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A register-based analysis of Nordic enterprises





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Preface

Globalisation pressures and demographic trends affect the chances of the Nordics to be prosperous and indirectly threaten the welfare states as we know them. These pressures and trends underline the twin challenge to the Nordics of productivity stagnation and a decreasing work force. A contribution to an answer to both challenges can be an increase in productivity and new ways to increase the work force.

A good work environment can do both: If less people have to take sick leave as result of bad work environments, this will contribute to increasing the work force. Also, for some time, a relationship between work environment and productivity has been hypothesised. Happy, healthy workers, in short, are more productive than not-so-happy and not-so-healthy workers are.

Therefore, the main objective of the Nordic Council of Ministers co-operation in the area of working environment is to promote health and welfare at work and thus productivity in society.

In this context, the Nordic Council of Ministers has initiated a project aiming at clarifying the impact on productivity of work environment and well-being in companies. This report presents an empirical analysis measuring the coherence between working environment and productivity in the Nordic countries. The report state that we do in fact find a positive coherence between improved working environment and productivity and the result is consistent across the Nordic Countries.

As far as we know, this is the first analysis that tests the relationship between working environment and productivity. At least when using large scale datasets being representative for individuals and enterprises in the four Nordic Countries. With its focus on working environment and productivity, this report contributes to the scarce empirical literature on working environment, work wellbeing and productivity.

Since data has not been collected for this purpose, and as challenges have been met with regards to matching data at company level, the results should not be seen as conclusive in any way. In order to do more thorough studies across the Nordic countries, there is a need to harmonise data at individual level.

This is an explorative analysis and we are in unexplored territory. As such, this report should not be seen as conclusive in any way. The au-

thors hope that the report will spur an interest and inspire further investigations of the subject. It should be stressed that non-results in this analysis can not be considered a negative results. A non-results only implies that we could not establish a either positive or negative correlation in the models.

The project, funded by the Nordic Council of Ministers, was conducted by a group of experts, consisting of

- Otto Melchior Poulsen, The National Research Centre for Working Environment (Denmark).
- Guy Ahonen, Työterveyslaitos/Finnish Institute of Occupational Health (FIOH), Finland.
- Steinar Asnaess, STAMI, Norway.
- Ulf Johansson professor at Mälardalen University, Sweden.
- Jan Mouritsen (CBS, Denmark), in co-operation with the research based Scandinavian consultancy DAMVAD. We would like to thank the participating experts for their valuable contributions. Any omissions or misunderstandings remain the sole responsibility of DAMVAD.

Summary

This report provides the final report for measuring the relation between a good working environment and productivity. It thus completes a three year research project focusing on the possible connection between working environment, work wellbeing, and productivity.

With its focus on working environment and productivity, this report contributes to the scarce empirical literature on working environment, work wellbeing and productivity. As far as we know, this is the first analysis that tests the relationship between working environment and productivity using harmonized register-based and survey data from the four Nordic countries and applying micro-econometric techniques to the data.

The applied data was collected for other purposes and, thus, the analyses must be seen as a first take on testing whether or not there is indeed a relationship between working environment and productivity (and whether or not it is a positive one). Thus, it should be stressed that a non-result does not equal a negative result. As such, this can be seen as an explorative study, exploring the possibilities of actually linking data on working environment and work wellbeing with register data on productivity in enterprises.

The main results of this report are:

Working environment/work wellbeing is positively correlated to productivity.

We show that physical working environment is an important, statistically significant predictor of productivity. This result is robust to various empirical specifications in Denmark and Sweden, the two countries in which national data protection regulations do not prohibit the matching of individual-level information on working environment with company-level information on productivity and other company-level characteristics, and thus allow us to harmonize data at individual level.

In Norway and Finland we also identify that *physical working environment is an important, statistically significant predictor of productivity*. However, in Norway and Finland data regulations prohibit the matching of information on individual-level working environment and company-level performance. Thus the analysis is performed at sector level and shows similar results.

The fact that physical working environment and productivity are found to be positively related in all four countries, also after adjusting for a range of other productivity-related factors such as educational level and capital intensity, provides support in favour of the Becker-Huselid hypothesis.

Working environment/work wellbeing may interact with the level of education in affecting company productivity

In Sweden, a strong interaction is found between the level of education and physical working environment. This is not too surprising, as one could hypothesise that the importance of physical working environment varies between different educational qualifications. However, the same result does not appear in the Danish context, where data also allows for testing of the interaction hypothesis at company level.

In the cases of Norway and Finland, we find – as in Denmark – that there are no differences between working environment/ work wellbeing and productivity at different levels of education.

Psychosocial working environment does not seem to be strongly related to productivity

In Sweden and in Denmark, only in one case do we find a positive relationship between psychosocial working environment and productivity. This is a somewhat surprising result, as factors such work-life imbalances and work-related “stress” are included in the concept of psychosocial working environment as defined here – and since it is easy to see how work-related “stress” could affect and hamper productivity.

The result might be explained with the level at which data is collected. Psychosocial working environment is closely related to the individual person, whereas physical working environment is related to groups within the company or the whole company. We might see huge variation in personal perceptions of psychosocial working environment, but at company level the differences even out. Thus, a non-result here cannot be interpreted solely as a negative result, but as much a question of how data is collected. Thus, we can neither confirm nor reject a correlation between psychosocial working environment and productivity.

As for the Norwegian case, we cannot find any significant correlation at all. Identical non-results are found in Finland. Again it is important to stress that these non-results are not the same as negative results last section contains the appendix as well as references and a summary in Danish.

Sickness absence is negatively correlated with company-level productivity

In Norway, we have had the possibility to test whether sickness absence is correlated with productivity. We find a strong negative and correlation between sickness absence and company-level productivity. Even when we include year dummies in order to take into account the development of productivity over time, we still find a strong negative correlation. Thus, one can argue that lowering sickness absence will have a positive impact on productivity, even though we do not test for causality.

This report delivers a first statistical piece of empirical evidence on which to base the assertion that working environment and productivity are in fact related. The analysis *tests* the relationship across the *four Nordic countries of Denmark, Sweden, Norway, and Finland*. Since data has not been collected for this purpose, and as challenges have been met with regards to matching data at company level, the results should not be seen as conclusive in any way. In order to do more thorough studies across the Nordic countries, there is a need to harmonise data at individual level. This calls for relaxation of the legislation in Finland and Norway to allow academia to analyse micro-level data. Further, stronger coherence in measuring work wellbeing across the Nordic countries will improve the possibility for more comparative analysis across the Nordic countries. Finally, there is a need for stronger focus on the causality between working environment and productivity. The question of causality, along with the question of drivers, should be investigated further in studies to come.

This is an explorative analysis and we are in unexplored territory. As such, this report should not be seen as conclusive in any way. The authors hope that the report will spur an interest and inspire further investigations of the subject.

1. Introduction: Working environment and productivity – partners in the Nordics?

Working environment and productivity are usually perceived as two opposites. On the one hand, many practitioners and researchers consider working environment as an extra, resource-consuming, non-productive activity, which managers dislike because of the lack of production stemming from it. On the other hand, some argue that productivity and the urge to increase productivity is the major source of malfunctioning working environment, because it raises the bar of what is expected of workers without necessarily giving them extra means or resources to handle this.

However, working environment and productivity are not *necessarily* conflicting. Whether or not they are in fact counterparts is an empirical question. That empirical question is exactly what this report sets out to answer.

Taking its point of departure in the theory of Becker and Huselid (1998), this report builds on a theoretical model, which assumes a positive relationship between working environment and productivity. Using *register-based* and *survey data* from the four Nordic countries of Denmark, Sweden, Norway, and Finland, this model is tested empirically and we test whether or not working environment and productivity are counterparts.

The report is the culmination of a three-phase project, financed by the Nordic Council of Ministers, and led by DAMVAD. Phases one and two set up the analytical framework of the empirical model. Phase 1 built up the theoretical model and identified relevant indicators of working environment and productivity. Phase 2 focused on the collection of register-based data, with information about enterprises' financial performance and survey data, as well as measuring the working environment in the four Nordic countries (Denmark, Sweden, Norway, and Finland).

With its focus on working environment and productivity, this report contributes to the scarce empirical literature on working environment,

work wellbeing and productivity. As far as we know, this is the first analysis that tests the relationship between working environment and productivity using harmonized register-based and survey data from the four Nordic countries and applying micro-econometric techniques to the data.

Leading Nordic experts on working environment and productivity also joined the project, namely Ulf Johansson (Mälardalens Högskola, Sweden), Steinar Aasnaes (STAMI, Norway), Otto Melchior Poulsen (NFA, Denmark), Jan Mouritsen (CBS, Denmark), and Guy Ahonen (FIOH, Finland). We would like to thank the participating experts for their valuable contributions. Any omissions or misunderstandings remain the sole responsibility of DAMVAD.

The remainder of the report is organised as follows: Section 2 describes the theoretical model in further detail, while section 3 describes the approach of the project. Sections 4–7 present data and results for each of the four Nordic countries. Whereas the last Section contains the appendix.

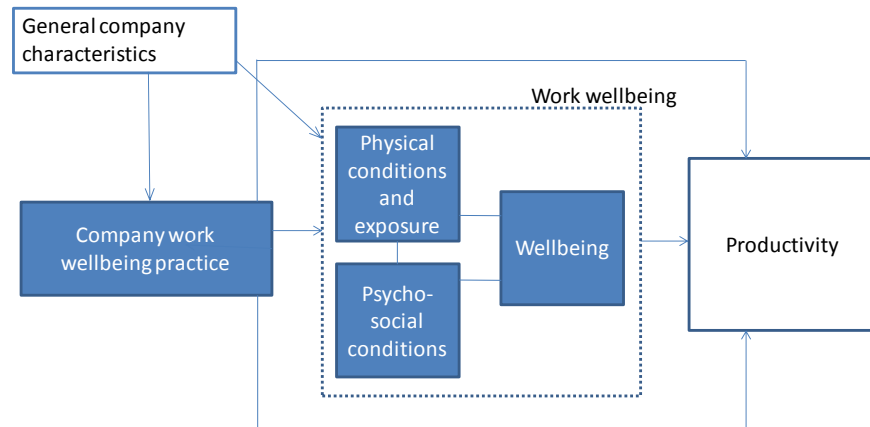
2. Theoretical model

The theoretical model was developed during phase 1 of this project. This report merely presents the basic idea of the model – see <http://www.norden.org/da/publikationer/publikationer/2011-569> for a more thorough discussion of the model, the concepts of physical and psychosocial working environment and work wellbeing.

The basic hypothesis of the model is that improving the work wellbeing of employees will increase productivity because improving wellbeing at work reduces risks, uncertainty, hostile conditions, injuries, toxic exposures, and sickness absence, which all move resources away from work tasks into unproductive actions.

According to Becker and Huselid, improving the work wellbeing of workers pays off, because it gives a strategic advantage to the company (Becker & Huselid 1998).

Chart 2.1 Overall model for company practice, work wellbeing and productivity



Source: DAMVAD and expert group, 2011.

One result – if this model stands and is proven empirically – is that enterprises can actually improve productivity if they improve the working environment and work wellbeing of their employees. We will test this hypothesis in this report. Although we are not able to test the causality, we will test the correlation between working environment and productivity.

We exploit the richness of data in the Nordic countries. The model allows for including general company characteristics. This is done in order to isolate the effects of adjustments in work wellbeing initiatives and, thus, make sure that observed changes in productivity are not an effect of a change in exports, R&D level and the educational level of the employees or other factors which usually affect productivity.¹

2.1 Definitions

Definitions of the concepts in the theoretical model, i.e. physical conditions and exposure, psychosocial conditions, and wellbeing, as well as company work wellbeing practice were discussed at length in “Measuring Work Wellbeing and Productivity in the Nordic Countries”. Therefore, definitions are merely repeated in the present report:

- The physical working environment of the employee includes the overall health and safety of the employee including the identifiable workplace, causes of accidents and illness.
- The psychosocial working environment of the employee includes, among other things, a set of job factors related to the interaction between people, their work and the organisation.
- The wellbeing of the employees is conceptualised here as the more explicit results of the working environment, that is, work-related injuries, work-related diagnoses, illness/sickness, etc.

In the appendix we present the individual national indicators composing the index of physical working environment, psychosocial working environment and wellbeing. The indicators have been identified through the work launched in previous phases of the project. The three different indexes are presented in the following.

¹ These are common growth drivers when focusing on endogenous growth theory (Romer 1994) assuming growth to be the result of endogenous forces such as knowledge, technology and human capital. The empirical models includes as many growth drivers as possible, but we have not been able to include export and R&D.

2.1.1 *The physical working environment index*

Physical conditions and exposures constitute a central part of work wellbeing that affects employees' psychosocial and physical health.

Indicators included in the working environment index

Indicator
Physical conditions
Light
Noise
Temperature
High repetition of motion
Work involves simultaneous lifting and sub-optimal movement/positioning
Work involves static load on muscles
Exposure
Production or use of certain chemicals
Exposure to smoke, dust, fumes (skin contact/breathing/eye contact)
Production using technical equipment and machinery
Work includes risk of falling from heights
Work includes traffic risk

Source: DAMVAD and expert group, 2011.

2.1.2 *The psychosocial working environment index*

Psychosocial conditions also constitute a central part of work wellbeing and affect employees' psychosocial and physical health. Here, the psychosocial indicators are tentatively divided into three categories, namely influence, demands, and work-reward balance and leadership. This section draws on the collection of indicators across six countries made available by courtesy of Aasnaes. Many of the indicators in this section coincide in topic with the indicators of "company practice". However, the indicators below primarily measure how the psychosocial conditions are *experienced by employees*, whereas the indicators above in the company practices section measure what the company does and does not do. Hence, the important difference is one of level: company practice is at company level, whereas psychosocial conditions are taken to be at the individual or employee level.

Indicators included in the psychosocial working environment index

Indicator**Influence**

Freedom to decide one's own work tasks
Framework allowing deliverance of the same quality as desired by oneself
Freedom to organise the day, including breaks

Demands

Work at high speed
Large work load
High cognitive demands

Work-reward balance and leadership

Clarity of expectations in work
Trust and respect from leadership
Predictability of work
Work-reward balance

Source: DAMVAD and expert group, 2011.

2.1.3 The wellbeing index

The work wellbeing indicators measure the “result”/output/effect in terms of the state of the workers’ health and safety in a broadly defined context. This can be done on the basis of two main categories of indicators:

- Fact-based indicators, that is, indicators that measure the state of work wellbeing in an “objective” manner.
- Self-reported indicators, or “subjective” measurement of work wellbeing.

Indicators included in the wellbeing index

Indicator**Health**

Annual number of work-related diagnoses
Annual number reporting sick or ill
Long-term sickness
Mortality rate
Average retirement age
Number of recipients of benefits due to being unfit for work
Stress
Depression

Safety

Work-related injuries
Self-reported work-related health problems
Work-related deaths

Source: DAMVAD and expert group, 2011.

3. Approach

The overall research project was split into three phases. The present report being the product of phase 3 of the project.

In phase 1, the theoretical model for the analysis of the relation between working environment, wellbeing, and productivity was created, as well as a thorough indicator and data manual for the measurement of working environment and wellbeing.²

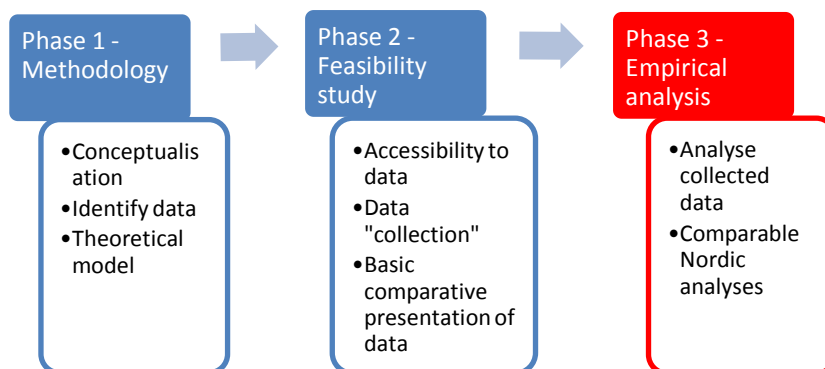
In phase 2, the project uncovered available data in the four countries and made this available to analyse. In the case of Finland, DAMVAD received working environment data at aggregate level courtesy of FIOH, and at company level characteristics were analysed on location at Statistics Finland. In the case of Sweden, the data was analysed via an internet connection to Statistics Sweden provided for DAMVAD by Statistics Sweden. For Norway and Denmark, data was analysed via an internet connection to Statistics Denmark, to whom Statistics Norway delivered relevant data.

