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Investments in Worker Health and Labor Productivity: Evidence from Vietnam

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Abstract

The health and safety of workers are important determinants of their productivity. In manufacturing industries, occupational health and safety (OHS) measures are critical workplace practices for employers to ensure better working conditions for employees, particularly in industries with rampant indoor pollution. This paper studies the impact of investments undertaken by small and medium enterprises in Vietnam in worker health and safety (including in air quality improvements, heat and noise protection as well as in lighting measures) on labor productivity using a production function approach and panel data from 2011-2015. We find that the amount invested by the firm per worker has a significant positive effect on labor productivity. Moreover, our results hold true for both small and large firms, and for firms belonging to different subgroups of industries. Given historically poor working conditions in Vietnam, policy implications relate to the importance of OHS measures and pollution abatement in influencing economic outcomes such as productivity.

Keywords: Investments in health; Indoor pollution; Labor productivity; Small and medium enterprises; Vietnam

JEL Codes: D83; Q18; Q54; C23;C26

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1 Introduction

Human capital investments have important repercussions on the quality of labor, and thus on firm-level performance. The economic literature has for long regarded education and training of workers to be an important means of augmenting human capital, however good health has also been recognized as a critical determinant of productivity (Currie and Madrian, 1999). The onus of improving public health outcomes lies on both policy-makers, as well as on firms: while governments can implement regulations and standards, ensure that sanitation and nutrition-related guidelines are met, and provide education, the private sector has the primary responsibility to ensure a healthy work environment for employees.

An important example of how they can do this is by adopting occupational health and safety (OHS) measures for workers. Investment in health and safety of workers is an important determinant of not just their well-being, but it has also been found through case studies to have an impact on the bottom-lines of firms (WHO, 2010). These measures are a means to mitigate the risks due to chronic illnesses and disabilities due to difficult working conditions, as well as of accidents and chemical exposures that may inflict workers (Currie and Madrian 1999, Pouliakas and Theodossiou 2013). They are thus likely to lead to a healthy workforce, that is more productive, and can work more and better (Well, 2007).

According to estimates from the International Labour Organization, about 2.3 million women and men around the world succumb to work-related accidents or diseases every year; and there are around 340 million occupational accidents and 160 million victims of work-related illnesses annually worldwide (International Labour Organization, 2019). In developed countries, policies such as regulations, information disclosure and financial incentives like compulsory accident insurance have tried to attenuate these occupational incidents, and ensure that firms provide basic standards of health and safety for their workforce, although the literature has been ambiguous on whether these measures have been effective (Viscusi 1979, Weil 1996, Pouliakas and Theodossiou 2013). In developing countries, where a higher proportion of the workforce is engaged in manual labor, and regulatory enforcement is often weak, OHS investments are often either not undertaken, or not to the extent that may be necessary (Lucchini and London, 2014).

Our objective in this study is to shed light on the role of investments to mitigate indoor pollution (and thus improve worker health and safety) such as investments in air quality, lighting, and heat and noise mitigation systems on labor productivity outcomes for manufacturing firms by adopting the production-function approach, and using data on a sample of small and medium enterprises (SMEs) in Vietnam. Labor productivity is an important economic outcome to consider, for several reasons. Firstly, labor productivity has been shown to be an important barometer of several important economic indicators such as firm-level competitiveness, economic growth and living standards in an economy (OECD, 2008). It has also been found to be an important determinant of export competitiveness, and the relationship between these factors has been found to hold in both directions (Bernard and Bradford Jensen 1999, Bernard et al. 2007, Bartelsman and Doms 2000). This is of particular relevance with respect to firms in countries that are relatively more export-oriented (such as Vietnam, for example[1]).

Vietnam is an interesting and relevant case study: SMEs comprise almost 98% of all enterprises in the economy, and employ about 80% of the country's workforce (Dezan Shira & Associates, 2017). Moreover, as a rapidly developing economy, the industrialized sector in Vietnam has expanded significantly, especially after its accession to the World Trade Organization. Vietnam is now one of Asia's largest exporters, and the "ramping up" of its manufacturing sector has posed increased pressure on both working conditions, and the environmental sustainability of Vietnam's development. For a long period, Vietnam had a reputation for being a “sweatshop” for many large multinationals, with several reports in popular media outlets commenting on poor working conditions of laborers in

[1] Vietnam's share of exports of goods and services as percentage of gross domestic product (GDP) was 101.59%, whereas its share of imports as percentage of GDP was 98.79% in 2016 (World Integrated Trade Solution, 2016).

the country (Greenhouse 1997, Guilbert 2018). While regulations have been passed on worker health and safety over the years, there is less evidence on whether they have been effective in improving working conditions. This lends to the importance of a study on whether investments in OHS may lead to improvements in labor productivity in low and middle-income countries (LMICs) such as Vietnam, where a) employers may find it costly to undertake these investments, and b) where workers have suffered due to inferior working conditions.

In this paper, we adopt a structural approach based on production function estimation to better understand whether a specific type of 'good' workplace practice (investment in worker health and safety) has an impact on labor productivity, in a context where working conditions have historically been poor. While a broad consensus emerges from studies based on production function estimation on the importance and effectiveness of workplace practices such as information technology, or of management practices, in determining firm-level productivity outcomes (Black and Lynch 2002, Lee et al. 2013, Bloom and Van Reenen 2007), these studies have less to say on the specific types of firm-level interventions which we consider in our paper. To this end, a stream of literature has adopted a reduced-form approach to study the effect of ambient pollution (or its mitigation) on worker productivity, mostly relying on natural experiments or quasi-experimental settings (Hanna and Oliva 2015, Lichter et al. 2017, Zivin and Neidell 2012, He et al. 2019, Carson et al. 2011, Walker 2011, Chang et al. 2019).

Through our study, we contribute to the literature on the impact of improving indoor environmental quality on labor productivity by using a production function approach as an alternative to the reduced-form approaches used to study this question so far in the literature. To the best of our knowledge, our study is one of the first to adopt a production-function approach to evaluate the effects of investment in health on labor productivity, not just in a developing country, but also among developed countries. We treat investment in worker health as an example of a vital management practice, given that improved health outcomes due to improved indoor environmental quality are likely to lead to fewer sick days, fewer risks of illness and disabilities, and workers that can work harder and longer (Well 2007, Currie and Madrian 1999). Other inputs may also be used more efficiently due to better health of workers, for instance, physical capital per worker (Well, 2007). In our opinion, these may be some of the channels through which investment in worker health may affect labor productivity.

The focus of this paper is on a sample comprising predominantly small and medium enterprises (SMEs) in Vietnam. We use panel data from the UNU-WIDER Vietnam SME firm-level database (United Nations University UNU-WIDER, 2011) that collects information on about 2500 firms, mostly SMEs, from 2011-2015 biennially. The specific types of measures that we are studying include investments to improve indoor air quality in manufacturing enterprises (such as the establishment of efficient ventilation systems), in heat protection, in lighting, as well as in protection against noise pollution (through investment in noise protection gear for instance).[2] We evaluate the effects of investment in equipment to improve worker health, possibly through reduced indoor pollution, on the productivity of workers over a broad spectrum of industries. We are able to provide estimates of the impact of investments on productivity in monetary terms; this has important policy implications, especially in developing countries where investments in worker health by firms are often few, and of low to negligible amounts.

Our paper presents evidence spanning various estimation methodologies on the impact of investments in health on labor productivity. We employ an ordinary least squares (OLS) estimator, a within estimator, as well as a dynamic panel data (DPD) estimator to estimate the production functions, although we emphasize the DPD model, given the advantages it offers us in this context. Moreover, we account for the fact that many firms do not undertake these investments (namely, the "zero-observation" problem) following two different methodologies adopted from the literature.

