Moving to Productivity: The Benefits of Healthy Buildings

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Abstract

Health is a critical factor for the generation of value by workers. Companies bear substantial costs associated with absenteeism and presenteeism among their employees. This study investigates the impact of the environmental conditions in the workplace on the health and job satisfaction of employees, as core factors of productivity. We provide quasi-experimental evidence based on the relocation of 70% of the workforce of a municipality in the south of the Netherlands. We construct a longitudinal dataset based on individual surveys of the entire municipality workforce and include measures before and after the move. The estimation results show a significant improvement in the perceived environmental conditions and health of the relocated workers. The relocation effects remain persistent in the medium term (two years after the moving date). The results from the heterogeneity analysis show the older groups of employees enjoyed larger health impacts.

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1 Introduction

Workers represent a critical input factor for the modern firm, but our understanding

of the effects of workplace environmental conditions on human performance is limited. Companies bear substantial costs in the form of both absenteeism and presenteeism, that is, productivity losses due to workers not being able to work at full capacity (Hemp, 2004). Based on a sample of 28,902 working adults in the US Stewart et al. (2003) document that 13% of the total workforce experienced a loss in productive time due to common pain conditions such as headaches or back problems. The authors estimate a loss of $61.2 billion per year in pain-related productive time.

The literature provides some evidence of the harmful effects of indoor environmental quality (IEQ) in the workplace. Poor indoor air quality in the form of high levels of CO_2 or pollutants has been linked to the prevalence of absenteeism, sick-building symptoms (Fisk et al., 2009), and cognitive performance of workers (Allen et al., 2016; MacNaughton et al., 2016). Inadequate thermal conditions in the form of suboptimal temperatures or relative humidity have been linked to the prevalence of increased heart rate, respiratory problems, sick-building syndrome, and reduced cognitive performance (Lan et al., 2011; Seppänen et al., 2006). Noise is also a risk factor commonly found in workplaces. The exposure to unhealthy decibel levels leads to cardiovascular disease, stress, and sleep disruption, ultimately harming employees' cognitive performance and labor productivity (Dean, 2017). Finally, light quality has been linked to eye-irritation problems and changes in the circadian rhythm of adults (Cedeño-Laurent et al., 2018).

Recent reviews of the literature from MacNaughton et al. (2015) and Altomonte and Schiavon (2013) provide a comprehensive overview of the literature investigating the benefits for occupants located in so-called ”green” buildings. In both reviews, the results from the majority of the surveyed studies indicate that individuals in ”green” buildings evaluate better their perceived health and the environmental conditions at their workplace. However, these studies are based on cross-sectional comparisons of the reported values of participants working in ”green” buildings with the answers from those working in conventional buildings. The validity of the results therefore relies on strong assumptions about the differences between employers and employees in ”green” and ”non-green” buildings, that is assuming an absence of selection bias, which would arise when the health and working conditions of occupants in sustainable buildings might differ from the health and working conditions of those working in conventional buildings, beyond the building infrastructure.

This paper evaluates the changes in (1) employee-perceived environmental conditions in their workplace, (2) health outcomes, and (3) job satisfaction, following the relocation of 70 % of the workforce of a large municipality in the Netherlands (N=1,200) to a new office building designed to enhance indoor environmental quality.[1] We develop a unique dataset monitoring the perceived working conditions, health, and job satisfaction of more than 600 municipality workers up to two years after the relocation. In total, we surveyed the employees four times, once before the move and three times after the move. We employ a traditional difference-in-differences (DiD) approach to estimate the impact of the move on perceived working conditions and employee health. Based on the quasi-experimental variation created by the relocation, we show significant long-term benefits in the working conditions and health of employees, but not in employee satisfaction.

The literature documents significant discrepancies between the short- and long-term reported impacts associated with material upgrades due to hedonic adaptation, a psychological process that attenuates the long-term impact in conditions. For instance, individuals can even adapt to serious chronic health conditions (i.e., disabilities), exhibiting high levels of happiness or life satisfaction close to the baseline level again in the long term (Loewenstein and Ubel, 2008). A recent study by Galiani et al. (2018) shows this adaptation also appears to exist when evaluating the impact of major building infrastructure improvements. Two years after the intervention, Galiani et al. found the beneficiaries of the program reported well-being levels identical to the baseline levels before the intervention.

In a second step of the study, we therefore decompose the estimates of the three surveys administered in the two years after the moving date, to investigate the discrepancy between short- and long-term effects. The estimates of health and perceived environmental quality show a persistence over time. However, none of the job satisfaction measures deviate significantly from the baseline in the long term.

