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Looking After Number Two? Competition, Cooperation and Workplace Interaction

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ABSTRACT

Looking After Number Two? Competition, Cooperation and Workplace Interaction*

We build a model of worker interdependence in which two workers can either compete or cooperate and compare performance under either scenario to that of a single worker working in isolation. We show that whilst competition unequivocally reduces performance, cooperation may raise or lower performance. Employing a unique data set in which workgroups are comprised of either one or two workers, we are able to test explicitly for the presence of cooperation. We find empirical support for cooperative behavior.

JEL Classification: J33, J41, J54

Keywords: absence, worker interdependency

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1. Introduction

Economists traditionally modeled human behavior in terms of individual constrained maximization, saying relatively little about the effect of relationships between family, friends, neighbors and work colleagues. Such neglect perhaps reflected not an ignorance of the importance of such interactions, but rather an awareness of how difficult it is to model theoretically, and measure empirically, such phenomena. This reticence has dissipated in recent years with a flurry of work emerging on the relationship between social interaction and phenomena such as crime [Glaeeser et al. (1996)], educational choices [Sacerdote (2001, Lalive and Catteneo (2009)], school drop-out behaviour [Evans et al. (1992). labour productivity [Mas and Moretti (2009)], labour supply [Grodner and Kniesner (2006)], unemployment [Topa (2001)], disability behaviour [Rege et al. (2009)] and retirement [Duflu and Saez (2003)]. We add to this literature by modeling and measuring the relationship between a very precise workplace interaction and outcome.

Very few employees work in complete isolation and so one would expect employee-interaction to be important for many workplace decisions and, therefore by extension, the labour market equilibria that relate to those decisions. A prime example is absenteeism.

There is a small, but growing, literature examining worker-interaction and absenteeism [see, for example, Ichino and Maggi. (2000), Skåtun and Skåtun (2004). Heywood and Jirjahn (2004). Barmby and Larguem (2009). Hesselius *et al*. (2010). Dale-Olsen et al. (2011)]. Most of this literature has, of necessity, tried to interpret data where the margin of interaction between workers is to a large extent unknown. In the application we examine here, that of optometrist services, the margin is very clearly defined because of the nature in which the service is organized. Each firm (i.e. workplace) is staffed by either one or two optometrists. In the latter case the two workers are substitutes in production - the absence of one imposes a utility cost on the other who will be expected to take on additional work for no additional pay. By identifying such costs, we are able to derive clear comparisons as regards absence behavior within single- and two-worker firms.

We explore the possible role of this worker interdependency in the generation of workplace absenteeism within an extended Barmby *et al*. (1994) - hereafter BST - framework. BST focus on an atomistic worker whose health is represented by a continuous random variable, δ, and who absents if realized health is above some threshold level, $\tilde{\delta}$, determined by wages, sick pay and contracted working hours. In our extension, firms comprise two interdependent workers who either cooperate or compete with one another by maximising joint or individual utility accordingly. We show that sickness absence decisions are strategic complements - the more likely worker 1 is to absent, the more likely will worker 2 call in sick since the latter's expected utility is increasing in worker 2's health threshold (i.e. with the likelihood that workers 2 does not absent).

Within this extended framework, we derive the equilibrium absence rates for three cases of interest - single-worker firm; two-worker non-cooperative firm; two-worker cooperative firm - and show that, relative to the single-worker optimum, non-cooperation implies a lower health threshold whilst cooperation yields either a higher or lower health threshold. Intuitively, if workers do not care about each other and choose to maximize their own individual utility rather than the joint utility of themselves and their co-worker, then there will be inefficiently high absence due to the effort externality an absenting worker imposes on his non-absenting colleague. Cooperation internalises this externality and permits an efficient level of absence to be reached.

Our empirical analysis suggests that absence is lower when employees work in pairs rather than in isolation, a result which lends support for the cooperative equilibrium outcome in our theoretical model.

The paper is set out as follows: Section 2 recapitulates the original BST contribution, which Section 3 then extends to a two-worker environment. Our empirical results are set out in Section 4 and final comments are collected in Section 5.

2. Single Worker

We follow BST assuming that individual workers make utility maximizing absence decisions conditional on a realization of their state of health. BST models individuals as homogenous risk neutral utility maximisers endowed with a stock of time, T, which they allocate between work and leisure. Utility is an increasing function of income and leisure, with individuals attaching a weight to each depending upon some parameter, δ, representing their general level of health. δ is increasing in sickness and randomly distributed over the interval $\left[0,1\right]$ with individuals valuing non-market (i.e. leisure) time more as $\delta \to 1$. Thus:

$$u = \left(1 - \delta\right)x + \delta l \qquad (1)$$

where x (l) denotes income (leisure). Prospective workers sign enforceable employment contracts that specify a particular level of remuneration, w, in return for a particular supply of effort. Considerations as to the intensity or quality of effort are ignored and for simplicity productivity is construed by mere attendance. After the contract is signed, but before production commences, each worker realises his state of health and makes an *ex post* utility maximising decision as regards absence. This decision is derived from a discrete choice with workers comparing between the two alternative of absence, a, or non-absence, na, with the utility payoffs using the utility function in (1) given by:

$$u^{na} = \left(1-\delta\right) w + \delta\left(T-h\right) \tag{2}$$

$$u^{a} = \left(1-\delta\right) s + \delta T \tag{3}$$

where s denotes the (exogenous) level of sick pay and h denotes contractual hours. It is apparent that the relative magnitude of these payoffs depends on δ with the worker being indifferent between absence and non-absence at a critical level of health $\delta = \tilde{\delta}$ such that:

$$u^{na}\left(\tilde{\delta}\right) = \left(1-\tilde{\delta}\right) w + \tilde{\delta}\left(T-h\right) = \left(1-\tilde{\delta}\right) s + \tilde{\delta} T = u^{a}\left(\tilde{\delta}\right) \tag{4}$$

which implies:

$$\tilde{\delta} = \frac{w-s}{w-s+h} \tag{5}$$

$\tilde{\delta}$ may be interpreted as the worker's reservation, or threshold, level of sickness - the level of sickness at which the worker is indifferent between absence and non-absence - and thus defines a utility maximizing decision rule. To be sure, the worker will choose absence for all $\delta > \tilde{\delta}$ and non-absence otherwise. The situation is illustrate graphically in Figure 1 following.[1]

[1] Note that the above decision rule may be derived equivalently from expected utility maximization - see Appendix A1.

