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The behavioural economics of health protection: an empirical evidence of moral hazard in U.S. hog farms*

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Healthy workers are productive. When firms could not pay according to worker's health preventative effort levels due to asymmetric information, they provide an incentive contract to cope with the moral hazard problem. We test the existence of *ex ante* moral hazard in the U.S. hog farms. Using a national employee survey data in 1995 and in 2000, we find that even though employers provide protective devices to reduce the negative effects of poor environmental conditions on employees' respiratory health, many employees do not wear the devices, which is consistent with the moral hazard behaviours. The probability of using a protective device is 10 per cent lower in the farms with an agency problem than in family farms without an agency problem, even after we control for medical insurance provision types. Reducing pollutants, providing protective devices and instilling the importance of using masks help to alleviate moral hazard incidences.

Key words: health, incentive contract, moral hazard, preventative efforts, work environment.

1. Introduction

Moral hazard has been well documented in the context of medical insurance (Arrow 1963; Zweifel and Manning 2000; Einav *et al*. 2013). Because insurers have imperfect information on the actions of insured workers, workers' incentives to preserve their own health diminish with medical coverage, resulting in the risk of moral hazard. In order to cope with the moral hazard problem of insured workers, the insurer can only offer partial insurance and insured workers take some risk. Facing this incentive insurance contract, insured workers will exert proper effort to maximise their own utility.

In spite of theoretical predictions and abundant empirical evidence of moral hazard in medical insurance, evidence of moral hazard in other fields is limited. For example, Hennessy and Wolf (2018) characterise moral hazard

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issues in livestock production when an indemnity affects a farm's biosecurity investment even when the government would prefer that farmers take every available precaution to prevent diseases. Fraser (2013) uses a principal-agent model and establishes that when the cost of compliance to the agri-environmental policy exceeds the expected penalty from being caught cheating, a moral hazard problem occurs.

When work environment is harmful, firms require workers to make preventative efforts to stay healthy, which in turn increase labour productivity. However, workers' efforts are often poorly monitored. Thus, employers cannot pay workers according to the level of their efforts in preserving their own health. Because workers must bear all the costs of making preventative efforts while they cannot seize all the extra revenue caused by the enhanced productivity, they will exert less effort than in farms without agency problems. The asymmetric information between employers and employees leads to moral hazard problem. Therefore, the employer may use an incentive contract to alleviate the associated moral hazard problems. The employer can incentivise health preventative efforts via workers' wages by paying a low fixed wage rate to workers who are absent due to illness that was caused by low levels of effort to protect their health and paying a high fixed wage rate to workers who are present at the workplace.

In this study, we empirically test whether this moral hazard problem exists in hog farms with agency relationship and hence employees exert a lower level of efforts in wearing preventative devices than that in farms without agency problems. Before we proceed to conduct empirical analysis, we need to clearly define our moral hazard problem. As we know, if hog farms purchase medical insurance for their employees, the employees may put less effort, which will reduce labour productivity. In other words, lower level of health preventative effort affects not only the insurer's profit but also the employer's profit. Hence, both the insurer and the employer want to alleviate this moral hazard problem by designing appropriate contracts. In this study, we control for the effect of insurance contracts and instead focus on testing the moral hazard problem caused by incentive contracts offered by the farms with agency problems.

We use survey data from the U.S. hog industry to test whether after controlling for the availability of medical insurance, moral hazard problem in exerting preventative efforts can be alleviated from the incentive contract offered by employers. According to the Bureau of Labor Statistics, agriculture is second to mining in the risk of occupation death (Hurley *et al.* 2000). In particular, the fatality rate in livestock production is 12 per thousand, more than twice the average for all U.S. industries, which is five per thousand. This reflects an increasingly hazardous work environment due to improved efficiency and economies of scale in agriculture production.

Pork production in the United States is a significant part of the economy, generating about half million jobs (2012 U.S. Census of Agriculture). However, the work environment is harmful due to the hazardous gases and dusts released from manure, feed, and other materials. Several cross-sectional and longitudinal studies have shown that working in such an environment negatively affects the respiratory health of swine confinement workers (Holness *et al.* 1987; Crook *et al.* 1991; Zejda *et al.* 1993; Dosman *et al.* 2000; Bullers 2005; Basinas *et al.* 2015). The respiratory hazards are in barns, manure pits and silos and could cause acute and chronic air contaminants. Hurley *et al.* (2000) found hog producers earn a higher return from investment than grain producers, which is compensated for the higher occupational health risks in hog farms. Wearing protective devices can effectively reduce incidences of respiratory diseases. In fact, urged by occupational safety legislation and regulation, the majority of farms provide protective devices to their labourers to improve the safety of the workplace (Pickrell *et al.* 1995; Sundblad *et al.* 2006). However, a substantial number of employees do not wear them (Carpenter *et al.* 2002). We control possible factors that are correlated with protective efforts of workers which include individual worker's social economic characteristics, job responsibilities, hog operation types, farm size, advanced technologies and other farm characteristics. An additional potential factor, but often neglected, for such low protective efforts is moral hazard behaviour in spite of the fact that labourers are informed of the harmful effects of their hazardous work environment.

We use a classic principal-agent model to describe the moral hazard problem associated with the preventative effort. We begin by presenting a utility-maximisation problem of an individual's choices in making health preventative efforts. He or she maximises the expected utilities by choosing health preventative efforts, such as wearing a protective mask. The employer maximises profits by designing an incentive contract, paying a higher wage rate to healthy workers, and a lower wage rate to unhealthy workers.

We empirically explore these issues using survey data on employees and producers in U.S. hog farms from 1995 to 2000. This includes detailed information on the provision of protective devices, work environments, device wearing behaviours, incentive plans, hog farm types, individual social and economic characteristics, and respiratory symptoms. Crucial to identify and estimate moral hazard, the variation in farms' incentive contracts is available in the data set. A worker's effort of wearing a mask can positively influence his productivity through influences on health status, but this effort also creates a disutility for the worker. By assuming that family operations differ from nonfamily operations in that family members are residual claimants of the farm's profit and hence family farms do not suffer from this moral hazard problem, we are able to test whether this moral hazard problem exists on the nonfamily farms and whether an incentive contract is designed to cope with concern.

We find that the probability to use a protective device is lower in the nonfamily farms than in the family farms that bear no agency problem. Since having respiratory diseases significantly reduces marginal labour productivity, and workers respond to economic incentives provided in their compensation contracts, our results show that hog producers alleviate moral hazard problems by offering higher wages to healthy workers.

The identification of moral hazard evidence is complicated by two possible endogeneity problems: first, a selection bias from nonrandom selection into farms providing protective devices; and second, unobserved factors correlated to both sorting into family farms and preventative behaviours. We address the problem of nonrandom selection into farms using the degree of production specialisation as exclusion variables in a Heckmen's two-step regression. In order to solve the endogeneity problem, we use whether a worker lives in main districts of pork production as instrument variable where hog industry experienced rapid growth and consolidation in the early 1990s due to changes in cost-efficient supply chain and the majority of farms are very large. Our results are robust to endogeneity, sample selection and omitted variable bias. Our study indicates that designing an incentive contract, reducing pollutants and educating employees in work safety could effectively improve employees' health.

Our paper is organised as follows. The next section presents a theoretical model of moral hazard associated with work environment. The third section introduces our data set and descriptive evidence of moral hazard. The fourth section tests whether hog workers take moral hazard actions by choosing not to wear masks; whether employers respond to this moral hazard problem by designing an incentive compensation scheme; and whether our empirical findings are robust to endogeneity, sample selection and omitted variable bias. Finally, the last section concludes the paper and offers policy suggestions.

2. A descriptive model

In this section, we describe the moral hazard problem associated with preventative actions in a hazardous work environment through a standard principal-agent model, adapted from Laffont and Martimort (2009, p. 148). We assume that an agent's health preventative effort positively affects his health and hence his productivity. The effort level, denoted as e, measures the amount of effort devoted to wearing a protective device. We omit individual level subscript i to simplify notation. A key element in our model is that e is assumed to be either unobservable to the employer or to be monitored at substantial cost by the employer. Otherwise, the employer would be able to pay according to the observed effort levels and punish the workers who do not wear masks. From the perspective of workers, there is a trade-off between wearing and not wearing a mask. On one hand, wearing a device is uncomfortable and involves the effort of putting on and taking off the device. We assume that the cost function is $\varphi(e)$ and $\varphi'(e) > 0, \varphi''(e) > 0$. On the other hand, wearing a mask prevents respiratory diseases and increases labour productivity. However, only when the respiratory symptoms occur will workers be absent from work. We assume that with probability P, a worker is healthy and at work. With probability $1 - P$, a worker is sick from not wearing a mask. $P(e, x)$ is a function of effort level e and work environment x with $P_e > 0$, $P_{ee} < 0$, $P_x > 0$ and $P_{ex} < 0$,[1] which means a higher effort level can reduce the probability of getting sick ($P_e > 0$), but this marginal effect is decreasing with effort level ($P_{ee} < 0$). Holding effort levels constant, the probability of getting sick is lower with better environmental conditions, $P_x > 0$. A better work environment abates the marginal benefit of making health-protective efforts, indicating $P_{ex} < 0$.

Failure to use the dust mask or respirator provided by an employer puts employees' health at risk and increases the likelihood that they will require sick days or file for disability. An employee's illness and absence from work will reduce labour productivity in addition to inconveniencing co-workers. Either way, the cost of employment increases. Therefore, coupled with the fact that workers' efforts are costly to monitor, the employer could design an incentive contract to induce workers' health preventative effort by offering different wages to employees with different productivity levels.[2] If a worker is at work, his productivity is $\bar{q}$, and he is paid at the wage rate $\bar{w}$; if he is absent from work due to illness, his productivity is $\underline{q}(\underline{q} < \bar{q})$, and he is paid at the wage rate $\underline{w}, \bar{w} > \underline{w}$.[3]

Under this contract, the worker chooses an effort level to maximise the expected utility $\mathrm{Max_e}\, P(e,x)\bar{w} + (1 - P(e,x))\underline{w} - \varphi(e)$.

