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## Abstract

While a number of researchers analyze pro-environmental behavior in households, the study on individuals' energy and resource conservation practices in the workplace is still in the early stage. Paying a particular attention to social norms in the workplace, this paper estimates a structural model of the social interactions in individuals' decisions to engage in environmentally friendly practices in the workplace using data from a Japanese survey. Accounting for endogeneity that stems from simultaneity, common shocks and nonrandom group selection, we find some influence of social norms on individuals' pro-environmental behavior in the workplace.



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# Social Norms in Individual Pro-environmental Practices in the Workplace[1]

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## Abstract

While a number of researchers analyze pro-environmental behavior in households, the study on individuals' energy and resource conservation practices in the workplace is still in the early stage. Paying a particular attention to social norms in the workplace, this paper estimates a structural model of the social interactions in individuals' decisions to engage in environmentally friendly practices in the workplace using data from a Japanese survey. Accounting for endogeneity that stems from simultaneity, common shocks and nonrandom group selection, we find some influence of social norms on individuals' pro-environmental behavior in the workplace.

## 1. Introduction

Conservation of energy and resources is among the most important issues to reduce greenhouse gas emissions and to environmentally sustain our society, inducing a number

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of studies to examine what derives or prevents individuals' environmentally friendly behaviors in households (e.g., Nyborg et al., 2006; Nolan et al., 2008; Hage et al., 2009; Steg and Vlek, 2009). Given the fact that many people spend a significant amount of working time in their life, understanding such behavior in the workplace would also be vital for the environmental sustainability, but the research is still in the early stage.

Although the number of existing researches on individuals' pro-environmental behavior at work is limited, employees' energy and resource conservation practices such as activities related to light use, computer use, travelling, copy-machine use and recycling at organizations are examined (e.g., Greaves et al., 2013; Blok et al., 2015). In the survey studies on environmentally friendly behavior in the workplace, a few articles such as Gao et al. (2017) pay attentions to social norms that is one of the intriguing factors found important in household pro-environmental behavior literature (e.g., Oskamp et al., 1991; Barr, 2007). The approach they typically use is to investigate whether there is statistical correlation between the survey respondents' intentions to behave environmentally friendly and social norms in the workplace.

While their results might shed some light on the association between employees' voluntary pro-environmental practices and social norms in the workplace, they could not be interpreted as causal because their analyses do not account for potential endogeneity

that is pointed out in the literature on social interactions (e.g., Manski, 1993; Manski, 2000; Moffitt, 2001). To address this methodological issue and identify the effect of social norms, our study treats social norms in individuals' environmentally friendly behaviors in the workplace as endogenous, and examines how social norms in the workplace plays a role on those behaviors.

Specifically, the model used in this study explicitly incorporates two sources of endogeneity: simultaneity and correlated effects (Krauth, 2006; Soetevent and Kooreman, 2007). First, if an individual's workplace pro-environmental behavior is directly influenced by that of his /her colleagues who are considered as members in his/her social group, the individual's behavior also influences his/her colleagues' behavior. Second, "correlated effects" are the correlation in unobserved characteristics among individuals in the workplace group. If an individual's unobserved characteristics are correlated with those of his/her colleagues, his/her colleagues' behavior that is social norms becomes endogenous. This correlation in unobserved characteristics would arise due to nonrandom formation of working groups or/and to common unobserved characteristics such as common institutional environments. It should be noted that distinguishing between these effects is important to predict the impact of an intervention (Moffitt, 2001).

This study estimates a game-theoretic model of social interactions in individuals' decisions to engage in energy and resource conservation practices in the workplace by dealing with simultaneity and between-peer correlation in unobserved characteristics. Because the estimation approach is an equilibrium-based structural method, we estimate the model by simulated maximum likelihood and adopt the low-equilibrium selection rule. To identify the effect of social norms, a restriction on correlated effects is imposed. Our preliminary results show that the social norms influence individual and voluntary pro-environmentally behavior in the workplace to a certain degree even after taking into account the aforementioned endogeneity, and that the magnitudes of the endogenous social effects are heterogenous across environmental practices.

The remainder of the paper proceeds as follows: Section 2 explains the survey from which we construct the variables for this study and then provides the summary statistics for those variables. Section 3 outlines our econometric framework; we first describe our structural model, and then we discuss our method for estimating the structural parameters of the model. Section 4 presents the estimation results, and the final section concludes.