2 Study Set-Up

2.1 Background

In 2016, Venlo, a municipality in the southeast of the Netherlands, inaugurated a second, newly constructed office building for use by the municipality. The new municipality building was built following green and sustainable principles: In addition to glass and concrete, the north wall of the building is covered with vegetation, and includes a green wall of 2,000 m^2. The installation of green walls has been associated with an improvement in outdoor and indoor air quality, transforming carbon dioxide (CO2) into oxygen, and filtering fine particles from outdoor sources of pollution (Perini and Rosasco, 2013). In addition, the plants serve as natural insulation against heat, cold, and sound (Cuce, 2016). The building is also equipped with state-of-the-art natural ventilation technology. The air enters the building at the top, where it is oxygenated by plants and brought to the bottom of the building, from where the purified air then circulates naturally

[1] Around 70 % of the subjects were relocated; the remaining 30 % stayed in their original workplaces over the entire study period.

throughout the building using physical principles rather than mechanical ventilation systems.

In the summer of 2016, 70% of the 1,461 workers of the municipality were moved to the newly constructed office building. Office space in the previous workplace was organized in enclosed private offices that several people shared. In the new building, the office space follows an open office layout. Open offices tend to generate noise complaints among occupants, who can be distracted by high levels of noise and loss of privacy (Kim and de Dear, 2013). The selection of movers was quasi-random, through selection of teams rather than individuals.

2.2 Survey Design

We received permission from the municipality to send surveys to all of its employees, asking them to complete it via email. [2] The survey included anonymized individual identifiers, allowing us to build a longitudinal dataset that tracks the responses from the same employee over multiple survey waves. Our sample includes the survey responses of the treatment group, individuals relocated to the new "green" building, and those of the control group, comprising those employees who were not relocated to the new building.

The surveys span both the period before and after the relocation. We first sent a questionnaire to all employees one month before the relocation took place, serving as the baseline survey in the analysis. After the relocation, we surveyed all employees three times - those individuals that were relocated as well as those who remained in their original workplace during the entire sample period.

The survey includes the module developed by the Center for the Built Environment (CBE) at the University of California, Berkeley, to monitor the perceived environmental conditions of occupants in their workplaces (Zagreus et al., 2004). The core questions in the survey assess occupant (dis)satisfaction and comfort with indoor environmental quality (IEQ) issues, including indoor air quality, thermal comfort, lighting, and acoustics. We ask participants to rate their satisfaction with different aspects of the environment on a 7-point scale ranging from "very satisfied" to "very dissatisfied," with a neutral midpoint. In a second set of questions, we ask participants to rate each IEQ dimension on 7-point scales ranging from "support" to "interferes" in their ability to get their work done.

The survey includes two questions about the health status of individuals. First, we examine changes in the health status of workers based on the prevalence of sick-building-syndrome symptoms. This concept is widely examined in the building science and public health literature and refers to "a collection of non-specific symptoms including eye, nose and throat irritation, mental fatigue, headaches, nausea, dizziness and skin irritations, which seem to be linked with occupancy of certain workplaces" (WHO, 1983). The survey includes a question asking whether

[2]See Appendix B for the text of the invitation sent to the employees.

the subject suffers from syndrome symptoms (”Do you regularly have symptoms (e.g. tiredness, headache, eye irritation, nasal congestion, dry throat, dry skin) that disappear when you leave the building - when you are at work?”). In addition, we collect self-stated sick-leave data based on the number of days missed due to health reasons in the year before the survey (”How many days were you unable to work this year due to illness?”).[3]

We measure the job satisfaction of employees based on a series of Likert scales, where respondents rate the frequency with which they experienced job-related emotions (see Panel B Table 3 for the complete list of questions). The frequency of the scale ranges from ”Daily” to ”Never,” and includes the options ”A few times a week,” ”Once a week,” ”Few times a month,” ”Once a month,” and ”Few times a year or less.”

Finally, the survey includes questions about basic demographic characteristics of respondents (i.e., age and gender) and some details of the employee’s employment contract (i.e., working hours, and years in the current organization). In addition, the survey includes a series of questions that ask participants to grade their (dis)satisfaction with layout, furniture and equipment in their workplace, based on the same scales that are used to grade the perceived environmental conditions in the workplace.