We find that health investments have a noteworthy and positive impact on worker

[2] While we have information on these four types of investments, we choose to club them together into one measure of investment in health, as we feel that they are very closely related to one another.

productivity among small and medium enterprises in Vietnam. We find that increasing investment in health per worker by 1% leads to an increase in labor productivity by about 0.12%. This is equivalent to an investment in health per worker of 1 Vietnamese Dong (VND) leading to an increase of revenue per worker by 0.45 VND (or an investment of 43 cents per worker leading to an increase of revenue per worker by 19 cents (in US dollar (USD) terms)). This suggests that workers may be experiencing better health outcomes due to these investments, which enables them to work more (plausibly due to lower risks of illness, accident or disability).

Moreover, we find that this effect is prevalent across firms of different size, and that it is not driven only by larger firms. Our results are confirmed for firms belonging to industries that are not pollution-intensive, as well as those that are. Lastly, we are able to test the validity of our main results for different subgroups of industries.

The structure of the paper is as follows: Section 2 provides a brief review of the literature, Section 3 provides details on the data and methodology used for the analysis, Section 4 includes the main results of the paper as well as of robustness checks, while Section 5 concludes and includes policy implications.

2 Previous Literature

As mentioned in the previous section, two strands of literature are a fit for this study. The first that is relevant to this paper is the one on production function estimation, which has been augmented in some studies to assess the impact of not just traditional inputs such as capital, labor and raw materials, but also of management or workplace practices, investments in infrastructure such as information technology (IT), and pro-worker activities (such as allowing workers to work from home, or work part-time) on worker productivity.

Black and Lynch (2002) was one of the first studies to evaluate the impact of workplace practices on labor productivity by estimating a production function; using a DPD approach, and panel data on firms in the US, they found that there was a positive effect of the intensity of the implementation of good workplace practices on labor productivity. Bloom and Van Reenen (2007) showed that good management practices (such as performance reviews, rewards for good performance, setting clear targets, etc.) had a strong and positive effect on worker productivity across a broad spectrum of countries. Bloom et al. (2010) also used production function approaches to evaluate the effects of better management practices on energy intensity of firms, and they found that better managed firms released fewer emissions. Lee et al. (2013) provided evidence from California on the positive (and significant) effects of IT- specific labor and IT capital on hospital productivity.

Methodologically, our study is similar to these papers. Like some of these studies, our baseline model also uses the DPD methodology to estimate the firm-level production function. We use information on investments in worker health and safety to construct our measure of 'health capital', following work by Grossman (1972) in which health is considered as a durable capital good in the production function.

This literature, however, has not adequately focused on the impact of efforts to improve worker health on firm-level outcomes. While a few studies in the health and development literature have also evaluated the effects of indoor air pollution mitigation on household-level outcomes (by studying whether there are any improvements in indoor air quality, respiratory health as well as education outcomes due to investments in technologies such as improved cook-stoves (ICS), for example (Hanna et al., 2016)), there is scant evidence on whether workers may also reap the benefits of efforts at the workplace to improve their health.

In the second stream of literature, several papers have looked at the effect of outdoor air pollution (or even temperature) on worker productivity outcomes, and have focused on developing countries, where the concentration of pollutants is often more pronounced (Dominici et al., 2014). Most of these studies employ either a natural experiment-based, or a quasi-experimental approach to evaluate this question. Many utilize daily-level data on pollution and output or productivity. For instance, He et al. (2019) used data on daily shifts in worker output at two manufacturing sites in China to find that SO_2 and $PM_{2.5}$

concentrations did not have a significant effect on worker output.

On the other hand, Hanna and Oliva (2015) studied the short-term impact of the closure of a refinery in Mexico City on work hours, and they found that due to reduced levels of SO_2 in the refinery's vicinity, there was an increase in the hours worked by laborers residing in nearby neighborhoods. Zivin and Neidell (2012) is another study that found that even marginally lower levels of ozone could lead to significant improvements in worker productivity among agricultural workers in California, suggesting that environmental improvements may be an effective means of achieving positive economic outcomes. Likewise, Lichter et al. (2017) found that higher levels of air pollution had a significant negative effect on the number of passes made in a match by football players, and that these negative effects already began to appear at moderate levels of pollution. Another study that analyzed the effect of improving working conditions is that of Adhvaryu et al. (2018). They found that investing in LED lighting in garment factories in Bangalore, India raised the productivity of workers, especially on hot days, as their use decreased the temperature on factory floors. The results of these studies suggest that worker productivity could potentially be influenced by the negative effects of pollution, which has important repercussions for the course of policy.

3 Data and Empirical Approach

3.1 Model Specification and Econometric Approach

Our methodology closely resembles that adopted by Black and Lynch (2002) and Lee et al. (2013), who estimate, using an augmented Cobb-Douglas production function, the effects of workplace practices, IT and human capital investments on labor productivity across a broad spectrum of firms in the US (namely, firms pooled over several industries), and the effects of IT labor and capital on labor productivity in hospitals in California, respectively.

In line with Black and Lynch (2002), we use data on firms belonging to a broad spectrum of industries for the analysis, rather than focusing on any one particular industry. While we have data on firms belonging to about 18 different industries, we do not have sufficient observations for any single industry, and thus we choose to pool data over all industries in our sample for the regression analysis. This also enables us to use a broader, more representative sample of firms. However, in the empirical section, we also provide robustness checks of our main results, using different subgroups of industries.

Following Black and Lynch (2002), we estimate the average labor productivity by dividing all terms of a standard Cobb Douglas production function by the total labor force of the firm. The general econometric specification that we estimate given our panel data setting can be expressed as:

$$ln\frac{Y_{i,t}}{L_{i,t}} = \alpha_0 + ln\frac{I_{i,t}}{L_{i,t}}\alpha_1 + ln\frac{K_{i,t}}{L_{i,t}}\alpha_2 + ln\frac{M_{i,t}}{L_{i,t}}\alpha_3 + \gamma_{j,t} + \mu_{i,t} \tag{1}$$

We define the output and input variables as described below. $\frac{Y_{i,t}}{L_{i,t}}$, our dependent variable, denotes the labor productivity of firm 'i' in year 't'. $Y_{i,t}$ is the revenue (defined as the sum of the products of the total quantity sold of the top three products produced by the firm 'i' and their respective sales prices in year 't'). $L_{i,t}$ denotes the total labor force of the firm. $\gamma_{j,t}$ denotes an industry 'j'-specific time-trend, and $\mu_{i,t}$ denotes the idiosyncratic error term. By measuring labor productivity in terms of revenue, we assume perfect competition in both product and factor markets, the homogeneity, divisibility and substitutability of factors of production, constant production technology and full employment. Given that our sample comprises micro or small enterprises, these assumptions are likely to be tenable.

Our main independent variable of interest (and one of the inputs) in equation (1) is the value of 'health capital' (or total investments undertaken by the firm in worker health) per worker, $\frac{I_{i,t}}{L_{i,t}}$. Following work by Grossman (1972), we consider health to be a durable capital good in the production function, and our measure comprises investments made in protection against poor air quality, noise protection, heat protection and lighting, and is measured in VND per worker.

The other (normalized) inputs are the log of capital per unit of labor $\frac{K_{i,t}}{L_{i,t}}$, and of raw materials per unit of labor $\frac{M_{i,t}}{L_{i,t}}$. The variable for capital $K_{i,t}$ is defined as the market value (in VND) of total equipment and machinery owned by the firm at the end of the previous year. $M_{i,t}$ is defined as the market value (in VND) of the raw materials and input inventory assets of the firm at the end of the previous year.