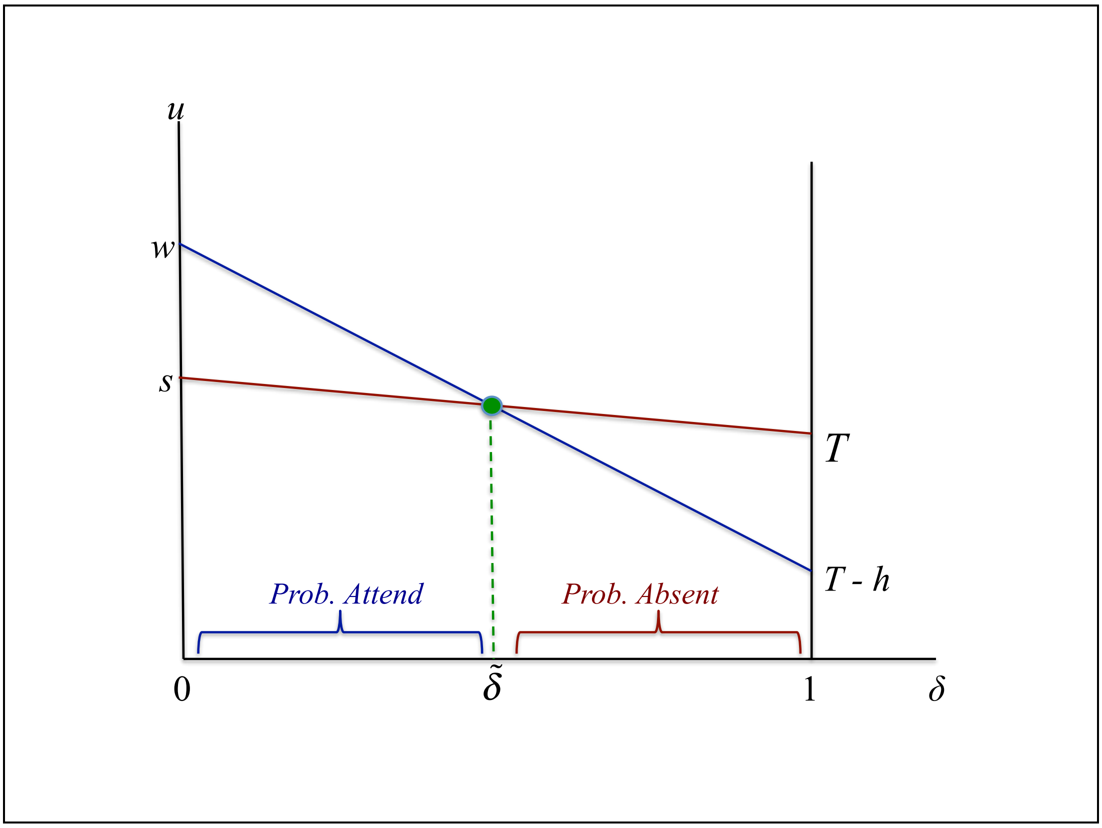

Figure 1: Single Worker - Reservation Level of Sickness

3. Two-Workers

3.1 Non-Cooperative Equilibrium

Our point of departure is to consider the situation where production in the firm is undertaken by two workers, i = 1, 2, who behave in the way just described. Their work, however, is interdependent in the sense that if one of them is absent then this will impose a cost on the other worker, possibly in terms of extra effort, which is equivalent to supplying additional hours $e \in (0,h]$. Thus, the expected utilities of not absenting and absenting are:

$$\mathbf{E}\{u_1^{na}\} = (1-\delta_1)w + \delta_1\left[T - h - (1-\tilde{\delta}_2)e\right] \tag{6}$$

$$\mathbf{E}\{u_1^{a}\} = (1-\delta_1)s + \delta_1 T \tag{7}$$

Each worker will now be comparing uncertain options when computing their reservation sickness level, thereby yielding two reaction functions:

$$
\begin{aligned}
&u_1^{na}\left(\tilde{\delta}_1\right)=\left(1-\tilde{\delta}_1\right)w+\tilde{\delta}_1\left[T-h-\left(1-\tilde{\delta}_2\right)e\right]=\left(1-\tilde{\delta}_1\right)s+\tilde{\delta}_1 T=u_1^a\left(\tilde{\delta}_1\right)\\
&\Rightarrow\\
&\tilde{\delta}_1=\frac{w-s}{w-s+h+\left(1-\tilde{\delta}_2\right)e}\equiv R_1\left(\tilde{\delta}_2\right)
\end{aligned}
\tag{8}
$$

And similarly:

$$
\begin{aligned}
&u_2^{na}\left(\tilde{\delta}_2\right)=\left(1-\tilde{\delta}_2\right)w+\tilde{\delta}_1\left[T-h-\left(1-\tilde{\delta}_1\right)e\right]=\left(1-\tilde{\delta}_2\right)s+\delta_2 T=u_2^a\left(\tilde{\delta}_2\right)\\
&\Rightarrow\\
&\tilde{\delta}_2=\frac{w-s}{w-s+h+\left(1-\tilde{\delta}_1\right)e}\equiv R_2\left(\tilde{\delta}_1\right)
\end{aligned}
\tag{9}
$$

where $R_i\left(\tilde{\delta}_j\right)$ denotes worker *i*'s reaction function – i.e. worker *i*'s optimal reservation level of sickness as a function of worker *j*'s reservation level of sickness. It is apparent that the two reaction functions are upward sloping implying that the two worker's reservation sickness levels are strategic complements for one another. To be sure:

$$
\frac{\partial R_i\left(\tilde{\delta}_j\right)}{\partial\tilde{\delta}_j}=\frac{\left(w-s\right)e}{\left[w-s+h+\left(1-\tilde{\delta}_j\right)e\right]^2}>0
\tag{10}
$$

And:

$$
\lim_{\delta_j\to 0}R_i\left(\tilde{\delta}_j\right)=R_i\left(0\right)=\frac{w-s}{w-s+h+e}\equiv\tilde{\delta}_i^{\min}
\tag{11}
$$

$$
\lim_{\delta_j\to 1}R_i\left(\tilde{\delta}_j\right)=R_i\left(1\right)=\frac{w-s}{w-s+h}\equiv\tilde{\delta}_i^{\max}
\tag{12}
$$

Such that:

$$\Delta R_i \equiv R_i(1) - R_i(0) \Leftrightarrow \tilde{\delta}_i^{\max} - \tilde{\delta}_i^{\min} \equiv \Delta\tilde{\delta}_i = \frac{(w-s)e}{(w-s+h)(w-s+h+e)} > 0 \tag{13}$$

The reaction functions and associated Nash equilibrium, $\tilde{\delta}^n = \left(\tilde{\delta}_1^n, \tilde{\delta}_2^n\right)$, are illustrated in Figure 2 following:

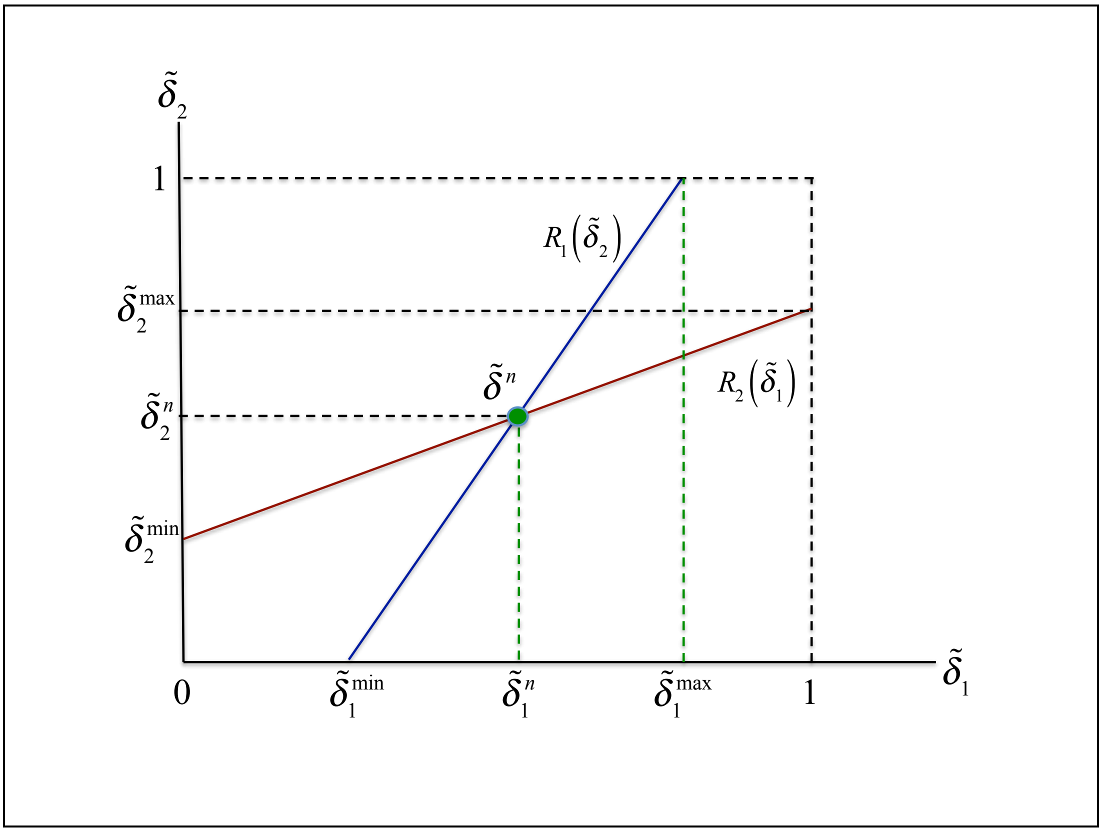

Figure 2: Two-Workers – Nash Equilibrium Reservation Sickness

Figure 2 graphs the two workers' reaction functions as upward sloping in $\left(\tilde{\delta}_2, \tilde{\delta}_1\right)$ space, illustrating the idea that each worker's optimal reservation level of sickness is an increasing function of the his co-worker's reservation level of sickness. Intuitively, the more likely it is that one worker will absent (i.e. the lower is $\tilde{\delta}_j$) then the more likely it is that the other worker will also absent (i.e. the lower is $\tilde{\delta}_i$) given the potentially higher costs of attendance.