2.3 Descriptive Statistics

The response rate of the surveys ranged between 35% and 40%. In the first wave, we gathered 573 valid answers, 585 in the second wave, 569 in the third, and 530 in the fourth. The median completion time of the survey was 11 minutes. We observe no differences in response time between relocated (treated) and non-relocated (control) employees, suggesting no differences in attention or effort between the two groups (but, of course, our goal is not to empirically assess such differences).

Table 1 shows the demographic characteristics of the relocated and non-relocated workers in wave 1. The non-relocated employees were younger, on average, than those in the relocated group, as reflected by the higher percentage of individuals below 31 years old (19% vs. 10%). The gender ratio does not differ between two employee groups.

[Insert Table 1 about here]

Looking at the current contract characteristics of the two groups of employees, we find the non-relocated individuals were younger and less experienced than those in the relocated group. The total working hours and gender balance do not differ significantly between the treatment and control group.

[3]Respondents were asked to choose between the following options to report the number of sick days: I did not report sick this year, (2) 1 day, (2) 2-5 days, (3) 5-10 days, and (4) more than 10 days.

3 Methods And Results

We use DiD models to estimate the impact of the improvement in building conditions on workers' perceived working conditions and health status. The DiD research design relies on the assumption that the characteristics of workers who were relocated to the new building changed over time in a way that is comparable to those who were not relocated. To alleviate concerns of potential biases in our results, we estimate our parameter of interest in a regression model with a rich set of fixed effects and time-varying control variables. See Appendix A for a more extensive discussion of the empirical strategy.

3.1 Difference-in-Differences Results

Table 2 provides the estimation results. Column (1) shows the estimated DiD coefficients, including time, individual-fixed effects, and time-varying controls. We also include changes in working hours, perceived quality of furniture, and office layout as time-varying controls.

The estimation results indicate the relocation of workers is associated with a significant decrease in the level of dissatisfaction of perceived environmental quality in all measures, except for noise and privacy. The highest impact associated with the relocation is on the air-quality dimension, where the dissatisfaction scale drops 1.4 points on a 7-point scale. In relative terms, when compared to the average value of these scales in the baseline survey for the relocated group, the relocation to the new building improves employee satisfaction with air quality by 32% (1.44/4.50). Similarly, the relocated employees attach a 26% (1.09/4.14) lower value to the scale evaluating whether air quality hinders work.

The relocation of workers to the sustainable building generates significant improvements in the perception of light quality and temperature. The absolute and relative improvement in the scales of these two parameters is smaller than the changes observed for the air-quality dimension. Temperature dissatisfaction among relocated workers drops, on average, by 0.59% - 17% compared to the average value of the relocated group before the move. Similarly, the relocation reduces dissatisfaction with the light quality in the building by 0.5% - 28% compared to the average value of the relocated group before the move.

Importantly, we observe significant improvement in the health of individuals. Although we document no changes in absence due to illness, we observe significant changes in the health status of individuals. Column (1) of Table 2 shows a decrease of 21.6% in the prevalence of sick-building syndrome among the relocated workers after the move. The relocation of workers generates a substantial drop in the prevalence of sick leave syndrome symptoms when compared to the baseline probability of reporting sick building syndrome symptoms among the relocated employees, by 42%.

[Insert Table 2 about here]

3.2 Dynamic Effects

We test for the existence of a possible rebound in the improvement of perceived satisfaction and health experienced by the relocated employees. Evidence from psychology and behavioral economics shows that individuals tend to adapt, in the medium term, to changes in their physical or material conditions (e.g., Kahneman and Deaton, 2010). Thus, the estimated changes in the subjective assessments presented in the previous section might be biased by an overreaction of individuals in the short term. In addition, the potential material depreciation of the new building might also distort the results.

Figure 1 shows the the changes in responses across survey waves (k) with respect to the baseline survey for the relocated (blue) and non-relocated employees (gray), together with their associated confidence intervals. The three surveys cover both the cold and warm seasons. Overall, we observe stability in the coefficients describing the changes in health status over time [4]. We find no evidence of a rebound in the estimated changes in the health status of the employees. The estimation results indicate that the drop in the prevalence of sick-building syndrome remains at the initial level ($\delta_{k=1} = 0.210$).