Given this parameterisation, the optimisation problem for the employers is to maximise their expected profit by choosing the appropriate wage rate:

$$\mathrm{Max}_{\{\bar{w},\underline{w}\}}\, P(e,x)\bar{q} + [1 - P(e,x)]\underline{q} - [P\bar{w} + (1 - P)\underline{w}], \tag{1}$$

[1] The marginal probability of efforts with respect work environment P_{ex} is assumed to be negative because a better work environment abates the marginal benefit of making health preventative efforts.

[2] The employer could also use other instruments, such as health insurance contracts, to improve efficiency. However, offering well-designed health insurance plans will only partially solve the moral hazard problem. In an economy that enforces mandatory insurance, the power of regulating workers' behaviour though commonly held medical insurance is lost. The main contribution of our study is to identify another incentive scheme that could alleviate the moral hazard problem. In the fourth section, we control different types of medical insurance and examine whether moral hazard from agency contracts still exists. Hence, for the moment, in our theoretical model, we assume away the choice of medical insurance plans.

[3] In practice, the employers may not set a 'fixed' lower wage rate for the ones who got respiratory diseases and are absent from work. However, the lower wages may take other forms which workers are aware of *ex ante*. For example, after workers use up normal paid sick leave days, they suffer from reduced salaries due to additional sick leaves. Another form of penalty is fewer bonuses due to longer sick leave or lower productivity. Moreover, sick workers are also less likely to get promoted inside the firm, therefore they experience slower wage growth. Based on National Agricultural Workers Survey in Hernandez *et al*. (2016), 33 per cent of farm workers receive a cash bonus from their current farm employers, such as holiday bonus, incentive bonus and end-of-season bonus. In our data, about one half of the workers are provided bonus or incentive plans. Furthermore, 84 per cent of such incentive plans are based on productivity, such as feed efficiency, conception rates and farrowing rates. It is therefore reasonable to assume that healthy workers will earn a premium over the unhealthy ones' *ex ante*.

$$s.t. \operatorname*{Max}_{e} P\bar{w} + (1-P)\underline{w} - \varphi(e), \qquad \text{(IC)}$$

$$\bar{w} \geq 0; \underline{w} \geq 0 \qquad \text{(LL)}.$$

As usual, the employer faces the incentive compatibility (IC) constraint and the limited liability (LL) constraint. The optimisation problem yields the wage contracts $(\bar{w}^*, \underline{w}^*)$.

If there is no agency problem, the producer maximises the expected profit by choosing an optimal effort level. The first best effort level solves the following problem:

$$\operatorname*{Max}_{e} P\bar{q} + (1-P)\underline{q} - \varphi(e).$$

And the first-order condition gives:

$$\Delta q = \frac{\varphi'(e^{\mathrm{FB}})}{P_e}, \tag{2}$$

where $\Delta q = \bar{q} - \underline{q}$ and e^{FB} *are* denoted as first best effort level.

In contrast, in an incentive contract, the employer takes into account workers' endogenous choices in effort level and hence the corresponding expected utilities. The IC condition in optimisation problem (1) gives the first-order condition (3), under which workers select optimal health preventative effort:

$$P_e \Delta w = \varphi'(e). \tag{3}$$

Given that $\underline{w}^* = 0$ must be true in an optimised profit function, under the IC conditions in Equation (1) by substituting (3) into problem (1), we can rewrite the employer's problem that is simplified as:

$$\operatorname*{Max}_{e} P(e,x)\bar{q} + [1 - P(e,x)]\underline{q} - \frac{P}{P_e}\varphi'(e).$$

Therefore, we have $\Delta q = -P_{ee}P_e^{-2}P\varphi'(e) + \varphi'(e) + P_e^{-1}\varphi''(e)/P_e$. Denote the optimal effort level as e^{SB}. It is apparent that $e^{\mathrm{SB}} < e^{\mathrm{FB}}$, given the assumption of $P_{ee} < 0$. Workers under incentive contracts who work in farms with agency problem make less effort to preserve their health than those without incentive contracts without agency problem. This is the first prediction that we will test.

> H_0(I): The moral hazard problem results in a second best effort level for the workers with optimal incentive contracts in the presence of moral hazard, which is lower than the first best effort level for the workers in the absence of moral hazard.

When the work environment is clean and free of hazardous gases and dusts, the marginal benefit of wearing masks is smaller than the marginal cost, which reduces the incentives for workers to use protective devices. We expect that workers will exert less effort to wear the devices when they are exposed to a better environment. By making total differentiation on Equation (3), we have $\partial e^{\mathrm{SB}}/\partial x(P_{ee}\bar{w} - \varphi''(e)) = -P_{ex}\bar{w}$, that is:

$$\frac{\partial e^{\mathrm{SB}}}{\partial x} < 0. \tag{4}$$

This leads to our second null hypothesis:

H_0 (II): With the incentive contract, the second best effort level decreases with work environmental conditions.

Up to this point, we predict that moral hazard problems will be present in the incentive contract. Next, we show that employers alleviate this moral hazard problem with an incentive contract. Through offering different wage rates according to labour productivity, the employers design incentive contracts to affect workers' health preventative efforts and hence to enhance productivity. From (3) and (4), we see that the wage rate of workers is higher if they are healthy and lower if they are sick and on leave. $\bar{w} = \varphi\prime(e^{\mathrm{SB}})/P_e > \underline{w} = 0$. This is the third null hypothesis that we will test:

H_0 (III): By designing an incentive contract, employers respond to the moral hazard problem, that is $\bar{w}^* > \underline{w}^*$.

3. Data and econometric specifications

We test these hypotheses using survey data from employees on U.S. hog farms in 1995 and 2000 collected from subscribers to National Hog Farmer Magazine. Because subscribers to National Hog Farmer Magazine are not a representative sample of all hog farm employees and because propensity to respond to surveys may also differ by farm size, the survey data are weighted to conform to the size distribution of employees on U.S. hog farms.[4]

[4] We base our sample weights on the Agricultural Census Data of the U.S. Department of Agriculture (USDA). To be consistent with USDA classifications, each hog farms in our survey samples is categorised into one of eight regions and one of the three size levels. The number of employees who have either full time or part time jobs on hog farms is taken as the population universe. The weights are computed as follows: let N be the total number of employees on U.S. hog farms and let n_j of them be in region size cell j. The proportion of employees in the j^{th} cell is n_j/N. The corresponding number of employees in the j^{th} cell in our sample is s_j. Each worker in our sample is then assigned a probability weight of n_j/s_j. More description about the data can be found at Yu *et al.* (2012b).

Worker's health protection behaviours are hardly observable in the hog farms. The monitoring cost for employers is substantial. Employers may observe whether employees wear masks by walking in places such as swine confinement buildings. However, there is a monitoring cost in continuously observing or monitoring the employees for the whole day. Moreover, investment in electronic monitoring systems such as cameras was very costly in the 1990s and early 2000s. More importantly, even sometimes worker's mask-wearing behaviours can be observed by employers, but this behaviour is not contractible. In other words, how much of working time in wearing masks in a specific task is not enforceable between employers and employees and could not be written in the labour contract.

Furthermore, even though employees self-reported they did not wear masks in the survey, this did not mean employers could observe employees behaviour at no cost. Employee's responses to the survey questions were confidential and employee's answers would not be revealed to employers. This guarantees that employees could truly report their mask-wearing behaviours. Therefore, the information researchers collected is not necessarily deliverable to employers, at least not in the same amount. Therefore, under such circumstances, it is very likely that asymmetric information plays a significant role in explaining the employee's moral hazard behaviours.

The data set includes all the information necessary to test for possible moral hazard behaviour in the hog farms. There are several advantages of using our data set to study moral hazard associated with occupation and work environment and safety issues. First and foremost, the direct measure of workers' health preventative efforts is available as workers are asked whether they wear protective masks at their workplaces. This allows us to clearly define moral hazard in our study. Because the effort to wear a mask and respiratory symptoms is only partially correlated, using reported illness or injuries may underestimate moral hazard incidences. Hence, an advantage of our study is that we examine *ex ante* moral hazard rather than ex post moral hazard by using a direct measure of effort (Zweifel and Manning 2000; Bolduc *et al*. 2002). We define the dependent variable *Mask* as a binary variable, equal to one if a worker wears a protective mask at work and zero if he does not.

Second, hog farms are heterogeneous in the degree of agency relationship between employers and employees. Even if family operations account for less than half of the inventory and sales in the U.S. pork industry, family farms still compose the majority of hog farms, totalling 85 per cent of hog operations in 2007 (USDA, Agricultural Census, 2007[5]). A family farm operation could be a proxy for whether there is an agency relationship between a worker and his employer. If all employees are family members, there should not be a moral hazard problem as hidden action should be

[5] https://www.agcensus.usda.gov/Publications/2007/Online_Highlights/Fact_Sheets/Farm_Numbers/small_farm.pdf.

effectively nonexistent. Thus, we expect to observe lower health preventative effort levels in the nonfamily farms. Based on this argument, we define the key independent variable *FMR* as the ratio of the number of family members over the number of total employees.[6]

Third, evaluations of work environment that are specifically relevant in pork production are available. Each worker reports the gas level and dust level in his or her farm. Given an incentive contract, we are able to test whether optimal protection levels are reduced due to better work environment. Finally, our data set also includes questions about worker demographics, past experience on hog farms, job tenure, educational background and farm characteristics. Such variables help us to control for other possible channels through which moral hazard could be induced.

We apply a linear probability model to study the hog workers' choices of whether to wear protective masks:[7]

$$Mask_{ij} = \gamma FMR_j + \boldsymbol{Env_{ij}}\boldsymbol{\beta}_1 + \boldsymbol{X_{ij}}\boldsymbol{\beta}_2 + \boldsymbol{Z_j}\boldsymbol{\beta}_3 + \varepsilon_{ij}, \tag{5}$$

where $Mask_{ij}$ is a binary variable, equal to one if worker i on farm j wears a mask. The key independent variable, FMR_j, is the ratio of family members over total labourers on farm j. The vector $\boldsymbol{Env_{ij}}$ includes the employee self-reported gas level and dust level, both of which are binary and equal one if gas or dust level is low. The vector $\boldsymbol{X}$ includes a worker's social economic characteristics and the vector $\boldsymbol{Z}$ includes other farm characteristics. ε is the error term, capturing unobserved factors that may be related to a worker's choices. The estimate of γ is used to test whether moral hazard is present in the hog farms. If the estimate of γ is significantly positive, workers on farms without agency problems do not have incentives to take hidden actions and therefore are more likely to wear protective devices than their counterparts.

