Online Appendices to "How productive is workplace health and safety?"*

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Abstract

This document contains supplemental descriptive and robustness analyses, mentioned in the main text of our paper Buhai, I.S., Cottini, E. and Westergaard-Nielsen, N. (2015), "How Productive is Workplace Health and Safety", forthcoming at the *Scandinavian Journal of Economics*.

*Accessible at http://www.sebastianbuhai.com/papers/publications/online_appendix_workenv.pdf

A Supplemental material to "How Productive is Workplace Health and Safety?"

A.1 Employee vs. employer representative in VOV

The VOV 2001 questionnaire is answered both by one safety group representative of the employees ("type-1" respondent) and by one safety group representative of the employer ("type-2" respondent) for each establishment, such that the initial dataset contains two observations for each establishment surveyed. For our reported analysis, we keep only the answer of the employees' safety representatives and do not use the second measure, though note that they are fairly highly correlated for the specific work environment measures (the correlation coefficient is between 0.35 and 0.70 for each of these specific safety and health measures, with an average across all of them higher than 0.50). Our decision to select type-1 answers is mainly motivated by the fact that their variation is somewhat higher than the ones of type-2, with the latter tending to cluster around "very good" or "good" for most questions. To illustrate the difference in the variance between the two types with one (extreme) example, consider the answer to the general question concerning the work environment related standard (the correlation between the two measures for this general work environment indicator is only 0.17). Table A.1 presents the answers of both types to the question: "What do you consider the work environment related standard to be at the company?", for observations where both types's answers are nonmissing. We define a general work environment ordered variable, taking values that range from 1=very good to 5=very poor.

Table A.1: Differences between types, all plants

General work environment	Type=1		Type=2		Total	
	N	%	N	%	N	%
very good	156	13.15	362	30.57	518	21.9
good	707	59.17	693	58.53	1400	59.1
not bad	286	24.16	123	10.39	409	17.3
poor	30	2.53	5	.42	35	1.5
very poor	5	.42	1	.08	6	.2
Total	1184		1184		2368	

From Table A.1 it appears clearcut that type 1 answers have more variance than type-2 answers[1], although this discrepancy is less pronounced for any of the specific work environment indicators. The choice of type-1 versus type-2 answers does not have however any implication on our conclusions: performing our estimations with type-2 answers we obtain results that are qualitatively identical to the ones reported in the paper.

A.2 Mono-plant vs. multi-plant firms in VOV

Given that we match our datasets via the firm identifier, and that VOV is collected at establishment level, we are compelled to limit our analysis to firms that have a single establishment. How representative is this sub-sample of private Danish sector in terms of geographical and industry distribution, relative to the initial dataset? The two tables below compare their distribution by industries, Table A.2, and respectively the distribution by regions, Table A.3. We note that the mono-plant firms keep largely the same geographical distribution as the plants in the initial sample, and that the only considerable changes are in the case of two industries: real estate, where the proportion of plants decreases from 4.3% of the total sample, initially, to 2.4%, in the working sample, and private firms operating in public administration, defense and compulsory social security category, where the plant percentage decreases from 5% in the initial sample to 0.7% in the working sample of mono-plants. Since these are relatively small industries in Denmark, the representativeness of the sample is arguably largely unaffected, either industry or location-wise. All our results need to be interpreted, however, with this potential limitation in mind.

A.3 Data loss in merging VOV-IDA-REGNSKAB

We face some unavoidable sample reduction during the merging procedure, which we describe below:

- We start with 1962 establishments sampled in VOV 2001 (we have two observations for each of these establishments, corresponding to type-1 and type-2 respondents, as

[1]The discrepancy remains the same if we consider only the mono-plant firms, as used in the empirical analysis.

Table A.2: Distribution by industries

	All-plants		Mono-plant firms	
	N	%	N	%
Agriculture, fishing, mining and quarrying	33	3.6	27	4.7
Manufacturing	546	59.7	357	62.4
Electricity, gas and water supply	1	0.1	1	0.2
Construction	59	6.5	47	8.2
Wholesale and retail trade	68	7.4	45	7.9
Hotels and restaurant	5	0.5	4	0.7
Transport, post and communication	45	4.9	32	5.6
Financial intermediation	17	1.9	6	1
Real estate, renting and business activities	39	4.3	14	2.4
Public administration, defense and social security	46	5	4	0.7
Education	32	3.5	20	3.5
Health and social work	12	1.3	6	1
Other community, social and personal service activities	11	1.2	9	1.6
Total	914		572	

