The impact of workplace conditions on firm performance *

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Abstract

This paper estimates the impact of work environment health and safety practice on firm performance, and examines which firm-characteristic factors are associated with good work conditions. We use Danish longitudinal register matched employer-employee data, merged with firm business accounts and detailed cross-sectional survey data on workplace conditions. This enables us to address typical econometric problems such as omitted variables bias or endogeneity in estimating i) standard production functions augmented with work environment indicators and aggregate employee characteristics and ii) firm mean wage regressions on the same explanatory variables. Our findings suggest that improvement in some of the physical dimensions of the work health and safety environment (specifically, "internal climate" and "repetitive and strenuous activity") strongly impacts the firm productivity, whereas "internal climate" problems are the only workplace hazards compensated for by higher mean wages.

Keywords: occupational health and safety, work environment, production function estimation, firm performance, compensating wage differentials
JEL codes: J28, J31, L23

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1 Introduction

In this paper we investigate which firm characteristics associate with good work environment practice and the impact of workplace conditions on firm performance. Despite a sizable economic literature that has paid attention to determinants of capital investments, technological innovations or work reorganization in general, and to their respective effect on firm or establishment financial performance, there has been virtually no study on the impact of detailed, physical as well as psycho-social, work environment health and safety conditions, on firm performance indicators. Ours is the first study to focus on the effects of specific health and safety workplace indicators on firm productivity and mean wage. We are able to link detailed work conditions data from a representative Danish cross-sectional survey of establishments to the longitudinal register matched employer-employee data, merged with information on the firms' business accounts. This allows us to use empirical specifications where we can address to a considerable extent econometric problems typical in such contexts, such as omitted variables or endogeneity.

Work environment related issues have been prioritized in labour policy debates all throughout the industrialized nations. Improving the general work environment has been for instance a declared target of the European Union, as stated in the consolidated version of the Treaty establishing the European Community.[1] More recently, the 2001 report on employment of the European Commission includes specific work conditions in its "social policy agenda".[2] The same EC report concludes by stating that– although "job quality" is acknowledged to have generally improved within the EU– "working conditions" are still an exception; for instance, the total costs of occupation-related health risks and accidents are estimated to be enormous, with values in the range of 2.5%- 4% of the EU member states' GNPs[3]. The estimated costs of job-related illnesses for the USA are equally large, cca. 3% GNP, see e.g. Leigh et al (1996). See also Figure 2 in the next section for a per-country histogram of estimated aggregate costs of job-related risks and illnesses.

Despite the hot policy context, intuitive implications of the macro-level discussion mentioned above have been so far neither backed up, nor falsified by thorough empirical research using microdata. We do not know for instance whether in practice a "better workplace environment" actually pays off in terms of higher worker productivity or, for that matter, to what extent "bad" workplace health and safety conditions are compensated for by wage premia. Our paper aims to help in filling this knowledge gap and contribute to the research based evidence in the microeconomics of the firm's work environment and production organization. Thus, we believe it is important to know both i) which firm and aggregate

[1] In the protocol of the Treaty of Maastricht (1992), the social compentencies of the European Community were expanded to include "working conditions". A "European Foundation of The Improvement of Living and Working Conditions" had been in place already since 1975.

[2] Explicit reference is made to: intrinsic job quality; skills, life-long learning, and career development; gender equality; health and safety at work; flexibility and security; inclusion and access to the labour market; work organisation and work-life balance; social dialogue and worker involvement; diversity and non-discrimination; overall work performance.

[3] Citing directly from the text of the report, "The evolution of job quality in the EU in recent years was generally positive, with the exception of working conditions which do not seem to have improved. Accidents at the workplace and occupational diseases remain a challenge to the EU economies, with direct and indirect costs due to work-related health risks and accidents at work estimated to amount to between 2.6% and 3.8% of GNP in the EU".

employee characteristics are statistically associated with better workplace conditions and, crucially, ii) the impact of enacting/improving specific work environment conditions on the performance of firms. To give a concrete example for i), do written work environment rules or work environment training courses for all employees, but also, e.g., higher aggregate human capital level, proportion of managers, female employees in the firm, age of the firm etc., associate with better workplace environment quality? At the same time, expenditures by firms to improve workplace conditions should be seen as investments in the economic sense, ie. costs borne today in order to reap benefits in terms of higher profits tomorrow. Such investment decisions from the part of the employer need therefore to be strategic; it is not ex ante obvious which of the specific dimensions of the workplace environment should be targeted, and in which way an improvement in them would impact firm productivity or employee welfare. Hence, to consider an example for ii), should one pay equal attention to perceived physical workplace problems such as noise or heavy lifting burden or internal climate conditions, and to perceived problems in the psycho-social realm (decision lattitude of the employees, stress, working with colleagues etc.)? Are these workplace environment dimensions equally relevant in enhancing firm productivity and/or should they be equally compensated for by higher wages when unsolved? The empirical literature so far has indeed been silent[4] on whether better workplace environment –and if so, precisely which dimensions of the "workplace environment"– leads to a better firm productivity, and whether workplaces where work environment is perceived more hazardous than in others are more likely to pay employees a job hazard premium. A priori, one can for instance envisage at least two channels through which good health and safety conditions at the workplace could be improving firm performance: on the one hand, the employee pool would likely be more satisfied/enthusiastic and hence directly more productive at the job and/or the firm would be more able to retain the most productive employees[5], while on the other hand, there will be less problems related to absenteeism due to job-related illnesses and diseases, which again might indirectly translate in better firm performance. As stated earlier however, it is ultimately an (so far, unanswered) empirical question whether in practice the reasoning above is confirmed and if so, to what extent; i.e. whether improvement in all, or perhaps only in some of the specific workplace conditions implies higher marginal firm productivity.

To the best of our knowledge, there have not been so far any studies explicitly analysing determinants of workplace health and safety conditions or the impact of such workplace practice on firm productivity and/or wages, in country-wide representative datasets. The few studies that come somewhat close to ours in terms of focus, though only indirectly address our concerns, are case studies such as Katz et al (1983), who analyse the relationship among plant–level measures of industrial relations performance, economic performance and quality of working life programs, among plants within a division of General Motors, or Gittel et al (2004), who investigate the link between quality of labor relations (understood

[4]A legitimate concern would also be the precise theoretical connection between workplace environment conditions and firm performance. While this has not been modeled explicitly in the existent literature, what we have in mind here is a similar mechanism as that between various (general) organizational change proxies and firm performance, obviously inheriting all analogous problems related to endogeneity and reverse causality.