[Insert Figure 1 about here]

3.3 Heterogeneous Effects

We then study whether some subgroups are more sensitive to indoor environmental conditions than others. First, we explore gender differences. The current indoor climate regulations in office buildings tend to be based on a thermal comfort model developed in the 1960s. That model optimizes the environmental conditions to satisfy an average male. A recent study in biophysics indicates the existing model significantly miscalculates the metabolic rate of female thermal demand (Kingma and Van Marken Lichtenbelt, 2015). This is line with the many field studies showing females express more dissatisfaction than males with low temperatures (for a review of the literature, see Karjalainen, 2012). In addition, the presence of pre-existing diseases in the respiratory or cardiovascular systems among older population groups might exacerbate the health impacts of certain hazards in the indoor environment (e.g., indoor pollutants) (Li et al., 2018). For the analysis of the differences across demographic groups, we therefore stratify our sample by gender and age.

Table 2 Columns 2 to 6 presents the results of the heterogeneity analysis. Columns 2 and 3 display the results for the two gender subsamples, and columns 4 to 6 show the estimates

[4] We also test for the persistence of effects on perceived satisfaction. Results are omitted for brevity, but show no rebound in the perceived benefits toward the initial levels.

for the three age groups in our sample. We observe no significant discrepancies in responses to scales in the noise, air, and light-quality dimensions across gender or age groups. However, the results for thermal dissatisfaction indicate the drops in dissatisfaction rates associated with the new building are present only among male employees. Relocated women did not significantly adjust their ratings after being transferred to the new building. Similarly, we observe significant changes in thermal dissatisfaction among the older employees only (beyond 30 years old).

When focusing on the health measures, we find the relocation of workers to the new building generates similar drops in the prevalence of sick-building-syndrome symptoms in female and male employees. The estimates suggest the impact of the relocation becomes more significant with the age of employees. We observe significant decreases in the probability of reporting sick-building syndrome among the oldest group of employees only (over 50 years old). The coefficient associated with the group of workers between 30 and 50 years old is marginally significant (i.e., at the 10% level).

3.4 Environmental Conditions and Health

The relocation to a new building involves significant changes in a variety of factors regarding the workplace of employees. We therefore analyze how the changes in different dimensions of indoor environmental conditions contributes to the change in the prevalence of sick-building-syndrome symptoms, with respect to the initial situation just before the moving date.

Figure 2 presents the estimated coefficients Θ_s of equation 3, describing the association between the probability of reporting sick building syndrome symptoms and each of the four factors related to the indoor environmental conditions in the workplace. The estimations indicate that poor air quality is, on average, the only significant contributor to the prevalence of sick building syndrome symptoms. The presence of perceived deficient air quality is associated with an increase of about 10 percentage points in the odds of reporting sick building syndrome in our sample.

We also include a series of furniture-quality factors as regressors in the empirical model, as placebos to construct a falsification test. The absence of significant coefficients associated with these factors supports the hypothesis that the health improvements displayed in this study are mainly driven by an improvement in environmental conditions in the workplace and not by a general building-quality improvement.

[Insert Figure 2 about here]

4 Discussion and Public Health Implications

Human health is a critical factor for the generation of output by workers. Companies bear substantial costs associated with absenteeism and presenteeism among their employees (Hemp, 2004; Stewart et al., 2003). In addition, increasing evidence shows job satisfaction translates into higher productivity for workers and ultimately higher value for companies (Edmans, 2012).

This study investigates the impact of the indoor environmental conditions in the workplace on the health and job satisfaction of employees, as core factors of productivity. We exploit quasi-experimental evidence based on the relocation of 70% of the workforce of a municipality in the south of the Netherlands. The estimation results show a significant improvement in the perceived indoor environmental conditions and health of the relocated workers. We find the largest improvements in perceived air quality of the workplace, reducing the level of dissatisfaction by 1.62 points on a 7-point Likert scale. In addition, we observe significant improvements in the health status of individuals. In particular, we observe a 0.22-percentage-point reduction in the prevalence of sick building syndrome.

The results of the heterogeneity analysis show the existence of differences among workers. The relocation to the new building had significant effects on men and not women. On the contrary, the relocation led to a drop in sick building syndrome that was similar in magnitude between men and women. The analysis of different age subsamples indicates increasing benefits with age. Older individuals benefited the most from the move in terms of perceived environmental quality and health status.

Of course, the analysis in this paper is restricted by the availability of data. First, the analysis relies on self-reported data of participants' sick leave, based on a categorical variable. Ideally, the analysis would include administrative data of sick leave with the exact number of sick days in the year (or months) preceding the survey. Similarly, the changes in environmental conditions are based on the perceived environmental conditions of workers in their workplaces. Ideally, we would rely on sensor data to objectively document changes in indoor environmental quality. Advances in indoor sensor technology should make such data available in the near future.