² See "Measuring Work Wellbeing and Productivity in the Nordic Countries" at <http://www.norden.org/da/publikationer/publikationer/2011-569>

In phase 3, this data was analysed, and the results are presented in the present report.

The three phases are depicted in figure 3.1 below.

Chart 3.1 The three phases of the project



Source: DAMVAD, 2012.

3.1 Phase 1 – Indicators of working environment

In Phase 1, the project group consisting of Nordic experts on working environment and DAMVAD developed a conceptualisation of working environment and wellbeing to ensure a common understanding of these important concepts. Further, the theoretical model already presented was developed. Finally, data-enabling analysis in the four Nordic countries was identified and described in a data measurement, indicator and “how to measure” manual. Also, data quality was assessed in this manual with regards to its relevance, accuracy, availability, and cross-country comparability. The assessment of quality and relevance was a consequence of the diversity of data measuring work wellbeing and working environment.

There is quite a large amount of data, especially from surveys used for measuring different aspects of working environment in the Nordic countries. Yet there is no data linking working environment to productivity. This project and the data used helps shed light on the effects of working environment and general wellbeing in Nordic enterprises. This

can be done, because workplace is identifiable (in Denmark and Sweden). In Norway and Finland, identifying the workplace does not conform to national data disclosure regulations, and the analyses have to be performed at a more aggregate level.

Phase 1 resulted in:

- Description of the relevant concepts, i.e. working environment, occupational health, and work wellbeing.
- Development of the theoretical model presented above in chart 2.1, describing the relationship between working environment, wellbeing, and productivity.
- An indicator manual, identifying indicators for working environment (physical working environment, psychosocial working environment, and work wellbeing).
- A description of existing Nordic data available to measure these factors.
- The conclusion that it was in fact possible to find data covering the different aspects of the model presented in chart 2.1

The report containing the results of phase 1 of the project is available for download at <http://www.norden.org/da/publikationer/publikationer/2011-569>

3.2 Phase 2 – Data acquisition

In phase 2 of the project, actual data availability was identified as part of testing the feasibility of the planned study. Also, data was collected (or arrangements were made for the data to be made available). Finally, basic comparative presentation of the data was made. This report has not been published as an independent piece of work, since phase 2 to a large extent consisted of the *process* of collecting the relevant data. Therefore, phase 2 is described in somewhat more detail in the following.

The data “collected” was either made available directly on location at the central statistical bureaus, via internet connections to the central statistical bureaus, or it was indirectly available via Statistics Denmark.

There are different ways in which data can be made available and there are different criteria which have to be met in the four countries. Below is a description of the following elements for Denmark, Sweden, Norway and Finland:

- Data owners.
- Formal requirements for access to data.
- The access to data.

3.2.1 *Linkable and non-linkable data*

There is one very important difference between the data made available in Denmark and Sweden and the data made available in Finland and Norway. Because of national data-disclosure regulations in Finland and Norway, it is not possible to match individual-level information about working environment to company-level information on productivity, company characteristics, etc.

Obviously, when individual-level data on working environment and company-level data on productivity are not linkable, it is not possible to relate the (individually reported) information on working environment to productivity. Thus, it is not possible to analyse the relation between these variables at company level.³

3.2.2 *The general accessibility of data*

The relevant data can be grouped into six different areas, as indicated in the figure below. The six areas are:

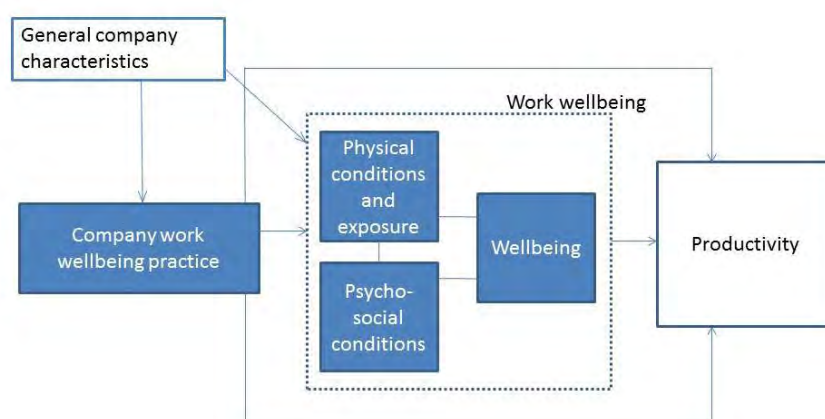
1. The general company characteristics, e.g. covering sector and number of employees.
2. Company work-wellbeing practice identified at company level.
3. Physical conditions and exposure, including the overall health and safety of the employees, see appendix 10.1 for a full list.
4. Psychosocial conditions, including a set of job factors related to the interaction between people, their work and the organisation, see appendix 9.1 for a full list.

³ This is the case in Norway and Finland. Our solution is to aggregate company level data from our different sources of data. Then we use the aggregated level of data to run the analysis.

5. Work wellbeing covering work-related injuries, work-related diagnoses, illness etc., see appendix 9.1 for a full list.
6. Productivity covering the value added per employee and following the OECD manual for measuring productivity. We use the capital-labour multi factor productivity measure based on value added.⁴ This will usually be identifiable using a company registration number, whereas the work wellbeing factors will be identifiable using civil registration number of the respondents.

Whereas company characteristics, company work-wellbeing practice and productivity are identified at company level, the various working environment indicators are identified at individual level. The model presented aggregates the information at company level.

Chart 3.2 The cohesion of different sources of information



Source: DAMVAD and expert group, 2011: Measuring Work Wellbeing and Productivity in the Nordic Countries – A Manual.

It has been possible to acquire various amounts of relevant data for each of the different countries. In the table below, an indication of data availability is given. We have given the data a mark depending on the following three levels. For each level where we can access data we provide the country with a “+” mark:

⁴ See OECD Productivity Manual, measurement of aggregate and sector-level productivity growth, OECD Manual 2001.

- General company characteristics, like sector, size etc.
- Productivity measures, hence financial information of the enterprise.
- Information regarding working environment.

In Denmark and Sweden, most relevant data is available and linkable (and, therefore, also available as “non-linkable data”). In Norway, data is not linkable, due to national data disclosure regulations. Likewise in Finland. This is reflected in table 3.1 below.

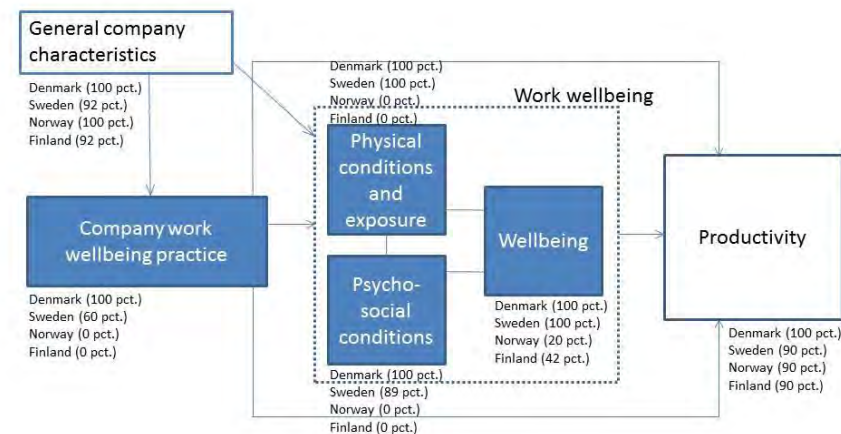
Table 3.1: The accessible data in the Nordic Countries

	Finland	Norway	Denmark	Sweden
Linkable	(+)	(+)	+++	+++
Non-linkable	+++	+++	+++	+++

Source: DAMVAD, 2012.

The more specific levels for the data acquisition at the linkable level are depicted in figure 3.3 below. For Norway and Finland, it is clear that linkable data is only accessible on factors regarding wellbeing, general company characteristics and productivity. For Sweden, the majority of the data is accessible as linkable data. For Denmark, all of the relevant variables are accessible as linkable data.

Chart 3.3 The acquisition of linkable data

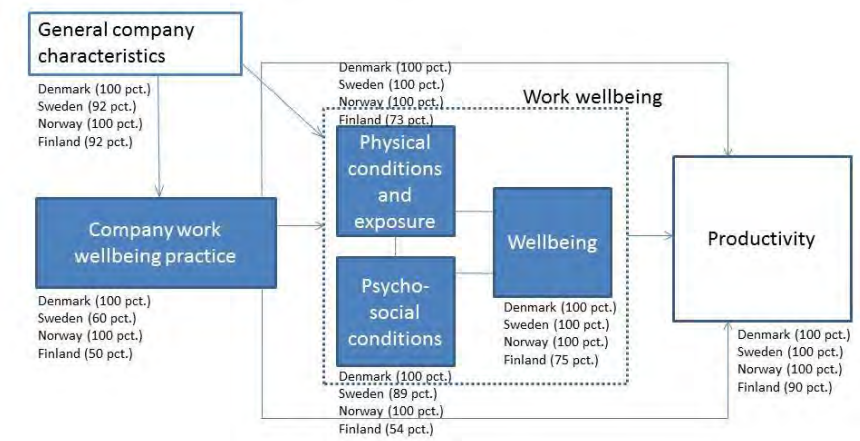


Source: DAMVAD, 2012.

The status on the acquisition of non-linkable data is shown in figure 3.4 below. The main difference here is that 100% of the Norwegian data can be acquired as non-linkable data, just as in Denmark – and that the Finnish data is accessible to a much larger extent than is the case with linkable

data. The majority of the data is made available in Sweden. In all of the groups no less than 60% of the indicators are available.

Chart 3.4 The acquisition of non-linkable data



Source: DAMVAD, 2012.

3.3 Phase 3 – empirical analyses

In phase 3, the data collected on basis of the theoretical model, and the indicators identified in phases 1 and 2, are used as the basis for empirical analysis.

As a result of data availability, two different approaches are followed for Denmark/Sweden and Norway/Finland: The relation between working environment and productivity is analysed using standard regression techniques (pooled OLS) in Denmark and Sweden, whereas the relation between working environment and productivity is analysed at a more aggregate level in Norway and Finland, where information on working environment at the individual level cannot be matched to company performance. Thus, in Norway and Finland, the relation between working environment and productivity is analysed at sector level (NACE08 3-digit level).

We use pooled OLS in Denmark and Sweden, because working environment data is available as repeated-measurement data in these two

countries. It is not, however, available as panel data,⁵ which would allow analysis of particular enterprises over time. Pooled OLS does not restrict the analyses from being conducted on the same specific enterprises – but it does utilise all the data available in estimating coefficients, including information about measurement times (year of surveying).

For the Finnish and Norwegian data, we use pooled OLS regression techniques as well. However, as a result of national data-disclosure regulations, these analyses cannot be conducted on company-level data. Instead, the analyses are conducted on sector level, utilising information on working environment, productivity, capital and labour intensity, etc. at sector level. Ideally, analyses would be conducted at company level for these two countries as well. However, given data accessibility, this approach still allows for conclusions to be made with regards to the relation between working environment and productivity at a more aggregate level.

In all cases, to analyse the role of working environment with regards to productivity, three indices were computed, reflecting the distinction in the theoretical model between physical working environment, psychosocial working environment, and work wellbeing. The indices were computed as additive indices on the basis of survey data, identified as part of phase 1 of the project as described above.

⁵ Panels or time series containing longitudinal data would have given us the possibility to have a stronger say about causality. If we had information regarding each company and person, this would have strengthened the analysis as we could have set up time series following the development and changes in productivity as well as work environment and work wellbeing over time. This would have given us a better foundation to include the question of causality in the analysis.

4. Denmark

4.1 Main results

The analysis covering Denmark is based on harmonized data sourced from the General Firm Statistics and the National Working Environment Cohort. Data covers 5,139 observations and represents all private sectors except from primary sectors such as agriculture, forestry and fishing. The main results from the analysis are:

- There is a strong positive relationship between physical working environment and productivity. This relationship is very robust and remains highly significant even when we add a range of controls such as time, sector and educational level among employees.
- The two other indices, psychosocial and wellbeing, are not significant in any specification of the model.
- There are no specific effects from different measures on the relationship between the working environment indices and productivity in terms of the share of employees in any specific educational group. This implies that neither highly educated employees nor less educated employees experience different effects from initiatives to improve the working environment or work wellbeing.
- Regressions for each line of sector show a positive, significant relationship between physical working environment and productivity for Trade and transport sector and in the Business service sector.

4.2 Outline of data

In Denmark, the analysis is based on financial key figures in the General Firm Statistics (FIRM) from Statistics Denmark. We harmonise this data with statistics from the National Working Environment Cohort (NAK) and from the National Research Centre for the Working Environment (NFA).

General Firm Statistics – FIRM

The General Firm Statistics contains information on enterprises in Denmark with at least five full-time employees a year. This information includes financial key figures on revenue, exports, number of employees, value added, and the sector of the company, etc. This information is based on information annually reported to the tax authorities (SKAT) by the enterprises.

The National Working Environment Cohort – NAK

The National Working Environment Cohort holds information on the working environment and health of Danes. The information contained here is based on survey data. The available data is collected every five years, meaning the present analysis uses data from 2005 and 2010.

In 2005, 20,000 respondents were selected to answer a survey on working environment and health. Almost 13,000 of these answered, and among these 11,000 were wage-earners.

In 2010, the survey was sent to 30,000 persons during September and October. Approximately 10,600 wage-earners and self-employed people responded to the survey.

4.3 Data coverage: coverage degree, representivity, etc.

In the years 2005 and 2010, the General Firm Statistics contains observations of a total of 591,966 enterprises. Enterprises which exist in both years enter the analyses with two observations – one for 2005 and one for 2010.

The population is restricted to solely include enterprises with a minimum of five full-time employee equivalents. This restriction is imposed because a certain number of employees is needed in order to consider working environment as a meaningful concept at company level and the data on very small enterprises is limited.

After restricting the dataset to only include enterprises with a minimum of five full-time employee equivalents (FTE), we end up with a total of 89,740 enterprises. This constitutes the population for which we need to add data on working environment from NAK as well as data on value added. When we merge the 89,740 enterprises with the enterprises present in NAK and restrict to enterprises with information on value added, we end up with a base population of 5,139 enterprises.

In the following, we examine data coverage and representivity of these 5,139 enterprises compared to the full population of 89,740 company observations. These are the enterprises with at least five full-time

employee equivalents, with information on value added and where at least one employee has answered the survey on working environment (the NAK survey).

The enterprises in the analysis cover 5.7% of the total number of enterprises. These are relatively large enterprises in terms of the number of full-time employee equivalents, as the analysis covers 18.4% of the total number of full-time employee equivalents, cf. table 4.1.

Table 4.1 Coverage degree, number of enterprises and FTE

	Population	Coverage degree	
	Number	Number	Percent
Enterprises	89,740	5,139	5.7%
Full time employee equivalents	4,966,495	970,540	19.5%

Source: DAMVAD, 2014. On basis of data from Statistics Denmark and the National Working Environment Cohort.

Note: The figures include observations from both 2005 and 2010 and hence an employee and a company can be counted twice. Enterprises with less than 5 FTE are not included.

The degree of coverage is not equally distributed across sectors. The analysis encompasses a very small part of the sectors Agriculture, forestry and fishing, Arts, entertainment and other services and Financial and insurance. The reason is that these sectors do not calculate value added, which is the core of our productivity measure. The sector Public administration, service and education is not included either, since there is no financial information available about enterprises in this sector. This is because enterprises in this sector do not operate on market conditions.

Thus, the primary reason for the moderate degree of coverage for these sectors is the limited possibility of obtaining a register-based measure of productivity. In addition, Agriculture, forestry and fishing is relatively poorly covered by the NAK survey in terms of number of enterprises.

The base population includes between 0 and 11% of the enterprises in each of the sectors.