[5]Ample evidence showing that employee attitudes influenced by workplace organization can have significant efects on economic outcomes appear in several papers. One such recent study is for instance Bartel et al (2003).

as union representation), shared governance, wages and firm performance, in the airline industry. More generally, there is also a large, ongoing, literature focusing on the impact of firms' industrial resource management system and general reorganization therein, on firm financial performance; e.g., a number of recent studies conclude by promoting the advantages of using high involvement or high commitment human resources practices (e.g. Osterman, 1994; Gittleman et al. 1998 and Batt, 2002). A few other studies have found empirical links between the use of such practices and overall firm-level performance (e.g. Huselid, 1995; Osterman, 2000; Cappelli and Newmark, 2001; Caroli and Van Reenen, 2001; Guthrie 2001), while yet others have gone in more detail, but narrowed the scope of their analysis to particular industries (Batt, 1999; Ichiniowski et al., 1997; Ichiniowski and Shaw, 1998). Finally, a number of recent papers have used individual worker data to study the relationship between new workplace practices and workplace safety and health (Askenazy, 2001; Brenner et al., 2004; Askenazy and Caroli, 2006).

In terms of research methodology, Black and Lynch (2001) is the most related study to our paper; they estimate an augmented production function that incorporates variables reflecting work reorganization and firm specific aggregate employee characteristics, next to classical production inputs. While Black and Lynch apply their methodology to investigate workplace reorganization affecting firm productivity, we adapt it for specific improvement in workplace environment health and safety indicators, looking at effects both on firm productivity and on the firms' mean wages[6]. As in Black and Lynch (2001), we have survey data for the workplace environment explanatory variables and independently measured, objective, further firm-specific explanatory and explained variables.

The first part of the empirical analysis consists in estimating binary outcome (logit) models of general and specific work environment quality indicators on several aggregate employee characteristics, as well as on proxies of good practice in terms of work environment, such as e.g. having written work environment rules or offering work environment training courses for all employees. This gives an idea of which such variables are mostly associated with good work environment outcomes, e.g. in the spirit of Osterman (1994), who looked at the association between firm characteristics and human resource reorganization. The second, and main, part of our analysis consists in estimating standard Cobb-Douglas production functions, augmented with employees' aggregated characteristics such as e.g. proportion of females, proportion of unskilled workers, average human capital in the firm, and the specific work environment indicators. The longitudinal dimension of the register firm data enables us to estimate these augmented production functions in two simple steps, using either fixed firm effects (FE) or system-generalized method of moments (GMM) estimations in the first stage, where we only work with the production inputs and aggregate employees' characteristics, and ordinary least squares (OLS) of the mean residuals resulting from the first stage on the cross-sectional work environment indicators, in a second stage. This closely follows the strategy set out in Black and Lynch (2001), allowing us to address eventual endogeneity biases due to unobserved time-invariant firm heterogeneity and simultaneity of classical inputs and output in the production function. Analogous to the estimation of the production functions, we also investigate the explanatory power of work environment conditions and other employee aggregate characteristics in accounting

[6] Another recent study that succesfully applies the methodology in Black and Lynch, to study the productivity impact of shop-floor employee involvement, is Zwick (2004).

for between-firm mean wage differentials, using firm fixed effects estimation in a first stage, and a second stage that uses the average residual from the first stage regressed on the workplace condition indicators. A major improvement relative to Black and Lynch (2001) is that in our dataset we observe all firm and employee characteristics over time, and not only the evolution of the firm production inputs, and that we can also proxy for likely time-variant unobservables such as managerial ability, which might otherwise remain correlated with the work condition indicators in the second stage OLS estimation, by instrumenting for changes and lagged levels of the proportion of managerial positions over time.

The main findings of our study can be summarized as follows. In terms of firm characteristics associated with good work environment outcomes, the following factors are found to have explanatory power in accounting for the variation in the workplace conditions among firms: the proportion of managerial positions, all-employee work environment courses offered in the firm and, to less extent, the proportion of female employees in the firm's workforce and prioritizing work environment practice at the firm. These variables are statistically significant and of expected signs for several of the specific workplace environment indicators. More important, in terms of effects of work environment indicators on firm performance, our results suggest that only improvement in some of the physical dimensions of workplace environment, specifically "internal climate" and respectively, "repetitive and strenuous work activity" (positively) impacts the firm aggregate productivity. At the same time, the only workplace health and safety condition with explanatory power in the between-firm mean wage differential is the "internal climate", suggesting a compensating wage differential story.

The remainder of the paper is organised as follows. The data and Danish institutional context are overviewed in the following section. In Section 3. we put forward the empirical specification and estimation results for determinants of good workplace conditions. Section 4 contains the main analysis, the impact of the workplace environment on firm performance, both in terms of firm productivity and firm aggregate wage. Section 5 briefly summarizes and presents some concluding remarks.

2 Data description and the Danish context

2.1 Denmark and workplace conditions

Studying Denmark in the workplace environment context turns out a very sensible thing to do. First, Denmark tops the OECD charts on job satisfaction of employees with their work conditions, as shown in Figure 1, reproduced from the online statistics source on job quality of the "Canadian Policy Research Networks"[7]. At the same time, Denmark is a country with a very generous social safety net (and publicly funded universal health care system) and might thus be argued to be very vulnerable to externalization of the costs of occupational-related risks/injuries from the employer to the society[8]. Dorman (2000) states for instance that "[i]ronically countries with highly developed public welfare programs are more vulnerable to cost externalization, since these programs either pool risks

[7] The exact web address is http://www.jobquality.ca/indicators/international/satisfaction_main.shtml

[8] We are not aware of attempts to decompose the burden of the job-related injury and disease costs on shares of various societal agents for other countries than the US, where Leigh et al (1996) estimate that, out of the approx. 3% of the GDP that is translated in such costs, 11% falls on the employer, 9% on the consumer and 80% on the worker.

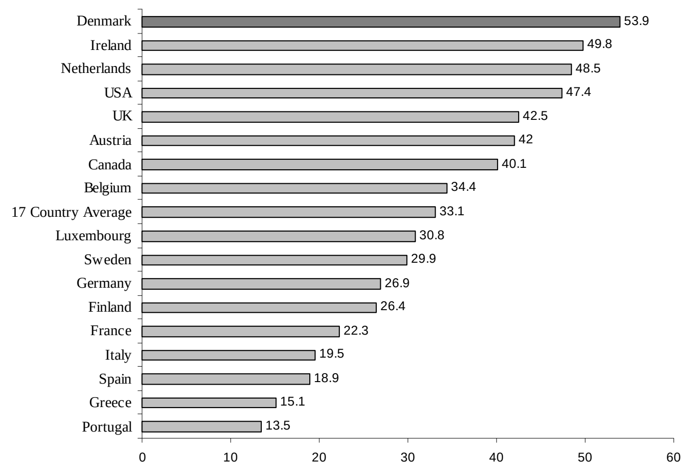

Figure 1: Percentage of workers that report being "very satisfied" with working conditions in their main paid job, by country

(dissipating the risk to the individual enterprise) or transfer a portion of the burden to taxpayers. An example would be publicly funded health care systems, which absorb much of the cost of occupational accidents and diseases". However, in terms of estimated total costs ("aggregate economic costs") of occupational-related injury and disease, although these are very high in absolute terms, Denmark does not fare too badly in comparison to other OECD countries– and in particular relative to its Scandinavian neighbours– as seen from Figure 2 below, reproduced from Beatson and Coleman (1997), with the US estimate from Leigh et al (1996). Finally, a huge deal of attention has been given and continues to be given to enhancing workplace conditions in Denmark, on the policy stage. For instance, explicit targeting of improvement in both psychosocial and physical workplace conditions has been recently topping the agenda of both the Danish Ministry of Labour and the Danish Working Environment Authority[9], see also Hasle and Moller (2001).