The results in this paper add to a significant body of research that is mostly based on engineering measures or on cross-sectional analysis. The quality of indoor environmental conditions may have significant economic implications for our service society, which strongly depends on buildings in order for workers to be productive. Our findings show that variation in different dimensions of indoor environmental quality affect perceived health outcomes, which may have implications not just on worker productivity, but also on the cost of absenteeism.

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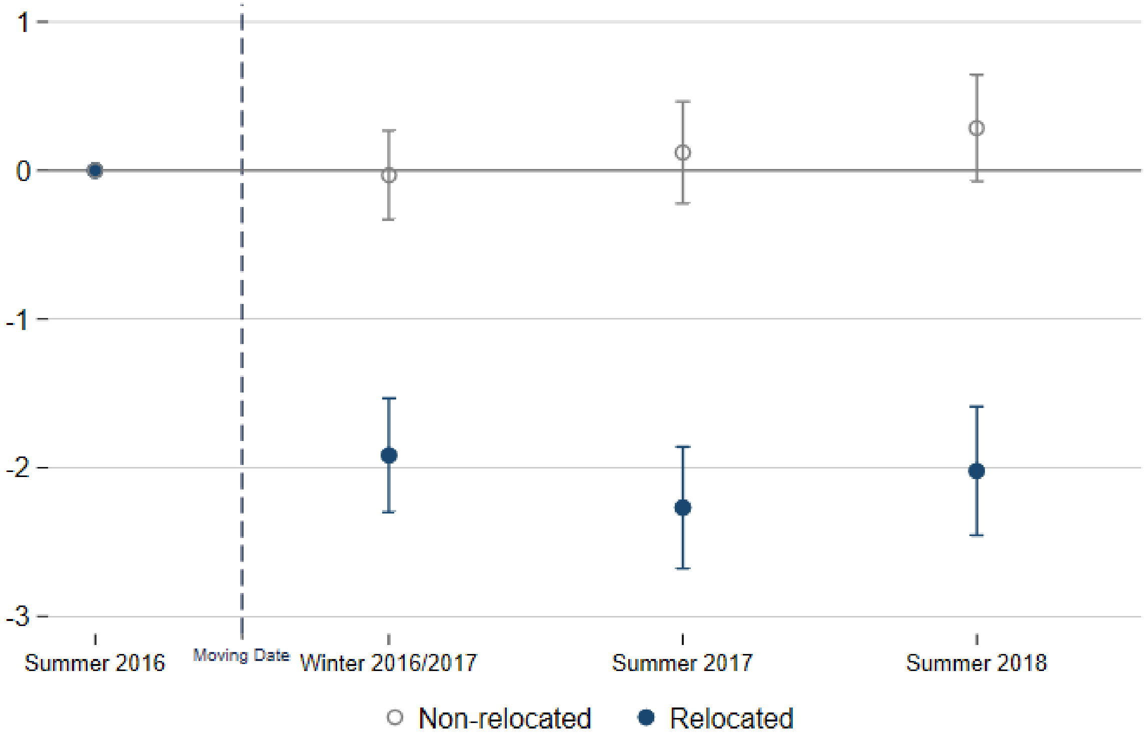
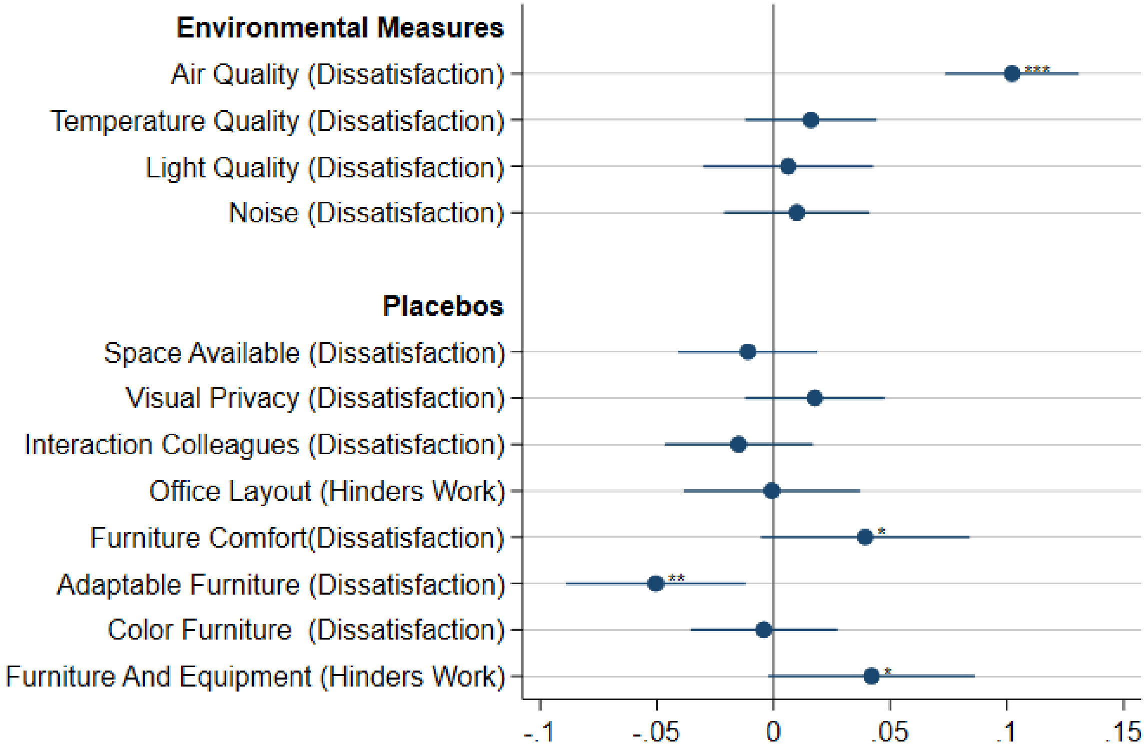
Figures And Tables