We first present summary information on our dependent variables and key variables of interest and then introduce other control variables. According to

[6] Farm labour composition is not available in the employee data set that we use in this study. However, the contemporaneous survey on employers has information on the ratio of family members over total employees, which helps us proxy the presence of agency relationship at the farm level. The detailed description of the corresponding employer data is available in Yu *et al.* (2012a). Specifically, the variable ratio of family members over total number of employees is regressed on farm characteristics that include hog production processes, locations, farm size and technology complexity. We then predict the ratio of family members for farms where a labourer works based on farm characteristics of the employee. This predicted variable is used as a proxy for the degree of agency relationship between employers and employees on hog farms and is defined as the variable *FMR*. Alternatively, we also use a binary variable to define a farm as a family farm if more than half of its employees are family members. Doing so obtains qualitatively similar results, which we therefore do not report.

[7] We use Probit specification, which obtains qualitatively identical regression results. Furthermore, because Linear Probability Model (LPM) is better than a Probit model when the instrumental variable approach is applied, which we do in the next section (Angrist and Krueger 2001), we choose a LPM specification.

our survey data, not all farms provide masks to workers. Among all employees working on nonfamily operations, 93 per cent report that their farms provide masks. In contrast, 77 per cent of employees working on family operations report that farms provide masks. As mentioned above, the pork industry is regulated because of its hazardous environment. Farms are required to provide masks at no cost to employees by the U.S. Department of Labor's Occupational Safety and Health Administration[8] (OSHA). OSHA requires the use of personal protective equipment, including masks, and provides detailed description of programs on the website to guide the employers in reducing the hazards to employees, including occupational safety and health program, training program, decontamination program, personal protective equipment programs and emergency response plans to name a few.[9] However, the probability of an OSHA inspection is virtually zero. For example, as shown in Courtney and Clancy (1998), OSHA's inspection rate about musculoskeletal disorders in the workplaces is < 1 per cent on average and larger farms are significantly more likely to be inspected by small farms. Therefore, some farms in fact choose not to provide masks even at the risk of fines or other penalties.

Overall, 84 per cent of employees work on the farms which provide masks. However, only 21 per cent of employees wear masks. Thus, approximately three quarters of workers are not well protected and are at risk of respiratory diseases. Among farms providing masks, the probability of wearing masks at work is roughly 20 per cent. The mask-wearing rate is surprisingly low across farms in the pork industry. The low protective efforts are associated with farm types, worker's occupations, work environment quality and incentives to protect their health.

Over the last decade, hog farms have become increasingly specialised. Previously, almost all hog operations used farrow-to-finish production in which the gestation, farrowing, nursery and finishing phases of production were performed in one operation. But this approach has given way to large operations that specialise in only one or two phases (McBride and Key 2003). To account for the fact that family farms and nonfamily farms have experienced different structural changes, and thus workers may have different incentives to wear masks, we include farm-level characteristics in the vector $\boldsymbol{Z}$ in the regression. As shown in Table 1, family farms are two folds more likely to be farrow-to-finishing farms than the general farms which are more likely to specialise in one or several of the production processes. Furthermore, associated with specialisation of farms is workers' job responsibility. The production process in which a worker is employed may affect their decision to wear a mask. Some workers are responsible for a broader range of tasks while

[8] The requirement by OSHA can be found at https://www.osha.gov/pls/publications/publication.athruz?pType = Industry&pID = 252 and an example of OSHA inspection could be seen at https://www.osha.gov/SLTC/asbestos/checklist_text.html.

[9] https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table = STANDARDS&p_id = 9768.

others may be responsible for a narrow range of tasks. Some jobs require more interaction with pigs, feed and manure on the farms while other jobs require less intense interactions. Therefore, we include occupational tasks in the vector X in our regression models. The detailed list of job responsibilities is shown in Table 1.

Accompanying consolidation and specialisation of hog farms has been technological innovation. The advanced technologies and practices, including improved genetics, nutrition, housing and handling equipment, and veterinary and medical services have significantly improved operation efficiency and reduced production risks.[10] Adopting more complex technologies and practices boosts productivity and helps prevent the spread of diseases, which may also reduce incentives to engage in health preventative behaviour. We use the total number of technologies adopted on a farm as a measure of production complexity. According to our data, nonfamily farms use 3.6 more technologies than family farms on average and almost five times larger at the same time.

Additional variables and their summary statistics are shown in Table 1. Workers on the family farms are significantly older than their counterparts on the nonfamily farms. The average tenure is more than nine years for the former with 33 per cent of employees having had prior hog farmwork experience. Workers on family hog farms have 3.5 more years of tenure with their current employers and are 22 per cent less likely to have previous experience on other hog farms than those on nonfamily farms. Furthermore, 62 per cent of employees on family farms were raised on hog farms, 13 per cent more than those on nonfamily farms. The average worker on a family farm is less educated and barely finishes a junior college program.

4. Empirical results of moral hazard in U.S. hog farms

In this section, we first present empirical evidence of moral hazard in U.S. hog farms, testing hypotheses I and II. We then test hypothesis III, examining whether the designed contract bears any incentives for motivating workers to make health preventative efforts. In general, the sign and the magnitude of the estimated coefficients are robust across models. Our main variable of interest, the family member ratio (FMR, hereafter), consistently has a significantly positive impact on the probability of wearing a mask. In line with our theoretical illustration, these results confirm the presence of *ex ante* moral hazard in the case of not choosing to wear masks and hence being at risk of respiratory diseases.

As can be seen in Table 2, the LPM estimation shows that compared to an observably equivalent worker, a worker on a farm with 10 per cent more

[10] There were seven technologies included in the surveys that were available to hog farmers every year between 1995 and 2005. The technologies are used to improve gene pool, maximize efficiency and carcass quality, target nutrition programs, curb disease spread and increase output. More information about technology adoption and the relationship between these technologies can be found in Yu *et al.* (2012a).

Table 1 Descriptive statistics

Variable	Workers in nonfamily farm			Workers in family farm†			Diff
	Obs	Mean	SD	Obs	Mean	SD	
Dry cough	658	0.33	0.47	58	0.33	0.47	
Throat irritated	642	0.28	0.45	59	0.29	0.46	
Chest tightness	626	0.21	0.41	57	0.16	0.37	
Wheezing	611	0.16	0.37	57	0.16	0.37	
Cough with phlegmatic	656	0.36	0.48	59	0.37	0.49	
Worker info							
Age	1,710	34.37	8.95	341	37.74	11.79	***
Male	1,884	0.90	0.30	364	0.93	0.25	**
U.S. citizen	1,289	0.90	0.30	319	0.93	0.25	**
Education (in years)	1,825	14.22	2.28	358	13.34	2.21	***
Tenure	1,846	6.11	6.17	348	9.58	8.55	***
Raised on farm	1,850	0.49	0.50	361	0.62	0.49	***
Ever work on farm	1,880	0.55	0.50	359	0.33	0.47	***
Ln(Wage/day)	1,742	4.45	0.49	335	3.95	0.65	***
Not buy insurance	1,840	0.10	0.30	331	0.15	0.36	***
Employer buy insurance	1,840	0.59	0.49	331	0.31	0.46	***
Employee buy insurance	1,840	0.08	0.27	331	0.29	0.45	***
Insurance co-paid	1,840	0.16	0.37	331	0.05	0.23	***
No available insurance	1,840	0.07	0.25	331	0.20	0.40	***
Paid sick benefit	1,895	0.60	0.49	368	0.24	0.43	***
Pigs farrowed bonus	1,895	0.05	0.23	368	0.02	0.14	***
Pigs weaned bonus	1,896	0.23	0.42	368	0.07	0.26	***
Pigs/crate bonus	1,896	0.02	0.12	368	0.01	0.07	*
Farrowing rate bonus	1,896	0.03	0.17	368	0.01	0.07	***
Pound of pork bonus	1,896	0.05	0.23	368	0.04	0.20	
Feed efficiency bonus	1,896	0.05	0.22	368	0.05	0.22	
Mortality rate bonus	1,896	0.05	0.21	368	0.03	0.16	**
Other bonus	1,896	0.20	0.40	368	0.13	0.33	***
Occupational responsibility							
Breeding	1,896	0.66	0.47	368	0.62	0.48	**
Insemination	1,896	0.53	0.50	368	0.18	0.38	***
Pregnancy test	1,896	0.51	0.50	368	0.25	0.44	***
Sow culling	1,896	0.70	0.46	368	0.60	0.49	***
Herd_Vaccination	1,896	0.65	0.48	368	0.60	0.49	**
Baby processing	1,896	0.58	0.49	368	0.67	0.47	***
Nursery	1,895	0.48	0.50	368	0.62	0.49	***
Buy feeder pigs	1,896	0.04	0.21	368	0.12	0.33	***
Sell market pigs	1,896	0.33	0.47	368	0.57	0.50	***
Replace stock	1,896	0.46	0.50	368	0.47	0.50	
Buy medicine	1,896	0.49	0.50	368	0.57	0.50	***
Plan diet	1,896	0.20	0.40	368	0.43	0.50	***
Feed processing	1,895	0.23	0.42	368	0.57	0.50	***
Finish manage	1,896	0.41	0.49	368	0.65	0.48	***
Manure handling	1,896	0.42	0.49	368	0.76	0.43	***
Maintain facility	1,896	0.74	0.44	368	0.81	0.39	***
Pressure washing	1,896	0.64	0.48	368	0.73	0.44	***
Production records	1,896	0.72	0.45	368	0.56	0.50	***
Financial records	1,895	0.20	0.40	368	0.27	0.44	***
Field crops	1,894	0.16	0.37	367	0.51	0.50	***

Table 1 (*Continued*)