2.2 Overview of the datasets

We use three distinct datasets, which we match based on the *firm (business unit) identifier*. The matching procedure, resulting data selection and structuring of the data is described in detail in the Appendices. Here we overview and give the essential information about the data; descriptive statistics of the variables used in the final working dataset are presented in Table 1.

First, we make use of the "Company Surveillance Data" (referred to as VOV, its Danish acronym, throughout the rest of this paper), a 2001 survey on detailed workplace health

[9] The Working Environment Act (1999) introduces for instance several concrete measures aimed at improving the workplace environment, e.g. unannounced screening of all Danish enterprises within a period of seven years, obligation for companies to assess their workplace conditions in the firm at least every three years, obligation for enterprises to seek for professional advice in workplace environment related matters etc.

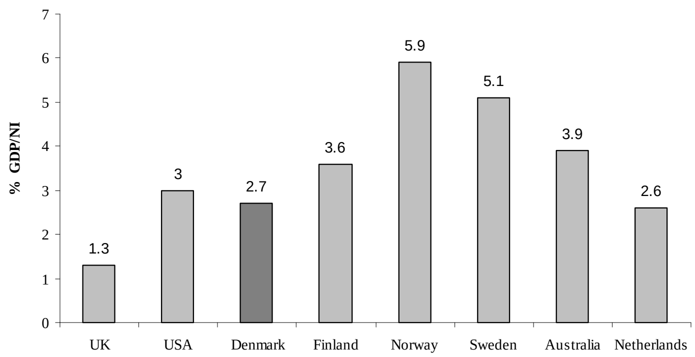

Figure 2: Estimates of aggregate economic cost of occupational injury and disease (%), by country

& safety conditions and work environment practice, in a representative sample of Danish establishments within the private sector. The data covers information on subjective, general and specific, working environment status, and on various actions taken to address working environment problems. These answers are provided by a health and safety representative of the employees in each of the plants in the sample[10] and were collected by persons specially trained for this type of surveys, from the National Institute for Occupational Health (AMI) in Copenhagen. Among the specific workplace dimensions covered we count problems related to "chemical loads", heavy lifting", "repetitive and strenuous work", "psycho-social" issues, "internal climate", "accidents and danger of accidents". Among the "work environment actions" undertaken, the representatives of the companies report on the firm's link to any formal occupational health and safety institute, whether the firm has a written working environment policy, whether general or specific work environment courses have been offered to the employees etc. A detailed discussion on the construction of the work environment indicators from the original questionnaire is presented in Appendix A1. Although the VOV is collected at the establishment level, we are able to link it to the employer-employee and firm business account datasets only via the firm identifier, which means that we will be limiting our empirical analysis to firms with a single establishment. The summary statistics table below contains therefore information on the sample of the mono-plant firms. In Appendix A3. of this paper we show that the industry and geographic distribution of the firms with a single plant remains very similar to the initial dataset covering also the firms with more than one plant.

The second database used in this paper is the "Integrated Database for Labor Market

[10] In Appendix A2. we mention that we have two independent measures for each of the work environment indicators, given that both a health and safety representative from the side of the employees, and a health and safety representative from the managerial side, were asked to answer the work environment questionnaire. Analogous to Bloom and van Reenen (2006), we note that our two independent measures for the specific workplace conditions have a fairly high correlation, which suggests that there isn't much bias in the individual answers. As explained in more detail in this Appendix, we choose to use for the empirical analysis the answers of the employees' health and safety representatives, given that there is somewhat more variation in these (the managers' representatives tend to rank work conditions as "good" or "very good" more often).

Research" (IDA henceforth), constructed by Denmark Statistics from a variety of data registers used for the production of official EU and Denmark aggregate statistics. This data has been used and described in several previous studies, including Mortensen (2003), Bingley and Westergård-Nielsen (2003) or Buhai et al (2008). In a very brief depiction, IDA allows for matching of workers at establishments (local entities) and of establishments to firms (legal entities). It tracks every single work establishment and every single individual between 15 and 74 years old in Denmark. Apart from deaths and permanent migration, there is no attrition in the dataset. IDA is collected as of 1980 and includes detailed individual demographics such as gender, age, level of education, labor market state, experience, earnings, occupation, marital status etc.; other individual characteristics such as worker tenure can be reliably constructed, even if not present in the initial IDA. The labor market status of each person is recorded at the 30th of November each year. On the side of the employers, we have information on plant and firm employment size, region of firm location and industry category[11] and we can reliably construct a lower bound for the age of the firm (equal to the longest tenure among all of its employees). In this paper the information from IDA is used for constructing employee aggregate characteristics at the firm level, such as proportion of certain employee groups (i.e. proportion of females, unskilled, managers), mean and variance of education levels overall and per group, mean and variance wage in each firm, and the firm demographics indicators mentioned above.

Finally, we make use of a third dataset, on the firms' financial accounts. The statistics of business accounts (REGNSKAB henceforth), compiled by Denmark Statistics, cover construction and retail trade from 1994; the coverage was extended to manufacturing from 1995, to wholesale trade from 1998, and to the remaining part of the service industries from 1999 onwards. These statistics are aggregations of items of the annual accounts of business enterprises, notably items of the profit and loss account, the balance sheet and the statement of fixed assets. For the purpose of this paper we are specifically interested in the reported values for sales, capital stock and intermediate inputs (materials). There are several ways through which the statistics in REGNSKAB are gathered. The most thorough coverage is applied to firms that are selected for direct surveying; each year these are all firms with more than 50 employees plus the firms with profits higher than a certain threshold, while smaller firms are included based on a rotation scheme. The firms are given the choice of either filling in a lengthy questionnaire or submitting their annual accounts plus detailed specifications. The questionnaire is modelled on the list of items set out in the Danish annual accounts legislation, so as to facilitate responding. The resulting data for the direct-surveyed firms are highly reliable. The other very reliable part of REGNSKAB is obtained from the tax forms submitted by firms, detailed enough for our purpose here. The rest of the data (typically the smaller firms - accounting for less than 20% of total turnover in the typical year) is obtained by stratified imputation based on employment size groups, with the method yielding results in large margins of error. For our paper we use therefore only firms directly surveyed and the firms where information has been obtained

[11] In our empirical analysis, we use the following broader industry indicators: 1. Agriculture & Mining; 2. Manufacturing; 3. Electricity, gas and water supply; 4. Construction; 5. Wholesale and retail trade; repairs 6. Hotels and restaurants; 7. Transport, storage and communications; 8. Financial intermediation; 9. Real estate, renting and business activities; 10. Public administration, defense and social security; 11. Education; Health and Social Work; 12. Other community, social and personal service activities

from their tax forms, implying again some data loss when linking to the other datasets. See Appendix A4. for an overview of the data loss due to the merger. For means and standard deviations of the variables of interest in the merged working dataset see the lower panel in the summary statistics table below.