This model can either be estimated assuming constant returns to scale, or increasing or decreasing returns to scale. We test for constant returns to scale, and find that the restrictions implied by this assumption are valid for our data. The value of all the inputs, as well as the dependent variable, have been deflated using 2010 constant prices (World Bank, 2017).

There are several empirical approaches available to an econometrician interested in production function estimation using panel data, such as OLS, a fixed effects estimation that accounts for time-invariant unobserved heterogeneity, and approaches that account for both time-invariant heterogeneity as well as endogeneity issues related to input choice.

While the fixed effects estimator addresses time-invariant unobserved heterogeneity, it is still likely to suffer from endogeneity, due to correlated unobservables (unobserved determinants of production that may be correlated with observed input choice by the firms), simultaneity bias (namely that the inputs, output and investments are chosen simultaneously), as well as measurement error (especially in the measure of inputs in the production process, such as capital and raw materials). In order to deal with these econometric challenges, the modern empirical literature on the estimation of production functions has proposed several approaches.

These can be divided into two sets of methodologies: the first one uses observed input choices as a means of accounting for unobserved productivity shocks (Olley and Pakes 1996, Levinsohn and Petrin 2003 and Ackerberg et al. 2015), while the second set of models adopts the dynamic panel approach (Arellano and Bond 1991, Arellano and Bover 1995, Blundell and Bond 1998). Each set of methodologies has distinct advantages and disadvantages.

The first set of models assume that the error term, denoted by $\mu_{i,t}$ in model (1) above, can be expressed as follows:

$$\mu_{i,t} = \rho_i + \nu_t + \omega_{i,t} + \eta_{i,t} \tag{2}$$

where ρ_i denotes the time-invariant firm fixed effect, ν_t denotes the common, time-varying productivity shock, while $\eta_{i,t}$ is the residual. $\omega_{i,t}$ is now an unobserved productivity term which evolves according to an autoregressive process, that may be correlated with the observed inputs. In this context, the three most common modeling strategies are those proposed by Olley and Pakes (1996) (OP), Levinsohn and Petrin (2003) (LP), and Ackerberg et al. (2015) (ACF), and they make different assumptions about the variation in ρ_i, the evolution of $\omega_{i,t}$, as well as the timing of input selection (Lee et al. 2013, Ackerberg et al. 2015). These models use two-step estimators, and proxy variables to control for productivity shocks. The OP methodology uses investment as a proxy variable, LP uses material inputs, while ACF uses both. Ackerberg et al. (2015) suggest that the OP and LP models suffer from collinearity in input choices, due to the functional dependence problem. They propose an estimator that relaxes some of the assumptions made in these models, and is a viable alternative to these estimation methods.

One drawback of these methods of production function estimations is that they do not take into account the unobserved heterogeneity in total factor productivity across firms (Lee et al., 2019), which is particularly relevant in our case because of the diversity of firms across industries and regions of Vietnam. Moreover, they are not very tractable when the dependent variable measures labor productivity, as in our case. Given these challenges, in this paper, we opt to estimate a dynamic panel data (DPD) version of model (2) instead, using a system generalized method of moments (GMM) procedure along the lines of Arellano and Bover (1995) and Blundell and Bond (1998), as the third model of our study. In this estimation, we treat all inputs (capital, raw materials and health capital) as endogenous variables.

The system GMM methodology involves using lagged values of both the levels, and differences in firm-level inputs (capital per worker and material per worker), output per worker as well as the investment in worker health per capita as instruments for the current values of these variables (to augment the approach of Arellano and Bond (1991)). These lagged values are assumed to be correlated with the current values, but independent of the error term (Arellano and Bover 1995 and Blundell and Bond 1998). This methodology has been adopted in similar studies, such as in Black and Lynch (2002), Bloom and Van Reenen (2007), and Lee et al. (2013). In our econometric analysis, we thus choose to use, in addition to the OLS and the fixed effects production function estimator, the DPD estimator, given that we have a panel with large within variation, and short time dimension, and that the estimates obtained from the DPD approach are more robust in the presence of measurement error.

Another econometric issue that we need to address in our estimation framework is that the variable for health capital is populated with zero values for about 47.18% of observations in our sample (since not all firms undertake investments in health capital). Directly taking the log transformation of this input for the production function estimation would not only reduce our sample size (given that log of zero is undefined), but also not enable us to capture the decision of firms to undertake investments in worker health adequately.

In order to solve this issue, we use two approaches. As a first cut, we take the logarithmic transformation after adding a small number (for e.g., 0.0001) to the health capital per unit labor. This will retain the observations of firms with zero investment in our sample. Our second approach uses the inverse hyperbolic sine (IHS) transformation, as is commonly done for variables assuming the value of zero, in the literature (Pence 2006, Kristjánsdóttir 2012, Muehlenbachs et al. 2017, Jayachandran et al. 2017). The IHS transformation enables us to consider the zeroes in our estimation, while retaining all the other logarithmic features of the model to estimate production functions.[3]

Summarizing, in order to estimate the production functions, we use three econometric approaches (OLS, fixed effects, and DPD) and use two different treatments for the zero-observation problem (the first is taking the log transformation of the health capital variable added to a very small number, and the second is taking the IHS transformation (given in expression (5)). The DPD model estimated using the IHS transformation is the baseline model of our paper. While the main models are sparse in terms of control variables in line with the production-function methodology, we also estimate one version of our baseline model including some firm and respondent-level controls.

3.2 Data

For this study, we use data from the UNU-WIDER Vietnam SME firm-level database (United Nations University UNU-WIDER, 2011). The database tracks a sample of 2500 predominantly small and medium-sized firms in nine provinces of Vietnam biennially over the period 2011-2015, creating an unbalanced panel. The data set collects information on the economic accounts, as well as data on various enterprise-level, as well as some employee-level characteristics. The enterprises surveyed are distributed across approximately 18 sectors such as food processing, fabricated metal products, and manufacturing of wood products. Firms are classified according to the current World Bank definition, with micro-enterprises having up to 10 employees, small-scale enterprises up to 50 employees, medium-sized enterprises up to 300 employees, and large enterprises having more than 300 employees.[4] The database also includes variables related to firm performance, enterprise history, employment, business environment, and owner/ manager background character-

[3] The exact transformation can be represented as:

$$\widetilde{x} = ln(x + \sqrt{x^2 + 1}) \tag{3}$$

.

[4] 99.8% of the 7701 observations in our data sample have fewer than 300 employees. The results of the analysis that follows are robust to restricting the sample to fewer than 300 employees.

istics.

The geographical coverage of our study is nine provinces of Vietnam, from different regions, the north (Hanoi, Phu Tho, and Hai Phong), south (Ho Chi Minh City, Long An, and Khanh Hoa), and central (Nghe An, Quang Nam, and Lam Dong), including some of the most important manufacturing centers of the country (such as Ha Noi, Hai Phong, Quang Nam, Ho Chi Minh City, and Long An). The survey is representative at the province level (Sharma and Tarp, 2018).

The database also collects information on investments undertaken by the firm in equipment to protect both worker health, the value of the investment made by the firm in this equipment, as well as the year when the investment was undertaken. In this paper, we focus on four kinds of investments that we feel are likely to have an impact on worker health, namely in air quality (in improving ventilation, or removing particles and dust), equipment that prevents excessive heat (such as fans, air conditioners, and cooling systems), improved lighting (such as window systems and light bulbs) as well as noise reduction equipment (such as investments in protective gear). We have information on investments made by firms since 1981, however most of the investments made in what we call 'health capital' are closer to the sample period of 2011-2015.