Table 4.2 Degree of coverage on sector level, number of enterprises and FTE

	Total population		Degree of coverage, percent	
	No. of enterprises	FTE	Enterprises	FTE
Agriculture, forestry and fishing	2,546	27,789	*	1.2%
Sector, mining and quarrying and utility services	12,509	621,395	11.8%	56.2%
Construction	12,488	53,994	5.1%	24.7%
Trade and transport etc.	30,228	820,125	6.6%	42.1%
Information and communication	3,320	155,530	9.7%	60.5%
Finance and insurance	1,301	148,201	0.7%	0.3%
Real estate and rental services	2,115	36,410	3.6%	14.0%
Other business services	9,807	292,012	7.5%	41.4%
Public administration, service and education	10,292	0	0.0%	0.0%
Arts, entertainment and other services	5,089	107,470	0.5%	1.5%
No information	45	0	0.0%	0.0%
All sectors	89,740	970,540	5.7%	19.5%

Source: DAMVAD, 2014. On basis of data from Statistics Denmark and the National Working Environment Cohort.

Note: *= Discretionized because of few observations. Enterprises with less than 5 FTE are not included.

The enterprises in the base population are relatively large compared to the population as a whole, cf. table 4.3. Hence, the base population covers only 2.8% of the smallest enterprises with 5–25 full-time equivalents, whereas one in three of the largest enterprises with more than 1,000 full-time equivalents are represented in the base population.

Table 4.3 Degree of coverage on company size groups (FTE)

	Total population, no.	Degree of coverage, percent
	Enterprises	Enterprises
5 –25	73,094	2.8%
26 –50	8,569	10.0%
51 –250	6,368	23.8%
251 –1000	1,271	45.0%
1000 –	438	33.3%
All enterprises	89,740	5.7%

Source: DAMVAD, 2014. On basis of data from Statistics Denmark and the National Working Environment Cohort.

4.4 Representivity

Overall, the industrial distribution of enterprises in the analysis is in accordance with the distribution in the population cf. table 4.4. Thus, Construction constitutes nearly 14% of the population, whereas it constitutes 12.4% in the analysis. Trade and transport comprises 34% of the population, while nearly 38% of the enterprises in the analysis belong to this sector. In Real estate and rental services as well as Other business services, the representivity is relatively good. Nevertheless, there are sectors, which are

not equally well represented. Hence, Sector, mining and quarrying and utility services composes 27.6% of the enterprises in the regression – this corresponds to an over-representation of 13.7 percent points compared to the population as a whole.

Table 4.4. Representivity on sector level

	Total population	Enterprises in the regression
Agriculture, forestry and fishing	2.8%	-
Sector, mining and quarrying and utility services	13.9%	27.6%
Construction	13.9%	12.4%
Trade and transport etc.	33.7%	37.8%
Information and communication	3.7%	6.0%
Finance and insurance	1.4%	0.1%
Real estate and rental services	2.4%	1.5%
Other business services	10.9%	14.2%
Public administration, service and education	11.5%	-
Arts, entertainment and other services	5.7%	0.4%
No information	0.1%	-
All sectors	89,740	5,139

Source: DAMVAD, 2014. On basis of data from Statistics Denmark and the National Working Environment Cohort.

Note: Enterprises with less than 5 FTE are not included.

The representivity across size groups is challenged by the fact that the enterprises in the base population are relatively large measured in terms of the number of full-time equivalents. Hence, the group of enterprises with 5–25 full-time equivalents constitutes approximately 40% of the enterprises in the base population, even though more than 80% of the enterprises in the total population are in this group, cf. table 4.5. The other size groups with more than 25 full-time equivalents are over-represented compared to their shares in the total population. Nonetheless, the data still contains important information about the working environment and it is unique in that it is possible to harmonise different sources of data at micro level.

Table 4.5 Representivity on company size groups (FTE)

	Total population	Enterprises in the regression
5 –25	81.5%	39.8%
26 –50	9.5%	16.7%
51 –250	7.1%	29.5%
251 –1000	1.4%	11.1%
1000 –	0.5%	2.8%
All enterprises	89,740	5,139

Source: DAMVAD, 2014. On basis of data from Statistics Denmark and the National Working Environment Cohort.

4.5 Results

The following section presents the results of the Cobb-Douglas regressions using the data described previously in chapter 4.

In the basic model – the Cobb-Douglas model of production – we look at the correlation between capital and labour on the one hand and productivity on the other. The dependent variable is productivity measured as value added over full-time employee equivalents. We have three indices of working environment: physical, psychosocial and wellbeing.

The model including the indices for working environment and wellbeing was fitted with log-transformed indices. The theoretical background for this is that when the Cobb-Douglas production function is fitted, it is standard to assume log-linear relationships – that is, production (productivity) is in some way an exponential function of the factors introduced to the production. An argument to log-transform the indices is to interpret them as specifying the labour-input in the Cobb-Douglas production function indices.

The basic model

The first model in column one and two investigates the simple link between the indices and productivity, leaving out all controls but capital and labour. This model builds upon the theoretical relationship in the Cobb-Douglas production function. Capital and number of full-time employees are positive and significantly correlated with productivity. This is as expected according to theory, and we will not elaborate further on these findings.

Adding working environment, however, shows two very important results:

- Physical working environment is positively and significantly correlated with our measure of productivity.
- Psychosocial working environment and wellbeing do not seem to be related to productivity, as the estimates are insignificant. Yet this result should not lead to the conclusion that psychosocial working environment and wellbeing have a negative or non-effect on productivity. We just cannot state either a positive or negative relation to productivity.

A potential effect from the two insignificant indices could be suppressed in the first model, but should then be expressed when expanding the model to include different control variables. As the results will show, this is not true for the Danish case, and the results regarding the indices in the simple model are very robust and do not change, no matter which control variables we add to the regression.

We expand the model in steps, which will be explained in the following.

Education

Educational level is measured by the share of employees in four educational groups at company level. The share of unskilled workers is the reference group. In all models with educational level the results show a positive, significant contribution from education to productivity. The conclusion in relation to working environment is that:

- The physical working environment is still significant, although the size of the estimate is slightly reduced.
- The two other indices, psychosocial working environment and wellbeing, remain insignificant.

The fact that the size of the estimate for physical working environment is slightly reduced when controlling for education indicates that the educational level amongst employees is correlated with the physical working environment.

In table 4.7 we further elaborate our analysis of the effect of education and add interaction terms between each index and educational level. As the results show, we do not find any significance of the interaction terms, which means that it is not possible to divide the overall effect from working environment into specific effects for each educational group.

Table 4.7 Regression model with interaction terms

	Without index	With index
ln (capital per FTE)	0.0840***	0.0841***
ln (FTEs)	0.0293***	0.0292***
ln (physical index)		0.0957
ln (psychosocial index)		-0.0217
ln (wellbeing index)		-0.0567
share of skilled employees	-0.581	-0.461
share of short and medium cycle higher education	-0.532	-0.382
share of long cycle higher education	1.519	1.604
interaction term: physical and skilled workers	0.116*	-0.0282
interaction term: physical and short/medium cycle	0.228	0.0957
interaction term: physical and long cycle	-0.403	-0.506
interaction term: psychosocial and skilled workers	0.0803	0.114
interaction term: psychosocial and short/medium cycle	0.0169	0.0461
interaction term: psychosocial and long cycle	-0.414	-0.395
interaction term: wellbeing and skilled workers	0.0358	0.119
interaction term: wellbeing and short/medium cycle	0.0539	0.123
interaction term: wellbeing and long cycle	0.677	0.740
constant term	11.70***	11.62***
N	5090	5090
R2	0.264	0.264

Source: DAMVAD, 2014. On basis of data from Statistics Denmark and The National Working Environment Cohort.

Note: *=significant at the 1 percent level, i.e. $p < 0.1$; **= $p < 0.05$; ***= $p < 0.01$. The model includes year dummy for year 2010 and sector dummies at the 10-grouping level of DB07.

Line of sector

Enterprises are very different across sectors, and thus type of sector plays an important role when it comes to productivity. When we expand the model and control for sector, almost all of the sector-dummies come out as significant. Nonetheless, the index for physical work conditions is still positive and significant, even when we add these sector dummies.

Hence, next we test whether the working environment has a different impact in different sectors by running the full model-regression for each type of sector. Due to the importance of type of sector, we have decided to make this division despite the fact that some regressions are based on a small number of observations, which could affect the results.

The results are shown in table 4.8 below. We see the physical index is positive and significant in the Trade and transport sector as well as in the Other business service sector, indicating that there is a positive relationship between the physical working environment and productivity in these sectors.

The results also show that there is no correlation between the physical working environment and productivity in other sectors. It was expected that the physical working environment would have an impact in the more traditional sectors like construction and production sectors, as this is more physical work. Nonetheless, these results indicate that there is no significant correlation. This could be due to the fact that the physical working environment has been improved in the period over which the analysis was conducted, meaning there is no significant variation in the data.

Table 4.8 Regression models explaining company productivity *within* sectors

	Manufacturing, mining and quarrying, and utility services		Construction		Trade and transport etc.		Information and communication		Real estate		Other business services		Arts, entertainment and other services	
	Without index	With index	Without index	With index	Without index	With index	Without index	With index	Without index	With index	Without index	With index	Without index	With index
ln (capital per FTE)	0.136***	0.138***	0.0428*	0.0418*	0.0731***	0.0718***	0.0854***	0.0807***	0.142***	0.143**	0.0716***	0.0653***	-0.00651	-0.0159
ln (FTEs)	0.0347***	0.0344***	0.0547***	0.0519***	0.0202***	0.0191**	0.0353*	0.0401**	-0.0203	-0.0217	0.00390	0.00749	0.000428	0.0389
ln (physical index)		-0.0343		-0.0273		0.170***		-0.110		-0.338		0.210*		0.137
ln (psychosocial index)		0.0705		-0.147*		0.0690		0.000834		-0.407		-0.0801		0.508
ln (wellbeing index)		0.0148		0.0993		-0.0317		0.133		0.604		0.183*		1.578
constant term	11.06***	10.81***	12.30***	12.59***	11.76***	10.90***	11.92***	11.81***	11.39***	11.84***	12.07***	10.78***	12.39***	2.547
N	1456	1413	659	632	2038	1913	318	305	78	75	776	722	19	19
R2	0.250	0.257	0.0850	0.0897	0.229	0.239	0.201	0.203	0.365	0.404	0.266	0.276	0.562	0.612

Source: DAMVAD, 2014. On basis of data from Statistics Denmark and The National Working Environment Cohort.

Note: * =significant at the 1 percent level, i.e. p<0.1; ** = p<0.05; *** = p<0.01. The models also contain shares of educational group and year 2010 dummy, but these are excluded from the table.

Year/time

Technological development, business-cycle fluctuations and other time-related factors are also likely to play a role when it comes to productivity. The most important in this context is technological development, which we cannot measure directly. In columns 7 and 8 of table 4.6 a year dummy has been added to the regression where type of sector dummies are also included. This takes into account all the factors mentioned previously. Doing this, we see that the index for physical working environment remains positive and significant whereas there is still no effect for the two other indices. Adding the year dummy increases the explanatory power of the regression, although only slightly compared to the regressions in columns 5 and 6 without the year dummy.

In columns 9 and 10, the year dummy is added to the more basic regression leading to an R-squared of about three percentage points more than the models in columns 1 and 2 where years are absent (with and without the indices). This is also true when comparing the models in columns 7 and 8 of table 4.6 to the models in columns 5 and 6.

The results indicate that, after controlling for all the factors mentioned above, time has not played a significant role in explaining productivity between 2005 and 2010. In other words, this result indicates that when comparing 2005 and 2010 there is no significant effect of time which has not been already controlled for.

More importantly, the coefficient of the physical working environment is very robust as it is almost unchanged when controlling for time. This indicates that the *relationship between physical working environment and productivity is consistent over time*.

5. Sweden

5.1 Main results

The analysis covering Sweden is based on harmonized data covering a combination of LISA and FEK covering company characteristics and financial performance with the Working environment Survey. Data covers 15,683 observations and represents all private sectors except from Fishing and Financial intermediation. Further the data covers Education as well as Health and social work; sectors normally considered as public sector. The main results from the analysis of the Swedish data are:

- The physical working environment is an important predictor of productivity – and this seems to be consistent across a range of models estimated with different specifications.
- The degree to which the physical working environment affects productivity strongly interacts with educational levels.
- The psychosocial working environment does not seem to be an important predictor of productivity – only in one case do we obtain significant results for the psychosocial working environment.
- Work wellbeing is an important predictor of productivity. This result too is consistent across several model specifications.
- Results are different depending of the type of sector in question. However, in all of those sectors with relevant data and enough units to perform analysis, working environment or work wellbeing (or both) affects productivity positively and significantly. Psychosocial working environment affects productivity positively and significantly in the following sectors: Transport, Storage, and Communication.

5.2 Data, data coverage, representivity, and measurement precision

The data forming the basis for the analyses of the Swedish case is constituted by a combination of information on company characteristics, company financial performance (LISA and FEK), and information from the Arbetsmiljöundersökningen (the Working environment Survey, AMU). Combining these sources allows us to analyse the relationships between financial performance and working environment *at company level* – that is, combining information about a company's financial performance with

information about that company's working environment is possible in the Swedish case.

This leaves a unique opportunity to analyse the correspondence between working environment/work wellbeing in a company and the productivity of that company.

5.2.1 Data coverage

The LISA database is a longitudinal database meant for analyses of the labour market, social conditions, etc. It enables matching of individuals to these individuals' work place/company, and contains a multitude of information on these enterprises (the unit of analysis in this case), e.g. sector, location, financial key variables, etc. FEK contains further information on the enterprises' financial performance. This information is needed to calculate the productivity of the enterprises.

Finally, AMU is a survey of a representative sample of some 3,300–4,800 individuals on the Swedish labour market, depending on survey year. An obvious consequence of this is that the analyses cannot be performed for every Swedish company, but will have to focus on those enterprises with employees who have answered the questionnaire. The survey has been performed every second year since 1999, with 2011 not yet ready for analysis when this project initiated, which leaves six years of data accessible for analysis.

With LISA as the basis, corresponding to all Swedish enterprises, and restricting to enterprises with more than five employees, of the approximately 482,000 enterprises in 1999, about 112,000 enterprises were not represented in either of AMU or FEK, rendering these analyses impossible. 4,500 enterprises were represented in AMU, and just short of 370,000 enterprises were represented in FEK. Unfortunately, not all of the enterprises in AMU were also represented in FEK – leaving just less than 3,500 enterprises ready for analysis in the 1999 data, cf. table 5.1.

Table 5.1. Number of enterprises in the AMU and FEK databases

	Not in FEK	In FEK
Not in AMU	112,141	365,225
In AMU	1,049	3,491

Source: DAMVAD 2014, based on data from Statistics Sweden.

Note: Grand total of 481,906 enterprises corresponds to number of enterprises with more than five employees in LISA (Företag).

This means that about $\frac{3}{4}$ of 1% of all the enterprises with more than five employees in Sweden in 1999 (as represented by the LISA (Företag) database) lend themselves to analysis in the relevant context.

The number of enterprises ready for analysis ranges between 2,652 and 3,840 for the years 2001, 2003, 2005, 2007, 2009.

5.2.2 Representivity

Although this is not a large selection of Swedish enterprises, statistical analyses of the relationship between working environment and productivity may still very well be warranted.⁶ This is because the sheer number of enterprises represented is not really a good indicator of whether or not the distribution of enterprises is well represented in the data.

The usability of this data depends much more on representativeness of the data – which is, in turn, a function of the selection process by which the data has been selected for analysis.

An indication of the representativeness can be given by looking at the distribution of all Swedish enterprises across types of sector according to LISA, compared to the distribution of enterprises across types of sector in the data made ready for analysis.

While not reflecting in any way perfectly the distribution of enterprises across all types of sector, the data made ready for analysis does reflect, by and large, the distribution of enterprises across types of sector, cf. table 5.2.

Table 5.2. Representivity across sectors, LISA and analysis in 1999 and 2009

Type of sector SNI 92 / Line of sector SNI 2002	LISA – 1999	Analysis – 1999	LISA – 2009	Analysis – 2009
A: Agriculture, hunting and forestry	2.2%	0.9%	2.4%	1.6%
C: Mining and quarrying	0.2%	0.4%	0.2%	0.4%
D: Manufacturing	18.1%	35.4%	14.1%	25.3%
E: Electricity, gas and water supply	0.5%	1.6%	0.4%	1.5%
F: Construction	10.3%	7.6%	13.2%	10.4%
G: Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household Goods	24.9%	20.4%	22.1%	20.9%
H: Hotels and restaurants	5.5%	2.9%	7.7%	3.3%
I: Transport, storage and communication	7.3%	7.1%	6.9%	8.2%
J: Financial intermediation	1.1%	.	.	.
K: Real estate, renting and business activities	16.1%	16.9%	18.4%	18.5%
M: Education	2.0%	0.9%	3.9%	2.5%
N: Health and social work	4.2%	3.2%	3.9%	4.6%
O: Other community, social and personal service activities	6.9%	2.5%	6.9%	2.8%

Source: DAMVAD 2014, based on data from Statistics Sweden.

