, it captures how easy it is to substitute one factor for the other. When AES<0, computers and labour (capital) are complements; when AES>0, computers and labour (capital) are substitutes.

C – Descriptive statistics

Table C.1 Variation of the workplace wage share and selected workplace characteristics, 2004 and 2011

Variable	2004		2011	
	Mean	Std. Dev.	Mean	Std. Dev.
Wage share	0.70	0.35	0.69	0.34
Daily wage per employee (in thousands of £)	0.64	6.42	0.38	1.84
Daily income per employee (in thousands of £)	3.59	31.75	8.80	60.03
Share of professional occupations	0.36	0.27	0.43	0.31
Share of intermediate occupations	0.14	0.19	0.15	0.17
Share of employees using computers	0.57	0.45	0.65	0.36
Share of employees with pay negotiated by unions*	2.21	2.63	1.41	2.33
Work effort**	3.94	0.40	4.07	0.36
Monitoring**	9.74	1.64	8.98	1.72
N	694			

*: from 0(none) to 6 (all)
**: Summative index of employees' responses

D – Stepwise regression models

Table D.1 Effect of workplaces' characteristics on the wage share (log). Elaborations from WERS 2004 and 2011. Beta coefficients and standard errors

Share of employees using computers (log)	-0.54***	-0.86***	-0.84***	-0.80***	-0.60***	-0.51*
	0.15	0.17	0.17	0.17	0.18	0.2
Number of employees (log)		0.03	0.03	0.04	0.05	0.05
		0.04	0.04	0.04	0.04	0.04
Share of professional employees (log)		0.67***	0.62**	0.59**	0.56**	0.64**
		0.19	0.2	0.2	0.2	0.21
Share of intermediate employees (log)		0.66**	0.80***	0.79***	0.83***	0.82***
		0.23	0.24	0.24	0.25	0.25
Workplace work effort (log)			0.81**	0.99**	1.02***	0.86**
			0.31	0.31	0.3	0.32
Monitoring (log)			-0.22	-0.18	-0.2	-0.12
			0.21	0.21	0.2	0.22
Share of employees with pay negotiated by unions (log)			0.19**	0.19**	0.16**	0.18**
			0.06	0.06	0.06	0.06
Employee involvement in decisions (log)			-0.04	-0.09	-0.11	-0.17~
			0.09	0.09	0.09	0.1
Improvement groups			-0.22*	-0.20~	-0.22*	-0.18
			0.11	0.11	0.11	0.11
Just-in-time			0.02	-0.02	0.05	0.04
			0.09	0.09	0.09	0.09
UK market share (log)				-0.14*	-0.09	-0.08
				0.06	0.06	0.06
Workplace faces competition from overseas				0.11	0.06	0.1
				0.09	0.09	0.09
Financial performance (log)				-0.36*	-0.40**	-0.42**
				0.15	0.14	0.15
Share of professional employees (log)*Share of employees using computers (log)					3.22***	3.97***
					0.68	0.73
Share of intermediate employees (log)*Share of employees using computers (log)					2.39*	3.09**
					0.94	0.97
Workplace's work effort (log)*Share of employees using computers (log)						-2.22~
						1.13
Monitoring (log)*Share of employees using computers (log)						0.01
						0.77
Share of employees with pay negotiated by unions (log)*Share of employees using computers (log)						0.51*
						0.23
Employees' involvement in decisions (log) * Share of employees using computers (log)						-0.62~
						0.33
Improvement groups*Share of employees using computers (log)						-0.98*
						0.47
Just-in-time*Share of employees using computers (log)						-0.05
						0.34
2011	0.15*	0.1	0.07	0.05	0.02	0.03
	0.08	0.08	0.08	0.08	0.08	0.08

Constant	-0.77***	-0.81***	-0.76***	-0.35	-0.39~	-0.40~
	0.1	0.16	0.16	0.24	0.23	0.23
Observations	694	694	694	694	694	694
Adjusted R-squared	0.04	0.06	0.07	0.09	0.12	0.13

~ 0.10 * 0.05 ** 0.01 *** 0.001

Other control variable: industry category

Capital per employee is measured in thousands of pounds

Table D.2 Effect of workplaces' characteristics on the income level (log). Elaborations from WERS 2004 and 2011. Beta coefficients and standard errors