Having overviewed the data, we stress that the *objective* variables in the two (independent) official datasets, IDA and REGNSKAB, are thus completely different in terms of source than the *subjective* workplace indicators contained in the VOV survey. This is a clear bonus vis-à-vis much of the earlier literature that used subjective measures of both dependent and independent variables, typically gathered from the very same respondents.

Table 1: Descriptive statistics VOV, IDA and REGNSKAB 2001

variable	definition	mean	s.d.	N
	VOV2001			
GENWE	work environment standard at the company is 5=VG,4=G, 3=NB, 2=B, 1=VB	3.86	.68	449
HLIFT	1 if problems related to heavy lifting have been solved, 0 otherwise	.76	.43	448
REPWO	1 if problems related to repetitive and strenous work have been solved, 0 otherwise	.78	.41	442
CHEM	1 if problems related to chemical loads have been solved, 0 otherwise	.88	.33	441
NOISE	1 if problems related to noise causing deafness have been solved, 0 otherwise	.77	.42	444
YOUNG	1 if problems related to young people's work have been solved, 0 otherwise	.94	.24	436
PSYCH	1 if problems related to psychological conditions have been solved, 0 otherwise	.78	.41	439
ICLIM	1 if problems related to internal climate have been solved, 0 otherwise	.71	.45	441
ACC	1 if problems related to accidents or danger of accidents have been solved, 0 otherwise	.80	.40	441
COURS	1 if courses with general work environment content have been held at the firm, 0 otherwise	.24	.43	426
ACTWE	1 if action plans have been drawn up to solve the work environment problems, 0 otherwise	.57	.49	437
PRIWE	1 if work environment problems have been prioritised to be solved, 0 otherwise	.68	.47	441
WRIT	1 if the firm has a Written Work Environment Policy, 0 otherwise	.32	.46	363
	IDA			
pfem	women as a proportion of all employees	.25	.26	572
pturn	employees with tenure less than two years as a proportion of all employees	.21	.22	572
punsk	unskilled as a proportion of all employees	.10	.19	572
pman	managers as a proportion of all employees	.078	.15	572
educ	average years of education among all employees	12.22	1.58	572
fsize	number of employees in the firm	49.37	96.09	572
agefirm	age of the firm	12.05	9.38	572
wage	mean wage in the firm	171.48	35.7	565
	REGNSKAB			
capital		15780.5	42698.6	465
sales		72639.3	190177	465
materials		54673.6	170577.6	465

3 Which are the factors associated with a good work environment?

In this section we focus on analysing the firm characteristics that may be correlated with the quality of the work health and safety environment in that firm, in other words we are investigating what differentiates firms with good workplace environment from the rest of the firms. To that aim we estimate different models that use alternative dependent variables as measure of the firm work environment quality. Our empirical methodology is analogous to Osterman (1994), who investigated the factors associated with the establishments' adoption of innovative work practices. Consider the following equation

$$WE_i = \alpha + \beta X_i + \gamma Z_i + \varepsilon_i \tag{1}$$

where WE_i represents the indicator of work environment health and safety quality for the ith firm, X_i is a vector of average firm and employees characteristics, Z_i is a vector of work environment actions that can improve workplace conditions and ε_i is an error term. Definitions and descriptive statistics for the variables used in our final specification can be found in Table 1 above.

We estimate logit models using both the general and all the specific work environment indicators. In all the estimations we transform the coefficients so that they have a direct interpretation, ie. we report the marginal change in probability of the specific work environment indicator being 1, given a one unit change in the independent variable[12].The first binary outcome model we estimate is contained in Table 2 (column1); the dependent variable is *GENWE*, an indicator taking value 1 if the "general work environment standard" at the company is "very good" or "good" and respectively 0 if it is "not bad", "poor" or "very poor"[13]. The only variable statistically significant at conventional significance levels is COURS[14], possibly suggesting that firms that held general courses with work environment content, with all the firm's employees, are more likely to increase the employees' awareness with respect to the work environment and thus ultimately obtain a better work environment compared to those that did not hold such courses. However, we cannot give a causal interpretation to this result, aiming only to emphasize the statistical association in this exercise.

Columns (2) to (9) in Table 2 show estimates for a series of logits in which the dependent variables refer to specific work environment problems, with 1 if the specific condition "has been solved" and 0 otherwise. Most of the regressors take expected signs, but few are significant. The first covariate which is statistically significant is the log firm size: the larger the firm size the less likely are those firms "characterized by a good work environment", ie. having solved work environment related problems. The simple straightforward explanation for this result is that larger firms typically experience, in *absolute numbers*, more work environment related problems than smaller firms.[15].

[12] The transformation is standard: $\frac{\delta p_i}{\delta x_{ij}} = p_i(1-p_i)\beta_j$ with $p_i = \frac{e^{x_i'\beta}}{1+e^{x_i'\beta}}$; this expression is evaluated at the mean probability in the sample.

[13] We estimated also an ordered probit model with the dependent variable taking 5 values from "very good" to "very poor" and the results were qualitatively the same.

[14] Not shown in the estimates table for conserving space, the age or industry of the firm does not, surprinsingly, have any explanatory power in this general between-firm work environment differential either.

[15] This would be consistent with earlier literature where small and medium enterprises are the ones ex-

The somewhat unexpected outcome is the importance the "proportion of managers" seems to have for several of the specific workplace health and safety indicators. In 3 equations (corresponding to HLIFT, REPWO and PSYCH) the coefficient on "*pman*" is positive and statistically significant, i.e. a higher proportion of managers in the firm is positively associated with better work environment in terms of heavy lifting, repetitive and strenuous work and psycho-social issues.

The variable COURS is again statistically significant for REPWO and NOISE and correlates positively with a good workplace environment, while the estimated coefficient on *pfem* is positive and significant for YOUNG suggesting that firms with a higher proportion of females in the workforce are less likely to face problems connected with young employees. Finally PRIWE, prioritizing work environment in the firm, is found positive and significant for the solution of problems connected to the internal climate[16].

An interesting remark is that many other aggregate firm characteristics (some of them not mentioned in the summary statistics table above for space reasons) do not have any power in explaining the between-firms workplace environment differential. What is perhaps most surprising is that such covariates like the proportion of "turnover employees"[17], "having a written working environment policy", "mean education of managers" , "mean experience of the managers" (both these latter ones potentially proxying manager ability), "mean tenure in the firm", "variance in the age composition", "average firm tenure" or experience, are not statistically significant [18].

The findings from our specifications above suggest that there are only a couple of robust variables positively associated with most specific measures of good workplace environment. Namely, these are the higher proportion of managers and respectively, offering courses with work environment content. To less extent, the proportion of females within the firm and prioritizing work environment practice in the firm also seem to explain across-firm differences in some of the work environment dimensions. If we are willing to speculate somewhat, our conclusions herein could be interpreted in the sense that the higher proportion of managers being positively associated with better workplace conditions indicates the beneficial effect of managerial involvement in workplace environment related issues and, analogously, that raising employee awareness by means of work environment related courses can also raise workplace conditions. In fact, these two factors could well be complementary within a firm, as supported for instance by studies such as Kato and Morishima (2002), who pro-

periencing greater occupational safety and health problems *relative* to larger enterprises, see for instance Dorman (2000). This is for instance because often the improvement in workplace environment has substantial overhead costs and the smaller the firm, the smaller the revenue base over which these costs can be distributed; moreover, the formal work environment structures (eg. safety groups) and level of expertise in general is usually lower in smaller firms; finally, the market for SME's is usually more competitive, with finance more difficult to obtain, thus implying lower investment in general and particularly fewer expenditures on "non-essential" items.

