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Socializing at Work: Evidence from a Field Experiment with Manufacturing Workers[†]

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Through a field experiment at a seafood-processing plant, I examine how working alongside friends affects employee productivity and how this effect is heterogeneous with respect to an employee's personality. This paper presents two main findings. First, worker productivity declines when a friend is close enough to socialize with. Second, workers who are higher on the conscientiousness scale show smaller productivity declines when working alongside a friend. Estimates suggest that a median worker is willing to pay 4.5 percent of her wage to work next to friends. (*JEL* C93, J24, J28, J31, L66, O15, P23)

This paper investigates how working alongside friends affects employee productivity and whether this effect varies as a function of a worker's personality skills. I designed and implemented a field experiment that randomly assigned workers to workstations in a seafood-processing plant in Vietnam. I exploit this exogenous variation to estimate the effect of having socially tied coworkers nearby on worker productivity. I then examine the difference in this effect across workers with heterogeneous personality skills using self-reported measures of workers' personalities collected as part of the baseline survey.

Peer influence on worker productivity has been widely studied in both theoretical and empirical literature. Kandel and Lazear (1992) suggests that shame or social norms could be motives for workers to change effort levels in the presence of their peers. Recently, a number of empirical studies document evidence of peer pressure or social incentives affecting worker productivity (Falk and Ichino 2006; Mas and Moretti 2009; Bandiera, Barankay, and Rasul 2010; Herbst and Mas 2015). This paper focuses on a specific peer group, friends, which I define as peers whom

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workers are socially connected to in the workplace. Working with friends may create a sense of competition or assist in coping with boredom, leading to greater motivation. Alternatively, the presence of a friend could lead to goofing off during work and to workers becoming less productive. Identifying the prevailing effect in an actual work environment is empirically challenging but, nonetheless, important for organizing human resources in the workplace.

In addition, the influence of peers can be heterogeneous with respect to differences in individual personalities. Studies consistently show strong relevance between personality factors and job performance (Schmidt and Hunter 1998; Mount, Barrick, and Stewart 1998; Callen et al. 2015) and labor market outcomes (Heckman and Rubinstein 2001; Heckman, Stixrud, and Urzua 2006). Accordingly, in light of evidence of peer effects on job performance, a natural question to ask is how the effects depend on one's personality characteristic or trait.

This field experiment was conducted in collaboration with the management of a seafood-processing plant. The plant hires female processing workers whose main task is to fillet fish, which is an individual task, while standing at work tables. Compensation is a combination of a fixed daily wage plus a piece rate based on each worker's individual output. Prior to the experiment, workers could choose their work positions at the start of the workday. I focus on friendship ties between these processing workers.

During the five-month experiment period (August 2014 to December 2014), processing workers were randomly assigned to different work positions each day. This created random variation in the presence of friends at various spatial proximities to the worker. The outcome data on daily worker productivity and data on work positions were collected from the firm's employee records database. Prior to the experiment, data on each worker's friendship ties at the plant, their personality characteristics, and other background data were collected through a baseline survey.

As the first main result, I find that when a friend is working alongside there is an average 6 percent drop in worker productivity. Yet, I find no effect when friends are working at positions that are observable but further away (for example, at the same table but not immediately adjacent). One explanation for the negative effect only when friends are immediately adjacent to each other is that friends are socializing, such as engaging in chitchat and gossip, and this is possible only when they are within close distances. Since workers are paid partially based on individual performance, the productivity loss implies an average 4 percent decline in the daily wage when a friend is present alongside them.

In the second main result, I find that the magnitude of the productivity loss associated with working alongside friends depends on the worker's level of conscientiousness. Specifically, I observe a 9 percent loss in productivity among low-conscientiousness workers (scored less than 1 standard deviation below the average) when a friend is working alongside but only a 2 percent loss among high-conscientiousness workers (scored more than 1 standard deviation above the average). Moreover, observations on worker positions prior to random assignment indicate that the likelihood of working alongside a friend is 50 percent higher in low-conscientiousness workers compared to high-conscientiousness workers.

Previous studies suggest that workers willingly forgo money or time to work together with their peers (Hamilton, Nickerson, and Owan 2003; Bloom et al. 2015).[1] To gauge workers' willingnesses to pay from wages to work with friends, I use a simple structural model to estimate each worker's consumption value of working with friends. I find that 87 percent of workers positively value working alongside their friends. Converting consumption value to wages shows that a median worker is willing to pay 4.5 percent of her wage—in the form of forgone productivity—to work with friends. Concerning heterogeneity, willingness to pay to work with friends is decreasing in job tenure and conscientiousness.

The main contribution of this paper is twofold. First, identification is based on a random assignment process. As a result, whether a worker is assigned to work near her friend on a given day is exogenously determined. While this is not the first study to exploit random assignments in the workplace, it contributes to the relatively small number of such studies.[2] Second, it explores heterogeneity in workplace social interaction behavior with respect to worker personality. Previous studies have shown that social interaction patterns depend to a large extent on the environment (Herbst and Mas 2015). Another possibly important determinant of social behavior is individual personality. To the best of my knowledge, this is the first study to investigate the relationship between social interaction behavior and personality in the workplace.

This study joins a number of field experiments that investigate social interactions and worker behavior.[3] Most notably, Bandiera, Barankay, and Rasul (2005, 2007, 2009, 2013) implement field experiments to study how social connections within a firm affect worker performance across a wide array of incentive schemes in the context of a UK fruit farm. In that same context, Bandiera, Barankay, and Rasul (2010) exploits a quasi-random feature of assigning workers to different fields and document pacing behaviors between socially tied workers; workers slow down when working alongside lower ability friends and speed up when working alongside higher ability friends.[4] While the nature of the tasks performed by workers in the fruit farm setting and by processing workers in the current fish plant can be quite similar in that they are routine and individualistic, unlike farmwork, processing jobs are done while staying in the same position throughout the day.[5]

[1] Hamilton, Nickerson, and Owan (2003) finds at a garment manufacturing plant that workers choose to engage in team production in which workers of the same team have stations adjacent to each other, despite earning less than what they would earn from working individually. Bloom et al. (2015) finds from a working from home experiment that workers are willing to pay, in terms of commute time, to work in the office rather than at home. They document qualitative evidence that workers value socializing with coworkers. These findings relate to a compensating differentials model in which a worker is willing to accept a lower pecuniary benefit for a favorable nonpecuniary job attribute (Rosen 1987).

[2] Guryan, Kroft, and Notowidigdo (2009) exploits random group assignments in professional golf tournaments. The authors find no evidence of peer influence on golf performances.

[3] Bandiera, Barankay, and Rasul (2011) provides a general overview of the literature on field experiments in firms.

[4] The authors further explain that the behavior is driven by incentives to socialize with their partners and not because of social preferences such as inequality aversion. In a recent study, Amodio and Martinez-Carrasco (2018) investigates productivity spillovers in an egg production plant, at which worker compensation is largely based on a fixed wage, and find that working next to a friend mitigates free-riding behavior.

[5] Cornelissen, Dustmann, and Schönberg (2017) shows that peer effects, in general, differ across occupation types. For instance, when considering the full set of jobs available at a local municipal level, the authors find peer effects only among jobs that involve routine tasks.

This study also relates to the emerging literature on the economics of noncognitive skills (Borghans et al. 2008, Almlund et al. 2011). Notably, Heckman et al. (2010) and Conti et al. (2012) evaluate a preschool intervention program and find that the program positively impacted employment and earnings outcomes largely through changes in the program participants' noncognitive skills. In a field experiment in Pakistan, Callen et al. (2015) report findings that health sector workers with higher scores on the Big Five personality factors are more likely to exhibit better job performance than workers with lower scores. I contribute to this line of study by focusing on understanding how peer influences are dependent on workers' own personalities.

This paper proceeds in six parts. Section I describes the field context and experimental design. Section II presents the data and descriptive statistics. Section III outlines the conceptual framework that guides the empirical analysis. Section IV presents the empirical strategy and main results of working with friends on productivity. Section V delivers the conclusion of this paper.

I. Field Context and Experimental Design

A. *Field Context*

For this study, I partnered with a seafood-processing plant in Vietnam. The plant manufactures canned and pouched seafood products, which are mainly exported to US markets. One of the main tasks in producing seafood products is a semi-processing job in which tasks range from gutting to filleting fish. The plant hires processing workers who specialize in this task. I studied these workers who were, at the time of the study, regular employees at this plant.

The plant has three teams of processing workers that specialize in the filleting process, with each team working in a separate processing room (Figure 1). Filleting takes place on rectangular work tables that are identical in size and are positioned side by side (Figure 2). Each table is typically occupied by four processing workers although up to six workers are allowed to work at one table. Workers process fish individually, and for compensatory reasons, the management records each individual worker's output (i.e., fish fillet). Fillets are placed on individual trays, which are weighed at one side of the room using an electronic scale and recorded by a designated worker. Weighed trays are then placed on racks for quality inspections. Trays that pass inspection are sent to the next production stage, whereas rejected trays are returned to the worker for supplementary work. Therefore, the output measure that I use from the firm's dataset is quality-adjusted individual output.