5.2.3 Measurement precision

Another issue is how well the individual enterprises' working environment is measured. As the survey of the working environment is not directed towards the company level, but rather the individual level (and a representative distribution of *individuals* across the Swedish *labour market* has been the aim), for a lot of the enterprises in the data ready for analysis the working environment is measured on the basis of the

⁶ The reader is urged to think about the extremely common (and high quality!) opinion polls, predicting the outcome of elections in e.g. the USA on the basis of 5-600 respondents.

answers of one employee. Whereas this *does* introduce a level of measurement uncertainty, it *does not* introduce bias into the measurements. The individuals were randomly selected for the survey, and as such they are still a random selection of the enterprises' employees – and therefore a non-biased representation of the working environment in the enterprises.

Between 85 and 88% of the employees in the enterprises are thus represented by one employee, with 7–9% of the employees in the enterprises each year being represented by two employees, cf. table 5.3.

Table 5.3. Number of employees representing the enterprise

Year	Number of employees representing the enterprise				
	1	2	3	4	5
	Percent of employees				
1999	85	9	2	1	0
2001	87	7	2	1	1
2003	87	7	3	1	1
2005	87	8	2	1	1
2007	87	8	2	1	1
2009	88	7	3	1	1

Source: DAMVAD 2014, based on data from Statistics Sweden.

5.3 Results

The analyses have been performed by running regressions standard productivity explaining factors against productivity – and then adding the working environment indices to the regressions to see if working environment has extra explanatory power over and above that of the standard productivity explaining variables. These regressions are reported in table 5.4 below.

Table 5.4. Eight regression models explaining productivity in Swedish enterprises with more than five employees

	Without index	With index	Without index	With index	Without index	With index	Without index	With index	Without index	With index	Without index	With index	Without index	With index
	C, L	C, L	C, L, education	C, L, education	C, L, sector	C, L, sector	C, L, sector, year	C, L, sector, year	C, L, year	C, L, year	C, L, education, sector	C, L, education, sector	C, L, education, year	C, L, education, year
In (capital per FTE)	0.113***	0.115***	0.135***	0.135***	0.114***	0.115***	0.116***	0.117***	0.115***	0.117***	0.128***	0.128***	0.136***	0.135***
In (FTEs)	0.038***	0.033***	0.021***	0.020***	0.036***	0.033***	0.034***	0.032	0.037***	0.033***	0.020***	0.020***	0.021***	0.020***
In (physical index)		0.377***		0.033		0.276***		0.277***		0.379***		0.037*		0.046**
In (wellbeing index)		0.062***		0.039***		0.057***		0.064***		0.070***		0.030**		0.046***
In (psychosocial index)		-0.001		0.034*		-0.031		-0.032		-0.002		0.010		0.034
Constant term	11.805***	9.861***	11.099***	10.658***	11.521***	10.156***	11.473***	10.070***	11.690***	9.705***	10.660***	10.660***	11.080***	10.552***
R2	0.17	0.18	0.28	0.28	0.24	0.24	0.26	0.26	0.19	0.20	0.32	0.32	0.29	0.29
N	15.683	15.169	15.683	15.169	15.683	15.169	15.683	15.169	15.683	15.169	15.683	15.169	15.683	15.169

Source: DAMVAD, 2014, based on data from Statistics Sweden.

Note: * = significant at the 1 percent level, i.e. $p < 0.1$; ** = $p < 0.05$; *** = $p < 0.01$. When specified, shares of educational groups, year dummies for 2001, 2003, 2005, 2007 and 2009 and sector dummies (19-grouping NACE) are included in the model, but are not presented in the table.

The basic model

The basic model – the Cobb-Douglas model of production – shows the expected results of capital and labour being significant and strong predictors of productivity. This is no surprise, and will not be elaborated further in this report.

Adding working environment, however, shows two very important results:

- Physical working environment and wellbeing are both significant and quite strong predictors of productivity.
- Psychosocial working environment does not seem to be related to productivity, when judging on the grounds of the basic Cobb-Douglas model of production. In fact, the standard error of the estimate is much larger than the estimate, reflecting no real correlation between the two.

The model including the indices for working environment and wellbeing was fitted with log-transformed indices. The theoretical background for this is that when the Cobb-Douglas production function is fitted, it is standard to assume log-linear relationships – that is, production (productivity) is in some way an exponential function of the factors introduced to the production. Since all other variables are log-transformed, it is logical to log-transform the indices (logging both right-hand-side and left-hand-side variables).

In addition, we tested the basic model fitted without log transformation. This yielded results showing very limited correlation between working environment/wellbeing and productivity. As the log-transformed variables seem to be closely related to productivity, this result supports the hypothesis that there is in fact a log-linear relationship between working environment/wellbeing and productivity.

Education

When adding education to the equation, another two important results appear:

- This eliminates the explanatory power of the physical working environment, rendering this variable insignificant in the prediction of productivity in Swedish enterprises.
- Concomitantly, psychosocial working environment becomes a significant predictor of productivity.

These two results indicate that there is an *interaction* in explaining productivity between the educational level of the employees of the company and working environment.

Further, the first result is supported when running the model with type of sector included with and without education (models 3 and 6), and both results are supported when running the model with year of measurement included with and without education (models 4 and 7).

Since an interaction effect is indicated here, the model was run with interaction between education and working environment.

Table 5.5. The full model with interaction terms

	Without interaction terms	With interaction terms
ln (physical index)	0.049**	-0.239**
ln (wellbeing index)	0.038***	0.038***
ln (psychosocial index)	0.009	0.008
ln (capital per FTE)	0.129***	0.129***
ln (FTEs)	0.020***	0.020***
Share of secondary level education	0.294***	-1.222**
Share of lowest level tertiary education	0.827***	-1.273
Share of mid-level tertiary education	1.019***	-3.438**
Share of highest level tertiary education	0.318**	6.016
Interaction term: physical index and secondary level education		0.344**
Interaction term: physical index and lowest level tertiary education		0.470*
Interaction term: physical index and mid-level tertiary education		0.984***
Interaction term: physical index and highest level tertiary education		-1.253
Constant	10.602***	11.868***
R2	0.33	0.33
N	15.169	15.169

Source: DAMVAD, 2014, based on data from Statistics Sweden.

Note:*=significant at the 1 percent level, i.e. $p<0.1$; **= $p<0.05$; ***= $p<0.01$. The model also includes year dummies for year 2001, 2003, 2005, 2007 and 2009 and sector dummies at 19-grouping NACE rev.2 level.

Note: When including the interaction factors, the parameter estimate for education level rises, e.g. share of highest level tertiary education rises from 0.318 to 6.016 and loses its significance. Thus one would suspect problematic multicollinearity, but as we explain in the appendix 8.2 multicollinearity is not a concern.

The interaction terms with interactions between share of employees within education groups on the one hand and physical working environment on the other are all significant, except for the term with the fourth educational group (university level). Educational groups are arranged such that the longer the education, the higher the educational

group number. Hence, these results do not indicate that there is in fact an interaction between physical working environment and the highest levels of education (university-level education).

However, there is in fact interaction between educational groups 1 (lowest education) through 3 (mid and higher education), indicating that an increase in the share of these educational groups in the enterprises does increase the importance of the physical working environment. Furthermore, given the insignificance of the fourth interaction term, the importance of the physical working environment does not increase with increased shares of staff with university level education.

Further, the education terms and the physical working environment term actually change signs. Education groups 1 and 3 have significant regression coefficients in the model with interaction, whereas groups 2 and 4 have insignificant coefficients.

The collective effect of the physical working environment in the model with interaction terms is positive and significant, cf. table 5.5. Also, the collective marginal effect of increasing the shares of one of the educational groups is positive and significant.

Table 5.6. Collective marginal effects of education and physical working environment

	Physical index	Physical X edu-group 1	Physical X edu-group 2	Physical X edu-group 3	Share of education group 1	Share of education group 2	Share of education group 3	Collective marginal effect
Coeff. (see table 5.4)	-0.248	0.355	0.479	0.985	-1.271	0	-3.44	
Collective physical W-E	-0.248	0.188	0.060	0.116				0.116
Collective, edu-group 1		1.581			-1.271			0.310
Collective, edu-group 2			2.133			0.000		2.133
Collective, edu-group 3				4.387			-3.440	0.947

Source: DAMVAD, 2014, based on data from Statistics Sweden.

Note: Interaction term as well as share of education group 4 are insignificant and left out of the table.

Type of sector

Type of sector is an important predictor (or rather, set of predictors) of productivity. This is no surprise, since the enterprises in different types of sector work under entirely different conditions – which entails different productivity.

Still, the physical working environment and the work wellbeing indices are significant predictors of productivity. Thus, it is not true that (physical) working environment and work wellbeing are merely expressions of the different conditions in the different types of sector – rather, this supports a hypothesis, which states that within *each* of the sectors, it is true

that enterprises with a better working environment have a higher productivity than enterprises with a poorer working environment.

To test this latter hypothesis, the model was estimated *within* sectors. For those sectors with sufficient units in the data to perform regression analyses, apart from sector N (administrative and support services, e.g. leasing, renting, HR), either physical or psychosocial working environment, or work wellbeing is a significant and positive predictor of productivity, i.e. better working environment/wellbeing is positively correlated with productivity, cf. table 5.7. This is in support of the hypothesis that also *within* each of the sectors, working environment is closely related to productivity – and that the working environment indicators do not merely reflect different sectors.

Table 5.7. Models explaining productivity *within* sectors

	Sector D	Sector F	Sector G	Sector I	Sector K	Sector N	Sector O
ln (physical index)	0.003	-0.043	0.086**	0.172***	0.244***	0.054	0.282*
ln (wellbeing index)	0.048*	0.074**	0.078***	-0.045	0.038	-0.022	0.032
ln (psychosocial index)	-0.015	-0.035	0.019	0.114*	-0.073	-0.105	0.122
ln (capital per FTE)	0.148***	0.064***	0.081***	0.137***	0.160***	0.057***	0.121***
ln (FTEs)	0.021***	0.034***	0.036***	0.010	0.028***	-0.012*	0.061***
Constant term	10.817***	12.200***	11.087***	10.308***	10.142***	12.464***	9.432***
R ²	0.27	0.14	0.16	0.30	0.34	0.23	0.22
N	4.886	1.614	3.742	1.356	3.152	681	466

Source: DAMVAD, 2014, based on data from Statistics Sweden.

Note: *=significant at the 1 percent level, i.e. $p < 0.1$; **= $p < 0.05$; ***= $p < 0.01$. Educational groups and year dummies are included, but not presented in the table.

Psychosocial working environment is a significant predictor of productivity in sector I (Transport, storage, and communication), but not in any of the other sectors. Physical working environment is a significant predictor in sectors G (Wholesale and retail sale; mechanics; personal and household goods), I (Transport, storage, and communication), K (Real estate, renting, and business activities), and O (Other community, social and personal service activities). Finally, work wellbeing is a significant predictor in sectors D (Manufacturing), F (Construction), and G (Wholesale and retail sale; mechanics; personal and household goods).

Taken together, there are no reported sectors where there is not a significant positive relationship between one of the working environment/work wellbeing indices on the one hand and productivity on the other. Sectors not reported in the table either do not report data on val-

ue added (such as Finance and Public administration), or there were not enough enterprises in the type of sector to conduct the analysis within that sector.

Year/time

Time does play a role concerning predicting productivity. This, too, is not surprising, if a certain improvement in the use of resources as time passes is assumed.

However, the extra explanatory power resulting from the addition of the years of measurement is not overwhelming, cf. model 4 compared to model 1 in table 5.4. In model 4, the years are added, leading to an R-squared of about two percentage points more than in model 1, where years are absent (with and without the working environment/wellbeing indices). Comparing models 3 and 5 of table 5.4 shows that this is also true when type of sector is included in the equation.

Therefore, it is fair to say that time is not *the* most important variable in predicting productivity (it is noted that the *development* in productivity is different to the level of productivity), although there is a significant correlation.

More importantly, the coefficients of working environment and wellbeing *remain almost the same* with or without the year variables added. This indicates that the *relationship between physical working environment and wellbeing on one side and productivity on the other side is consistent over time*.

6. Norway

6.1 Main results

The analysis covering Norway diverges to some extent from the analysis in Denmark and Sweden. The analysis connecting productivity to efforts regarding working environment and work wellbeing is carried out on sector level as opposed to micro level in the two other countries. We disaggregate sectors to a three-digit NACE level, as this is the level given in data, and end up with 448 observations.

When linking sickness absence to productivity, we are allowed to use micro-level data, and an extra analysis utilizing micro-level data is conducted.

The main results from the analysis are:

- We see that sickness absence has a negative and strong correlation with productivity. This implies that an improvement (reduction) in sickness absence will lead to better productivity. However, the result could also imply that improving productivity will help relieve sickness absence. The correlation does not tell us anything about the causality.
- Further, we see that the physical working environment has a positive correlation with productivity. Again, we cannot tell whether improved productivity will improve the physical working environment or if the causality runs in the opposite direction. This effect is also significant when controlled for educational level and time.
- Finally, we can conclude that there are not any particular effects of working environment or work wellbeing on certain levels of education. Thus, we cannot conclude that highly educated people benefit more from focusing on work wellbeing and aspects of psychosocial working environment as opposed to employees with lower formal education.

6.2 Data and methodology

The Norwegian analysis is conducted on data from Statistics Norway. The working environment is measured on the basis of the Living Conditions (*Levekårsundersøkelsen*) survey in 2000, 2003, 2006 and 2009.

Due to national data protection regulations, it is not possible to link the survey to company data, as it is in Denmark and Sweden. Therefore, we have chosen another approach in which we aggregate data at a three-digit

NACE-level (only two digits in 2000 and thus excluded from this analysis). Enterprises' financial performance and the employees' educational level are measured at the micro level utilising data from statistics Norway. The latter is aggregated to sector level at a three-digit NACE-level.

Living conditions (in Norwegian: Levekårsundersøkelsen)

In 1996 Statistics Norway started collecting data for the Coordinated Living Condition statistics. Statistics Norway collects data every year but in a three-theme cycle covering: health, households and working life. In 2003, Statistics Norway ratified and harmonised the survey to the EU Survey on Income and Living Conditions (EU-SILC).

In this analysis, we are interested in the part of the Living Condition survey focusing on working life. The survey covers among other things indicators on working environment and work wellbeing. A prerequisite for participating in this analysis is that the respondents are employed.

Register data from Statistics Norway

All enterprises with more than five employees are included in the analysis. Statistics Norway have organised their information regarding enterprises in four different registers:

- Services to offshore, oil and gas sectors.
- Transport, tourism and ICT sectors.
- Construction sector.
- Manufacturing sectors.

Calculating the productivity measure stems from the four different files containing company information. It is important to note that in the register covering services to offshore, oil and gas, there is no record of full-time equivalents. Therefore, number of employees is used instead.

Educational level is an important explanatory variable of productivity. We have divided education into three levels:

- Lower level covering the obligatory primary and lower secondary school
- Short and medium-cycle tertiary education that covers vocational upper secondary education, academy profession, professional bachelor.
- High-cycle tertiary education covering masters and PhD's.

6.2.1 Data coverage

The register-level data from Statistics Norway covers all enterprises in Norway. The four different registers should cover most of the private sector in Norway, except for the primary sector. The data in the registers is not meant for time series analysis across the private sector in Norway. Thus, we need to harmonise the four registers in order to conduct the analysis.

The Living Condition survey is a survey covering representative sample of 3,489 (in 2003) to 12,550 (in 2006). We did not use data from the survey in 2000 as for this year data only allows aggregation to a two-digit level, whereas analysis for the remaining years was conducted at the three-digit level. Thus, we use data from the Living Condition survey in 2003, 2006 and 2009. The number of respondents varies between type of sector. An analysis restricted to sectors with more than 10 respondents reported very similar results in regard to significance, as presented in this chapter (see appendix section 8.1.3).

National data protection regulations prohibit coupling of working environment data (individual-level data) to register-based information on the financial performance of enterprises. Therefore, we aggregate the company and individual-level information on a three-digit NACE-level. In total, the register data from Statistics Norway covers 222 sectors at a three-digit NACE-level in 2009, where 201 sectors contain enterprises with more than five employees. The Living Condition survey covers persons employed in 173 of these sectors, and the analysis will be conducted on these sectors. In 2003, 127 sectors are included and 152 in 2006. This gives a total of 448 observations in the regression analysis.