Table 1 below presents some summary statistics on the types of investments that we are focusing on in this study. We find that while the percentage of observations in our sample with positive levels of investment varies across the types of investments, the median year of investment by firms was (slightly) before the period of our data sample. Moreover, we see that the average amount of investment is highest for equipment protecting against heat, as well as investments in air quality improvements, whereas the percentage of observations in our sample with positive investment in protection against heat is the highest at around 41%, closely followed by investment in lighting.

We use the information on the type of investment, the amount of investment, as well as the time that the investment was made to construct our measure of 'health capital', following Grossman (1972) where health is considered as a durable capital good in the

Table 1: Summary Statistics on Investments in Worker Health by SME's in Vietnam

Type of investment	% of obs with positive investment	Mean amount of investment (in VND)	Median year of investment
Air quality	12.75	4.8 million	2010
Protection against noise	8.12	2.5 million	2009
Protection against heat	41.06	5.5 million	2010
Lighting	39.41	2.2 million	2010

Notes: Source: UNU-WIDER Vietnam Database. The investment amounts are measured at constant (2010) prices.

production function. If the firm makes an investment during the period 2011-2015, the variable for health capital takes the value of the investment made in the relevant years (and is fixed at the first non-zero value over the three years of data, if a firm only invested once). If the firm purchased equipment prior to the first year of our sample (namely 2011), the variable capturing health capital is equal to this amount for all three years of our sample (unless the firm undertakes other investments during the period 2011-2015, in which case the value of the health capital is equal to the value of those investments in the corresponding years when they were made).

Table 1 also suggests that many observations in our sample have zero values of investment, as we discussed in the previous section, i.e. not all firms have been undertaking these investments. On considering these four types of investments together to generate our independent variable measuring health capital, we find that for 47.18% of observations, this variable takes the value of zero. Thus, we use the two methodologies described in the previous section to address this zero-observation problem in our estimation.

Table 2 below presents summary statistics on the modeling variables, including the dependent variable, as well as our main independent variables. We find that the average labor productivity (which in our data is the revenue from the sale of the top three products of the firm, divided by the total number of workers) is equal to about 33.2 million VND per worker per year (which amounts to about 1429 USD per worker per year). The average value of health capital is about 890,000 VND per worker per year (at constant 2010 prices), which corresponds to about 38 USD per worker per year. As one can expect, the average value of health capital per worker is smaller than that of equipment/machinery or raw materials per worker.

Regarding the respondents of the survey, we learn that about 61% of them are males, while 72% of them are the owners of the firm (28% are managers). The average age of the respondent is about 46 years, whereas about a third of them are college-educated. The average age of the firm is about 15 years, whereas almost 65% of the sample comprises household enterprises (the rest are sole/private proprietorships, limited liability companies, cooperatives and partnerships).

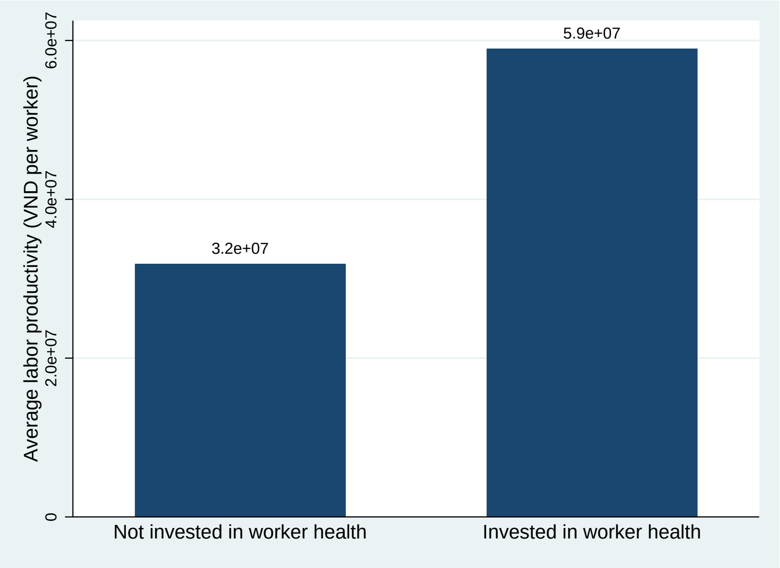
In Figure 1 (a), we express the relationship between the decision to invest in worker health and the average labor productivity of workers in a bar plot. We find that the decision to invest in worker health is correlated with firms having higher levels of labor productivity. The average labor productivity for firms that do no invest in worker health is about 32 million VND, whereas it is measured to be about 59 million VND for firms that have invested in worker health. Complementarily, Figure 1 (b) provides the kernel density plot of the deviation of the labor productivity from the industry means, for firms that have not invested in worker health, and those that have invested at the highest quartile in worker health. From this graph, it seems reasonable to conclude that higher per capita levels of investment in worker health are positively associated with the distribution of labor productivity outcomes among firms in Vietnam. While these insights are descriptive, and do not imply causality of investment decisions on labor productivity, they are certainly suggestive of the role of these investments in improving labor outcomes (particularly in the Vietnamese context).

Table 2: Summary Statistics of Variables in Regression Sample

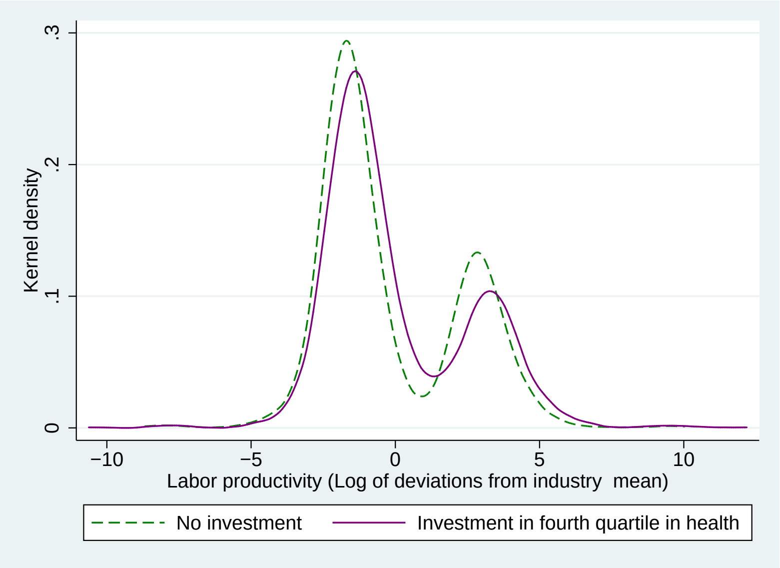
Variable	Number of observations	Mean	Standard Deviation	Minimum	Maximum
Labor productivity (in VND per worker)	6,053	33.2 million	619 million	11.443	24.6 billion
Value of health capital (in VND per worker)	6,053	886723.7	13.1 million	0	866 million
Value of equipment/machinery (in VND per worker)	6,053	28.3 million	59.9 million	3362.114	1.24 billion
Value of raw materials and input inventories (in VND per worker)	6,053	13.1 million	47.8 million	16180.540	2.27 billion
Whether respondent is the owner	6,053	0.72	1 0.448	0	1
Whether respondent is a male	6,053	0.607	0.488	0	1
Whether respondent is college educated	6,053	0.296	0.456	0	1
Whether firm is a household enterprise	6,053	0.646	0.478	0	1
Age of respondent	6,053	46.139	10.866	17	94
Age of firm	6,053	15.462	10.162	2	76

Notes: Source: UNU-WIDER Vietnam Database. The amount-related variables are deflated to constant (2010) prices.