Variable	Workers in nonfamily farm			Workers in family farm†			Diff
	Obs	Mean	SD	Obs	Mean	SD	
Hog farm info							
Annual output	1,896	1.77	1.10	368	0.28	0.24	***
Technical level	1,896	4.93	1.77	368	1.61	0.87	***
Low gas level	1,873	0.55	0.50	363	0.53	0.50	
Low dust level	1,878	0.29	0.45	366	0.23	0.42	**
All-round farm	1,896	0.06	0.23	368	0.21	0.41	***
Finishing farm	1,896	0.28	0.45	368	0.10	0.30	***
Not finishing farm	1,896	0.58	0.49	368	0.67	0.47	***
North-east area	1,896	0.04	0.21	368	0.07	0.26	**
South-east area	1,896	0.16	0.37	368	0.02	0.14	***
North-west area	1,896	0.15	0.35	368	0.02	0.13	***
Wearing mask	1,850	0.21	0.41	361	0.20	0.40	
Supplying mask	1,844	0.88	0.32	344	0.61	0.49	***

Note: ***$P < 0.01$; **$P < 0.05$; *$P < 0.1$. The variable 'low gas level' and 'low dust level' are dummy variables with one indicating the self-reported gas and dust level are low, respectively, and zero indicating otherwise. The original responses include three categories: 1 (low), 2 (medium) and 3 (high), and we group the last two categories into one and then set it zero if workers report their gas or dust level is medium or high. †Family farm is defined as farms on which the family farmworkers ratio is >75%.

family members is 9.9 per cent more likely to wear a mask.[11] After controlling for environmental conditions, this impact increases to 10 per cent. The second model shows that workers on farms with low dust and gas levels are significantly less likely to wear masks, regardless of farm types. Hog labourers in an environment with low gas and dust levels are 19 per cent less likely to wear masks than those in a cleaner environment. A cleaner work environment exacerbates risk-taking behaviour, even after holding the agency relationship across farms constant. Compared to the first model, R^2 from the second model which includes environmental conditions increases from 0.08 to 0.11, indicating that environment matters to a substantial degree in individual's health-protective efforts. Hence, neither hypothesis I nor hypothesis II can be rejected.

Because both a non-agency employment contract and a clean work environment may induce workers to take moral hazard actions, it is possible that the two factors could be substitutes in terms of inducing workers not to make less health preventative efforts. We therefore add an interaction term for family farm types and environment. As shown in the third model in Table 2, the coefficient of the interaction term is not significant and the coefficient of family farm has not qualitatively changed.

Next, we consider several factors that may affect the estimates of moral hazard problems. If these factors are not considered, our estimates may be

[11] In alternative regression models, we define farm types as a binary variable, equal to one if FMR is above the median (or 75 percentile) and find that the coefficient is also significant at the 5 per cent level. We opt to use the continuous measure of FMR, trying to utilise full information on variation in family member ratios on farms.

Table 2 Regression results of the moral hazard behaviours and

Variables	Whole sample, no environment controls	Whole sample	Whole sample	Whole sample + paid sick leave	Whole sample + medical insurance	Subsample: raised on hog farms	Whole sample + training
FMR†	0.99** (2.31)	1.00** (2.37)	1.00** (2.31)	0.93** (2.07)	0.95** (2.18)	1.33** (2.56)	0.90** (1.99)
Low gas level	—	−0.11*** (−2.78)	−0.13 (−1.14)	−0.11*** (−2.76)	−0.12*** (−2.82)	−0.16*** (−3.13)	−0.13*** (−3.08)
Low dust level	—	−0.08* (−1.79)	−0.06 (−0.51)	−0.08* (−1.74)	−0.07 (−1.46)	−0.09* (−1.78)	−0.06 (−1.32)
Job training of using masks	—	—	—	—	—	—	0.07** (2.06)
Raise on farm	0.01 (0.28)	0.02 (0.47)	0.02 (0.46)	0.02 (0.43)	0.01 (0.36)		0.02 (0.48)
Annual output	0.08* (1.77)	0.07 (1.63)	0.07 (1.63)	0.08* (1.80)	0.07 (1.54)	0.11** (2.19)	0.08* (1.79)
Technical level	0.07*** (2.64)	0.07*** (2.79)	0.07*** (2.80)	0.08*** (2.85)	0.08*** (2.80)	0.08** (2.46)	0.08*** (2.97)
All-round farm	−0.02 (−0.17)	−0.03 (−0.27)	−0.03 (−0.28)	−0.04 (−0.38)	−0.03 (−0.30)	−0.32** (−2.02)	−0.04 (−0.39)
Finishing farm	−0.07 (−0.76)	−0.08 (−0.90)	−0.08 (−0.90)	−0.09 (−0.93)	−0.09 (−1.00)	−0.38*** (−2.74)	−0.09 (−0.96)
Not finishing farm	−0.06 (−0.67)	−0.08 (−0.89)	−0.08 (−0.89)	−0.07 (−0.88)	−0.08 (−0.98)	−0.38*** (−2.65)	−0.09 (−1.05)
Male	0.03 (0.36)	−0.01 (−0.18)	−0.01 (−0.18)	−0.01 (−0.09)	−0.02 (−0.22)	0.05 (0.67)	−0.02 (−0.32)
Age	0.01 (1.14)	0.02 (1.44)	0.02 (1.43)	0.02 (1.47)	0.02 (1.23)	0.03** (2.14)	0.02 (1.32)
Tenure	−0.00 (−0.30)	−0.00 (−0.61)	−0.00 (−0.60)	−0.00 (−0.57)	−0.00 (−0.21)	−0.00 (−1.30)	−0.00 (−0.44)
Education	−0.01 (−1.18)	−0.01 (−1.27)	−0.01 (−1.28)	−0.01 (−1.11)	−0.01 (−1.44)	−0.02 (−1.40)	−0.01 (−1.45)
	−0.02 (−0.59)	−0.03 (−0.87)	−0.03 (−0.87)	−0.03 (−0.84)	−0.02 (−0.63)	−0.08* (−1.75)	−0.01 (−0.28)

Table 2 (*Continued*)

Variables	Whole sample, no environment controls	Whole sample	Whole sample	Whole sample + paid sick leave	Whole sample + medical insurance	Subsample: raised on hog farms	Whole sample + training
Ever work on farm							
FMR × dust level	—	—	−0.03 (−0.16)	—	—	—	—
FMR × gas level	—	—	0.02 (0.13)	—	—	—	—
Employer-provide insurance	—	—	—	—	−0.06 (−1.02)	—	−0.07 (−1.05)
Self-buy insurance	—	—	—	—	−0.04 (−0.43)	—	−0.05 (−0.54)
Co-pay insurance	—	—	—	—	−0.03 (−0.36)	—	−0.04 (−0.42)
No available insurance	—	—	—	—	0.02 (0.24)	—	0.02 (0.24)
Paid sick benefit	—	—	—	−0.13 (−1.07)	—	—	−0.14 (−1.15)
FMR × paid sick benefit	—	—	—	0.13 (0.69)	—	—	0.18 (0.93)
F-test	—	—	—	—	0.61‡	—	—
Prob > *F*	—	—	—	—	0.66	—	—
Observations	1,413	1,401	1,401	1,400	1,366	694	1,352
R-squared	0.08	0.11	0.11	0.12	0.13	0.20	0.13

Note: $^{***}P < 0.01$; $^{**}P < 0.05$; $^{*}P < 0.1$. *t*-statistics in parentheses. Standard error is robust. The samples in above regressions are from employee survey of 1995 and 2000. †FMR is abbreviation of family member ratio among workers. ‡Test jointed significance of medical insurance. Each regression also controls a constant term, a dummy of year 1995, whether the farm is in the north-east, south-east and west with Midwest as the base and all occupations variables in Table 1.

subject to omitted variable bias. First, in addition to compensation, benefits may also provide incentives and hence affect worker's health preventative efforts. For example, if workers do not get paid for missing days due to illness and only get paid if they show up, they are effectively residual claimants. Hence, we would expect that first best effort levels can be achieved on farms depleting paid sick leave. If family farms do not offer paid sick leave benefits, our estimates of moral hazard problem are contaminated by such penalty incentives and we are not able to disentangle to what degree moral hazard problem is present. As can be seen from Table 1, only 24 per cent of employees on family farms are covered by paid sick leave benefits, 36 per cent less than those on general farms. We therefore control whether employers offer paid sick leave benefits in the regression. As can be seen from the fourth model in Table 2, workers on farms offering paid sick leave benefits have a lower probability of wearing a mask. This is consistent with the moral hazard problem discussed in the insurance literature. However, the coefficient is not significant at the 5 per cent level. The negative impact of sick leave benefits on wearing mask probability is offset with FMR, indicating the presence of moral hazard of our interest. However, this interaction term is not significant either. After controlling for the sick leave benefits, our estimated FMR coefficient is reduced by seven per cent in magnitude but is still significant at the 5 per cent level. The presence of moral hazard associated with incentive contracts is robust to depletion of sick leave benefits.

Second, it is well documented that the availability of medical insurance could induce workers' moral hazard behaviour, though the evidence is mixed (Zweifel and Manning 2000). For example, increases in automobile insurance are associated with higher accident rates, suggesting insurance reduces consumers' incentives to take preventative actions (Chiappori 2000). When employers purchase medical insurance, which pays workers' health bills in full or in proportion, the cost of hidden action borne by employees is reduced and less preventative effort will be made. On the other hand, when either the cost of health insurance is borne by workers or health insurance is unavailable to workers, moral hazard may be alleviated but still exist. If nonfamily farms tend to provide medical insurance more than family farms, then we risk underestimating the moral hazard problem caused by incentive contracts. The survey asks whether medical insurance was provided by the employer, purchased by employees themselves, purchased by the employer and co-paid by employees or not purchased by either party. As shown in Table 1, family farms are significantly less likely to purchase health insurance or co-paid insurance than nonfamily farms. Employees on family farms are more likely to purchase insurance out of their own pockets. However, the proportion of not buying insurance or having no insurance is almost twenty per cent more in family farms. We therefore control for types of insurance in order to remove possible omitted variable bias caused by health insurance. In the fifth regression in Table 2, we include insurance types specified by the cost structure of insurance. The estimation results show that provision of medical insurance is negatively correlated with mask-wearing rate, indicating that there exist moral hazard problems associated with health insurance. However, the different medical insurance types do not significantly affect moral hazard behaviours. After controlling insurance types, a worker on a farm with 10 per cent more family members is 9.5 per cent more likely to wear a mask. Our finding of an insignificant relationship between medical insurance and moral hazard behaviour is consistent with Spenkuch (2012). Heterogeneity in incentive contracts across farms still significantly matters in the level of workers' efforts in wearing masks. It implies that workers are unable to obtain the benefits from increased output, so their optimal effort is not first best efficient, even though employment contracts in our setting incentivise workers to stay healthy and increase productivity.