Table A.3: Distribution by regions

	All plants		Mono-plant firms	
	N	%	N	%
Copenhagen	197	21.6	103	18
Roskilde	24	2.6	19	3.3
Vestsjaeland	54	5.9	36	6.3
Storstroem	27	3	22	3.8
Fyn and Bornholms	105	11.5	53	9.3
Soenderjylland	67	7.3	43	7.5
Ribe	56	6.1	32	5.6
Vejle	73	8	50	8.7
Ringkoebing	43	4.7	28	4.9
Aarhus	69	7.5	48	8.4
Viborg	97	10.6	64	11.2
Nordjylland	102	11.2	74	13
Total	914		572	

explained earlier in these Appendices).

- We need to find the firm identifier for most of the initial establishments, since these are often included in the dataset only by their name, with that name string often entered only partially, etc. This has been done- via painstaking manual work performed by extremely patient and dedicated research assistants- using an auxiliary business statistics dataset, which matches names to firm identifiers. We were unfortunately not able to retrieve the firm identifier for 490 of the initial establishments.

- We use only mono-establishment firms in merging VOV to IDA and REGNSKAB since we do not have establishment identifiers in VOV to merge with establishment identifiers in IDA, and since in REGNSKAB we have business account statistics at the business unit=firm level. That leaves us with a sample of 572 firms in the merged VOV-IDA dataset, and 465 firms in the merged VOV-IDA-REGNSKAB dataset. We have less firms in REGNSKAB given the sampling procedure in the construction of that dataset and its reliability only for part of the firms, see also the REGSKAB overview in the data description part of this paper. Remark however, as also stated earlier in the main text of this paper, that using mono-plant firms in productivity analysis is by no means unusual, but rather the established practice when estimating production functions using data originating from both firm (typically, all business account data) and establishment level, see, for instance, Carlsson and Skans (2012).

- For the production function estimation we use all the available observations in the merged dataset VOV-IDA-REGNSKAB; we end up with smaller sample sizes, given that several of our variables used in the estimation have missing observations.

A.4 Descriptive between-firm work environment differentials

In here we detail the descriptive analysis of the health and safety between-firm work environment differentials mentioned in the data section. Specifically, we are interested in observable firm and employee aggregate characteristics that correlate with the firms' quality of the work environment. Our methodology is similar to, e.g., Osterman (1994), who studied the factors

associated with adoption of innovative work practices. Consider the following regression,

$$WE_i = \alpha + \beta X_i + \gamma Z_i + \varepsilon_i \quad (1)$$

where WE_i the indicator of work environment health and safety quality for the ith firm, X_i a vector of firm and aggregate-employee characteristics, Z_i a vector of work environment practices, and ε_i an idiosyncratic error term. Definitions and summary statistics for the variables used in our final specification can be found in Table 1 from the main text[2].

We estimate simple logit models using both the general and the specific work environment indicators. In all estimations we report the marginal change in probability of the specific work environment indicator being 1, given a one unit change in the independent variable. The first binary outcome model estimated is shown in Table A.4, column (1); our dependent variable is an indicator taking value 1 if the general work environment at the company (as perceived by workers) is "very good" or "good", and respectively 0 if it is "not bad", "poor" or "very poor"[3]. The only regressor statistically significant at conventional significance levels is having undertaken training courses with a work environment content [4], suggesting that firms offering courses to employees are also more likely to improve their work environment standard, perhaps by rendering their workforce more active and more aware. We stress again that here we aim to emphasize statistical associations, without drawing causal links.

Columns (2) to (9) in Table A.4 show estimates for a series of logits, in which the dependent variables refer to specific work environment problems, with 1 if the specific condition "is solved" and 0 otherwise. There are few statistically significant regressors.

[2]Next to the reported specifications, we have used alternatives with a much wider series of other aggregate employee-characteristics, such as mean and standard deviation, of education, experience, tenure (in the whole firm or per particular employee group, such as managers), as well as proportion of other worker categories, such as "turnover", white-collar, top managers, etc. None of these have statistical power (or a large coefficient magnitude) in explaining the between-firm work condition differentials, for any of the work environment indicators.

[3]We also estimated an ordered probit model with the dependent variable taking 5 values from "very good" to "very poor"; the results are qualitatively identical.

[4]Not reported in the table, the age, industry, or geographical location of the firm do not have any explanatory power in this general between-firm work environment differential.