Figure 1: Labor Productivity and Investments in Worker Health (Source:UNU-WIDER)



(a) Decision to invest in worker health and labor productivity



(b) Kernel density plot: deviation of labor productivity from industry means

4 Results

4.1 Main Results

Table 3 below presents the results of the estimations using the log transformation for the health capital variable, whereas Table 4 includes the results of the estimation using the IHS transformation.[5] In column (1) of Table 3, we present the results of the OLS estimation, column (2) includes the results of the fixed effects model, while column (3) presents the results of the DPD estimation using the system GMM methodology. The parameter estimates of column (1) suggest that health capital has a positive effect on the productivity of workers; however, in the absence of corrections for unobserved heterogeneity or endogeneity, we find that the value of the coefficient is small (even though it is significant at the 1% level). In the model of column (2), we are able to control for unobserved heterogeneity across firms. The fixed effects model suggests that a 1% increase in the amount of health capital per worker is related to a 0.122% increase in labor productivity (given the log-linear specification of our production function, the coefficients on the inputs in this Table can be interpreted as elasticities). Lastly, according to the DPD estimation results in column (3), health capital has a significant impact (at the 1% level) on labor productivity, with a 1% increase in the amount of health capital per worker leading to a 0.07% increase in labor productivity in our sample.

The other input variables have coefficients as expected; the log of the value of machinery and equipment per worker (our measure of capital) has a positive and significant coefficient across models. We find that the variable capturing raw materials is insignificant in the DPD model of column (3), even though it consistently also has positive coefficients across the three specifications. In these models, we use industry-specific time-trends to control for industry-specific shocks that may influence firms' decisions. In addition, we also incorporate year fixed effects to capture the unobserved heterogeneity that may in-

[5] In both the results of Tables 3 and 4, we impose constant returns to scale, a restriction that we test using our data, and we find that it is valid.

Table 3: Production function estimation using the logarithmic transformation on the health capital variable

Dependent Variable: Log of labor productivity Column	OLS (1)	Fixed Effects (2)	DPD (3)
Log of value of health capital per worker	0.004***	0.122***	0.067***
	(0.001)	(0.039)	(0.017)
Log of value of capital per worker	0.185***	0.116***	0.256**
	(0.011)	(0.025)	(0.115)
Log of value of raw materials and input inventories per worker	0.192***	0.099***	0.123
	(0.013)	(0.019)	(0.117)
Observations	6058	6058	6058
Hansen J-Statistic			57.14
P-Value			0.172

Notes: Dependent variable is the log of labor productivity (measured in terms of revenue per worker). All specifications include industry-year time trends and year fixed effects. Specification in column (2) includes firm-level fixed effects. Specification in column (3) includes lagged values of the endogenous variables in levels as instruments for the difference equation, and lagged differences as instruments for the equation in levels. In the specification of column (3), industry-year and year fixed effects are included as instruments in the levels equation, and industry fixed effects are included as instruments in the difference equation. Regression sample comprises firms with manufacturing as the main production sector that do not change their location over the duration of the sample. Huber-White standard errors are reported in parentheses. *,** and *** respectively denote significance at 10%, 5% and 1% levels. The coefficients of the constant are not reported.

fluence all firms in our sample (in any given year).

While these results are a useful starting point, transforming variables using the logarithmic transformation (by adding 0.0001 to the observations taking the value zero) may result in biased parameter estimates, especially if the number of zero cases is a significant proportion of the total number of observations (Battese, 1997). Thus, in this paper, we choose to resolve this potential problem by adopting the IHS methodology, as has been often done in the literature.

In Table 4, we follow this estimation approach in order to address the possible bias in the estimations of Table 3 due to the "zero-observation" problem. As before, column (1) includes the results of the OLS estimation, column (2) the fixed effects estimation, and columns (3) (not including any respondent or firm-level controls) and (4) (including respondent and firm-level controls) present the results of the DPD model estimated using system GMM. We believe that the augmented production function estimation of column

(4), i.e. with additional controls, is interesting from an econometric point of view, because it also considers (and accounts for) some time-varying heterogeneity of firm characteristics that could influence the production process.

Using the IHS transformation, we find that the variable of interest, capturing the amount of health capital per worker, is significant at the 1% level across specifications, and has a positive coefficient. For instance, in Figure 2, we find a robust positive association between residuals of health capital and of labor productivity, based on the fixed effects model results of column (2) of Table 4. We find that the magnitude of this effect increases in moving from the OLS results to those using the GMM approach, with a 1% increase in the amount of the health capital per worker likely to lead to a 0.124% increase in labor productivity in column (3), and a 0.121% increase in column (4).[6]

Moreover, the results of the test for the validity of the overidentification restrictions is valid at the 5% level for both the estimations in columns (3) and (4). The difference in the size of the magnitudes between column (2), and columns (3) and (4) has also been observed in other studies where both fixed effects and DPD methods have been employed in production function estimation, such as Lee et al. (2013). The results of column (4) suggest that those firms with respondents who are owners (as opposed to managers) are more likely to report having higher levels of labor productivity, whereas firms with older respondents have lower levels of labor productivity. In this model, we find that being a household enterprise, as well as the gender and education of the respondent and the age of the firm, do not significantly affect the labor productivity.

The magnitude of the coefficient on the variable of interest in column (4) of Table

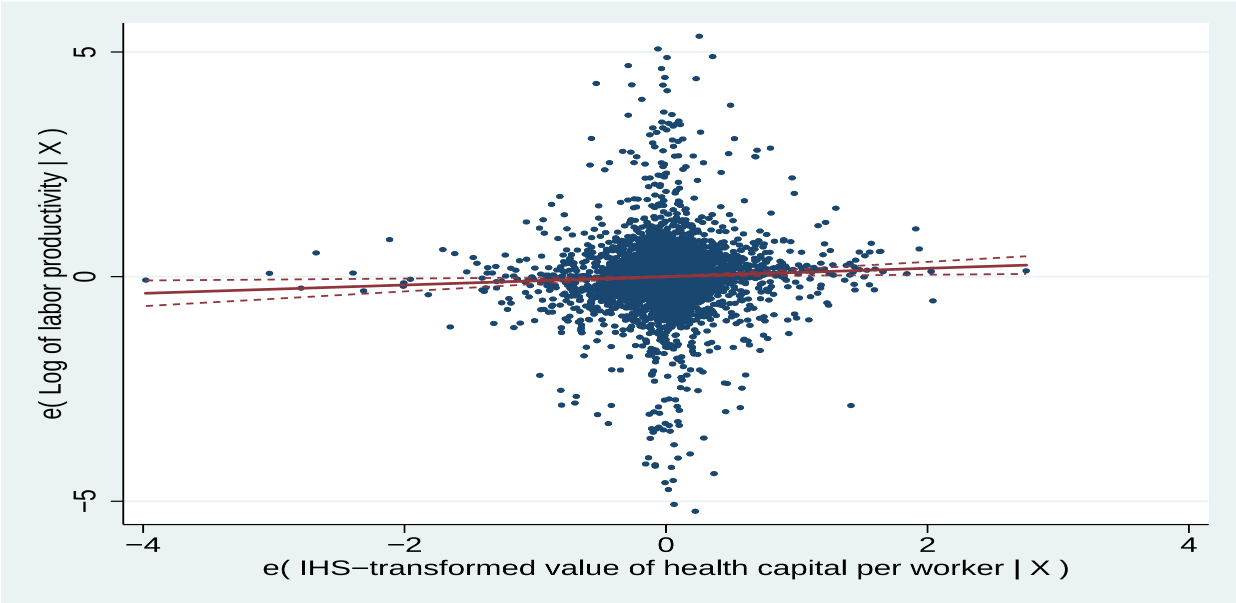
[6] The interpretation of the coefficient when the explanatory variable is IHS transformed, and the dependent variable is log transformed, is given by the following expression:

$$\beta = \frac{\frac{\partial y}{y}}{\frac{\partial x}{\frac{x(x+\sqrt{x^2+1})+1}{x+\sqrt{x^2+1}}}} \tag{4}$$

where y denotes the dependent variable, x denotes the explanatory variable, and β denotes the coefficient on x. For large x, this expression reduces to the standard expression for elasticity, namely $\frac{\frac{\partial y}{y}}{\frac{\partial x}{x}}$. Thus, we can interpret the coefficient as an elasticity in our case.