Work material (i.e., steamed fish) arrives at processing rooms in large tray carts. Managers distribute the trays to tables based on the number of workers at each table. Workers process the stock of fish allocated to their table. Thus, externalities may arise from other workers at the table if there are constraints on fish supplied to a table. Accordingly, one of the main duties of managers is to reallocate fish across tables according to each table's work speed. In a companion paper, Park (2018) shows that a 1 percent increase in the average ability of workers at the table is associated with a 1 percent increase in the per capita quantity of fish allocated to that table; other dimensions of table characteristics, such as job tenure or age of workers at a table, are

FIGURE 1. EXHIBIT OF PROCESSING ROOMS

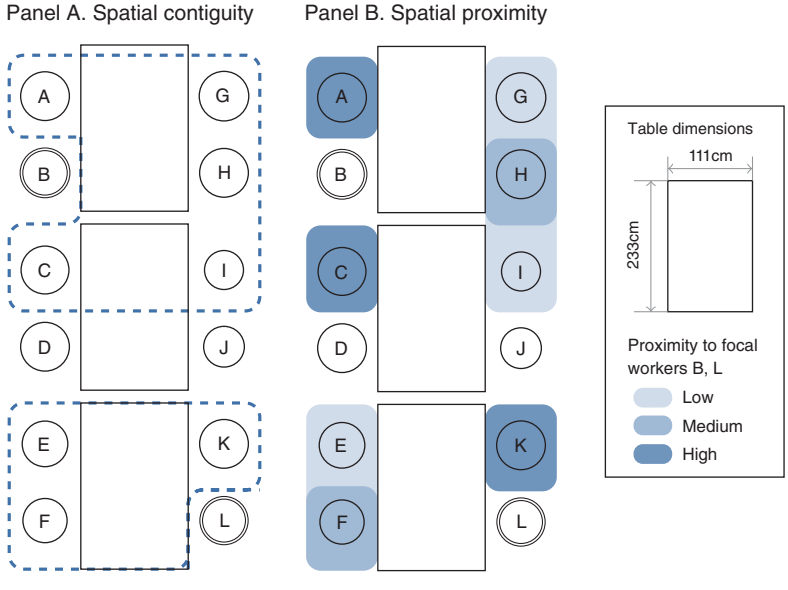

FIGURE 2. SPATIAL CONTIGUITY AND PROXIMITY

Notes: In panel A, areas enclosed by dotted lines represent work spaces that are spatially contiguous with worker B and L, respectively. Note that worker B is at an interior position and, therefore, contiguous with more work spaces than worker L, who is at a corner position. In panel B, work positions with different levels of proximity to a focal worker (B or L) are shaded in different brightnesses. Among work spaces that are contiguous with the focal workers, the closest positions are shaded in dark blue (e.g., D and J), and positions with the least proximity are shaded in light blue (e.g., G and I). Positions that are not spatially contiguous with either worker B or L are not shaded (e.g., D and J).

found to be insignificant predictors of fish allocation. These findings are reassuring regarding the importance of the production technology when interpreting the results.

Compensation during the study period was fixed to a two-part wage system: a base wage and a performance wage. The base wage is determined by whether a worker is on site as workers are not paid for days they are absent. The performance

wage is based on a piece rate per kilogram of fish processed. As a result, compensation pertains to the individual worker's attendance and output. Wages are paid on a monthly basis.

Before the intervention, workers were able to choose their work positions at the start of each workday. In general, within a processing room, there was no restriction on where workers should be positioned or whom they could work with. This allows me to observe to some extent workers' choice behaviors regarding whom to work next to or whom to work away from prior to the experiment. Importantly, the intervention was not revealed until the first day of implementation.

B. *Randomization of Worker Positions*

The field experiment was designed to randomly assign workers to workstations each day. For this purpose, I developed a code for generating random sequences tailored to the capacity of each processing room. Each worker was given a unique ID number and the workstations in a room were numbered from 1 to N, where N is the total number of processing workers in that room. For each room and workday, a random sequence of length N was generated, and workers were assigned to their respective positions according to the order of their number in that sequence. Online Appendix Figure 3-1 provides a sample of worker-position assignment forms for each processing room. To ensure compliance, workers were instructed not to switch nor fill in empty workstations.

Human resources staff at the management office used the code to generate the sequences and recorded the resulting worker positions normally a week before the actual assignment.[6] On days with processing work, processing managers first came to the office to collect their room's assignment form and then arranged worker positions according to this form. Human resources staff made daily visits to the processing rooms to check compliance with the assigned positions.

II. Data and Descriptive Statistics

A. *Employee Records Data*

The firm's employee records database records daily information on the tasks performed, work time, which measures the number of minutes spent processing fish, and the weight of fish processed by each individual worker. Using this database, I construct each worker's daily productivity, measured in kilograms of fish processed per hour.

As part of the study, worker positions were recorded for six months. Specifically, human resources staff visited processing rooms and recorded the ID number of the worker occupying each workstation. The firm started recording worker positions six weeks prior to the randomization phase and continued until the end of the study period. I combined the worker-position records with the employee records

[6]This was intended to account for possible new hires and job turnovers during the experiment period. Nonetheless, there were no new hires and only four job turnovers during the randomization period.

Table 1—Summary on Survey Participation

	Target population size	Participation from target population	Participation rate
Baseline	114	112	0.98
End line	105	101	0.96

Notes: For the baseline survey, target population size is the number of processing workers employed by the company at the time of this survey. For the end line survey, target population size is the number of processing workers who participated in the baseline survey and worked under randomized position assignments, including those who had quit during the randomization period. Participation from target population is the number of processing workers that participated in each of the surveys. Participation rate is calculated from (participation from target population)/(target population size).

data to produce a dataset that consists of 104 workers and approximately 7,800 worker-workday observations.

B. *Survey*

A baseline survey was administered two weeks prior to the start of the randomization. It consisted of three modules: socioeconomic status, social ties, and personality measures.[7] In the first module, each worker was asked about her socioeconomic background, experience in searching and applying for her current job, and her experience as a processing worker. The second module asked each worker to report on their social ties within her processing room and, for each reported social tie, the details of the relationship, such as the duration of the relationship, whether the tie had been formed prior to working at this plant, and the frequency of activities shared inside and outside of the workplace.[8] The last module was a Vietnamese-translated version of the Big Five Inventory (BFI), which is a self-report inventory with 44 short-phrase questions designed to measure the 5-factor analytically derived personality dimensions: extraversion, agreeableness, conscientiousness, neuroticism, and openness.[9] To collect qualitative information on each worker's post-intervention preference with regard to working with friends, an end line survey was conducted during the third week of December 2014.[10]

Table 1 presents the summary statistics on survey participation for both surveys. Overall, processing workers who regularly attended work during the survey periods were the main targets. Two workers did not participate in the baseline survey because of long absences and, therefore, were excluded from the dataset. Approximately, 10 percent of the workers, or 11 out of 112, who participated in the baseline survey

[7] Upon completion, workers were paid 30,000 Vietnamese dong (approximately $1.50) as a token of appreciation for participating in the survey.

[8] I only find three family ties among workers in the same processing room and, due to the small sample size, count these as friendship ties. The results are robust to dropping family ties from the friendship sample.

[9] The questionnaire, originally from John, Donahue, and Kentle (1991) and John, Naumann, and Soto (2010), was translated in Vietnamese and translated back in English by a professional translation company. Both versions were additionally checked by a native Vietnamese with experience in Vietnamese-English translations. The original version of the BFI is available for research purposes at http://www.ocf.berkeley.edu/~johnlab/bfi.php. The Vietnamese-translated version of the BFI is available from the author upon request.

[10] Participants were paid 20,000 Vietnamese dong (about $1.00) as a token of appreciation.

TABLE 2—SUMMARY STATISTICS: SOCIOECONOMIC VARIABLES

Variable	Mean	Variable	Mean
Panel A. Socioeconomics		*Panel B. Job search experience*	
Female	1	Learned about job opening through	
Married	0.68	Friend	0.71
Completed secondary school	0.48	Family member	0.21
Age (years)	31.61	Ex-coworker	0.13
	(9.34)	Job advertisements	0.06
Tenure at current job (months)	19.44	Received help when applying to job	0.40
	(16.87)	Conditional on help received	
		Helper is currently working at plant	0.91
Experience in fish	32.76	Relationship with helper	
processing (months)	(32.65)	Friend	0.52
		Family member	0.33
Lives in house with		Ex-coworker	0.13
Water pipe connection	0.72	Type of help	
Tiled floors	0.69	Information on job opening	0.64
Cable TV	0.56	Information on job details	0.27
Refrigerator	0.54	Recommendation to manager	0.05
Internet connection	0.11		
Owns motorcycle	0.59		

Notes: Standard deviations are provided in parentheses.
Source: Data on survey module 1 from 114 processing workers

left their jobs during the study period, although 7 of these 11 workers had quit prior to the commencement of the experiment: the other 4 workers left their jobs during the 5-month experimental period.

C. *Descriptive Statistics*

Table 2 provides summary statistics on the socioeconomic status of each worker and the job search experience. Processing workers at this plant were all females as the management only hired females for this particular job. At the time of the baseline survey, the average worker in my sample had 19 months of tenure at her current job and 33 months of experience in fish processing. Three-quarters of the surveyed workers had learned about job openings through their friends, and nearly 20 percent of the surveyed workers reported to had received help from a friend currently working at the plant when applying for this job.

Table 3 describes the frequency of friendships reported in the baseline survey. The median worker reported having four friends in her processing room. One worker reported to have no friends in her processing room. The median worker was mentioned as a friend four times. Summary characteristics of reported friendships are shown in panel A of Table 4. Among all reported friendships, 56 percent are mutual, 15 percent had formed prior to the current job, and the average duration of a friendship was approximately 19 months.[11] The bottom panel reports survey responses with respect to the frequency of activities shared with friends during the previous three months. The survey questionnaire used a five-point scale for all

[11] Although not shown in Table 4, 98 percent of the reported friendships were formed at least a month before the collection of the worker-position data in the preexperimental period.