Third, it is possible that workers do not have enough knowledge of the potential harms of hazardous gas and dust at workplaces, and as a result, they do not take measures to protect themselves due to their lack of awareness of the health risks (Viscusi 1995). However, to what extent workers have knowledge of work safety and necessary prevention is unobserved. In order to assess whether information disadvantages may lead to an inefficient level of protective mask use, we adopt two strategies to identify the level of workers' knowledge of safety. One strategy is to examine the mask-wearing behaviours of workers born and raised on hog farms, respectively. If moral hazard problems disappear among farm born workers, we have to conclude that it is due to an unawareness of the hazardous impact on health of not wearing masks. As shown in the sixth column in Table 2, the evidence of moral hazard is strengthened. That is to say, workers on farms composed of more family members are more likely to wear masks than those on farms with more general labourers. A 10 per cent increase in FMR induces a 13.3 per cent increase in health preventative efforts. Hence, we could not reject hypothesis I, even after we control for the awareness of work safety. Furthermore, workers on farms with low gas and dust levels are 25 per cent more likely to reduce health preventative efforts than those on farms with a hazardous environment. The subsample regression further confirms that the hypothesis I and hypothesis II cannot be rejected.

The second strategy is to include employer's job training on using masks. More importantly, if farms with fewer family members tend not to provide job trainings, our estimate is subject to omitted variable bias. Hopefully, the survey asks whether the employer provides training of using the mask. We add a dummy variable indicating whether employers provide job training of using masks. We find that workers who receive training are more likely to wear a mask. After controlling for the mask usage training variable, the coefficient of the variable FMR is still statistically significant and positive even though the magnitude of the estimated coefficient becomes smaller.

4.1 Heterogeneity of moral hazard evidence

In this subsection, we examine heterogeneous evidence of moral hazard across farms with different monitoring levels and worker compositions. By doing so, we are able to clearly demonstrate in what circumstances moral hazard presents itself to a greater degree. Firstly, job evaluation could positively affect workers to follow farm's policies, including wearing masks. In the survey, there are some questions about job evaluation of hog farm employees. These questions ask whether an individual employee is under formal job evaluation procedures, and how often these procedures are conducted. Among all farm employees, 46 per cent of them are under formal job evaluation. The majority of those with job evaluation are evaluated annually. Therefore, we run separate regression for workers subject to job evaluation and workers not subject to job evaluations. The first two columns in Table 3 report the regression results after adding the job evaluation and its frequency. While the magnitude of the FMR coefficient is smaller than that in Table 2, the variable FMR is still significantly positive.

Next, we compare the workers on farms conducting job evaluations to those on farms without conducting job evaluations. Job evaluation is an important method of performance appraisals in human resource management. Conducting a job evaluation will increase worker's productivity and by giving safety guidance to workers, job evaluations could serve as a self-check procedure for workers to follow the firm policies. That said job evaluations could serve as monitoring tools from the perspective of employers when employer's monitoring cost is high, regulating worker's behaviours. Therefore, we expect that workers subject to job evaluations are less likely to evoke hidden actions, and hence, moral hazard problem is alleviated in such farms. On the contrary, the strong relationship between family member ratio and wearing mask probabilities should still exist on farms without conducting job evaluations. We then run separate regressions on the two subsamples and report the regression results in the third and fourth columns of Table 3. When there is no job evaluation, a worker on a farm with 10 per cent more family members is 11 per cent more likely to wear a mask. When there is job evaluation, a worker on a farm with 10 per cent more family members is only 7.5 per cent more likely to wear a mask. Moreover, the coefficient in the fourth column is not statistically significant. Both regressions confirm that employer's monitoring is important in shaping worker's health-protective behaviours.

Secondly, it is possible that workers may not wear masks when hired on hog operations, but may start to wear them once respiratory symptoms appear. If workers on family farms are more likely to experience respiratory symptoms before choosing to wear masks, the estimates of FMR's coefficient cannot measure the moral hazard driven by the agency contract. If this is the case, the positive coefficient on FMR means that workers on family operations take ex post efforts rather than *ex ante* preventative efforts to reduce moral hazard.

Table 3 Regression results of heterogeneous moral hazard

Variables	Whole sample + job evaluation	Whole sample + job evaluation + evaluation frequency	Subsample Workers without job evaluation	Subsample Workers with job evaluation	Subsample: Healthy workers	Whole sample + migrants
FMR	0.86** (1.98)	0.87* (1.85)	1.11* (1.78)	0.75 (1.36)	1.41** (1.98)	1.56*** (2.88)
Low gas level	−0.10** (−2.45)	−0.08* (−1.82)	−0.13** (−2.49)	−0.11* (−1.89)	−0.11 (−1.24)	−0.11** (−2.39)
Low dust level	−0.08* (−1.75)	−0.07 (−1.52)	−0.04 (−0.65)	−0.10* (−1.69)	−0.05 (−0.96)	−0.14** (−2.55)
Raise on farm	0.02 (0.42)	0.00 (0.12)	0.02 (0.41)	0.05 (0.96)	−0.10 (−1.25)	−0.00 (−0.06)
U.S. citizen	—	—	—	—	—	0.19 (1.13)
FMR × U.S. citizen	—	—	—	—	—	−0.40 (−1.40)
Observations	1,365	1,225	705	660	227	998
R-squared	0.11	0.13	0.13	0.22	0.44	0.14

Note: $^{***}P < 0.01$; $^{**}P < 0.05$; $^{*}P < 0.1$. *t*-statistics in parentheses. Standard error is robust. The samples in above regressions are from employee survey of 1995 and 2000. Each regression also controls gender, age, tenure, education and farm types and whether the farm is in the north-east, south-east and west with Midwest as the base and all occupations variables in Table 1.

Due to data limitation, we are not able to discern when workers started to wear protective devices. By selecting a more 'clean' subsample where workers are healthy and free from respiratory symptoms, we circumvent the presence of the ex post moral hazard problems. The subsample size shrinks to 230 because information about respiratory disease incidences is only available in the 2000 survey. As can be seen in the fifth regression of Table 3, the coefficient of FMR becomes large and still significantly positive, indicating our conclusion is robust. Thus, we cannot reject hypothesis I.

Lastly, we consider the possible heterogeneous composition of employees across farms. Although the majority of workers are from the United States, farms may also hire migrant workers. In fact, 10 per cent of employees on nonfamily farms are migrant workers, which are three per cent higher than those on family farms, as shown in Table 1. Considering that migrant workers in the agricultural industry most likely grew up on farms too, if their compliance to work safety requirement was not important in their home country, they may tend not to use masks, then our conclusion on the moral hazard problem is subject to this heterogeneous workforce composition. The data set has information on the nationality of employees, asking them whether their nationality is the United States, Asian, Hispanic, Mexican, Caucasian or other nations. We create a binary variable, equal to one if a worker is native. Removing the missing observations, the regression results are shown in the last column of Table 3. Indeed, migrant workers are found to be less likely to wear masks, but this relationship is not statistically significant. After controlling for the nationality of workers, the coefficient of the variable FMR is still significantly positive. A 10 per cent increase in family member proportion increases the probability to wear masks by 15.6 per cent.

4.2 Measurement of environment

Workers exposed to occupational health hazards are found to be more likely to quit their jobs than are otherwise comparable workers not exposed to hazard (Robinson 1990). Workers make decisions of leaving jobs based on objective risk index and subjective risk perceptions. In our study, we find that workers on hog farms take more health preventative actions in worse work environments. An objective report on the dust and gas levels in workplaces provides a bias-free assessment of workplace air quality. However, the gas and dust levels in the survey are self-reported measures. If the heterogeneous assessment of work environment is systematically different across workers on different farms, bias towards true work environment could result in inconsistent estimation of moral hazard problems. As a robustness check, we thus try to obtain both an objective and subjective assessment of environmental conditions.

Specifically, we decompose the self-reported environment evaluation into two parts. One is unbiased, which we call the objective evaluation, and the other is biased, which we call the subjective evaluation. We further assume the two components are linearly additive before running the regression model, $\boldsymbol{Env_{ij}} + \boldsymbol{F_j}\,\boldsymbol{\varphi} + \boldsymbol{\eta_i}$, where $\boldsymbol{Env_{ij}}$ is a vector of gas level and dust levels reported by worker i on farm j and $\boldsymbol{F_j}$ is a vector of farm-level characteristics. It is arguably true that the fitted value $\widehat{\boldsymbol{Env_{ij}}}$ objectively measures the gas and dust levels. The residuals $\widehat{\boldsymbol{\eta}}_i$ capture the subjective bias in evaluating his or her work environment. We replace the environment variable $\boldsymbol{Env_{ij}}$ with the objective evaluation $\widehat{\boldsymbol{Env_{ij}}}$ and subjective value $\widehat{\boldsymbol{\eta}}_i$ in the modified model shown below:

$$Mask_{ij} = \widehat{\boldsymbol{Env_{ij}}}\boldsymbol{\tau}_1 + \widehat{\boldsymbol{\eta}}_i\boldsymbol{\tau}_2 + \boldsymbol{X_i\kappa} + \zeta_i. \tag{6}$$

We use farm scale, technology complexity, production process and specialisation to predict the farm-level environment $\widehat{\boldsymbol{Env_{ij}}}$. Although the estimation is parsimonious, the model captures the main heterogeneous characteristics on hog farms that may affect workplace environment. As can be seen in Table 4, a low objective dust level is associated with a 38 per cent lower effort to wear masks than for a high objective dust level. However, the relationship between objective gas level and health preventative effort is no longer significant, although the coefficient is still negative. Furthermore, self-reported bias in both gas and dust levels are significantly associated with preventative efforts, suggesting that the workers' upwardly biased assessment of the environment induces them not to wear masks. Therefore, our conclusions are robust and not subject to the subjective measurement of work environment. The coefficient of the variable FMR is still positive and significant, indicating that *hypothesis I* cannot be rejected.[12]

4.3 Sample selection and endogeneity of self-selection into family farms

In this subsection, we examine two econometric issues. One is sample selection bias caused from truncating the sample of all farms which provide protective devices. The second problem is that our estimation of moral hazard may be subject to endogeneity problem, which stems from worker's selecting farms with different employment relationships.