With the available data, it is possible to analyse the effect of sickness absence on productivity. In the case of sickness absence, a variable delivered by Statistics Norway, it is possible to link individual-level data to enterprises. This analysis contains 277,332 company observations between 2001 and 2011; all with more than five full-time employees.

6.2.2 Representativity

The registers used at Statistics Norway have full coverage of the Norwegian private sector, excluding the primary sector. The Living Condition survey covers different samples in 2003, 2006 and 2009:

- In 2003 the Living Condition survey covers 4,913 persons chosen according to 109 strata covering different geographical and urban regions of Norway. The response rate in 2003 was 71.0%. Our analysis is conducted on the 2,413 respondents who are employed.
- In 2006 a nationwide random sample of 18,679 persons was drawn from persons between 18–66 years on 31.12.2006 from the Norwegian population database.⁷ This age limitation is to cover the working population. The panel is established as an extension of the cross-sectional sample in 2006. The response rate in 2006 is 67.2%. From this survey, we use data from 9,214 respondents who are employed.
- In 2009, a nation-wide, random sample of 18,999 persons was drawn for a survey among persons in the age 18–66 years in 2009, from the Norwegian population database.⁸ The age limitation is primarily to restrict the population to those within working age. The response rate in 2009 is 59.8%. 8,616 respondents are employed.

Table 6.1. The Living Conditions survey, sample and response rates

	2000	2003	2006	2009
Gross sample	4,940	4,913	18,679	20,460
Net sample	3,185	3,489	12,550	12,225
Response rate	64.5%	71.0%	67.2%	59.8%

Source: Norwegian Social Science Data Services.

6.3 Results

The following section presents the results of the Cobb-Douglas regressions using the data described previously in chapter 4. As previously described, in the basic model (Cobb-Douglas production model) we look at the correlation between output, the productivity,⁹ and a range of input factors such as capital and labour. Further, the models include three indices of working environment: Physical, psychosocial and wellbeing. Finally, the models include year dummies in order to capture the aver-

⁷ Bereg2.

⁸ Bereg1.

⁹ Productivity is defined as in the Danish and Swedish analysis.

age productivity trend. As is the case for Denmark and Sweden the variables are fitted with log-transformed indices.

The regressions are presented in table 6.2. We begin with a simple model of the correlation between productivity and the input factors capital and labour. Sequentially we add explanatory variables to the model. Thus in the right-hand column we present a full model including indices, education level and time dummies.

Table 6.2. Model regression explaining productivity in Norwegian sectors (3-digit NACE level)

	Without index	With index	Without index	With index	Without index	With index	Without index	With index
	C, L	C, L	C, L, education	C, L, education	C, L, year	C, L, year	Full model	Full model
ln (capital per FTE)	0.103***	0.106***	0.116***	0.114***	0.104***	0.103***	0.116***	0.111***
ln (FTEs)	0.0452*	0.0220	0.0310	0.000180	0.0475*	0.0245	0.0320	0.00313
ln (physical index)		1.166***		0.527***		0.979***		0.304*
ln (psycho- social index)		-0.415		-0.411		-0.240		-0.236
ln (wellbe- ing index)		-0.0494		-0.0592		0.101		0.0828
constant term	11.96***	8.811***	11.24***	10.98***	11.99***	8.325***	11.29***	10.70***
N	538	448	538	448	538	448	538	448
R2	0.172	0.259	0.360	0.395	0.258	0.320	0.437	0.460

Source: DAMVAD 2014, based on data from Statistics Norway and the Living Condition survey from 2003, 2006 and 2009.

Note: * p<0.1; ** p<0.05; *** p<0.01. When specified, year dummies for 2006 and 2009 are included in the model, but these are not presented in the table.

The basic model

The basic model – the Cobb-Douglas model of productivity – shows that labour is a significant positive predictor of productivity. This is following standard literature. The coefficient for capital is positive and significant, implying that additional investments in capital will add to productivity. According to these results, a 1% increase in capital per full-time employee will increase productivity by 0.0932%, holding all other factors constant in the initial model.

Adding working environment, we need to keep in mind the problems with linking, but the model shows some important findings:

- Physical working environment is a strong predictor of productivity.

Since we cannot say anything about causality, this result shows that

there is a strong correlation between the physical working environment and productivity.

- Neither psychosocial nor wellbeing are significant predictors of productivity. Hence the indicators of psychosocial and wellbeing do not correlate significantly with changes in productivity.

The model including the index of working environment, both physical and psychosocial as well as wellbeing is fitted with log-transformed indices. This approach follows the theoretical foundation of the Cobb-Douglas production function. The productivity function assumes log-linear relations between the input factor and output. Since all other variables in the model are log-transformed and the indices are closely connected to the labour input, it is important to also log-transform the indices.

Further, we see that the effect of increasing labour input becomes insignificant. The interpretation of the result could be that additional labour inputs will not increase productivity relatively speaking. Thus, the productivity does not increase more than the level of input. However, the aggregation of data may also lead to the insignificance of the results, as we are now unable to test whether enterprises *within* an sector benefit from growing in terms of labour input. This latter interpretation is supported in the micro-level analysis presented below, which identifies a positive and significant relationship between labour inputs and productivity.

Education

Level of education is often seen as a key driver of productivity. Moreover, it is important to include the factors determining level of education in productivity models. Including educational level as an explanatory variable in the model implies the following the results:

- In general including shares of employees with certain levels of education does not alter the results of the physical, psychosocial and wellbeing factor. The physical index is still positively significant.
- There is a strong, positive correlation between the share of employees with university-level education and productivity at sector level.
- Further, intermediate level of education has a positive correlation to productivity at sector level.

The results indicate that increasing the share of employees with high educational level will increase productivity. The reference group is employees with lower-level education.

Further, we do not find general economies of scale from increasing labour stock at sector level. A possible explanation of this result is that Norway has “full employment” in macroeconomic terms. This means that labour and especially labour with the right set of competences is difficult

to access at sector level. The pool of attractive labour force is simply too small. Thus, Norwegian sectors are not facing increasing returns on scale when hiring more employees. The Norwegian Labour and Welfare Administration confirm this in their annual survey of Norwegian enterprises, stating that they have trouble in recruiting the right persons. In 2013 an estimated 32,300 positions were vacant in Norway and looking back on previous years reveals high numbers of vacant positions. E.g. in 2006 there was an estimated 60,000 vacant positions in Norway. The vacant positions are present in almost all of the Norwegian sectors.

It should be noted that we do find an economies of scale effect in the company-level regression (see table 6.4). Therefore, the aggregation to lines of sector may be explanatory in relation to the missing effect on the sector level regressions.

Year

We see that including year dummies captures the economic growth in Norway throughout the last decade. As such, one can argue that it is important to include these in the model.

Including year dummies does not alter the results of the model. Equally as importantly, we see that the coefficient to the physical index almost stays the same with and without the time dimension added to the model. This indicates that the relationship between physical working environment and productivity is constant over time.

Including all variables

The full model includes all of the above-mentioned groups of variables. In the previous models, we saw a positive correlation between better physical working environment and productivity. This result is still significant on a 10% significance level, when all control variables are included.

Working environment effects and level of education

The data enables us to combine factors of working environment and wellbeing with the level of education. This allows us to answer an interesting question, whether better working environment or well being correlates differently with productivity, given different level of education. Maybe highly educated people benefit more from focusing on work wellbeing and aspects of the psychosocial working environment as opposed to employees with lower formal education.

The data and models do not show any differences in working environment or wellbeing among different levels of education and the correlation to productivity. There are no effects from either type of working environment indices or work wellbeing on company productivity in enterprises with higher shares of employees with medium-cycle tertiary education or high-cycle tertiary education. Thus, we cannot conclude that there are any particular effects of working environment or work wellbeing on certain levels of education.

Table 6.3. The regression model with interaction terms

	Full model including interaction term
ln (capital per FTE)	0.112***
ln (FTEs)	0.003
interaction term: physical and medium-cycle	0.379
interaction term: physical and high-cycle	0.494
interaction term: psychosocial and medium-cycle	-0.564
interaction term: psychosocial and high-cycle	0.246
interaction term: well and medium-cycle	0.335
interaction term: well and high-cycle	-0.483
constant term	11.40***
N	448
R2	0.461

Source: DAMVAD 2014, based on data from Statistics Norway and the Living Condition survey from 2003, 2006 and 2009.

Note: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. Year dummies for year 2006 and 2009 are included, but are not presented in the table.

Sickness absence and productivity

As a special Norwegian case, we have gained access to data regarding sickness absence. The data has been made available at company level, which allows a micro-level analysis on the correlation between sickness absence and productivity. A negative correlation will be one key argument for focusing on decreasing sickness absence, e.g. through a better working environment.

There is a negative correlation to sickness absence and productivity. This result has two important implications. First that the absence of employees correlates negatively to productivity. This means the increasing absence will hamper productivity growth in the economy. Second, the results show that focusing on reducing sickness absence and in fact succeeding in reducing sickness absence will add positively to productivity. The result is only valid for the private sector in this analysis, but there is no reason not to think that reducing sickness absence will add to productivity in the public sector as well.

There is a positive correlation between labour input and productivity. That is a change compared to the models at sector level. We see that disaggregating the analysis to company level changes the level of significance of labour input. Again, it is difficult to determine the direction of causality, i.e. do growing enterprises become more productive, or do productivity increases lead to company growth? Nonetheless, this is an interesting result. This points out that certain enterprises attract productive employees within the sector. At the sector level, we found no significant effect of increases in size. One interpretation of this combination of results may be that, at sector level, this flow of productive employees or flow of employees towards productive enterprises evens out the correlation between labour input and productivity. This actually implies that most sectors are stable over time, but within the sector there are dynamics and mobility where some enterprises grow and prosper and others decline and vanish. However, another explanation

could be that aggregation to sector level blurs the correlation between size and productivity. This would have to be elaborated and tested further before drawing any firm conclusions.

Table 6.4. Correlation between productivity and sickness absence

	Model including sickness absence, year, and sector dummies (not included in table)
ln (capital per FTE)	0.0755***
ln (FTE)	0.0242***
Sickness absence	-0.819***
Share of medium-cycle tertiary education	0.232***
Share of high-cycle tertiary education	0.657***
Constant term	12.19***
<i>N</i>	277,332
R ²	0.191

Source: DAMVAD 2014, based on data from Statistics Norway.

Note: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. The model also includes year dummies for year 2002 to 2011. Further the model include sector dummies at A*38-level following NACE Rev2 structure.

7. Finland

7.1 Main results

The analysis covering Finland diverges to some extent from the analysis in Denmark and Sweden. The analysis carried out connects productivity to efforts regarding working environment and work wellbeing at sector level as opposed to micro level in the two other countries. We disaggregate the sector as much as possible and end up with 218 observations corresponding to the sectors included in data at a three-digit NACE-level. The observations cover the years 2003, 2006 and 2009, meaning that on average we will have 73 observations a year. Thus, the analysis and approach will be equal to the analysis of Norway. The main results from the analysis are:

- Physical working environment has a positive correlation with productivity. Again, we cannot tell whether improved productivity will improve the physical working environment or if the causality runs in the opposite direction. Even when including measures regarding level of education in the different sectors, we see that physical working environment keeps the explanatory power.
- On the other hand we see that psychosocial working environment and work wellbeing does not correlate with productivity. Thus changing psychosocial working environment and work wellbeing will not affect productivity in Finnish sectors.
- Finally, we can conclude that there are not any particular effects of working environment or work wellbeing on certain levels of education. This is the same result as in Norway and we cannot conclude that highly educated people have more benefit from focusing on work wellbeing and aspects of psychosocial working environment as opposed to employees with lower formal education.

7.2 Data and methodology

The Finnish part of the analysis follows largely the same approach as the Norwegian. In the Finnish case, there exists no identification of the respondents' place of employment in our accessible data, so linking working environment with company statistics directly at a micro level is not feasible. The two-digit NACE sector classification is present, however, so as in the Norwegian case, we start by aggregating company statistics at this level.

Statistics Finland has a ready-made data register for research purposes, which combines company statistics and employee data. To gather the needed statistics at sector-level, we combined data from the Business register, the Financial statement register and the combined employer-employee register (FLEED).

The working environment surveys were conducted by the Finnish Institute of Occupational Health for the years 2000, 2003, 2006 and 2009. As it was only possible to create the link between the respondents' answers and the sector grouping of their employer through their data access, the Finnish Institute of Occupational Health constructed the three indices at sector level separately. These were subsequently combined with our data on company statistics at sector level and then used for the regression.

Data restrictions

As government-owned enterprises as well as household undertakings are not operating on competitive markets, they are not price takers and their value added per FTE is not a suitable measure of productivity, even if data on value added may exist. Therefore, we exclude undertakings which, according to the sector variable of the Business register, belong to "General Government" and "Households". Further, enterprises owned by the general government are also deleted. Similar to the analyses of the other countries, we exclude enterprises in years where the number of full-time employees falls below five.

As being employed is a prerequisite for having an sector affiliation, only employed respondents of the working environment survey are included when forming the indices.

Education variables

As for Norway, we include the average share of the employees at each educational level to control for the fact that education normally entails higher productivity. The educational levels are ordered according to the Finnish Standard Classification of Education with the grouping:

- Upper secondary level education.
- Lowest level tertiary education.
- Lower-degree level tertiary education.
- Higher-degree level tertiary education.
- Doctorate or equivalent level tertiary education.

Working environment indices

As in the case for Norway, we use the mean of each index across respondents within each sector when constructing the index variable for the regression analysis. Here, sectors differ somewhat in size measured in terms of the number of workers, and accordingly the number of respondents to the working environment surveys differs by sectors. The mean number of enterprises with respondents per sector is 22 for the physical index, 16 for psychosocial index and 21 for the wellbeing index. These numbers are not equal, as a respondent is excluded from the average index if he or she has not answered one or more questions used for the index. As an example, if a respondent has answered all questions regarding the physical index but misses one in the wellbeing, this respondent enters as an observation when calculating the physical index but not the wellbeing index. Hence, the number of respondents per index for a given type of sector is allowed to vary. Further, about half of the sector-type observations have indices calculated on the basis of at least 10 enterprises. We only carried out the regression on a sample with sectors having at least 10 enterprises with respondents to the working environment survey and in fact this made the level of significance a little higher and increased the coefficient to the physical index (see the appendix for results).

Linking working environment, measured by the three indices, and financial performance at a two-digit NACE-level in the four years – 2000, 2003, 2006 and 2009 – gives a total of 213 observations, which are used in the pooled OLS regression. The results are presented in the following section. The dependent variable, productivity, is measured as the average productivity of enterprises within each line of sector. Capital intensity is likewise the average capital intensity within a sector. Company size is measured by number of employees to estimate the economies-of-scale effect.

7.3 Results

The following section presents the results of the Cobb-Douglas regressions using the data described previously in chapter 4. As previously described, in the basic model (Cobb-Douglas production model) we look at the correlation between output, productivity,¹⁰ and a range of input factors such as capital and labour. Further, the models include three indices of working environment: Physical, psychosocial and wellbeing. Finally, the models include year dummies in order to capture the average productivity trend. As in the Norwegian case, we include year dummies for observa-

¹⁰ Productivity is defined as in the Danish, Norwegian and Swedish analyses.

tions in the years 2003, 2006 and 2009. As is the case for Denmark, Norway and Sweden, the variables are fitted with log-transformed indices.

The regressions are presented in table 7.1. We begin with a simple model of the correlation between productivity and the input factors capital and labour. Sequentially we add explanatory variables to the model. Thus at the right-hand column we present a full model including indices, education level and time dummies.

Table 7.1 Regression model explaining productivity in Finnish sectors (2-digit NACE)

	Without index	With index	Without index	With index	Without index	With index	Without index	With index
	C, L	C, L	C, L, education	C, L, education	C, L, year	C, L, year	Full Model	Full model
ln (capital per FTE)	0.240***	0.234***	0.236***	0.233***	0.239***	0.233***	0.235***	0.232***
ln (em- ployees)	0.00317	0.00168	-0.00256	-0.000578	0.000893	0.00175	-0.00476	-0.000533
ln (physi- cal index)		0.738***		0.528**		0.738***		0.530**
ln (psy- chosocial index)		-0.199		-0.340		-0.0830		-0.221
ln (wellbe- ing index)		-0.176		-0.0722		-0.201		-0.106
constant term	8.289***	6.741***	8.097***	7.611***	8.329***	6.373***	8.125***	7.258***
N	228	213	228	213	228	213	228	213
R2	0.476	0.535	0.523	0.567	0.485	0.540	0.532	0.571

Source: Damvad 2014, based on data from Statistics Finland and the Finnish Institute of Occupational Health from 2000, 2003, 2006 and 2009.