Table 3—Frequency Counts of Friendship Reports

Panel A Number of friends reported by worker	Frequency	*Panel B* Number of times mentioned as a friend	Frequency
0	1	0	1
1	2	1	9
2	8	2	15
3	30	3	29
4	32	4	19
5	27	5	18
6	7	6	12
7	4	7	8
8	1	8	1
Mean	4.01	Mean	3.81
Median	4	Median	4
Standard deviation	1.35	Standard deviation	1.74

Source: Data on survey module 2 from 112 processing workers

Table 4—Characteristics of Reported Friendships

Panel A. Basic characteristics of reported friendships

	Mean	SD
Total number of reported friendships in sample[a]	287	
It is a mutually reported friendship	0.56	
Friendship formed before employment at current job	0.15	
Respondent learned processing skills from reported friend	0.42	
Respondent lives with reported friend	0.06	
Weekly time spent with reported friend outside workplace (hours)	2.21	3.76
Duration of friendship (months)	18.94	18.33

Panel B. Summary statistics on shared activities in reported friendships

	Frequency in the past three months[b]				
Shared activities	Very often (1)	Often (2)	Sometimes (3)	Rarely (4)	Almost never (5)
Go shopping together	17.1	9.4	8.0	12.2	53.3
Talk during break or lunch times	34.8	31.7	16.4	6.6	10.5
Work together at same table	40.1	34.2	13.9	3.1	8.7
Help each other at work	37.1	30.4	14.7	5.6	12.2
Give personal advice to this person	23.7	17.1	17.8	12.5	28.9
Receive personal advice from this person	22.3	14.6	16.0	13.3	33.8
Lent or borrowed money from one another		7.3	15.7	22.0	55.0

[a] Mutually reported friendships are counted as one friendship.

[b] All items—except *lent or borrowed money from one another*, which uses a four-point scale—use a five-point response scale. In the survey sheet, response semantics differed across items to account for natural differences in the frequency of activities. For the questions, *how often did you go shopping together*, *how often did you give advice on personal matters*, and *how often did you receive advice on personal matters* workers could choose from (1) more than once a week, (2) once a week, (3) once every two weeks, (4) once a month, and (5) less than once a month. For questions *how often did you talk to each other during break or lunch*, *how often did you work together at same table*, and *how often did you help each other's work*, workers could choose from (1) more than once a day, (2) once a day, (3) once every two days, (4) once a week, and (5) less than once a week. For the question *how many times did you lend or borrow money with each other*, workers could choose from (1) more than 5 times, (2) 2–5 times, (3) once, and (4) never.

TABLE 5—SUMMARY STATISTICS AND CORRELATIONS: BIG FIVE PERSONALITY FACTORS

Variable	Extraversion	Agreeableness	Conscientiousness	Neuroticism	Openness	Own ability	Friends' ability	Number of friends
Mean	3.60	4.08	3.84	2.59	2.75	0.00	0.00	4.84
Standard deviation	0.57	0.70	0.58	0.72	0.61	0.11	0.08	1.77
Correlation matrix								
Extraversion	1.00							
Agreeableness	0.33	1.00						
Conscientiousness	0.34	0.59	1.00					
Neuroticism	−0.39	−0.51	−0.50	1.00				
Openness	0.29	−0.02	0.03	0.07	1.00			
Own ability	0.34	0.15	0.12	−0.17	0.10	1.00		
Friends' ability	0.41	0.28	0.16	−0.27	0.25	0.66	1.00	
Number of friends	0.10	0.10	0.06	0.02	0.11	0.20	0.16	1.00

Notes: Data on Big Five personality factors are from survey module 3. Worker's own ability is a standardized coefficient estimate of individual-worker fixed effects. Friends' ability is the average of the friends' own abilities.

activities, except exchange of money, although the actual word descriptions varied across items.[12] Overall, survey reports suggest that workers frequently interact with their friends both inside and outside the workplace. In the main analysis, I define a friendship to exist between two workers if either one reported the other as a friend. As a robustness check, I show that the main results are robust to using only mutually reported friendships.

Table 5 presents summary statistics on the Big Five personality factors along with a correlation matrix of worker characteristics that are used throughout the empirical analysis. The first two rows show each variable's mean and standard deviation. The next five rows represent the Big Five correlation matrix, which show high correlations between four personality traits; extraversion, agreeableness, conscientiousness, and neuroticism. While the Big Five factors were initially constructed to be orthogonal to each other, between-factor correlations are commonly found in empirical studies of the Big Five factors (Anderson et al. 2011). It is therefore reasonable to include all five factors in regression specifications to account for inter-trait correlations.

The last three rows are for worker's own ability, or processing skill (measured as estimated worker fixed effects; details provided in online Appendix Section 1), average ability of friends, and number of friends. Among the Big Five, extraversion shows the highest correlation with own ability ($\rho = 0.34$). Note that own ability is also highly correlated with average ability of friends ($\rho = 0.66$) suggesting that friends are likely to have, on average, similar production skills. Interestingly, ability also has the highest correlation with number of friends ($\rho = 0.20$).

The previous table suggests the possibility that friends are more likely than non-friends to share similar characteristics, such as ability or personalities. To test this idea, I estimate a dyadic model of friendship using workers own and friends' characteristics. Specifically, I estimate a reduced-form regression that predicts

[12] The survey questionnaire sheet is available from the author upon request.

Table 6—Dyadic Regression of Friendship

	Dependent variable (= 1 if yes)			
	All reports	Mutual reports	All reports	Mutual reports
	Linear probability model		Logit model	
Variable	(1)	(2)	(3)	(4)
Absolute difference between x_i and x_j, $\lvert x_i - x_j \rvert$				
Age	−0.005	−0.003	0.947	0.946
	(0.001)	(0.001)	(0.012)	(0.016)
Job tenure	−0.022	−0.014	0.810	0.821
	(0.007)	(0.006)	(0.057)	(0.069)
Ability	−0.304	−0.358	0.026	0.000
	(0.067)	(0.052)	(0.023)	(0.001)
Extraversion	−0.030	−0.014	0.745	0.827
	(0.008)	(0.007)	(0.067)	(0.091)
Agreeableness	−0.007	−0.009	0.944	0.905
	(0.011)	(0.009)	(0.094)	(0.111)
Conscientiousness	−0.001	0.003	0.971	0.985
	(0.011)	(0.009)	(0.101)	(0.118)
Neuroticism	0.001	0.003	1.006	1.036
	(0.009)	(0.007)	(0.085)	(0.103)
Openness	−0.008	−0.005	0.934	0.935
	(0.009)	(0.007)	(0.077)	(0.099)
Observations	1,808	1,808	1,808	1,808

Notes: In columns 1 and 3, the dependent variable is equal to one if at least one worker reported the other as a friend. In columns 2 and 4, the dependent variable is equal to one if the friendship is mutually reported. In both cases, the relationship is symmetric. Columns 3 and 4 report odds ratios. All regressions also include two indicator variables—symmetries of marital status and secondary school completion—but estimates are not reported in this table. Robust standard errors are provided in parentheses.

the existence of a friendship between two workers, i and j, using the following specification:

$$F_{ij} = \alpha + \xi \left| x_i - x_j \right| + \zeta z_{ij} + u_{ij}, \tag{1}$$

where F_{ij} is equal to one if there exists a friendship between i and j, x_i and x_j are characteristics of i and j, and z_{ij} is a vector of additional attributes between i and j which does not take the absolute difference form. Note that equation (1) is specified in a way such that a dyadic relationship is undirectional. That is, all regressors are symmetric.

Table 6 reports estimates of equation (1) using a linear probability model in columns 1 and 2 and a logit model in columns 3 and 4. Columns 1 and 3 use as the dependent variable all reports of friendships. Both columns suggest that two workers are significantly more likely to report each other as a friend the closer they are to each other in age, job tenure, ability, and, among the Big Five personality dimensions, extraversion. Estimates on the other four personality factors are statistically insignificant and close to zero. Refining the definition of a friendship only to mutual reports does not significantly change the results (shown in columns 2

and 4). Although not reported in this paper, inclusion of dyadic-averaged characteristics, for instance, the average ability of workers in a dyad, does not alter the qualitative findings.

III. Conceptual Framework

To guide the empirical analysis, here I present a model of effort choice embedded with social ties (or friendships) and skills in which the skills can separately take the form of processing skills and personality skills. I first discuss the effect of working with socially connected coworkers on effort choice, which is then followed by predictions on heterogeneous effects with regard to worker skills. In the Appendix, I further develop this framework into a structural model to estimate workers' consumption values of working with socially connected coworkers.

A. *Effort Choice*, *Friendships*, *and Skills*

Denote e as the worker's choice of effort for production. The productivity of worker i, y_i, is measured in kilograms of fish processed per hour. For simplicity, assume that the productivity of worker i is given by $y_i = e_i$. As in the empirical setting, I assume that workers are paid a combination of a fixed base wage plus a piece rate. Workers derive utility from wage, $W(\cdot)$, where $W_e > 0$ and $W_{ee} < 0$.

Workers are considered to be heterogeneous in their fish processing skills, θ, and personality skills, denoted by a k-length vector N, $N = \{\nu_1, \ldots, \nu_k\}$.[13] Denote $C(e, \theta, N, f)$ as the worker's cost function from exerting effort level e, where f is an indicator of the presence of friends.[14] Assume $C_e > 0$ and $C_{ee} > 0$ such that the cost of effort is increasing and the marginal cost of effort is also increasing in the current level of effort.[15] The worker's utility maximizing effort level in each state with regard to the presence of friends can therefore be characterized as follows:

$$e^{nf} \in \arg\max_e W(e) - C(e, \theta, N, nf), \tag{2}$$

$$e^{f} \in \arg\max_e W(e) - C(e, \theta, N, f), \tag{3}$$

where e^{nf} denotes the optimal effort in the *absence* of friends and e^{f} denotes the optimal effort in the *presence* of friends.