[16] As in the case of the general work environment indicator above, the age of the firm is not found significant for any of the work environment specific dimensions. However, as expected, there are industry differences in this case. For instance the baseline category, agriculture, is clearly the worst in terms of "heavy load" problems, while chemical loads are worst for the manufacturing category etc.

[17] As defined in Table 1, in our data *pturn* represents the employees with tenure less than two years, as a proportion of all employees (hence, employees who just entered the firm and are observed for the first time in the data).

[18] Results for all alternative models using these variables are available on request from the authors.

vide evidence on the association between top-level management and shop-floor employee participation in workplace organization decisions.

Table 2: Logit estimates of work environment on firm characteristics in 2001, marginal effects

	GENWE	HLIFT	REPWO	CHEM	NOISE	YOUNG	PSYCH	ICLIM	ACC
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
pfem	.083	.041	.140	.035	-.025	.066*	.023	-.195	.225
	(.119)	(.131)	(.118)	(.038)	(.076)	(.036)	(.121)	(.137)	(.165)
punsk	-.0007	.205	-.184	-.016	.163	-.051	.026	.195	-.118
	(.148)	(.179)	(.165)	(.057)	(.128)	(.065)	(.134)	(.199)	(.139)
pturn	-.020	-.030	.137	.004	-.044	-.023	-.207	-.219	.003
	(.150)	(.125)	(.146)	(.051)	(.091)	(.032)	(.134)	(.166)	(.141)
pman	.049	.640**	.654**	.074	.191	.129	.676**	.139	.309
	(.204)	(.310)	(.302)	(.079)	(.141)	(.101)	(.294)	(.259)	(.235)
educ	.014	-.008	.010	-.015	.012	-.001	-.004	-.027	.001
	(.019)	(.021)	(.022)	(.012)	(.012)	(.007)	(.023)	(.026)	(.026)
log fsize	-.019	-.110***	-.076***	.001	-.041***	-.008	-.091***	-.091***	-.078***
	(.023)	(.026)	(.024)	(.007)	(.015)	(.006)	(.024)	(.026)	(.026)
COURS	.194***	-.069	.103*	.020	.082**	-.025	-.023	-.023	-.037
	(.056)	(.060)	(.059)	(.015)	(.033)	(.016)	(.055)	(.062)	(.052)
WRIT	.059	.080	.017	-.016	.040	-.002	-.026	-.031	.051
	(.062)	(.063)	(.067)	(.015)	(.036)	(.015)	(.062)	(.063)	(.058)
ACTWE	.089	.053	.090	-.010	-.022	-.002	-.016	-.129	.061
	(.067)	(.070)	(.079)	(.017)	(.047)	(.017)	(.074)	(.085)	(.064)
PRIWE	.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 parantheses. Estimations also include a constant term, regional and industry dummies and dummies for firm age categories, ie. age 0-5, 5-10, 10-15, 15-20, with the baseline 20+

4 Impact of work environment on firm performance

4.1 Impact on firm productivity

In the second part of the paper we are first interested in the determinants of the firm's total factor productivity, focusing on the role of the workplace's health and safety environment. To that aim, we will be estimating standard Cobb-Douglas production functions, augmented with the firm specific workplace environment indicators used as dependent variables in the binary outcome regressions from the previous section, and with employee aggregate characteristics. Our analysis largely traces the two-step empirical strategy by Black and Lynch (2001), technique that has also been recently used in a related context by Zwick (2004). Namely, although VOV is cross-sectional, we can make use of the information compiled from IDA and REGNSKAB for previous years as well, and hence are able to estimate three distinct specifications for the production function.

The simplest specification is using only the cross-sectional sample with all variables, i.e. estimating the following OLS regression:

$$\ln(Y/L)_i = c + \alpha \ln(K/L)_i + \beta \ln(M/L) + \delta X_i + \gamma' Z_i + \varepsilon_i \tag{2}$$

with c a constant term, Y/L sales per firm size, K/L capital per firm size, M/L intermediate inputs (materials) per firm size, vector X containing the firm specific characteristics of employees and vector Z containing our establishment specific workplace practices [19]. We use the stock value of capital K and intermediate materials M reported in the REGNSKAB database[20]. The results of the estimation above are reported in column(1) of Table 3. All the OLS estimations control also for location, industry and age of the firms.

Since our cross-sectional estimates from (2) may be subject to endogeneity due to unobserved heterogeneity in the firm characteristics that above is all captured by the error term ε_i, we exploit further the fact that we observe the IDA and REGNSKAB datasets of our firm aggregate variables over time, in order to eliminate any unobserved *time-invariant* firm fixed effects, and use the residual from the first stage, averaged over time (ie. the time-invariant component of the residual), as dependent variable in a second stage OLS regression on the 2001 cross-section of work environment indicators[21]. The empirical specification in this case is given by:

[19] We verify that the constant returns to scale restriction is not rejected in our data. Unlike Black and Lynch(2001), we cannot clearly distinguish between "production" and "non-production" workers in our data, hence we will use the general specification using all the firm's labour force.

[20] K is computed by adding the intangible and tangible fixed assets; M is calculated as sales minus value added, using the value added formula provided provided by Denmark Statistics.

[21] Just like in Black and Lynch (2001), in the first stage we have the option of using all the available observations (including observations for establishments with missing information on certain work environment indicators in the 2001 cross-section) or just the observations from the establishments used in the second stage. Since results are identical with either alternative (less so the magnitude of the standard errors in the first stage regression, but they do not affect the statistical significance interpretation of the point estimates for any of our variables), we report the 1st stage results for the larger sample.

$$\widetilde{\ln(\frac{Y}{L})}_{it} = a\widetilde{\ln(\frac{K}{L})}_{it} + b\widetilde{\ln(\frac{M}{L})}_{it} + c\widetilde{X}_{it} + \widetilde{\nu}_{it} \text{ (step1)} \quad (3)$$
$$R_i = d + e'Z_i + \xi_i \quad \text{(step 2)}$$

where R_i is the (time) average of $R_{it} \equiv \ln\widetilde{(Y/L)}_{it} - \widehat{a}\ln\widetilde{(K/L)}_{it} - \widehat{b}\ln\widetilde{(M/L)}_{it} - \widehat{c}\widetilde{X}_{it}$

where the upper tilde means that we use deviations from the means over time[22]. Note that we differ already slightly from Black and Lynch (2001), in that we also observe the firm aggregate employee characteristics over time, and thus can use them as well in the first stage regression. The values for sales, capital and materials were deflated using the net price index provided by Denmark Statistics, with a base year of 2000. In the reported results we use $t = \overline{1998, 2001}$, since this is a very likely period over which the work environment indicators are not expected to vary[23]. However, varying the time period by including also earlier periods (earliest available is 1994, but that includes very few establishments also observed in 2001) or using less lags does not affect the qualitative interpretations of the results. The results of this second empirical strategy are presented in column (2) of Table 3.