Note: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

The basic model

The basic model – the Cobb-Douglas model of productivity – shows a somewhat surprising result that labour is not a significant positive predictor of productivity at sector level. The interpretation of the result could be that additional labour inputs will not increase productivity relatively speaking.

However, the aggregation of data may also lead to the insignificance of the results, as we are now unable to test whether enterprises *within* an sector benefit from growing in terms of labour input. This latter interpretation was supported in the Norwegian case, as we did a productivity analysis on micro-level data. Having the same result here when focusing on sector level just adds to our interpretation that on micro level we will see an impact from labour input but the impact disappears within sector level.

The coefficient for capital is positive and significant, implying that additional investments in capital will add to productivity. According to these results, a 1% increase in capital per full-time employee will increase productivity by 0.240%, keeping all other factors constant in the initial model.

Adding working environment, we use the same approach as doing the analysis on Norwegian data, implying that we need to keep in mind the problems with linking the model, but there are some important findings:

- Physical working environment is a strong predictor of productivity. Since we cannot say anything about causality, this result shows that there is a strong correlation between the physical working environment and productivity. The results are even stronger than we see in Norway.
- Neither psychosocial nor wellbeing are significant predictors of productivity. Hence the indicators of psychosocial and wellbeing do not correlate significantly with changes in productivity.

As in the case of Norway, the model including the index of working environment, both physical and psychosocial, as well as wellbeing is fitted with log-transformed indices. This approach follows the theoretical foundation of the Cobb-Douglas production function. The productivity function assumes log-linear relations between the input factor and output. Since all other variables in the model are log-transformed and the indices are closely connected to the labour input, it is important to also log-transform the indices.

Education

Level of education is often seen as a key driver of productivity. Moreover, it is important to include the factors determining level of education in productivity models. Including educational level as an explanatory variable in the model implies the following the results:

- In general including share of employees with certain levels of education does not alter the results of the physical, psychosocial and wellbeing factors. We actually see that the positive correlation between physical working environment and productivity is still significant.
- There is a strong, positive correlation between the share of employees with doctoral level of education and productivity at sector level.
- Further, intermediate level of education has a positive correlation to productivity at sector level.

The results indicate that increasing the share of employees with high educational level will increase productivity.

Year

When year dummies are included in the model we see that there is no significant correlation with development in productivity. Thus year in itself does not explain productivity in Finland.

Further, we can state that including year dummies does not alter the results of the model. We still find that physical working environment is a strong predictor of productivity. Moreover, psychosocial and work wellbeing are not correlated with productivity.

As importantly, we see that the coefficients to physical working environment, psychosocial and wellbeing almost stay the same with and without the time dimension added to the model. This indicates that the relationship between physical, psychosocial and wellbeing on the one side and productivity on the other are constant over time.

Including all variables

The full model includes all of the above-mentioned groups of variables. In the previous models, we saw a positive correlation between better physical working environment and productivity. The positive correlation is still apparent in the full model, whereas the positive correlation between education level and productivity is persistent.

Working environment effects and level of education

The data enables us to combine factors of working environment and wellbeing with the level of education. As was the case in Norway, this allows us to answer an interesting question: Does better working environment or wellbeing correlate differently with productivity, given different level of education? The hypothesis is that highly educated people have more benefit from focusing on work wellbeing and aspects of psychosocial working environment as opposed to employees with lower formal education.

The data and models do not show any differences in physical and psychosocial working environment or wellbeing among different levels of education and the correlation to productivity in Finnish sectors. There are no effects from either types of working environment indices or work wellbeing on company productivity in enterprises with higher shares of employees with high-level university degrees, neither at master nor doctoral level. Thus we cannot conclude that there are any particular effects of working environment or work wellbeing on certain levels of education among the work force in Finnish sectors.

Table 7.2 The regression model with interaction terms

	Model inclusive interaction terms
ln (capital per FTE)	0.236***
ln (FTEs)	-0.00266
interaction term: physical and lowest level	2.839
interaction term: physical and lower-degree level	-0.469
interaction term: physical and higher-degree level	-0.989
interaction term: physical and doctorate or equivalent	8.242
interaction term: psychosocial and lowest level	0.564
interaction term: psychosocial and lower-degree level	-5.558
interaction term: psychosocial and higher-degree level	3.591
interaction term: psychosocial and doctorate or equivalent	-10.88
interaction term: wellbeing and lowest level	2.361
interaction term: wellbeing and lower-degree level	-7.071
Constant term	8.163***
<i>N</i>	213
<i>R</i> ²	0.583

Source: Damvad 2014, based on data from Statistics Finland and the Finnish Institute of Occupational Health from 2000, 2003, 2006 and 2009.

Note: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. Shares of educational groups and year dummies are included in the model, but not presented in the table.

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9. Sammenfatning

Denne rapport udgør slutrapporten for forskningsprojektet, der omhandler måling af sammenhænge mellem virksomheders produktivitet og vækst på den ene side og medarbejdernes arbejdsmiljø på den anden side. Forskningsprojektet har varet i 3 år og bygger på data på tværs af fire nordiske lande, Danmark, Finland, Norge og Sverige.

Med sit fokus på netop sammenhænge mellem arbejdsmiljø og produktivitet bidrager forskningsprojektet og denne rapport til den begrænsede empiriske litteratur, der er på dette felt. Til vores kendskab er der per i dag ikke gennemført analyser af sammenhængen mellem arbejdsmiljø og produktivitet ved hjælp af registerbaseret data fra nationale statistiskkontorer, koblet til arbejdsmiljødata og ved brug af økonometriske modeller.

Forskningsprojektet har givet ganske mange resultater. Disse resultater præsenteres kortfattet herunder. Det er dog vigtigt at understrege, at et "ikke-resultat" ikke er det samme som et negativt resultat. Det betyder blot, at det ikke er lykkedes at finde et sammenhæng, hverken positiv eller negativ.

Hovedresultaterne fra rapporten er følgende:

- *Arbejdsmiljø og medarbejdernes trivsel har en positiv sammenhæng med virksomheders produktivitet.* Rapporten viser, at et godt fysisk arbejdsmiljø og medarbejdernes trivsel har en signifikant og positiv sammenhæng med virksomheders produktivitet. Resultatet er robust overfor forskellige modelspecifikationer i både Danmark og Sverige. For Danmark og Sverige har vi opnået tilladelse til at koble arbejdsmiljødata med registerdata på individniveau.
- *For Norge og Finland viser rapporten ligeledes en positiv sammenhæng mellem fysisk arbejdsmiljø og virksomheders produktivitet.* Sammenlignet med analyserne for Danmark og Sverige har det ikke været muligt at opnå tilladelse til at koble arbejdsmiljødata og registerdata på individniveau. Derfor er resultaterne for Norge og Finland aggregeret på brancheniveau. At det alligevel lykkedes at påvise en positiv sammenhæng mellem arbejdsmiljø og virksomhedernes produktivitet, hvilket kan tolkes som, at resultatet er robust.
- *Det psykiske arbejdsmiljø ser ikke ud til at kunne forklare forskelle i virksomheders produktivitet.* Det betyder ikke, at der er en negativ sammenhæng mellem psykisk arbejdsmiljø og produktivitet. Det betyder blot, at vi kun i begrænset omfang finder en sammenhæng. I

Sverige og Danmark finder vi således kun i enkelte modeller, at der er en sammenhæng mellem psykisk arbejdsmiljø og produktivitet. Derfor mener vi ikke at resultatet er robust og konkluderer derfor, at vi ikke kan finde sammenhænge mellem psykisk arbejdsmiljø og produktivitet. Konklusionen gælder ligeledes for *Norge* og *Finland*, hvor vi, på de aggregerede data, ikke finder nogen sammenhæng mellem psykisk arbejdsmiljø og virksomhedernes produktivitet i nogen af modellerne.

- *Sygefravær har en negativ sammenhæng med produktivitet.* For Norge har vi fået tilladelse til at koble individdata om sygefravær med øvrige registerdata. Her finder vi en signifikant negativ sammenhæng mellem sygefravær og produktivitet. Resultatet er gældende på tværs af alle vores forskellige produktivitetsmodeller. Det betyder, at vi konkluderer, at resultatet er robust. Det har ikke været muligt at få denne type af data for de øvrige lande i forskningsprojektet.

Dette forskningsprojekt leverer de første kvantitative bevis for sammenhænge mellem arbejdsmiljø, medarbejdernes trivsel og deres produktivitet baseret på registerbaseret data. Forskningsprojektet tester sammenhængen på tværs af de fire nordiske lande; Danmark, Finland, Norge og Sverige. Eftersom data kommer fra forskellige kilder og er indsamlet til andre formål, skal resultaterne ikke ses som endelige. De skal i stedet ses som et første forsøg på at måle virksomhedernes effekter af et godt arbejdsmiljø og trivsel blandt medarbejderne.

I forhold til at kunne udføre mere grundige analyser med større fokus på kausale sammenhænge kræver det en større grad af harmonisering af data. For Norge og Finland gælder det i første omgang om at opnå samme tilladelse til at anvende individdata, som kan opnås i Sverige og Danmark. Dette vil styrke muligheden for at lave komparative analyser af effekterne af forbedret arbejdsmiljø og trivsel på tværs af de nordiske lande.

Endvidere kræver det mere fokus på at skabe tidsserier både på person og virksomhedsniveau for arbejdsmiljøundersøgelserne. Dette gøres ved at lade de samme virksomheder indgå i arbejdsmiljøundersøgelserne over tid. Dette vil også give mulighed for at imødekomme dette forskningsprojekts største mangel; nemlig spørgsmålet om kausalitet. Det er vores stærkeste anbefaling af arbejdet med at afdække kausalitet må fortsætte. Samtidig med arbejdet med at afdække kausale sammenhænge bør der også igangsættes forskning med fokus på hvilke drivere, der påvirker de kausale effekter. Hvad driver en positiv sammenhæng mellem arbejdsmiljø og produktivitet både i negativ og positiv retning? Det er et helt centralt spørgsmål, som stadig står ubesvaret!

Dette forskningsprojekt er meget eksplorativt, og vi betræder helt ny jord. Derfor skal rapportens resultater heller ikke ses som endegyldige på nogen måde. Vi har med forskningen fået en kraftig indikation af, at der er en markant og positiv sammenhæng mellem et godt arbejdsmiljø

og virksomhedernes produktivitet. Og dermed får vi bekræftet en hypotese, som mange håber er rigtig. Men vi viser også, at der stadig er meget forskning, der skal udføres, før vi kan udtale os endegyldigt om arbejdsmiljøets betydning for virksomhedernes produktivitet. Det er forfatterens store håb, at denne rapport vil bidrage til mere oplyste diskussioner og yderligere forskning inden for dette område.

10. Appendix

10.1 Methodological approach to index calculations

To compute the statistical effects of working environment on productivity, we calculate an index of physical, psychosocial, and wellbeing factors for each individual in the working environment surveys. These three indices are created in accordance with the appendix from the Phase I report of this project and based on data from Levekårsundersøkelsen (Norway), Den nationale arbejdsmiljøkohorte (Denmark), Arbetsmiljöundersökningen (Sweden) and the Institute of Occupational Health (Finland). The relevant questions in the newest edition of these surveys were identified in Phase I, and the same questions have been used, when possible, from earlier editions of the surveys. For the case of Finland, the Phase I report suggested use of more data registers than were finally accessible and the only questions used were those of the Work and Health Survey. The questions used for the Norwegian indices differ to some extent over the years, as the questions of the surveys change. Only the 2009 survey was used to identify relevant questions, so it was necessary to include questions similar to those proposed in the Phase I report, yet not with the exact same wording. If more than one question with similarity to an identified question occurred, all such questions were included in the relevant index.

Indices are calculated as a mean of the relevant questions for each respondent. All questions are normalized with outcomes ranging from 0 to 100 – with 100 being the most positive answer in relation to working environment. If, for instance, a question has 5 answer categories such as “never”, “infrequently”, “sometimes”, “frequently” and “always”, and “never” is a very negative response to the question asked, a value of 0 is associated with “never”, 25 is associated with “infrequently” and so on up till 100. If a question only has three categories, the possible answers will take the values 0, 50 or 100. Especially for the physical index, some questions in the surveys are hard to scale meaningfully in this manner. In such cases, we have disregarded the questions from the indices.

Each index is then calculated by taking the mean of the values corresponding to the individuals' answers to the questions that individual has actually answered. If there are m questions in an index, and the answers to three of the questions are missing for an individual, the index value is then the mean of $m-3$ questions. The indices are finally computed at company level as the average of indices of all respondents working in each company. In mathematical terms, each index for a given company is calculated as:

$$\frac{1}{N} \sum_{j=1}^N \frac{1}{m_j} \sum_{i=1}^{m_j} x_{i,j},$$

where N is the number of survey respondents in the company, m_j is the number of questions answered by respondent j , and x is the value of an answer. The approach in Finland differs in one aspect from this, because respondents need to have answered all relevant questions for the specific index to be ascribed an index value.

In the following chapter 9.1.1 til 9.1.4 we present questions from the surveys composited to construct the different indices. Some of the questions are marked by brackets. It is where the question in relevant years are slightly different than the question presented. But they the implication are alike, which also have been confirmed by the expert group.

10.1.1 Denmark

Table 9.1 Survey questions included in the Danish working environment indices

	2005	2010
Physical index		
Are you exposed to noise so loud that you have to yell in order to communicate with a person standing right next to you?	x	x
Does your work entail working with your back severely stooping without supporting with your hands and arms?	x	x
Does your work entail that you twist and bend your back several times per hour?	x	x
Does your work entail having your arms lifted in or above shoulder level?	x	x
Of your total working time, how much do you spend pushing and pulling?	x	x
Of your total working time, how much time do you spend carrying or lifting?	x	x
What does what you carry or lift usually weigh?	x	x
Does your work entail standing in the same spot?	x	x
Does your work entail squatting or kneeling when you work?	x	x
Does your skin have contact with cleanser and/or disinfectants?	x	x
For how large a part of your total working hours are your hands are wet or moist?	x	x
Psychosocial index		
Do you participate in planning of your own work?	x	x
Are you able to perform your work at a quality level that you are completely satisfied with?	x	x
Is it necessary to work very quickly?	x	x
Is your work unevenly distributed so that it can pile up?	x	x
How often does it occur that you do not finish all your work tasks?	x	x
Is your work emotionally draining?	x	x
Are you affected emotionally by your work?	x	x
To what extent does your immediate superior ensure that the individual employee has good development opportunities?	x	x
Is your work recognised and valued by the management?	x	x
To what extent do you get the information you need to do your job well?	x	x
Do you receive important information, e.g. about central decisions, changes and future plans in proper time?	x	x
Do you receive all relevant information in order to do a satisfactory job?	x	x
Do you get help and support from you superior?	x	x
Is your superior motivated to listen to your issues in relation to work?	x	x
How often do you receive help and support from your colleagues?	x	x
How often are your colleagues willing to listen to your problems at work?	x	x

	2005	2010
Wellbeing index		
Have you ever been told by a medical doctor that you suffered from one of the following conditions? [depression, asthma, diabetes, cardiovascular disease, cancer, impaired hearing, eczema, back disorder, others]	x	x
How many days did you report sick last year?	x	x
Have you, within the last 12 months, experienced a work-related accident, which led to your absence from work for longer than the day of the accident?	(x)	x
In general, how do you assess your health?	x	x
Have you within the last month been troubled by [feeling of heaviness, headache, dizziness, restlessness, depressed, difficulty concentrating, problems sleeping, difficulties focusing, passivity, discomfort or nausea, palpitation, almost catching a cold, migraine, tense muscles, lost appetite, stomach ache, heartburn, alternating stools, constipation]?	x	x
Have you within the last year been troubled by pain or discomfort in shoulders or neck?	x	x
Have you within the last year been troubled by pain or discomfort in hands, forearm or elbow?	x	x
Have you within the last year been troubled by pain or discomfort in lower back?	x	x
How often have you felt enthusiastic and full of life in the last 4 weeks?	x	x
How often have you felt very nervous in the last 4 weeks?	x	x
How often have you felt so down that nothing could cheer you up in the last 4 weeks?	x	x
How often have you felt relaxed and calm in the last 4 weeks?	x	x
How often have you felt full of energy in the last 4 weeks?	x	x
How often have you felt worn out in the last 4 weeks?	x	x