It is apparent from equations (2) and (3) that the difference in optimal effort level between states is driven by the difference in marginal costs of effort when working

[13] In general, processing skills and personality skills are likely to influence each other and be correlated. For instance, processing ability may influence personality characteristics if better processing ability leads to being more sociable. Conversely, high conscientiousness may positively affect training motivation and acquire better processing skills.

[14] As in Almlund et al. (2011), the optimal effort level also depends on noncognitive factors. Here, however, I introduce noncognitive factors as parameters of cost (N) rather than as part of the production function to represent the idea that the cost of exerting effort may depend on an individual worker's personality.

[15] By definition, workers with higher levels of processing skills, θ, and personality characteristics, N, exert effort at a lower cost.

with a friend and when without. If working with friends motivates a worker and drives down the cost of exerting effort ($C_e(nf) > C_e(f)$), then we would observe $e^{nf} < e^f$. On the other hand, if working with friends result in greater effort costs due to idle chats or spread of negative work behavior between friends ($C_e(nf) < C_e(f)$), effort level will be higher when working without friends, $e^{nf} > e^f$. In the empirical analysis section, I compare e^{nf} and e^f within a worker based on random assignments of worker positions to estimate the effect of friends on worker productivity.

B. *Heterogeneous Effects on Worker Effort*

Next, I consider worker heterogeneity in behavioral responses to the presence of friends. Using the model framework, the difference in the marginal cost of effort between the two states $C_e(nf) - C_e(f)$ can vary as a function of worker characteristics, such as production skill or noncognitive skills. Studies provide evidence that one's production skill, or ability, has crucial influence on the job performances of coworkers who work nearby (Mas and Moretti 2009; Bandiera, Barankay, and Rasul 2010). In an agricultural field setting, Bandiera, Barankay, and Rasul (2010) finds that the effect of the presence of friends significantly depends on the relative ability between friends working alongside each other in the same field, and that this is due to pacing work speed in line with friends of different abilities. In the current context, work positions are fixed and work speed pacing may be unnecessary if it is for the sake of socializing. Alternatively, if workers' preferences are shaped by social concerns, such as aversion to inequity (Andreoni and Miller 2002, Charness and Rabin 2002), it is still possible for workers to adjust their work speed according to that of their friends. Thus, work speed pacing will arise if the following condition on marginal cost of effort is met: $C_e(f, \theta_i > \theta_j) > C_e(f, \theta_i < \theta_j)$, where θ_i is own production skill and θ_j is friend's production skill.

Heterogeneous effects can be caused by different levels of peer pressure, which may positively covary with the ability of the peer.[16] For example, workers may experience social pressure when a high-ability friend is working nearby compared to when a low-ability friend is present: $C_e(f, \theta_j = \theta_{high}) < C_e(f, \theta_j = \theta_{low})$. In this case, the effect of working with friends on productivity will be relatively more positive (or less negative) the more able one's friend is.

Noncognitive skills, or personality characteristics, may play an important role in determining social interaction behaviors.[17] For example, workers who are more talkative, which is positively measured by extraversion, may have stronger preferences to socialize in the presence of friends relative to less talkative workers. If socializing has a positive influence on performance, then the higher the extraversion the greater the increase in one's performance from working with friends: $C_{e,\varepsilon}(f) < 0$, where ε denotes extraversion. Conversely, if socializing has a negative effect on worker

[16] I investigate peer pressure in the usual coworker-ability framework in a companion paper (Park 2018).

[17] For a brief introduction to the taxonomy of the Big Five personality factors, I refer the reader to John, Naumann, and Soto (2010).

performance, the effect size will be larger for workers with high extraversion than for workers with low extraversion: $C_{e,\varepsilon}(f) > 0$.

Studies on personality and job performance single out conscientiousness as a strong and positive predictor of job performance across a wide array of occupation groups (Mount, Barrick, and Stewart 1998; Callen et al. 2015). Not surprisingly, conscientiousness is constructed to measure one's ability to exert self-control and self-discipline. According to this definition, individuals with high conscientiousness are expected to cope better with distractive situations, such as working right next to a friend. This can be written out in marginal cost terms as $C_{e,c}(f) < 0$, where c denotes conscientiousness. The personality psychology literature does not provide compelling evidence as to whether agreeableness and openness are predictors of job performance.[18] Neither does it provide evidence of a strong association between neuroticism—a reverse measure of emotional stability—and job performance (Barrick and Mount 1991, Bono and Judge 2003).

IV. The Effect of Working with Friends

This section presents the empirical framework followed by the estimation results on the effect of working with friends. The primary goal is to provide a compelling empirical strategy that identifies the effect of working with friends and its mechanism regarding friendships at work. In subsequent parts of this section, I investigate heterogeneous effects of working with friends and present estimates on workers' willingnesses to pay to work with friends.

A. *Econometric Specification*

To identify the effect of working with friends on individual productivity, I exploit within-worker variations in productivity and spatial proximity to friends across workdays caused by the randomized position assignments. The idea of spatial proximity in the current context is illustrated in Figure 2, panel A, which presents a diagram with workstations at three tables. Areas enclosed by the dotted lines represent work spaces that are spatially contiguous to workers B and L, respectively. This spatial area surrounding a worker is of interest because it is not unreasonable for social interactions to arise mainly between workers that are next to or facing each other. Also, work tables are arranged closely side-by-side rendering table boundaries irrelevant in determining spatial contiguity.

Next, I divide one's surrounding space into finer categories depending on the proximity and orientation of a workstation to the worker's reference position. In Figure 2, panel B, for example, workstations that are spatially contiguous to workers B and L are shaded in three different degrees of darkness to represent the different

[18] With regard to economic preferences, Dohmen et al. (2008) finds positive correlations between agreeableness, as well as openness, and social preferences, such as trust and positive reciprocity. Experimental studies find that other types of economic preferences, such as time preference or risk preference, are not significantly associated with the Big Five factors but rather work as complements in determining lifetime outcomes (Kautz et al. 2014).

levels of proximities and orientations to workers B and L. In accordance, I adopt the following terminology throughout the remainder of the paper.

DEFINITION 1: *A and B are in* high proximity *if A and B work at positions alongside each other.*

DEFINITION 2: *A and B are in* medium proximity *if A and B work at positions that are right across and facing each other.*

DEFINITION 3: *A and B are in* low proximity *if A and B work at positions that are contiguous but neither alongside nor facing each other.*

As depicted in Figure 1, workers are required to wear face masks inside the processing rooms which makes it difficult for a worker to communicate with others unless they are close to each other. One's observability, however, is not severely obstructed by wearing a mask. I use this natural variation in communicability and lack thereof in observability across different proximities to identify the mechanism in effect. Specifically, social interactions may arise from indirect interactions, such as motivation or social preferences (e.g., inequity aversion), or because of direct interactions, such as helping each other's work or socializing. While both indirect and direct interactions require a worker to be able to observe her friend, the latter additionally requires that the two workers be physically close to each other, or have *high proximity*. Therefore, if it is direct interactions that is driving the result, then we would expect the magnitude of the effect to decrease as proximity with a friend falls. In contrast, the effect would persist even under *low proximity* if observability alone is the medium of social interactions affecting performance.

First, to check if the presence of friends at spatially contiguous positions has any affect at all on a worker's productivity, I estimate the following panel data specification:

$$y_{irt} = \beta \cdot Contiguous_{irt} + X_{irt} + \theta_i + \lambda_{rt} + \varepsilon_{irt}, \tag{4}$$

where y_{irt} is the log productivity (log of kilograms of fish processed per hour) of worker i in room r on day t. The term $Contiguous_{irt}$ is an indicator variable equal to one if worker i has at least one friend working at a spatially contiguous position in room r on day t, and zero otherwise. The term X_{irt} contains information on the number and mean ability of coworkers (excluding worker i) working at positions spatially contiguous to worker i in room r on day t, and θ_i and λ_{rt} are the worker and room $\times$ day fixed effects, respectively. The worker fixed effect accounts for unobserved time-invariant worker characteristics while the room $\times$ day fixed effect accounts for time-varying productivity shocks occurring at the room $\times$ day level. The latter type of shock may be especially relevant to this setting as each processing room is associated with a different production line, each of which has its own preprocessing and post-processing facilities operated by different groups

of workers.[19] The error term for individual i in room r on day t is represented by ε_{irt}. The sole parameter of interest in equation (4) is the coefficient on the variable *Contiguous*, β. Under this model specification, β can be interpreted as the effect of a friend's presence on worker productivity. Yet, because contiguous is a broad-ranging measure of proximity, it is difficult to discern the mechanism behind the effect of friends—both direct and indirect social interactions may occur when working near a friend.

For that reason, I proceed to my main specification that takes into account different levels of proximity between friends:

$$(5) \qquad y_{irt} = \gamma_L \cdot Low\ Prox_{irt} + \gamma_M \cdot Med\ Prox_{irt} + \gamma_H \cdot High\ Prox_{irt} + X_{irt} + \theta_i + \lambda_{rt} + \varepsilon_{irt},$$

where *Low Prox*, *Med Prox*, and *High Prox* are indicator variables equal to one if there is at least one friend working at low, medium, and high proximity, respectively. All other variables are defined as above. In equation (5), γ_L is the effect on a worker's productivity from having a friend working at low proximity; γ_M and γ_H each represent the effect on productivity from the presence of a friend working at medium and high proximity, respectively.