4 can be interpreted in monetary terms as follows: an increment to health capital per worker of 1 VND is likely to lead to an increase of revenue per worker by 0.45 VND. This is equivalent to an increase in the health capital per worker by 43 cents per USD, and a consequent increase in labor productivity of 19 cents per USD.[7] We think that the magnitude of this effect is of considerable importance, given that not all firms invest in health capital, and that the size of these firms is rather small.

Figure 2: Labor productivity and investment at health



Notes: Source: UNU-WIDER Vietnam Database. The graph plots the residuals from the regression of the log of labor productivity controls and fixed effects versus the residuals from the regression of the IHS transformed value of health capital per worker on all controls and fixed effects respectively (following the model of column (2) of Table 4).

4.2 Robustness Checks

In Table 5, we present some additional results. For these estimations, we use the DPD methodology with respondent and firm-specific controls of column (4) of Table 4, because it accounts for some of the time-varying heterogeneity of firm characteristics that could

[7] Given the exchange rate of 1 VND = 0.000043 USD).

Table 4: Production function estimation using the IHS transformation on the health capital variable

Dependent Variable: Log of labor productivity Column	OLS (1)	Fixed Effects (2)	DPD (without controls) (3)	DPD with controls (4)
Log of value of health capital per worker	0.008***	0.093***	0.124***	0.121***
	(0.002)	(0.036)	(0.032)	(0.032)
Log of value of capital per worker	0.184***	0.121***	0.246**	0.257**
	(0.011)	(0.025)	(0.114)	(0.118)
Log of value of raw materials and input inventories per worker	0.191***	0.103***	0.128	0.128
	(0.013)	(0.019)	(0.116)	(0.116)
Whether respondent is a male				-0.047
				(0.063)
Whether respondent is the owner				0.159***
				(0.063)
Age of respondent				-0.004*
				(0.003)
Whether respondent is college educated				-0.016
				(0.087)
Age of firm				0.001
				(0.003)
Whether firm is a household enterprise				-0.123
				(0.176)
Observations	6058	6058	6058	6053
Hansen J-Statistic			57.66	58.79
P-Value			0.160	0.07

Notes: Dependent variable is the log of labor productivity (measured in terms of revenue per worker). All specifications include industry-year time trends and year fixed effects. Specification in column (2) includes firm-level fixed effects. Specifications in columns (3) and (4) include lagged values of the endogenous variables in levels as instruments for the difference equation, and lagged differences as instruments for the equation in levels. In the specifications of columns (3) and (4), industry-year and year fixed effects are included as instruments in the levels equation, and industry fixed effects are included as instruments in the difference equation. Regression sample comprises firms with manufacturing as the main production sector that do not change their location over the duration of the sample. Huber-White standard errors are reported in parentheses. *,** and *** respectively denote significance at 10%, 5% and 1% levels. The coefficients of the constant are not reported.

further influence the production process. In columns (1) and (2), we present the results of the estimations for the sub-sample of firms that hire less than the first quartile, and more than the third quartile of workers, respectively. We thus distinguish between firms that are "small (less than or equal to three employees)" and "large (more than or equal to 12 employees) " in terms of the size of the total labor force to understand whether the positive effects of health capital vary across firms based on size. We find that the variable for amount of health capital per capita is significant in both columns (1) and (2), suggesting that the positive effects of health capital that we observe have likely influenced not just the larger firms, but also those that are smaller in size. Moreover, we find that higher levels of capital stock have a relatively strong, positive and significant impact on labor productivity for larger firms, while more raw materials have a significant and positive effect on the labor productivity of smaller firms, which can also be expected.

While in our paper, we focus on the effects of reduced indoor air pollution (through investment in abatement equipment) on labor productivity, one may argue that the positive effects that we observe may be driven by firms that are heavy polluters in terms of their impact on air, water, and soil. According to the Porter Hypothesis, firms that pollute can benefit from environmental regulations, which may facilitate efficiency, and encourage innovations that improve productivity and competitiveness of firms (Porter 1991, Porter and van der Linde 1995). For example, a recent study found that an important national energy efficiency program in China had a positive, statistically-significant effect on annualized total factor productivity change for a sample of iron and steel industry firms (Filippini et al., 2019). Vietnam ranks high in terms of the Environmental Regulatory Regime Index given its gross domestic product (GDP) per capita (Esty and Porter, 2001), which implies that firms may have experienced improvements in productivity due to these regulations, in line with the Porter Hypothesis, and not necessarily because they invested in indoor pollution abatement equipment.

In columns (3) and (4) of Table 5, we estimate the main model for the sub-sample of firms that do not belong to industries that are known to have been pollution-intensive in

Vietnam (Dore, 2008) (column (3)), and for those that belong to these industries (column (4)). These industries have been classified as pollution-intensive based on their impact on air, water and land. The industries that we consider to be "pollution-intensive" for these estimations are wood, paper, refined petroleum, chemical products, rubber, non-metallic mineral products, basic metals, fabricated metal products, electronic machinery, motor vehicles, and furniture. The results of column (3) reveal that the positive effects of health capital on labor productivity are persistent even for firms belonging to industries that are not known to be pollution-intensive, even though we also observe a slightly smaller coefficient for the health capital variable in column (4) (the coefficients in columns (3) and (4) are not statistically different from one another). Thus, we find that investments in indoor pollution abatement equipment had a positive effect on labor productivity across a spectrum of industries, and not just those that contribute to outdoor pollution.

In columns (5) and (6), we test for the robustness of our results in different subgroups of industries. The two largest industry groups in our data are the food and beverage industry, and the fabricated metal industry (together, they comprise about 50% of our regression sample). The results of our analysis in column (4) of Table 4, where we pool data over all industries may be driven by these two industries. In column (5), we re-estimate the model of column (4) of Table 4 for the sub-sample of firms belonging to these industries, and in column (6), we estimate the model for firms in all other industries. Our main results are robust for both sub-samples of firms, suggesting that they are not driven by the dominance of any particular industry in our sample.[8]

5 Conclusion and Policy Implications

Our findings suggest that health capital, measured as investments in worker health and safety (through air quality investments, protective equipment against heat and noise, as

[8] We also note that the over-identification test is not satisfied at the 1% level for the results of column (5), while the results of the test are valid for all other estimations in Table 5 at the 1% level.