Table A.4: Logit estimates of firm characteristics on work environment indicators, marginal effects

	general work environment	heavy lift	repetitive work	chemical loads	noise	problems with young workers	mental stress	internal climate	accidents
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
proportion female	.083	.041	.140	.035	-.025	.066*	.023	-.195	.225
	(.119)	(.131)	(.118)	(.038)	(.076)	(.036)	(.121)	(.137)	(.165)
proportion unskilled	-.0007	.205	-.184	-.016	.163	-.051	.026	.195	-.118
	(.148)	(.179)	(.165)	(.057)	(.128)	(.065)	(.134)	(.199)	(.139)
proportion turnover	-.020	-.030	.137	.004	-.044	-.023	-.207	-.219	.003
	(.150)	(.125)	(.146)	(.051)	(.091)	(.032)	(.134)	(.166)	(.141)
proportion managers	.049	.640**	.654**	.074	.191	.129	.676**	.139	.309
	(.204)	(.310)	(.302)	(.079)	(.141)	(.101)	(.294)	(.259)	(.235)
average education	.014	-.008	.010	-.015	.012	-.001	-.004	-.027	.001
	(.019)	(.021)	(.022)	(.012)	(.012)	(.007)	(.023)	(.026)	(.026)
logarithm of firm size	-.019	-.110***	-.076***	.001	-.041***	-.008	-.091***	-.091***	-.078***
	(.023)	(.026)	(.024)	(.007)	(.015)	(.006)	(.024)	(.026)	(.026)
courses	.194***	-.069	.103*	.020	.082**	-.025	-.023	-.023	-.037
	(.056)	(.060)	(.059)	(.015)	(.033)	(.016)	(.055)	(.062)	(.052)
written policy	.059	.080	.017	-.016	.040	-.002	-.026	-.031	.051
	(.062)	(.063)	(.067)	(.015)	(.036)	(.015)	(.062)	(.063)	(.058)
action plans on work env.	.089	.053	.090	-.010	-.022	-.002	-.016	-.129	.061
	(.067)	(.070)	(.079)	(.017)	(.047)	(.017)	(.074)	(.085)	(.064)
prioritise work environment	.104	-.045	-.073	-.008	.033	-.005	.048	.176*	-.106
	(.070)	(.080)	(.083)	(.023)	(.053)	(.019)	(.077)	(.096)	(.074)
Nobs	305	279	280	230	279	175	297	302	264
Log-lik	-147.06	-129.56	-125.14	-66.86	-129.48	-42.57	-140.79	-152.98	-117.36

Significance levels: *** 1%,**5%, *10%; White heteroskedastic-consistent standard errors in parentheses. The estimations also include a constant term, regional and industry indicators, and dummy variables for firm age categories, ie. age 0-5, 5-10, 10-15, 15-20, with the baseline 20+

An unexpected outcome is the importance of the "proportion of managers"[5] in explaining between-firm discrepancies in several of the specific workplace indicators. In three equations (corresponding to heavy lifting, repetitive work, and mental stress) the coefficient on proportion of managers is positive and statistically significant, i.e. a higher proportion of managers in the firm is associated with better work environment in terms of these conditions. The relevance of this indicator extends beyond statistical significance, as it also has the largest magnitude relative to other work environment indicators.

Having undertaken specific courses on the work environment correlates positively with the repetitive work and loud noise indicators. The estimates also show that firms with a higher proportion of women are found to have less problems connected with young employees. Finally, prioritizing work environment is found positive and statistically significant for solving problems connected to the internal climate[6]. The estimated magnitudes of all other covariates found statistically relevant are considerably smaller than that for proportion of managers.

The findings above suggest that there are only a couple of robust firm and aggregate-employee level variables statistically associated with most of the specific measures of good workplace environment. The most relevant is the proportion of managers, followed by offering training courses. To less extent, the proportion of females within the firm and prioritizing work environment practice in the firm also help explain across-firm differences in some of work environment dimensions. Our descriptives could indicate a beneficial effect of both managerial involvement (proportion of managers) and employee awareness in workplace environment quality improvement. In fact, there exists supportive evidence that these two factors could well be complementary within a firm, e.g., Kato and Morishima (2002), who provide evidence on the association between top-level management and shop-floor employee participation in workplace organization.

[5] Other potential proxies for 'managerial ability', such as means (or standard deviations) of managerial education, age, experience, or tenure, are found not to matter.