## 2. Survey Design, Variable Definition and Data Set

### 2.1. Survey Design

In this study, we use data derived from an online survey conducted in February 2016. The target subjects are aged 20 years or older and reside in Japan. In total, 2,618 individuals recruited among 1,350,000 survey monitors registered with Market Development Research, which is a marketing research company in Tokyo, participated in the survey. We requested the company to broadly divide the country into six regions and collect subjects in such a way that the density of the respondents in each region is approximately equal to the corresponding density in the Population Census in Japan and that the distributions of age and gender in each region are matched with those in the Census. We decided to apply this adjustment because we were concerned about a possible correlation between internet accessibility and residential locations; people in urban areas may be more likely to participate in an online survey than those in rural areas. We exclude non-working respondents, such as students and homemakers, and those with incomplete answers.

### 2.2. Variables Used for Analysis and Their Summary Statistics

In this subsection, we first describe the variables used for our analysis and then

present their summary statistics. The choice variables we examine are based on the following survey items: “(D)o you separate used papers into recyclable and non-recyclables? ”, “(D)o you separate rubbish into each type? For example, separations are into burnable items, nonburnable items, plastic bottles, cans, glass containers, caps and labels of plastic bottles and so on,” and “(D)o you take the stairs when you go to neighborhood floors, for example, one floor above or a couple of floors below?”. For each of the first two questions, respondents are asked to choose from “separate strictly”, “separate roughly”, “not separate at all”, and “impossible to separate”. We created two indicator variables which equal one if the respondent chose “separate strictly” or “separate roughly” and zero if he/she chose “not at all” for the corresponding practice. For the third question, respondents are asked to choose from “regularly”, “sometimes”, “not at all”, “(T) he stairs are the only way to go to a different floor.” and “(T)there is only the first floor. Or, never go to other floors.” For this item, we created an indicator variable which equals one if the respondent chose “not at all” and zero if he/she chose “regularly” or “sometimes.”

Social norms among a group of colleagues in the workplace are a particular focus in this study. For the social group in the workplace, we use the following survey item:“(H)ow many persons are there in the same office room where you work?”. Then,

with respect to separation of recyclable papers/separation of rubbish/ taking the stairs practice, the respondents are asked to answer the practice implementation situations of up to five persons who sit closest to them in the same office room. Regarding social norms for the separation of recyclable papers practice, a fraction of the colleagues who a respondent answers separate papers strictly or roughly is used for a variable to represent the social norm in the workplace. In an analogous manner, we also create data for a social norm variable in terms of the separation of rubbish/ taking the stairs practice.

In addition to social norms, socio-demographic factors may also influence respondents' energy-saving practices. Our models therefore include age, a dummy for being male, a dummy for a bachelor's degree or higher, a dummy for low income (annual income of less than 2 million yen), a dummy for high income (annual income of more than 10 million yen).

The summary statistics in Table 1 indicates that, out of those whose working conditions allow them to make decisions on whether to separate papers for recycling or not, 26.5 % of the respondents participate in the practice. A majority of workers is not engaged in the practice, thus leaving extensive room for further paper resource conservation at offices.

Table 2 presents the relationship between the probability of implementing the paper

separation practice and the percentage of colleagues who do so. The probability seems to be increasing in the strength of the social norm in the workplace. When none of the colleagues is engaged in the practice, the probability is 0.05; when 30-60% of the colleagues are engaged in the practice, the probability becomes 0.38, and this value increases to 0.84 when all five colleagues who sit closest to the respondent in the office room are engaged in the practice.

To further describe this relationship, we estimate a naive probit model where the dependent variable is an indicator for the paper separation practice, and an explanatory variable is the fraction of colleagues who are engaged in that practice. The first column of Table 3 presents the estimation result. The coefficient on the fraction is found to be positive and significant at the 1% level. Even after controlling for various factors, we find that the coefficient remains positive and significant at 1% level. Overall, these results suggest that paper recycling practice is positively and significantly correlated with the workplace norms. It is, however, unclear whether this positive correlation is due to endogenous social effects or correlated effects. As Manski (1993) criticized in the social interactions literature, the reduced-from coefficient on the social norm variable may be a result of either or both effects.