A panel data regression of equation (5) may generate biased estimates if the error term, ε_{irt}, is correlated with the presence of friends at a specific proximity. For instance, self-selection bias in the form of workers choosing to work alongside friends on days when they feel less productive would negatively bias the estimate of the impact of working alongside friends on productivity. On that account, as underscored by Manski (2000), the randomization of worker-workstation assignments offers an advantage in identifying social interaction effects in the current context.

Although randomization of position assignments helps overcome the problem of workers self selecting into certain proximities to friends, proximity variables can yet be considered to be endogenous given that they can only be realized if the worker actually showed up on the day of assignment. This would be problematic if work attendance is both correlated with the position assignment and some unobserved determinant of worker productivity. For instance, if workers were informed about the position assignments in advance, which is a clear breach of protocol, or if the days that they work close to their friends were predictable, workers might show up even on days when they are under-motivated or fatigued if a friend is assigned to work at close proximity but not under a position assignment with no friend working nearby. I check for this possibility by regressing worker attendance on assigned proximities and find no statistically significant relationship suggesting that there was no leakage of information on position assignments.[20]

In general, correlations between unobserved determinants of worker productivity and realized worker position could potentially bias the estimate of interest.

[19] Regression results from including alternative fixed-effect specifications are separately reported as part of a robustness check.

[20] Regression results are available from the author upon request.

Accordingly, for the main specification, I use an instrumental variables strategy that exploits variation in the assigned proximities to friends. The idea is to instrument three endogenous variables (worker is observed working with a friend at low, medium, or high proximity) with three exogenous variables (worker is assigned to work with a friend at low, medium, or high proximity). Assuming randomized workstation assignments, assigned proximity variables should be exogenous to any unobserved factor determining a worker's daily productivity.

In light of the importance of the assumption of random assignment, I use information on workers and workstations during the experiment period to conduct a numerical exercise that can formally show how random the assigned proximities are compared to a simulated distribution of randomly generated proximities.[21] Specifically, I generate 1,000 replications of randomly generated position assignments for the entire experiment period. If the randomization of worker-workstation assignments was successful, then the probability of being assigned to work with a friend during the experiment and the average probability obtained from 1,000 replications should be within a reasonable distance.

The first two columns of Table 7 each report the average assigned (column 1) and average realized (column 2) probability of having at least one friend present at each level of proximity during the experiment.[22] On average, a worker was assigned to work at a spatially contiguous position with at least one friend around half of the time (0.54). With respect to each proximity, the probability of being assigned with at least one friend at low, medium, and high proximity was, on average, 0.27, 0.18, and 0.24, respectively. Realized probabilities are lower than assigned probabilities across all proximities mainly because of worker absence—if one of the workers in a friendship pair is absent, then the other worker is observed as not working with a friend.

The third column shows the average probability of working with a friend taken from 1,000 replications of worker-workstation assignments for the entire randomization period. Simulated probabilities are slightly smaller than assigned probabilities but larger than the realized probabilities. For example, the simulated probability of working with a friend at low proximity is 0.23, which differs by -0.04 and $+0.02$ from the assigned and realized probability, respectively. To statistically assess whether the difference between assigned and simulated probabilities is acceptable under conventional significance levels, I construct, for each worker, 95 percent and 99 percent confidence intervals using the sample mean and standard deviation from the 1,000 replications. The proportion of workers that have an assigned probability outside each worker-specific confidence interval is reported in the last two columns. The last column reports that 91 percent and 98 percent of the worker sample have assigned probabilities at low and high proximity, respectively, that lie within the 99 percent confidence interval. Overall, the results of this exercise suggest that the randomization of workstation assignments was successful.

[21] In Park (2018), I use the same dataset used in this paper and show that it passes the conventional test of exogeneity between a worker's and her peer's characteristics.

[22] Realized probability is based on worker-position records made by HR staff during unexpected visits.

TABLE 7—PROXIMITY TO FRIENDS DURING EXPERIMENT PERIOD

	Probability (proximity = X)			Proportion of sample outside	
X =	Assigned	Realized	Simulated	95 percent CI	99 percent CI
Contiguous	0.54	0.46	0.48	0.21	0.11
	(0.18)	(0.16)	(0.18)		
Low Prox	0.27	0.21	0.23	0.19	0.09
	(0.12)	(0.10)	(0.12)		
Med Prox	0.18	0.15	0.14	0.26	0.13
	(0.09)	(0.07)	(0.07)		
High Prox	0.24	0.19	0.23	0.08	0.02
	(0.12)	(0.09)	(0.11)		

Notes: The first three columns of this table present assigned, realized, and simulated probabilities of having at least one friend at different levels of proximities throughout the experiment period. Assigned probabilities are calculated by taking the mean of each assigned proximity-specific indicator variable over all worker-day observations (observations = 7,290). Realized probabilities are based on worker-position records made by HR staff during daily unexpected visits to processing rooms. Simulated probabilities are obtained from 1,000 replications of random assignments of workers to work positions. Standard deviations are presented in parentheses. The proportion of the sample outside 95 percent and 99 percent confidence intervals indicates, for a given proximity, the fraction of workers whose assigned probability during the experiment period lies outside the worker-specific confidence interval constructed using the mean and standard deviation obtained from simulating random worker-position assignments.

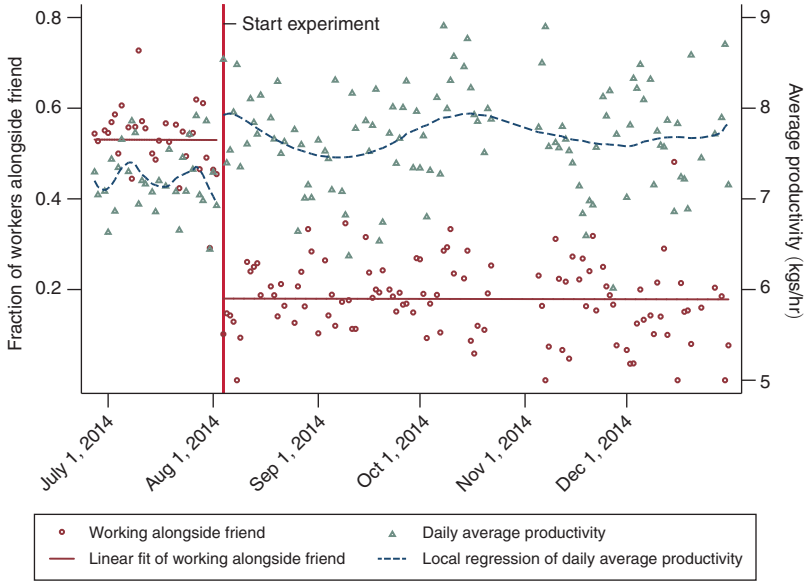

FIGURE 3. WORKER POSITIONS AND PRODUCTIVITY ACROSS TIME

Before proceeding to the main estimation results, here I present descriptive findings on the relationship between working with friends and job performance. Figure 3 presents daily plant-level statistics on worker productivity and the probability of working alongside a friend (i.e., high proximity) during the six month study period. Before the experiment the average worker produced about seven kilograms of fillet per hour and worked alongside a friend more than half of the time. With the

Table 8—Baseline Results: OLS Estimates

	Dependent variable: log(productivity)			
	Pre-experiment		Experiment	
	(1)	(2)	(3)	(4)
Contiguous	−0.049		−0.021	
	(0.017)		(0.007)	
Low Prox		−0.004		−0.001
		(0.015)		(0.006)
Med Prox		−0.012		−0.007
		(0.015)		(0.012)
High Prox		−0.062		−0.052
		(0.015)		(0.010)
Adjusted R^2	0.65	0.66	0.44	0.44
Observations	1,839	1,839	5,731	5,731

Notes: All regressions include worker fixed effects, room × day fixed effects, and control variables at the individual spatial level, including the number of workers working at contiguous positions and the mean of their average productivities. Standard errors are two-way clustered by worker and day.

start of the experiment, the probability of working next to a friend falls to less than 20 percentage points while daily average productivity jumps by around 10 percent. While suggestive of a negative impact of friends on productivity, it is well known that this in itself cannot serve as evidence of a causal relationship. One reason would be due to possible observer effects, also known as the Hawthorne effects (Levitt and List 2011). Next, I present results from estimating equations (4) and (5) to provide causal evidence on the effect of working with friends.

B. *Estimation Results*

Table 8 reports Ordinary Least Squares (OLS) estimates based on equations (4) and (5). Columns 1 and 2 use data from the preexperimental period and find that the presence of at least one friend at a contiguous and, more specifically, a high-proximity position is associated with declines in worker productivity. Columns 3 and 4 each estimate equations (4) and (5) using the experimental period data. The estimates from the experimental period are relatively smaller than those from the preexperimental period. This is possible if, before the experiment, workers were choosing to work with their closest friends leading to stronger effects, as the experiment only captures the productivity change associated with the presence of an average friend.

Next, I present IV estimates based on assigned proximities to friends. The top panel of Table 9 presents first-stage results. Each level of realized proximity is strongly related to the assignment to that level of proximity. The *F*-statistics from the tests of joint significance of the three instruments are reported at the bottom of the panel. The statistics are sufficiently large to remove concerns about weak instruments.