Figure 1: Trends in Sick Building Syndrome (1=Yes)



Note: The figure shows the estimated coefficient of the time dummies describing the survey times before (= 0) and after the moving date. The dots represent the point estimates and the bars the 95% confidence intervals. The vertical, dashed gray line indicates the moving date. The set of control variables include the average hours worked per week and the layout scales.

Figure 2: Effect Environmental Problems on Sick Building Syndrome



Note: The figure shows the point estimates of and confidence intervals associated with each ot the elements of vector Θ in Equation 3. The dots represent the point estimates and the bars the 95% confidence intervals. All regressions include time varying controls (contract type), individual and survey-wave fixed effects. * p<0.1, ** p<0.05, *** p<0.01.

Table 1: Descriptive statistics sample in first survey wave (Before the move, July 2016)

	Non-Relocated (N=247)	Relocated (N=326)	Diff.
Age			
Below 31 Years Old (1=Yes)	0.19	0.10	0.09**
31-50 Year Old (1=Yes)	0.34	0.45	-0.11**
50 Years Old or Older (1=Yes)	0.47	0.45	0.02
Gender			
Female (1=Yes)	0.46	0.50	-0.04
Health			
Sick Building Syndrome (1=Yes)	0.44	0.42	0.03
No Days on Sick Leave (1=yes)	0.53	0.53	-0.01
Time Working for The Company			
Less than 1 Year	0.23	0.12	0.11***
1-2 Years	0.38	0.24	0.14***
3-5 Years	0.16	0.27	-0.11**
More than 5 Years	0.23	0.37	-0.14***
Working Hours per Week			
Less than 10 Hours	0.06	0.03	0.03
11-30 Hours	0.41	0.49	-0.08
More than 30 Hours	0.53	0.48	0.05