The Nash equilibrium in the two-worker situation is given by the intersection of the two reaction functions at $\tilde{\delta}_1^n = \tilde{\delta}_2^n = \tilde{\delta}^n$ which implies:

$$\tilde{\delta}^n = \frac{(w-s+h+e) \pm \sqrt{(w-s+h+e)^2 - 4(w-s)e}}{2e} \tag{14}$$

We can compare the two-worker situation to the single worker equilibrium most readily by focusing directly on the reactions functions set out in equations (8) and (9). Taking worker 1, for example, and assuming perfect attendance by worker 2 yields the single-worker reservation level of sickness:

$$\lim_{\delta_2 \to 1} R_1(\tilde{\delta}_2) \equiv \tilde{\delta}_1^{\max} = \frac{w-s}{w-s+h} = \tilde{\delta} \tag{15}$$

It is apparent that the Nash Equilibrium is not Pareto efficient and that a collusive agreement between the workers would be mutually beneficial. To see this, we first derive in Appendix A3 the expected utility of worker 1 within the two-worker setting:

$$\begin{aligned} &\mathbf{E}\{u_1\} = \int_0^1 u_1 f(\delta_1)\, d\delta \\ &\Rightarrow \\ &\mathbf{E}\{u_1\} = \tilde{\delta}_1(w-s) - \frac{\tilde{\delta}_1^2}{2}\left[w-s+h+(1-\tilde{\delta}_2)e\right] + \frac{1}{2}(T+s) \end{aligned} \tag{16}$$

Maximizing worker 1's expected utility with respect to worker 2's reservation level of sickness yields:

$$\frac{\partial \mathbf{E}\{u_1\}}{\partial \tilde{\delta}_2} = \tfrac{1}{2}\tilde{\delta}_1^2 e > 0 \tag{17}$$

Thus worker 1's expected utility is an increasing function of worker 2's reservation level of sickness; intuitively, worker 1's expected utility increases with the probability of worker two attending work since this reduces worker 1's expected effort cost. This implies that worker 1's utility increase as he moves up his reaction function in Figure 2, implying that his indifference curves are 'u-shaped'. To be sure, totally differentiating (16) with respect to $\tilde{\delta}_1$ and $\tilde{\delta}_2$ and setting the resulting expression to zero implies:

$$
\begin{aligned}
&d\mathbf{E}\{u_1\} = \frac{\partial \mathbf{E}\{u_1\}}{\partial \tilde{\delta}_1} d\tilde{\delta}_1 + \frac{\partial \mathbf{E}\{u_1\}}{\partial \tilde{\delta}_2} d\tilde{\delta}_2 = 0 \\
&\Rightarrow \\
&d\mathbf{E}\{u_1\} = \left\{(w-s) - \tilde{\delta}_1\left[w-s+h+\left(1-\tilde{\delta}_2\right)e\right]\right\} d\tilde{\delta}_1 + \left\{\tfrac{1}{2}\tilde{\delta}_1^2 e\right\} d\tilde{\delta}_2 = 0
\end{aligned}
\tag{18}
$$

Worker 1's indifference curves are thus given by:

$$
\left.\frac{d\tilde{\delta}_2}{d\tilde{\delta}_1}\right|_{d\mathbf{E}\{u_1\}=0} = \frac{2\left\{\tilde{\delta}_1\left[w-s+h+\left(1-\tilde{\delta}_2\right)e\right]-(w-s)\right\}}{\tilde{\delta}_1^2 e} \tag{19}
$$

Recall from (8) that along worker 1's reaction function we have:

$$
\tilde{\delta}_1\left[w-s+h+\left(1-\tilde{\delta}_2\right)e\right] = w-s \tag{20}
$$

such that:

$$
\left.\frac{d\tilde{\delta}_2}{d\tilde{\delta}_1}\right|_{d\mathbf{E}\{u_1\}=0} = \frac{2\left\{\tilde{\delta}_1\left[w-s+h+\left(1-\tilde{\delta}_2\right)e\right]-(w-s)\right\}}{\tilde{\delta}_1^2 e} = 0 \tag{21}
$$

Worker 1's indifference curves are therefore horizontal as they cross $R_1\left(\tilde{\delta}_2\right)$. Increasing $\tilde{\delta}_1$ beyond the level defined by $R_1\left(\tilde{\delta}_2\right)$ whilst holding $\tilde{\delta}_2$ constant yields:

$$\left.\frac{d^2\tilde{\delta}_2}{d\tilde{\delta}_1^2}\right|_{dE\{u_1\}=0} = \frac{2\left[w-s+h+\left(1-\tilde{\delta}_2\right)e\right]\tilde{\delta}_1^2 e - 2\tilde{\delta}_1^2 e\left\{2\left[w-s+h+\left(1-\tilde{\delta}_2\right)e\right]-\left(w-s\right)\right\}}{\tilde{\delta}_1^4 e^2}$$

$$\Rightarrow \tag{22}$$

$$\left.\frac{d^2\tilde{\delta}_2}{d\tilde{\delta}_1^2}\right|_{dE\{u_1\}=0} = \frac{2\left[w-s+h+\left(1-\tilde{\delta}_2\right)e\right]}{\tilde{\delta}_1^2 e} > 0$$

Thus, worker 1's indifference curves are positively (negatively) sloped to the right (left) of $R_1\left(\tilde{\delta}_2\right)$. Similar arguments apply to worker 2 such that the Nash equilibrium implies an intersection of the two workers' indifference curves - see Figure 3 following:

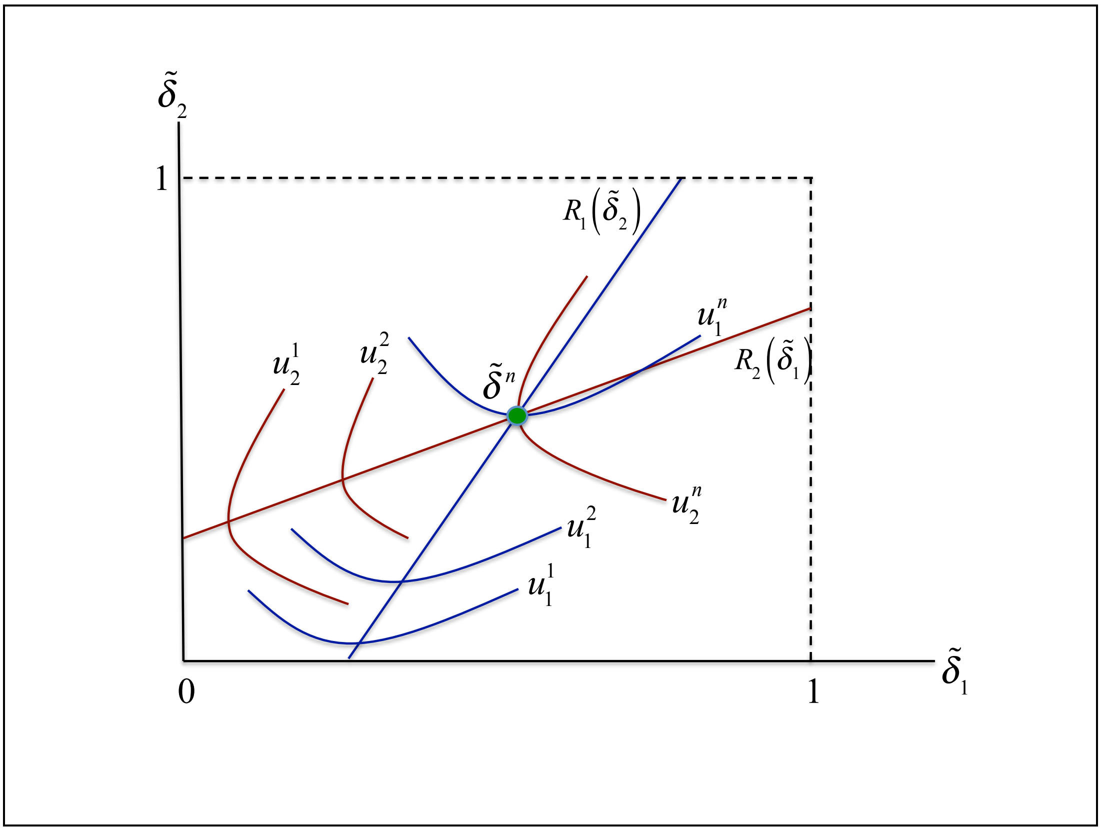

Figure 3: Pareto Inefficiency of Nash Equilibrium

The Nash equilibrium is Pareto inefficient and a mutually preferable, cooperative outcome, $\tilde{\delta}^m$, is possible to the northeast of $\tilde{\delta}^n$ within $\left(u_2^n, u_1^n\right)$. The cooperative solution, $\tilde{\delta}^m$, will lay somewhere along a contract curve mapped out by the tangencies of the two workers' indifference curves above $\left(u_2^n, u_1^n\right)$, the precise location depending upon the relative bargaining powers of the two workers. One possible solution is illustrated in Figure 4 following:

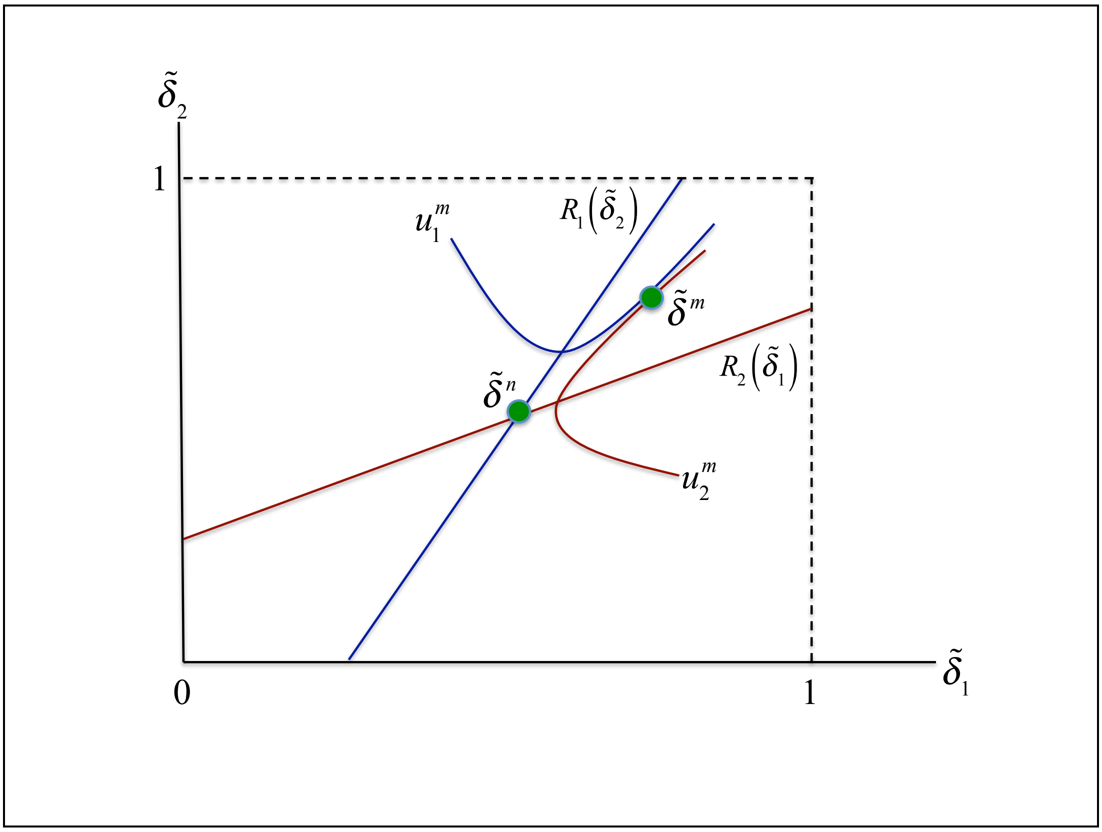

Figure 4: Cooperative Solution

3.2 Cooperative Equilibrium

We derive the cooperative equilibrium formally by first obtaining the joint expected utility of the two workers. It is shown in Appendix A2 that this is given by:

$$\mathbf{E}\{u\} = \int_0^1\int_0^1 (u_1 + u_2) f(\delta_1, \delta_2)\, d\delta_1 d\delta_2$$

$$\Rightarrow \tag{23}$$

$$\mathbf{E}\{u\} = \left(\tilde{\delta}_1 + \tilde{\delta}_2\right)(w - s) - \tfrac{1}{2}\left(\tilde{\delta}_1^2 + \tilde{\delta}_2^2\right)(w - s + h) - \tfrac{1}{2}\left[\tilde{\delta}_1^2\left(1 - \tilde{\delta}_2\right) + \tilde{\delta}_2^2\left(1 - \tilde{\delta}_1\right)\right]e + T + s$$

Maximizing expected joint utility as given by (23) with respect to worker 1's reservation level of sickness yields:

$$\frac{\partial \mathbf{E}\{u\}}{\partial \delta_1} = (w-s) - \tilde{\delta}_1 \left[w-s+h+\left(1-\tilde{\delta}_2\right)e \right] + \frac{\tilde{\delta}_2^2}{2} e = 0 \tag{24}$$

Solving for $\tilde{\delta}_1$ yields:

$$\tilde{\delta}_1 = \frac{w-s+\frac{1}{2}\tilde{\delta}_2^2 e}{w-s+h+\left(1-\tilde{\delta}_2\right)e} \tag{25}$$

And by symmetry, maximizing expected joint utility with respect to worker 2's reservation level of sickness yields:

$$\tilde{\delta}_2 = \frac{w-s+\frac{1}{2}\tilde{\delta}_1^2 e}{w-s+h+\left(1-\tilde{\delta}_1\right)e} \tag{26}$$

The solution to (25) and (26) yields the joint utility maximizing critical levels of sickness $\tilde{\delta}^m = \left(\tilde{\delta}_1^m, \tilde{\delta}_2^m\right)$. Given the symmetry of the two workers, it must be the case that $\tilde{\delta}_1^m = \tilde{\delta}_2^m = \tilde{\delta}^m$ such that:

$$\begin{aligned} &\tilde{\delta}^m = \frac{w-s+\frac{1}{2}\left(\tilde{\delta}^m\right)^2 e}{w-s+h+\left(1-\tilde{\delta}^m\right)e} \\ &\Rightarrow \\ &\tilde{\delta}^m = \frac{(w-s+h+e) \pm \frac{1}{2}\sqrt{4(w-s+h+e)^2 - 24(w-s)e}}{3e} \end{aligned} \tag{27}$$

Whilst it is difficult to compare the Nash and cooperative solutions directly from (14) and (27), it is apparent from an examination of the Nash reaction functions (8) and (9) and the cooperative equations (25) and (26) that the cooperative solution must entail a higher equilibrium critical level of sickness for the two workers. To see this, we first define equations (25) and (26) as:

$$\tilde{\delta}_1 = \frac{w - s + \frac{1}{2}\tilde{\delta}_2^2 e}{w - s + h + \left(1 - \tilde{\delta}_2\right)e} \equiv C_1\left(\tilde{\delta}_2\right) \tag{28}$$

$$\tilde{\delta}_2 = \frac{w - s + \frac{1}{2}\tilde{\delta}_1^2 e}{w - s + h + \left(1 - \tilde{\delta}_1\right)e} \equiv C_2\left(\tilde{\delta}_1\right) \tag{29}$$

It is apparent that, in terms of Figure 2, $C_1\left(\tilde{\delta}_2\right)$ is upward sloping, coincides with $R_1\left(\tilde{\delta}_2\right)$ at $\tilde{\delta}_2 = 0$ and lays to the right of $R_1\left(\tilde{\delta}_2\right)$ at all $\tilde{\delta}_2 \in \left(0,1\right]$. To be sure:

$$\frac{\partial C_1\left(\tilde{\delta}_2\right)}{\partial \tilde{\delta}_2} = \frac{\left\{\tilde{\delta}_2\left[w - s + h + \left(1 - \tilde{\delta}_2\right)e\right] + \left(w - s\right)\right\}e}{\left[w - s + h + \left(1 - \tilde{\delta}_2\right)e\right]^2} > 0 \tag{30}$$