10.1.2 Sweden

Table 9.2 Survey questions included in the Swedish working environment indices

	2001	2003	2005	2007	2009
Physical index					
Are you exposed to... Noise that is so loud that you cannot converse in a normal tone of voice?	x	x	x	x	x
Are you exposed to... Vibrations that make your whole body shake and vibrate (for example, from a tractor, forklift, or other work machine)?	x	x	x	x	x
Are you exposed to... Vibrations from hand-held machines or tools?	x	x	x	x	x
Are you exposed to... Cold (outdoor work in winter, work in chilled room or the like)?	x	x	x	x	x
Are you exposed to... Poor lighting (too weak or glaring)?	x	x	x	x	x
Are you exposed to... Oil or cutting fluids (in contact with your skin)?	x	x	x	x	x
Are you exposed to... Acid or basic (corroding) chemical compounds?	x	x	x	x	x
Are you exposed to... Cleaning agents and/or disinfectants (in contact with your skin)?	x	x	x	x	x
Are you exposed to... Water which comes in direct contact with your skin several times an hour (ind. washing your hands)?	x	x	x	x	x
Are you exposed to... Human secretions like saliva, blood, urine, human faeces or vomit?	x	x	x	x	x
Are any of the following noticeably present that you can see or smell in your workplace... Dust from metals, stone, quartz, cement, asbestos, mineral wool, or the like?	x	x	x	x	x
Are any of the following noticeably present that you can see or smell in your workplace... Dust from textiles, wood, flour, animals or plants?	x	x	x	x	x
Are any of the following noticeably present that you can see or smell in your workplace... Chemicals (gases, vapours, solvents, pesticides or plastic chemicals)?	x	x	x	x	x
Are any of the following noticeably present that you can see or smell in your workplace... Tobacco smoke from others' smoking (passive smoking)?	x	x	x	x	x
Do you use a car at work? (Do not include commuting to and from work)	x	x	x	x	x
Have you during last three months ... Hade to lift at least 15 kgs several times a day?	x	x	x	x	x
Psychosocial index					
Is it possible for you to set your own work pace?	x	x	x	x	x
Is your work sometimes so stressful that you do not have time to talk or even think of anything other than work?	x	x	x	x	x
Is there any part of your work day when you do nothing but wait and remain prepared in case something might happen?	x	x	x	x	x
In the main can you take short breaks at any time in order to talk?	x	x	x	x	x
If your tasks feel difficult, do you have access to advice or help?	x	x	x	x	x
Can you receive support and encouragement from your superiors when your work becomes troublesome?	x	x	x	x	x
Can you receive support and encouragement from your fellow workers when your work becomes troublesome?	x	x	x	x	x
Does your superior (boss) ever express appreciation for your work?	x	x	x	x	x
Do other persons express appreciation for your work (e.g. fellow workers, patients, customers, clients, passengers, students)?	x	x	x	x	x
How do you experience your work... Far too much to do/Far too little to do?	x	x	x	x	x
How do you experience your work... Tasks too difficult/Tasks too easy?	x	x	x	x	x
How do you experience your work... Too little influence/Too much influence?	x	x	x	x	x
How do you experience your work... Too little support and help from fellow workers and superiors/Too much involvement from fellow workers and superiors?	x	x	x	x	x
How do you experience your work... Too isolated from others/Enough contact with others?	x	x	x	x	x
How do you experience your work... Mentally stressful work/Calm and pleasant work?	x	x	x	x	x
How do you experience your work... Constrained and unfree/Unconstrained and free?	x	x	x	x	x
How do you experience your work... Very unhappy with my working hours/Very happy with my working hours?	x	x	x	x	x
How do you experience your work... Extremely meaningless work/Extremely meaningful work?	x	x	x	x	x
How do you experience your work... Generally speaking, I am very dissatisfied with my work/Generally speaking, I am very satisfied with my work?	x	x	x	x	x
Wellbeing index*					
After work, do you experience pain in any of the following place ...upper parts of your back or neck?	x	x	x	x	x
After work, do you experience pain in any of the following places ...lower parts of your back?	x	x	x	x	x
After work, do you experience pain in any of the following places ...shoulders or arms?	x	x	x	x	x

	2001	2003	2005	2007	2009
After work, do you experience pain in any of the following places ...wrists or hands?	x	x	x	x	x
After work, do you experience pain in any of the following places ...hips, legs, knees, or feet?	x	x	x	x	x
Does it happen that you are physically exhausted when you get home from work?	x	x	x	x	x
Does it happen that you cannot dismiss your job from your thoughts when you are off work?	x	x	x	x	x
Have you during last three months ...had heartburn, acid burping, a burn in the pit of your stomach, or upset stomach?	x	x	x	x	x
Have you during last three months ...been tired and listless?	x	x	x	x	x
Have you during last three months ...had headaches?	x	x	x	x	x
Have you during last three months ...had itching or other irritation in your eyes?	x	x	x	x	x
Have you during last three months ...had a hard time sleeping because thoughts about your work keep you awake?	x	x	x	x	x
Does it happen that you feel ill at ease going to your job?	x	x	x	x	x
Does it happen that you feel uneasy and despondent as a result of difficulties you are facing at work?	x	x	x	x	x
Does it happen that after the end of your work day you feel that your work contributions have been insufficient?	x	x	x	x	x
Does it happen that after work you are too tired or don't have enough time for your family, friends or leisure activities?	x	x	x	x	x
How often during the past 12 months have you attended work although, considering your state of health, you should have reported sick?	x	x	x	x	x

*In all questions for this index, except the last, the respondent is asked to include only the past three months.

10.1.3 Norway

Table 9.3 Survey questions included in the Norwegian working environment indices

	2003	2006	2009
Physical index			
Are you, in your day-to-day work, exposed to noise so loud that you have to stand next to someone and shout in order to be heard?	x	x	x
Are you, in your day-to-day work, exposed to vibrations that make your whole body shake and vibrate (for example, from a tractor, forklift, or other work machine)?	x	x	x
Are you, in your day-to-day work, exposed to vibrations from hand-held machines or tools?	x	x	x
Are you, in your day-to-day work, exposed to heat, i.e. temperatures of approx. 28 degrees Celsius or higher?	x	x	x
Are you, in your day-to-day work, exposed to cold, i.e. working outdoors in the winter, or working in cold rooms, etc.?	x	x	x
Are you, in your day-to-day work, exposed to bad indoor climate in the form of: draught, dry air or bad ventilation?	x	x	x
Are you, in your day-to-day work, exposed to poor or blinding light or irritating reflections?	x	x	x
Are you, in your day-to-day work, exposed to skin contact with oils, lubricants or cutting fluids?	(x)	x	x
Are you, in your day-to-day work, exposed to skin contact with cleaning products, disinfectants, solvents or other degreasing agents?	(x)	x	x
Do you in your day-to-day work get water on your skin several times per hour? Including hand washing?	x	x	x
Are any of the following noticeably present that you can see or smell in your workplace? Dust or smoke from metals, dust from minerals, organic dust or gases/vapour.	x	x	x
Is tobacco smoke from others' smoking noticeably present that you can see or smell in your workplace?		x	x
Are you, in your day-to-day work, exposed to biological material such as human secretions like saliva, blood, urine, human faeces or vomit?			x
Are you, in your day-to-day work, exposed to biological material such as laboratory materials like biological samples from patients or animals?			x
Are you, in your day-to-day work, exposed to biological material such as rubbish like offal, sewage or used medical disposables?			x
Are you, in your day-to-day work, exposed to biological material such as living or dead animals?	x	x	x
Is your work so strenuous that your breath quickens?	x	x	x
Do you need to squat or kneel in the course of your work?	x	x	x
Is it necessary to lift in awkward poses?	x	x	x
Do you work standing up?	(x)	(x)	x
Do you work with your hands raised to shoulder height or higher?	x	x	x
Do you work in positions leaning forward without supporting yourself on your hands or arms?	x	x	x
Does your work involve repeated movements with just one of your hands or arms?	x	x	x
Does your day-to-day work require you to lift things heavier than 20 kg?	x	x	x
Does your day-to-day work require you to lift things heavier than 10 kg?	x	x	x
How would you evaluate the risk of a physical injury in your own work?	x	x	x
How would you evaluate the risk of a Repetitive Strain Injury in your own work?	x	x	x
How would you evaluate the risk of being troubled by other health impairments in your own work?	x	x	x
Psychosocial index			
Do you sometimes have to perform tasks that you do not feel adequately trained to do?	x	x	x
How often do you have to do things that you think should be done in a different way?	x	x	x
How often are you given tasks without being given sufficient tools and resources to complete them?	x	x	x
How often do you receive contradictory requests from two or more different people?	x	x	x
How well does the following description fit your immediate superior? "Your immediate superior treats employees with trust and respect?"	x	x	x
How often do you have to work quickly?	x	x	x
How often do you have too much to do?	x	x	x
Do you sometimes have so much to do that you have to miss lunch, work longer than your normal working hours or take work home with you?	x	x	x
How well does the following description fit your current job? ... "There is normally not time to perform tasks properly."	x	x	x
Are you free to choose when to take a break from your work: e.g. to stretch your legs or take a breather in some other way?	x	x	x
Does your job require a lot of repetition and repeats several times an hour?	x	x	x
Can others' life or your own life be put in danger if you make mistakes at work?	x	x	x

	2003	2006	2009
To what extent are you free to decide your own tasks?	x	x	x
To what extent are you free to decide how to go about doing your work	x	x	x
To what extent are you free to choose your own work pace?	x	x	x
If needed, how often is it possible for you to get help and support from your immediate superior?	(x)	x	x
If needed, how often is it possible for you to get help and support from colleagues?	(x)	x	x
Do you get feedback from your superiors on how you have performed your work?	x	x	x
Does your immediate superior treat employees fairly and impartially?		x	x
Does your immediate superior value your achievements at work?		x	x
Do you experience a bad relationship between superiors and employees at work?	x	x	x
Do you experience a bad relationship between colleagues at work?	x	x	x
How often do demands from work disturb your home or family life?	x	x	(x)
Are you subject to violence or threats at work?		x	x
Are you subject to bullying or unpleasant behaviour from your colleagues?		x	x
Are you subject to bullying or unpleasant behaviour from your superiors?		x	x
Are you subject to sexual harassment?		x	x
In general, how pleased are you with your work?		x	x
Does your employer give you plenty of notice of important decisions, changes and future plans?			x
How often is it unclear what is expected of you in your job?			x
How often do you experience distractions and interruptions of your work?			x
To what extent do you have hide negative emotions, e.g. remorse, anger, irritability, despair or the like from customers, clients or others not employed at your work place?			x
To what extent can you influence decisions that are important to your work?		x	x
To what extent do you have deal with negative emotions, e.g. remorse, anger, irritability, despair or the like in customers, clients or others not employed at your work place?			x
To what extent do you agree or disagree with the following statement? "My salary is appropriate to my efforts and performance at work."	(x)		x
To what extent do you agree or disagree with the following statement? "In relation to my efforts and performance, I get the respect and recognition that I deserve at work."			x
If you announce your views about the working conditions of your work place, will they then be respected?	x	x	x
Do you risk being met with unwillingness from your superiors if you deliver a critical point of view about working conditions?	x	x	x
Do you risk being met with unwillingness from your colleagues if you deliver a critical point of view about working conditions?	x	x	x
Have you often, occasionally or never been involved in unpleasant conflicts with your superiors?			x
Have you often, occasionally or never been involved in unpleasant conflicts with your superiors?			x
How often are you contacted, by phone or otherwise, about work related issues outside of your working hours?			x
How often does your work involve assignments which disagree with your personal values?	x		x
To what degree do you have sufficient time to carry out your work in a safe manner?		x	
How often are you satisfied with the quality of your work performance?		x	x
How often are you satisfied with the quantity of work you accomplish?		x	
How often are you satisfied with your ability to solve problems arising in the course of your job?			x
Do you feel as a part of a community at your work place?			
Do you have somebody at your work place to discuss import personal issues with?	x	x	
Do you receive feedback from your colleagues on your work performance?	x	x	
Does your immediate superior distribute assignments fairly?	x	x	
Have you noticed of any sort of bullying or harassment taking place at your job within the past six months?		x	
Have you yourself been harassed at your job within the past six months?		x	
In some jobs, one can freely decide when and how fast to do different tasks. Eg. one can work quickly some days and relax others. How often do you have this opportunity?		x	
How does the following description match your work? Does it match very well/well/ not well/ poorly... "Superiors or colleagues pose contradicting demands."	x	x	
How does the following description match your work? "Many assignments give a sense of job satisfaction." Does it match very well/well/ not well/ poorly?	x	x	
How does the following description match your work? "Many assignments give a pleasant sense of mastering."	x	x	
Does it happen that you feel ill at ease due to criticism or difficulties at your job?	x	x	
How are the opportunities at your job to apply the skills and experience you have achieved through education and previous work?	x	x	
How are the opportunities at your job to further develop yourself professionally within the areas you desire?	x	x	

	2003	2006	2009
How are the opportunities at your job to take further education and supplementary training?	x	x	
Is there a danger of material damages or loss of production if you fail at your job?	x		
Do you mostly experience your work as a burden?	x		
Do you have so many assignments that it is difficult to focus on each single one?	x		
To what extent can you freely decide when to take vacation or take time off in lieu? To full extent/somewhat/or little extent?	x		
To what extent can you determine... the quality criteria of your work? To full extent/somewhat/or low extent.	x		
How does the following description match your current job? Does it match very well/ well/ not well/ poorly ... "Your job puts too high requirements for mastering new assignments?"	x		
How does the following description match your current job? Does it match very well/ well/ not well/ poorly ... "There is a good social environment at your work place?"	x		
Do your job assignments occasionally become so challenging that you need assistance?	x		
Are you very content/ content/ neither content nor discontent/ discontent/ or quite discontent with ... your job safety?	x		
Are you very content/ content/ neither content nor discontent/ discontent/ or quite discontent with ... the relationship between you and your co-workers?	x		
Are you very content/ content/ neither content nor discontent/ discontent/ or quite discontent with ... the degree to which you can develop professionally?	x		
Are you very content/ content/ neither content nor discontent/ discontent/ or quite discontent with ... the variations in your job assignments?	x		
Are you very content/ content/ neither content nor discontent/ discontent/ or quite discontent with ... the amount of work?	x		
How does the following description match your current job? Does it match very well/ well/ not well/ poorly ... "There are clear expectations of your work performance?"	x		
Do you fear that declining to fulfil wishes from your superiors will have negative consequences?	x		
How does the following description match your current job? Does it match very well/ well/ not well/ poorly ... "You often have to work extra or bring unsolved assignments home in order to be done in due time?"	x		
How does the following description match your current job? Does it match very well/ well/ not well/ poorly ... "You have to put in extra effort to ensure that the results of your work live up to standards?"	x		
How does the following description match your current job? Does it match very well/ well/ not well/ poorly ... "There is too much stress and rush?"	x		
How does the following description match your current job? Does it match very well/ well/ not well/ poorly ... "The quality requirements of your work are unclear?"	x		
How does the following description match your current job? Does it match very well/ well/ not well/ poorly ... "Working for your company makes you proud?"	x		
Are there circumstances at your workplace that affect you in a way which harms your relation with family and friends?	x		
How is the climate with regards to teamwork at your workplace? Is it not at all/ little / somewhat/ quite well/ or very well characterized by support and encouragement by fellow employees?	x		
How is the climate with regards to teamwork at your workplace? Is it not at all/ little / somewhat/ quite well/ or very well characterized as rule-governed and rigid?	x		
Wellbeing index			
Have you in the course the past month been very troubled/ quite troubled/ a little troubled/ or not troubled by... pain in the small or lower part of the back?	x	x	x
Have you in the course the past month been very troubled/ quite troubled/ a little troubled/ or not troubled by... pains in your neck and/or shoulders?	x	x	x
Have you in the course the past month been very troubled/ quite troubled/ a little troubled/ or not troubled by... pains in your elbows, lower arms or hands?	(x)	(x)	x
Have you in the course the past month been very troubled/ quite troubled/ a little troubled/ or not troubled by... pains in your hips, legs, knees or feet?	x	x	x
Have you in the course the past month been very troubled/ quite troubled/ a little troubled/ or not troubled by... headaches or migraines?	x	x	x
Have you in the course the past month been very troubled/ quite troubled/ a little troubled/ or not troubled by... eczema, itchy skin or rash?	x	x	x
Have you in the course the past month been very troubled/ quite troubled/ a little troubled/ or not troubled by... eye irritations such as itchy, tender, red or runny eyes?	x	x	x
Have you in the course the past month been very troubled/ quite troubled/ a little troubled/ or not troubled by... hearing problems, which have made it difficult for you to follow conversations when several people are talking, or have you experienced tinnitus?	x	x	x
Have you in the course the past month been very troubled/ quite troubled/ a little troubled/ or not troubled by... nervousness, anxiety or restlessness?	x	x	x
Have you in the course the past month been very troubled/ quite troubled/ a little troubled/ or not troubled by... dejection or depression?	x	x	x
Have you in the course the past month been very troubled/ quite troubled/ a little troubled/ or not troubled by... sleep disruptions, such as problems falling asleep, waking up too early or getting too little sleep?	(x)	(x)	x
Have you in the course the past month been very troubled/ quite troubled/ a little troubled/ or not troubled by... stomach pain and/or diarrhoea? Respiratory problems, such as coughing, mucus, shortness of breath or wheezing?	x		x
Have you during the past 12 months been very troubled/ quite troubled/ a little troubled/ or not troubled by respiratory afflictions such as coughing, sputum, heavy breathing or wheezing?	x		x
Does it happen that you feel mentally exhausted when returning home from work?			
Have you during the past 12 months had sick leave of at least 14 consecutive days?	x	x	x
Have you in the course the past month been very troubled/ quite troubled/ a little troubled/ or not troubled by... feeling of tightness in the chest or whistling sounds?	x	x	
Does it happen that you feel physically exhausted when returning home from work?	x	x	
How do you assess your own work capacity compared to the physical requirements of your work?			
How do you assess your own work capacity compared to the mental requirements of your work?			
On how many occasions during the past 12 months have you attended work although you felt so ill, that you rather should have stayed home?			x
Does it happen that you feel worn out when returning home from work?	x		

The table shows the results of the model if we exclude sectors with less than ten respondents in a given year. We do this to test the robustness of the Norwegian results. If we compare the results with the results of table 6.2 we see that it does not change common denominator or significance and there are only marginal changes of the coefficients. Thus the results are robust.