The bottom panel reports the second-stage results. The estimates in column 1 suggest that workers are on average 5.6 percent less productive when at least one friend is present at a high-proximity position relative to when no friend is present at high

Table 9—IV Estimation Results

Panel A. First-stage results			
	Endogenous variables		
Instruments	*Low Prox*	*Med Prox*	*High Prox*
Assigned *Low Prox*	0.792	−0.009	−0.004
	(0.013)	(0.006)	(0.006)
Assigned *Med Prox*	−0.004	0.817	−0.019
	(0.006)	(0.015)	(0.006)
Assigned *High Prox*	−0.011	−0.005	0.791
	(0.006)	(0.005)	(0.015)
F-statistic	1,359.26	1,010.41	1,116.95
Panel B. IV/2SLS			
Variable		log(productivity)	log(wage)
Low Prox		0.000	−0.020
		(0.006)	(0.012)
Med Prox		−0.003	−0.011
		(0.010)	(0.014)
High Prox		−0.056	−0.043
		(0.010)	(0.017)
Observations		5,731	5,731

Notes: Dependent variables in the bottom panel are the worker's log productivity (kilograms/hour) and log hourly wage (daily wage/hour). All regressions include worker fixed effects and room × day fixed effects and control variables at the individual spatial level. Standard errors are two-way clustered by worker and room × day.

proximity. As a benchmark, the 5.6 percentage point effect size corresponds closely to the estimated ability difference between a worker at the seventy-fifth percentile and a worker at the fiftieth percentile. Surprisingly, the estimates for other proximities are insignificant and close to zero. Friends seem to affect productivity only when they are adjacent to each other. In the current context, unlike communicability, observability does not vary much across proximities. Thus, what is likely driving the productivity drop are interactions that can only arise when in close proximity, such as socializing.

In online Appendix Section 2, I conduct various robustness checks on estimating the effect of working with friends on productivity. First of all, I take into account possible spillovers from friend pairs that are nearby but unconnected to the focal worker since the presence of friend pairs may impact the productivity of other workers in the vicinity. Next, I test how the results depend on whether the friend is at the same table and whether the worker is at a corner station since workstations at corners of the rooms may naturally be more worker friendly relative to workstations in the center. I also include different sets of fixed effects across several specifications. Results are presented in online Appendix Table 2-1. Estimates on high proximity vary between −0.051 and −0.069 and are all statistically significant at the 1 percent level. In Table 2-2, I show that the proximity estimates are nearly unchanged when friends are defined using only bilateral reports or when I limit friendships to friendships that formed prior to the start of working at their current job or friendships observed to work apart during the preexperiment period. This last set of results suggests that the

self reports collected in this study are likely representing one's social network in the workplace rather than a simple listing of recent "chat buddies."[23]

Column 2 shows estimation results from using worker's hourly wage as the dependent variable. Given that workers are partially compensated on a piece rate scheme, the results in column 1 imply that workers should earn less when working with friends in high proximity. Not surprisingly, the estimate indicates that on average workers lose about 4 percent of their hourly wage when working with their friends at high proximity. When converted into monthly terms, this is commensurate to the loss of a full day's wage. In comparison, Bandiera, Barankay, and Rasul (2010) reports an average worker losing 10 percent of her earnings when a lower ability friend is present on the same field, whereas earnings are reported to increase by 10 percent with the presence of a higher ability friend. In the next section, I also show that the productivity drop is smaller the higher the ability of the friend. However, unlike Bandiera, Barankay, and Rasul (2010), the effects on productivity and wage remain negative.

An interesting question related to the counterfactual timeline of this study is how much wage loss workers incurred prior to the experiment and, without the intervention, probably would have continued to do so. For this purpose, I perform a back-of-the-envelope calculation by multiplying worker-specific estimates on wage loss when a friend is at high proximity with the probability of working alongside a friend during the preexperiment period.[24] This suggests that before the experiment the expected daily wage loss due to working with friends was about 3 percent for an average worker. For a more structural approach, in Section IVD, I draw on a probabilistic choice model to estimate how much workers are willing to pay out of wage to work with friends.

C. *Heterogeneous Effects on Productivity from Working with Friends*

In this section, I explore whether workers with different skills respond differently to the presence of their friends. Specifically, guided by the framework in Section IIIB, I examine heterogeneous effects with respect to two potentially crucial skills of human capital in the workplace: production skill and personality skills.

Production Skill.—First, I examine whether the effect of working with friends is heterogeneous to the reference worker's production skill or that of her friends'. To obtain measures of production skill, I build on the approach of Mas and Moretti (2009) and use estimates of worker fixed effects. The estimation strategy is described in more detail in online Appendix Section 1. The standardized ability estimates of workers at the twenty-fifth and seventy-fifth percentile are -0.073 and 0.071, respectively, implying an ability differential of about 15 percent.

[23] It is rather important to make this distinction because the question of this paper is not how chatting affects productivity but how working with friends—as in socially connected coworkers—affects productivity.

[24] The effect size of working with friends on wage may arguably depend on the frequency of working with friends. For example, we can expect workers to talk with their friends less on a given day if they were able to work together for several consecutive days relative to working alongside, say, only once a week. Nevertheless, I do not find a significant difference in the IV estimates between days when it is the second or third consecutive day of working with a friend and days when it is the first day of working with a friend following a spell of no friends for at least two days.

TABLE 10—HETEROGENEOUS EFFECTS: PRODUCTION SKILL

	Dependent variable: log(productivity)			
Variable	(1)	(2)	(3)	(4)
High Prox	−0.059	−0.060	−0.050	−0.054
	(0.010)	(0.010)	(0.010)	(0.011)
× Own ability	0.070			
	(0.085)			
× Friend's ability		0.186		
		(0.089)		
× Moreable			−0.017	
			(0.014)	
× Moreable × |own ability − friend's ability|				−0.101
				(0.158)
× Lessable × |own ability − friend's ability|				0.014
				(0.123)
Observations	5,731	5,731	5,731	5,731

Notes: The dependent variable is the worker's log productivity (kilograms/hour). All regressions include worker and room × day fixed effects along with the externality variables at the individual spatial level (e.g., friends working next to each other, $\sum_{j \in \mathcal{C}(i)} High\ Prox_j$). Standard errors are two-way clustered by worker and room × day level and corrected for sampling variability of the estimated ability term using a Bayesian parametric bootstrap procedure. Column 3 uses an indicator variable equal to one if the reference worker has higher ability than her friend at high proximity, and zero otherwise. Column 4 uses a measure of absolute difference in ability with respect to that of her friends at high proximity. All regressions include a full set of interactions between other proximity variables and each ability measure (not presented in this table). The full table is available in online Appendix Section 3.

To check for heterogeneous effects, I extend equation (5) to include interactions terms between proximity and production skill:

$$(6) \quad y_{irt} = \sum_{K=L,M,H} \gamma_K \cdot K\,Prox_{irt} + \xi_K \cdot K\,Prox_{irt} \times \hat{\theta}_j + X_{irt} + \theta_i + \lambda_{rt} + \varepsilon_{irt},$$

where $\hat{\theta}_j$ denotes the estimated production skill of worker j. I adopt the instrumental variables strategy from the previous section and instrument for both the proximity variable and the interaction term. Here, for succinctness, I only report estimates pertinent to high-proximity positions. Reports on estimates for low and medium proximities are provided in online Appendix Table 3-1.

Column 1 of Table 10 reports coefficient estimates associated with the high-proximity parameter (γ_H) and the interaction term (ξ_H) using the production skill of the focal worker ($i = j$). The estimate on the interaction term is positive but statistically insignificant. Column 2 checks whether worker productivity is differentially affected by the ability of friends in high-proximity positions. The estimate is statistically significant and indicates that working alongside a friend with an ability corresponding to the seventy-fifth percentile on the ability distribution is associated with a productivity decline of 4.6 percent, whereas working alongside a friend at the twenty-fifth percentile is associated with a decline of 7.3 percent. Thus, working next to a low-ability friend is associated with a 60 percent larger productivity drop compared to working next to a high-ability friend.

In columns 3 and 4, I test for heterogeneity using ability differences in relative and absolute terms between friends. Both estimates on the interaction terms are largely insignificant and close to zero. Therefore, I find no evidence of work speed pacing between friends in the current manufacturing context with fixed worker positions. This suggests that for this type of production process assigning friends next to each other may create inefficiencies regardless of ability differences.

There may be several reasons behind the finding that high-ability friends are less detrimental to one's productivity compared to low-ability friends. One possible explanation is that high-ability workers talk less than low-ability workers and, therefore, when working next to friends who do not talk much there is less of an effect on a worker's productivity. Another explanation is that high-ability workers motivate their peers and that balances out part of the negative effect associated with the presence of a friend. Yet, the lack of productivity increase from high-ability friends in lower proximities makes this view less favorable.

Personality Skills.—Next, to estimate heterogeneity with respect to personality skills, I replace production skill in equation (6) with a vector of worker i's standardized scores on the Big Five personality measure. As before, I instrument for all proximity variables and interaction terms and report only high-proximity estimates here. Coefficient estimates for other proximities are shown in online Appendix Table 3-2.

Estimates on the Big Five interacted with high proximity are reported in Table 11. Column 1 shows that, among the five factors, conscientiousness is statistically significant and has a positive sign. The estimate size suggests that if conscientiousness is 1 standard deviation below the sample mean then working alongside a friend is associated with a 9.4 percent decline in productivity while if conscientiousness is 1 standard deviation above then it is associated with a 1.6 percent drop. For comparison, this 8 percentage point differential corresponds to about four-fifths of a standard deviation of production skill in this sample.

By construction of the Big Five, conscientiousness measures a person's self-discipline or willingness to achieve a goal. However, there might be other worker characteristics correlated with self-reported conscientiousness and with determinants of social interactions in the workplace. For instance, as shown in Table 5, conscientiousness is positively related with production skill. Accordingly, columns 2 and 3 include interaction terms between proximity and additional worker characteristics (age, job experience, production skill) as control variables. The estimated coefficient on conscientiousness is almost identical to that in column 1. To be conservative, I reestimate the coefficients after restricting the friendship set to mutual reports. Reassuringly, columns 4 and 5 present qualitatively similar estimates.