Although the specification from (3) above would take care of any time-invariant firm effects that could be correlated with the choice of inputs in the first stage, the typical simultaneity problem in choosing the production inputs or the measurement error in the explanatory variables (capital and materials) has still not been dealt with. The pitfall in production function estimation, known since Marschak and Andrews (1944), is the endogeneity of input choices in the production function, given their likely correlation to unobserved productivity shocks, c.f. Griliches and Mairesse (1998). To address that, analogous to Black and Lynch (2001), we exploit the fact that we can observe all variables (except the ones from the VOV dataset) over time, to apply a system-GMM estimation à la Arrelano and Bover (1995) and Blundell and Bond (1998, 2000) in the first stage, and to subsequently use the averaged residuals over time from this first stage as dependent variable in a second stage, as an OLS on the vector Z, containing the work environment indicators. This approach involves estimating the 1st stage from expression (3), without the upper tilde on the variables, by using appropriately *lagged values of both levels and changes* in capital, material, labour and output, as *instruments for levels* of capital, material and labour. Furthermore,

[22] We assume that ν_{it} is a disturbance with 0 mean, so that taking deviations from the average over time eliminates or considerably reduces its contribution to the residual.

[23] A provision in the Danish Work Environment Act states that workplace assessments shall be undertaken "at least every 3 years", which suggests that 1998-2001 is a likely period on which to expect workplace indicators not to change much. This expectation is enforced also by the fact that another question in the VOV questionnaire, asking about the last time a work environment assessment was implemented and what types of problems were found at that time, suggests that 60 to 80% (depending on the specific work environment indicators) of the observed work environment indicators do not change since the last assessment (there are many missing values however). Moreover, most previous work environment assessments, if the question on the timing is answered (many missing values however also here), are indeed reported to have been implemented in the interval 1998 to 2001. Note that the length of this time period is shorter than in the case of work reorganization measures as analyzed in Black and Lynch (2001, 2004). This is not unusual, given the faster expected impact of changes in workplace environment conditions than that of crucial changes in the organization of the entire production process, for instance.

as a plus relative to Black and Lynch (2001), given that the proportion of managers in a firm was strongly associated with a firm having a good workplace environment for most workplace indicators (see the previous section), we are also instrumenting with lagged levels and changes of that variable; this proxies for the time-varying "managerial ability" that might still remain correlated with the work environment indicators in the final stage of the estimation procedure. The estimates of this latest strategy are presented in the third column of Table 3, where again we use time lags down to 1998, as in the fixed-effects strategy from the previous column. We first check that the conditions for applying the system-GMM are in place: the validity of the instruments and respectively, the assumption of no serial correlation in the levels error term ν_{it}. According to the Sargan-Hansen test for overidentifying restrictions, we do not reject the validity of our instruments at conventional statistical levels. We also do not reject the null hypothesis of no serial correlation in ν_{it}; since the reported LM tests are performed for the differenced residuals $\Delta\nu_{it}$, cf. Arrelano and Bond (1991), we are interested in confirming the absence of the second order serial correlation, whereas the negative first-order serial correlation is consistent with our specification, see also Dearden et al (2006).

What can be learnt from the estimations in Table 3? Firstly, whether we instrument the proportion of managers GMM-style (the reported estimate in the table is for this case) or we do not, does not influence at all the results; hence, time-varying managerial ability (at least as proxied by proportion of managers over time) does not appear to matter in this production function estimation. Secondly, a number of results are completely consistent with the findings in Black and Lynch (2001). Thus, we notice that our point estimate for K/L increases from the 1st (simple OLS) to the 3rd 2-stage (OLS+ system GMM) estimation strategy, as expected, suggesting that indeed the latter empirical specification accounts to some extent for the fact that in the previous two strategies the estimates were more tainted by measurement error[24]. Next, we also find that only the "proportion of turnover employees" is statistically significant and of the expected sign, among our common aggregate worker characteristics in the production function estimates. Also consistent with Black and Lynch (2001), most of the results concerning the effect of aggregate employee characteristics are qualitatively and quantitatively robust over both the FE and system-GMM specifications in columns 2 and 3. Finally, what can we say in terms of the impact of the workplace health and safety environment, our main concern? In both the fixed effects and the system-GMM specifications we find that the only work environment actions that matter are having solved "internal climate problems" and respectively, having solved problems concerning the "repetitive and strenuous work", both having rather large marginal contributions relative to the other production inputs. This suggests that these two physical dimensions of the work safety and health environment tend to be critical for the firm's total factor productivity, while psycho-social dimensions as well as other work environment criteria such as general work environment status, do not seem to contribute at all to enhancing firm performance.

[24] Our point estimate for K/L is still on the low end of what is found in the literature, even when using the sys-GMM. Using a back-of-the-envelope computation, our estimates would suggest that capital accounts for roughly 1/4 of value added (sales minus intermediary material costs) and labour for the rest. There are however also other papers that have found even lower capital intensities in such augmented production frameworks, using the same system-GMM technique, see for instance Zwick (2004).

Table 3: Augmented production functions

	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)
pfem	.002	-.053	-.053
	(.106)	(.053)	(.053)
punsk	-.262**	-.022	-.013
	(.111)	(.033)	(.036)
pturn	-.138	-.082***	-.096***
	(.130)	(.021)	(.035)
pman	.329	.017	.127
	(.217)	(.075)	(.187)
educ	.002	-.006	.003
	(.016)	(.006)	(.008)
Nobs 1^{st}stage		1627	1627
Sargan			χ^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	
WRIT	.021	.018	.011
	(.031)	(.030)	(.029)
COURS	.044	.043	.040
	(.035)	(.034)	(.034)
ACTWE	.004	-.0006	.022
	(.047)	(.048)	(.046)
PRIWE	-.030	-.028	-.029
	(.046)	(.047)	(.046)
HLIFT	-.021	-.035	-.041
	(.044)	(.044)	(.044)
REPWO	.070	.094**	.092**
	(.045)	(.042)	(.042)
CHEM	.074	.058	.059
	(.073)	(.063)	(.063)
NOISE	-.008	.010	.006
	(.035)	(.031)	(.030)
YOUNG	-.022	-.043	-.043
	(.047)	(.041)	(.040)
PSYCH	-.025	-.013	-.012
	(.036)	(.037)	(.035)
ICLIM	.041	.074**	.080**
	(.037)	(.031)	(.031)
ACC	.011	-.008	-.015
	(.036)	(.031)	(.030)
R^2	0.920	0.225	0.242
Nobs	215	215	215

Significance levels: *** 1%,**5%, *10%; White heteroskedastic-consistent standard errors in parantheses. Estimations also include a constant term, regional, industry indicators and dummies for age categories of the firm. For the 1st stage FE and GMM regressions we also control for interaction between year and industry dummies. 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 brackets, after the test coefficients

4.2 Impact on mean wages

The other indicator for "firm performance" that we are going to look at in this study is the firm's mean wage, a classical proxy for the employees' welfare. This is obtained from IDA, averaging over the hourly wages of all workers in the firm[25].