And:

$$\lim_{\tilde{\delta}_2 \to 0} C_1\left(\tilde{\delta}_2\right) = C_1\left(0\right) = \frac{w - s}{w - s + h + e} \equiv \tilde{\delta}_1^{\min} = R_1\left(0\right) = \lim_{\tilde{\delta}_2 \to 0} R_1\left(\tilde{\delta}_2\right) \tag{31}$$

$$\lim_{\tilde{\delta}_2 \to 1} C_1\left(\tilde{\delta}_2\right) = C_1\left(1\right) = \frac{w - s + \frac{1}{2}e}{w - s + h} > \frac{w - s}{w - s + h} \equiv \tilde{\delta}_1^{\max} = R_1\left(1\right) = \lim_{\tilde{\delta}_2 \to 1} R_1\left(\tilde{\delta}_2\right) \tag{32}$$

Analogous arguments apply to the relationship between $C_2\left(\tilde{\delta}_1\right)$ and $R_2\left(\tilde{\delta}_1\right)$ such that it must be the case that $\tilde{\delta}^m > \tilde{\delta}^n$.

Comparing the reaction functions $R_1\left(\tilde{\delta}_2\right)$ and $R_2\left(\tilde{\delta}_1\right)$ with $\tilde{\delta}$, the single worker's reservation level of sickness as defined by equation (5), it is apparent that $\tilde{\delta}_1^{\max} = R_1\left(1\right) = \tilde{\delta}$

and $\tilde{\delta}_2^{\max} = R_2(1) = \tilde{\delta}$, which implies that the crossing point of $R_1(\tilde{\delta}_2)$ and $R_2(\tilde{\delta}_1)$ must lay to the southwest of $\tilde{\delta}$ such that $\tilde{\delta}^n < \tilde{\delta}$. Therefore, as compared to the single worker situation, two workers who do not act cooperatively when working together will each have a lower reservation level of sickness and thus a higher level of absence. We also know that the cooperative outcome implies a higher reservation level of sickness as compared to the non-cooperation equilibrium such that $\tilde{\delta}^m > \tilde{\delta}^n$. What we do not know is how $\tilde{\delta}^m$ compares to $\tilde{\delta}$. Depending on the value of effort, $\tilde{\delta}^m$ may be located to the northeast of $\tilde{\delta}$, as per Figure 5 following, or to the southwest of $\tilde{\delta}$ between $\tilde{\delta}^n$ as per Figure 6 following:

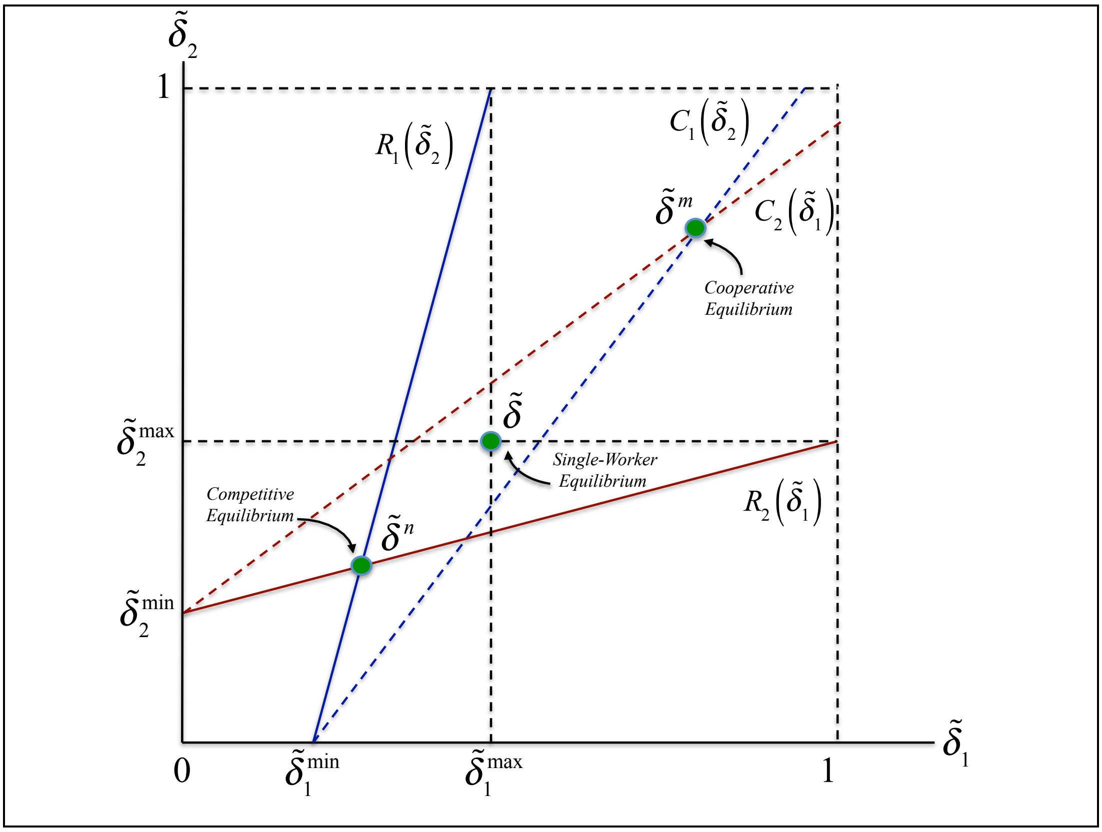

Figure 5: Cooperative and Nash Solutions (i)

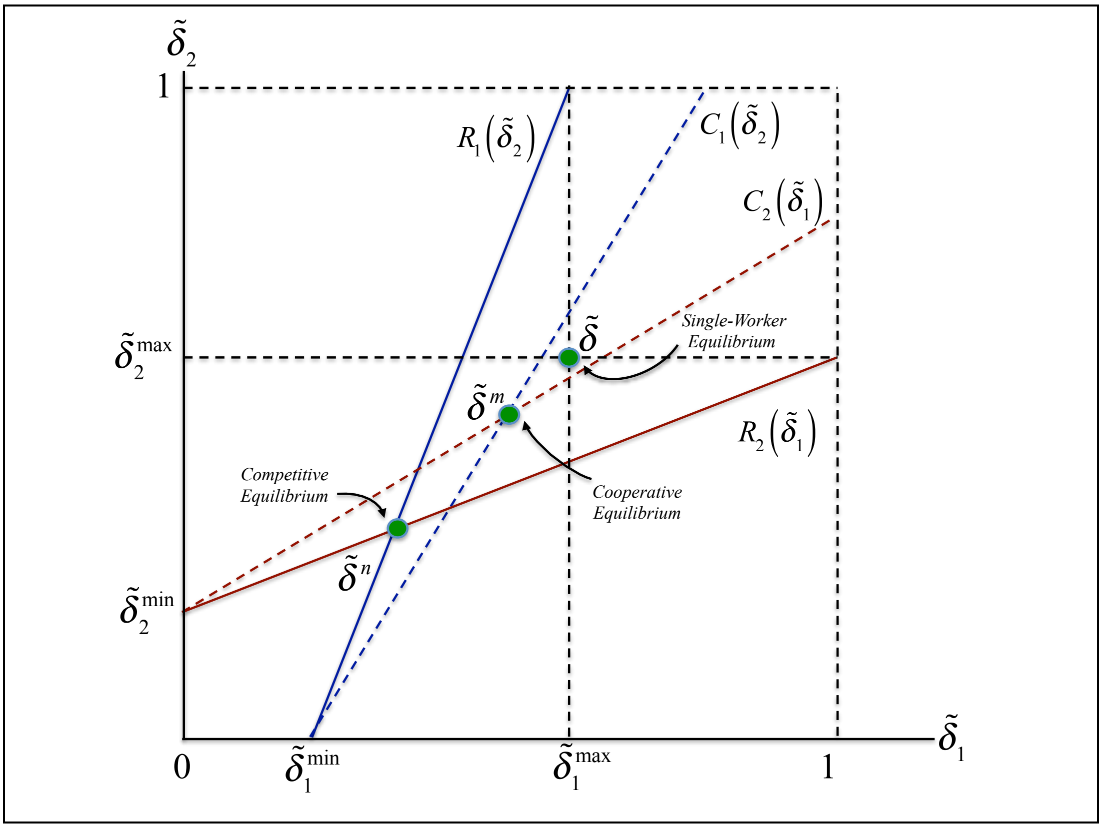

Figure 6: Cooperative and Nash Solutions (ii)

It is apparent from equations (8)-(9) and (28)-(29) that the larger is *e*, the additional effort cost from co-worker absence, the further will $C_1(\tilde{\delta}_2)$ $[C_2(\tilde{\delta}_1)]$ lay to the right of [above] $R_1(\tilde{\delta}_2)$ $[R_2(\tilde{\delta}_1)]$, the further to the northeast will the cooperative functions intersect and the more likely will it be the case that $\tilde{\delta}^m > \tilde{\delta}$. Intuitively, the larger the potential gains from cooperation, the more likely will attendance rates within two-worker firms exceed those within single-worker firms.