* p<0.05, ** p<0.01, *** p<0.001

Table 2: Estimation results difference-in-difference

		(1) Full Sample	(2) Men	(3) Women	(4) Age Below 31	(5) Age 30-50	(6) Age Above 50
Indoor Environmental Conditions							
Air Quality	Dissatisfaction	-1.443***	-1.622***	-1.545***	-1.766**	-1.439***	-1.677***
		(0.163)	(0.256)	(0.229)	(0.627)	(0.280)	(0.231)
	Hinders Work	-1.091***	-1.077***	-1.322***	-1.615***	-1.516***	-1.125***
		(0.149)	(0.232)	(0.198)	(0.432)	(0.267)	(0.215)
Temperature Quality	Dissatisfaction	-0.593**	-1.070***	-0.437	-0.794	-0.707*	-0.698**
		(0.195)	(0.263)	(0.272)	(0.737)	(0.302)	(0.267)
	Hinders Work	-0.529**	-1.056***	-0.359	-1.041	-0.624	-0.741**
		(0.182)	(0.260)	(0.233)	(0.608)	(0.339)	(0.231)
Light Quality	Dissatisfaction	-0.503**	-0.607**	-0.720**	-0.871	-0.038	-0.871***
		(0.157)	(0.191)	(0.223)	(0.530)	(0.228)	(0.184)
	Hinders Work	-0.435**	-0.473*	-0.695***	-1.531**	-0.172	-0.677***
		(0.150)	(0.190)	(0.207)	(0.480)	(0.208)	(0.192)
Views	Dissatisfaction	-0.338*	-0.560**	-0.544**	-1.454*	-0.233	-0.478*
		(0.146)	(0.212)	(0.196)	(0.601)	(0.180)	(0.192)
Noise	Dissatisfaction	0.211	0.014	0.097	1.006*	-0.104	0.006
		(0.158)	(0.216)	(0.196)	(0.486)	(0.229)	(0.206)
	Hinders Work	0.069	-0.155	0.065	1.130**	-0.127	-0.208
		(0.148)	(0.199)	(0.191)	(0.396)	(0.219)	(0.199)
Privacy	Dissatisfaction	-0.024	-0.318	-0.014	0.470	-0.158	-0.397
		(0.171)	(0.230)	(0.245)	(0.645)	(0.263)	(0.239)
Health Indicators							
Sick Building Syndrome	Dummy (1=Yes)	-0.216***	-0.277***	-0.223**	-0.355	-0.216*	-0.255**
		(0.056)	(0.075)	(0.078)	(0.223)	(0.085)	(0.078)
Sick leave	Dummy (1=Yes)	- 0.019	0.053	-0.002	0.333*	0.089	-0.000
		(0.066)	(0.085)	(0.084)	(0.159)	(0.107)	(0.082)
Wave-Fixed Effects		YES	YES	YES	YES	YES	YES
Individual-Fixed Effects		YES	YES	YES	YES	YES	YES
Controls		YES	YES	YES	YES	YES	YES

Notes: Robust standard error clustered at the individual level. * p<0.1, ** p<0.05, *** p<0.01. Controls in Column (5) include the satisfaction scales for layout and furniture scales listed in Table and average working hours per week.

A Appendix. Estimation Strategy

We use DiD models to estimate the impact of the improvement in building conditions on workers' perceived working conditions and health status. The DiD research design relies on the assumption that the characteristics of workers who were relocated to the new building changed over time in a way that is comparable to those who were not relocated. To alleviate concerns of potential biases in our results, we estimate our parameter of interest in a regression model with a rich set of fixed effects and time-varying control variables:

$$Y_{it} = \mu_i + \tau_t + \delta Relocated * AfterMove_{it} + \beta X_{it} + \epsilon_{it} \tag{1}$$

where Y_{it} includes the set of outcome variables describing the perceived working conditions, health status, and job satisfaction of individual i at time t. We include the scales describing the perceived noise, temperature, light, and air quality in the workplace. We consider two health outcomes in the analysis: a dummy variable indicating the individual suffers from sick-building syndrome and a dummy variable indicating the individual missed work in the previous year due to illness. In addition, we include the set of job satisfaction questions described in the previous section.

Our prime parameter of interest is δ, describing the average change in the outcomes (Y_{it}) after the move for the employees who relocated to the new building. The individual fixed effects (μ_i) should reduce bias resulting from differences between the movers and non-movers. In addition, we the time dummy variables τ_t for each survey wave, non-parametrically adjust for possible shocks in the city or employer that coincide with the move (e.g., pollution reduction in the city). Finally, we include a set of individual time-varying controls, X_{it}. The set of controls includes the average working hours per week and the reported scales rating the *Office Layout* (See Table 3 for the full list of scales in this category). [5] ϵ_{it} is the error term, which might be correlated within individuals. Therefore, we cluster standard errors at the individual level.

We then use an event-study analysis to capture dynamic effects of the new building on the workers. Equation 2 estimates the effects of the relocation separately by year:

$$Y_{it} = \mu_i + \tau_t + \sum_{k=1}^{K} \delta_k Relocated * AfterMove_{it}^{k} + \beta X_{it} + \epsilon_{it} \tag{2}$$

Here, the coefficient δ_k describes the effect of working in the newly constructed office k periods after the moving date. Thus, $Relocated * AfterMove_{it}^{k}$ is an indicator for being k time periods relative to the moving date. The reference category is $k = 0$; hence, the post-treatment effects are relative to the year immediately before the treated individuals were relocated to the new building.