[6] Not reported, firm age and region are not statistically significant for any of the work environment specific dimensions. However, there are industry differentials in specific workplace indicators. For instance, agriculture, is the 'worst' in terms of "heavy load" problems, while chemical loads are worst for the manufacturing category, etc. Since these are not key covariates, we omit them from the tables for the sake of space.

A.5 Analysis using continuous work environment indicators

We show that an alternative transformation of the work environment multi-category variables, into continuous, rather than binary indicators, does not change any conclusions. While most literature uses dichotomization of categorical variables in survey contexts like ours, a few studies such as Muñoz de Bustillo et al (2011), Eurofond (2012), or Leschke and Watt (2014) transform them in continuous indicators through mapping onto [0,1]; we repeat our analysis following this strategy, using equal category weights[7]. The three tables A.5, A.6 and A.7 below correspond to, respectively, the upper panel of Table 1; the descriptive analysis in online appendix Table A.4; and the main causal analyses in Table 2. Comparing Table A.5 with Table 1 (upper panel), the variance of the continuous indicators is lower than of their binary counterparts. As descriptive analysis, Table A.6 with continuous indicators is very similar to Table A.4., e.g., with *proportion of managers* strongly associated with several specific good work conditions. Our estimates from Table 2 appear fully robust to the alternative in Table A.7, with only minor differences. "*Monotonous repetitive work*" is now statistically significant and quantitatively very important even in the OLS column (1), not only in the FE and GMM, where, just as earlier, "*internal climate*" also remains statistically significant (at lower, but inconsequential, conventional statistical significance level) and strongly positive.

Table A.5: Descriptive statistics VOV with continuous indicators (corresponds to the upper panel of Table 1 from the main text)

variable	definition	mean	s.d.	N
	VOV continuous indicators			
general work env.	indicator between 0 and 1, increasing in work environment quality	.623	.228	449
heavy lift	indicator between 0 and 1, increasing in extent of problem solved	.861	.262	448
repetitive work	indicator between 0 and 1, increasing in extent of problem solved	.863	.275	442
chemical loads	indicator between 0 and 1, increasing in extent of problem solved	.918	.233	441
noise	indicator between 0 and 1, increasing in extent of problem solved	.862	.269	444
problems w young	indicator between 0 and 1, increasing in extent of problem solved	.938	.241	436
mental stress	indicator between 0 and 1, increasing in extent of problem solved	.849	.306	439
internal climate	indicator between 0 and 1, increasing in extent of problem solved	.823	.302	441
accidents	indicator between 0 and 1, increasing in extent of problem solved	.878	.260	441

[7]Whereas this indicator uses more information as it does not concatenate categories into one or the other binary dimension, it does make a strong assumption that categories should be equally weighted when mapping onto the continuous [0,1] interval. It is possible to weigh categories unequally, but subject to typically even stronger assumptions (among the three cited studies, only Leshke and Watt, 2014 have also a variant with unequal category weights). Ultimately it is thus not clear whether this method is more efficient than dichotomization, reflected in that most of the literature uses the latter.

Table A.6: OLS estimates of firm characteristics on continuous work environment indicators (corresponds to Table A.4 from the Online Appendices)

	general work environment	heavy lift	repetitive work	chemical loads	noise	problems with young workers	mental stress	internal climate	accidents
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
proportion female	.097	-.016	.074	.033	-.032	.147*	.075	-.078	.079
	(.070)	(.073)	(.070)	(.047)	(.065)	(.089)	(.108)	(.093)	(.084)
proportion unskilled	-.074	-.002	-.164	-.016	.108	-.118	-.053	.018	-.085
	(.073)	(.139)	(.152)	(.061)	(.126)	(.197)	(.187)	(.107)	(.117)
proportion tunover	.015	.014	.077	-.0007	-.012	-.073	-.130	-.100	-.009
	(.070)	(.076)	(.080)	(.054)	(.071)	(.094)	(.129)	(.102)	(.080)
proportion managers	-.085	.372**	.320**	.091	.213	.309	.564**	.179	.196
	(.099)	(.151)	(.151)	(.101)	(.145)	(.244)	(.235)	(.159)	(.137)
average education	.004	-.005	-.0001	-.016*	.011	.005	-.003	-.014	.002
	(.011)	(.011)	(.013)	(.008)	(.014)	(.014)	(.015)	(.015)	(.012)
logarithm of firm size	-.015	-.059***	-.046***	.005	-.042***	-.027	-.080***	-.047***	-.041**
	(.011)	(.014)	(.014)	(.010)	(.015)	(.020)	(.024)	(.018)	(.017)
courses	.089***	-.024	.068*	.037	.089**	-.092*	-.024	-.039	-.035
	(.028)	(.037)	(.039)	(.026)	(.038)	(.054)	(.056)	(.042)	(.037)
written policy	.047*	.024	.024	-.020	.045	-.038	-.029	-.062	.037
	(.028)	(.041)	(.048)	(.027)	(.040)	(.060)	(.062)	(.046)	(.040)
action plans on work. env.	.048	.033	.069	-.017	-.008	.028	.022	-.021	.055
	(.041)	(.042)	(.057)	(.029)	(.047)	(.076)	(.065)	(.055)	(.055)
prioritise work environment	.010	.003	-.035	-.0003	.043	-.006	.104	.074	-.077
	(.043)	(.052)	(.065)	(.032)	(.058)	(.075)	(.083)	(.058)	(.058)
Nobs	305	279	280	230	279	175	297	302	264
R^2	.161	.172	.163	.109	.156	.161	.149	.165	.131