Table 5: Robustness Checks

Dependent Variable: Log of labor productivity	Employ less than 25th percentile of labor	Employ more than 75th percentile of labor	Non-Polluting industries	Polluting industries	Food and fabricated metal industries	Other industries
Column	(1)	(2)	(3)	(4)	(5)	(6)
Log of value of health capital per worker	0.085*	0.090*	0.191***	0.102***	0.157***	0.123***
	(0.050)	(0.051)	(0.075)	(0.034)	(0.063)	(038)
Log of value of capital per worker	0.176	0.339***	0.447*	0.184	0.078	0.301**
	(0.111)	(0.129)	(0.257)	(0.152)	(0.239)	(0.145)
Log of value of raw materials and input inventories per worker	0.217***	0.006	0.083	0.169	0.057	0.126
	(0.081)	(0.136)	(0.228)	(0.147)	(0.333)	(0.152)
Whether respondent is a male	0.187	-0.045	0.119	-0.148	0.076	-0.147*
	(0.123)	(0.147)	(0.096)	(0.095)	(0.096)	(0.085)
Whether respondent is the owner	0.092	0.265*	0.128	0.167**	0.219**	0.115
	(0.107)	(0.163)	(0.114)	(0.086)	(0.113)	(0.080)
Age of respondent	-0.007**	-0.010*	0.001	-0.005	-0.007	-0.002
	(0.003)	(0.006)	(0.006)	(0.003)	(0.005)	(0.004)
Whether respondent is college educated	0.024	-0.145	-0.120	0.033	-0.209	0.137
	(0.135)	(0.186)	(0.178)	(0.091)	(0.150)	(0.104)
Age of firm	0.0002	-0.003	0.013**	-0.003	0.006	-0.003
	(0.003)	(0.006)	(0.007)	(0.004)	(0.006)	(0.005)
Whether firm is a household enterprise	-0.074	-0.319	-0.193	-0.084	-0.550**	0.071
	(0.153)	(0.476)	(0.215)	(0.252)	(0.285)	(0.222)
Observations	1968	1581	2748	3305	3049	3004
Hansen J-Statistic	54.96	43.82	13.62	32.16	6.99	43.23
P-value	0.02	0.275	0.02	0.075	0	0.223

Notes: All models are estimated using the DPD methodology (the specification of column (4) of Table 4). Dependent variable is the log of labor productivity (measured in terms of revenue per worker). All specifications include industry-year time trends and year fixed effects. All specifications include lagged values of the endogenous variables in levels as instruments for the difference equation, and lagged differences as instruments for the equation in levels. In all specifications, industry-year and year fixed effects are included as instruments in the levels equation, and industry fixed effects are included as instruments in the difference equation. Regression sample comprises firms with manufacturing as the main production sector that do not change their location over the duration of the sample. Huber-White standard errors are reported in parentheses. *,** and *** respectively denote significance at 10%, 5% and 1% levels. The coefficients of the constant are not reported.

well as in more or better lighting), are likely to improve the working conditions, and thus lead to improved firm-level outcomes, such as labor productivity. These results are particularly important, given that while some of these industries have been important for Vietnam's economic development, they have also been responsible for significant environmental deterioration, as well as poor working conditions for labor in the country (Dore, 2008).

The main contribution of this study is that we identify an effect for investment in worker health on labor productivity using the production function approach which allows us to control for choice of important inputs, and is an alternative to the experimental and quasi-experimental approaches thus far adopted to study the effect of pollution on firm-level outcomes. The policy implications of this study are particularly noteworthy: referring to the results of our main specification (in column (4), Table 4), back-of-the-envelope calculations suggest that the magnitude of the effect is significant. We find that investing 43 cents per USD in equipment to reduce indoor air pollution by SMEs in Vietnam can lead to an increase in labor productivity of 19 cents per USD. We feel that this effect is of considerable importance, given that a) small business owners in low and middle-income countries may find such investments to be costly, and b) workers in these firms need, and can benefit greatly from, such investments.

Moreover, it suggests the possibility that both researchers and policy-makers need a better understanding of the reason for underinvestment in worker health and safety, especially in developing country settings. Factors such as low awareness of legislative requirements, corruption, costs of investment, and difficulties in complying with regulation have been found to be significant setbacks among SMEs, even in developed countries (Vickers et al., 2005), and these may be highly relevant in the case of developing countries such as Vietnam as well. Our study does not address this question, however it is remains an important area for future research.

Our results suggest that OHS may be important, both as a form of human capital investment and as a workplace practice, and that it may be particularly biting for workers in the manufacturing sector in developing countries. This has repercussions for policy-makers, given that regulations are often weakly implemented in many such contexts. Moreover, given the rapid industrialization underway in several developing countries, these findings also have a bearing on policies regarding indoor pollution and environmental quality, in general.

References

Ackerberg, Daniel A., Kevin Caves, and Garth Frazer (2015) "Identification Properties of Recent Production Function Estimators," *Econometrica*, Vol. 83 (6), pp. 2411–2451.

Adhvaryu, Achyuta, Namrata Kala, and Anant Nyshadham (2018) "The Light and the Heat: Productivity Co-benefits of Energy-saving Technology," *NBER Working Paper No. 24314*.

Arellano, Manuel and Stephen Bond (1991) "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations," *Review of Economic Studies*, Vol. 58 (2), pp. 277–297.

Arellano, Manuel and Olivia Bover (1995) "Another Look at the Instrumental Variable Estimation of Error-Components Models," *Journal of Econometrics*, Vol. 68 (1), pp. 29–51.

Bartelsman, Eric J and Mark Doms (2000) "Understanding Productivity: Lessons from Longitudinal Microdata," *Journal of Economic Literature*, Vol. 38 (3), pp. 569–594.

Battese, George E. (1997) "A Note on the Estimation of Cobb-Douglas Production Functions When Some Explanatory Variables Have Zero Values," *Journal of Agricultural Economics*, Vol. 48 (1-3), pp. 250–252.

Bernard, Andrew B. and J. Bradford Jensen (1999) "Exceptional Exporter Performance: Cause, Effect, or Both?," *Journal of International Economics*, Vol. 47 (1), pp. 1–25.

Bernard, Andrew B, J. Bradford Jensen, Stephen J Redding, and Peter K Schott (2007) "Firms in International Trade," *Journal of Economic Perspectives*, Vol. 21 (3), pp. 105–130.

Black, Sandra and Lisa M Lynch (2002) "How To Compete: The Impact of Workplace Practices and Information Technology on Productivity," *Review of Economics and Statistics*, Vol. 83 (3), pp. 1–47.

Bloom, Nicholas, Christos Genakos, Ralf Martin, and Raffaella Sadun (2010) "Modern Management: Good for the Environment or Just Hot Air?," *Economic Journal*, Vol. 120 (544), pp. 551–572.

Bloom, Nicholas and John Van Reenen (2007) "Measuring and Explaining Management Practices Across Firms and Countries," *Quarterly Journal of Economics*, Vol. 122 (4), pp. 1351–1408.

Blundell, Richard and Stephen Bond (1998) "Initial Conditions and Moment Restrictions in Dynamic Panel Data Models," *Journal of Econometrics*, Vol. 87 (1), pp. 115–143.

Carson, Richard T, Phoebe Koundouri, and Céline Nauges (2011) "Arsenic Mitigation in Bangladesh: A Household Labor Market Approach," in *American Journal of Agricultural Economics*, Vol. 93 (2), pp. 407–414.

Chang, Tom Y., Joshua Graff Zivin, Tal Gross, and Matthew Neidell (2019) "The Effect of Pollution on Worker Productivity: Evidence from Call Center Workers in China," *American Economic Journal: Applied Economics*, Vol. 11 (1), pp. 151–172.

Currie, Janet and Brigitte C. Madrian (1999) "Health, Health Insurance and the Labor Market," *Handbook of Labor Economics*, Vol. 3, Part C, pp. 3309–3416.