D. *Willingness to Pay from Wages to Work with Friends*

The findings presented so far indicate that workers are, on average, 6 percent less productive when friends are working alongside. This raises an important question: to what extent would workers be willing to pay out of their wages to work with their friends? Furthermore, how does one's willingness to pay to work with friends correlate with one's personality as well as other characteristics? In this section, I

TABLE 11—HETEROGENEOUS EFFECTS: PERSONALITY SKILLS

Friendship based on:	Dependent variable: log(productivity)				
	All reports			Mutual reports	
	(1)	(2)	(3)	(4)	(5)
High Prox	−0.057	−0.076	−0.058	−0.061	−0.088
	(0.010)	(0.030)	(0.009)	(0.009)	(0.029)
× Extraversion	−0.004	−0.005	−0.007	0.007	0.001
	(0.008)	(0.008)	(0.008)	(0.009)	(0.008)
× Agreeableness	0.001	0.000	−0.001	0.000	0.000
	(0.008)	(0.008)	(0.008)	(0.010)	(0.010)
× Conscientiousness	0.040	0.040	0.040	0.027	0.028
	(0.008)	(0.008)	(0.008)	(0.009)	(0.009)
× Neuroticism	0.010	0.006	0.011	0.003	0.003
	(0.007)	(0.007)	(0.007)	(0.007)	(0.008)
× Openness	−0.002	0.000	−0.003	0.001	0.002
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
× Age		0.000			0.000
		(0.007)			(0.001)
× Job tenure		0.001			0.001
		(0.001)			(0.001)
× Ability			0.028		0.042
			(0.060)		(0.075)
× Friend's ability			0.171		0.203
			(0.085)		(0.137)
Observations	5,731	5,731	5,731	5,731	5,731

Notes: The dependent variable is the worker's log productivity (kilograms/hour). The measure for personality skills is a worker's self-reported Big Five personality score standardized using the sample mean and standard deviation. All regressions include room × day fixed effects, proximity variables (including low and medium), proximity variables interacted with Big Five factors, and controls at the individual spatial level. Standard errors are two-way clustered by worker and room × day and provided in parentheses. Significance levels are corrected to account for testing five hypotheses, one for each of the five personality dimensions, using the Holm-Bonferroni method. All regressions include a full set of interactions between other proximity variables and each personality measure (not presented in this table). The full table is available in online Appendix Section 3.

partially lay out the framework and results of the structural approach for estimating workers' willingnesses to pay from wages to work with friends. Full details of the model and estimation strategy are delivered in the Appendix.

The conceptual framework is based on the idea of compensating differentials, introduced by Rosen (1987), in which workers are willing to forgo wage in exchange of desirable work attributes, for instance, working with friends. If workers are indeed willing to pay to work with friends then we should observe workers choosing to work alongside friends even at the cost of earning lower wages. In terms of the model, I adopt a random utility model in which a worker decides whether or not to work next to a friend given her wage utility and cost of effort. I assume that workers have heterogeneous intrinsic valuations on working with friends which allows me to separately estimate each worker's consumption value of working with friends.

The estimation strategy is the maximum likelihood estimation using combined data on worker positions from the preexperiment period and productivity estimates

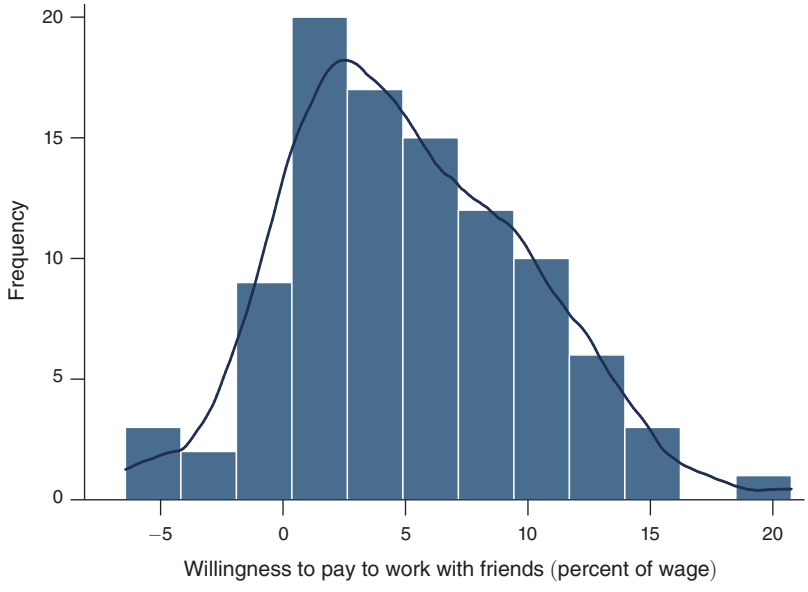

FIGURE 4. WILLINGNESS TO PAY FROM WAGES TO WORK WITH FRIENDS

Notes: A worker's willingness to pay (WTP) is obtained by converting the worker's estimated consumption value of working with friends ($\hat{s}_i$) in wage terms (z_i). Formally, I solve for z_i in

$$2\left(\sqrt{Wage_i^{nf}} - \sqrt{Wage_i^{nf}(1 - z_i)}\right) = \hat{s}_i$$

for each worker, where utility from wage is assumed to be a CRRA type with the relative risk parameter equal to $1/2$.

of working with friends during the experiment period. A worker's willingness to pay (WTP) is then calculated by converting the estimated consumption value into interpretable wage units. That is, I derive the amount of wage loss, as a percentage of wage when working without friends, that leaves the worker indifferent between working with friends at high proximity and working without friends in contiguous positions.

Figure 4 presents a histogram of estimated workers' WTP from wages to work with friends. Interestingly, 13 out of 98 workers show a negative value on working with friends. The median worker is willing to pay 4.5 percent of her wage to work alongside friends. For comparison, Hamilton, Nickerson, and Owan (2003) reports garment factory workers switching from individual to team production at the cost of forgoing approximately 8 percent of their individual wage. In their setting, team production enabled workers to socialize with their teammates but also allowed specialization of production tasks. In the current processing environment, tasks are individually carried out.

To understand heterogeneity of WTP with respect to individual characteristics, I run separate ordinary least squares regressions of WTP on production skill and personality skills, along with other background characteristics. The regression results are reported in Table 12. Column 1 indicates that WTP to work with friends is negatively associated with job experience and being married. Column 2 shows

Table 12—Willingness to Pay and Worker Characteristics

	Willingness to pay from wages to work with friends (percent of wage)		
	(1)	(2)	(3)
Age	0.350	0.434	0.203
	(0.382)	(0.363)	(0.317)
$(\text{Age})^2$	−0.005	−0.006	−0.003
	(0.005)	(0.005)	(0.004)
Job tenure	−0.335	−0.347	−0.316
	(0.091)	(0.088)	(0.097)
$(\text{Job tenure})^2$	0.005	0.005	0.004
	(0.003)	(0.002)	(0.002)
Married	−2.343	−2.456	−1.543
	(1.213)	(1.171)	(0.984)
Secondary education	−0.005	0.267	0.109
	(0.934)	(0.929)	(0.821)
Number of friends reported	−0.123		
	(0.461)		
Weekly hours spent with friends	−0.197		
	(0.219)		
Production skill ($\hat{\theta}_i$)		−6.736	
		(5.395)	
Extraversion			0.076
			(0.506)
Agreeableness			−0.218
			(0.581)
Conscientiousness			−2.354
			(0.596)
Neuroticism			−0.024
			(0.497)
Openness			−0.209
			(0.411)
Observations	98	98	98
Adjusted R^2	0.11	0.13	0.34

Notes: The dependent variable is the worker-specific estimate of willingness to pay to work with friends as a percent of the daily average wage. Bootstrapped standard errors with 300 replications are presented in parentheses.

that a worker's WTP and production skill are not particularly related. Column 3 includes all five personality skills and background characteristics. The results suggest a significant negative correlation between conscientiousness and WTP to work with friends.

V. Conclusion

In collaboration with the management, I designed and implemented a field experiment at a seafood-processing plant in Vietnam. The experiment randomly assigned workers to different work positions on a daily basis for five months. I find that a worker is less productive on days when a friend is assigned to work right next to her. However, I find no productivity effects on days when a friend is assigned to other

positions that are similarly observable but are farther from the worker. The finding arguably rules out potential mechanisms that can be caused solely from observing a peer's performance. Moreover, estimates from a structural approach suggest that most workers are willing to pay out of their wages to work next to friends. The overall evidence suggests that friends socialize with each other when they are in close proximity and derive nonwage benefits as a result.

My findings also suggest that the extent to which friends can impact a worker's productivity is heterogeneous with respect to his or her own conscientiousness, one of the Big Five personality factors. Workers with high conscientiousness are less influenced when friends are alongside and have lower WTP to work with friends. These results are robust to controlling for other characteristics of the worker, such as age, job tenure, and production skill. While it is beyond the scope of this study, it would be interesting to explore production complementarities between task type and personality.

It is worthwhile to mention that one should take into consideration the technology of the production and incentive structure when extrapolating these results to other organizational contexts. That is, social relationships in the workplace may not always be detrimental to job performance nor to a firm's profit. Studies find that the presence of social relationships can enhance performance when friends can provide incentives to speed up (Bandiera, Barankay, and Rasul 2010) or if friends can serve as a source of social pressure in work environments with incentives to free ride on one's peer (Bandiera, Barankay, and Rasul 2013; Amodio and Martinez-Carrasco 2018).

I also emphasize that there might be benefits to workplace socializations that have not been captured in this study. Socializing with peers may be a channel of information flows (Cowgill, Wolfers, and Zitzewitz 2009) or facilitate technology transfers in the workplace (Lavy and Sand 2015). Furthermore, interviews during the end line survey suggest that many consider working with a friend as a nonpecuniary benefit associated with their current job. Accordingly, as theoretically pointed out by Rosen (1987), this firm may have been enjoying lower levels of worker absences and job turnovers prior to this study by allowing workers to socially interact with their friends at work.