First, if workers are randomly drawn into either farms providing protective devices or farms not providing such devices, our analysis using the former sample is not subject to sample selection bias. However, if workers care more about health and positively select themselves into farms providing masks, the conditional probability of wearing a mask is higher for workers who know farms provide masks than for those who do not know. The bias could also be in the reverse direction. Because farms adopt protective devices, workers may

[12] Workers with different job responsibilities may be exposed to different levels of hazardous environment. For example, workers having office type responsibilities tend to report lower dust or gas levels because they have little need for a protective device. We therefore select a subsample (composed of 92 per cent of the total sample) in which all workers have at least one field job responsibility. We find a robust regression result to Tables 2 and 3.

feel that they were protected and then less alerted to make health preventative efforts. Then, the conditional probability to wear masks will be lower than if workers are randomly assigned.

Second, because moral hazard could be heterogeneous across workers, the selection of workers into different farms could be affected by their anticipated behavioural responses and contracted wages to different degrees (Einav *et al.* 2013). Workers' anticipated behavioural responses to whether firms provide protective devices or whether employment contract is family-based, they anticipate that they will subsequently choose different levels of protection efforts and this in turn affects their utility from working on different types of farms. Hence, we adopt the approach of finding an instrumental variable to obtain a consistent estimator of moral hazard associated with the presence of incentive contracts.

We look for an instrumental variable that is significantly correlated with workers' selection into family operations but is not correlated with the motivation to protect health. While family operations traditionally constitute the majority of farms, new nonfamily operations have dramatically emerged in the last two decades, and such farms tend to be large and specialised in only one or two phases of pork production. Therefore, we use whether a worker lives in main districts of pork production to instrument the variable FMR, including Iowa, Missouri, Nebraska, Minnesota or South Dakota. Among them, Iowa has been the top state in hog production, hog inventory and the number of farms since the 1960s (USDA, 1969 Census). The remaining four states also have a large scale of hog production and relatively large number of farms. Family-based operation is the dominant type of production among these hog farms.[13] Hog workers living in these states are more likely to select themselves into family operations, and this selection based on geography is uncorrelated with behaviours of wearing masks at work. Therefore, we instrument FMR by whether an employee is in these main districts of hog production.

We now use two-stage least squares (2SLS) to rigorously estimate moral hazard behaviours at the same time correcting sample selection and endogeneity problems. According to Wooldridge (2010, p. 567), we re-structure the estimation equation as follows:

$$Mask_{ij} = \gamma FMR_j + \boldsymbol{Env_{ij}\beta}_1 + \boldsymbol{X_{ij}\beta}_2 + \boldsymbol{Z_j\beta}_3 + \varepsilon_{ij} \qquad \text{if } Provision_j = 1,$$

[13] While family operations traditionally constitute the majority of farms, new non-family operations have dramatically emerged in the last two decades, and such farms tend to be large and specialised in only one or two phases of pork production. Starting from the 1980s, North Carolina hog industry experienced rapid growth and consolidation, due to cost-efficient supply chain change (McBride and Key 2003). Hog workers living in North Carolina are more likely to select themselves into family operations, and this selection based on geography is uncorrelated with behaviours of wearing masks at work. Alternatively, we instrument FMR by whether an employee is in North Carolina and we find a robust result (the magnitude is larger in fact).

$$FMR_i = \boldsymbol{W_{ij}}\boldsymbol{\gamma^f} + z_{ij}\delta^f + v_{ij}, \tag{7}$$

$$Provision_j = 1(\boldsymbol{W_{ij}}\boldsymbol{\gamma^p} + z_{ij}\delta^p + u_{ij} > 0).$$

The variable $Provision_j$ is binary, equal to one if farm j provides protective masks to workers, equal to zero otherwise. We allow arbitrary correlation among ε, v and u. The vector $\boldsymbol{W}$ includes all variables appearing in Equation (5). z_{ij} is the instrumental variable, a dummy variable indicating whether farm j is in one of the main production districts. $\boldsymbol{\gamma^f}, \boldsymbol{\gamma^p}, \delta^f$ and δ^p are corresponding estimable coefficients.

We first estimate a Probit model (the third equation in the system Equations (7)) of choice to sort into a farm providing masks. Then, inverse mills ratio (IMR) is predicted and plugged into the first equation. We apply 2SLS and estimate the final Equation (8), as shown below. Then, γ will be a consistent estimator:

$$Mask_{ij} = \gamma FMR_j + \boldsymbol{Env_{ij}}\boldsymbol{\beta}_1 + \boldsymbol{X_{ij}}\boldsymbol{\beta}_2 + \boldsymbol{Z_j}\boldsymbol{\beta}_3 + \alpha IMR + \varepsilon_{ij}. \tag{8}$$

As can be seen from the Table 5, the coefficient of FMR is still significantly positive and the magnitude is larger than the one obtained from LPM models in Table 2. A 10 per cent increase in family member proportion improves the probability to wear masks by 12 per cent, slightly larger than the estimates from using OLS. At the same time, the coefficient of IMR is negative though not significant at the 5 per cent level, indicating that unobservable features that drive workers to self-select themselves into farms providing masks make them less likely to wear masks. Surprisingly, workers who are aware of sorting into farms providing masks are less likely to wear masks than if they are randomly assigned to such farms. The behaviour can be explained by the time inconsistency preference found in the literature (Laibson 1997; Fang and Silverman 2009).

4.4 Do employers use compensation incentives?

An important parameter in a worker's decision to exert health preventative effort is the estimated marginal productivity. Wearing a mask helps reduce the probability of illness and hence reduces the rate of absence. Therefore, being ill and absent from the job could reduce a worker's labour productivity while at the same time generating negative externalities to family members and co-workers. In response, employers could design an incentivised employment contract in which workers receive high pay when healthy and low pay if absent, that is $\bar{w}^* > \underline{w}^*$.

We next conduct two analyses to test if employers use compensation incentives described in the second section. First, we establish the relationship between wearing mask and respiratory symptoms, testing whether wearing masks effectively reduces risks of getting respiratory diseases but no other

Table 4 Moral hazard with objective and subjective measures of pollution level

Variable	Wearing mask	Objective dust level	Objective gas level
Objective gas level	0.78 (0.54)	—	—
Objective dust level	−0.38 (0.34)	—	—
Self-reported bias of gas level	−0.34*** (0.13)	—	—
Self-reported bias of dust level	−0.33* (0.17)	—	—
FMR	0.94*** (0.35)	—	—
Male	0.01 (0.24)	—	—
Age	0.05 (0.04)	—	—
Education	−0.06** (0.03)	—	—
ROHF†	0.04 (0.13)	—	—
Annual output		−0.09** (−2.06)	−0.04 (−0.98)
Technical level		0.05*** (2.65)	0.05*** (2.94)
All-rounded farm		−0.07 (−0.42)	−0.04 (−0.24)
Finishing farm		−0.20* (−1.67)	0.06 (0.47)
Not finishing farm		−0.29** (−2.54)	−0.09 (−0.76)
Year_1995	0.14 (0.15)	−0.09 (−1.46)	−0.11* (−1.79)
Constant	−1.40 (0.98)	−0.42*** (−2.73)	0.11 (0.59)
Observation	1,388	2,198	2,191

Note: ***$P < 0.01$; **$P < 0.05$; *$P < 0.1$. t-statistics in parentheses. Standard error is robust. The samples in above regressions are from employee survey of 1995 and 2000. 'Self-reported bias of gas/dust level' is measured by estimated residuals. A large number means workers have subjective bias believing gas/dust level is low. Each regression also controls whether the farm is in the north-east, south-east and west with Midwest as the base. †ROHF is an abbreviation of raising on hog farms. It is a dummy variable and equal to 1 if the worker is raised on hog farms.

diseases. Second, we link health status of workers to their wages and test whether unhealthy workers are paid less.

When testing the impact of wearing masks on health, we are suspicious of a potential reverse causality problem, which might arise since workers may choose to wear masks when they get sick, or sick workers are more likely to wear masks. To properly address this endogeneity problem, we use 'providing training of using protective masks by employers' as an instrumental variable. Table 6 reports the 2SLS regression results. As shown in the lower panel of Table 6, provision of training how to properly use a protective mask is significantly correlated with the probability of wearing masks. The upper panel shows that wearing masks significantly reduce the occurrence of dry cough, wheezing chest and cough with phlegm. While wearing masks is not significantly associated with incidences of chest tightness or throat irritation, their coefficient is negative. The column 6 reports how wearing masks affect the number of respiratory diseases symptoms. Wearing masks significantly lowers the likelihood of experiencing respiratory symptoms. In contrast, nonrespiratory diseases, namely loss of hand strength, hand tangling and falling asleep, are regressed on the dummy variable of wearing masks. As shown in the last two columns of Table 6, the coefficients are not statistically significant.