Table 9.4 Regression model explaining productivity in Norwegian sectors (3-digit NACE level) with more than 10 respondents

	Without index		With index		Without index		With index		Without index		With index		Without index		With index	
	C, L		C, L		C, L, education		C, L, education		C, L, year		C, L, year		Full model		Full model	
ln (capital per FTE)	0.105***		0.0849***		0.118***		0.0851***		0.104***		0.0851***		0.116***		0.0865***	
ln (FTE)	0.0441 *		0.00160		0.0298		-0.0205		0.0475 *		0.000850		0.0320		-0.0222	
ln (physical index)			1.792***				0.718**				1.879***				0.703*	
ln (psycho-social index)			0.876				0.0191				0.750				-0.103	
ln (wellbeing index)			-0.184				-0.0512				-0.128				-0.406	
constant term	11.94***		1.431		11.21***		8.601***		11.86***		1.325		11.16***		10.67***	
N	538		219		538		219		538		219		538		219	
R2	0.183		0.346		0.390		0.504		0.224		0.351		0.411		0.510	

Source: DAMVAD 2014, based on data from Statistics Norway and The Living Condition survey from 2003, 2006 and 2009.

Note: * p<0.1, ** p<0.05, *** p<0.01. Shares of educational groups and year dummies are in the model, but excluded from the table.

10.1.4 Finland

Table 9.5 Survey questions included in the Finnish working environment indices

	2000	2003	2006	2009
Physical index				
Does the air at your workplace feel dry?		x	x	x
Does the air at your workplace feel stale?		x	x	x
Is there a smell of mould or of a cellar in your working environment which is often noticed in premises damaged by damp or when handling mouldy material?	x	x	x	x
Is there a smell of cigarettes in your working environment because of other people's smoking?	x	x	x	x
Is there noise in your working environment or in your work?	x	x	x	x
Is there vibration in your working environment or in your work?	x	x	x	x
Is there cold or draughts in your working environment or in your work?	x	x	x	x
What about inadequate lighting or glare?		x	x	x
Is there dust in your working environment or in your work?		x	x	x
Are you exposed to solvents (e.g., thinners, fuel or paint solvents) at work or in your working environment?		x	x	x
In your work do you use chemicals or substances that are hazardous for your health or that are dangerous?		x	x	x
Are the premises where you mainly work functional and practical from the point of view of working effectively?		x	x	x
Next I would like to ask about how strenuous your work is. Is your work physically...?	x	x	x	x
Does your work involve lifting or carrying by hand, without any equipment?		x	x	x
Does your work involve stooping or otherwise having your back in an awkward working position?		x	x	x
Does your work involve working with one or both hands above shoulder height?		x	x	x
Does your work involve strong gripping or turning movements of your hand such as using a screwdriver, cutting, twisting or moving heavy objects manually?	x	x	x	x
Psychosocial index				
During the past 12 months have you done overtime for pay or time off in lieu?	x	x	x	x
What is the time you spend at work each week, not including overtime?		x	x	x
During the last 12 months have you done any overtime without compensation?	x	x	x	x
How many hours a month on average?		x	x	x
How often do you have to be flexible in your working times either because the job requires it or your supervisor asks you to?			x	x
People sometimes find it hard to reconcile the conflicting demands of home and work. Do you have difficulties in concentrating on work because of things at home?	x	x	x	x
How often do you feel that you are neglecting things at home because of your job?	x	x	x	x
Is learning to use and using the computer programs at work?	x	x	x	x
Is your work mentally ... light/fairly light.../very strenuous		x	x	x
Do you get over the stress caused by your work after the working day or shift?				
During the past 12 months have you been threatened at work or on the journey to and from work? OR What about physical violence such as being held or pushed?	x	x	x	x
Mental violence means continual repeated teasing, bullying or offensive behaviour. Have you earlier or are you at the moment been the object of mental violence and teasing in your own place of work?				
Have you experienced sexual harassment at your place of work during the past 12 months?	x	x	x	x
How often do you have to rush to get work done?	x	x	x	x
Do you have to interrupt work you are doing to carry out something else that has cropped up or to do something that is more urgent?		x	x	x
How often do you find yourself in situations at work that arouse negative feelings in you such as anger, hate, fear or shame?		x	x	x
Can you influence things that affect you at your workplace?	x	x	x	x
What about the amount of work?				
Can you affect the length of your working day?	x	x	x	x
Does your work have clear objectives?	x	x	x	x
Can we talk about joint working, objectives and their achievement at your workplace?	x	x	x	x

	2000	2003	2006	2009
Do you receive support and help from your colleagues when you need it?	x	x	x	x
Do you get help and support from your line manager?	x	x	x	x
What kind of opportunities do you have to develop yourself professionally in your present workplace?			x	x
Are your relations with your colleagues at your workplace generally... Very good//.../tense, rancous?	x	x	x	x
Is the atmosphere at your place of work... more strained and tense//.../or more relaxed and pleasant?	x	x	x	x
Is the atmosphere at your place of work... more supportive and encouraging of new ideas//.../or more prejudiced and holding fast to old ways of doing things?	x	x	x	x
At my place of work decisions are made on the basis of correct information?				x
Decisions made at my place of work are consistent i.e. the rules are the same for everyone?				x
How interested is the management at your workplace in the health and wellbeing of staff?		x	x	x
Does your immediate line manager deal with employees fairly and equally?		x	x	x
Are men and women at your workplace treated ... completely equally//.../or extremely unequally?	x	x	x	x
Are different aged people at your workplace treated ... completely equally//.../or extremely unequally?	x	x	x	x
How satisfied are you with your present work?	x	x	x	x
By stress we mean a situation in which a person feels themselves to be excited, restless, nervous or uneasy or they may find it difficult to sleep because they constantly have things on their mind. Do you currently feel this kind of stress?	x	x	x	x
Does your job involve working nights?	x	x	x	x
Does your job involve working weekends	x	x	x	x
How often do you feel yourself to be strong and dynamic at work?			x	a
How often are you enthusiastic about your work?			x	
How satisfied are you with your life at present?	x	x	x	x
Wellbeing index				
During the past 12 months have you had an accident at work or on the journey between your workplace and home? // Did you most recent accident at work results in incapacity for work or sick leave?	x	x	x	x
How would you evaluate the risk of accident in your own work?	x	x	x	x
During the past 12 months have you had a single spell of sick leave that lasted at least 3 weeks?				
Do you have a long-term, at least 3 months, illness or injury diagnosed by a doctor?	x	x	x	x
Do these long-term sicknesses or injuries as diagnosed by a doctor cause problems in your current job?	x	x	x	x
Have you had, in the past six months, long term or repeated mental or physical ailments or symptoms which you think affect your work or which are made worse by work?	x	x	x	x
Have you had, during the past month, long term or repeatedly... pain, pressing feeling or tightness of the chest //.../pain in the thighs or legs?	x	x	x	x
Have you had, during the past month, long term or repeatedly ... depression or dejection //.../lack of interest or feelings of lack of meaning? (Apathy).	x	x	x	x
Which of your long term sicknesses or injuries as diagnosed by a doctor cause problems in your current job? Accident injury//.../Urogenital disease.				
How many days have you be off work during the past six months because of your health?	x	x	x	x

The table shows the results of the model if we exclude sectors with less than ten respondents in a given year. We do this to test the robustness of the Finnish results. If we compare the results with the results of table 7.1 we see that there are small changes common denominator or but not in significance and there are only marginal changes of the coefficients. Thus the results are somewhat robust.

Table 9.6 Regression model explaining productivity in Finnish sectors (2-digit NACE level) with respondents from more than 10 enterprises

	Without index		With index		Without index		With index		Without index		With index		Without index		With index	
	C	L	C	L	C	L	C	L	C	L	C	L	C	L	Full Model	With index
In (capital per FTE)	0.277***		0.250***		0.275***		0.253***		0.272***		0.249***		0.270***		0.253***	
In (employees)	0.0119		0.00772		0.0226		0.0156		0.0271		0.0165		0.0312		0.0218	
In (physical index)			1.173***				1.087***				1.128***				1.011**	
In (psychosocial index)			0.883				0.486				1.640*				1.142	
In (wellbeing index)			-0.172				-0.111				-0.365				-0.269	
share of lowest level tertiary education					1.809**		0.990						1.499*		0.843	
share of lower-degree level tertiary education					1.350*		0.996						1.849**		1.188	
share of higher-degree level tertiary education					-1.172		-1.404*						-1.206		-1.317	
share of doctorate or equivalent level tertiary education					3.148*		2.499*						3.210**		2.415*	
year 2003									-0.150		-0.0701		-0.131		-0.0705	
year 2006									-0.0660		0.137		-0.0448		0.0954	
year 2009									-0.218*		-0.0506		-0.208		-0.0697	
constant term	7.809***		0.0254		7.335***		1.529		7.859***		-2.242		7.439***		-0.285	
N	96		96		96		96		96		96		96		96	
R2	0.570		0.652		0.635		0.678		0.598		0.671		0.657		0.692	

Source: Damvad 2014, based on data from Statistics Finland and the Finnish Institute of Occupational Health from 2000, 2003, 2006 and 2009.

Note: * p<0.1, ** p<0.05, *** p<0.01.

10.2 Cobb-Douglas production function and the math behind the model

Our strategy is to form a relationship which is suitable for a linear regression relating the working environment indices to the productivity of a company. As a standard approach, the starting point of the specification is a classical Cobb-Douglas production function: $Y = AK^\alpha L^\beta$, where A is total factor productivity, Y is value added, K is material assets and L is full-time employees. Although it is intuitively attractive, it rarely happens that $\alpha + \beta = 1$ in empirical examples, so when we divide through with L to get an expression of productivity (defined as value added per Full-time employee), we get: $y = Ak^\alpha L^{\beta-(1-\alpha)}$. Taking the natural logarithm of this expression, we obtain a linear relationship which in itself could be applied to estimate, say, total factor productivity: $\ln(y) = \ln(A) + \alpha \ln(k) + (\beta - (1 - \alpha)) \ln(L) = \text{Constant} + \alpha \ln(k) + \rho \ln(L)$.

We now claim that as an empirical relationship, the explanatory power of this equation will increase as we add our indices of work well-being which are log-transformed (this claim is validated by significant F-tests of this group of variables). From the empirical literature on productivity, it is well known that educational skills of the staff are important, so we add to the equation the share of employees on various educational levels. To avoid multicollinearity, we leave out the share of employees with the lowest level of education. Further, we control for trend effects by including a dummy variable for each year and a dummy for type of sector to control for inter-sector differences. The resulting regression equation thus becomes:

$$\begin{aligned} y = & \text{Constant} + \alpha \ln(k) + \rho \ln(L) + \theta_{\text{physical}} \ln(I_{\text{physical}}) \\ & + \theta_{\text{psychosocial}} \ln(I_{\text{psychosocial}}) \\ & + \theta_{\text{well-being}} \ln(I_{\text{well-being}}) + \sum_{k=1}^K \varphi_k \text{SEL}_k \\ & + \sum_{j=1}^J \omega_j \text{Industry}_j + \sum_{l=1}^L \vartheta_l \text{year}_l + \varepsilon \end{aligned}$$

where SEL_k is the share of employees at educational level k and ε is the error term for a given company in a given year. This generic equation holds for Sweden and Denmark, as we are able to combine company-level data with the working environment surveys for these countries. The size of K and L differ, however, to make the specifications most meaningful.

As it was not possible to link the working environment surveys to personal register data in Finland and Norway, creating company-specific indices to use in the regression was not a feasible strategy here. We did have the sector affiliation of the respondents, so to perform a similar analysis as for Sweden and Denmark, we aggregated data to sector level

and ran the same regression (excluding sector dummies). For the case of Norway, the median productivity and median capital intensity per sector was used together with total shares of workers on each educational level. Aggregation for Finland was done by taking the mean productivity and mean capital intensity across enterprises for each line of sector. Finally, for Finland the classification of sector lines follows the two first digits of Nace02 and Nace08, such that there is one observation for sector 01 in 2003, one in 2006 etc. In Norway a three digit Nace-level is used to link working environment and sector performance. This gives us a total of 213 observations for Finland and 241 for Norway in each pooled OLS regression, only regarding the sectors for which we have respondents to the surveys.

Multicollinearity and interaction terms

From the correlation matrices, it is evident that there is a very high degree of correlation between the interaction terms and their components. Such a high degree of correlation will in many cases be a sign of problematic multicollinearity. This is, however, not the case when the correlation is between an interaction term and its constituents. The reason is that one could form an alternate regression model with all variables demeaned – meaning that the variables are demeaned before the interaction term is produced – which produces the same sum of squared errors as the original model. In a model with demeaned variables, the multicollinearity would almost certainly be removed. This is because a high positive value of the interaction term can only be achieved if both variables in the interaction term are higher than average or both below average. If only one of them is above average, the interaction term is negative. Hence, it is not likely that a linear combination of the variables in the interaction term can predict the size of the interaction term itself, so multicollinearity by an interaction term is not present when variables are demeaned. As the sum of squared errors remains unchanged for the demeaned model, so will an F-test for the interaction term and its constituting variables. This means that the presence of multicollinearity did not alter any conclusions with respect to the significance of the variables involved in the interaction term, in so far it arose only by collinearity between the interaction term and its constituting variables. In conclusion, multicollinearity is of no concern in this case. This line of reasoning is found in Cronbach, L. J. (1987) *Statistical Tests for Moderator Variables: Flaws in Analyses Recently Proposed*.



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Working environment and productivity

Globalisation and demographic trends underline the twin challenge of the Nordics with productivity stagnation and a decreasing work force. Increasing productivity and the work force will be an answer to both. A good work environment can do both: If less people have to take sick leave as result of bad work environments, this will contribute to increasing the work force.

Also, for some time, a relationship between work environment and productivity has been hypothesised. Happy, healthy workers, in short, are more productive than not-so-happy and not-so-healthy workers are. This report is based on the most comprehensive empirical study of the cohesion between working environment and productivity. It confirms the hope of many, i.e. that improvements in working environment and improved productivity are highly correlated. The results are robust across time and the investigated countries.



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