We are interested in the extent to which differentials in mean wages offered by the firms are explained by work environment conditions and by other aggregate employee characteristics. Comparing the mean wages of firms that implement good work health and safety practice to those that do not directly by nonparametric propensity score matching– previously used in the literature in similar contexts, e.g., Janod and Saint-Martin (2004)– is not feasible here given the rather low sample sizes of our working datasets. Hence, we will implement two simple strategies using log mean wage as dependent variable, following the methodology used in the previous subsection, on firm productivity. The first method is to use OLS in the cross-sectional 2001 sample, while the second consists in exploiting the fact that we observe variables obtained from IDA over time, and hence we can use that information to develop a 2-stage estimation analogue to the second estimation strategy from the previous subsection, where in the first stage we recover a firm fixed component of the residual and we use it as dependent variable in the second stage, with the workplace environment indicators as independent variables. The second strategy takes care of any unobserved time-invariant firm heterogeneity that might be correlated with the firm specific characteristics. The above can be written as

$$\text{OLS: } \ln(Y)_i = c + \acute{\alpha} X_i + \beta' Z_i + \varepsilon_i \tag{4}$$

$$\begin{aligned} &\text{2-stage, FE+OLS:} \\ &\widetilde{\ln(Y)}_{it} = \acute{a}\widetilde{X}_{it} + \widetilde{\nu}_{it} \quad \text{(stage 1)} \\ &R_i \equiv d + b' Z_i + \xi_i \ \text{(stage 2)} \\ &\text{with } R_i \text{ the (time) average of } R_{it} \equiv \widetilde{\ln(Y)}_{it} - \widehat{a}\widetilde{X}_{it} \end{aligned} \tag{5}$$

where c and d are constant terms, vector X collects the firm specific characteristics, vector Z contains the work environment proxies, v is a time-invariant firm effect and ε, ν and ξ are error terms. Y is mean wage. $\widehat{a}$ is the estimated value of a from the first stage. The upper tilde indicates that we take the deviations from the means over time[26]. All OLS estimations control for regional, industry and age of the firm indicators.

The estimates for logwages as dependent variable are in Table 4; the first column contains estimates of the OLS, the second contains estimates of the two-stage FE+OLS estimation.

What is the interpretation of the log wage regression estimates? First, there are some differences between the cross-sectional estimates and the estimates using the 2-stage strategy

[25] We take care of the outliers in wages by trimming the top 1 percentile of the cross-sectional wage distribution and truncating all reported wages below the legal minimum wage, in each year. For the empirical specifications where we use different time periods, we deflate wages with the consumer price index (using 2000 as base year).

[26] We use 1998-2001 as the time period in the reported estimates, although the results are virtually identical when we vary it, including less or more lags (earliest possible being 1994).

Table 4: Mean logwages and work environment

	OLS 2001	2-stage FE+OLS
	(1)	(2)
		1^{st} stage
pfem	-.212***	-.159***
	(.051)	(.048)
punsk	.102	.015
	(.057)	(.035)
pturn	.022	-.0004
	(.054)	(.016)
pman	.335***	.012
	(.092)	(.053)
educ	.051***	.038***
	(.009)	(.006)
Nobs 1^{st}stage		2095
		2^{nd} stage
WRIT	.020	.026
	(.023)	(.023)
COURS	.018	.020
	(.020)	(.020)
ACTWE	-.009	.018
	(.028)	(.023)
PRIWE	.022	.015
	(.033)	(.028)
HLIFT	.029	.015
	(.022)	(.021)
REPWO	-.035	-.011
	(.022)	(.021)
CHEM	-.004	.026
	(.034)	(.027)
NOISE	-.011	-.015
	(.022)	(.022)
YOUNG	.054*	.024
	(.032)	(.030)
PSYCH	.019	.034
	(.023)	(.022)
ICLIM	-.020	-.040*
	(.023)	(.024)
ACC	.030	.019
	(.026)	(.025)
R^2	0.491	0.323
Nobs	295	295

Significance levels: *** 1%,**5%, *10%; White heteroskedastic-consistent standard errors in parantheses. Estimations also include a constant term, regional, industry indicators and dummies for age categories of the firm. For the 1st stage FE regression we also control for interaction between year and industry dummies.

(the effect of the aggregate employee characteristics is identified from variations over time in this latter case, since they are included in the first stage). Thus, "proportion of managers" is significant in first column, but ceases to be significant when we use the 2 step FE+OLS technique from the 2nd column; there is a similar case with having "problems related to young employees" (YOUNG). Since the second stage takes into account possible unobserved time-invariant heterogeneity in the employee characteristics that could be correlated with the workplace environment indicators, we prefer the 2-step specification. Other conclusions are carrying over from the 1st to the 2nd column and confirm pervasive results throughout the empirical literature: a higher proportion of female employees is strongly associated with a lower mean wage at the firm, while a higher mean employee education translates in higher firm mean wages. Could there be any compensating differentials story to be told? In the cross-section OLS estimation none of the work environment indicators turns out to matter, except YOUNG (with a positive sign), but that becomes statistically not different from 0 in the second column. However, in our preferred 2nd column of estimates, having solved "internal climate" conditions, is associated with a lower wage, which might indicate the fact that bad internal climate is compensated for by higher mean wages. Quite surprising is that none of the other work environment indicators or other employee aggregate characteristics appears to explain the mean wage differentials across firms.

5 Summary and discussion

This is the first paper to investigate which are the firm characteristics associated with a good workplace health and safety environment and what is the impact of such good work environment practice on firm performance, both in terms of total factor productivity and firm mean wage. We have merged Danish data from three independent sources to investigate: a. which aggregate employee characteristics can explain the between-firm differential in workplace environment and b. what is the impact of improving workplace conditions on firm productivity and firm wages. Our findings suggest, on the one hand, that few factors are associated with a good work environment practice, but that those found relevant are important across several work environment indicators. The main factors are the proportion of managers and respectively, courses with work environment content offered to all the employees. The first factor might suggest that high management involvement is important, while the second might indicate the role the employees' awareness plays, in enhancing workplace conditions. Other factors that seem to matter less are the proportion of female employees and prioritizing work environment practice at the firm. On the other hand, we have found that the explanatory power of work environment related practice in explaining between-firm wage differentials is rather low. Once we control for industry, regional and firm age effects, the only work environment dimension accounting for a compensating wage differential story is the internal climate at the workplace. The conclusion regarding the importance of this physical dimension of the workplace environment is consistent also in the light of the firm productivity estimates. According to the results from the production function estimations, the work environment related factors that contribute to enhancement of firm productivity are having solved problems related to "internal climate" and respectively, to "repetitive and strenuous work", both with relatively large marginal contributions to enhancing firm productivity.