We then add these diseases variables one by one and also add the total number of respiratory diseases into wage equations. We use the daily wage rate to measure a worker's marginal productivity of labour, assuming that the labour market in the pork industry is competitive. Equation (9) links daily

Table 5 Two-stage least squares estimation of moral hazard behaviours

Variables	Mask supply	1st Step: FMR	2nd Step: Wear Mask
Family worker ratio	—	—	1.20* (1.77)
Inverse mill ratio	—	0.50*** (17.01)	−0.58 (−1.34)
IV	0.16* (1.72)	0.06*** (19.92)	—
Low gas level	0.13 (1.57)	−0.02*** (7.08)	−0.14*** (−3.13)
Low dust level	0.05 (0.55)	0.01*** (4.44)	−0.09** (−2.05)
Technical level	0.16*** (6.51)	−0.03*** (−13.50)	0.05 (1.40)
Annual output	0.21*** (4.68)	−0.06*** (−23.82)	0.05 (0.92)
All-rounded farm	−0.29 (−1.43)	0.04*** (4.37)	0.02 (0.16)
Finishing farm	−0.22 (−1.19)	0.02*** (3.05)	−0.05 (−0.55)
Not finishing farm	−0.18 (−1.04)	0.05*** (8.14)	−0.05 (−0.58)
Male	0.12 (0.89)	0.02*** (3.70)	−0.04 (−0.59)
Age	0.00 (0.03)	0.00 (0.74)	0.02 (1.22)
Tenure	0.01 (1.16)	0.00** (4.28)	0.00 (0.25)
Education	−0.01 (−0.66)	−0.00*** (−6.85)	−0.01 (−0.85)
Ever work on farm	0.06 (0.71)	0.01*** (4.14)	−0.04 (−1.12)
Constant	0.14 (0.26)	0.55*** (21.71)	−0.53 (−0.88)
Observations	1,785	1,401	1,401
R-squared	0.11	0.97	—
Weak IV test			
Cragg–Donald Wald *F*	—	844.59	—
10% critical value	—	16.38	—
Under identification test			
Kleibergen–Paap statistic	—	157.70	—
Prob > chi-square	—	0.00	—

Note: ***$P < 0.01$; **$P < 0.05$; *$P < 0.1$. *t*-statistics in parentheses. Standard error is robust. The samples in above regressions are from employee survey of 1995 and 2000. IV is an indicator whether the farm was in Iowa, Missouri, Nebraska, Minnesota or South Dakota. These states are main pork production area back in 1971.Source: http://usda.mannlib.cornell.edu/usda/AgCensusImages/1969/05/09/654/Table-20.pdf.

wage rate offered by employers to workers' illnesses and tests whether incentive contracts systematically differ across farms with different agency relationships:

$$Wage_{ij} = \theta_1 S_i + \theta_2 D_{ij}^{FMR} + \theta_3 S_i \times D_{ij}^{FMR} + \boldsymbol{\alpha}_1 \boldsymbol{Env_{ij}} + \boldsymbol{\alpha}_2 \boldsymbol{X_{ij}} + \boldsymbol{\alpha}_3 \boldsymbol{Z_j} + \boldsymbol{\mu_{ij}}, \quad (9)$$

where $Wage_{ij}$ is the log daily wage rate of worker i on farm j, measuring the marginal productivity of labour in equilibrium. The variable S_i measures various types of respiratory diseases that worker i experiences, including dry cough, throat irritation, chest tightness, wheezing chest and cough with phlegm. D_{ij}^{FMR} is a binary variable, equal to one if the family member ratio in farm j is larger than the 75 percentile and zero if smaller than the 75 percentile.[14] A negative estimated θ_1 means that worker i is penalised for his

[14] We also run the regression using the continuous measure FMR. Some of the coefficients of disease variables are not significant at the 5 per cent level. We opt to choose the binary variable D_i^{FMR}, capturing the possible nonlinear relationship between logarithmic daily wage and incentive contract.

Table 6 Two-stage least squares regression results of diseases incidences

Variables	Respiratory disease						Other diseases	
	Dry cough	Wheezing chest	Throat irritation	Chest tightness	Cough with phlegm	Number of respiratory symptoms	Loss of hand strength	Hand tangle and fall asleep
Second-stage impacts								
Wear mask	−0.71 (−1.59)	−1.04* (−1.67)	−0.73 (−1.06)	−0.31 (−0.63)	−1.21* (−1.73)	−3.24 (−1.46)	0.70 (1.20)	0.61 (1.04)
Low gas level	−0.46*** (−4.56)	−0.49*** (−2.95)	−0.46*** (−3.06)	−0.28** (−2.23)	−0.54*** (−2.91)	−2.24*** (−4.07)	−0.13 (−1.03)	−0.15 (−1.21)
Low dust level	−0.12 (−1.44)	0.05 (0.73)	−0.12 (−1.56)	−0.04 (−0.83)	−0.09 (−0.94)	−0.07 (−0.30)	0.03 (0.39)	−0.02 (−0.22)
ROHF	0.09 (1.23)	0.02 (0.27)	0.03 (0.37)	0.01 (0.13)	0.11 (1.37)	0.32 (1.20)	−0.02 (−0.26)	−0.01 (−0.08)
Annual output	0.01 (0.23)	0.03 (0.77)	−0.02 (−0.43)	0.03 (1.00)	0.03 (0.92)	0.05 (0.39)	0.02 (0.56)	0.04 (1.08)
Technology	−0.02 (−0.65)	−0.02 (−0.70)	−0.01 (−0.53)	−0.03 (−1.34)	−0.03 (−1.17)	−0.15* (−1.72)	−0.01 (−0.27)	−0.01 (−0.41)
All-round farm	−0.17 (−1.09)	−0.11 (−0.65)	−0.09 (−0.53)	−0.12 (−0.89)	0.05 (0.29)	−0.78 (−1.36)	−0.16 (−0.93)	−0.29* (−1.85)
Finishing farm	−0.12 (−0.88)	−0.17 (−1.36)	−0.02 (−0.12)	−0.19** (−2.01)	0.02 (0.12)	−0.60 (−1.30)	−0.19* (−1.72)	−0.15 (−1.33)
Not finishing farm	0.01 (0.07)	−0.10 (−0.75)	0.17 (1.17)	−0.16 (−1.59)	0.10 (0.83)	−0.18 (−0.37)	−0.20* (−1.79)	−0.12 (−0.96)
Male	0.09 (0.79)	0.01 (0.10)	0.15 (1.16)	−0.13 (−1.27)	0.14 (1.21)	0.04 (0.10)	−0.15 (−1.22)	−0.20* (−1.65)
Age	0.01 (1.53)	0.00 (0.31)	0.01 (1.08)	0.00 (0.17)	0.00 (0.11)	0.01 (0.52)	0.01 (1.27)	0.00 (0.23)
Tenure	−0.01* (−1.76)	−0.01 (−1.27)	−0.01 (−0.88)	0.00 (0.04)	−0.01 (−1.08)	−0.05 (−2.29)	−0.01 (−1.20)	0.00 (0.29)
Education	−0.04 (−1.60)	−0.05** (−2.46)	−0.03 (−1.22)	−0.03* (−1.92)	−0.02 (−0.98)	−0.16* (−1.92)	0.04 (1.32)	0.04 (1.45)
First-stage results and test statistics								
Training of using masks	0.14*** (2.97)	0.10*** (2.08)	0.10*** (2.02)	0.11*** (2.27)	0.11*** (2.54)	0.10** (2.09)	0.11*** (2.35)	0.11*** (2.41)
SW *P*-value	0.0032	0.0379	0.0436	0.024	0.0115	0.0369	0.0191	0.0165
CD *F*-test	12.23	5.94	5,34	7.16	8.67	6.05	7.23	7.91
Endogeneity *P*-value	0.05	0.02	0.18	0.57	0.05	0.10	0.15	0.16
Observations	430	403	420	412	435	393	406	422

Note: $^{***}P < 0.01$; $^{**}P < 0.05$; $^{*}P < 0.1$. Robust z-statistics in parentheses. The sample of regressions is from survey of 2000. Each regression also controls gender, age, tenure, education and farm types and whether the farm is in the north-east, south-east and west with Midwest as the base and all occupations variables in Table 1.

illness that results in a low attendance rate and corresponding low productivity. A positive θ_3 means that this penalty due to illness will disappear for workers on family farms and it only matters for workers nonfamily farms.

The regression results using various illness measures are shown in Table 7. For a worker on general farms, if he experiences one more respiratory disease, their daily wage is significantly four per cent less than that of their healthy counterpart. Among the respiratory symptoms, throat irritation and cough with phlegm significantly reduce daily wage rate. Wages offered to healthy workers are significantly higher than those offered to workers with respiratory diseases. However, all of these negative effects are only present in nonfamily farms and is completely absent in family farms, holding other characteristics and incentive plans constant. Therefore, we cannot reject hypothesis III.

Furthermore, the last two columns of Table 7 show that workers having other nonrespiratory diseases that are not correlated with mask-wearing behaviours also receive lower wages. Therefore, on the one hand, the regression results further confirm that unhealthy workers are paid less. On the other hand, we find evidence that not wearing masks leads to severe respiratory diseases and hence reduce labour productivity, although we cannot exclude the case where workers experiencing other diseases that are uncorrelated with mask-wearing behaviours also have a lower productivity. Combining the finding aforementioned that family farmworkers are more likely to wear masks, we find that moral hazard problem is less severe in family farms.