4. Empirical Analysis

We test our theory by comparing the absence rates of workers who work either alone or in pairs. By examining the interaction between the latter, we are able to ascertain whether the evidence suggests a cooperative or competitive (i.e. Nash) equilibrium outcome. Empirically, if the level of absence is estimated to be lower in two-worker as compared to single-worker firms, then that should be interpreted as evidence of cooperation, since the critical level of sickness can only be higher in the former than the latter when workers act cooperatively. The opposite result would have an ambiguous interpretation, since it is possible under both the competitive and cooperative scenarios to have a lower reservation sickness level and therefore a higher level of absence. Symbolically, whilst we know that $\tilde{\delta} > \tilde{\delta}^n$ and $\tilde{\delta}^m > \tilde{\delta}^n$, we are unable to tie down the relationship between $\tilde{\delta}$ and $\tilde{\delta}^m$.

Our data comprise the daily absence records of sixty-five optometrists employed by a private ophthalmic optician company and who are allocated to one of its twenty-two practices operating in the northeast of Scotland over the period April 2005 - September 2008. The optometrists are professional service providers who examine eyes, prescribe spectacles or contact lenses, give advice on visual problems and detect any ocular disease or abnormality, referring the patient to a medical practitioner if necessary. Alongside them, there are dispensing opticians who meet with the patients after the eye examination with the optometrist and who provide advice on spectacles and related products. Finally, each practice has also a receptionist in charge of booking appointments and managing the cash register.

The data is of particular interest to our theoretical framework because we only observe optometrists working either on their own or in pairs. Specifically, practices that have one examination room (fifteen out of the twenty-two practices in the sample) always have only one optometrist for eye examinations (*single-testing*). In contrast, two optometrists may test together (*double-testing*) in the seven practices with two examination rooms.[2] We can therefore distinguish both when (i.e. on which day) and where (i.e. in which practice) examinations were undertaken by one or two optometrists. By comparing the daily absence

[2] Thus, whilst single-optometrist practices can only undertake single-testing, two-optometrists practice can undertake both single- and double-testing.

records between single-testing and double-testing practices, we are able to test whether workers are behaving competitively or cooperatively.

Double-testing optometrists are close substitutes in production since in the absence of one optometrist the other optometrist is expected under the terms of their employment contract to pick up, without additional pay, as many appointments as possible in order to minimise the cancelling and rescheduling of appointments. Therefore, double-testing implies a joint production process that fits well within the framework of our theoretical model.

Although the majority of optometrists are allocated to specific practices, there is some degree of mobility. Every month a rota schedule assigns optometrists to practices, the allocation being determined primarily by contractual negotiation and the geographical location of the optometrists. Thus, the process of the rota schedule can be considered to be exogenous.

The absence data are constructed using three different company records: (i) the absence records, (ii) the monthly rota schedules and (iii) the business records of the twenty-two practices. The business records contain daily information on which optometrists were examining at each practice, enabling us to identify cases where a replacement optometrist was sent to cover a colleague who was absent that day. Furthermore, we can derive daily information on whether: (i) the practice was undertaking *Single-Testing* or *Double-Testing*; (ii) the practice offered eye examination either in the morning or afternoon only (*Half-Day*). Finally, we are able also to identify the practice in which an optometrist spends the majority of their time (*Main Practice*).

Table 1 presents definitions and summary statistics of the main variables used in the analysis. The number of working days that optometrists missed over the sample period due to absence account for 1.3% of their total contracted days. Despite that fact that there is some flexibility in the allocation of optometrists across practices, optometrists spent three quarters of their working time in a particular practice. Double-testing occurred on approximately 19% of the working days covered by the sample whilst 5% of testing was undertaken on half-days (i.e. with eye examinations appointments only in the morning or afternoon). Finally, we calculate the average probability of a replacement worker being sent to a practice when the originally assigned optometrist is absent. This is estimated at practice level per year. On average, the expected replacement probability is 36.4%. A detailed discussion on how this probability is estimated is presented in Appendix A4:

Table 1: Variable List and Definitions

Variable	*Mean*	*Std. D*	*Definition*
Absence	0.013	0.112	1 *if optometrist absent today; 0: otherwise*
Lag Absence	0.013	0.112	1 *if optometrist absent yesterday; 0: otherwise*
Main Practice	0.748	0.434	1 *if optometrist's main practice; 0: otherwise*[1]
Half-Day	0.051	0.220	1 *if testing only in morning or afternoon today; 0: otherwise*
Double-Testing	0.188	0.391	1 *if two optometrists are assigned to the practice today; 0: otherwise*
Replacement Probability	0.364	0.391	*Expected replacement probability in current practice*

Note: 1. *Main Practice is defined annually as the practice in which the optometrist worked more than any other over the year.*

The estimated equation of interest is an absence model with a binary dependent variable. The key explanatory variable is *Double-Testing*, a dummy variable that reflects whether or not there are two optometrists that are assigned to perform the eye examinations in a practice that day. This is the main variable of interest in our analysis, since the sign and significance of the estimated coefficient will indicate whether optometrists, when working together, behave cooperatively to maximise joint expected utility, or independently with their individual expected utility solely in mind. A positive coefficient will have an ambiguous interpretation since $\tilde{\delta}^n < \tilde{\delta}$ and $\tilde{\delta}^n < \tilde{\delta}^m$ whilst $\tilde{\delta}^m$ exceed or fall short of $\tilde{\delta}$ depending upon the effort cost of absence. A negative coefficient, however, can only be interpreted as evidence that workers act cooperatively, since only the cooperative outcome is able to yield a reservation level of sickness in excess of the single-worker equilibrium.

Our estimator is a probit model with robust standard errors and our results are presented in Table 2. [3] The basic model specification (column 1) includes only *Double-Testing* and the predicted average probability of a replacement optometrist being sent to the practice if absent (*Replacement Probability*).[4] For robustness purposes we also consider alternative specifications that include: (i) the optometrist's absence the previous day (*Lag Absence*) in order to capture any state dependence effects (column 2); (ii) whether the optometrist is working at their main practice (*Main Practice*) and / or working only half a day (*Half-Day*) (column 3); (iii) the days of the week, in order to capture unobserved time preferences (column 4); and, (iv) the month of the year, for unobserved seasonal effects (column 5).

In all specifications considered, optometrists exhibit lower absence when working in teams of two (*Double-Testing*) as compared to when working alone (*Single-Testing*). The estimated marginal effects suggest that moving from single-testing to double-testing reduces the probability of absence by 0.002-0.004 percentage points. Whilst small in absolute terms, with an average absence rate of 1.3 percent and predicted probabilities of absence in the range 0.005-0.008, this implies a potential relative fall in the probability of absence of between 30-50 percent.

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[3] Given that our dataset is a long panel, consisting of a relatively small number of optometrists observed over a relatively long period of time, we also considered a fixed effects model as an alternative estimator. Fixed effects regression uses only information from changes within an individual (optometrist), so it excludes all individuals who were never absent from work (zero variation). We decided against the fixed effects model because it excluded almost half of the optometrists from our sample.