## 3. The Model and Estimation

This study estimates a binary choice model of pro-environmental practices in the workplace with endogenous social effects and correlated effects (Brock and Durlauf 2001; Krauth 2006). To allow for observed correlations in pro-environmental behavior among individuals in the same working group, the econometric model incorporates three primary elements: simultaneity, nonrandom group selection, and common random shocks, by adopting the approach proposed by Krauth (2006).

### 3.1. Economic Environment

Economic agents in our model are working individuals, each of whom belongs to a particular workplace group. A group, which is denoted as $g$, consists of colleagues siting close to each other in the same office room. There are $G$ groups. $i$ denotes individuals within each group. Each workplace group is composed of $n_g$ individuals for $g = 1,\ldots,G$. No groups are defined to overlap. The size of group $g$, $n_g$, is finite and exogenously given.

Each individual makes a decision on whether to implement a pro-environmental practice in the workplace, $y_{gi} \in \{0,1\}$. The individual's utility depends on his or her own choice of pro-environmental practice, the choices of other members of his/her workplace group, and his/her own exogenous characteristics. Specifically, the difference between an

individual's utilities for the two choices is:

$$u_{gi}(1;\mathbf{y}_g,\mathbf{x}_{gi}) - u_{gi}(0;\mathbf{y}_g,\mathbf{x}_{gi}) = \boldsymbol{\beta}\mathbf{x}_{gi} + \gamma\overline{y}_{gi} + \varepsilon_{gi},$$

where $u_{gi}(y_{gi}; \mathbf{y}_g, \mathbf{x}_{gi})$ is the utility function, $\mathbf{x}_{gi}$ is a vector of constant and exogenous the individual's characteristics that are available in the data, $\mathbf{y}_g$ is a vector of decisions on pro-environmental practices made by his/her colleagues in the his/her workplace group, $\varepsilon_{gi}$ captures unobserved exogenous characteristics of the individual, and $\overline{y}_{gi}$ is the average value of the pro-environmental practices implemented by colleagues in his/her workplace group:

$$\overline{y}_{gi} \equiv \frac{1}{(n_g - 1)} \sum\nolimits_{j \neq i} y_{gj}.$$

We assume that each person knows the number of colleagues in his/her group who choose to implement the pro-environmental practice, i.e., the number of persons for whom $y_{gj} = 1, j \neq i$ (as well as his/her own choice $y_{gi}$).

The parameter $\gamma \geq 0$ represents the endogenous social effect. In other words, when an endogenous social effect exists, $\gamma > 0$, an individual is more likely to choose to implement the pro-environmental practice because more of his/her colleagues are engaged in the practice. Conversely, correlations of $\varepsilon_{gi}$ among members of a given workplace group introduce correlated effects due to nonrandom group selection and common random shocks in the model. The joint distribution of characteristics among

members within the same workplace group is assumed to be independently and identically normally distributed as follows:

$$\begin{bmatrix} \boldsymbol{\beta}\mathbf{x}_{g1} \\ \vdots \\ \boldsymbol{\beta}\mathbf{x}_{gn_g} \\ \varepsilon_{g1} \\ \vdots \\ \varepsilon_{gn_g} \end{bmatrix} \sim N\left( \begin{bmatrix} \mu \\ \vdots \\ \mu \\ 0 \\ \vdots \\ 0 \end{bmatrix}, \left[\begin{array}{c|c} \mathbf{A} & \mathbf{0} \\ \hline \mathbf{0} & \mathbf{B} \end{array}\right] \right),$$

where **A** (**B**) is a matrix where each of the diagonal terms is $\sigma^2$ (1), all of the off-diagonal terms are $\rho_x\sigma^2$ ($\rho_\varepsilon$), and **0** is a matrix of zeros. Note that $\rho_x$ and $\rho_\varepsilon$ must be between $-1/(n_g - 1)$ and 1 to guarantee positive definiteness of the variance-covariance matrix.