5. Conclusion

As economic development and innovation lead to a more diverse collection of occupations, the heterogeneity of the work environment increases. Even within a specific industry, there is much variation in work environment quality. This paper provides an empirical analysis of *ex ante* moral hazard in a hazardous work environment. We select the pork industry where employees are at risk of respiratory diseases and incentive contracts vary across farms. Multiple pollutants increase the risk of having respiratory diseases and reducing pulmonary function, and under an incentive, contract workers tend to reduce their effort to wear masks in the presence of low pollution levels. Using employee survey data from the U.S hog industry from 1995 to 2000, we find that, even though hog producers provide protective devices to reduce the negative effects of a harmful environment on employee health, only a small proportion of employees wear them. We illustrate workers' health preventative behaviour using a classic principal-agent model. The empirical results confirm our theoretical prediction that workers employed on family hog farms are less likely to have moral hazard incidences than their counterparts on general farms. We find that within the group of workers whose employers

Table 7 Estimation of marginal productivity of labour associated with health status

Variables	Log(Hourly Wage)							
Family Farm (FMR > 0.75)	−0.08 (−0.43)	0.05 (0.32)	0.01 (0.07)	0.01 (0.08)	−0.00 (−0.00)	−0.12 (−0.70)	−0.10 (−0.60)	−0.10 (−0.60)
Number of disease	−0.02* (−1.72)	—	—	—	—	—	—	—
FF × Number of Disease	0.10 (1.48)	—	—	—	—	—	—	—
Dry cough	—	−0.02 (−0.61)	—	—	—	—	—	—
FF × dry cough	—	−0.02 (−0.13)	—	—	—	—	—	—
Throat irritation	—	—	−0.04 (−0.84)	—	—	—	—	—
FF × throat irritation	—	—	0.19 (1.14)	—	—	—	—	—
Chest tightness	—	—	—	−0.06 (−1.29)	—	—	—	—
FF × chest tightness	—	—	—	0.21 (1.15)	—	—	—	—
Whizzing chest	—	—	—	—	−0.07 (−1.25)	—	—	—
FF × whizzing chest	—	—	—	—	0.22 (1.40)	—	—	—
Cough with phlegm	—	—	—	—	—	−0.09** (−2.35)	—	—
FF × cough with Phlegm	—	—	—	—	—	0.41** (2.27)	—	—
Loss of hand strength	—	—	—	—	—	—	−0.15*** (−2.94)	—
FF × loss of hand strength	—	—	—	—	—	—	0.63*** (3.20)	—
Hand tangle and fall asleep	—	—	—	—	—	—	—	−0.08* (−1.92)
FF × hand tangle and fall asleep	—	—	—	—	—	—	—	0.61*** (3.13)
Paid sick benefit	0.10** (2.01)	0.13*** (2.63)	0.11** (2.36)	0.11** (2.23)	0.12** (2.48)	0.11** (2.53)	0.11** (2.19)	0.12** (2.42)
FF × paid sick benefit	−0.05 (−0.23)	−0.04 (−0.21)	−0.06 (−0.28)	−0.06 (−0.31)	−0.05 (−0.22)	−0.04 (−0.20)	0.02 (0.11)	0.02 (0.09)
Pigs farrowed bonus	−0.05 (−0.59)	−0.09 (−1.18)	−0.07 (−0.90)	−0.06 (−0.69)	−0.07 (−0.84)	−0.08 (−1.09)	−0.07 (−0.83)	−0.03 (−0.42)

Table 7 (*Continued*)

Variables	Log(Hourly Wage)							
Pigs weaned bonus	−0.03 (−0.62)	−0.04 (−1.13)	−0.04 (−0.94)	−0.04 (−1.09)	−0.04 (−1.11)	−0.04 (−1.05)	−0.03 (−0.67)	−0.04 (−1.13)
Pigs/crate bonus	−0.52 (−1.42)	−0.30 (−1.00)	−0.54 (−1.54)	−0.55 (−1.53)	−0.26 (−0.82)	−0.19 (−0.63)	−0.53 (−1.54)	−0.50 (−1.30)
Farrowing rates bonus	−0.01 (−0.06)	0.03 (0.31)	−0.01 (−0.08)	−0.01 (−0.08)	0.01 (0.15)	0.04 (0.48)	0.02 (0.24)	−0.00 (−0.02)
Pound of pork bonus	−0.07 (−1.03)	−0.06 (−1.01)	−0.05 (−0.81)	−0.06 (−0.84)	−0.07 (−1.09)	−0.08 (−1.35)	−0.05 (−0.76)	−0.03 (−0.54)
Feed efficiency bonus	0.07 (0.84)	0.09 (1.10)	0.07 (0.82)	0.08 (0.94)	0.09 (1.06)	0.07 (0.86)	0.08 (0.93)	0.05 (0.66)
Mortality rate bonus	−0.02 (−0.31)	−0.03 (−0.42)	−0.01 (−0.13)	−0.03 (−0.46)	−0.03 (−0.39)	−0.00 (−0.05)	−0.04 (−0.54)	−0.04 (−0.57)
Other bonus	−0.01 (−0.18)	−0.04 (−0.85)	−0.01 (−0.18)	−0.01 (−0.26)	−0.01 (−0.22)	−0.02 (−0.43)	−0.00 (−0.00)	−0.02 (−0.39)
Work hours/week	−0.02*** (−8.21)	−0.02*** (−8.30)	−0.02*** (−8.33)	−0.02*** (−8.19)	−0.02*** (−8.21)	−0.02*** (−8.05)	−0.02*** (−8.21)	−0.02*** (−8.16)
Annual output	0.08*** (3.38)	0.08*** (3.68)	0.08*** (3.58)	0.08*** (3.41)	0.08*** (3.40)	0.08*** (3.65)	0.08*** (3.43)	0.08*** (3.31)
Technical level	0.03* (1.72)	0.02* (1.80)	0.03* (1.81)	0.03* (1.74)	0.02 (1.62)	0.02* (1.82)	0.03* (1.76)	0.03** (2.05)
All-rounded farm	0.21* (1.85)	0.16 (1.40)	0.17 (1.44)	0.14 (1.24)	0.17 (1.43)	0.16 (1.46)	0.16 (1.35)	0.15 (1.27)
Finishing farm	0.10* (1.95)	0.10* (1.84)	0.09* (1.78)	0.10* (1.86)	0.09* (1.70)	0.10** (1.98)	0.08 (1.53)	0.09 (1.62)
Not finishing farm	0.08 (1.46)	0.08 (1.39)	0.08 (1.46)	0.06 (1.12)	0.08 (1.37)	0.08 (1.53)	0.04 (0.69)	0.05 (0.91)
Male	0.24*** (3.30)	0.21*** (3.16)	0.22*** (3.23)	0.23*** (3.25)	0.22*** (3.08)	0.22*** (3.46)	0.21*** (3.17)	0.20*** (2.99)
Age	0.04** (2.37)	0.04*** (2.70)	0.04*** (2.64)	0.05*** (2.87)	0.04*** (2.66)	0.03* (1.96)	0.05*** (2.99)	0.04** (2.55)
Tenure	−0.00 (−0.23)	−0.00 (−0.43)	−0.00 (−0.60)	−0.00 (−0.48)	−0.00 (−0.62)	−0.00 (−0.04)	−0.00 (−0.21)	0.00 (0.21)
Education	0.04*** (3.67)	0.04*** (4.18)	0.04*** (4.05)	0.04*** (3.81)	0.04*** (3.97)	0.03*** (3.49)	0.04*** (3.97)	0.04*** (3.43)
Raise on farm	−0.02 (−0.61)	−0.00 (−0.11)	−0.01 (−0.21)	−0.01 (−0.16)	−0.01 (−0.23)	−0.02 (−0.58)	0.00 (0.03)	0.01 (0.33)
Ever work on farm	0.10** (2.36)	0.09** (2.23)	0.09** (2.18)	0.08** (2.01)	0.08** (2.00)	0.12*** (3.20)	0.09** (2.17)	0.10** (2.33)
Constant	1.18*** (2.78)	0.94** (2.12)	0.85* (1.95)	0.93** (2.04)	0.96** (2.17)	1.37*** (3.63)	0.90** (2.02)	0.95** (2.17)
Observations	414	451	441	433	424	456	424	442
R-squared	0.62	0.61	0.61	0.62	0.61	0.62	0.62	0.60

Note: $^{***}P < 0.01$; $^{**}P < 0.05$; $^{*}P < 0.1$. *t*-statistics in parentheses. Standard errors are robust. Family farm is a dummy variable with 75 percentile as the threshold, equal to one if family member ratio is greater or equal to 75 percentile. Disease variables are only available in the employee survey from 2000. Each regression also controls a survey year dummy and whether the farm is in the north-east, south-east and west with Midwest as the base. FF, family farm.

provide protective masks, those employed farms with 10 per cent more family members will have 10 per cent less moral hazard incidences than those employed on a general farm. Our evidence of moral hazard is significant and robust to sample selection, endogeneity, awareness of occupational risks, medical insurance availability and availability of other incentive plans.

At the same time, workers' moral hazard behaviour exposes employers to additional costs by increasing absentee rates and reducing labour productivity. Workers who are sick, especially those who have symptoms of chest tightness and cough, are paid significantly less, indicating that compensation packages are influenced by incentives.

Our study underscores the importance of producers adopting methods to reduce moral hazard problems. The major problem of hidden action in moral hazard is the high monitoring cost. With the rapid development of new technologies, decreased monitoring costs could motivate workers to make health preventative efforts and partially offset production inefficiency. When the monitoring cost is high, alternative approaches should be used. For example, producers could reduce pollutants by using more ventilating devices, providing protective devices and instilling the importance of using masks to employees. In fact, Fukakusa *et al*. (2011) find that using masks is positively correlated with safety training in the workplace. Similarly, we find a direct evidence of providing job training to workers on how to use masks significantly increases mask-wearing probabilities. Indirectly, we also find that employees who grew up on a farm are more likely to wear masks. Both evidences indicate that educating workers on the importance of protective devices producers can encourage their employees to use the devices in the workplace and hence reduce their health risks.

This study utilises the survey conducted in 1995 and 2000. The data set used in this study has unique information to test moral hazard issues because it includes information regarding a variety of work safety variables on hog farms, such as whether individual employee wears masks in the workplaces, whether employers provide devices, whether there is a kind of employer monitoring, to name a few. However, it is possible that health consciousness increases over time, especially due to government policy implementations and broader information channels, such as Internet availability and popularity, which makes moral hazard problem less severe. Cramer *et al*. (2017) conducted a survey among the workers in Midwestern farms. They find the workers nowadays are aware of the importance of wearing a mask, and there is no difference between the young farmers (age < 50) and old farmers. However, the wearing rate is still lower than our expectation. Sixty-four per cent young farmers and 45 per cent old farmers wear a mask at work, and the overall wearing rate is 48 per cent. Therefore, it is still important to explore why there is a remarkably low wearing rate despite the workers recognise the importance of protective masks. At the same time, increased health consciousness may affect worker's sorting into different farms that have different hygienic conditions and health insurance availabilities in the first place. It will then affect mask-wearing frequency too. The question is whether the increases health consciousness will remove the agency problem overall, which calls for further research.

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