In a final step, we estimate to what extent the changes in each of the environmental scales with respect to their baseline level translate into changes in health status with respect to the baseline:

$$Health_{it} - Health_{ib} = \tau_t + \Theta_s(IEQ_{its} - IEQ_{ibs}) + \beta(X_{it} - X_{ib}) + u_{it} - u_{ib} \quad (3)$$

where $Health_{it}$ takes the value of 1 if individual i reports sick-building-syndrome symptoms at time t, and zero otherwise. $Health_{ib}$ takes the value of 1 if individual i reports sick-building-syndrome symptoms in the baseline survey. $Health_{it} - Health_{ib}$ describes the difference between individual i's probability of stating sick-building-syndrome status at time t and in the baseline survey b. Similarly, $IEQ_{its} - IEQ_{ibs}$ describes the changes in the values reported in the environmental scale s for individual i at time t, with respect to his answers in the baseline survey b. The coefficients of interest, Θ_s, describe how changes in environmental scale s translate into changes in the probability of reporting sick-building-syndrome symptoms. In addition, we include the changes in a set of control variables for building quality $X_{it} - X_{ib}$. Error terms are clustered again at the individual level.

B Appendix. Invitation Survey

Dutch (original)
Maastricht University en de gemeente Venlo nodigen u uit om deel te nemen aan een onderzoek over werkplek beleving en kwaliteit. Dat doen we door middel van een enquete over uw werkplek en het gebouw waarin die zich bevindt.
De enquete gaat over uw huidige werkplek. Over een paar maanden zullen we u opnieuw vragen om de vragenlijst in te vullen, of u nu gaat verhuizen naar het nieuwe stadskantoor of niet. De informatie wordt gebruikt om gebouwen en werkplekken te verbeteren, niet alleen in Venlo, maar ook in de rest van Nederland en daarbuiten. Het invullen van de vragenlijst duurt ongeveer tien minuten. We danken u heel hartelijk voor uw hulp!
English (translated)
Maastricht University and the municipality of Venlo invite you to participate in a study on workplace experience and quality. We do this by means of a survey about your workplace and the building in which it is located.
The survey is about your current workplace. In a few months we will ask you again to complete the questionnaire, whether you are moving to the new city office or not. The information is used to improve buildings and workplaces, not only in Venlo, but also in the rest of the Netherlands and beyond. It takes approximately ten minutes to complete the questionnaire. We thank you very much for your help!

Table 3: Description questions in survey

Variable Name	Survey Question
Indoor Environmental Condition	
Temperature Quality (Dissatisfaction)	How satisfied are you with the temperature at your workplace?
Temperature Quality (Hinders Work)	In general: does the thermal comfort at your workplace support or hinder your work?
Air Quality (Dissatisfaction)Â	How satisfied are you with the air quality at your workplace (i.e. stuffy/stale air, air cleanliness, odors)?
Air Quality (Hinders Work)	In general: does the air quality at your workplace support or hinder your work?
Light Quality (Dissatisfaction)	How satisfied are you with the amount of light in your workplace?
Views (Dissatisfaction)	How satisfied are you with the visual comfort at your workplace (glare, reflections, contrast ratios)?
Light Quality (Hinders Work)	In general: does the light in your workplace support or hinder your work?
Noise (Dissatisfaction)	How satisfied are you with the noise level at your workplace?
Privacy (Dissatisfaction)	How satisfied are you with the acoustic privacy at your workplace (possibility of having conversations without colleagues listening in)?
Noise (Hinders Work)	In general: does the noise at your workplace support or hinder your work?
Office Layout	
Space Available (Dissatisfaction)	How satisfied are you with the space available for carrying out your work and storing work equipment?
Visual Privacy (Dissatisfaction)	How satisfied are you with the visual privacy at your workplace?
Interaction Colleagues (Dissatisfaction)	How satisfied are you with the opportunities for interaction with your colleagues?
Office Layout (Hinders Work)	In general: does the workplace structure support or hinder your work?
Furniture Comfort(Dissatisfaction)	How satisfied are you with the comfort of your office furniture and equipment (eg chair, desk, computer)?
Adaptable Furniture (Dissatisfaction)	How satisfied are you with the options to adjust your furniture to your needs?
Color Furniture (Dissatisfaction)	How satisfied are you with the color and quality of floor coverings, furniture and other surface materials?
Furniture And Equipment (Hinders Work)	In general: Does the office furniture and equipment support or hinder your work?

All questions are based on 7-point Likert scales, from satisfied (1) to dissatisfied (7).