The parameter $\rho_x$ represents the correlation in observed characteristics among individulas within a given workplace group. For example, the value of $\rho_x$ reflects how educational levels are correlated among members in a given workplace group. The parameter $\rho_\varepsilon$ represents the correlation in unobserved characteristics among members of a workplace group, that is, the correlated effect. For instance, a large value of $\rho_\varepsilon$ could imply that individuals with similar skills tend to form a group in the workplace. Hence, group selection is not random but depends on their existing abilities. Because the order of group members is irrelevant, the joint distribution of characteristics is symmetric. As in a standard probit model, $\varepsilon_{gi}$ captures unobserved characteristics and is normalized to have a mean of zero and unit variance for the purposes of identification. Further, no

correlation is assumed between observed characteristics of an individual and unobserved ones. We presume that the observed characteristics of one group member are not correlated with the unobserved characteristics of his or her colleagues in the workplace group.

### 3.2 Equilibrium

Individuals' strategies are, for all $i = 1,\ldots,n_g$,

$$y_{gi}(\mathbf{y}_{g-i}, \mathbf{x}_{gi}) = \begin{cases} 1 & if\ u_{gi}(1;\mathbf{y}_g, \mathbf{x}_{gi}) - u_{gi}(0;\mathbf{y}_g, \mathbf{x}_{gi}) > 0 \\ 0 & otherwise \end{cases} \quad (1)$$

where $\mathbf{y}_{g-i}$ denotes the vector of decisions made by colleagues in person $i$'s workplace group. Let $\mathbf{S}_G$ be the set of pure strategy Nash equilibria of the normal form game:

$$\mathbf{S}_G \equiv \left\{ \mathbf{y}_g \in \{0,1\}^{n_g} \text{ such that equation (1) is satisfied for } g = 1,...,G \right\}.$$

If there is no endogenous social effect, the equilibrium is unique and has a probability of 1: each individual makes his or her own decision regardless of his or her colleagues' behavior. If there is an endogenous social effect, there is a positive probability that more than one strategy profile across members of a workplace group may satisfy (1) such that no unique equilibrium exists. Hence, to pin down the unique likelihood function, the estimation requires the imposition of an equilibrium selection rule.

An equilibrium selection rule is a function, *sel*(**s**,**S**), that allocates a probability

to each pure strategy Nash equilibrium:

$$sel(\mathbf{s},\mathbf{S}) \equiv \Pr(\mathbf{s}_G = \mathbf{s} |\ \mathbf{S}_G = \mathbf{S}),$$

where $sel(\mathbf{s},\mathbf{S}) \geq 0, \sum_s sel(\mathbf{s},\mathbf{S}) = 1$ and $sel(\mathbf{s},\mathbf{S}) = 0$ if $\mathbf{s} \notin \mathbf{S}$. This study adopts the low-activity equilibrium selection under which we allocate a probability of 1 to the equilibrium with the lowest value of $\sum_{i=1}^{n_g} y_{gi}$ when multiple equilibria exist.

### 3.3 Identification Strategy

To identify the causal effect of social norms on individuals' energy and resource conservation practices in the workplace separately from the effect of unobserved characteristics, and for our econometric model to be nonparametrically identified, we impose an "equal correlation" restriction following the idea of Altonji et al. (2005). This identification restriction amounts to the assumption that $\rho_\varepsilon = \rho_x \equiv \rho$ in our model. The equal correlation restriction stems from the following idea. Consider that a researcher creates a survey to collect information on characteristics that are deemed relevant to individuals' energy and resource saving behaviors in the workplace. The probability that each characteristic is absent is 50%. The researcher copes with this problem by introducing variables that represent unobserved characteristics into the economic model of voluntary pro-environmental behavior at work. Then, the expected correlations in the

observed (unobserved) characteristics among working individuals in a given social group are equal to those of all relevant characteristics. Although the equal correlation assumption seems to be rather strong, it may not be unreasonable as a natural focal point.