Appendix: Estimation of the Consumption Value of Working with Friends

This section presents details of the structural analysis of estimating workers' consumption values of working with friends. All tables and figures can be found in online Appendix Section 3.

A. *Conceptual Framework on the Selection of Working with Friends*

First, I model how the worker selects whether or not to work with friends using a binary choice framework. The goal is to build a model that allows estimation of each individual worker's consumption value of working with friends. Let y_i^f and y_i^{nf} denote worker i's utility maximizing productivity levels derived from equations (2) and (3), respectively. Suppose workers have heterogeneous intrinsic valuations

for working with friends: worker i derives a constant utility, s_i, from working with friends. I specify worker i's utility from working with, and without, friends using the following random utility model:

$$u_i^f = w_i^f - c_i^f + s_i + \varepsilon_i^f, \tag{A1}$$

$$u_i^{nf} = w_i^{nf} - c_i^{nf} + \varepsilon_i^{nf}, \tag{A2}$$

where

$$w_i^f = W\left(h + \rho \cdot y_i^f\right), \quad w_i^{nf} = W\left(h + \rho \cdot y_i^{nf}\right), \tag{A3}$$

$$c_i^f = C\left(y_i^f, \theta, N, f\right), \quad c_i^{nf} = C\left(y_i^{nf}, \theta, N, nf\right),$$

and ε_i^f and ε_i^{nf} are mean-zero stochastic error terms. Fixed hourly wage and piece rate wage are each denoted by h and ρ, respectively. Denote F_i as the indicator variable equal to one if worker i is working with a friend, and zero otherwise. Then worker i chooses the presence of friends according to

$$F_i = \begin{cases} 1 & \text{if } u_i^f > u_i^{nf} \\ 0 & \text{otherwise.} \end{cases} \tag{A4}$$

An implication of the theory of compensating wage differentials is that workers are willing to forgo wage in exchange of desirable work attributes that are nonpecuniary and consumed as part of the work (Rosen 1987). In the current context, the attribute of interest is working with friends. Wage is a function of individual productivity. If working with friends has a negative impact on productivity then working with friends entails a monetary cost in the amount of the forgone potential wage. Yet, if workers consider working with friends as a desirable attribute, then we would observe workers choosing to work with friends even in the presence of negative impacts on productivity and, therefore, lower earnings.[25]

B. *Model Assumptions and Estimation Strategy*

For estimation, I make the following model assumptions. Since effort is not directly observable, I substitute effort with productivity, measured as kilograms of fish processed per hour. Assume that the wage benefit function is of the following CRRA type:

$$W(y) = \frac{\left(h + \rho \cdot y\right)^{1-\delta}}{1-\delta}, \tag{A5}$$

where h is the fixed wage (per hour), ρ is the piece rate (per kilogram), and y is productivity (kilograms per hour). I set δ to $1/2$. A sensitivity analysis, which is

[25] This model implicitly assumes that workers are knowledgeable about their utility differences between the two states and that they are rationally deciding whether or not to work with friends. In fact, either of these assumptions may fail. Unfortunately, I do not have sufficient data to independently test these assumptions.

available from the author upon request, shows that the result is robust to a range of values for $\delta < 1$. Cost function is a quadratic function of productivity:

$$C(y,\theta,f) = \begin{cases} \frac{1}{2}\theta^{f}y^{2} & \text{if friend is present alongside the worker} \\ \frac{1}{2}\theta^{nf}y^{2} & \text{otherwise} \end{cases}, \tag{A6}$$

where θ^{f} and θ^{nf} are cost of effort parameters dependent on whether or not a friend is present nearby, respectively. I substitute θ^{f} with the inverse of the estimate on the worker fixed effect when working alongside friends, $1/\hat{\theta}_i^{H}$, and θ^{nf} with the inverse of the estimate on the worker fixed effect when working without friends, $1/\hat{\theta}_i$. This way the cost of effort parameters are interpreted as the reciprocals of the worker's production skill when working alongside friends and when working without friends, respectively.

I use a random utility model assuming that error terms, $(\varepsilon_i^{f}, \varepsilon_i^{nf})$, are distributed i.i.d. according to a type-1 extreme value distribution. Then, from equations (A1)–(A4), I obtain the probability of worker i working alongside a friend as follows:

$$\Pr(F_i = 1) = \Lambda(s_i - x_i), \tag{A7}$$

where Λ is the CDF of the logistic distribution and x_i is the difference in wage and effort costs between the two states $\left(\left(w_i^{nf} - c_i^{nf}\right) - \left(w_i^{f} - c_i^{f}\right)\right)$. The parameter of interest is s_i, which is worker i's consumption value of working with friends. The right hand side of equation (A7) indicates a worker's preference based on the cost and benefit she incurs. Identification is based on the difference between the hypothetical probability of working alongside friends, drawn from the utility difference (x_i), and the actual observed probability during the experiment period $(\Pr(F_i = 1))$. The maximum likelihood estimator for s_i in equation (A7) is obtained in explicit form as

$$s_i = x_i + \text{logit}\left(\frac{1}{T}\sum_{t=1}^{T}\mathbf{1}_{\{F_{it}=1\}}\right), \tag{A8}$$

where $\mathbf{1}_{\{F_{it}=1\}}$ is an indicator variable equal to one if on day t worker i has a friend at high proximity, and zero otherwise.[26]

Calculating s_i in equation (A8) requires knowledge on x_i, and $F_{i1}, \ldots, F_{iT}$. I use individual-worker data from the experiment period to derive estimates on x_is.[27] For data on the probability of working alongside friends, $F_{i1}, \ldots, F_{iT}$, I use

[26] The proof is provided in online Appendix Section 4.

[27] Specifically, since x_i is unobservable, I approximate x_i with $\hat{x}_i$, which is the difference in mean net utility, excluding the utility value of working with friends, between when working with friends and when working without friends at high proximity. That is,

$$\hat{x}_i = \frac{1}{T_{nf}}\sum_{t=1}^{T_{nf}}\left\{2\left(h + \rho \cdot y_{it}\right)^{\frac{1}{2}} - \frac{1}{2}\theta_i^{nf}\left(y_{it}\right)^{2}\right\} - \frac{1}{T_f}\sum_{k=1}^{T_f}\left\{2\left(h + \rho \cdot y_{ik}\right)^{\frac{1}{2}} - \frac{1}{2}\theta_i^{f}\left(y_{ik}\right)^{2}\right\}, \tag{A9}$$

where $t = 1, \ldots, T_{nf}$ denote days without friends at high proximity and $k = 1, \ldots, T_f$ denote days with friends at high proximity.

worker-position records from the preexperiment period. However, because the number of positions in the processing room is fixed, this may have imposed a constraint on the worker's choice set of available positions. For instance, a worker may have wanted to work alongside a friend, but in case there is no empty position, she may not have been able to. Accordingly, I adjust a worker's observed probability by the difference between 0.5, which is the median of the logistic distribution, and the predicted probability of working alongside a friend assuming that positions were randomized during this period.[28] The idea is to use each worker's predicted probability based on randomization and the number of friends present in the room as the benchmark value (which is what would be the observed probability if a worker were to be indifferent) instead of using the unconditional median (0.5).

Online Appendix Table 3-3 provides summary statistics on the unadjusted observed probability of working with at least one friend at various levels of proximity during the preexperiment period. On average, workers are working next to at least one friend in high proximity half of the time (column 1). I find significantly large differences between observed and randomized probabilities, obtained from 500 simulations of worker positions assuming random assignment (column 2). Online Appendix Figure 3-2 plots cumulative distribution functions of both observed and predicted probabilities of the presence of at least one friend at high proximity in the preexperiment period. The cumulative distribution function obtained from observed data lies largely to the right of the cumulative distribution function generated by simulations of random worker positions.[29] Overall, evidence suggests that workers had a tendency to work with friends in high proximity—that is, to work alongside each other.

C. *Estimates of Workers' Consumption Values of Working with Friends*

Online Appendix Figure 3-3 presents the empirical cumulative distribution function of estimates of workers' consumption values ($\hat{s}_i$) of working next to friends. Not all workers have positive estimates: 13 workers negatively value working with friends. These workers are less likely to work with their friends than what is predicted under random assignment even though they are found to be more productive when working alongside friends relative to when no friend is alongside. I test robustness of these estimates with regard to how friendship is defined. Currently, I define two workers as friends if either one of them reported the other as a friend in the baseline survey. While 55 percent of the reported friendships were mutually reported, 45 percent were unilateral reports. Including unilaterally reported friendships may lead to an overestimation of a worker's value of working with friends if only the respondent worker enjoys the presence of the friend she reported in the survey while the reported friend does not. To be conservative, I restrict the friendship sample to mutually reported friendships, excluding all unilateral reports, and

[28] To derive the predicted probability, I run 500 simulations of randomly assigning workers to positions for all workdays in the preexperiment period. I exclude days on which there was no friend present in the room.

[29] A Kolmogorov-Smirnov test of equality significantly rejects at the 1 percent level that the two distributions are equal.

repeat the estimation strategy presented in the previous section. Online Appendix Figure 3-4 presents the empirical CDF of workers' consumption values using only mutually reported friendships. The Kolmogorov-Smirnov equality of distribution test fails to reject that the unrestricted (all friendships) and the restricted (mutual friendships) distributions are equal (p-value $= 0.994$). This suggests that the estimates on workers' consumption values to work alongside friends are robust to the definition of friendship.

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