As Black and Lynch (2001), we are aware that neither of our 2-step methods can fully account for possible endogeneity of the work environment indicators in the production function: some time-varying unobserved heterogeneity correlated both with firm profits and work environment indicators could, theoretically, still bias our final estimates. However, in practice, it is not easy to think of a clear source for such further omitted variable bias: in addition to the careful methodology borrowed from Black and Lynch, we have also fully exploited the fact that in our data we observe all aggregate employee characteristics over time. In particular we have been able to instrument the current proportion of managers in our system-GMM procedure with its changes and lagged levels, which could be thought of as proxying time-varying managerial ability of the firm.

It will be interesting to see similar future studies using different datasets and comparing their findings to the ones in this paper. In particular, ideally one would like to be able to use longitudinal observations also on firm workplace health and safety conditions, next to observing all other firm characteristics over time. Given the enormous aggregate costs of job-related accidents and illnesses in all developed nations, it is obvious that corporations, trade unions and policy agents should all be very interested in the outcomes of such research, hence we do not expect to remain the only paper in this area for long.

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A Data selection and structuring

A.1 Construction variables VOV

The main dataset in the merging procedure is VOV. Herein we describe the construction of the variables in this dataset.

The key variables of interest are working conditions indicators constructed from the questionnaire; these indicators cover aspects such as physical, psychological strain and danger of accidents.

A set of dummies regarding specific work environment problems is created, that take value 1 if the firm indicates that the "majority" of problems have been solved and value 0 if "few" or " none" problems have been solved[27]. These variables are developed from the question " To what extent problems related to heavy lifting (*HLIFT*)/ repetitive and strenuous work (*REPWO*)/ chemical loads(*CHEM*)/ noise causing deafness (*NOISE*)/ problems in connection with young people´s work (*YOUNG*)/ psycho-social conditions[28](*PSYCH*)/ internal climate problems and accidents (*ICLIM*)/ accident or danger of accident (*ACC*), have been solved ?". On average, about 75% of firms report that the majority of the specific work environment problems have been solved.[29]

A subjective "general work environment status" indicator GENWE is constructed from the question "What do you consider the work environment related standard to be at the company? very good/good/not bad/poor/very poor", and takes value 1 if the general work environment standard at the company is very good or good and value 0 if it is not bad, poor or very poor.

Another set of dummy variables describes various actions undertaken in connection with the work environment, such as WRIT, which is derived from the question "Does the company have a written work environment policy?yes/no/don´t know)"; COURS, "Has the company\workplace held courses, project days, seminars or similar events for its employees where the work environment has to a greater or lesser extent been included as a subject? yes/number of events in the last year/no/don´t know"; ACTWE "Have you drawn up action plans to solve the work environment problems?yes/no/don´t know" and PRIWE, "Have you prioritised the work environment problems that are to be solved?yes/no/don´t know".

[27] We note here that we do not know precisely *when* these problems have been actually solved, hence we cannot perform, e.g., an analysis of changes in firm performance on changes in these indicators, since we cannot know which lagged time period to use in order to compute changes in firm performance (or other firm characteristics). What we know from another question in this survey is that the last workplace environment assessment took place within the last three years for most firms in the sample (there is also a Danish organic law that states that these assessments should be done at least every 3 years) and that at this last assessment some of these problems were reported not to have been solved (20 to 40% depending on the precise workplace indicator); unfortunately we have too many missing observations in order for an empirical analysis using changes in the workplace indicators from the last assessment (whenever that was) to be feasible.

[28] From conversation with the people who designed the VOV questionnaire we know that "psycho-social" conditions are meant to include issues such as pressure of time, lack of influence, work times, working alone, perceived violent/uncooperative environment etc.

[29] For mono-plant firms only we get the same proportion, compare e.g. Table 1.

Table 5: Differences between types, all plants

GENWE	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	

A.2 Employee representative vs. employer representative in VOV

The VOV 2001 questionnaire is asked to both one safety group representative of the employees ("type 1") and one safety group representative of the employer ("type 2"), for each establishment, so that the initial data contains two observations for each establishment surveyed. The first selection step is that we only keep the answer of the employees' safety representatives and we 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 slightly higher than 0.50). Our decision is mainly motivated by the fact that the variation in answers of type 1 is somewhat higher than the ones in type 2, with the latter tending to cluster around "very good" or "good" for most questions. Since the questionnaire related to health and safety assessment of the workplace, we believe the workers' answers to be the ones more reliable[30]. 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 5 present 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 an ordered variable defining the general work environment (*GENWE*), taking values that range from 1=very good to 5=very poor.

From Table 5 it appears clear that type 1 answers have more variance than type 2 answers[31], although the difference is lower for all of the specific work environment indicators. In fact, performing all our estimations with the answers of type 2 we get identical qualitative results, with the exception that in some cases the statistical significance is lost if using the employer representative's answers[32].

[30] One rationale for that is the fact that previous research has clearly documented that employee attitudes at the workplace can have significant impact on economic outcomes at those firms, see for instance Bartel et al (2003); hence, we would precisely like to use the answers of the employees' safety and health representative for our investigation.

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

[32] We also note here that an empirical strategy in which one would instrument one of the measures with the other one, is not directly feasible given that we deal with ordinal (and mostly binary) indicators here, as well

Table 6: 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	

A.3 Mono-plant firms vs. multi-plant firms in VOV

Given that we have to match the datasets on the firm identifier, we select only firms that have a single establishment (plant) for the rest of the analysis. How representative does this sample remain of the private Danish sector in terms of geographical and industry distribution? The two tables below show respectively the distribution by industries, Table 6., and the distribution by regions, Table 7., for both the initial sample of all plants and the working sample of mono-plant firms. We notice 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: for "real estate" where the proportion of plants decreases from 4.3% of the total sample, initially, to 2.4%, in the working sample, and especially for the private firms operating in the" 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.

A.4 Data loss in merging VOV-IDA-REGNSKAB

We face some unavoidable sample reduction during the merging procedure, which we briefly 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, as explained earlier in these Appendices).

known in the econometrics literature. Moreover this strategy would be dubious as well, in the light of our goal: if anything, it is likely that eventually both these measures would be correlated with some unobserved time-varying measure of managerial ability, and thus, with firm performance and hence the validity of the instrument is not met.

Table 7: 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	

- We need to find the firm identifier for most of the initial establishments, since these were often sampled in the dataset only by their name and that string was sometimes entered only partially in the database etc. This was done (by a very tedious manual work performed by very patient student research assistants) using an auxiliary business statistics dataset (known as KØB), matching names to firm identifiers. We were not able to find the firm identifier for 490 of the initial establishments.

- We need to use only mono-plant firms in merging to IDA and REGNSKAB, since we do not have establishment identifiers in VOV to match directly with establishments in IDA and since in REGNSKAB we have of only business account statistics at the business unit, that is the 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.

- For the production function estimation we use all the available observations in VOV-IDA-REGNSKAB, while for the impact on mean wages, we use all the available observations in VOV-IDA. In the empirical analyses we end up de facto with even smaller sample sizes, given that many of our variables used in the estimation have missing observations.