[4] As a robustness check, we also incorporated the observed replacement ratio into an alternative specification, restricting the sample to practices that had some level of absence during a particular year. The estimates overall remained the same and are available upon request.

Table 2: Regression Estimates - Probit

Dependent Variable: Absence = 1

	(1)			(2)			(3)			(4)			(5)		
	Coef.	*ME*	*SE*	*Coef.*	*ME*	*SE*	*Coef.*	*ME*	*SE*	*Coef.*	*ME*	*SE*	*Coef.*	*ME*	*SE*
Workplace Controls															
Double-Testing	-0.202***	-0.004	0.074	-0.175**	-0.002	0.084	-0.180**	-0.002	0.086	-0.167*	-0.002	0.087	-0.178**	-0.002	0.088
Replacement Probability	2.212***	0.051	0.145	1.688***	0.027	0.158	1.728***	0.026	0.164	1.740***	0.025	0.165	1.736***	0.025	0.165
Lag Absence	-	-	-	2.282***	0.382	0.089	2.305***	0.383	0.090	2.314***	0.380	0.092	2.299***	0.369	0.093
Main Practice	-	-	-	-	-	-	-0.037	-5.74^{e-4}	0.073	-0.025	-3.68^{e-4}	0.075	-0.030	-4.24^{e-4}	0.074
Half-Day	-	-	-	-	-	-	0.500***	0.014	0.106	0.536***	0.015	0.110	0.547***	0.015	0.111
Day Controls															
Tuesday	-	-	-	-	-	-	-	-	-	-0.221*	-0.003	0.117	-0.220*	-0.003	0.117
Wednesday	-	-	-	-	-	-	-	-	-	-0.264**	-0.003	0.117	-0.267**	-0.003	0.118
Thursday	-	-	-	-	-	-	-	-	-	-0.278**	-0.003	0.115	-0.274**	-0.003	0.116
Friday	-	-	-	-	-	-	-	-	-	-0.142	-0.002	0.110	-0.138	-0.002	0.110
Saturday	-	-	-	-	-	-	-	-	-	-0.395***	-0.004	0.119	-0.399***	-0.004	0.119
Sunday	-	-	-	-	-	-	-	-	-	-0.245	-0.003	0.285	-0.251	-0.003	0.284
Month Controls															
February	-	-	-	-	-	-	-	-	-	-	-	-	-0.101	-0.001	0.154
March	-	-	-	-	-	-	-	-	-	-	-	-	-0.163	-0.002	0.153
April	-	-	-	-	-	-	-	-	-	-	-	-	-0.386**	-0.004	0.167
May	-	-	-	-	-	-	-	-	-	-	-	-	-0.109	-0.001	0.135
June	-	-	-	-	-	-	-	-	-	-	-	-	-0.168	-0.002	0.145
July	-	-	-	-	-	-	-	-	-	-	-	-	-0.283*	-0.003	0.163
August	-	-	-	-	-	-	-	-	-	-	-	-	-0.036	-4.85^{e-4}	0.138
September	-	-	-	-	-	-	-	-	-	-	-	-	-0.163	-0.002	0.146
October	-	-	-	-	-	-	-	-	-	-	-	-	-0.057	-7.39^{e-4}	0.151
November	-	-	-	-	-	-	-	-	-	-	-	-	-0.099	-0.001	0.161
December	-	-	-	-	-	-	-	-	-	-	-	-	-0.224	-0.002	0.183
Constant	-3.158***	-	0.071	-3.151***	-	0.079	-3.185***	-	0.097	-2.994***	-	0.120	-2.849***	-	0.156
Predicted Probability		0.008			0.006			0.005			0.005			0.005	
Observations		18178			18178			18178			18178			18178	
Pseudo Log-Likelihood		-1129.587			-831.871			-821.439			-814.705			-809.816	

*Note: 1. Probit estimates with robust standard errors; 2. Level of statistical significance: * for 0.1, ** for 0.05, *** for 0.01; 3. ME = Marginal Effects; 4. SE = Standard Error*

These result supports the cooperative equilibrium outcome in which workers act to maximize joint expected utility and suggests that they have a higher reservation level of sickness, $\tilde{\delta}^m$, than that of a single worker, $\tilde{\delta}$. Diagrammatically, this means that $\tilde{\delta}^m$ is located to the northeast of $\tilde{\delta}$, as per Figure 5.

The remaining results accord largely with our ex ante expectations. Specifically, optometrists exhibit higher absence when working half-days or in practices that are more likely to get another optometrist to cover for absence. Lag absence is also a good predictor of current absence, with optometrists who were absent the previous day being more likely to be absent the following day as well. There is no evidence that optometrists are less likely to absent when working in their main practice and whilst there is some evidence of 'Monday blues' there is no real evidence of seasonal variation.

5. Final Comments

We develop a theoretical model of worker interaction and explore the impact on absence from workers acting cooperatively or competitively. Our model suggests that a non-cooperative equilibrium outcome yields an inefficiently high absence rate on account of the effort externality an absenting worker imposes on his non-absenting colleague. In contrast, when workers cooperate the externality is internalized and a lower, efficient level of absence can be reached. We test the model on a dataset of optometrists who either work in pairs (*Double-Testing*) or alone (*Single-Testing*). We find that those working in pairs are significantly less likely to absent, a result that supports the cooperative equilibrium prediction from our theoretical model.

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Appendix

A1: *Deriving decision rule from expected utility maximization.*

The individual's expected utility may be written as:

$$\mathbf{E}\{u\}=\int_0^1 u f(\delta)\,d\delta$$

$$\Rightarrow$$

$$\mathbf{E}\{u\}=\int_0^{\tilde{\delta}}\left[(1-\delta)w+\delta(T-h)\right]d\delta+\int_{\tilde{\delta}}^1\left[(1-\delta)s+\delta T\right]d\delta$$

$$\Rightarrow$$

$$\mathbf{E}\{u\}=\left[\delta w+\frac{\delta^2}{2}(T-w-h)\right]_0^{\tilde{\delta}}+\left[\delta s+\frac{\delta^2}{2}(T-s)\right]_{\tilde{\delta}}^1 \tag{A1.1}$$

$$\Rightarrow$$

$$\mathbf{E}\{u\}=\tilde{\delta}w+\frac{(\tilde{\delta})^2}{2}(T-w-h)+\left[s+\frac{1}{2}(T-s)\right]-\left[\tilde{\delta}s+\frac{(\tilde{\delta})^2}{2}(T-s)\right]$$

$$\Rightarrow$$

$$\mathbf{E}\{u\}=\tilde{\delta}(w-s)-\frac{(\tilde{\delta})^2}{2}(w-s+h)+\left(\frac{T+s}{2}\right)$$

Maximizing (A1.1) with respect to $\tilde{\delta}$ implies:

$$\frac{\partial \mathbf{E}\{u\}}{\partial\tilde{\delta}}=w-s+\tilde{\delta}(-w-h+s)=0$$

$$\Rightarrow \tag{A1.2}$$

$$\tilde{\delta}=\frac{w-s}{w-s+h}$$

A2: Deriving expected utility of worker 1 within the two-worker setting

$$\mathbf{E}\left\{u_1\right\}=\int_0^1 u_1 f\left(\delta_1\right)d\delta$$

$$\Rightarrow$$

$$\mathbf{E}\left\{u_1\right\}=\int_0^{\tilde{\delta}_1}\left\{\left(1-\delta_1\right)w+\delta_1\left[T-h-\left(1-\tilde{\delta}_2\right)e\right]\right\}d\delta_1+\int_{\tilde{\delta}_1}^1\left[\left(1-\delta_1\right)s+\delta_1 T\right]d\delta_1$$

$$\Rightarrow$$

$$\mathbf{E}\left\{u_1\right\}=\left[\delta_1 s+\frac{\delta_1^2}{2}\left(T-h-\left(1-\tilde{\delta}_2\right)e-w\right)\right]_0^{\tilde{\delta}_1}+\left[\delta_1 s+\frac{\delta^2}{2}\left(T-s\right)\right]_{\tilde{\delta}_1}^1 \tag{A2.1}$$

$$\Rightarrow$$

$$\mathbf{E}\left\{u_1\right\}=\tilde{\delta}_1 w+\frac{\tilde{\delta}_1^2}{2}\left[T-h-\left(1-\tilde{\delta}_2\right)e-w\right]+s+\frac{1}{2}\left(T-s\right)-\tilde{\delta}_1 s-\frac{\tilde{\delta}_1^2}{2}\left(T-s\right)$$

$$\Rightarrow$$

$$\mathbf{E}\left\{u_1\right\}=\tilde{\delta}_1\left(w-s\right)-\frac{\tilde{\delta}_1^2}{2}\left[w-s+h+\left(1-\tilde{\delta}_2\right)e\right]+\frac{1}{2}\left(T+s\right)$$