Share of employees using computers (log)	1.34***	1.58***	1.84***	1.54***	1.17**	1.06*
	0.31	0.33	0.33	0.42	0.43	0.48
Capital per employee (log)		0.33***	0.34***	0.28***	0.30***	0.24***
		0.03	0.03	0.05	0.05	0.05
Number of employees (log)		1.07***	1.02***	0.93***	0.92***	0.90***
		0.08	0.08	0.1	0.1	0.1
Share of professional employees (log)		-0.04	-0.03	-0.14	-0.11	0.23
		0.37	0.4	0.49	0.48	0.53
Share of intermediate employees (log)		-0.49	-0.39	-0.92	-0.89	0.34
		0.46	0.47	0.57	0.6	0.87
Workplace work effort (log)			1.30*	0.91	0.85	0.76
			0.58	0.75	0.74	0.73
Monitoring (log)			0.96*	0.8	0.87~	0.99*
			0.41	0.5	0.5	0.49
Share of employees with pay negotiated by unions (log)			-0.03	-0.13	-0.08	-0.15
			0.11	0.15	0.15	0.14
Employee involvement in decisions (log)			-0.27	-0.06	-0.06	-0.05
			0.18	0.23	0.23	0.22
Improvement groups			0.37~	0.39	0.4	0.47~
			0.2	0.26	0.27	0.26
Just-in-time			-0.48**	-0.45*	-0.57**	-0.38~
			0.17	0.21	0.21	0.21
UK market share (log)				0.44**	0.36*	0.41**
				0.15	0.15	0.15
Workplace faces competition from overseas				0.1	0.19	0
				0.21	0.21	0.21
Financial performance (log)				0.51	0.60~	0.73*
				0.36	0.35	0.34
Share of professional employees (log)*Share of employees using computers (log)					-5.17**	-9.17***
					1.66	1.81
Share of intermediate employees (log)*Share of employees using computers (log)					-5.32*	-7.15**
					2.3	2.68
Share of employees using computers^2 (log)						4.04~
						2.24
Capital per employee^2 (log)						0.05***
						0.01
Share of professional employees^2 (log)						5.90**
						2.21
Share of professional employees^2 (log)						0.28
						3.22
Capital per employee (log) *Share of employees using computers (log)						-0.63**
						0.2
Share of professional employees (log)*share of intermediate employees (log)						9.01*
						3.93

Share of professional employees (log)*Capital per employee (log)						0.74**
						0.23
Share of intermediate employees (log)*Capital per employee (log)						0.84**
						0.27
2011	-0.08	0.2	0.25	0.09	0.17	0.11
	0.15	0.15	0.16	0.2	0.2	0.19
Constant	1.87***	-1.86***	-1.65***	-2.30***	-2.25***	-2.74***
	0.21	0.3	0.31	0.57	0.57	0.59
Observations	1249	1053	1026	679	679	679
Adjusted R-squared	0.04	0.28	0.29	0.25	0.27	0.32

~ 0.10 * 0.05 ** 0.01 *** 0.001

Other control variable: industry category
Income level and capital per employee are measured in thousands of pounds

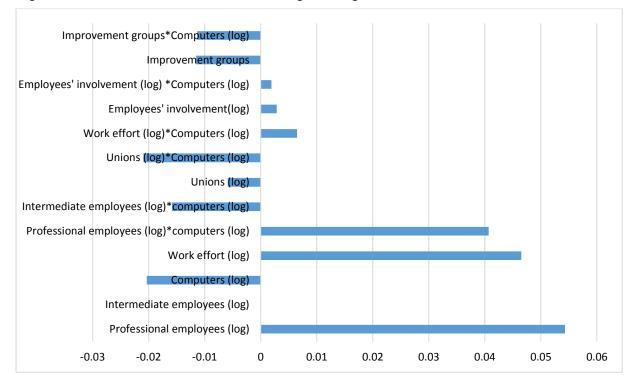## E – Factors' contribution to the change of wage share, 2004-2011

Figure E.1 Factors' contribution to the change of wage share, 2004-2011

In order to assess the extent to which the different factors have contributed to the stability of the wage share over the period, I construct a measure of each factor's contribution by multiplying its effect size by its actual change over the period of interest (Figure E1). The effect estimates are taken from Model 2. The increase in share of employees using computers contributed substantially to the decline of the wage share (extent of change (0.04)* effect size (-0.5 = -0.02). The level of computerisation has heterogenous effects depending on the factor it interacts with. The share of employees with pay negotiated by unions declined over time, which explains the negative contribution of both the main effect of union activity (extent of change (-0.03)* effect size (0.2)= -0.02) and the interaction term to the change in the wage share (extent of change (-0.04)*effect size (0.5) = -0.005). The share of intermediate employees declined too, leading to the same negative contribution to the change of the wage share of the interaction between computers and the share of intermediate employees (extent of change (-0.005)* effect size (3.1) = -0.015). The negative contributions are balanced by the positive contribution of work effort (extent of change (0.05)* effect size (0.9) = 0.05), which intensified over the period, and the share of professional employees, which also increased over time

(extent of change (0.08)* effect size (0.6) = 0.05). The interaction between computers and work effort contributed to increase the wage share (extent of change (-0.002)* effect size (-2.2) = 0.006) as did the one between computers and the share of professional employees (extent of change (0.001)* effect size (4) = 0.04). Improvement groups, which become more prevalent over time, contributed to reduce the wage share both when considering the main effect (extent of change (0.06)* effect size (-0.18) = -0.01) and the interaction with computers (extent of change (0.01)* effect size (-1) = -0.01). Finally, employee involvement in decisions, declined over time, leading to a positive contribution to wage share (extent of change (-0.02)* effect size (-0.17) = 0.003). The interaction between computers and employee involvement in decisions had a positive contribution to the wage share (extent of change (-0.003)* effect size (-0.6) = 0.002).