Significance levels: *** 1%,**5%, *10%; White heteroskedastic-consistent standard errors in parentheses. The estimations also include a constant term, regional and industry indicators, and dummy variables for firm age categories, ie. age 0-5, 5-10, 10-15, 15-20, with the baseline 20+

Table A.7: Augmented production functions with continuous indicators of health and safety conditions (corresponds to Table 2 from the main text)

	OLS 2001	2-stage FE+OLS	2-stage GMM+OLS
	(1)	(2)	(3)
		1^{st} stage	
K/L	.034*	.048***	.060**
	(.017)	(.011)	(.027)
M/L	.671***	.751***	.745***
	(.026)	(.022)	(.061)
proportion female	.002	-.053	-.053
	(.106)	(.053)	(.053)
proportion unskilled	-.262**	-.022	-.013
	(.111)	(.033)	(.036)
proportion turnover	-.138	-.082***	-.096***
	(.130)	(.021)	(.035)
proportion managers	.329	.017	.127
	(.217)	(.075)	(.187)
average education	.002	-.006	.003
	(.016)	(.006)	(.008)
Nobs 1^{st}stage		1627	1627
Sargan			$\chi^2(15)$=19.40 (p-value=0.20)
LM 1^{st} order serial corr			z=-3.65 (p-value=0.00)
LM 2^{nd} order serial corr			z=-0.30 (p-value=0.77)
		2^{nd} stage	
courses	.044	.045	.042
	(.035)	(.035)	(.034)
written policy	.015	.013	.006
	(.032)	(.031)	(.030)
action plans on work env.	-.009	-.017	-.014
	(.050)	(.049)	(.048)
prioritise work environment	-.022	-.019	-.019
	(.047)	(.049)	(.048)
heavy lift cont.	-.059	-.079	-.088
	(.083)	(.079)	(.080)
monotonous repetitive work cont.	.115*	.129**	.124**
	(.068)	(.061)	(.061)
chemical loads cont.	.109	.099	.101
	(.098)	(.085)	(.085)
noise cont.	-.010	.052	.045
	(.061)	(.052)	(.052)
problems with young workers cont.	-.038	-.073	-.072
	(.052)	(.046)	(.045)
mental stress cont.	-.043	-.045	-.039
	(.058)	(.056)	(.056)
internal climate cont.	.022	.076*	.082*
	(.062)	(.046)	(.046)
accidents cont.	.015	.023	.010
	(.059)	(.051)	(.050)
R^2	.919	.215	.231
Nobs	215	215	215

Significance levels: *** 1%,**5%, *10%; White heteroskedastic-consistent standard errors in parentheses. Estimations also include a constant term, regional, industry, and firm age category indicators. For the 1st stage FE and GMM regressions in columns (2) and (3), we also control for the interaction between years and industry indicators. The reported GMM here instruments appropriately for K, M, L, and the proportion of managers (there are no qualitative differences with the case where proportion of managers is not instrumented for). Sargan is a χ^2 test of overindentifying restrictions; LM is a Lagrange Multiplier test of 1^{st} and respectively 2^{nd} order serial correlation in Δv_{it}, distributed N[1,0] under the null; p-values for the significance test of the null hypotheses are reported in parentheses, after the test coefficients