Dezan Shira & Associates (2017) "Lower Taxes Proposed for Profitable SMEs in Vietnam," URL: `https://www.vietnam-briefing.com/news/lower-taxes-proposed-profitable-smes-vietnam.html/`.

Dominici, Francesca, Michael Greenstone, and Cass R Sunstein (2014) "Particulate Matter Matters," *Science*, Vol. 344 (6181), pp. 257–259.

Dore, Giovanna (2008) "Review and Analysis of the Impacts from Vietnamese Manufacturing Sectors," *World Bank Group*.

Esty, Daniel C. and Michael E Porter (2001) "Ranking National Environmental Eegulation and Performance: A Leading Indicator of Future Competitiveness?," in *The Global Competitiveness Report 2001–2002*, pp. 2–22.

Filippini, Massimo, Thomas Geissmann, Valerie Karplus, and Da Zhang (2019) "A Green Bargain? The Impact of an Energy Saving Program on Productivity Growth in China's Iron and Steel Industry," *Forthcoming, China Economic Review*.

Greenhouse, Steven (1997) "Nike Shoe Plant in Vietnam Is Called Unsafe for Workers," nov, URL: `https://www.nytimes.com/1997/11/08/business/nike-shoe-plant-in-vietnam-is-called-unsafe-for-workers.html`.

Grossman, Michael (1972) "On the Concept of Health Capital and the Demand for Health," *The Journal of Political Economy*, Vol. 80 (2), pp. 223–255.

Guilbert, Kieran (2018) "Adidas, Nike urged to ensure fair wages for Asian workers making World Cup kits," *Reuters*.

Hanna, Rema, Esther Duflo, and Michael Greenstone (2016) "Up in Smoke: The Influence of Household Behavior on the Long-Run Impact of Improved Cooking Stoves," *American Economic Journal: Economic Policy*, Vol. 8 (1), pp. 80–114.

Hanna, Rema and Paulina Oliva (2015) "The Effect of Pollution on Labor Supply: Evidence From a Natural Experiment in Mexico City," *Journal of Public Economics*, Vol. 122, pp. 68–79.

He, Jiaxiu, Haoming Liu, and Alberto Salvo (2019) "Severe Air Pollution and Labor Productivity: Evidence from Industrial Towns in China," *American Economic Journal: Applied Economics*, Vol. 11 (1), pp. 173–201.

International Labour Organization (2019) "World Statistic: The Enormous Burden of Poor Working Conditions," URL: `https://www.ilo.org/moscow/areas-of-work/occupational-safety-and-health/WCMS{_}249278/lang--en/index.htm`.

Jayachandran, Seema, Joost De Laat, Eric F. Lambin, Charlotte Y. Stanton, Robin Audy, and Nancy E. Thomas (2017) "Cash for Carbon: A Randomized Trial of Payments for Ecosystem Services to Reduce Deforestation," *Science*, Vol. 357 (6348), pp. 267–273.

Kristjánsdóttir, Helga (2012) "Exports From a Remote Developed Region: Analysed by an Inverse Hyperbolic Sine Transformation of the Gravity Model," *World Economy*, Vol. 35 (7), pp. 953–966.

Lee, Jinhyung, Jeffrey S Mccullough, and Robert J Town (2013) "The Impact of Health Information Technology on Hospital Productivity," *The RAND Journal of Economics*, Vol. 44 (3), pp. 545–568.

Lee, Yoonseok, Andrey Stoyanov, and Nikolay Zubanov (2019) "Olley and Pakes-style Production Function Estimators with Firm Fixed Effects," *Oxford Bulletin of Economics and Statistics*, Vol. 81 (1), pp. 79–97.

Levinsohn, James and Amil Petrin (2003) "Estimating Production Functions Using Inputs to Control for Unobservables," *Review of Economic Studies*, Vol. 70 (2), pp. 317–341.

Lichter, Andreas, Nico Pestel, and Eric Sommer (2017) "Productivity Effects of Air Pollution: Evidence from Professional Soccer," *Labour Economics*, Vol. 48, pp. 54–66.

Lucchini, Roberto G. and Leslie London (2014) "Global Occupational Health: Current Challenges and the Need for Urgent Action," *Annals of Global Health*, Vol. 80 (4), pp. 251–256.

Muehlenbachs, Lucija, Stefan Staubli, and Ziyan Chu (2017) "The Accident Externality from Trucking," *NBER Working Paper No. 23791*.

OECD (2008) "Labour Productivity Indicators: Comparison of Two OECD Databases, Productivity Differentials and The Balassa-Samuelson Effect," *OECD Statistics Directorate*.

Olley, G Steven and Ariel Pakes (1996) "The Dynamics of Productivity in the Telecommunications Equipment Industry," *Econometrica*, Vol. 64 (6), pp. 1263–1297.

Pence, Karen M (2006) "The Role of Wealth Transformations: An Application to Estimating the Effect of Tax Incentives on Saving," *The B.E. Journal of Economic Analysis & Policy*, Vol. 5 (1), pp. 1–26.

Porter, Michael E. (1991) "Essay: America's Green Strategy," *Scientific American*, Vol. 264 (4), p. 168.

Porter, Michael E and Claas van der Linde (1995) "Toward a New Conception of the Environment-Competitiveness Relationship," *Journal of Economic Perspectives*, Vol. 9 (4), pp. 97–118.

Pouliakas, Konstantinos and Ioannis Theodossiou (2013) "The Economics of Health and Safety at Work: An Interdiciplinary Review of the Theory and Policy," *Journal of Economic Surveys*, Vol. 27 (1), pp. 167–208.

Sharma, Smriti and Finn Tarp (2018) "Does Managerial Personality Matter? Evidence from Firms in Vietnam," *Journal of Economic Behavior and Organization*, Vol. 150, pp. 432–445.

United Nations University UNU-WIDER (2011) "Viet Nam SME database," URL: `https://www.wider.unu.edu/database/viet-nam-sme-database`.

Vickers, Ian, Philip James, David Smallbone, and Robert Baldock (2005) "Understanding Small Firm Responses to Regulation: The Case of Workplace Health and Safety," *Policy Studies*, Vol. 26 (2), pp. 149–169.

Viscusi, W Kip (1979) "The Impact of Occupational Safety and Health Regulation," *The Bell Journal of Economics*, Vol. 10 (1), pp. 117–140.

Walker, Reed W. (2011) "Environmental Regulation and Labor Reallocation: Evidence from the Clean Air Act," *American Economic Review*, Vol. 101 (3), pp. 442–447.

Weil, David (1996) "If OSHA is So Bad, Why is Compliance So Good?," *The RAND Journal of Economics*, Vol. 27 (3), pp. 618–640.

Well, David N (2007) "Accounting for the Effect of Health on Economic Growth," *Quarterly Journal of Economics*, Vol. 122 (3), pp. 1265–1306.

WHO (2010) "Healthy Workplaces : A Model for Action," *World Health Organization*.

World Bank (2017) "GDP Deflator: Linked Series," URL: `https://data.worldbank.org/indicator/NY.GDP.DEFL.ZS.AD?end=2017{&}locations=VN{&}start=1989{&}view=chart`.

World Integrated Trade Solution (2016) "Vietnam Trade Statistics," URL: `https://wits.worldbank.org/CountryProfile/en/VNM`.

Zivin, Joshua Graff and Matthew Neidell (2012) "The Impact of Pollution on Worker Productivity," *American Economic Review*, Vol. 102 (7), pp. 3652–3673.

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