### 3.4 Estimation Method

As workplace groups in our model are constructed not to overlap, we can omit the index of individual $i$ within a group $g$ for observed characteristics: $\mathbf{x}_g = \mathbf{x}_{gi}$. The data set thus consists of $N$ observations: $(\mathbf{x}_g, \mathbf{y}_g)$ for $g = 1,\ldots,N$. Let $\boldsymbol{\theta}_0 \in \Theta$ be the true parameter vector, and let $\boldsymbol{\theta}$ be arbitrary elements of $\Theta$. The simulated maximum likelihood (SML) estimator of $\boldsymbol{\theta}_0$ is defined as

$$\hat{\boldsymbol{\theta}} \equiv \underset{\boldsymbol{\theta}\in\boldsymbol{\Theta}}{\operatorname{argmax}} \sum_{g=1}^{N} \left( \ln\left( \frac{1}{K} \sum_{k=1}^{K} H_g^s(\boldsymbol{\theta}) \right) + \ln \Pr(\mathbf{x}_g ; \boldsymbol{\theta}) \right),$$

where $\left\{ H_g^k(\boldsymbol{\theta}) \right\}_{k=1}^{K}$ is a sequence of independent random variables such that

$$\frac{1}{K} \sum_{k=1}^{K} H_g^k(\boldsymbol{\theta}) \xrightarrow{p} \Pr(\mathbf{y}_g \mid \mathbf{x}_g ; \boldsymbol{\theta}).$$

In order to estimate the likelihood function, the Geweke, Hajivassiliou, and Keane (GHK) simulator is used because the calculation of $\Pr(\mathbf{y}_g|\mathbf{x}_g; \boldsymbol{\theta})$ requires the evaluation of a complex multidimensional integral.

## 4. Estimation Results

The third column in Table 3 displays the SML parameter estimates from the structural model using the low-activity equilibrium selection rule. The endogenous social effects are estimated to be positive (0.807) and significant at the 1% level. In other words, there is an evidence to support that colleagues have influence on an individual's decision to engage in a pro-environmental practice in the workplace.

The correlated effects are found to be positive (0.742) and significant at the 1% level, explaining the fact that the point estimates of the endogenous social effects from the naive probit models (Column 2 in Table 2), 2.623 for paper recycling, is larger than that from the structural model. Consistent with the argument by Manski (1993), the result implies that the reduced-form coefficient on the social norm variable may reflect the correlated effect as well as the endogenous social effect.

Table 4 and Table 5 exhibit the similar estimation results for separating rubbish practice and for taking stairs practice, respectively. The results from Table 3, 4, and 5 imply that social norms influence all three pro-environmental practices in the workplace. Regarding taking stairs practice, the correlated effects are statistically significant only at the 10% level, resulting the coefficient estimate on the fraction of colleagues participating in the practice is large and closer to that from naive probit estimation. This indicates that the

social norms in the workplace has a larger influence on the taking stairs practice than on paper recycling and separating rubbish practices.

## 5. Conclusion

In this study, we used data from a Japanese survey and examined the influence of social norms among colleagues on energy and resource saving practices in the workplace. This study adopted a structural estimation approach and dealt with simultaneity and correlations in the unobserved characteristics among individuals in the workplace that are inherent in the estimation of social interaction effects. From the preliminary results, we found that endogenous social effects were statistically significant for individuals' pro-environmental behavior in the workplace such as paper separation for recycling, separation of rubbish, and taking stairs. Our results should, however, be interpreted with caution, because social norms in the workplace have an influence on individual environmentally friendly behavior differently across types of practices.

In our preliminary analysis, we adopted the low-equilibrium selection rule and imposed an equal correlation restriction for nonparametric identification in estimation. In our future work, we use different types of equilibrium selection rules and restrictions on correlated effects for the robustness check on the results.

**Table 1. Summary Statistics**

| Variables | Mean | SD | Min | Max |
|---|---|---|---|---|
| Paper separation for recycling* | 0.265 | 0.441 | 0 | 1 |
| Fraction of colleagues who separate papers for recycling* | 0.266 | 0.415 | 0 | 1 |
| Separating rubbish | 0.378 | 0.485 | 0 | 1 |
| Fraction of colleagues who separate rubbish | 0.351 | 0.454 | 0 | 1 |
| Taking stairs* | 0.623 | 0.485 | 0 | 1 |
| Fraction of colleagues who take stairs* | 0.542 | 0.468 | 0 | 1 |
| Number of colleague group members | 4.388 | 1.161 | 1 | 5 |
| Age | 43.30 | 12.13 | 20 | 69 |
| Male | 0.601 | 0.490 | 0 | 1 |
| Married | 0.512 | 0.500 | 0 | 1 |
| Bachelor's degrees or higher | 0.532 | 0.499 | 0 | 1 |
| Nonregular employment | 0.352 | 0.478 | 0 | 1 |
| Income less than 2 million yen | 0.059 | 0.235 | 0 | 1 |
| Income more than 10 million yen | 0.118 | 0.322 | 0 | 1 |

Note.—The number of responses is 1292 except for the variables with * whose sample sizes are 1221 and 942 for paper separation for recycling and for taking stairs, respectively.