A3: Deriving joint expected utility

First, define:

$$\mathbf{X}_1\equiv\mathbf{E}\left\{u_1^{na}\right\}=\left(1-\delta_1\right)w+\delta_1\left[T-h-e\left(1-\tilde{\delta}_2\right)\right] \tag{A3.1}$$

and

$$\mathbf{Y}_1\equiv\mathbf{E}\left\{u_1^{a}\right\}=\left(1-\delta_1\right)s+\delta_1 T \tag{A3.2}$$

Thus, defining the joint utility of the two workers as $u=u_1+u_2$, we have:

$$\mathbf{E}\left\{u\right\}=\int_0^1\int_0^1\left(u_1+u_2\right)f\left(\delta_1,\delta_2\right)d\delta_1 d\delta_2 \tag{A3.3}$$

$$\Rightarrow$$

$$\mathbf{E}\left\{u\right\}=\int_0^1\left[\int_0^{\tilde{\delta}_1}\mathbf{X}_1\,d\delta_1+\int_{\tilde{\delta}_1}^1\mathbf{Y}_1\,d\delta_1+\int_0^1 u_2 d\delta_1\right]d\delta_2 \tag{A3.4}$$

$$\Rightarrow$$

$$\mathbf{E}\left\{u\right\}=\int_0^1\left[\int_0^{\tilde{\delta}_1}\left\{\left(1-\delta_1\right)w+\delta_1\left[T-h-e\left(1-\tilde{\delta}_2\right)\right]\right\}d\delta_1+\int_{\tilde{\delta}_1}^1\left[\left(1-\delta_1\right)s+\delta_1 T\right]d\delta_1+u_2\right]d\delta_2 \tag{A3.5}$$

$\Rightarrow$

$$\mathbf{E}\{u\} = \int_0^1 \left[\int_0^{\tilde{\delta}_1} \left\{ w + \delta_1 \left[T - w - h - e\left(1 - \tilde{\delta}_2\right) \right] \right\} d\delta_1 + \int_{\tilde{\delta}_1}^1 \left[\left(1 - \delta_1\right) s + \delta_1 T \right] d\delta_1 + u_2 \right] d\delta_2 \tag{A3.6}$$

$\Rightarrow$

$$\mathbf{E}\{u\} = \int_0^1 \left\langle \left\{ \delta_1 w + \frac{\delta_1^2}{2} \left[T - w - h - e\left(1 - \tilde{\delta}_2\right) \right] \right\}_0^{\tilde{\delta}_1} + \left[\delta_1 s + \frac{\delta_1^2}{2} \left(T - s\right) \right]_{\tilde{\delta}_1}^1 + u_2 \right\rangle d\delta_2 \tag{A3.6}$$

$\Rightarrow$

$$\mathbf{E}\{u\} = \int_0^1 \left\{ \tilde{\delta}_1 w + \frac{\tilde{\delta}_1^2}{2} \left[T - w - h - e\left(1 - \tilde{\delta}_2\right) \right] + s + \frac{1}{2}\left(T - s\right) - s\tilde{\delta}_1 - \frac{\tilde{\delta}_1^2}{2}\left(T - s\right) + u_2 \right\} d\delta_2 \tag{A3.7}$$

$\Rightarrow$

$$\mathbf{E}\{u\} = \int_0^1 \left\{ \tilde{\delta}_1 \left(w - s\right) - \frac{\tilde{\delta}_1^2}{2} \left[w - s + h + \left(1 - \tilde{\delta}_2\right) e \right] + \frac{1}{2}\left(T + s\right) + u_2 \right\} d\delta_2 \tag{A3.8}$$

Thus:

$$\mathbf{E}\{u\} = \int_0^1 \left(\mathbf{Z}_1 + u_2\right) d\delta_2 = \int_0^1 \mathbf{Z}_1\, d\delta_2 + \int_0^{\tilde{\delta}_2} \mathbf{X}_2\, d\delta_2 + \int_{\tilde{\delta}_2}^1 \mathbf{Y}_2\, d\delta_2 \tag{A3.9}$$

where:

$$\mathbf{Z}_1 = \tilde{\delta}_1 \left(w - s\right) - \frac{\tilde{\delta}_1^2}{2} \left[w - s + h + \left(1 - \tilde{\delta}_2\right) e \right] + \frac{1}{2}\left(T + s\right) \tag{A3.10}$$

$$\mathbf{X}_2 \equiv \mathbf{E}\left\{u_2^{na}\right\} = \left(1 - \delta_2\right) w + \delta_2 \left[T - h - e\left(1 - \tilde{\delta}_1\right) \right] \tag{A3.11}$$

$$\mathbf{Y}_2 \equiv \mathbf{E}\left\{u_2^{a}\right\} = \left(1 - \delta_2\right) s + \delta_2 T \tag{A3.12}$$

Thus:

$$\mathbf{E}\{u\} = \int_0^1 (\mathbf{Z}_1 + u_2) d\delta_2 = \int_0^1 \mathbf{Z}_1\, d\delta_2 + \int_0^{\tilde{\delta}_2} \mathbf{X}_2\, d\delta_2 + \int_{\tilde{\delta}_2}^1 \mathbf{Y}_2\, d\delta_2 = \mathbf{Z}_1 + \mathbf{Z}_2$$

$$\Rightarrow$$

$$\begin{aligned}\mathbf{E}\{u\} &= \tilde{\delta}_1(w-s) - \frac{\tilde{\delta}_1^2}{2}\left[w-s+h+(1-\tilde{\delta}_2)e\right] + \frac{1}{2}(T+s) + \\ &\quad + \tilde{\delta}_2(w-s) - \frac{\tilde{\delta}_2^2}{2}\left[w-s+h+(1-\tilde{\delta}_1)e\right] + \frac{1}{2}(T+s)\end{aligned} \qquad \text{(A3.13)}$$

$$\Rightarrow$$

$$\mathbf{E}\{u\} = (\tilde{\delta}_1 + \tilde{\delta}_2)(w-s) - \tfrac{1}{2}\left\{(\tilde{\delta}_1^2 + \tilde{\delta}_2^2)(w-s+h) + \left[\tilde{\delta}_1^2(1-\tilde{\delta}_2) + \tilde{\delta}_2^2(1-\tilde{\delta}_1)\right]e\right\} + T + s$$

A4: *Deriving the expected probability of obtaining a replacement in the incidence of an absence*

The purpose of the analysis here is to calculate how likely it is for a replacement to be sent to a practice when an optometrist is absent. Based on the information we have on replacement optometrists, we measure the average replacement probability for the practices that had some absence, separately per annum for each practice. This variable is the dependent variable in the equation we estimate, taking values from zero to one. The explanatory variables include the following practice-specific characteristics, calculated annually: (i) the mean absence rate (*Mean Absence*); (ii) the mean number of double-testing days (*Mean Double Testing*); (iii) the mean number of half-days (*Mean Half-Days*); and (iv) the distance of the practice from the company's nearest practice (*Distance*). By construction, there is variation in the dependent and independent variables both across practices and over time. The model is estimated at the practice level using a Tobit estimator and the results are set out in Table A4 following:

Table A4: Regression Estimate

Dependent Variable: Mean Replacement (at practice level)

	Coefficient	*Standard Error*
Mean Absence	21.456***	0.497
Mean Double Testing	0.261***	0.022
Mean Half-Days	1.208***	0.150
Distance	-0.007***	7.35^{e-4}
Constant	-0.045**	0.017
Observations	13066	
Log-Likelihood	-12124.816	

*Note: Tobit estimates. Level of statistical significance: * for 0.1, ** for 0.05, and *** for 0.01*

Based on these estimates, we derive the expected replacement probability for all the practices and years in the dataset.