**Table 2. Relationship between the probability of implementing the paper separation practice for recycling and the number of colleagues who do so**

| Percentage of colleagues who separate papers for recycling? | Nobs | Yes | No | Pr(Yes\|%colleague)x100 |
|---|---|---|---|---|
| 0 | 812 | 44 | 768 | 5.42 |
| 0 < % colleague <= 30 | 58 | 12 | 46 | 20.69 |
| 30 < % colleague <= 60 | 45 | 17 | 28 | 37.78 |
| 60 < % colleague <100 | 35 | 22 | 13 | 62.86 |
| 100 | 271 | 228 | 43 | 84.13 |

**Table 3. Estimation Results for Paper Separation for Recycling**

| | Naive probit | Naive probit | Structural |
|---|---|---|---|
| Fraction of colleagues engaged in the practice | 2.608*** | 2.623*** | 0.807*** |
| | (0.115) | (0.116) | (0.213) |
| ln (Age) | | 0.338* | 0.149 |
| | | (0.199) | (0.149) |
| Male | | -0.128 | -0.066 |
| | | -0.117 | (0.089) |
| Married | | -0.00539 | -0.050 |
| | | (0.116) | (0.088) |
| Bachelor's degee or higher | | 0.0574 | 0.098 |
| | | (0.109) | (0.084) |
| Non-regular employment status | | -0.110 | -0.132 |
| | | (0.123) | (0.092) |
| Income less than 2 million yen | | 0.113 | 0.173 |
| | | (0.234) | (0.179) |
| Income more than 10 million yen | | 0.0256 | -0.004 |
| | | (0.164) | (0.119) |
| Correlation in unobserved characteristics among colleagues | | | 0.742*** |
| | | | (0.067) |

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

**Table 4. Estimation Results for Separating Rubbish**

| | Naive probit | Naive probit | Structural |
|---|---|---|---|
| Fraction of colleagues engaged in the practice | 3.073*** | 3.128*** | 0.431*** |
| | (0.120) | (0.125) | (0.157) |
| ln (Age) | | 0.711*** | 0.543*** |
| | | (0.204) | (0.135) |
| Male | | -0.211* | -0.030 |
| | | (0.121) | (0.079) |
| Married | | -0.112 | -0.164*** |
| | | (0.120) | (0.079) |
| Bachelor's degee or higher | | -0.00375 | 0.006 |
| | | (0.112) | (0.074) |
| Non-regular employment status | | 0.0703 | -0.069 |
| | | (0.124) | (0.082) |
| Income less than 2 million yen | | -0.0711 | -0.019 |
| | | (0.227) | (0.156) |
| Income more than 10 million yen | | -0.0125 | 0.025 |
| | | (0.170) | (0.109) |
| Correlation in unobserved characteristics among colleagues | | | 0.884*** |
| | | | (0.038) |

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

**Table 5. Estimation Results for Taking Stairs**

| | Naive probit | Naive probit | Structural |
|---|---|---|---|
| Fraction of colleagues engaged in the practice | 2.149*** | 2.179*** | 2.142*** |
| | (0.113) | (0.115) | (0.266) |
| ln (Age) | | 0.518*** | 0.508*** |
| | | (0.198) | (0.176) |
| Male | | 0.272** | 0.229** |
| | | (0.120) | (0.108) |
| Married | | -0.156 | -0.150 |
| | | (0.118) | (0.107) |
| Bachelor's degee or higher | | -0.0479 | -0.089 |
| | | (0.111) | (0.100) |
| Non-regular employment status | | 0.0834 | 0.070 |
| | | (0.126) | (0.118) |
| Income less than 2 million yen | | -0.271 | -0.323* |
| | | (0.223) | (0.191) |
| Income more than 10 million yen | | -0.264* | -0.232 |
| | | (0.154) | (0.144) |
| Correlation in unobserved characteristics among colleagues | | | 0.188* |
| | | | (0.108) |

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

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